PERFORMANCE OF VANARAJA BIRDS ON DIFFERENT LEVELS OF ENERGY AND PROTEIN

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DOCTOR OF PHILOSOPHY

By

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PERFORMANCE OF VANARAJA BIRDS ON DIFFERENT LEVELS OF ENERGY AND PROTEIN

BY

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Submitted

In partial fulfilment of the requirements for the Degree

of

Doctor of Philosophy

in

Livestock Production and Management

of

Nagaland University

Dedicated
to my
Beloved family

Nagaland University

May & 2025

I, Gaurav Dubey, 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 basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and that the Thesis has not been submitted by me for any research degree in any other university/Institute. This is being submitted to the 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 **"Performance of Vanaraja Birds on Different Levels of Energy and Protein"**, 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 Mr. Gaurav Dubey Registration No. Ph.D/LPM/00461 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 **"Performance of Vanaraja Birds on Different Levels of Energy and Protein"** submitted by Mr. GAURAV DUBEY, Admission No. Ph-322/20 Registration No. Ph.D/LPM/00461 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 ………………............

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

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

ABSTRACT

This research aimed to evaluate the performance of Vanaraja birds on different levels of energy and protein. A total of 180 day-old Vanaraja chicks were randomly assigned to 9 dietary treatments with 5 replications, each consisting of 4 birds, in a randomized block design. The treatments included combinations of three protein levels (16%, 18%, and 20%) and three energy levels (2400, 2600, and 2800 kcal/kg diet): T1 (16% protein, 2400 kcal), T2 (16% protein, 2600 kcal), T3 (16% protein, 2800 kcal), T4 (18% protein, 2400 kcal), T5 (18% protein, 2600 kcal), T6 (18% protein, 2800 kcal), T7 (20% protein, 2400 kcal), T8 (20% protein, 2600 kcal), and T9 (20% protein, 2800 kcal).Up to 8 weeks of age, the birds were reared in a battery brooder system, followed by housing in cages under standard management practices. Growth parameters, feed intake and egg production were recorded during the study. Blood samples were collected at 2, 4, and 6 months for hematological and biochemical analyses. At the end of the study, birds in the T9 group exhibited the highest body weight (3584.60 g) and mean body weight gain (204.84 g), while the lowest feed intake (1484.50 g) and best feed conversion ratio (11.00) were observed in the T9 group. Mortality and livability were similar amongst the groups. The highest performance index (142.31) and egg production (64.80 eggs) were recorded in the T9 group, which also showed early sexual maturity (124.40 days). Hematological analysis revealed that the T9 group had the highest WBC count (248.82 × $10^6/\mu L$) and RBC count (3.10 × $10^6/\mu L$). Biochemical analysis showed that T9 had the highest total serum protein (4.12 g/dL), lysine (102.40 mg/dL) and methionine (33.20 mg/dL), while the T1 group had the lowest serum cholesterol levels (134.98 mg/dL). Highest HDL (55.40 mg/dl) and LDL found in (82.80 mg/dl) T9. Organ weights were significantly influenced by treatments, with the T9 group showing the highest spleen (6.18 g) and liver (72.80 g) weights. The T1 group recorded the highest gizzard (41.80 g) and heart weight (15.40 g). The highest net profit per bird (₹651.98) was achieved in the T9 group. In conclusion, a diet containing 20% protein and 2800 kcal/kg energy had a significant positive impact on the growth performance, egg production, and economic viability of Vanaraja birds. These findings suggest that this dietary formulation is optimal for the rearing of Vanaraja birds.

Keywords: Vanaraja birds, Dietary protein, Dietary energy, Performance index, Egg production, Hematology, Biochemical parameters, Organ weight, Lysine, Methionine, Profitability

LIST OF ABBREVIATIONS

ABBREVIATIONS	FULL FORM
ANOVA	Analysis of variance
ad libitum	Freely; as much as
BIS	Bureau of Indian Standards
ME	Metabolizable Energy
BW	Body weight
BWG	Body weight gain
CP	Crude Protein
CPL	Low crude protein
CPH	High crude protein
df	Degree of freedom
EDTA	Ethylenediaminetetraacetic Acid.
FCE	Feed Conversion Efficiency
FCR	Feed Conversion Rate/Ratio
Fig	Figure
g	gram
g/dl	gram per deciliter
GNC	Groundnut cake
Hb	Haemoglobin
HDEP	Hen-Day Egg Production
HHEP	Hen–Housed Egg Production
HDL	High density protein
ICAR	Indian Council of Agricultural Research

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

CHAPTER I
INTRODUCTION

INTRODUCTION

Poultry plays an important role in the livestock sector by increasing productivity. Kumari and Rao (2023) stated that the poultry sector provides employment to millions of people in the country and is considered to have the highest employability among all livestock sectors. India is the third-largest producer of eggs and ranks fifth in poultry production globally (Kumari and Rao, 2022). Gulati and Juneja (2023) reported that India is now the fifth-largest producer of broilers, producing 4.4 million metric tonnes (MMT) in 2020-2021, after China, the USA, Brazil, and the Russian Federation. In recent decades, India's poultry sector has seen a remarkable shift, positioning the country as a global leader—third in egg production and fifth in broiler meat production. Poultry products like meat and eggs provide millions, especially those in underprivileged areas, with crucial nutrients, including high-quality protein, essential vitamins and minerals, supporting both health and nutrition on a national scale (Kashyap and Goswami, 2024).

Poultry meat is a high-quality food source, offering protein with a high biological value, relatively low fat content, excellent digestibility, iron, several B vitamins and superior organoleptic qualities (Marcu *et al.*, 2013). Poultry meat is in high demand among consumers due to its unique flavour, exceptional nutritional value, and high digestibility (Marcu *et al.*, 2011). The quality of feed stuffs plays a crucial role in sustaining chicken production and ensuring profitability (Beski *et al.*, 2015). Studies on poultry production costs indicate that feed is the main cost component followed by miscellaneous items such as the cost of one-day-old chicks, medicines and labor. The marketing channel is well-organized and operates in a fairly competitive environment. Feed prices in both the wholesale and retail markets have increased significantly over the years (Vetrieval and Mangalam, 2013). The highest production cost on farms is feed, but the share of these costs varies by production system. In broiler production (BR), the share of feed costs is relatively lower than in other systems because of the higher share of facility costs (Kato and Shimizuike, 2022).

Salih and Singh, 2016 also concluded that one of the major challenges faced by the poultry industry is the high cost of feed. Feed prices constitute around 60–70 percent of the total production cost, making them a key factor in the production and market scenario of the poultry sector. If feed costs are lower, more farmers are likely to enter the business, and many would want to rear more birds (Mallick *et al.,* 2020). Several research efforts are ongoing to reduce feed consumption. On the other hand, there is a significant demand to produce high-quality poultry meat and eggs at lower prices, without relying on antibiotics and other medicines in poultry feed and water (Mehala and Moorthy, 2008).

A substantial portion of agricultural and industrial by-products, typically unsuitable for human consumption, finds a purpose in poultry farming, transforming into premium-grade, nutrient-dense protein products. This not only meets the nation's growing demand for high-quality protein but also helps bridge the gap between supply and demand. Among the most economical sources of animal protein are eggs and poultry meat, which serve as staples in many diets. Moreover, poultry manure is an excellent alternative to conventional fertilizers, offering valuable nutrients for soil enrichment and agricultural sustainability.

Vanaraja, a dual-purpose backyard poultry breed, was developed by the ICAR-Directorate of Poultry Research, Hyderabad, and has been extensively propagated across various agro-climatic regions of India over the past three decades. According to the 15th Livestock Census, the Vanaraja breed accounted for an estimated 0.0007% of the total Indian chicken population. This share witnessed significant growth, reaching 0.228% in the 20th Livestock Census, corresponding to an index point value of 89,240. Vanaraja has become popular among rural people, especially for generating extra income (Niranjan *et al.,* 2008). Vanaraja, a high-yielding dual-purpose chicken has been successfully introduced in various parts of the country, showing promising productive and reproductive performance under backyard management systems (Islam *et al.,* 2014). Vanaraja chickens can be reared more economically in semi-intensive systems (Baba *et al.,* 2015). The egg production of Vanaraja birds is also satisfactory, with Vanaraja layers producing heavier eggs than commercial layers (Swain *et al.,* 2008). The system of poultry rearing significantly influences the economics of poultry production (Mishra, 2005).

Fraps (1943) demonstrated that altering dietary protein levels can significantly affect broiler performance. He observed variations in body weight, feed intake, and, most notably, carcass composition among birds fed different protein levels. Energy is required for body functioning and protein is essential for tissues maintenance in the animal body (Jafarnejad and Sadegh, 2011). Feed intake increases during the growing stage, so the energy and protein balance should be optimal. It is widely agreed that determining the nutrient requirements for different types of poultry is essential for effectively utilizing their genetic potential to achieve specific production goals (Nahashon *et al.,* 2005). (Van Emous *et al.,* 2015) found that the factors included two levels of dietary protein during the rearing phase (high = CPh and low = CPl), three levels of dietary energy during the first phase of lay (3,000 kcal/kg AMEn = MEh1; 2,800 kcal/kg AMEn = MEs1; and 2,600 kcal/kg AMEn = MEl1), and two levels of dietary energy in the second phase of lay (2,800 kcal/kg AMEn = MEs2; and 3,000 kcal/kg AMEn = MEh2). Results indicated that pullets fed the low crude protein (CPl) diet exhibited a 12.8% increase in feed intake compared to those on the high crude protein (CPh) diet.

Both protein and energy in the diet are equally crucial for early growth and feed efficiency (Golian *et al*. 2010). Assessing the energy content of a diet is crucial in animal nutrition, as it significantly affects food intake. Energy in the feed in the proper proportion is essential during the juvenile period for the proper growth of chickens (Haunshi *et al.,* 2012). Chicks on a low-energy diet consume more feed (Hill and Dansky, 1954). Protein is considered one of the most expensive nutrients in commercial poultry feed. Protein and energy are key nutrients that affect poultry production (Rabie *et al.,* 2017; Yunana *et al.,* 2019). It has been found that the increased heat production in birds fed a low-protein diet can be attributed to both an increase in energy requirements for maintenance (MEm) and a sharp decrease in the efficiency of utilization of metabolizable energy (ME) for growth (Neto *et al.,* 2000).

Energy and protein play a significant role in the growth and performance of chickens. Gain in body weight is maximized with diets containing 19% and 21% crude protein (CP) at higher energy levels. Increasing dietary energy and protein significantly improved feed conversion (Gunawardan *et al*., 2008). If level of protein and energy is low then it leads to poor performance in terms of gain in body weight (Parveen *et al.,* 2016). The relationship between egg production and dietary energy levels had a significant impact on feed consumption. Higher egg production was associated with increased feed intake, while an increase in dietary energy led to a reduction in feed consumption (Ivy and Gleaves, 1976). Significantly higher egg production ($P < 0.05$) was observed in the T3 group compared to the other treatments, attributed to the higher protein and energy content of the diet (Geleta and Leta, 2015).

The protein and energy levels in the ration also affect the internal organs of chickens. If content of dietary energy is reduced below 2600 kcal then it increases the relative weights of the intestine and gizzard (Rao *et al.,* 2005). (Eits *et al.,* 2003) found in his experiment that chicken fed with higher protein and calories showed 10% improvement in body weight gain. Excessive dietary protein leads to increased heat production and water intake, which in turn raises the moisture content of the litter (Azizi *et al*., 2011). Protein is a crucial component for chickens, essential for muscle development, feather growth, and overall body maintenance. Optimal protein intake is especially vital during crucial stages like early growth and periods of high activity, such as egg production or broiler growth. Reducing the crude protein in meat-chicken diets alters the ingredient and nutrient profile beyond just the amino acid composition (Hillar and Swick, 2019). The bird's production performance is significantly influenced by the protein content in its diet (Rao *et al.,* 2007). Inadequate protein levels may lead to stunted growth, diminished egg production, and compromised immune function. Protein stands out among the essential nutrients required by birds, playing a pivotal role in promoting growth, optimizing feed utilization, bolstering immune function, and enhancing production performance (Panda *et al.,* 2011). Conversely, excessive protein consumption can strain the kidneys and disrupt metabolic equilibrium. Hence, striking the right balance in dietary protein is paramount for ensuring the health and productivity of chickens. A higher protein content diet (23%) increased the total cholesterol content in muscle compared to a lower protein content diet (19%) (Barteczko and Lasek, 2008). Energy and protein present in the feed affect the biochemical and hematological levels of birds. High levels of cholesterol are found in blood serum when the feed contains more protein and energy (Perveen *et al.,* 2017). Reducing protein levels in the feed and using synthetic amino acids is crucial to minimize feed expenditure and control nitrogen emissions, thus limiting environmental pollution (Cesare *et al.,* 2019). The net return improved with the increase in both dietary protein and dietary energy levels (Geleta and Leta, 2015).

Despite extensive research on commercial broilers, there is limited information on the specific nutritional requirements of Vanaraja birds, particularly under varying energy and protein levels. This study aims to fill this gap by evaluating the performance of Vanaraja birds in terms of growth, feed efficiency, carcass characteristics, and biochemical parameters under diverse nutritional conditions. The findings will contribute to developing cost-effective, sustainable feeding strategies for indigenous poultry breeds, enhancing productivity and profitability in rural and semi-intensive farming systems.

Hence, the present study entitled **"Performance of Vanaraja birds on different levels of Energy and Protein”** was conceived with the following objectives:

1. To study the effect of different levels of energy and protein on growth, haematological and biochemical traits of blood of Vanaraja birds,
2. To study the effect of different levels of energy and protein on reproduction, production and carcass traits of Vanaraja birds, and
3. To study economics of raising Vanaraja birds on different levels of energy and protein.

CHAPTER- II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Protein and energy are vital nutrients in poultry diets, contributing significantly to growth, health, and productivity. Protein supplies essential amino acids required for muscle development, tissue repair, and the synthesis of enzymes and hormones. It supports optimal growth rates, enhances feed efficiency, and strengthens the immune system. Energy, on the other hand, serves as a primary fuel source, sustaining metabolic functions, physical activity, and heat production. The proper balance of energy and protein in the diet ensures efficient nutrient utilization, reducing feed costs and improving performance. A deficiency in these nutrients can lead to poor growth, lower egg production, and weakened immunity, while excessive amounts may result in metabolic disorders. Therefore, maintaining an appropriate protein-to-energy ratio is crucial for promoting healthy growth, maximizing productivity, and ensuring the overall well-being of poultry. Numerous studies have investigated the impact of varying energy and protein levels in poultry diets to evaluate their effects on performance. Extensive reviews of previous research highlighting the influence of dietary energy and protein on poultry growth, production, and overall performance have been compiled and discussed under specific sub-sections.

2.1 Effect of different levels of energy and protein on growth and blood parameters

2.1.1 Body weight and body weight gain

Sunde (1956) found that growth was hindered on a low-protein diet when the energy level was high.

Mraz *et al.* (1958) found that Chickens receiving higher protein diets at the same energy level exhibited significantly greater body weight compared to those on lower protein diets.

Summers *et al.* (1964) concluded after giving different levels of protein (10%, 14%, 18%, 22%, and 26%) in diets that raising the protein level to 26% led to an increase in weight gain.

Gooch *et al.* (1971) reported a reduction in weight gain in broilers when the energy density was decreased from 2960 to 2880 kcal ME/kg.

Griffiths *et al.* (1977) found that both corn oil and poultry grease significantly ($P \leq 0.05$) increased body weight gains in male broilers, while animal vegetable blend fats did not produce similar effects.

Jackson *et al*. (1982) concluded that raising the protein level to 26% led to an increase in weight gain.

Leeson *et al.* (1996) found that broiler breeders on a high-protein diet with 16.7% crude protein had greater body weight than those fed a diet with 12.7% crude protein.

Holsheimer *et al*. (1992) concluded that higher protein is helpful in increasing the body weight gain.

Summers *et al.* (1992) concluded that diet containing higher energy level resulted in higher gain in body weight by the chicken.

Keshavarz and Nakazima (1995) found that the 18-week body weight showed a slight increase ($P < .05$) when the energy levels in the diets were raised or when fat was added.

Hussein *et al.* (1996) found that during weeks 15 through 20, higher dietary energy led to increased weight gain.

Cheng *et al.* (1997) found that reduction in the protein levels led to reduction in growth performance of the chicken.

Ferguson *et al.* (1998) concluded that results suggest that there is a point below which any further reduction in CP of the diet will cause a reduction in growth.

Toppo *et al.* (2004) found that six experimental diets were formulated with two energy levels (2600 and 2800 kcal ME/kg) and three protein levels (18%, 20%, and 22% CP). Body weight increased as the protein level rose from 18% to 20% CP, but no additional weight gain was observed when the protein level was further increased to 22%.

Van Nguyen and Bunchasak (2005) found that the growth performance of Betong chicks was significantly decreased when the crude protein (CP) level was 17%. However, body weight and weight gain showed slight improvement with an increased energy level.

Waldroup *et al.*, (2005) concluded that five primary diets were formulated with 16%, 18%, 20%, 22%, and 24% crude protein (CP). Reducing CP levels in the starter diets significantly impacted live performance. When CP levels dropped below 22%, there was a notable decrease in body weight gain.

Aftab *et al.* (2006) reported that the minimum dietary crude protein levels 20.7%, 18.0%, and 16.2%. In nearly all cases, lowering dietary protein led to reduced live weight and carcass yield.

Nawaz *et al.* (2006) found that broiler finisher diets with two levels of metabolizable energy (ME), 3000 and 3200 kcal/kg, and three levels of crude protein (CP), 16%, 17%, and 18%, as well as 18%, 19%, and 20%, were offered. Diets with high CP and low ME resulted in higher weight gain during the finisher phase.

Rama Rao *et al.* (2006) concluded that chickens fed a diet containing 14.5% crude protein experienced significantly lower weight gain ($P<0.05$) compared to those provided with diets containing 16% or higher protein levels during the period from 1 to 49 days of age.

Sterling *et al.* (2006) found that increasing dietary crude protein (CP) reduced the percentage of abdominal fat in both experiments. However, higher dietary lysine levels only reduced this fat percentage in starter-phase chicks. In both experiments, Ross broilers responded more significantly to supplemental lysine when fed a 17%

CP diet, but showed less response when fed a 23% CP diet in terms of body weight gain (BWG).

Das *et al.* (2007) revealed that birds were fed diets containing three different protein levels (22%, 23%, and 24%) and three energy levels (2700, 2800, and 2900 Kcal/kg). The results showed that body weight increased with higher energy and protein levels, reaching optimal gains at 2800 Kcal/kg and 24% protein. However, no further increases in body weight were observed beyond these levels.

Kamran *et al.* (2008) revealed that four dietary treatments were formulated with varying levels of crude protein (CP) and metabolizable energy (ME): 23%, 22%, 21%, and 20% CP, and 3,036, 2,904, 2,772, and 2,640 kcal/kg ME, respectively, while maintaining an ME ratio of 132 across all diets. Body weight was significantly increased ($p<0.05$).

Swain *et al.* (2008) concluded that Vanaraja Chicken fed feed ingredients of Groundnut cake (GNC) and sunflower cake (SFC) showed higher body weight and feed efficiency.

Dehury *et al.* (2008) found that the group of birds fed a diet with 20% crude protein (CP) and 2900 Kcal/kg of metabolizable energy (ME) consistently recorded the highest body weight across all measurement ages. Additionally, this diet resulted in the greatest body weight gain.

Ahmed *et al.* (2009) found that body weight was significantly affected ($P < 0.01$) by dietary energy levels and the interaction between protein and energy, though dietary protein levels alone did not have a significant impact. However, weight gain improved with increasing protein levels in the diets.

Marcu *et al.* (2009) found that including fodder with a higher protein content and an optimized energy-to-protein ratio leads to faster growth rates in poultry.

Hosseini *et al.* (2010) found that body weight was higher for the groups which fed > 3000 Kcal ME Kg^{-1} compared to those fed < 3000 Kcal ME $Kg^{-1.}$

Jafarnejad and Sadegh (2011) found that higher energy and protein levels lead to higher body weight.

Banday *et al*. (2013) found that after three dietary treatments were formulated to be iso-energetic at 2900 Kcal ME, with protein levels of 20% (T1), 21% (T2), and 22% (T3), The results showed significant improvements ($P < 0.05$) in body weight gains.

Deo *et al.* (2014) found that the chicks fed diets containing 18% and 20% CP showed significantly higher body weight gain from 0 to 12 weeks compared to those fed a 16% CP diet.

Haunshi *et al*. (2015) revealed that three diets with different nutrient densities were formulated: low density (LD) with 2400 kcal/kg ME and 14% CP, medium density (MD) with 2600 kcal/kg ME and 15% CP, and high density (HD) with 2800 kcal/kg ME and 16% CP. These diets, which were based on maize and soybean, were provided to the birds until they reached 40 weeks of age. The findings revealed that body weight gain from 25 to 40 weeks was significantly greater ($P < 0.05$) in the HD group compared to the LD group.

Infante Rodriguez *et al.* (2016) observed that body weight gain was not influenced by energy level in diets for broiler chicken.

Mandal *et al.* (2016) found that Chicks fed diets with 18% and 20% crude protein (CP) showed significantly higher body weight gain ($P < 0.01$) compared to those on a 16% CP diet.

Perween *et al.* (2016) reported that the effect of feeding different levels of energy and protein on growth parameters such as body weight gain and FCR was found to be significantly higher ($p<0.05$) containing 19% and 21% crude protein with 3000 kcal ME/kg in Vanaraja birds. The T9 group, fed a diet with 21% CP and 3000 kcal ME/kg, achieved the highest overall body weight gain. However, this was statistically comparable to the T6 group, which received a diet with 19% CP and 3000 kcal ME.

Miah *et al.* (2016) revealed that the diets with low protein density (LPD), moderate protein density (MPD), and high protein density (HPD) were formulated with crude protein (CP) levels of 11.42%, 19.19%, 21.30%, and 23.22%, respectively. Birds fed the HPD diet successfully reached the target weight of 750 g, while those on the LPD and MPD diets showed significantly lower body weights ($P < 0.05$).

Shiblee (2018) revealed that birds were randomly assigned to five dietary treatment groups labelled T0, T1, T2, T3, and T4, with supplements of 0 percent, 2 percent, 4 percent, 6 percent, and 8 percent meat and bone meal (MBM) which contains high protein and energy, respectively. The T4 group exhibited the highest average weight gain by the fourth week. The study concluded that increasing levels of supplemental MBM significantly enhanced performance parameters and carcass characteristics.

Vardhrajan *et al.* (2022) reported that various levels of crude protein (CP) significantly impacted ($P < 0.05$) the body weight gain (BWG) of Aseel chicken. Experimental diets were tailored to include differing CP levels, specifically 18.5 percent, 19.0 percent, 19.5 percent, 20.0 percent, 20.5 percent, 21.0 percent, and 21.5 percent, all of which were matched with an iso-caloric energy content of 2800 kcal ME/kg. He found that the T9 group, which was fed a diet containing 21% CP and 3000 kcal ME/kg, achieved the highest overall body weight gain.

Perween *et al.* (2017) found that nine experimental rations were formulated with three protein levels (17 percent, 19 percent, and 21 percent) and three energy levels (2600, 2800, and 3000 kcal ME/kg). Vanaraja chickens fed diets containing 19% CP and 3000 kcal ME/kg had lower feed intake compared to those fed diets with 17% CP.

Belloir *et al.* (2017) dLys ratio was increased from 63% to 68% and the dArg:dLys ratio was decreased from 112 percent to 108 percent. In experiment 1, the reduction of dietary CP from 19 percent to 15 percent (five treatments) did not alter feed intake or BW, but the feed conversion ratio was increased for the 16 percent and

15 percent CP diets (+2.4 percent and +3.6 percent, respectively), while in experiment 2 (three treatments: 19 percent, 17.5 percent and 16 percent CP) there was no effect of dietary CP on performance. In both experiments, dietary CP content did not affect breast meat yield. However, abdominal fat content (expressed as a percentage of BW) was increased by the decrease in CP content.

Deepak *et al* (2017) concluded that chicks fed diets containing 2600 and 2800 kcal ME/kg showed significantly higher body weight gain ($P < 0.05$) compared to those fed 2400 kcal ME/kg. Additionally, body weight gain increased significantly ($P < 0.001$) with higher crude protein (CP) levels in the diet.

Bhagat *et al.* (2020) found that Body weight and body weight gain of birds were found to be significantly higher ($p < 0.05$) in the group fed with T5 ration, which consisted of varying levels of crude protein (CP) and metabolizable energy (ME), compared to birds fed with T1, T2, T3, and T4 rations.

Chrystal *et al.* (2020) found that reducing dietary crude protein by 55 g/kg (from 227 g/kg to 172 g/kg) led to a 5.1% decrease in weight gain.

Tikate *et al.* (2021) found that the body weight and weight gain of broilers in group B were significantly higher ($P < 0.05$) than those in group A during the first, second, fifth, and sixth weeks of age, as well as throughout the entire duration of the experiment.

Brandejs *et al.* (2022) reported that reducing crude protein from 20% to 18% led to a significant decrease in body weight ($P < 0.05$).

Divya *et al.* (2023) reported that birds provided with diets containing higher protein levels (22% and 20% CP) demonstrated significantly greater body weight gain ($p \leq 0.05$) compared to those fed with lower protein diets.

Maynard *et al.* (2023) found that broilers fed the H diets performed better than those fed the L diets, regardless of sex, showing increased body weight and improved feed conversion ratio ($P < 0.05$).

2.1.2 Feed intake

Sugandi *et al*. (1975) found that birds fed the higher protein level consumed more feed ($P < 0.01$) compared to those fed the lower protein level.

Bartov (1995) found that chicks on the high-protein, low-energy (HPLE) diet consumed significantly less feed compared to those on the low-protein, high-energy (LPHE) diet during the study period.

Hussein *et al.* (1996) found that the higher energy level led to significantly lower feed intake. During Weeks 15 to 18, higher dietary energy levels led to greater weight gain while reducing feed intake.

Ferguson *et al.* (1998) reported that feed intake was reduced when Cp was higher in the diet.

Aletor *et al.* (2000) found that Chicks fed the lowest protein diets consumed more feed ($P \leq 0.05$).

Bregendahl *et al.* (2002) concluded that chicken fed low-protein diets consumed more feed in comparison to chicken fed high-protein diet.

Elangovan *et al*. (2004) found that feed intake was maximum in feed with 12% CP.

Toppo *et al.* (2004) found that total feed intake ($P < 0.01$) was higher in lower energy level diet with higher protein level.

Nahashon *et al.* (2005) reported that birds fed with 21% CP diet consumed significantly more feed ($P < 0.05$) compared to those on a 23% CP diet.

Nawaz *et al.* (2006) found that broiler finisher diets with two levels of metabolizable energy (ME), 3000 and 3200 kcal/kg, and three levels of crude protein (CP), 16%, 17%, and 18%, as well as 18%, 19%, and 20%, were offered. The chicks were randomly divided into 18 replicates of 15 chicks each, with 3 replicates for each diet. Feed intake was significantly higher ($p<0.05$) in diets with lower ME.

Kamran *et al.* (2008) revealed that Four dietary treatments were formulated with varying levels of crude protein (CP) and metabolizable energy (ME): 23%, 22%, 21%, and 20% CP, and 3,036, 2,904, 2,772, and 2,640 kcal/kg ME, respectively, while maintaining an ME ratio of 132 across all diets. Feed intake increased linearly as CP and ME levels were reduced in diets during the grower, finisher, and overall periods ($p<0.05$).

Ahmed *et al.* (2009) found that feed consumption was significantly lower ($P < 0.01$) at 2900 Kcal ME/kg compared to 2500, 2700, and 2800 Kcal ME/kg.

Haunshi *et al.* (2012) found that Birds fed diet with 2,400 kcal/kg ME had significantly lower BWG ($P < 0.004$), lower shank length ($P < 0.0007$), higher feed intake ($P < 0.0001$) and poor FCR ($P < 0.0001$) than those fed diet with either 2,600 or 2,800 kcal/kg ME.

Melesse *et al.* (2013) found that chickens fed the T3 and T4 diets showed higher feed consumption, whereas those on the T1 diet consumed less feed.

Perween *et al.* (2016) found that vanaraja chickens reared on a diet containing 19% crude protein (CP) and 3000 kcal ME/kg exhibited lower feed intake compared to those fed a diet with 17% CP, even when the energy level was increased.

Perween *et al.* (2017) concluded that showed that the effect of feeding different level of energy and protein had similar effect on energy metabolizability.

Deepak *et al.* (2017) reported that Feed intake was significantly higher ($P<0.05$) in groups fed diets with 2400 and 2600 kcal ME/kg compared to those fed a diet containing 2800 kcal ME/kg. The variation in crude protein levels within the diets did not exert a significant influence on feed intake.

Gupta *et al.* (2017) concluded that the Vanaraja birds of lower stocking density consumed higher amount of feed.

Bhagat *et al.* (2020) found that among the five dietary treatments featuring different combinations of crude protein (CP) and metabolizable energy (ME), the group fed with T4 ration, which consisted of 18% CP and 3000 Kcal/kg ME, exhibited significantly higher feed consumption ($p < 0.05$) compared to birds fed with other rations.

Divya *et al.* (2023) concluded that birds fed with diets containing 2800 kcal ME/kg exhibited significantly higher feed consumption ($p \leq 0.05$) compared to other groups.

Vardharajan *et al.* (2022) found that the group provided with a diet containing 21% crude protein experienced a weight gain that was 223.53 g higher than the group fed the lowest crude protein level of 18.5%. Despite these variations in crude protein levels, there was no significant influence ($P > 0.05$) observed on the feed intake across all treatment groups. However, it's worth noting that numerically, the highest feed intake was observed in the group fed the lowest crude protein level of 18.5%.

2.1.3 Feed conversion ratio

Sunde (1956) found that increasing dietary protein from 20% to 28% in low-energy diets actually decreased feed efficiency.

Toppo *et al.* (2004) found that feed conversion ratio (FCR, $P < 0.05$) was higher in lower energy diet and protein.

Ferguson *et al.* (1998) found that reducing the CP concentration (and lysine) below 215 g/kg (13.7 g/kg lysine) in diets fed to chicks during the first 3 weeks may slightly increase the feed-to-gain ratio.

Aletor *et al.*, (2000) found that Chicks fed with lower protein diet had reduced feed conversion efficiency (FCE) ($P \leq 0.05$).

Ojewola and Longe (1999) found that birds fed with 12.13 MJMe/kg and 27% protein showed that best FCR.

Nahashon *et al.* (2005) found that the better feed efficiency of birds on a 23% CP diet may be linked to their higher body weight and greater nitrogen and energy intake compared to birds on a 21% CP diet.

Waldroup *et al.* (2005) investigated five primary diets formulated with crude protein (CP) levels of 16%, 18%, 20%, 22%, and 24%. They found that reducing CP levels in the starter diets had a notable impact on live performance. Specifically, when CP levels dropped below 22%, the feed conversion ratio (FCR) significantly increased, indicating less efficient feed utilization. Reducing the crude protein (CP) levels in the diet led to significant increases in the feed conversion ratio (FCR) with each decrease in CP level.

Hosseini *et al.* (2010) found that birds fed lower energy and lower protein diet had higher FCR in comparison to other birds.

Haunshi *et al.* (2012) concluded that provision of 2,600 kcal/kg ME and 16% CP would be ideal for optimum growth of *Aseel* birds during juvenile phase. However, to obtain better FCR, feeding *Aseel* birds with diet having 2,800 kcal/kg ME and 16% CP would be ideal.

Van Emous *et al.*(2015) found that the factors included two levels of dietary protein during the rearing phase (high = CPh and low = CPl), three levels of dietary energy during the first phase of lay (3,000 kcal/kg AMEn = MEh1; 2,800 kcal/kg AMEn = MEs1; and 2,600 kcal/kg AMEn = MEl1), and two levels of dietary energy in the second phase of lay (2,800 kcal/kg AMEn = MEs2; and 3,000 kcal/kg AMEn = MEh2). Results indicated that pullets fed the low-protein (CPl) diet exhibited a 12.8% increase in feed intake compared to those on the high-protein (CPh) diet.

Hassan *et al.* (2016) concluded that feeding diets with high metabolizable energy and normal protein NRC-levels had a lesser improvement effect on performance, also without affecting carcass or body composition except an increased visible fat and a slight increase in ether extract.

Perween *et al.* (2016) reported that the FCR was significantly influenced by dietary treatment and level of protein and energy. It was observed that the FCR value is highest in T_1 group 2.96 and significantly greater than other treatment group diet having 17% protein and 2800 kcal energy and T_2 has comparable FCR with T_3. Similarly, FCR value of T_4, T_7 and T_4, T_8 were not significantly different ($p>0.05$).

Perween *et al.* (2017) found that the FCR was better ($P<0.05$) in 19% CP than 17% CP containing diets.

Belloir *et al.* (2017) reported that reducing dietary CP from 19% to 15% across five treatments led to an increase in the feed conversion ratio.

Deepak *et al*. (2017) found that the feed conversion ratio (FCR) was better in groups fed 2600 and 2800 kcal ME/kg compared to those fed 2400 kcal ME/kg. FCR also improved with higher crude protein (CP) levels in the diet.

Yunana *et al.* (2019) concluded that farmers can adopt or use low dietary levels of energy and proteins at the starter phase and use higher dietary levels of energy and proteins during the finisher phase.

Bhagat *et al.* (2020) concluded that among the five dietary treatments featuring different combinations of crude protein (CP) and metabolizable energy (ME), T5, comprising 18% CP and 3000 Kcal/kg ME, exhibited a significantly enhanced feed conversion ratio ($P < 0.05$) compared to T1, T2, T3, and T4 rations.

Chrystal *et al.* (2020) found that reducing the protein level in the diet increased the FCR (Feed conversion ratio).

Divya *et al.* (2023) found that among the various protein levels tested (18%, 20%, and 22%), birds fed with diets containing 22% and 20% crude protein (CP) exhibited significantly improved cumulative feed conversion ratio (FCR) ($p\leq0.01$).

Maynard *et al.* (2023) concluded that broilers fed the H diets showed decreased FCR compared to those fed the L diets, here H and L denotes higher density and lower protein respectively where H and L denotes higher and lower levels of protein.

Rao *et al.* (2004) found that the feed conversion ratio during 1 to 42 days of age varied ($P<0.05$) significantly with the energy levels and was comparable among the dietary groups containing 2600 to 2800 kcal ME/kg diet. Reducing the ME content of diet below 2600 kcal/kg diet adversely affected the feed conversion ratio. The DM digestibility was significantly ($P<0.05$) higher in chicks of the dietary groups received 2600 to 2800 kcal ME/kg diet as compared to all other dietary groups. Lowering the ME content of the diet below 2600 kcal/kg negatively impacted the feed conversion ratio.

Tikate *et al.* (2021) concluded that the feed conversion ratio (FCR) of broilers in group B (Energy, Crude protein, lysine and methionine) was significantly better ($P < 0.05$) compared to group A, both during the fifth week and across the overall performance period.

2.1.4 Performance index

Hussein *et al.* (1996) found that the dietary treatments did not have a significant impact on the mortality rate.

Neto *et al.* (2000) found that supplementing methionine improved the performance of chicks fed diets containing 17% protein.

Bregendahl *et al.* (2002) found that low-protein diets failed to support growth performance equivalent to that of high-protein control diets.

Nahashon *et al*. (2005) reported that the reduction in performance of birds fed a 16% CP diet was minimal when they received supplements of all essential amino acids at levels equivalent to those in a 20% CP diet.

Waldroup *et al.* (2005) found that lowering the crude protein (CP) levels in the diets significantly impacted the live performance of male broilers.

Nawaz *et al.*(2006) found that diets with low ME and high CP were found to deliver optimal performance for broiler chicks during both the starter and finisher phases.

Kamran *et al.* (2008) Four dietary treatments were formulated with varying levels of crude protein (CP) and metabolizable energy (ME): 23%, 22%, 21%, and 20% CP, and 3,036, 2,904, 2,772, and 2,640 kcal/kg ME, respectively, while maintaining an ME ratio of 132 across all diets. Further he concluded that Chicks fed low CP diets with a constant ME ratio exhibited slower growth. Feeding broiler chickens diets with low CP while maintaining a constant ME ratio negatively affected their growth performance.

Ahmed *et al.* (2009) concluded that a diet containing 24% crude protein (CP) and 2700 Kcal ME/kg outperformed other diets in terms of performance. Sixteen experimental rations were formulated with CP levels of 21%, 22%, 23%, and 24%, each combined with energy levels of 2500, 2700, 2800, and 2900 Kcal ME/kg. Among these, the diet with 24% CP and 2700 Kcal ME/kg provided better option compared to other diets.

Hosseini *et al.* (2010) found that when chicken fed diet higher nutrients density and higher protein improves the performance of the broiler chicken.

Azizi *et al.* (2011) found that no interaction was observed between diet energy and protein dilution and the duration of feeding the starter diet on body weight and feed intake.

Liu *et al.* (2017) found that the effect of protein on performance was influenced by the levels of dietary fats (lipids) included in the diet. In other words, while protein concentration is important, the presence and amount of lipids in the diet can modify or alter how effectively the protein contributes to the chickens' performance outcomes.

Perween *et al.* (2017) found that the results of the study indicated that diet containing 20% CP with 2900 kcal ME/kg showed enhanced growth performance in Giriraja chicks.

Panda *et al.* (2020) found that the conclusion is that reducing the nutrient density by 6% from the control diet, with a diet containing 2440 kcal ME per kg, 15.0% CP, 0.66% lysine, and 0.33% methionine, may be sufficient to maintain optimal performance in Vanaraja laying hens.

Maynard *et al.* (2023) concluded that broilers fed the H diets showed better performance compared to those fed the L diets, here H and L denotes higher density and lower protein respectively.

2.1.5 Haematological and biological constituents of blood

Haunshi *et al.* (2012) concluded that the levels of ME, CP, and their interaction had a significant impact on serum protein and cholesterol levels.

Deepak *et al.* (2017) The research revealed that chicks fed diets with 2400 kcal ME/kg exhibited significantly elevated serum total cholesterol levels ($P<0.001$). Conversely, serum total protein levels remained consistent and unaffected by variations in metabolizable energy (ME), crude protein (CP), and their interactions.

Panigrahy *et al.* (2017) reported in summer the level of glucose was significantly ($p<0.05$) lower both in male and female than winter season. During summer, the cholesterol level was non significantly higher in both males and females than winter.

Perween *et al.* (2017) concluded that the total cholesterol in serum was the highest in group fed higher level of protein and energy and the lowest in group fed lower protein and energy containing ration.

Lotha *et al.* (2020) reported that the values of the average cholesterol concentration of the Vanaraja birds at the end of the 10th week were 149.82, 137.07, 158.16 and 148.85 mg/dl in T_1, T_2, T_3 and T_4 groups, respectively.

2.2 Effect of different levels of energy and protein on reproduction, production and carcass traits

2.2.1 Reproductive and productive traits

Ivy and Gleaves (1976) found that a significant influence of egg production levels and dietary energy on feed consumption. As egg production increased, feed intake also increased, whereas higher dietary energy levels resulted in a decrease in feed intake.

Gunawardana *et al.* (2008) found that increasing the dietary protein intake from 15.3 to 16.3 grams per hen per day led to a 3.2% increase in egg production.

Rama Rao *et al.*(2014) concluded that In the peak production phase, increases in dietary energy and protein to 11.30 and 180 g/kg, respectively, led to noticeable improvements in egg production (EP), feed intake (FI), feed efficiency (FE), egg weight (EW), and egg mass (EM). These enhancements were specifically associated with the levels of ME and CP.

Gumpha *et al*. (2019) concluded that during phase I and II, egg weight was not influenced due to variation in CP contents of the diets. But in III phase, egg weight was significantly higher (P< 0.05) in 13 % CP diet compared to that of 17.5% CP diet.

Heijmans *et al.* (2021) found that broiler breeder hens a diet with a lower energy-to-protein ratio improved their productivity, particularly in the early laying phase.

2.2.2 Carcass traits

Heijmans *et al.* (2021) found that broiler breeder hens a diet with a lower energy-to-protein ratio improved their productivity, particularly in the early laying phase.

Hosseini *et al.* (2010) found that when chicken fed diet with higher ratio of ME:CP, the weight of liver and heart got increased. He further added that higher nutrients density and higher protein improves the carcass characteristics.

Marcu *et al.,* (2011) concluded that higher protein and energy influenced the carcass (breast, wings, thigh, shanks) positively. He also added that the nutritional value of chicken meat from the three groups was affected by the energy and protein levels in the diets provided during the growth phase.

Kumari *et al*. (2014) concluded that dressing percentage was also affected but not significantly by the supplementation of different additive, herbs/spices during the experiment.

Perween *et al.* (2017) found that high level of protein and energy in the diet significantly influenced ($P < 0.05$) carcass traits, including dressing percentage, eviscerated percentage, giblet percentage, and lymphoid organ weight.

Vardharajan *et al.* (2023) concluded that the 21% crude protein (CP) fed group achieved the highest dressing percentage (70.61%) when provided with diets maintaining an isocaloric energy content of 2800 kcal ME/kg.

Maynard *et al.* (2023) found that High-density diets (Diet H) led to significant increases in carcass, breast, and tender yields ($P < 0.05$).

2.3 Economics of raising chicken

Dehury *et al.* (2008) reported that considering the economics, CP 20% and ME 2900 Kcal/kg may be considered optimum for broiler finisher period during summer in hot and humid climate.

Swain *et al*. (2008) concluded that Vanaraja chickens fed with higher protein and calorie-rich feed demonstrated a lower cost per kilogram of feed.

Ahmed *et al.* (2009) found that sixteen experimental rations were developed with crude protein (CP) levels of 21%, 22%, 23%, and 24%, each at energy levels of

2500, 2700, 2800, and 2900 Kcal ME/kg. The lowest feeding cost was observed with the ration containing 24% CP and 2700 Kcal ME/kg.

Haunshi *et al.* (2012) concluded that provision of 2,600 kcal/kg ME and 16% CP would be ideal for optimum growth of *Aseel* birds during juvenile phase. However, to obtain better FCR, feeding *Aseel* birds with diet having 2,800 kcal/kg ME and 16% CP would be idle.

Banday *et al.* (2013) found that three dietary treatments were formulated to be iso-energetic at 2900 Kcal ME, with protein levels of 20% (T1), 21% (T2), and 22% (T3). The results showed significant improvements ($P < 0.05$) in feed conversion ratio (FCR) as the dietary crude protein (CP) increased.

Perween *et al*. (2016) concluded that total input cost per bird was calculated on the basis of total feed cost and cost of chicks, medicines, and other miscellaneous. As the level of protein and energy increases in diet, the cost of experimental ration also increases. However, when the cost of feed per kg live weight gain considered, it was found maximum in the T6 group fed diet containing 19% CP and 3000 kcal ME/kg and minimum in T1 group fed with 17% CP and 2600 kcal ME. A higher energy diet combined with a moderate protein level effectively supports achieving optimal performance in an economically efficient manner.

Torne *et al.* (2016) concluded that the study concluded that optimizing crude protein (CP) levels in commercial broiler diets by adding supplementary amino acids could increase profitability for broiler producers.

Bhagat *et al.* (2020) found that among the five dietary treatments featuring different combinations of crude protein (CP) and metabolizable energy (ME), T1 diet, with 21%, 20%, and 18% CP and 2800, 2900, and 3000 Kcal/kg ME, respectively, resulted in the highest economic return per bird in terms of return over feed cost (Rs. 47.61). Following T1, the economic returns decreased progressively with T5, T2, T3, and T4 diets yielding Rs. 36.28, Rs. 30.96, Rs. 21.04, and Rs. 20.59, respectively.

CHAPTER- III

MATERIALS AND METHODS

MATERIALS AND METHODS

The experiment was conducted to evaluate the growth performance, feed intake, feed conversion ratio, mortality, performance index, reproductive traits, egg production traits, haematological and biological blood constituents and economics of rearing Vanaraja birds provided with diet containing different levels of energy and protein following scientifically validated management methods

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 93.20º E to 95.15º longitude and latitude between 25.6º N at an elevation of 310 meters above mean sea level.

3.2 Preparation of the brooder house:

The brooding house was thoroughly cleaned and prepared one week prior to the chicks arrival. Disinfectants, such as lime and potassium permanganate, were applied to sanitize both the floor and walls, ensuring a hygienic environment for the incoming chicks. This proactive cleaning process was crucial for minimizing the risk of disease and promoting healthy brooding conditions. Brooding was conducted using a battery brooder system, which was thoroughly disinfected with a burner in advance. The feeders and drinkers were disinfected with a potassium permanganate solution and left to dry in the sun. To ensure optimal heat for the chicks, a bulb was installed inside the brooder. Newspaper was placed in the brooder for the first five days to prevent any injuries to the chicks. The brooder house was well-ventilated, and a foot

Californian cage

Painting cage

Disinfecting wall by lime powder

Burning Cage

Disinfecting floor

Plate 1 Cleaning shed before starting experiment

Cleaning shed

Cleaning battery brooder

Adding KMno4 in foot bath

Plate 2 Cleaning shed before starting experiment

Procured feed

Feed formulation

Plate 3 Procured feed and formulation

Procured chicks

Chicks Vaccination

Plate 4 Procured chicks and vaccination

bath filled with potassium permanganate solution was placed at the entry gate to maintain bio-security.

3.3 Experimental birds:

A total of 180-day-old Vanaraja chicks were sourced from the ICAR Research Complex for NEH Region, Nagaland Centre, Medziphema, Nagaland, for the experiment. Upon arrival, the chicks were weighed in groups of twenty and then randomly assigned to one of the dietary treatment groups. To reduce transportation stress, glucose water was administered immediately. The chicks were handled gently throughout this process. Each treatment group consisted of five replicates, with four birds per replicate, following a randomized block design. The birds were provided with the experimental diets according to the plan of work.

3.4 Feed Procurement:

The Raw items of the feed ingredients were purchased from the local market and veterinary shop to incorporate into the experimental diet.

3.5 Experimental Diet:

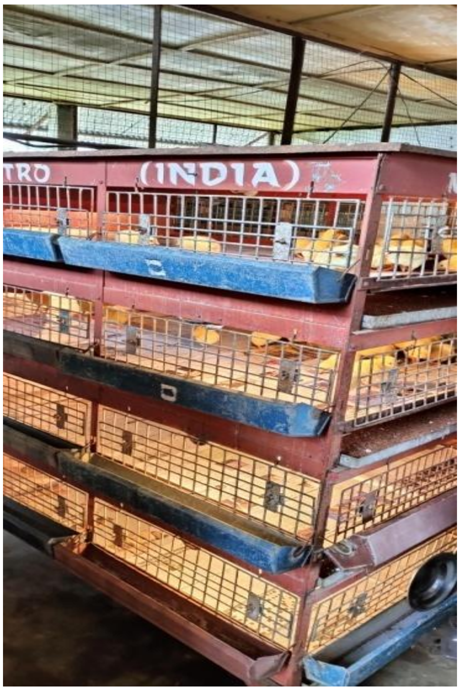
The feed ingredients used in the experiment included broken maize, wheat bran, groundnut cake (GNC), and mustard oil cake (MOC). The energy and protein levels were varied among the treatment groups as outlined in the table, with precise adjustments made to ensure that each group received a specific balance of these components. This careful distribution of energy and protein aimed to study their impact on the growth performance and other traits of Vanaraja birds. The distribution of energy and protein were as follows:

Table 3.1 Distribution of protein and energy levels in the experimental diet Vanaraja Chickens

S. N.	Treatment groups	Energy content (Mcal/kg feed)	Protein content (%)
1.	T_1	2400	16
2.	T_2	2600	16
3.	T_3	2800	16
4.	T_4	2400	18
5.	T_5	2600	18
6.	T_6	2800	18
7.	T_7	2400	20
8.	T_8	2600	20
9.	T_9	2800	20

3.5.1 Brooding and rearing

Brooding management was carried out for up to 6 weeks, as chicks at this stage require additional warmth due to their underdeveloped ability to regulate body temperature. Each section of the battery brooder was fitted with two 60-watt bulbs to provide both light and warmth, while trays were positioned beneath each segment to collect waste material. Before the chicks arrived, the brooder's temperature was pre-set at 95ºF (37.5ºC) for 24 hours using four 60-watt bulbs, and the heat was gradually reduced by 5ºF each week until reaching a stable range of 60ºF-70ºF (21ºC), or until the chicks developed full feathering, signalling their ability to maintain body heat. For temperature maintenance, the wire mesh walls were covered with gunny bags, ensuring that neither hot nor cold drafts could enter. Daily inspections of drinkers were carried out to prevent water spillage, which could dampen the litter and lead to unsanitary conditions. Regular checks of the litter trays were performed to keep the environment clean and free from harmful waste accumulation. By the



Chicks in battery brooder

Chicks drinking glucose water

Chicks feeding in battery brooder

Plate 5 Chicks management in battery brooder

time the chicks reached 8 weeks of age and were fully acclimatized, they were transferred from the brooder to layer cages, where their growth would continue under a different management system.

3.5.2 Feed and watering

Upon arrival, the chicks were carefully placed in the brooder and provided with electrolyte-enriched water to replenish energy and alleviate transportation stress caused by long journeys or adverse weather conditions. To ensure proper hydration, each chick was gently held, and its beak was dipped into the water.

The chicks were weighed in batches of 20 and randomly assigned to battery brooders. Initially, maize grit was offered on newspaper to encourage feeding behavior. From the second day onwards, standard chick feed was introduced. Feed and water were supplied ad libitum throughout the experimental period. The brooding setup included two drinkers positioned at the edges of each segment in the battery brooder, along with two linear feeders placed opposite each other. Feeders were filled up to three-fourths of their capacity to minimize wastage. A measured quantity of feed was provided twice daily once at 6 a.m. and again at 2 p.m. The leftover feed was collected and weighed the following morning to calculate the daily feed consumption of the birds accurately.

3.5.3 Lighting and health

Birds were provided with supplemental heat during the brooding phase (0–8 weeks) to ensure optimal growth and development. However, no additional heating was required during the growing period (9–20 weeks). This decision was based on the consideration that excess light exposure during the growing phase could induce early sexual maturity in pullets. Premature maturity often results in the production of a higher number of smaller-sized eggs, along with complications such as prolapse and egg-binding conditions.

During the growing phase, a natural daylight duration of approximately 12 hours was deemed sufficient. In contrast, the laying phase was managed with an extended light schedule, maintaining 16–17 hours of total light exposure per day to support consistent egg production. To ensure adequate rest, complete darkness was provided for 7 hours each night in the layer house. Vaccination schedule practised is as follows.

Table 3.2: 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	.020 ml	SC injection

* Repeated these two vaccines at every 6 months interval

Source: ICAR-Directorate of Poultry Research: ISO 9001-2008.

3.6. Experimental Procedure

A total of 180 birds were assigned to 9 treatment groups, with each group consisting of 20 birds. Each treatment was replicated 5 times, with 4 birds per replication. The chicks were initially raised in a brooder house using a battery cage system from 0 to 8 weeks of age. After 8 weeks, they were moved to cages, where they remained for the duration of the experiment, which lasted until they reached 34 weeks of age. Throughout the study, the chicks were provided with experimental diets containing varying levels of energy and protein.

The details of the distribution of chicks and their treatment are summarized in table 3.2

3.6.1. Growth traits

3.6.1.1 Body weight and body weight gain

Weight of the day-old chicks was recorded initially, followed by average body weight measurements of Vanaraja chicks at fortnightly intervals. These measurements were taken in the morning, prior to feeding and watering. A digital weighing scale with a maximum capacity of 20 kg was used throughout the experiment for weighing the birds. For the first four weeks, weights were recorded in groups of 10 chicks by placing them in a pre-weighed bamboo basket. After the chicks reached six weeks of age, individual birds were weighed every two weeks until they reached 34 weeks of age. The body weight gain of the chickens was measured by recording their body weight every fortnight. To determine the weight gain, the body weight recorded in the previous fortnight was subtracted from the current fortnight's weight.

3.6.1.2 Feed intake and feed conversion efficiency

Throughout the entire experimental period, all groups had unlimited access (ad libitum) to both feed and water. The daily feed intake was monitored by recording the amount provided to the birds, and any leftover feed was measured the next morning. Feed intake for each treatment group was calculated by offering a pre-measured quantity of feed using a digital scale, with measurements expressed in grams. The leftover feed was subtracted from the initial amount supplied the previous day to determine the actual feed consumption. Based on this, the average and weekly feed intake per bird was calculated and expressed in grams for each group. The Feed Conversion Efficiency (FCE) for the experimental groups was calculated using the formula provided by Banday (2014).

$$\text{Feed Conversion Efficiency (FCE)} = \frac{\text{Total feed consumed (g)}}{\text{Total body weight gain (g)}}$$

3.6.1.3 Mortality/liveability and performance index

Mortality was monitored throughout the experimental period and expressed as a percentage using the formula (Jalaluddin, 2014):

$$\text{Mortality (M)} = \frac{\text{Total number of birds that died}}{\text{Total number of live birds}} \times \mathbf{100}.$$

The liveability percentage was determined by subtracting the mortality percentage from 100.

The Performance Index (PI) was calculated as per Bird (1955):

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

3.6.2 Reproductive traits

3.6.2.1 Age at Sexual Maturity

Once the birds reached sexual maturity, marked by the laying of their first egg, egg production commenced. Eggs were gathered three times daily morning, afternoon, and evening with careful records kept for each treatment group. Following collection, the eggs were placed into trays and kept at room temperature for storage.

Feeding birds in cage

Birds feeding in growing period

Plate 6 Feed management during growing period

Hen laying eggs

Plate 7 Reproductive traits

3.6.2.2 Body weight at 1st laying and Age of first laying

The age at first egg was calculated by counting the days from hatch day to the day the first egg appeared. Body weight was recorded using a digital scale for accurate measurement.

3.6.2.3 Clutch period and total egg production up to 34th week of age

A clutch refers to a series of eggs laid by a hen on consecutive days, followed by a rest period of about a day or more. Daily egg production was tracked to determine the total egg production.

3.6.2.4 Carcass traits

At the end of the experiment, three birds from each treatment group were randomly selected for evaluating carcass traits. The body weight of the birds was recorded prior to culling. After culling, the weights of their organs and the dressed carcass were also measured.

3.6.4 Blood parameters

At the 2nd, 4th, and 6th months of age, three birds from each treatment were randomly selected from the five replicate groups for blood collection. Blood samples were drawn from the wing vein after sterilizing and numbing the area with disinfectant and cotton wool. Approximately 2.5 ml of blood was collected using sterile needles and placed into labelled, sterilized tubes containing Heparin as an anticoagulant. Various haematological parameters, including serum cholesterol, triglycerides, glucose levels, low-density lipoprotein (LDL), high-density lipoprotein (HDL), red blood cell (RBC) count, white blood cell (WBC) count, total serum protein, and amino acid levels, were analyzed using appropriate procedures.

Plate 8 Blood collection

3.6.4.1. White blood cell (WBC) analysis

Reagents for WBC Analysis:

The following reagents were used to prepare samples for WBC counting:

Table 3.3 Diluent Solution (e.g., Turk's Solution) Composition:

Component	Concentration
Glacial acetic acid	3 ml
Gentian violet (1%)	1 ml
Distilled water	Upto 100 ml

The acetic acid in the solution lyses the red blood cells, enabling easier visualization of white blood cells, while gentian violet stains the nuclei of WBCs. (Chandrasekar, M. (2011)

Procedure for WBC Analysis:

1. Sample Collection:

Whole blood was collected into an EDTA-coated tube to prevent clotting.

2. Dilution:

A 1:20 dilution of blood was prepared by adding 50 µl of whole blood to 1 ml of Turk's solution in a clean vial.

3. Loading the Hemocytometer

The diluted sample was mixed thoroughly and a small volume was loaded onto a hemocytometer.

4. Counting:

WBCs were counted under a microscope at 100x magnification in the designated squares on the hemocytometer grid.

5. Calculation:

The WBC count (in thousands per microliter) was calculated using the following

$$\text{WBC Count (thousand/µl)} = \frac{\text{Number of cells counted} \times \text{Dilution factor}}{\text{Volume of counted area (µl)}}$$

For a 1:20 dilution with a counted area volume of 0.1 µl, the final WBC count was derived accordingly.

6. End Point:

The calculated value for WBC was expressed in thousands per microliter (thousand/µl), providing a standardized measure of WBC concentration in chicken blood.

3.6.4.2 Red Blood Cell (RBC) Analysis

Reagents for RBC Analysis:

The following reagents were used to prepare samples for RBC counting:

Table 3.4 Diluent Solution (e.g., Hayem's Solution) Composition:

Component	Concentrations
Sodium Sulphate	205 g/L
Sodium Chloride	1.0 g/L
Mercuric Chloride	0.5 g/L
Distilled water	Upto 1 L

The diluent solution preserves RBCs and prevents clumping, ensuring an accurate count.

Procedure for RBC Analysis:

1. **Sample Collection**:

- A whole blood sample was collected in an EDTA-coated tube to prevent clotting.

2. **Dilution**:

- A 1:200 dilution of blood was prepared by adding 10 µl of whole blood to 2 ml of the diluent solution in a clean vial.

3. **Loading the Hemocytometer**:

- After mixing, a small volume of the diluted blood was loaded onto a hemocytometer.

4. **Counting**:

- Using a microscope at 400x magnification, RBCs were counted in the designated squares on the hemocytometer grid.

5. **Calculation**:

- The following formula was used to calculate the RBC count (in millions permicroliter):RBC Count(million/µl)= $\frac{\text{Number of cells counted} \times \text{Dilution factor}}{\text{Volume of counted area } (\mu\text{l})}$
- For a 1:200 dilution with a counted area volume of 0.02 µl, the RBC count was computed accordingly.

End Point:

The calculated value for RBC was expressed in millions per micro-litre (million/µl), providing a standardized measurement for RBC concentration in chicken blood.

3.6.4.3 Serum 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 reagent kit

Reagent 1 (R1)	**2×25 ml**
Good's buffer (pH 6.7)	50 mmol/L
Phenol	5 mmol/L
4AA	0.3mmol/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

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

3.6.4.4 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)	2×50 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 triglycerides 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:

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

3.6.4.5. 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)	**60 mL**
TODB	1mmol/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)	**10 mmol/L**
Choleseterol 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 37º C			
Reagent (2)	150 µl	150 µl	150 µl

End Point Method:

The solution was mixed and incubated for 5 minutes at 37º C. 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:

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

3.6.4.6 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
Good 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 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 Black (B) at 600 nm. LDL concentration was estimated as per the method described by Wieland and Seidal (1983).

Calculation:

LDL-C Conc. (mmol/l) = $\frac{\text{A Test} - \text{A Blank}}{\text{A Calibrator} - \text{A Blank}}$ × Calibrator Conc.

3.6.4.7 Total Serum Protein Analysis

Table 3.13 Reagents for Total Serum Protein Analysis:

The following reagents were used with a biuret-based total protein kit for analysis:

Reagent	Volume	Concentration
Biuret Reagent	2×50 ml	Copper (Cu^{2+}) 6 mmol/L
Sodium Hydroxide	-	100 mmol/L
Potassium Iodide	-	30 mmol/L

The biuret reagent reacts with peptide bonds in proteins, forming a purple complex whose intensity corresponds to protein concentration.

Standard:

Standard Protein Solution (5 g/dl)

Procedure for Total Serum Protein Analysis:

1. **Sample Preparation**:
   - Serum was separated from the collected whole blood sample and transferred to a clean, labelled vial.
2. **Setup**:
   - The assay included a blank, standard, and test sample as per the following protocol:

Table 3.14 Protocol for total serum protein analysis

	Blank	Standard	Test
Biuret Reagent (R1)	1.0 ml	1.0 ml	1.0 ml
Standard Solution	-	10	-
Serum Sample	-	-	10

3. **Incubation**:
   - All tubes were mixed thoroughly and incubated for 10 minutes at 37°C.
4. **Absorbance Measurement**:
   - The absorbance for the Standard (S) and Test (T) was read against the Blank (B) at 540 nm.
5. **Calculation**:

Total serum protein (g/dl) was calculated using the formula:

$$\text{Total Protein (g/dl)} = \frac{\text{Absorbance of Test}}{\text{Absorbance of Standard}} \times 5$$

End Point:

The calculated value for total serum protein was expressed in grams per deciliter (g/dl), providing a quantitative measure of protein concentration in chicken serum.

3.6.4.6 Lysine (Amino Acid) Analysis

Table 3.15 Composition of the Reagents for Lysine Analysis:

Reagent	Volume	Concentration
Ninhydrin Solution	2 x 50 ml	0.5% in ethanol
Acetate Buffer (pH 5.4)	-	0.2 M
Standard Lysine Solution	-	100 mg/dl

Ninhydrin reacts with amino acids like lysine to form a purple-blue complex, the intensity of which is directly proportional to the lysine concentration.

Standard:

Standard Lysine (Concentration 100 mg/dl)

Procedure for Lysine Analysis:

1. **Sample Preparation**:
   - Serum was separated from the whole blood and placed in a clean, labelled vial.
2. **Setup**:
   - The assay included a blank, standard, and test sample following this protocol:

Table 3.16 Protocol for Lysine analysis

	Blank	Standard	Test
Ninhydrin Solution	1.0 ml	1.0 ml	1.0 ml
Acetate Buffer	1.0 ml	1.0 ml	1.0 ml
Standard Solution	-	10 µl	-
Serum Sample	-	-	10 µl

3. **Incubation**:

The tubes were mixed thoroughly and incubated in a water bath at 100°C for 15 minutes to allow complete reaction.

4. **Cooling and Absorbance Measurement**:
   - The samples were cooled to room temperature, and absorbance for Standard (S) and Test (T) was read against the Blank (B) at 570 nm.
5. **Calculation**:
   - Lysine concentration (mg/dl) was calculated using the formula: Lysine (mg/dl) = $\frac{\text{Absorbance of Test}}{\text{Absorbance of Standard}}$ x 100

End Point:

The calculated lysine concentration was expressed in milligrams per deciliter (mg/dl), providing a precise measure of lysine levels in chicken serum.

3.6.4.7 Methionine (Amino Acid) Analysis

Table 3.17 Composition of the reagents for Methionine Analysis:

The following reagents were used for the colorimetric assay of methionine:

Reagent	Volume	Concentration
Ninhydrin Solution	2 x 50 ml	0.5% in ethanol
Citrate Buffer (pH 5.5)	-	0.1 M
Standard Methionine Solution	-	50 mg/dl

Ninhydrin reacts with methionine to produce a measurable colour change, allowing quantitative analysis of methionine concentration.

Standard:

Standard Methionine (Concentration 50 mg/dl)

Procedure for Methionine Analysis:

1. **Sample Preparation**:

- Serum was separated from whole blood and transferred to a clean, labelled vial.

2. **Setup**:
- The assay included a blank, standard, and test sample, prepared as follows:

Table 3.18 Protocol for Methionine analysis

	Blank	**Standard**	**Test**
Ninhydrin Solution	1.0 ml	1.0 ml	1.0 ml
Citrate Buffer	1.0 ml	1.0 ml	1.0 ml
Standard Solution	-	10 µl	-
Serum Sample	-	-	10 µl

3. **Incubation**:
- All tubes were mixed thoroughly and incubated at 100°C for 10 minutes to ensure a complete reaction.

4. **Cooling and Absorbance Measurement**:
- The samples were cooled to room temperature, and absorbance for Standard (S) and Test (T) was read against the Blank (B) at 570 nm.

5. **Calculation**:
- Methionine concentration (mg/dl) was calculated using the following formula:

  Methionine (mg/dl)= $\frac{\text{Absorbance of Test}}{\text{Absorbance of Standard}} \times 50$

-
-

End Point:

The calculated methionine concentration was expressed in milligrams per deciliter (mg/dl), providing a quantitative measurement of methionine levels in chicken serum.

3.7 Economics of Different Levels of Energy and Protein

The economic analysis of feeding diets with varying levels of energy and protein was conducted based on the total input costs, including expenses for chicks, feed, labour, medications, and other miscellaneous costs. The live weight of the birds at the conclusion of the experiment was used to determine the gross return per bird, from which the net profit per bird was calculated.

3.8 Statistical Analysis:

The experimental data were statistically analyzed across the various groups using ANOVA within a randomized block design, following the procedure outlined by Snedecor and Cochran (1998). Results are expressed as means with standard error, and statistical significance was determined at a level of $P<0.05$.

Carcass

Gizzard

Heart

Spleen

Liver

Plate 9 Carcass

CHAPTER- IV
RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

The present study was conducted using 180 day-old Vanaraja chicks, which were reared until they reached 34 weeks of age. The birds were subjected to nine distinct dietary treatments, labeled as T1, T2, T3, T4, T5, T6, T7, T8, and T9. The experimental diets were formulated with three different protein levels—16%, 18%, and 20% combined with three energy levels—2400 Kcal, 2600 Kcal, and 2800 Kcal for each protein level.

Data were systematically collected for various performance parameters, including body weight gain (BWG), body weight (BW), feed intake (FI), feed conversion ratio (FCR), mortality, liveability, performance index, carcass traits, hematological and biochemical parameters, and the economic feasibility of rearing.

All collected data were subjected to statistical analysis to determine significant differences and trends among treatments. The results were systematically organized and presented in tables to facilitate detailed comparisons. Additionally, graphical illustrations were included to provide a clear and quick visual representation of the key findings.

The subsequent sections of this chapter present and discuss the results obtained from the current research, providing insights into the effects of dietary treatments on the growth performance, carcass characteristics, blood profiles and economic viability of rearing Vanaraja chicks.

4.1 Productive traits

4.1.1 Body weight

The variations in body weight across different treatment groups, from day-old chicks to 34 weeks of age, are presented in Table 4.1. The mean body weights of the experimental groups, recorded at fortnightly intervals until the end of the 34th week, are illustrated graphically in Figure 4.1. A detailed statistical analysis of the average body weights at each fortnightly interval is provided in Appendix 1 (Body Weight).

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

FORTNIGHT	TREATMENTS									SEM	CD
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9		
0	32.8	33.6	34.4	36.5	34.2	33.4	33.15	35.0	32.35	2.1	NS
1st	110.60^{ab}	109.00^{a}	111.40^{ab}	111.00^{ab}	117.20^{c}	120.80^{d}	115.20^{bc}	115.80^{bc}	116.40^{c}	1.59	5.20
2nd	361.80^{a}	370.20^{bc}	370.60^{bc}	363.00^{a}	371.60^{c}	372.00^{c}	365.60^{ab}	371.80^{c}	372.60^{c}	1.74	5.69
3rd	676.40^{a}	711.60^{b}	800.00^{c}	675.60^{a}	703.40^{b}	806.20^{c}	680.60^{a}	710.20^{b}	806.40^{c}	2.98	9.72
4th	1140.0^{a}	1195.20^{c}	1234.60^{d}	1135.40^{a}	1158.40^{b}	1235.20^{d}	1137.40^{a}	1156.80^{b}	1255.80^{e}	2.60	8.48
5th	1394.60^{a}	1465.80^{c}	1555.80^{e}	1401.80^{b}	1490.80^{d}	1571.20^{f}	1393.80^{a}	1497.60^{d}	1575.20^{f}	3.44	11.22
6th	1581.00^{a}	1886.20^{d}	1905.40^{e}	1787.60^{c}	1879.60^{d}	1909.60^{e}	1770.40^{b}	1876.60^{d}	1909.80^{e}	2.88	9.38
7th	1816.40^{a}	2003.20^{e}	2127.60^{g}	1855.20^{b}	1999.20^{d}	2108.00^{f}	1868.60^{c}	2005.20^{e}	2138.20^{h}	3.05	9.93
8th	1979.80^{a}	2146.80^{b}	2217.80^{c}	1991.00^{a}	2136.40^{b}	2235.80^{d}	1991.40^{a}	2139.60^{b}	2223.20^{c}	3.87	12.62
9th	2025.00^{a}	2255.40^{b}	2315.40^{c}	2043.20^{a}	2266.80^{b}	2305.60^{c}	2037.80^{a}	2265.80^{b}	2312.0^{c}	6.82	22.26
10th	2209.20^{a}	2324.80^{c}	2418.00^{e}	2205.20^{a}	2329.60^{c}	2450.80^{f}	2237.40^{b}	2350.00^{d}	2464.60^{g}	3.10	10.12
11th	2364.40^{a}	2486.80^{d}	2506.80^{e}	2358.40^{a}	2493.40^{d}	2509.00^{e}	2375.60^{b}	2474.40^{c}	2510.60^{e}	7.23	23.58
12th	2514.20^{a}	2610.00^{d}	2716.00^{f}	2524.80^{b}	2620.00^{e}	2736.40^{g}	2537.80^{c}	2621.80^{e}	2739.0^{g}	2.88	9.41
13th	2776.40^{b}	2831.40^{c}	2945.00^{d}	2720.80^{a}	2841.60^{c}	2944.40^{d}	2732.80^{a}	2846.00^{c}	2953.80^{d}	6.20	20.22
14th	2936.60^{a}	3045.80^{c}	3130.80^{e}	2945.40^{b}	3044.60^{c}	3146.20^{f}	2946.20^{b}	3055.80^{d}	3149.60^{f}	2.61	8.52
15th	3093.20^{a}	3186.40^{b}	3290.40^{d}	3097.00^{a}	3190.80^{b}	3294.80^{d}	3099.00^{a}	3194.80^{c}	3293.40^{d}	2.35	7.65
16th	3196.40^{a}	3240.20^{c}	3294.60^{e}	3203.20^{ab}	3288.40^{e}	3295.00^{e}	3213.60^{b}	3273.80^{d}	3397.80^{f}	4.38	14.28
17th	3210.40^{a}	3219.00^{a}	3312.00^{c}	3270.40^{b}	3366.20^{d}	3316.80^{c}	3276.80^{b}	3384.60^{d}	3584.60^{e}	7.01	22.86
Total	33419.20^{a}	35187.8^{c}	36252.20^{d}	33689.0^{b}	35298.0^{c}	36357.80^{d}	33780.00^{b}	35375.60^{c}	36835.35^{e}	342.3	1013.82
Mean	1965.82^{a}	2075.63^{d}	2132.48^{h}	1981.70^{b}	2076.35^{e}	2134.57^{g}	1987.05^{c}	2080.91^{f}	2166.78^{i}	20.13	59.63

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

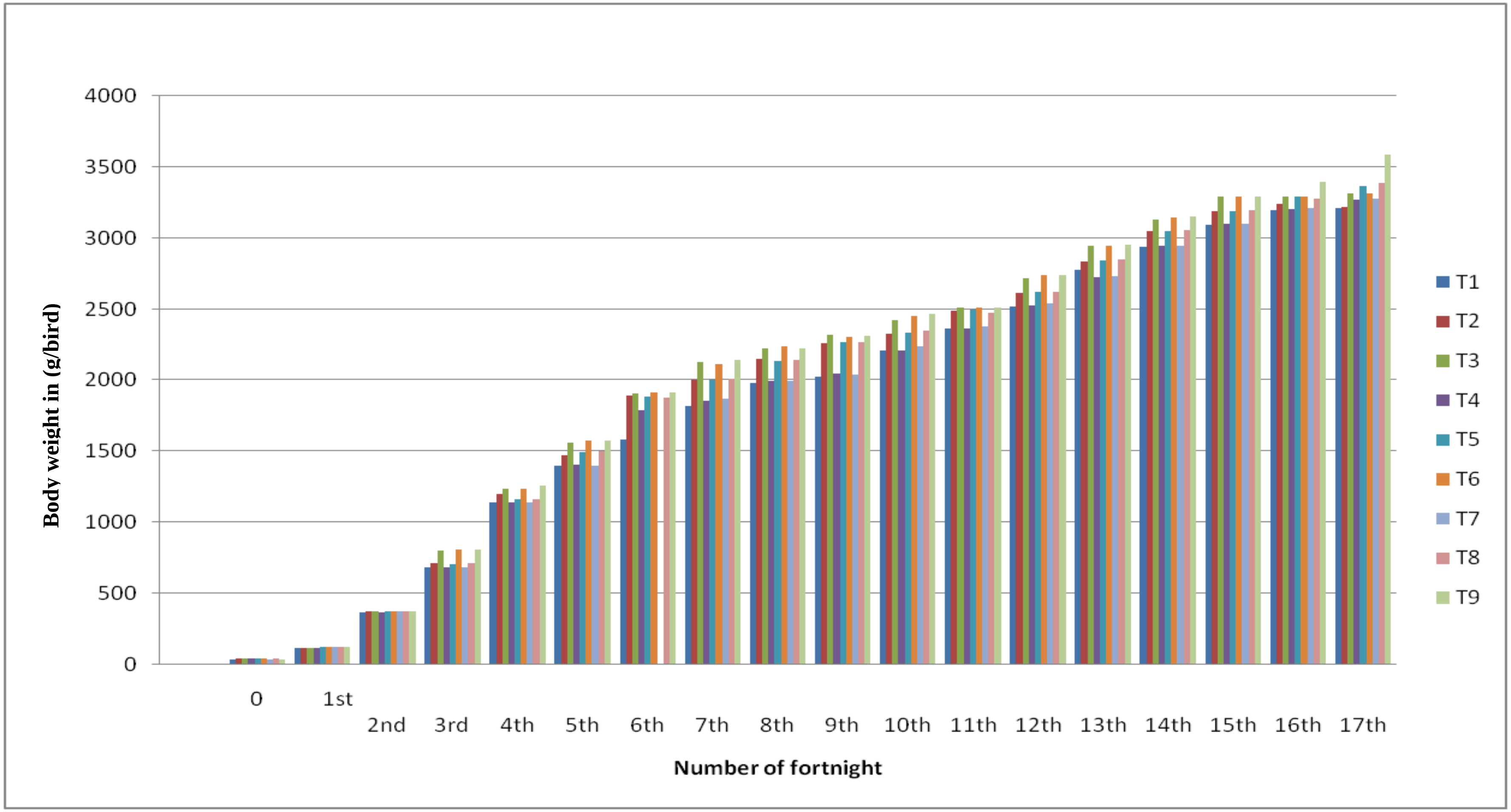


Fig. 4.1. Average body weight (g/bird/fortnight) of Vanaraja birds in different treatment groups

According to the table 4.1, the initial body weight of Vanaraja chickens for various treatment groups i.e., T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8, and T_9 during the trial was recorded as 32.80g, 33.60g, 34.40g, 36.50g, 34.20g, 33.40g, 33.15g, 35.0g and 32.35g. The corresponding body weight recorded at the end of the fortnight was 3210.40g, 3219.00g, 3312.00g, 3270.40g, 3366.20g, 3316.80g, 3276.80g, 3384.60g, and 3584.60g per bird respectively. Overall, mean body weight for various treatment groups i.e., T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8, and T_9 was as follows., 1965.82, 2075.63, 2132.48, 1981.70, 2076.35, 2134.57, 1987.05, 2080.91 and 2166.78 g/ bird. At the end of the trial i.e. 17th fortnight, ANOVA (Analysis of variance) showed that there was a significant ($P<0.05$) variation in BW among the treatment groups. The highest body weight was observed in T_9 (3584.60g), followed by T_8, T_5, T_6, T_3, T_7, T_4, T_2 and lowest in group T_1.

The results indicate that the overall mean body weight varied significantly among the treatment groups, the data suggests that as the treatments progressed from T1 to T9, there was a noticeable increase in average body weight, with T9 showing the highest overall body weight. This trend may indicate that certain treatments contribute to more substantial growth in poultry.

The above findings were in agreement with the observation of Jafarnejad and Sadegh (2011), who also reported that the group that consumed the higher protein diet exhibited greater body weight. Additionally, it was observed that at the higher energy level, the body weight of the treatments receiving the unrestricted fat diet was higher compared to those on the lower fat diet, which was not the case at the lower energy level. Likewise, Nguyen and Bunchasak, (2005) found that the growth performance of Betong chicks was significantly lower when the crude protein (CP) level was set at 17 percent. Similarly, Jackson *et al*. (1982) reported that a protein diet below 18 percent CP led to a reduction in growth rate and Body weight and feed efficiency improved with higher levels of dietary protein or energy.

Temim *et al*., (2000) found that diets with higher protein levels of 28% and 33% CP, compared to 20% CP, led to a slight improvement in chick performance. Likely, Vardharajan *et al*, 2023) found that the T9 group, which was fed a diet containing 21% CP and 3000 kcal ME/kg, had the most gain in body weight. Deo Chandra *et al.* (2014) found that the diets having 18% and 20% CP showed significantly higher body weight gain from 0 to 12 weeks compared to those fed a 16% CP diet. Haunshi *et al.* (2012) found that birds fed with lower energy and protein levels had lower body weight with respect to higher energy and higher protein levels. Similarly, Perween *et al.* (2016) reported a significant effect ($p<0.05$) of feeding different energy and protein levels on growth parameters, including body weight gain, in Vanaraja birds. The T9 group, which was fed a diet with 21% CP and 3000 kcal ME/kg, achieved the maximum gain in body weight body. Also, Miah *et al.* (2016) revealed that diets with low, moderate, and high protein density (LPD, MPD, and HPD) were formulated with crude protein levels of 11.42%, 19.19%, 21.30%, and 23.22%, respectively. Birds fed the HPD diet successfully reached the target weight of 750 g, while those on the LPD and MPD diets had significantly lower body weights ($P < 0.05$). Additionally, Waldroup *et al.* (2005) concluded that five primary diets with crude protein (CP) levels of 16%, 18%, 20%, 22%, and 24% were formulated. Body weight was higher when crude protein was 24%.

Variations in findings can also be attributed to factors such as differences in stress or strain levels, feed composition, treatment duration, agro-climatic conditions, and seasonal influences.

4.1.2 Gain in body weight

The average fortnightly gain in body weight for different treatment groups is tabulated in Table 4.2. The statistical analysis of their mean body weight gain is provided in Appendix 2 (Body Weight Gain). The growth pattern and total average weight gain throughout the experimental period are depicted graphically in Figure 4.2**.**

According to Table, the total body weight gain for T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8, and T_9 groups during the trial was 3236.80 g, 3327.80 g, 3374.00 g, 3241.60 g, 3334.60 g, 3383.00 g, 3241.20 g, 3350.80 g, and 3482.40 g, respectively. Overall mean for T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8, and T_9, treatments were 190.40g, 195.75g, 198.47g, 190.68g, 196.15g, 199.0g, 190.65g, 197.10g and 204.84g.

Body weight gain for different treatment groups at the 17th fortnight for the treatment groups T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8, and T_9 was 14.0g, 76.80g, 17.40g, 67.20g, 77.80g, 21.80g, 63.20g, 110.80g and 186.80. The results of the analysis showed that the overall mean body weight gain ($P<0.05$) was significantly different across the treatment groups, with T_9 having the highest body weight gain followed by T_6, T_3 , T_8, T_5, T_2, T_4, T_7 and T_1.

The T9 group, which was fed a diet containing 21% CP and 3000 kcal ME/kg, achieved the maximum body weight gain (Perween *et al.*, 2016). (Holsheimer and Veerkamp, 1992) found that weight gain and feed-to-gain ratios were significantly better ($P<.05$) on the high-energy diets compared to the low-energy diets.

This result is similar to Bhagat *et al.* (2020) found that body weight and body weight gain were significantly higher ($p < 0.05$) in the group fed the T5 ration, which contained higher levels of crude protein (CP) and metabolizable energy (ME), compared to birds fed the T1, T2, T3, and T4 rations. Also, Deo *et al.* (2014) found that chicks fed diets with 18% and 20% CP had significantly higher body weight gain compared to those fed a 16% CP diet. Moreover, Deepak *et al.* (2017) concluded that chicks fed diets with 2600 and 2800 kcal ME/kg exhibited significantly higher body weight gain ($P < 0.05$) compared to those fed 2400 kcal ME/kg. Furthermore, body weight gain increased significantly ($P < 0.001$) with higher crude protein (CP) levels in the diet. Similarly, Divya *et al*. (2023) reported that birds fed diets with higher protein levels (22% and 20% CP) exhibited significantly greater body weight gain ($p \leq 0.05$) compared to those on lower protein diets.

Variations in findings can also be attributed to factors such as differences in stress or strain levels, feed composition, treatment duration, agro-climatic conditions, and seasonal influences.

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

FORTNIGHT	TREATMENTS									SEM	CD
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9		
1^{st}	78.60^{a}	76.80^{a}	73.40^{a}	77.80^{ab}	83.80^{b}	87.0^{b}	79.60^{a}	82.0^{ab}	83.80^{a}	2.06	6.73
2^{nd}	251.20^{a}	261.20^{ac}	259.20^{bc}	252.0^{a}	254.40^{ab}	251.20^{a}	250.40^{a}	256.00^{ac}	256.20^{ac}	2.01	6.54
3^{rd}	314.60^{a}	341.40^{b}	429.40^{c}	312.60^{a}	331.80^{b}	434.20^{c}	315.0^{a}	338.40^{b}	433.80^{c}	3.15	10.28
4^{th}	463.60^{e}	483.60^{f}	434.60^{ab}	459.80^{de}	455.0^{cde}	429.0^{a}	456.80^{cde}	446.60^{bcd}	449.40^{c}	3.57	11.64
5^{th}	254.60^{a}	270.60^{b}	321.20^{cd}	266.40^{ab}	332.40^{de}	336.0^{e}	256.40^{a}	340.80^{e}	319.40^{c}	3.90	12.71
6^{th}	184.80^{a}	413.40^{d}	349.60^{b}	390.20^{c}	390.60^{cd}	338.40^{b}	376.60^{c}	379.0^{c}	343.40^{b}	7.00	22.83
7^{th}	235.40^{f}	117.0^{c}	222.20^{e}	67.60^{a}	119.60^{c}	198.40^{d}	98.20^{b}	$12.8.60^{c}$	228.40^{e}	3.99	13.01
8^{th}	163.40^{d}	143.60^{c}	90.20^{a}	135.80^{bc}	137.20^{bc}	127.80^{bc}	122.80^{b}	134.40^{b}	85.00^{a}	5.36	17.47
9^{th}	45.20^{a}	108.60^{d}	97.60^{c}	52.20^{a}	130.40^{d}	69.80^{ab}	46.40^{a}	126.20^{d}	88.80^{b}	8.32	27.14
10^{th}	184.20^{de}	69.40^{a}	102.60^{b}	162.0^{cde}	62.80^{a}	145.20^{c}	199.60^{f}	84.20^{ab}	152.60^{c}	8.40	27.40
11^{th}	155.20^{e}	162.0^{e}	88.80^{c}	153.20^{e}	163.80^{e}	58.20^{b}	138.20^{de}	124.40^{d}	46.0^{a}	8.60	28.05
12^{th}	149.80^{a}	124.0^{a}	209.20^{c}	166.40^{b}	126.60^{a}	227.40^{c}	162.20^{b}	147.40^{ab}	228.40^{c}	8.29	27.02
13^{th}	262.20^{c}	220.60^{b}	229.0^{b}	196.0^{a}	221.60^{b}	208.0^{b}	195.0^{a}	224.20^{b}	214.80^{ab}	7.12	23.21
14^{th}	160.20^{a}	214.40^{c}	185.80^{b}	224.60^{c}	203.0^{b}	201.80^{b}	213.40^{c}	209.80^{c}	195.80^{b}	6.80	22.19
15^{th}	156.60^{c}	140.60^{ab}	159.60^{c}	151.60^{bc}	146.20^{ab}	148.60^{ab}	152.80^{bc}	139.0^{a}	143.80^{ab}	3.07	10.03
16^{th}	103.20^{bc}	103.80^{bc}	104.20^{bc}	106.20^{bc}	97.60^{b}	100.20^{b}	114.60^{c}	79.0^{a}	104.40^{bc}	3.64	11.88
17^{th}	14.0^{a}	76.80^{b}	17.40^{a}	67.20^{b}	77.80^{b}	21.80^{a}	63.20^{b}	110.80^{c}	186.80^{d}	7.19	23.45
Total	3236.80^{a}	3327.80^{a}	3374.00^{a}	3241.60^{a}	3334.60^{a}	3383.00^{a}	3241.20^{a}	3350.80^{a}	3482.40^{a}	7.21	23.51
Mean	190.40^{a}	195.75^{b}	198.47^{cd}	190.68^{a}	196.15^{b}	199.00^{d}	190.65^{a}	197.10^{bc}	204.84^{e}	0.42	1.38

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

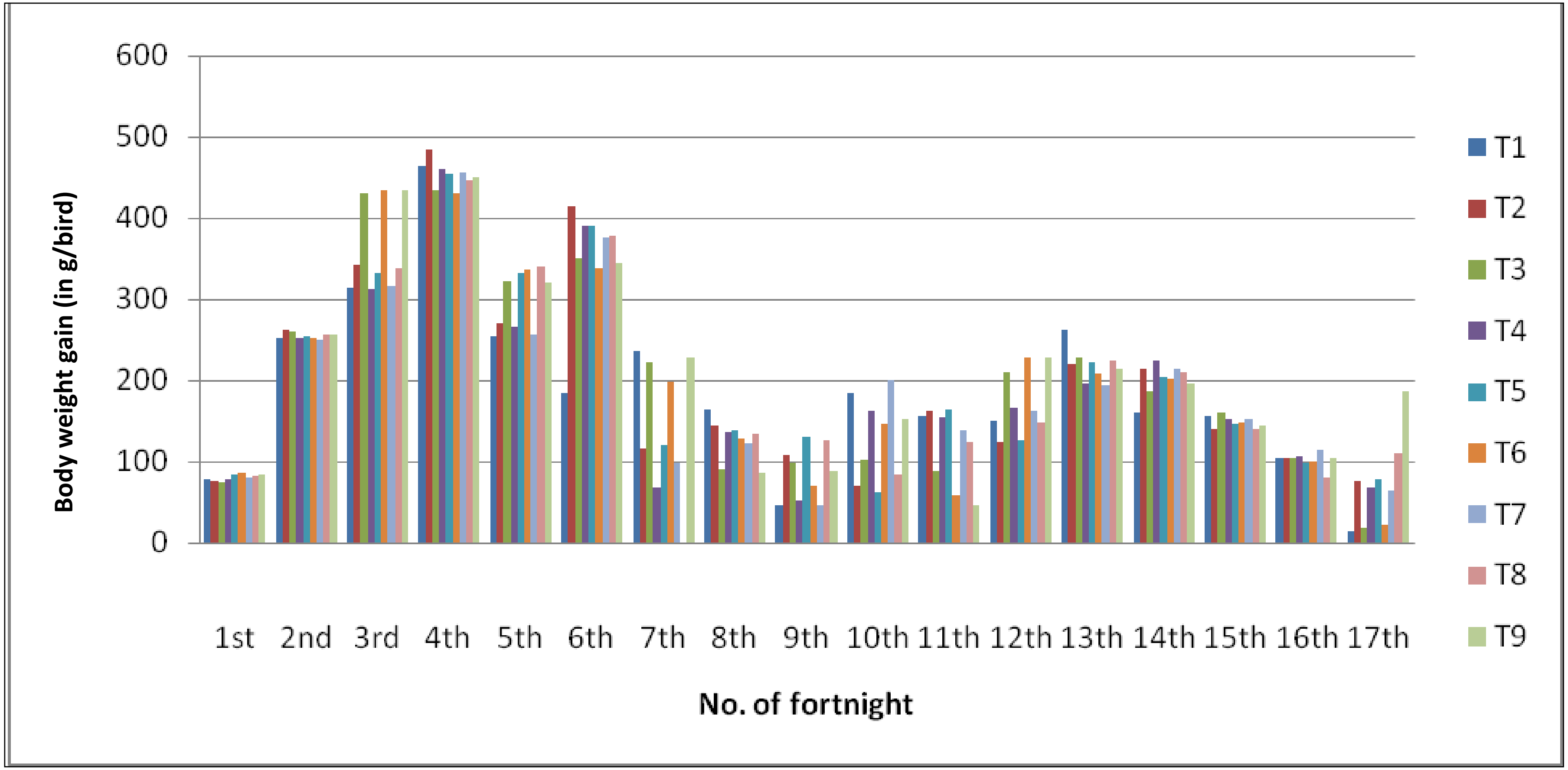


Fig.4.2. Average gain in body weight (g/bird/fortnight) of Vanaraja birds in different treatment groups

4.1.3 Feed intake

The average fortnightly feed intake, along with the total and mean feed intake for the various treatment groups— T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8, and T_9 from day-old to 34 weeks of age, is shown in Table 4.3. The statistical evaluation of total feed intake is provided in Appendix 3 (Feed Intake). The feed intake pattern throughout the experimental period is graphically illustrated in Figure 4.3**.**

From table 4.3, it was found that the total feed intake (FI) of treatments T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8, and T_9 during the trial was 27783.18g, 26713.26g, 27502.02g, 25640.26g, 26550.06g, 27477.08g, 25669.90g, 26191.70g, and 25236.50g, respectively. On the 17th fortnight, the lowest feed intake was observed in the T_5 group (1527.60g), followed by T_7, T_9, T_4, T_2, T_1, T_6, T_8, and T_3 (1550.20g, 1569.40g, 1595.80g, 1606.80g, 1617.00g, 1618.80, 1621.60 and 1623.40g respectively). Highest mean was recorded in T_1 (1634.30) and lowest mean was recorded in T_9 (1484.50).

The data revealed that the overall mean feed intake significantly decreased within the treatment groups, with T9 (1484.50g) having the lowest mean intake, followed by T4 (1508.25g), T7 (1509.99g), T8 (1540.70g), T5 (1561.76g), T2 (1571.55g), T_7 (1616.29g), T3 (1617.76g), and T1 (1634.30g). This finding is same as the result of Hussein *et al.* (1996) who found that after 18 weeks, half of the pullets in each rearing treatment received a layer diet with 16% CP and 0.34% methionine, while the other half were given a diet with 19% CP and 0.40% methionine. Increasing protein levels during Weeks 2 to 6 significantly ($P < 0.05$) enhanced body weight. Higher dietary energy reduced feed intake during Weeks 15 to 18. Similarly, According to Deepak *et al.* (2017), intake of feed was markedly higher ($P<0.05$) in the groups that received diets with 2400 and 2600 kcal ME/kg in comparison to the treatment that consumed the feed with 2800 kcal ME/kg. However, variations in the crude protein levels across these diets did not have a significant impact on feed intake. Also, Vardharajan *et al.* (2023) reported that the group receiving a diet with 21% crude protein had notable results; however, it should be noted that the group fed the lowest crude protein level of 18.5% attained the maximum feed intake numerically. Gupta *et al.* (2017) concluded that vanaraja birds kept at a lower stocking density consumed a greater amount of feed. Haunshi *et al*. (2012) observed that birds fed a diet with 2,400 kcal/kg ME had a higher feed intake ($P < 0.0001$). Additionally, Kamran *et al*. (2008) formulated a total of four nutritional treatments differing in CP and metabolizable energy (ME): 23%, 22%, 21%, and 20% CP, and 3,036, 2,904, 2,772, and 2,640 kcal/kg ME, respectively, while keeping a constant ME ratio of 132 across all diets. They found that feed intake increased linearly as CP and ME levels were reduced during the growing, finishing, and overall periods ($p<0.05$). Nahashon *et al*. (2005) found that birds fed a 21% CP diet consumed significantly more feed ($P < 0.05$) than those fed a 23% CP diet. Nahashon *et al.* (2005) found that birds fed a diet containing 25% crude protein (CP) had higher feed consumption compared to those on diets with 23% and 21% CP.

Variations in findings can also be attributed to factors such as differences in stress or strain levels, feed composition, treatment duration, agro-climatic conditions, and seasonal influences.

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

FORTNIGHT	TREATMENTS									SEM	CD
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9		
1st	250.80^{e}	253.20^{e}	256.60^{f}	256.60^{f}	221.20^{a}	233.20^{b}	237.40^{cd}	240.00^{d}	250.20^{e}	3.65	11.90
2nd	385.78^{f}	365.0^{e}	356.22^{d}	305.68^{b}	397.43^{h}	355.00^{d}	303.50^{a}	394.80^{g}	343.60^{c}	1.35	4.40
3rd	967.40^{f}	728.06^{a}	779.20^{bc}	785.44^{c}	827.60^{d}	842.0^{de}	764.20^{bc}	757.80^{b}	855.20^{e}	6.81	22.19
4th	982.80^{d}	987.80^{d}	1069.0^{e}	931.50^{abc}	980.81^{cd}	1093.40^{e}	967.20^{cd}	892.40^{ab}	884.50^{a}	15.34	50.01
5th	1148.60^{b}	1116.60^{b}	1155.20^{b}	1161.60^{b}	1163.80^{b}	1129.38^{ab}	1090.00^{a}	1090.40^{a}	1124.40^{ab}	12.41	40.47
6th	1716.60^{b}	1724.00^{b}	1672.60^{b}	1554.80^{a}	1695.20^{b}	1675.00^{b}	1671.60^{b}	1564.20^{a}	1537.00^{a}	16.79	54.75
7th	1994.40^{a}	1850.80^{ab}	1923.20^{def}	1877.00^{e}	1930.60^{def}	1986.20^{f}	1755.60^{bc}	1709.80^{d}	1668.40^{f}	25.13	81.97
8th	2021.80^{c}	1920.60^{b}	2038.80^{c}	2041.00^{c}	1926.00^{b}	1958.20^{c}	1850.80^{b}	1964.80^{c}	1760.80^{a}	25.70	83.83
9th	2154.20^{b}	2182.20^{b}	2148.20^{b}	1953.00^{a}	2111.40^{b}	2168.50^{b}	1953.40^{a}	1930.40^{a}	1906.00^{a}	34.55	112.67
10th	2351.60^{b}	2278.20^{b}	2348.00b	2156.00^{a}	2154.82^{a}	2325.60^{b}	2181.20^{a}	2276.00^{b}	2149.00^{a}	29.85	97.36
11th	2335.80^{d}	2243.80^{c}	2338.20^{d}	2037.04^{a}	2183.00^{b}	2271.60^{c}	2227.40^{c}	2257.20^{cd}	2115.20^{ab}	25.78	83.34
12th	2329.20^{d}	2232.80^{b}	2293.60^{c}	2061.60^{a}	2217.20^{bc}	2283.20^{c}	2147.20^{ab}	2255.60^{cd}	2115.20^{a}	28.42	92.68
13th	2327.40^{c}	2247.60^{b}	2316.80^{c}	2132.20^{a}	2222.80^{b}	2316.40^{c}	2135.20^{a}	2230.00^{b}	2134.40^{a}	14.03	45.76
14th	1828.80^{c}	1718.80^{b}	1825.60^{c}	1647.60^{a}	1716.80^{b}	1814.00^{c}	1633.60^{a}	1704.80^{b}	1632.60^{a}	10.30	33.58
15th	1743.80^{e}	1640.00^{b}	1718.00^{d}	1594.20^{a}	1661.20^{c}	1770.60^{f}	1589.80^{a}	1649.20^{bc}	1589.80^{a}	3.75	12.24
16th	1627.20^{b}	1618.00^{b}	1640.20^{b}	1549.20^{a}	1612.60^{b}	1636.00^{b}	1611.60^{b}	1653.00^{b}	1600.80^{b}	16.23	52.94
17th	1617.00^{b}	1606.80^{b}	1623.40^{b}	1595.80^{b}	1527.60^{a}	1618.80^{b}	1550.20^{a}	1621.60^{b}	1569.40^{a}	13.62	44.40
Total	27783.18^{e}	26713.46^{d}	27502.02^{e}	25640.26^{b}	26550.06^{d}	27477.08^{e}	25669.90^{b}	26191.70^{c}	25236.50^{a}	195.12	636.32
Mean	1634.30^{e}	1571.55^{d}	1617.76^{e}	1508.25^{b}	1561.76^{d}	1616.29^{e}	1509.99^{b}	1540.68^{c}	1484.50^{a}	11.47	37.43

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

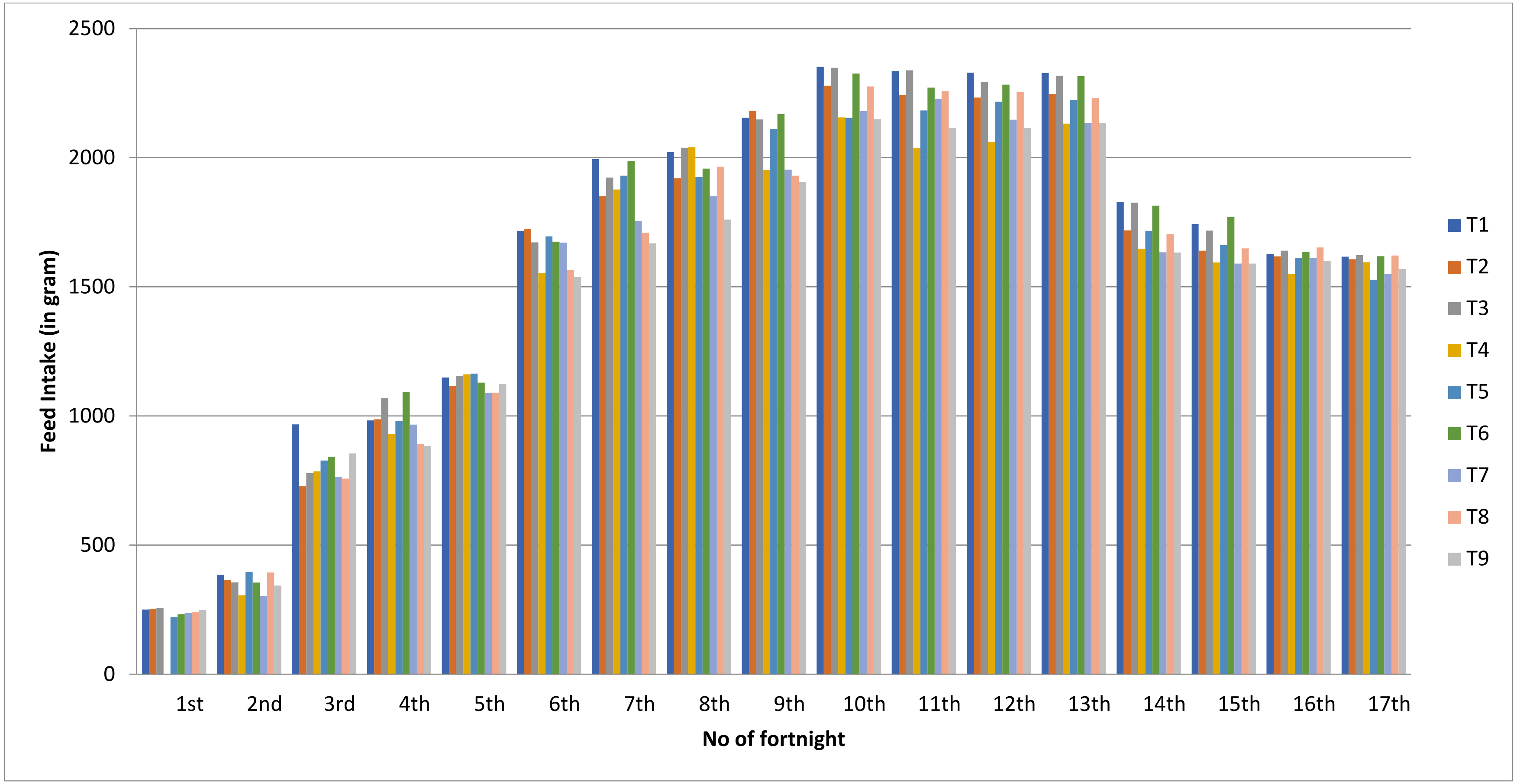


Fig. 4.3 Average feed intake (g/bird/fortnight) of Vanaraja birds in different treatment groups

4.1.4 Feed Conversion Ratio

The average fortnightly feed conversion efficiency (FCE) for the entire experimental period, from day-old to 34 weeks of age, is presented in Table 4.4. The graphical representation of FCE is illustrated in Figure 4.4, while the statistical analysis of the mean FCE values is provided in Appendix 4 (Feed Conversion Efficiency).

According to Table , the overall feed conversion ratio (FCR) for T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8, and T_9 groups during the experiment was 298.29, 197.80, 270.73, 203.66, 194.41, 260.69, 200.38, 185.96, and 187.15, respectively. The FCR at the conclusion of the testing period, i.e., the 17th fortnight, was highest for T_1 (115.50), followed by T_3 (93.27), T_7 (24.52), T_4 (23.74), T_1 (21.85), T_2 (20.91), T_5 (19.63), T_8 (14.63), and T_9 (8.40).

Meanwhile, the overall mean feed conversion ratio was significantly lowest in T8 (10.93), followed by T_9 (11.00), T_5 (11.43), T_2 (11.63), T_7 (11.78), T_4 (11.98), T_6 (15.33) and T_3 (15.92) and T_1 (16.98).

The above result shows the agreement with Waldroup *et al.* (2005) investigated five primary diets formulated with crude protein (CP) levels of 16%, 18%, 20%, 22%, and 24%. They found that reducing CP levels in the starter diets had a notable impact on live performance. Specifically, when CP levels dropped below 22%, the feed conversion ratio (FCR) significantly increased, indicating less efficient feed utilization. Reducing the crude protein (CP) levels in the diet led to significant increases in the feed conversion ratio (FCR) with each decrease in CP level. Similarly, Maynard *et al*. (2023) concluded that broilers fed the higher-density (H) diets had a lower feed conversion ratio (FCR) in comparison to those who consumed the lower-protein (L) diets. Also, Toppo *et al*. (2004) found that the feed conversion ratio (FCR, $P < 0.05$) was higher in diets with lower energy and protein levels. Additionally, Haunshi *et al.* (2012) concluded that providing a diet with 2,600 kcal/kg ME and 16% CP is ideal for optimum growth of Aseel birds when they were in the juvenile phase. However, for enhanced feed conversion ratio (FCR), a feed having 2,800 kcal/kg ME and 16% CP would be more suitable. Hosseini *et al*. (2010)

revealed that birds fed a lower energy and lower protein diet exhibited a higher FCR comparing to those on other diets. Also supported by Belloir et al. (2017) found that reducing dietary crude protein (CP) from 19% to 15% across five treatments resulted in an increase in the feed conversion ratio. Nahashon *et al.* (2005) found that the feed conversion ratio significantly decreased ($P < 0.05$) as the dietary crude protein (CP) level increased from 21% to 23%. Variations in findings can also be attributed to factors such as differences in stress or strain levels, feed composition, treatment duration, agro-climatic conditions, and seasonal influences.

The above finding is similar to Haunshi *et al.* (2012) who found that for optimal FCR, feeding Aseel birds a containing 2,800 kcal/kg ME and 16% CP would be ideal.

Nahashon *et al.* (2005) found that the enhanced feed efficiency in chicks consumed a 23% CP diet could be due to their higher body weight and increased nitrogen and energy intake compared to those on a 21% CP diet.

Variations in findings can also be attributed to factors such as differences in stress or strain levels, feed composition, treatment duration, agro-climatic conditions, and seasonal influences.

Table 4.4 Average feed conversion efficiency (Feed consumed/ Body wt gain) of Vanaraja birds in different treatment groups

FORTNIGHT	TREATMENTS									SEM	CD
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9		
1st	3.20^{bcd}	3.31^{d}	3.50^{e}	3.30^{de}	2.64^{a}	2.68^{a}	2.99^{b}	2.92^{ab}	2.99^{c}	**0.09**	**0.28**
2nd	1.53^{d}	1.39^{c}	1.37^{b}	1.21^{a}	1.56^{d}	1.41^{c}	1.21^{a}	1.54^{d}	1.34^{b}	**0.93**	**0.04**
3rd	3.07^{e}	2.13^{c}	1.81^{a}	2.51^{d}	2.49^{d}	1.93^{b}	2.42^{d}	2.24^{c}	1.97^{b}	**0.03**	**0.11**
4th	2.13^{a}	2.04^{a}	2.46^{d}	2.03^{b}	2.16^{c}	2.55^{d}	2.11^{bc}	2.00^{c}	1.97^{c}	**0.03**	**0.11**
5th	4.51^{e}	4.13^{d}	3.60^{c}	4.37^{e}	3.50^{bc}	3.36^{ab}	4.25^{e}	3.20^{a}	3.52^{c}	**0.06**	**0.20**
6th	9.30^{f}	4.17^{ae}	4.79^{de}	4.01^{ab}	4.35^{bc}	4.95^{e}	4.44^{cd}	4.13^{cd}	4.48^{e}	**0.11**	**0.34**
7th	8.47^{a}	15.92^{d}	8.66^{ab}	27.78^{f}	16.29^{de}	10.05^{b}	17.95^{e}	13.32^{c}	7.31^{a}	**1.12**	**1.79**
8th	12.37^{a}	13.37^{a}	22.60^{b}	15.02^{a}	14.03^{a}	15.32^{a}	15.07^{a}	14.61^{a}	20.71^{b}	**1.00**	**3.54**
9th	47.65^{d}	20.09^{ab}	22.01^{ab}	37.41^{cd}	16.19^{a}	31.06^{bc}	42.09^{c}	15.29^{a}	21.46^{ab}	**3.48**	**12.98**
10th	12.76^{a}	32.82^{c}	22.88^{b}	13.30^{a}	34.31^{c}	16.01^{ab}	10.92^{a}	27.03^{c}	14.08^{a}	**3.32**	**9.30**
11th	15.05^{a}	13.85^{a}	26.33^{b}	13.29^{a}	13.32^{a}	39.03^{c}	16.11^{ab}	18.14^{a}	45.98^{c}	**3.29**	**11.18**
12th	15.58^{d}	18.24^{e}	11.02^{ab}	12.40^{bc}	17.59^{d}	10.07^{a}	13.25^{bc}	16.07^{de}	9.28^{a}	**0.72**	**2.28**
13th	8.87^{a}	10.18^{bc}	10.11^{b}	10.87^{bc}	10.03^{b}	11.13^{c}	10.94^{bc}	9.94^{b}	9.93^{b}	**0.32**	**1.05**
14th	11.85^{e}	8.04^{abc}	9.88^{d}	7.38^{a}	8.48^{ab}	9.02^{cd}	7.75^{ab}	8.17^{ab}	8.38^{ab}	**0.34**	**1.24**
15th	11.17^{abd}	11.73^{d}	10.81^{a}	10.56^{c}	11.44^{cd}	12.19^{d}	10.53^{a}	11.91^{d}	11.11^{a}	**0.24**	**0.81**
16th	15.80^{a}	15.58^{a}	15.77^{a}	14.84^{a}	17.12^{a}	16.42^{a}	14.12^{a}	22.11^{b}	16.49^{a}	**0.78**	**2.82**
17th	115.50^{b}	20.91^{a}	93.27^{b}	23.74^{a}	19.63^{a}	74.25^{a}	24.52^{a}	14.63^{a}	8.40^{a}	**20.00**	**75.67**
Total	298.29^{g}	197.80^{a}	270.73^{a}	203.66^{a}	194.41^{a}	260.69^{a}	200.38^{a}	185.96^{a}	187.15^{a}	**35.86**	**63.68**
Mean	16.98^{a}	11.63^{ab}	15.92^{b}	11.98^{ab}	11.43^{a}	15.33^{ab}	11.78^{ab}	10.93^{a}	11.00^{ab}	**2.10**	**3.74**

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

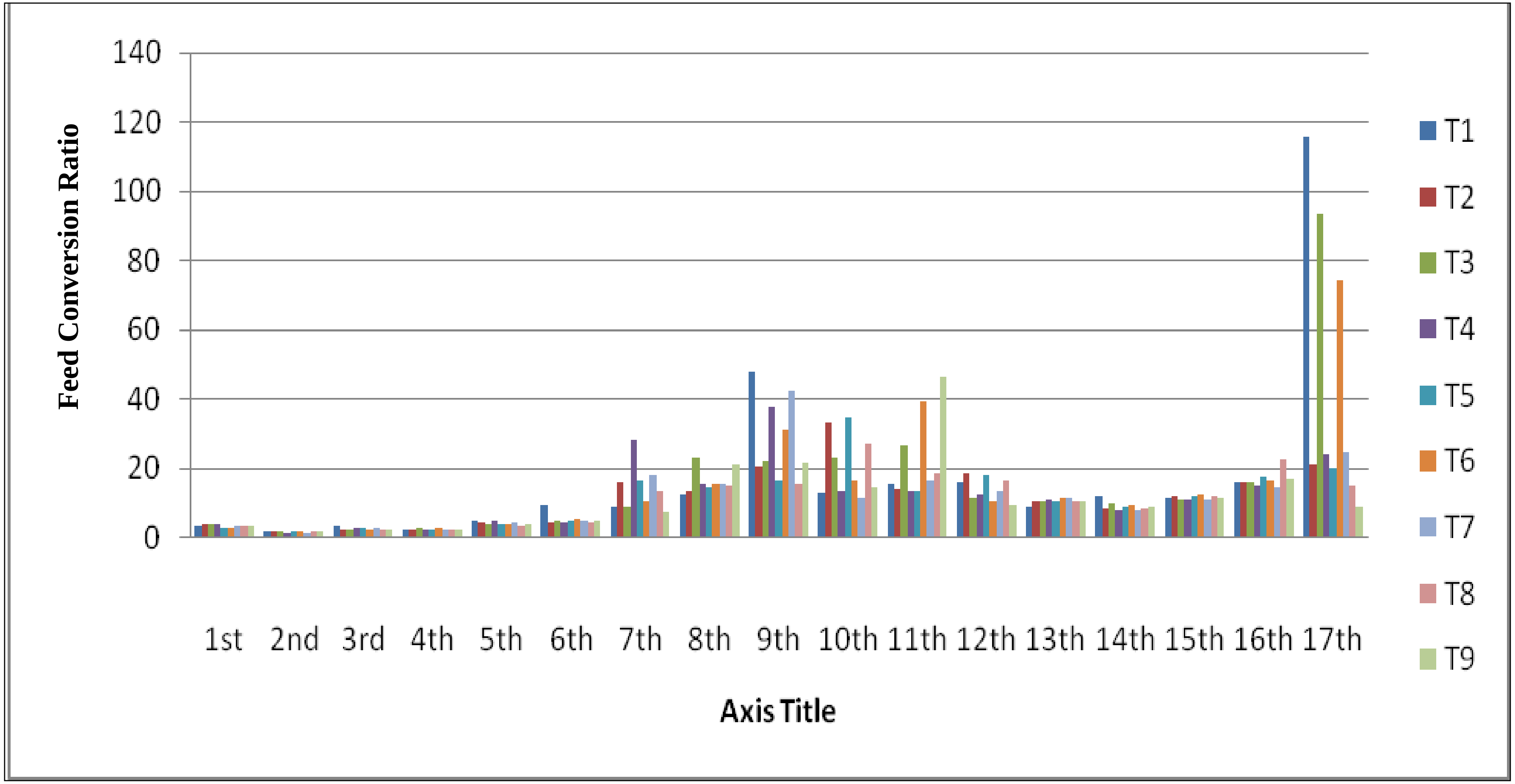


Fig. 4.4 Average feed conversion efficiency of Vanaraja birds in different treatment groups

4.1.5 Mortality, Liveability and Performance Index of Vanaraja birds in different treatment groups.

The average mortality (%), livability (%), and Performance Index (PI) for the entire experimental period across different treatment groups are presented in Table 4.5.

According to Table 5, According to the data, the experiment's mortality rate and liveability % for several groups of birds T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8, and T_9 were 0%, 5%, 10%, 0%, 0%, 0%, 0%, 0%, and 0%, and 100%, 95%, 90%, 100%, 100%, 100%, 100%, 100%, and 100%, respectively. The value of the performance index for T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8, and T_9 was 123.94, 127.03, 81.60, 125.47, 136.81, 95.56, 128.21, 140.22, and 142.31. According to the data obtained, mortality and liveability values showed variation primarily in T2 and T3, with higher mortality in T3. It could be because T3 had highest mortality likely because the birds consumed too much energy without sufficient protein, leading to fatty liver, weak immunity, metabolic disorders, and stress-related deaths. Meanwhile, the performance index was highest in T9 and lowest in T3.

The findings are similar with Perween *et al.* (2017) observed that a diet comprising 20% crude protein (CP) and 2900 kcal ME/kg resulted in improved growth performance in Giriraja chicks. Also, Hosseini *et al.* (2010) concluded that broiler chickens provided feed with higher nutrient density and increased protein levels led to improved performance. Additionally, Maynard *et al.* (2023) concluded that broilers fed higher-density (H) diets performed better than those fed lower-protein (L) diets. Another support by Waldroup *et al.* (2005) found that reducing crude protein (CP) levels in the feed significantly affected the live performance of male broilers, suggesting that an increase in CP levels is recommended. Similarly, Nahashon *et al.* (2005) concluded that the decline in performance for birds fed a 16% CP diet was minimal when they were supplemented with all essential amino acids at levels comparable to those in a 20% CP diet. Nawaz *et al.* (2006) revealed that diets with low metabolizable energy (ME) and high crude protein (CP) provided optimal performance for broiler chicken during both grower and finisher phases. Neto *et al.*

(2000) discovered that supplementing methionine enhanced the performance of chicks fed diets containing 17% protein.

In summary, low-protein diets performance of the growth was not same as the high-protein control diets (Bregendahl *et al*, 2002). Variations in findings can also be attributed to factors such as differences in stress or strain levels, feed composition, treatment duration, agro-climatic conditions, and seasonal influences.

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

TREATMENT GROUPS	MORTALITY (%)	LIVEABILITY (%)	PERFORMANCE INDEX
T_1	0%	100%	123.94
T_2	5%	95%	127.03
T_3	10%	90%	81.60
T_4	0%	100%	125.47
T_5	0%	100%	136.81
T_6	0%	100%	95.56
T_7	0%	100%	128.21
T_8	0%	100%	140.22
T_9	0%	100%	142.31

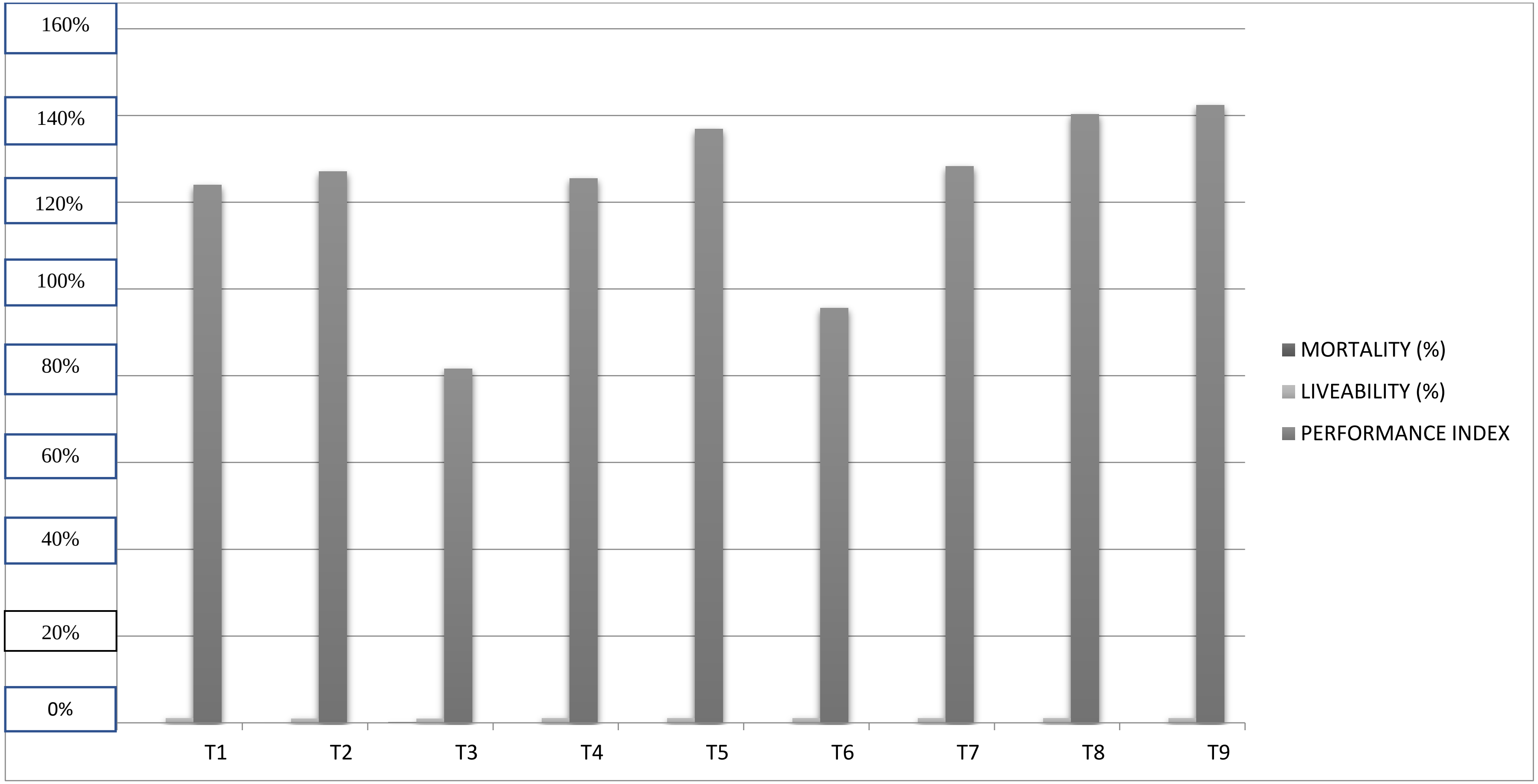


Fig. 4.5 Mortality, Liveability and Performance Index of Vanaraja birds in different treatment groups.

4.1.6 Haematological and biochemical constituents

Haematological studies

Table 4.9 presents the haematological parameters of Vanaraja birds subjected to different treatments, with a graphical representation provided in Figure 4.9. Detailed statistical analysis of these parameters is included in Appendix 8 (Haematological Parameters).

Table 4.6 Average on haematological parameters of Vanaraja birds at various ages in different treatment groups

TREATMENT	HAEMATOLOGICAL					
	WBC ($10^6/\mu L$)			**RBC** ($10^6/\mu L$)		
	2ND MONTH	**4TH MONTH**	**6TH MONTH**	**2ND MONTH**	**4TH MONTH**	**6TH MONTH**
T_1	230.40^{cd}	208.00^{e}	222.66^{a}	2.39^{a}	2.76^{a}	2.55^{a}
T_2	231.80^{a}	204.85^{a}	235.40^{b}	2.41^{a}	2.73^{a}	2.58^{a}
T_3	232.80^{ab}	207.40^{a}	216.89^{a}	2.43^{a}	2.74^{a}	2.57^{a}
T_4	233.00^{b}	226.39^{c}	233.40^{b}	2.35^{a}	2.82^{a}	2.58^{a}
T_5	236.60^{c}	217.11^{b}	230.80^{b}	2.36^{a}	2.86^{a}	2.66^{a}
T_6	240.40^{d}	224.51^{c}	234.40^{b}	2.40^{a}	2.95^{a}	2.68^{a}
T_7	240.60^{e}	228.27^{d}	246.40^{c}	2.38^{a}	3.09^{a}	2.70^{a}
T_8	242.00^{cd}	240.97^{f}	245.40^{c}	2.41^{a}	3.38^{b}	2.72^{a}
T_9	244.80^{cd}	241.66^{e}	248.82^{c}	2.49^{a}	3.43^{a}	3.10^{a}
SEM	2.12	0.89	1.93	0.02	0.14	0.09
CD Value(0.05)	6.93	2.91	6.30	0.07	0.46	0.28

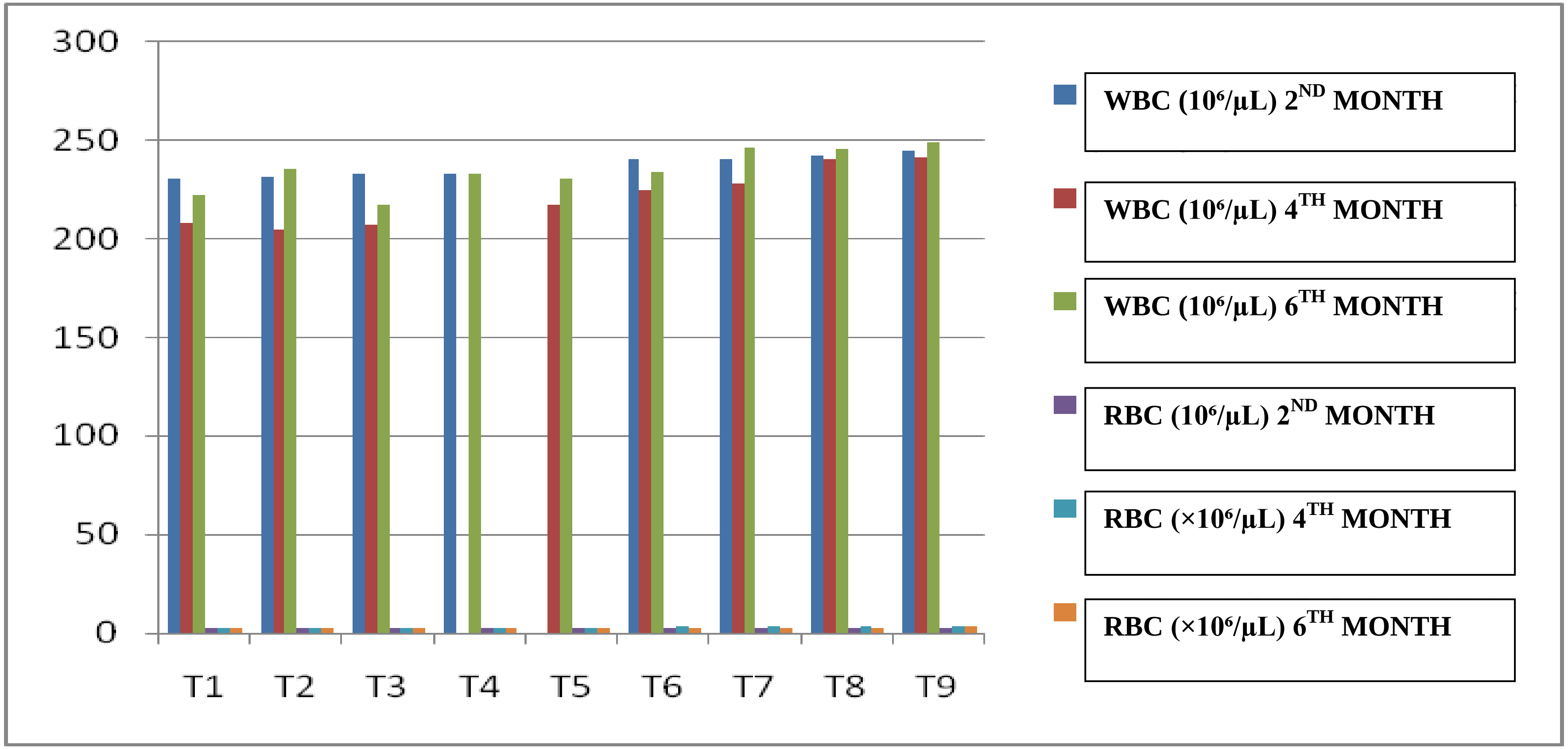


Fig. 4.6 Average on haematological parameters of Vanaraja birds at various ages in different treatment groups

Haematological Parameters of Vanaraja Birds at Various Ages

Table 7 displays the average haematological parameters, including white blood cells (WBC) and red blood cells (RBC), for Vanaraja birds across different treatment groups at 2 months, 4 months, and 6 months of age.

White Blood Cells (WBC):

At 2 months of age, the highest WBC count was observed in T9 (244.80). The lowest WBC count was found in T2 (230.40). At 4 months, T9 had the highest WBC count (240.97), while T2 had the lowest (204.85). At 6 months also, T9 had the highest WBC count (248.82), with T3 (216.89) showing the lowest value.

Red Blood Cells (RBC):

For RBC counts at 2 months, all treatment had similar values, ranging from 2.34 to 2.50, with no significant differences. At 4 months, T9 had the highest RBC count (3.43), significantly higher than other groups, with T1, T2, T3, and T4 showing values between 2.70 and 2.76. By 6 months, the RBC counts were similar across most treatments, T9 showed the highest value (3.10).

Overall Analysis:

The haematological parameters varied significantly between treatment groups, in RBC and WBC counts, with T9 consistently showing higher values compared to other groups. The RBC counts exhibited less variation across treatments, with notable differences primarily in the 4-month period. The SEM and CD values confirm the statistical significance of these differences.

Variations in findings can also be attributed to factors such as differences in stress or strain levels, feed composition, treatment duration, agro-climatic conditions, and seasonal influences

Table 4.7 Average blood biochemical constituents of Vanaraja birds at various ages (month) in different treatment groups

Treatme-nt	Serum cholesterol Month			Triglyceride Month			LDL(MG/DL) Month		
	2nd	4th	6th	2nd	4th	6th	2nd	4th	6th
T_1	137.88^{a}	112.80^{a}	134.98^{a}	100.95^{a}	90.61^{a}	127.40^{abc}	36.70^{b}	18.97^{a}	72.00^{a}
T_2	139.14^{a}	125.52^{ab}	138.40^{b}	115.16^{c}	106.48^{b}	131.80^{abc}	37.41^{a}	19.12^{a}	73.12^{a}
T_3	144.62^{a}	126.35^{ab}	139.00^{a}	117.84^{b}	121.52^{c}	130.80^{ab}	44.12^{c}	34.34^{b}	72.40^{a}
T_4	144.12^{ab}	127.09^{b}	148.40^{c}	119.51^{c}	120.37^{c}	134.20^{bc}	40.49^{b}	36.57^{b}	73.92^{ab}
T_5	153.07^{cd}	134.09^{c}	155.00^{d}	133.21^{d}	125.35^{d}	133.40^{a}	45.69^{c}	41.17^{c}	77.20^{c}
T_6	150.41^{b}	140.34^{d}	156.60^{d}	129.95^{d}	128.98^{e}	136.00^{c}	46.27^{d}	41.29^{c}	77.80^{bc}
T_7	148.47^{bc}	139.72^{d}	156.82^{d}	121.02^{c}	127.63^{e}	135.80^{c}	48.15^{d}	42.23^{c}	79.60^{c}
T_8	153.80^{c}	150.32^{e}	157.60^{d}	135.48^{e}	135.56^{f}	137.60^{a}	38.37^{b}	45.08^{d}	79.20^{c}
T_9	159.21^{d}	151.14^{e}	160.20^{d}	152.87^{f}	146.63^{g}	141.30^{c}	47.52^{d}	46.78^{d}	82.80^{c}
SEM	2.38	1.11	1.84	1.06	0.69	1.98	0.88	0.92	1.62
CD Value (0.05)	7.77	3.61	5.99	3.45	2.26	6.46	2.86	2.99	5.27

The serum cholesterol levels varied significantly across treatments throughout the experimental period. At the 2nd month, treatment T9 recorded the highest serum cholesterol level (159.21 mg/dL), while T1 had the lowest (137.88 mg/dL). By the 4th month, the highest cholesterol level was still observed in T9 (151.14 mg/dL), and the lowest in T1 (112.80 mg/dL). At the end of the 6th month, T9 maintained the highest serum cholesterol (160.20 mg/dL), whereas T1 (134.98 mg/dL) showed the lowest.

It is similar to the results of Perween *et al*., (2017) who found that Serum total cholesterol was highest in the group fed a diet with higher protein and energy levels, while it was lowest in the group given a ration with lower protein and energy content.

Triglyceride levels also varied significantly over time. At the 2nd month, T9 had the highest triglyceride concentration (152.87 mg/dL) and T1 the lowest (100.95 mg/dL). At the 4th month, T9 continued to show the highest triglyceride level (146.63 mg/dL), and T1 the lowest (90.61 mg/dL). By the 6th month, T9 again had the highest triglyceride level (141.30

mg/dL), while T1 recorded the lowest (127.40 mg/dL). Perween *et al*., (2017) who found that group which was fed the highest level of energy and protein showed higher ($P<0.05$) level of triglyceride and HDL.

For LDL cholesterol, significant differences were observed among treatments. At the 2nd month, T1 had the highest LDL level (47.52 mg/dL) while T1 had the lowest (36.70 mg/dL). At the 4th month, T9 showed the highest LDL concentration (46.78 mg/dL), and T1 again had the lowest (18.97 mg/dL). By the 6th month, T9 recorded the highest LDL (82.80 mg/dL), while T1 had the lowest (72.00 mg/dL).

The results indicate that higher levels of dietary protein and energy contributed to elevated serum cholesterol, triglyceride, and LDL levels, as observed in groups like T9, which consistently showed the highest values across all parameters and months. This finding is consistent with previous studies that link higher protein and energy intake with increased cholesterol synthesis in the liver, resulting in greater cholesterol and lipid accumulation in the blood.

Conversely, lower protein and energy levels, such as in T1 and T2, were associated with lower serum cholesterol and triglyceride levels, suggesting that a diet with moderate protein and energy intake might help in maintaining healthier lipid profiles. Particularly, the triglyceride levels in T1 were significantly lower than those in T9, demonstrating the impact of diet composition on blood lipid parameters.

The variations in LDL levels across treatments reflect the influence of diet on lipoprotein metabolism. Groups like T1 and T2, which had lower LDL levels, suggest that reduced dietary energy and protein intake might play a role in minimizing LDL cholesterol production. Meanwhile, the consistently higher LDL levels in T9 indicate the potential for higher risk of cardiovascular issues with higher dietary energy and protein intake.

These results align with the known metabolic pathways where dietary protein and energy levels directly impact cholesterol and lipid metabolism. The increase in triglyceride and LDL levels with higher protein and energy diets could be linked to increased fat absorption and liver synthesis, which requires further investigation to optimize dietary formulations for healthier lipid profiles in poultry.

Variations in findings can also be due to factors such as differences in stress or strain levels, feed composition, treatment duration, agro-climatic conditions, and seasonal influences.

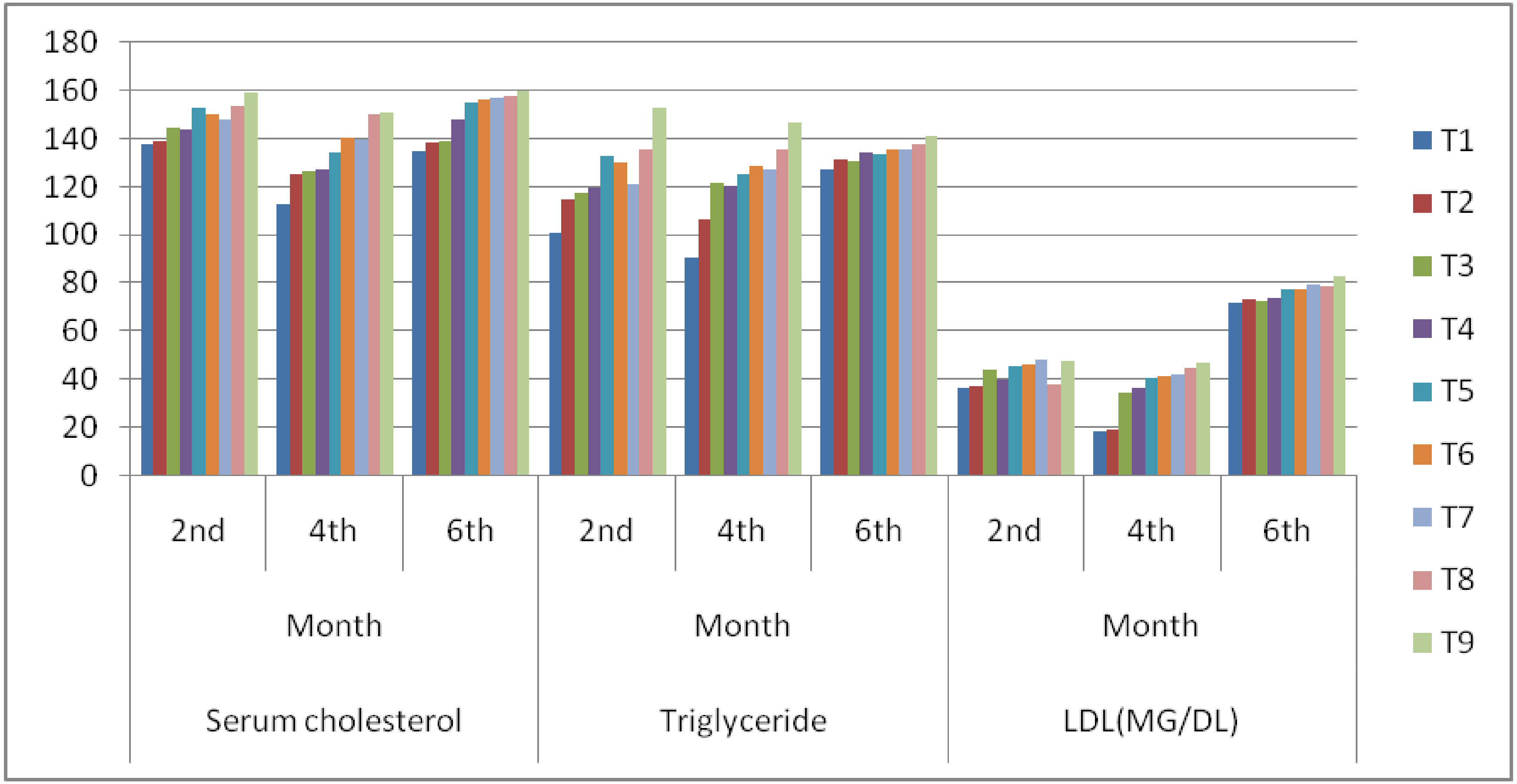


Fig. 4.7 Average blood biochemical constituents of Vanaraja birds at various ages (month) in different treatment groups

Table 4.8 Average on blood biochemical constituents of Vanaraja birds at various ages in different treatment groups

Treatment	HDL(mg/dl) Month			Total serum protein Month		
	2^{nd}	4^{th}	6^{th}	2^{nd}	4^{th}	6^{th}
T_1	72.20^{a}	60.19^{a}	48.20^{a}	3.85^{a}	3.49^{a}	3.57^{ab}
T_2	73.66^{b}	71.74^{cd}	52.80^{b}	4.31^{ab}	3.92^{a}	3.61^{a}
T_3	76.53^{a}	67.96^{b}	52.60^{b}	4.41^{ab}	4.01^{ab}	3.85^{bd}
T_4	78.62^{b}	72.73^{cde}	53.40^{b}	4.49^{ab}	3.91^{a}	3.77^{abc}
T_5	84.22^{d}	74.91^{e}	53.00^{b}	4.70^{b}	3.86^{a}	3.89^{cd}
T_6	74.01^{a}	70.20^{bc}	52.80^{b}	4.85^{b}	4.19^{b}	3.81^{cd}
T_7	81.59^{c}	73.58^{de}	53.40^{b}	4.83^{b}	4.40^{b}	3.84^{d}
T_8	80.96^{c}	79.58^{f}	53.80^{b}	5.67^{c}	4.56^{b}	4.05^{e}
T_9	89.41^{e}	80.15^{f}	55.40^{b}	5.96^{c}	4.76^{c}	4.12^{d}
SEM	0.66	1.10	1.09	0.23	0.21	0.04
CD Value (0.05)	2.15	3.60	3.55	0.74	0.67	0.14

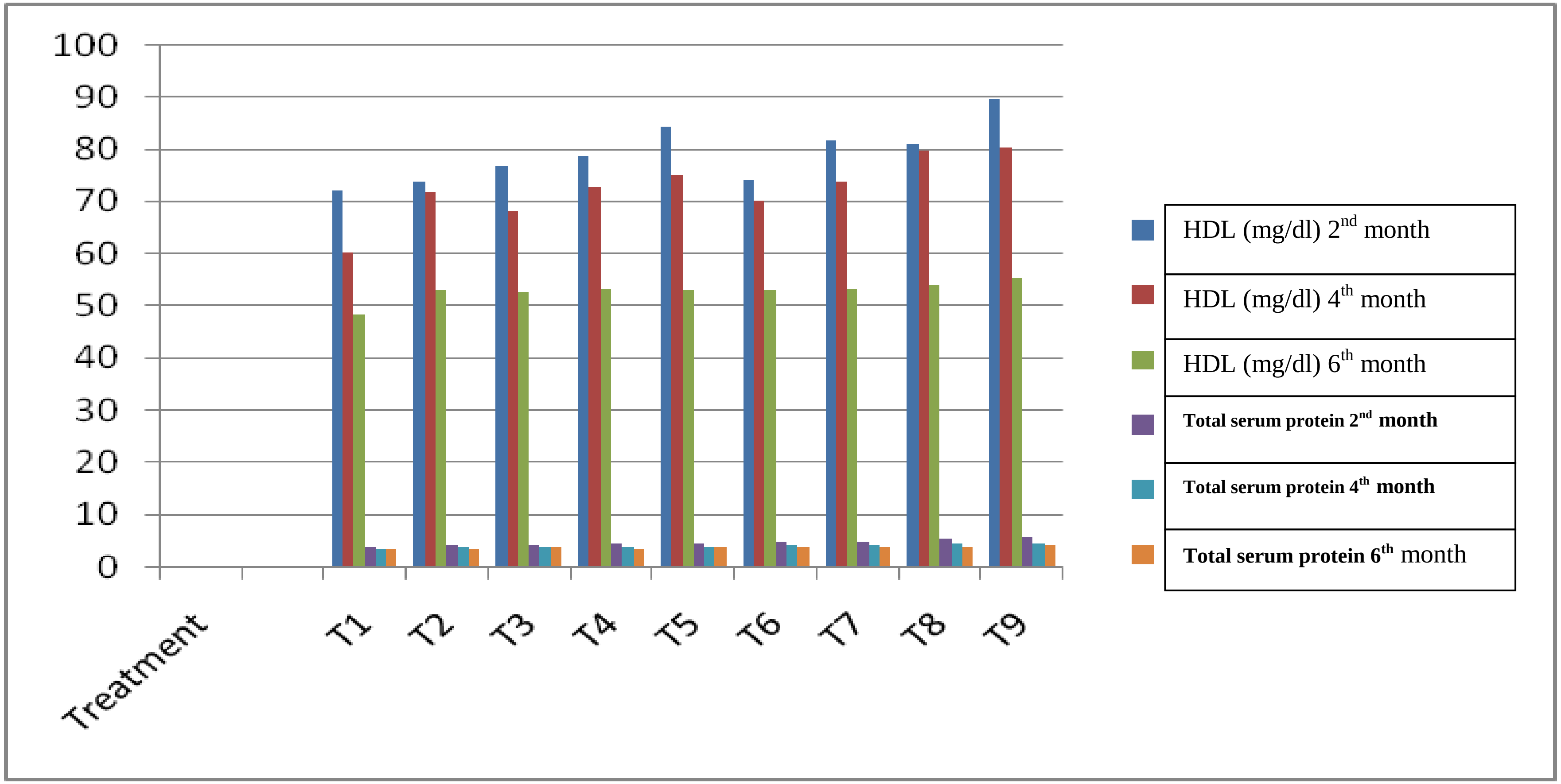


Fig. 4.8 Average blood biochemical constituents of Vanaraja birds at various ages in different treatment groups

High-density lipoprotein (HDL)

The HDL levels (mg/dl) of Vanaraja birds across treatments during the 2nd, 4th, and 6th months are shown in Table 4.9. The statistical analysis reveals significant variations ($P<0.05$) among the treatments.

During the 2nd month, T9 recorded the highest HDL value (89.41 mg/dl), which was significantly higher than all other groups. T5 (84.22 mg/dl) and T7 (81.59 mg/dl) also exhibited elevated HDL levels, whereas T1 (72.20 mg/dl) had the lowest values.

By the 4th month, T9 (80.15 mg/dl) maintained higher HDL concentrations, while T1 (60.19 mg/dl) showed the lowest value. T5 (74.91 mg/dl) and T7 (73.58 mg/dl) demonstrated moderately high values compared to other treatments.

At the 6th month, a significant decline in HDL levels was observed across all groups. However, T9 (55.40 mg/dl) continued to exhibit the highest value, followed closely by T8 (53.80 mg/dl) and T7 (53.40 mg/dl). The lowest HDL level was recorded in T1 (48.20 mg/dl). The overall trend indicates that treatments with higher nutritional input tend to maintain higher HDL concentrations over time.

Total Serum Protein

The total serum protein (g/dl) values among the different treatments also displayed significant differences ($P<0.05$) across months.

In the 2nd month, T9 recorded the highest total serum protein level (5.96 g/dl), followed by T8 (5.67 g/dl) and T7 (4.83 g/dl). The lowest value was found in T1 (3.85 g/dl). Treatments T6 (4.85 g/dl) and T5 (4.70 g/dl) also demonstrated higher values than T1.

By the 4th month, the highest protein content was again observed in T9 (4.76 g/dl), with T8 (4.56 g/dl) and T7 (4.40 g/dl) showing significantly higher levels compared to T1 (3.49 g/dl). T6 (4.19 g/dl) also maintained a relatively high protein level. Lowest in T1 (3.49).

In the 6th month, the trend persisted, with T9 (4.12 g/dl) and T8 (4.05 g/dl) retaining higher values. T1 (3.57 g/dl) had the lowest value, while T5 (3.89 g/dl) and T6 (3.81 g/dl) showed intermediate levels.

The higher HDL and serum protein levels observed in T9 can be attributed to their improved dietary formulations, providing balanced nutrition that supports lipid metabolism and protein synthesis. The significant decline in HDL levels over time across treatments suggests a physiological adaptation to age-related metabolic changes, where lipid reserves are mobilized for growth and maintenance.

Similarly, the gradual decline in total serum protein levels indicates metabolic adjustments, reflecting nutrient utilization patterns for growth, tissue repair, and immune functions. The consistently higher values in T8 and T9 demonstrate the efficacy of enriched diets in sustaining protein synthesis and lipid metabolism.

These findings align with previous studies (Azizi *et al.*, 2011) that reported enhanced haematological parameters with improved dietary formulations. Further investigation into dietary components, including amino acid profiles and lipid sources, may provide deeper insights into optimizing blood parameters for better growth performance in Vanaraja birds.

Perween *et al.*, (2017) found that the group which was fed the highest level of energy and protein showed higher ($P<0.05$) level of HDL.

Variations in findings can also be affected by factors such as differences in stress or strain levels, feed composition, treatment duration, agro-climatic conditions, and seasonal influences.

Table 4.9 Average blood biochemical constituents of Vanaraja birds at various ages (month) in different treatment groups.

Amino acid

Treatments	Lysine (mg/g)			Methionine (mg/g)		
	2nd month	4th month	6th month	2nd month	4th month	6th month
T_1	102.80^{a}	92.40^{a}	90.00^{a}	30.20^{a}	25.40^{a}	20.20^{a}
T_2	103.60^{a}	93.80^{ab}	89.60^{a}	30.60^{a}	26.20^{a}	21.00^{ab}
T_3	104.60^{ab}	94.80^{ab}	90.00^{a}	31.20^{a}	26.60^{a}	21.20^{ab}
T_4	106.00^{ab}	96.00^{ab}	91.00^{a}	33.40^{ab}	29.00^{a}	23.40^{abc}
T_5	106.80^{ab}	95.40^{ab}	89.80^{a}	33.80^{ab}	31.00^{a}	27.20^{c}
T_6	108.20^{ab}	96.60^{ab}	90.40^{a}	34.00^{ab}	30.20^{ab}	26.60^{bc}
T_7	108.80^{ab}	96.80^{ab}	91.80^{a}	38.80^{bc}	33.80^{bc}	28.80^{cd}
T_8	111.40^{bc}	99.60^{b}	94.40^{ab}	41.20^{c}	36.40^{c}	32.80^{d}
T_9	116.60^{bc}	107.00^{c}	102.40^{b}	42.40^{c}	38.80^{c}	33.20^{d}
SeM	2.19	2.00	2.13	1.88	1.80	1.76
CD Value (0.05)	7.14	6.52	6.96	6.12	5.86	5.75

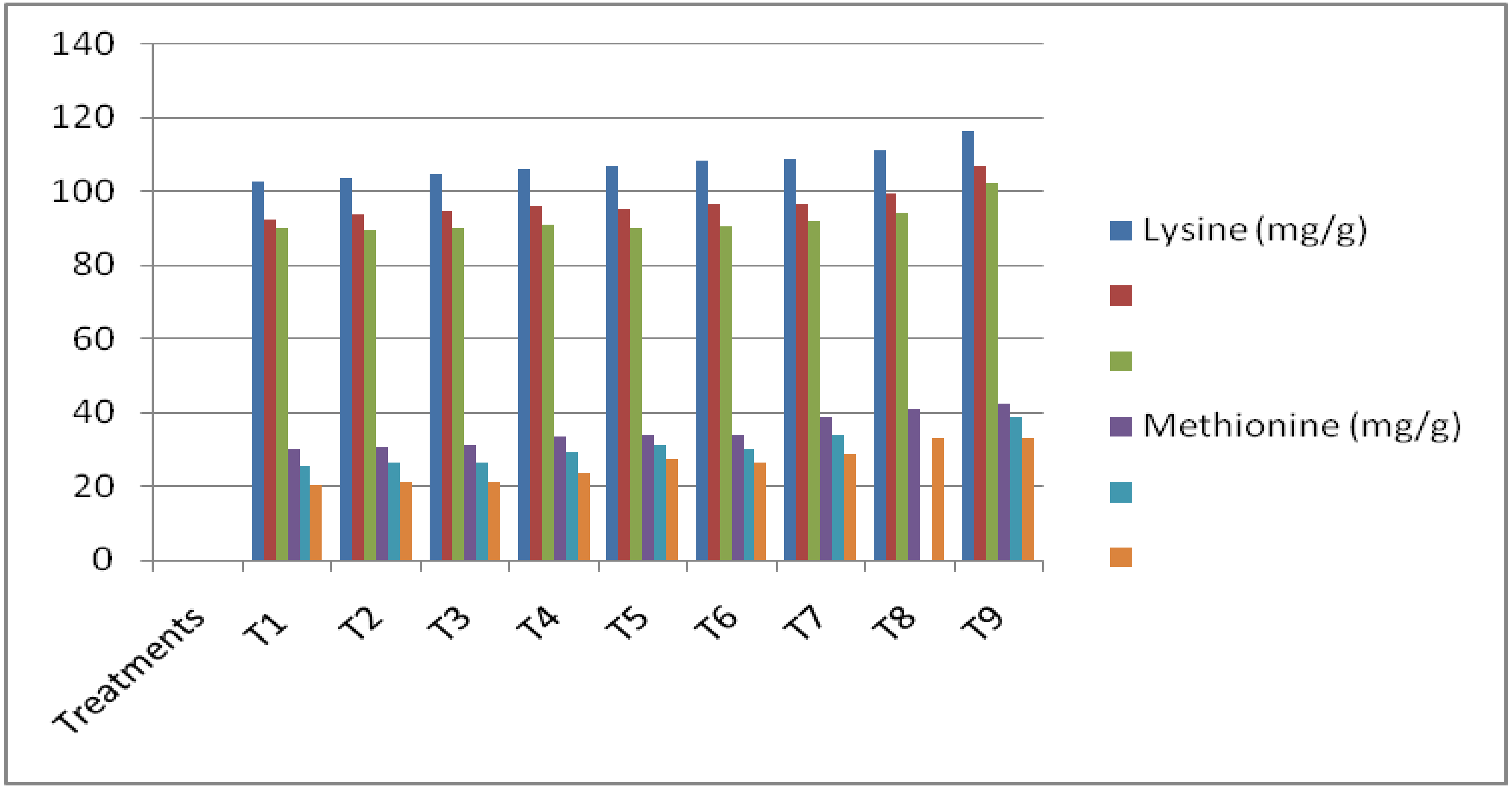


Fig. 4.9 Average blood biochemical constituents of Vanaraja birds at various ages (2,4,6 months) in different treatment groups.

Amino Acid Profile

Lysine

The lysine levels (mg/g) across treatments revealed significant variations ($P<0.05$) during all three months.

In the 2nd month, T9 recorded the highest lysine level (116.60 mg/g), significantly higher than all other treatments, while T1 had the lowest (102.80 mg/g). T8 (111.40 mg/g) and T7 (108.80 mg/g) also showed elevated lysine concentrations.

By the 4th month, T9 maintained the highest lysine value (107.00 mg/g), followed by T8 (99.60 mg/g) and T7 (96.80 mg/g). T1 (92.40 mg/g) showed the lowest lysine concentration.

At the 6th month, T9 continued to lead with 102.40 mg/g, while T8 (94.40 mg/g) and T7 (91.80 mg/g) also maintained relatively higher levels. T1 had the lowest lysine content (90.00 mg/g).

Methionine

Methionine concentrations (mg/g) showed similar trends across treatments and months.

In the 2nd month, T9 exhibited the highest methionine value (42.40 mg/g), significantly higher than T1 (30.20 mg/g), which had the lowest. T8 (41.20 mg/g) and T7 (38.80 mg/g) also showed higher values.

By the 4th month, T9 (38.80 mg/g) and T8 (36.40 mg/g) maintained higher methionine levels, whereas T1 (25.40 mg/g) recorded the lowest.

At the 6th month, T9 again demonstrated the highest methionine level (33.20 mg/g), followed by T8 (32.80 mg/g) and T7 (28.80 mg/g). The lowest methionine concentration was observed in T1 (20.20 mg/g).

The higher HDL and serum protein levels observed in T8 and T9 can be attributed to their improved dietary formulations, providing balanced nutrition that supports lipid metabolism and protein synthesis. The significant decline in HDL levels over time across treatments suggests a physiological adaptation to age-related metabolic changes, where lipid reserves are mobilized for growth and maintenance.

Similarly, the gradual decline in total serum protein levels indicates metabolic adjustments, reflecting nutrient utilization patterns for growth, tissue repair, and immune functions. The consistently higher values in T8 and T9 demonstrate the efficacy of enriched diets in sustaining protein synthesis and lipid metabolism.

The amino acid profile data reinforce these findings, highlighting the importance of lysine and methionine in protein metabolism and growth. The higher lysine and methionine levels observed in T8 and T9 suggest better protein deposition and muscle growth, contributing to improved performance. The gradual decline in amino acid levels over time reflects increased utilization for growth and metabolic processes.

These findings align with previous studies (Azizi *et al.*, 2011) that reported enhanced haematological parameters with improved dietary formulations. Further investigation into dietary components, including amino acid profiles and lipid sources, may provide deeper insights into optimizing blood parameters for better growth performance in Vanaraja birds.

Variations in findings can also be due to factors such as differences in stress or strain levels, feed composition, treatment duration, agro-climatic conditions, and seasonal influences.

4.2 Reproductive traits

4.2.1 Egg production traits (age of first laying, weight at first laying, clutch period, total egg production).

Age of first laying, BW at first laying, clutch period and total egg production were recorded after the onset of egg production. Data recorded has been shown in table.

Table 4.10 Average age of first laying, weight at first laying, clutch period, Total egg production of Vanaraja birds in different treatment groups

TREATMENT GROUPS	AGE OF FIRST LAYING	WEIGHT AT FIRST LAYING	CLUTCH PERIOD	TOTAL EGG PRODUCTION
T_1	144.00^{e}	2216.40^{d}	4.08^{ab}	53.60^{a}
T_2	142.60^{d}	2332.40^{g}	4.06^{a}	57.00^{b}
T_3	141.20^{d}	2326.60^{g}	4.24^{ab}	56.00^{ab}
T_4	$140.00c^{d}$	2205.20^{c}	4.26^{ab}	55.20^{a}
T_5	139.80^{cd}	2329.60^{g}	4.28^{ab}	56.20^{ab}
T_6	139.00^{cd}	2290.80^{e}	4.34^{b}	58.00^{b}
T_7	137.00^{c}	2087.40^{a}	4.28^{ab}	61.00^{c}
T_8	132.40^{b}	2192.00^{b}	4.56^{c}	60.20^{bc}
T_9	124.40^{a}	2304.40^{f}	4.34^{b}	64.80^{d}
SEM	0.82	3.22	0.08	0.82
CD Value (0.05)	3.60	10.50	0.26	2.71

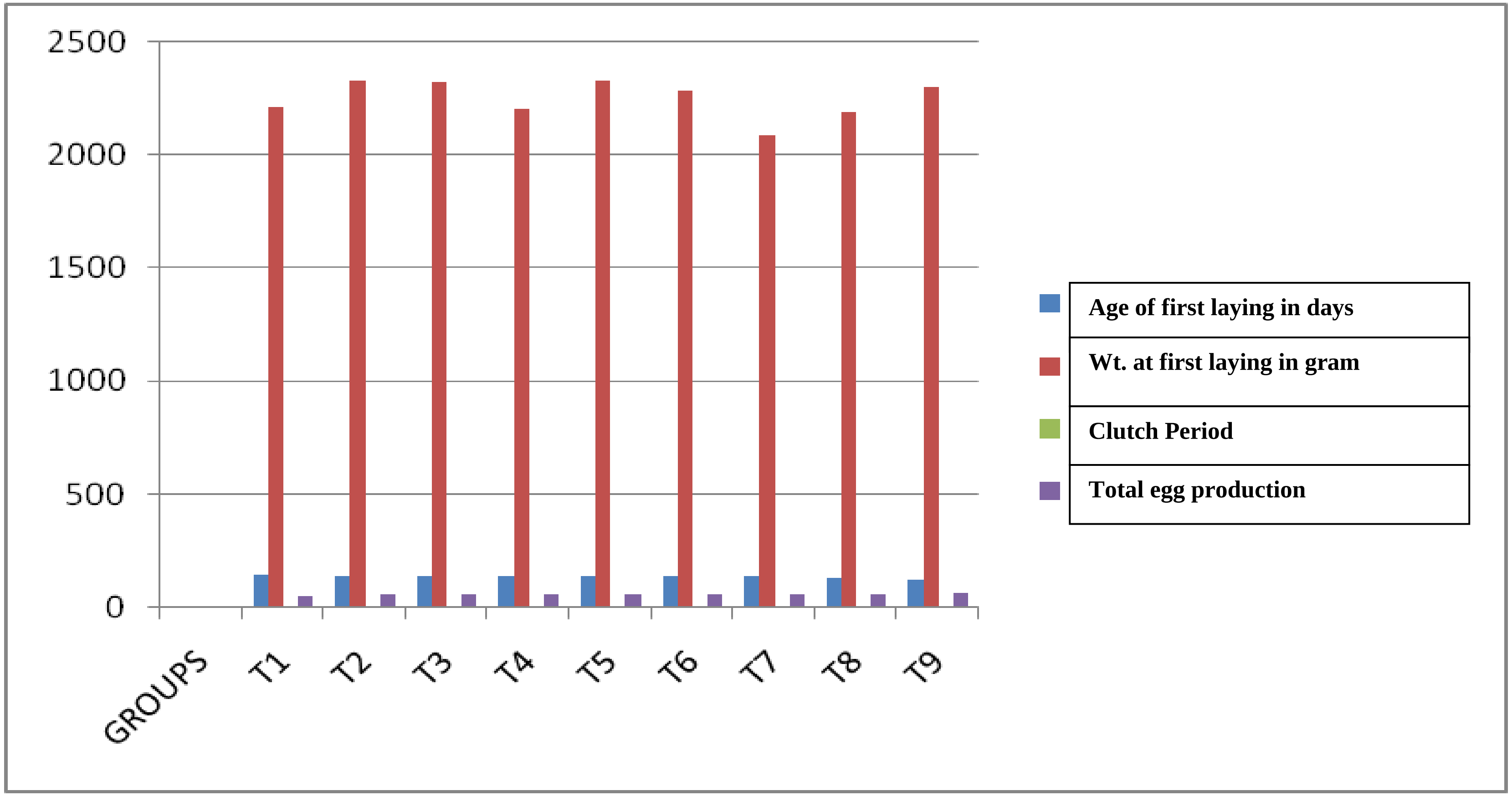


Fig. 4.10 Average age of first laying, weight at first laying, clutch period, Total egg production of Vanaraja birds in different treatment groups

Table 4.10 presents the average age of first laying, weight at first laying, clutch period, and total egg production for Vanaraja birds across different treatment groups.

The average age of first laying was significantly lower in T9 (124.40 days) and T8 (132.40 days), with respect to other groups. The highest age at onset of laying was observed in T1 (144.0 days), while the other groups ranged between 134.80 days and 142.40 days.

In terms of weight at first laying, T7 had the lowest weight (2087.40 g), whereas T2 (2332.40 g) and T3 (2326.60 g) had the highest weights. The weight at first laying for the other groups varied from 2205.20 g to 2329.60 g.

The clutch period was significantly longer in T8 (4.56 days) with respect to other treatments, with T4, T5, T6, T7, and T9 ranging from 4.08 to 4.34 days. The shortest clutch period was noted in T2 (4.06 days).

Total egg production was highest in T9 (64.80 eggs), T7 (61.0 eggs), and T8 (60.20 eggs), while the lowest production was recorded in T1 (53.60 eggs). The total egg production for the other groups ranged from 55.0 eggs to 60.0 eggs.

Hussein *et al*., (1996) found that increasing the crude protein in the layer diet from 16% to 19% significantly enhanced egg weight, while not affecting other production parameters.

Variations in findings can also be affected because of factors such as differences in stress or strain levels, feed composition, treatment duration, agro-climatic conditions, and seasonal influences

4.2.2 Carcass traits

Table 4.11 Effect of different levels of energy and protein on carcass characteristics of Vanaraja birds

TREATMENTS	GIZZARD	SPLEEN	LIVER	HEART
T_1	41.80^{c}	6.10^{c}	56.20^{a}	15.40^{c}
T_2	33.60^{ab}	4.62^{a}	60.40^{b}	11.84^{b}
T_3	35.20^{b}	5.00^{a}	61.60^{bc}	11.82^{b}
T_4	32.80^{ab}	4.74^{a}	56.80^{a}	10.34^{a}
T_5	31.60^{a}	4.56^{a}	60.40^{b}	9.48^{a}
T_6	31.60^{a}	4.62^{a}	61.20^{bc}	11.88^{b}
T_7	32.00^{a}	5.22^{b}	64.40^{c}	10.20^{a}
T_8	32.20^{ab}	5.84^{c}	63.00^{bc}	12.12^{b}
T_9	35.00^{b}	6.18^{c}	72.80^{d}	12.36^{b}
Sem	1.01	0.15	1.02	0.30
CD value (0.05)	3.30	0.50	3.32	0.97

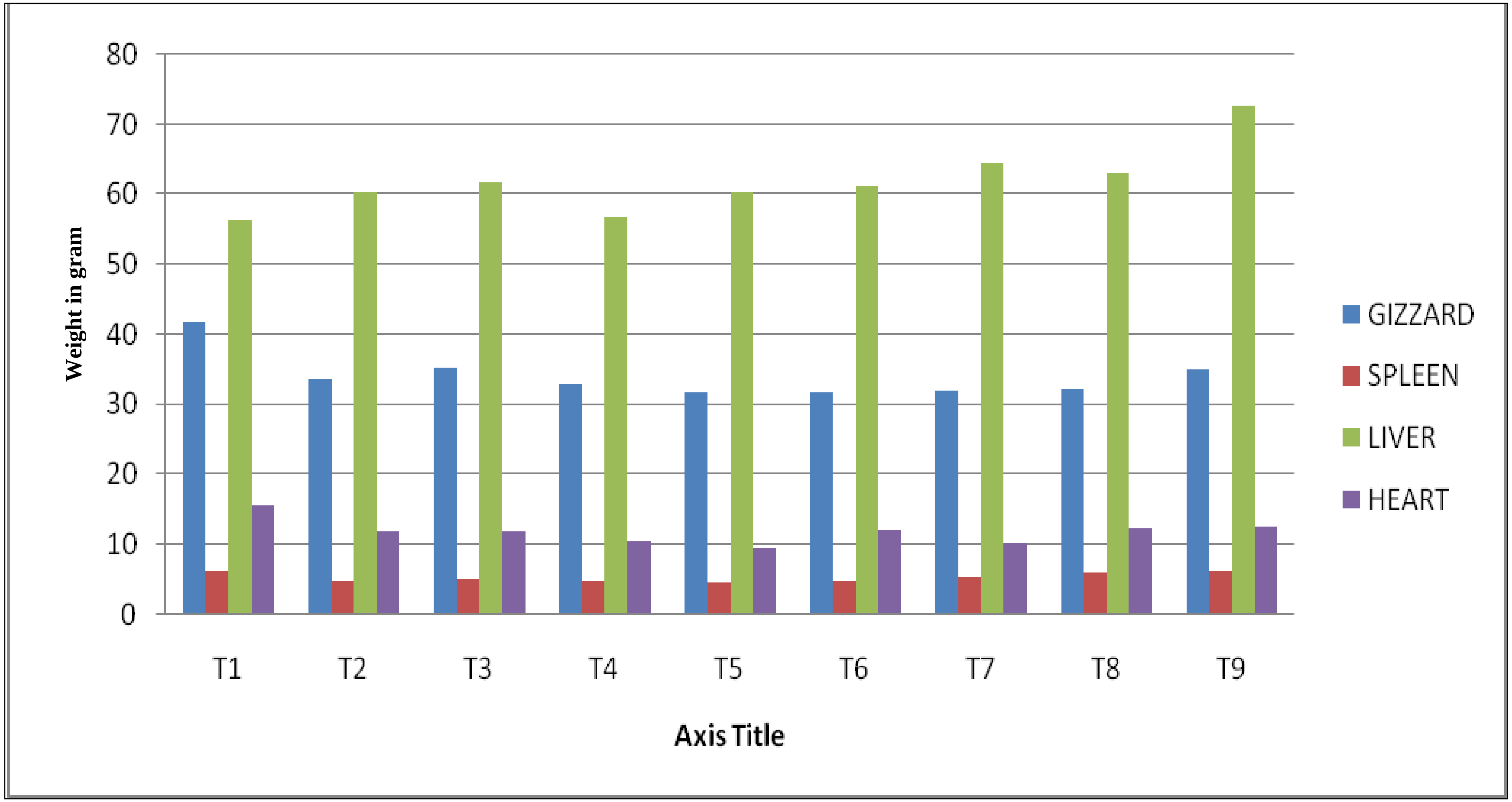


Fig. 4.11 Effect of different levels of energy and protein on carcass characteristics of Vanaraja birds

Organ Weights

Gizzard

The gizzard weight (g) varied significantly among treatments ($P<0.05$). T1 recorded the highest weight (41.80 g), followed by T3 (35.20 g) and T9 (35.00 g). Treatments T5 (31.60 g) and T6 (31.60 g) exhibited the lowest weights, suggesting that dietary formulations influenced gizzard size.

Spleen

Spleen weight (g) also showed significant variations. T9 (6.18 g) and T1 (6.10 g) had the highest weights, indicating better immune function. Conversely, T2 (4.62 g) and T5 (4.56 g) recorded the lowest weights.

Liver

Liver weight (g) was significantly highest in T9 (72.80 g), followed by T7 (64.40 g) and T8 (63.00 g). T1 and T4 (56.20 g and 56.80 g) showed lower values, reflecting possible differences in metabolic activity and nutrient utilization.

Heart

Heart weight (g) was also significantly affected. T9 (12.36 g) and T8 (12.12 g) exhibited the highest weights, while T5 (9.48 g) and T4 (10.34 g) recorded the lowest values.

The higher HDL and serum protein levels observed in T8 and T9 can be attributed to their improved dietary formulations, providing balanced nutrition that supports lipid metabolism and protein synthesis.

The amino acid profile data reinforce these findings, highlighting the role of lysine and methionine in protein metabolism and growth.

The organ weight variations demonstrate the impact of dietary treatments on growth performance and physiological development. Higher gizzard and liver weights in T9 suggest better digestion and metabolic efficiency. Increased spleen weight reflects enhanced immune competence, while heavier hearts indicate improved cardiovascular function, further supporting the dietary advantages of enriched formulations.

Variations in findings can be affected due to factors such as differences in stress or strain levels, feed composition, treatment duration, agro-climatic conditions, and seasonal influences.

4.3 Economics

Table 4.16 displays the performance of Vanaraja birds on different levels of energy and protein in various treatment groups.

The cost of production per bird across the treatments varied slightly, with the lowest cost observed in T9 (Rs 1178.8) and the highest in T1 (Rs 1280.8). These values are influenced by the feed cost, which was the primary contributor to the overall cost of production. The feed costs ranged from Rs 1010.0 in T9 to Rs 1112.0 in T1, indicating that the feed cost reductions were most pronounced in T9. Other costs such as the cost of birds, medicine, labor, and miscellaneous expenses remained constant across all treatments.

The average weight of birds upon the completion of the experiment showed variation across treatments. T9 had the highest average weight of 3.58 kg, while T1 had the lowest at 3.21 kg. The differences in bird weight can be attributed to the variations in the treatments, possibly indicating that some treatments were more effective in promoting growth. The heavier birds in T9 might suggest an optimal combination of factors contributing to better growth performance.

The production cost per kilogram of live weight was lowest in T9 at Rs 329.27, reflecting the reduced cost of production coupled with higher bird weight. On the other hand, T1 had the highest production cost of Rs 399.00 per kg. The cost of efficiency observed in T9 reveals that this approach in the treatment was the most cost-effective in terms of live weight production, while T1 was the least efficient.

Sales from live birds, eggs, gunny bags, and poultry manure contributed to the total receipt per bird. The sale of live birds generated the highest revenue, with T9 achieving Rs 1074.0 per bird, the highest among all treatments. The sale of eggs also contributed significantly, with **T9** recording Rs 622.08 in egg sales. The sale of other products, such as gunny bags and poultry manure, contributed modestly to the total revenue, with minor variations across treatments.

Net profit per bird varied from Rs 350.20 in T1 to Rs 651.98 in T9. The highest net profit was observed in T9, reflecting the cumulative effect of lower production costs and higher revenue. The net profit in T9 was 85.3% higher than in

T1, suggesting that the treatment strategies employed in T9 were particularly effective in maximizing profitability. Treatments T4 and T7 also showed relatively high net profits, with Rs 466.62 and Rs 510.30 per bird, respectively.

The net benefit per kilogram of live weight also showed a positive trend, with T9 leading at Rs 182.11 per kg. and T1 showed the lowest figure (Rs. 109.09). These figures indicate that T9 was the most profitable treatment on a per kg basis, highlighting the treatment’s superior cost-effectiveness and growth performance.

The benefit-cost ratio (BCR) ranged from 1.27 in T1 to 1.56 in T9, with the highest BCR observed in T9. This ratio indicates the economic efficiency of each treatment, where a higher BCR suggests a greater return for every rupee spent. A BCR of 1.56 in T9 signifies a very favorable economic return, making it the most efficient treatment from a profitability standpoint.

The data suggests that T9 was the most profitable treatment, with the highest average bird weight, the lowest production cost per kilogram of live weight, and the highest net profit per bird and per kilogram. This could be attributed to optimal feeding strategies or other management practices that maximized growth while minimizing costs. T9's high benefit-cost ratio further supports its economic viability.

On the other hand, T1 showed the lowest performance in terms of cost efficiency and profit generation. Despite having a moderate revenue from live birds and eggs, its higher production costs resulted in a lower net profit. The findings emphasize the importance of feed management and overall production strategies in reducing costs and maximizing returns.

Overall, the results demonstrate that more cost-effective treatments such as T9, which combine higher growth rates and lower production costs, provide significant economic advantages in poultry farming. Future studies could explore the specific factors influencing the success of T9, including feed composition, environmental conditions, and management practices, to optimize these outcomes further.

The maximum net profit per bird was observed in the T9 group, while the lowest was in the T4 group. Economic analysis also revealed that the ration containing 19% CP and 3000 kcal ME/kg provided a greater profit margin compared to other dietary protein and energy levels (Perween *et al.*, 2016).

Hussein *et al*., 1996 found that feed costs can vary significantly based on the choice and price of ingredients.

Table 4.12 Economics of Vanaraja production in different treatment groups (Rs/bird)

PARTICULARS	TREATMENTS								
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
Cost of bird	50	50	50	50	50	50	50	50	50
Feed cost	1112.0	1069.2	1100.8	1028.8	1075.6	1091.2	1040.8	1048.8	1010.0
Cost of medicine	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5
Cost of labour	83.3	83.3	83.3	83.3	83.3	83.3	83.3	83.3	83.3
Miscellaneous cost	26	26	26	26	26	26	26	26	26
Cost of production	1280.8	1238.0	1269.6	1197.6	1244.4	1260	1209.6	1217.6	1178.8
Avg. Wt. of bird(g)	3.21	3.31	3.31	3.27	3.36	3.31	3.27	3.38	3.58
Production cost/kg live bird	399.00	331.01	383.56	366.23	370.35	380.66	369.90	360.23	329.27
Sale of one live bird @300/kg	963.0	993.0	993.0	981	1008	993	981.0	1014.0	1074.0
Sale of egg @ Rs 9.6/egg	514.56	547.20	537.60	529.92	539.52	556.80	585.60	577.92	622.08
Sale of gunny bag @Rs 25/kg	18.44	17.83	17.06	18.30	17.72	17.13	18.30	17.41	16.98
Sale of Poultry Manure @Rs 3/kg	135	135	135	135	135	135	135	135	135
Total receipt (Rs)/ bird	1631.0	1693.03	1682.66	1664.22	1700.24	1701.93	1719.9	1744.33	1848.06
Net profit per bird	350.20	455.03	413.06	466.62	455.84	441.93	510.30	536.73	651.98
Net profit/kg live weight(Rs)	109.09	137.47	124.79	142.69	135.66	133.51	156.05	158.79	182.11
Benefit-cost ratio	1.27	1.36	1.32	1.38	1.36	1.35	1.42	1.43	1.56

CHAPTER- V
SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

The poultry industry in India plays a vital role in the livestock industry, significantly contributing to increased productivity and economic stability. This sector is a major source of employment, providing jobs to millions across the country, and is recognized for having the highest employability rates among all livestock sectors. As of recent years, India has positioned itself as the third-largest producer of eggs and the fifth-largest producer of poultry meat globally, showcasing the remarkable growth and transformation of the poultry industry. This production not only enhances food security but also addresses nutritional needs by supplying essential proteins, vitamins and minerals which are especially advantageous in underprivileged areas.

Poultry meat and eggs are gaining popularity for their high-quality protein content, digestibility and favorable fat profiles, making them a staple in many diets. The poultry industry not only meets the growing demand for high-quality protein but also provides a sustainable source of nutrition that able to accommodate various dietary needs. However, feed costs is a challenge, accounting for about 60-70% of the overall production costs. Efforts to manage these costs effectively can results increased profitability and expanded opportunities for farmers, encouraging more individuals to enter poultry farming.

The nutritional composition of poultry feed, particularly the levels of energy and protein, plays a crucial role in chicken farming. Energy is essential for supporting bodily functions, while protein is vital for tissue maintenance, muscle development, and overall growth. Studies indicate that optimal dietary protein levels can significantly enhance body weight gain, feed efficiency and egg production. For instance, diets with higher energy and protein content lead to better feed conversion ratios and overall performance of broilers and layers.

Research has revealed that the balance of protein and energy in the diet is critical during various growth phases. Birds require higher protein levels during the early stages of growth and peak production periods. Inadequate protein levels can result in stunted growth, reduced egg production, and weakened immune responses underscoring the necessity for careful formulation of poultry diets. Conversely, excessive protein can lead to increased metabolic stress and health issues.

Overall, the interplay of energy and protein in poultry nutrition is essential for maximizing the genetic potential of birds and achieving desired production outcomes. By optimizing these nutritional parameters, poultry producers can enhance productivity, ensure economic viability and contribute to food security in India.

The poultry industry in India plays a crucial role in enhancing the livestock industry, significantly contributing to productivity, employment, and economic growth. In this context, the present study involved rearing 180 day-old Vanaraja birds for 34 weeks under a systematic feeding regimen designed to assess the effects of varying dietary energy and protein levels. The study was conducted using a Randomized Block Design. Twenty birds were assigned into nine treatment groups (T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9) each having five replications with four birds per replications, allowing for a comprehensive analysis of performance outcomes based on nutritional interventions. So, the present study entitled “Performance of Vanaraja Birds on different levels of energy and protein” was undertaken.

The treatment groups were structured around specific energy and protein content, as outlined in the following table:

Table 5.1 Treatment groups were structured around specific energy and protein content

S. N.	Treatment groups	Energy content (Mcal/kg feed)	Protein content (%)
1.	T_1	2400	16
2.	T_2	2600	16
3.	T_3	2800	16
4.	T_4	2400	18
5.	T_5	2600	18
6.	T_6	2800	18
7.	T_7	2400	20
8.	T_8	2600	20
9.	T_9	2800	20

Body weight

The average body weight (g/bird/fortnight) recorded at the end of the 17th fortnight for the various treatment groups was as follows: T_1 had an average body weight of 3210.40g, T_2 recorded 3219.00g, T_3 had 3312.00g, T_4 weighed 3270.40g, T_5 was at 3366.20g, T_6 reached 3316.80g, T_7 showed 3276.80g, T_8 was at 3384.60g, and T_9 recorded the highest average body weight of 3584.60g per bird.

Among these, the T_9 group exhibited the highest body weight, indicating that the highest levels of energy and protein in the diet positively influenced growth. Statistically, there were significant differences ($P<0.05$) in body weight across the treatment groups, underscoring the importance of dietary composition in optimizing the growth performance of Vanaraja birds under the prevailing agro-climatic conditions.

Body weight gain

The overall mean BWG groups was T_1, T_2, T_3, T_4, T_5, T_6, T_7, $T_{8,}$ and T_9, treatments were 190.40g, 195.75g, 198.47g, 190.68g, 196.15g, 199.0g, 190.65g, 197.10g and 204.84g per bird, respectively. The highest value was seen in the T9 group in comparison to the other treatments. Statistical analysis revealed that there was a ($P<0.05$) difference in BW gain because of different levels of protein and energy and also the agro-climatic conditions.

Feed Intake

The mean of FI during the experimental period for $T_{1,}$ $T_{2,}$ $T_{3,}$ $T_{4,}$ $T_{5,}$ $T_{6,}$ $T_{7,}$ T_8 and T_9 groups was 1634.30g, 1571.55g, 1617.76g, 1508.25g, 1561.76g, 1616.29g, 1509.99g, 1540.68g and 1484.50g per bird, respectively. FI was lowered in T9 and highest in T1 group.

Feed Conversion Ratio

The overall mean of FCR of Vanaraja birds across the treatment groups was observed as follows: T1 (16.98), T2 (11.63), T3 (5.92), T4 (11.98), T5 (11.43), T6 (15.33), T7 (11.78), T8 (10.93), and T9 (11.0).

Mortality, Liveability and Performance Index

The mortality rates for the treatments $T_{1,}$ $T_{2,}$ $T_{3,}$ $T_{4,}$ $T_{5,}$ $T_{6,}$ $T_{7,}$ T_8 and T_9 were recorded as 0.0%, 5.0%, 10.0%, 0.0%, 0.0%, 0.0%, 0.0%, 0.0%, and 0.0%, respectively, while the corresponding liveability percentages were 100.0%, 95.0%, 90.0%, 100.0%, 100.0%, 100.0%, 100.0%, 100.0%, and 100.0%.

The performance index for groups $T_{1,}$ $T_{2,}$ $T_{3,}$ $T_{4,}$ $T_{5,}$ $T_{6,}$ $T_{7,}$ T_8 and T_9 was calculated as123.94, 127.03, 81.60, 125.47, 136.81, 95.56, 128.21, 140.22 and 142.31 respectively, with the T_1 group showing the highest performance index numerically among all treatment groups.

Reproductive traits

Age of first laying

Age of first laying for the various treatment groups $T_{1,}$ $T_{2,}$ $T_{3,}$ $T_{4,}$ $T_{5,}$ $T_{6,}$ $T_{7,}$ T_8 and T_9 was 144.0, 142.60, 141.20, 140.0, 139.80, 139, 137.0, 132.40 and 124.40 days, respectively. Early maturity was found in T_9 group.

Body weight at first laying

The body weight at the onset of egg production for the treatment groups $T_{1,}$ $T_{2,}$ $T_{3,}$ $T_{4,}$ $T_{5,}$ $T_{6,}$ $T_{7,}$ T_8 and T_9 was recorded as 2216.40 g, 2332.40 g, 2326.60 g, 2205.20 g, 2329.60 g, 2290.80 g, 2087.40 g, 2192.0 g, and 2304.40 g, respectively. According to the statistical analysis body weight at the beginning of egg production was significantly higher ($P<0.05$) in T2, followed by T_5, T_3, T_9, T_6, T_1, T_4, T_8, and T_7.

Clutch Period

The clutch period for the treatments $T_{1,}$ $T_{2,}$ $T_{3,}$ $T_{4,}$ $T_{5,}$ $T_{6,}$ $T_{7,}$ T_8 and T_9 was recorded as 4.08, 4.06, 4.24, 4.26, 4.28, 4.34, 4.28, 4.56, and 4.34, respectively. Statistical analysis revealed that the clutch period was numerically highest in T8, followed by T9, T6, T7, T5, T4, T3, T1, and T2.

Total egg production

The total egg production for the treatment groups $T_{1,}$ $T_{2,}$ $T_{3,}$ $T_{4,}$ $T_{5,}$ $T_{6,}$ $T_{7,}$ T_8 and T_9 was recorded as 53.60, 57.00, 56.00, 55.20, 56.20, 58.00, 61.00, 60.20, and 64.80, respectively. Statistical analysis revealed that the highest total egg production was observed in T9, followed by T7, T8, T6, T2, T5, T3, T4, and T1.

Haematological parameters

WBC

The WBC values for treatments $T_{1,}$ $T_{2,}$ $T_{3,}$ $T_{4,}$ $T_{5,}$ $T_{6,}$ $T_{7,}$ T_8 and T_9 at the 2nd month were recorded as 230.40, 231.80, 232.80, 233.00, 236.60, 240.40, 240.60, 242.00, and 244.80, respectively.

At the 4th month, the corresponding values were 208.00, 204.85, 207.40, 226.39, 217.11, 224.51, 228.27, 240.97, and 241.66, while at the 6th month, the values were 222.66, 235.40, 216.89, 233.40, 230.80, 234.40, 246.40, 245.40, and 248.82, respectively.

RBC

The RBC values for treatment groups $T_{1,}$ $T_{2,}$ $T_{3,}$ $T_{4,}$ $T_{5,}$ $T_{6,}$ $T_{7,}$ T_8 and T_9 at the 2nd month were recorded as 2.39, 2.41, 2.43, 2.35, 2.36, 2.40, 2.38, 2.41 and 2.49, respectively.

At the 4th month, the corresponding values were 2.76, 2.73, 2.74, 2.82, 2.86, 2.95, 3.09, 3.38, 3.43, while at the 6th month, the values were 2.55, 2.58, 2.57, 2.58, 2.66, 2.68, 2.70, 2.72 and 3.10, respectively.

Biochemical Parameters

HDL

The HDL values for treatment groups T_{1}, T_{2}, T_{3}, T_{4}, T_{5}, T_{6}, T_{7}, T_{8} and T_{9} at the 2nd month were recorded as 72.20, 73.66, 76.53, 78.62, 84.22, 74.01, 81.59, 80.96 and 89.41, respectively.

At the 4th month, the corresponding values were 60.19, 71.74, 67.96, 72.73, 74.91, 70.20, 73.58, 79.58 and 80.15 while at the 6th month, the values were 48.20, 52.80, 52.60, 53.40, 53.0, 52.80, 53.40, 53.80 and 55.40, respectively.

LDL

The LDL values for treatment groups T_{1}, T_{2}, T_{3}, T_{4}, T_{5}, T_{6}, T_{7}, T_{8} and T_{9} at the 2nd month were recorded as 36.70, 37.41, 44.12, 40.49, 45.69, 46.27, 48.15, 38.37 and 47.52, respectively.

At the 4th month, the corresponding values were 18.97, 19.12, 34.34, 36.57,4 1.17, 41.29, 42.23, 45.08 and 46.78 while at the 6th month, the values were 72.0, 73.12, 72.40, 73.92, 77.20, 77.80, 79.60, 79.20 and 82.80, respectively.

Total Serum Protein

The total serum protein values for treatment groups T_{1}, T_{2}, T_{3}, T_{4}, T_{5}, T_{6}, T_{7}, T_{8} and T_{9} at the 2nd month were recorded as 3.85, 4.31, 4.41, 4.49, 4.70, 4.85, 4.83, 5.67 and 5.96, respectively.

At the 4th month, the corresponding values were 3.49, 3.92, 4.01, 3.91, 3.86, 4.19, 4.40, 4.56 and 4.76 while at the 6th month, the values were 3.57, 3.61, 3.85, 3.77, 3.89, 3.81, 3.84, 4.05 and 4.12, respectively.

Serum Cholesterol

The serum cholesterol values for treatment groups T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9 at the 2nd month were recorded as 137.88, 139.14, 144.62, 144.12, 153.07, 150.41, 148.47, 153.80 and 159.21, respectively.

At the 4th month, the corresponding values were 112.80, 125.52, 126.35, 127.09, 134.09, 140.34, 139.72, 150.32 and 151.14 while at the 6th month, the values were 134.98, 138.40, 139.0, 148.40, 155.0, 156.60, 156.82, 157.60 and 160.20, respectively.

Triglyceride

The triglycerides values for treatment groups T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9 at the 2nd month were recorded as 100.95, 115.16, 117.84, 119.51, 133.21, 129.95, 121.02, 135.48 and 152.87, respectively.

At the 4th month, the corresponding values were 90.61, 106.48, 121.52, 120.37, 125.35, 128.98, 127.63, 135.56 and 146.63 while at the 6th month, the values were 127.40, 131.80, 134.20, 133.40, 136.0, 135.80, 137.60 and 141.30, respectively.

Amino acid

Lysine

The Lysine values for treatment groups T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9 at the 2nd month were recorded as 102.80, 103.60, 104.60, 106.0, 106.80, 108.20 and 108.80, respectively.

At the 4th month, the corresponding values were 92.40, 93.80, 94.80, 96.0, 95.40, 96.60 and 96.80 while at the 6th month, the values were 90.0, 89.60, 90.0, 91.0, 89.80, 90.40 and 91.80, respectively.

Methionine

The Methionine values for treatment groups T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9 at the 2nd month were recorded as 30.20, 30.60, 31.20, 33.40, 33.80, 34.0 and 38.80, respectively.

At the 4th month, the corresponding values were 25.40, 26.20, 26.60, 29.0, 31.0, 30.20 and 33.80 while at the 6th month, the values were 20.20, 21.0, 21.20, 23.40, 27.20, 26.60 and 28.80, respectively.

Carcass Traits

Gizzard

The value of Gizzard for treatment groups T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9 at the end of the experiment were 41.80, 33.60, 35.20, 32.80, 31.60, 31.60, 32.0, 32.20 and 35.0, respectively.

Spleen

The value of Spleen for treatment groups T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9 at the completion of the experiment were 6.10, 4.62, 5.0, 4.74, 4.56, 4.62, 5.22, 5.84 and 6.18, respectively.

Liver

The value of Liver for treatment groups T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9 at the end of the experiment were 56.20, 60.40, 61.60,5 6.80, 60.40, 61.20, 64.40, 63.0 and 72.80, respectively.

Heart

The value of Heart for treatment groups T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9 at the end of the experiment were 15.40, 11.84, 11.82, 10.34, 9.48, 11.88, 10.20, 12.12 and 12.36, respectively.

Economics

The cost of production per kg of live bird was maximum in group T_1 (Rs. 399.00), followed by T_3 (Rs. 383.56), T_6 (Rs. 380.66), T_5 (Rs. 370.35), T_7 (Rs. 369.90), T_4 (Rs. 366.23), T_8 (Rs. 360.23), T_2 (Rs. 331.01), and minimum in T_9 (Rs. 329.27). The maximum net profit per bird and benefit-cost ratio were found in T9

(Rs. 182.11 and 1.56, respectively), followed by T_8 (Rs. 158.79 and 1.43), T_7 (Rs. 156.05 and 1.42), T_4 (Rs. 142.69 and 1.38), T_2 (Rs. 137.47 and 1.36), T_5 (Rs. 135.66 and 1.36), T_6 (Rs. 133.51 and 1.35), T_3 (Rs. 124.79 and 1.32), and the lowest in T_1 (Rs. 109.09 and 1.27).

Conclusions

Based on the results, the following conclusions have been made:

- ❖ The average body weight and mean of gain in body weight were highest in the T_9 (3584.60 g/ bird and 204.84 g/ bird) group of the birds as compared to other treatments.
- ❖ The highest FI mean was observed in T_1 (1617.0 g/ bird) group and the best mean feed conversion efficiency was also found in the (16.98) group of the bird in comparison with the other groups.
- ❖ Mortality and liveability didn't differ amongst the groups. However, the performance index was highest in the T_9 (142.31) group of the birds.
- ❖ Among the groups, early sexual maturity was observed in T_9 (124.40 days) group. However, at the beginning of egg production, BW at strat of egg production was comparable highest in T1, (144 days) groups.
- ❖ Clutch period was highest in T_8 (4.56) and total egg production was highest in T_9 (64.80).
- ❖ In haematological parameters, highest value of WBC was recorded in T_9 (248.82×10^6/µL) group, and the RBC in T_2 (248.82×10^6/µL) group.
- ❖ In biochemical constituents of blood, there was lowest value in serum cholesterol (134.98 mg/dl), LDL (72.0 mg/dl), HDL (48.20), Total serum protein (3.57 mg/dl) and triglyceride (127.40 mg/dl) were observed in T_1 group. Lowest lysine level was found in T_2 (89.60 mg/g) and lowest methionine level was observed in the T_1 (20.20 mg/g) group of the bird.
- ❖ The highest net profit per bird was recorded in the T_9 (Rs 182.11) group of the bird.

Final Recommendations

Based on the overall results of the present study, it can be concluded that the birds in the T9 group (2800 Mcal/kg energy and 20% protein level) performed the best among all treatment groups. T9 exhibited the highest body weight, maximum weight gain, best performance index, early onset of sexual maturity, highest total egg production, and the highest net profit per bird. Although feed intake was not the highest in this group, the superior growth, reproductive performance, and economic returns clearly indicate that dietary formulation with 2800 Mcal/kg energy and 20% protein is optimal for improving the productive, reproductive, and economic efficiency of Vanaraja chickens under the experimental conditions. Therefore, a diet containing 2800 Mcal/kg energy and 20% protein is recommended for maximizing growth performance, egg production, and profitability in Vanaraja chickens.

Precautions for Chicken Farming

- ❖ **Proper Housing and Ventilation**:
  - o Ensure adequate space per bird to avoid overcrowding.
  - o Maintain proper ventilation to reduce heat stress and improve air quality.
- ❖ **Hygiene and Sanitation**:
  - o Regularly clean and disinfect poultry houses, equipment, and feeding areas.
  - o Use biosecurity measures to prevent the entry of diseases, such as footbaths and restricted access for visitors.
- ❖ **Optimal Feeding and Nutrition**:
  - o Provide a balanced diet with appropriate levels of protein, energy, vitamins, and minerals.
  - o Ensure clean and fresh water is available at all times.
- ❖ **Health Monitoring**:
  - o Regularly inspect birds for signs of illness, injury, or abnormal behavior.
  - o Vaccinate chickens against common diseases like Newcastle disease, infectious bronchitis, and fowl pox.
  - o Use antibiotics judiciously and only under veterinary guidance to avoid resistance issues.

- ❖ **Temperature and Lighting Management**:
  - Maintain appropriate temperatures based on the age and breed of birds (e.g., brooding chicks need warmer temperatures).
  - Use proper lighting schedules to promote growth and laying performance.
- ❖ **Litter Management**:
  - Keep the litter dry and change it periodically to prevent the buildup of harmful pathogens.
  - Avoid excessive moisture in the litter, which can lead to ammonia buildup and respiratory issues.
- ❖ **Protection from Predators and Pests**:
  - Install secure fencing and netting to prevent entry of predators like dogs, cats, or wild birds.
  - Use pest control measures to manage rodents, flies, and other pests.
- ❖ **Adequate Space for Movement**:
  - Provide sufficient floor space and perches, especially for free-range systems, to ensure bird comfort and well-being.
- ❖ **Record Keeping**:
  - Maintain records of feed consumption, vaccination schedules, egg production, and bird health.
  - Use data to monitor performance and make informed decisions.
- ❖ **Environmental Considerations**:
  - Properly dispose of dead birds, manure, and waste to minimize environmental pollution.
  - Avoid contamination of nearby water sources with farm runoff.

By adhering to these precautions, chicken farmers can ensure healthy, productive flocks and sustainable farming practices.

Future Plans

- ✓ Future research should focus on evaluating the effects of different dietary protein and energy levels on meat and egg quality traits in Vanaraja chickens. Further studies are required to assess parameters such as meat tenderness, flavour, nutritional composition, and egg quality characteristics to gain a comprehensive understanding of how dietary modifications influence both production and product quality.

- ✓ Research should focus on the influence of protein and energy levels on egg quality traits, including shell strength, yolk color and albumen quality.
- ✓ Investigations into the effects of protein and energy diets on the immune response, gut health and overall physiological adaptability of Vanaraja birds under diverse environmental conditions are recommended.
- ✓ Studies involving different feeding strategies, such as phase feeding or precision nutrition can be explored to optimize nutrient utilization and performance.
- ✓ Comprehensive economic analyses of production costs relative to protein and energy levels should be conducted to establish more cost-effective feeding practices.

Recommendations

- ✓ Nutritional strategies should be tailored to the specific growth stages and production objectives of Vanaraja birds to achieve optimal performance.
- ✓ Proper feed formulation should ensure a balanced supply of amino acids and energy to enhance both growth and reproductive performance.
- ✓ Regular monitoring of feed quality and storage conditions is essential to prevent nutrient losses and maintain feed efficiency.
- ✓ Farmers should adopt good management practices, including timely feed adjustments, to ensure the birds' nutritional needs are met without wastage.
- ✓ Based on findings, energy- and protein-rich diets should be fine-tuned to maximize growth, improve egg production, and ultimately enhance profitability for farmers.

APPENDICES

APPENDIX-1 (BODY WEIGHT)

ANOVA-1 BODY WEIGHT

ANOVA 1.1 Body weight at 1st fortnight

Source of Variance	df	SS	MSS	F Cal	F Tab at 5%	F Tab at 1%	S/NS at 5%	S/NS at 1%
Replication	4	62.80	15.70	1.24	2.67	3.97	NS	NS
Treatment	8	595.11	74.39	5.85	2.24	3.13	Significant	Significant
Error	32	406.80	12.71					
Total	44	1001.91						

SEM±	**1.59**
CD Value	**5.20**
CV	**3.12**

ANOVA 1.2 Body weight at 2nd fortnight

Source of Variance	df	SS	MSS	F Cal	F Tab at 5%	F Tab at 1%	S/NS at 5%	S/NS at 1%
Replication	4	40.09	10.02	0.66	2.67	3.97	NS	NS
Treatment	8	698.00	87.25	5.73	2.24	3.13	Significant	Significant
Error	32	487.20	15.23					
Total	44	1185.20						

SEM±	**1.59**
CD Value	**5.20**
CV	**3.12**

ANOVA 1.3 Body weight at 3rd fortnight

ANOVA TABLE								
Source of Variance	df	SS	MSS	F Cal	F Tab at 5%	F Tab at 1%	S/NS at 5%	S/NS at 1%
Replication	4	183.91	45.98	1.04	2.67	3.97	NS	NS
Treatment	8	131271.11	16408.89	369.57	2.24	3.13	Significant	Significant

Error	32	1420.80	44.40					
Total	44	132691.91						

SEM±	**2.98**
CD Value	**9.72**
CV	**0.91**

ANOVA 1.4 Body weight at 4th fortnight

Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	191.42	47.86	1.42	2.67	3.97	*NS*	*NS*
Treatment	8	91607.20	11450.90	338.66	2.24	3.13	*Significant*	*Significant*
Error	32	1082.0	33.81					
Total	44	92689.20						

SEM±	**2.60**
CD Value	**8.48**
CV	**0.49**

ANOVA 1.5 Body weight at 5th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	288.36	72.09	1.22	2.67	3.97	*NS*	*NS*
Treatment	8	222571.91	27821.49	470.06	2.24	3.13	*Significant*	*Significant*
Error	32	1894.0	59.19					
Total	44	224465.91						

SEM±	**3.44**
CD Value	**11.22**
CV	**0.52**

ANOVA 1.6 Body weight at 6th fortnight

Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	119.42	29.86	0.72	2.67	3.97	*NS*	*NS*
Treatment	8	466924.18	58365.52	1411.93	2.24	3.13	*Significant*	*Significant*
Error	32	1322.80	41.34					
Total	44	46246.98						

SEM±	**2.88**
CD Value	**9.38**
CV	**11.14**

ANOVA 1.7 Body weight at 7th fortnight

Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	199.02	49.76	1.07	2.67	3.97	*NS*	*NS*
Treatment	8	591709.64	73963.71	1595.33	2.24	3.13	*Significant*	*Significant*
Error	32	1483.60	46.36					
Total	44	593193.24						

SEM±	**3.05**
CD Value	**9.93**
CV	**11.79**

ANOVA 1.8 Body weight at 8th fortnight

Source of Variance	*df*	*SS*	*MSS*	*F Cal*	*F Tab at 5%*	*F Tab at 1%*	*S/NS at 5%*	*S/NS at 1%*
Replication	4	124.31	31.08	0.42	2.67	3.97	*NS*	*NS*
Treatment	8	438971.38	54871.42	732.96	2.24	3.13	*Significant*	*Significant*
Error	32	2395.60	74.86					
Total	44	441366.98						

SEM±	**3.87**
CD Value	**12.62**
CV	**14.99**

ANOVA 1.9 Body weight at 9th fortnight

Source of Variance	*df*	*SS*	*M SS*	*F Cal*	*F Tab at 5%*	*F Tab at 1%*	*S/NS at 5%*	*S/NS at 1%*
Replication	4	595.78	148.94	0.64	2.67	3.97	*NS*	*NS*
Treatment	8	651563.20	81445.40	349.70	2.24	3.13	*Significant*	*Significant*
Error	32	7452.80	232.90					
Total	44	659016.00						

SEM±	**6.82**
CD Value	**22.26**
CV	**26.43**

ANOVA 1.10 Body weight at 10th fortnight

Source of Variance	*df*	*SS*	*MSS*	*F Cal*	*F Tab at 5%*	*F Tab at 1%*	*S/NS at 5%*	*S/NS at 1%*
Replication	4	429.91	107.48	2.23	2.67	3.97	*NS*	*NS*

Treatment	8	397903.78	49737.97	1032.98	2.24	3.13	*Significant*	*Significant*
Error	32	1540.80	48.15					
Total	44	399444.58						

SEM±	**3.10**
CD Value	**10.12**
CV	**12.02**

ANOVA 1.11 Body weight at 11th fortnight

Source of Variance	*df*	*SS*	*MSS*	*F Cal*	*F Tab at 5%*	*F Tab at 1%*	*S/NS at 5%*	*S/NS at 1%*
Replication	4	7.23	546.80	0.52	2.67	3.97	*NS*	*NS*
Treatment	8	23.58	176850.0	84.57	2.24	3.13	*Significant*	*Significant*
Error	32	28.00	8364.80					
Total	44		185214.80					

SEM±	**7.23**
CD Value	**23.58**
CV	**28.0**

ANOVA 1.12 Body weight at 12th fortnight

Source of Variance	*df*	*SS*	*MSS*	*F Cal*	*F Tab at 5%*	*F Tab at 1%*	*S/NS at 5%*	*S/NS at 1%*
Replication	4	141.42	35.36	0.85	2.67	3.97	*NS*	*NS*
Treatment	8	319212.0	39901.50	959.17	2.24	3.13	*Significant*	*Significant*
Error	32	1331.20	41.60					
Total	44	320543.20						

SEM±	**2.88**
CD Value	**9.41**
CV	**11.17**

ANOVA 1.13 Body weight at 13th fortnight

Source of Variance	*df*	*SS*	*MSS*	*F Cal*	*F Tab at 5%*	*F Tab at 1%*	*S/NS at 5%*	*S/NS at 1%*
Replication	4	335.20	83.80	0.44	2.67	3.97	*NS*	*NS*
Treatment	8	323087.78	40385.97	210.17	2.24	3.13	*Significant*	*Significant*
Error	32	6149.20	192.16					
Total	44	329236.98						

SEM±	**6.20**
CD Value	**20.22**
CV	**24.01**

ANOVA 1.14 Body weight at 14th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	150.67	37.67	1.10	2.67	3.97	*NS*	*NS*
Treatment	8	300460.31	37557.54	1101.80	2.24	3.13	*Significant*	*Significant*
Error	32	1090.80	34.09					
Total	44	301551.11						

SEM±	**2.61**
CD Value	**8.52**
CV	**10.11**

ANOVA 1.15 Body weight at 15th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	116.09	29.02	1.05	2.67	3.97	*NS*	*NS*
Treatment	8	289964.84	36245.61	1316.82	2.24	3.13	*Significant*	*Significant*
Error	32	880.80	27.53					
Total	44	290845.64						

SEM±	**2.35**
CD Value	**7.65**
CV	**9.09**

ANOVA 1.16 Body weight at 16th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	129.11	32.28	0.34	2.67	3.97	*NS*	*NS*
Treatment	8	158916.0	19864.50	207.33	2.24	3.13	*Significant*	*Significant*
Error	32	3066.0	95.81					
Total	44	161982.0						

SEM±	**4.38**
CD Value	**14.28**
CV	**16.95**

ANOVA 1.17 Body weight at 17th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***

Replication	4	669.64	167.41	0.68	2.67	3.97	*NS*	*NS*
Treatment	8	449308.0	56163.50	228.68	2.24	3.13	*Significant*	*Significant*
Error	32	7859.20	245.60					
Total	44	457167.20						

SEM±	**7.01**
CD Value	**22.86**
CV	**27.14**

APPENDIX 2

ANOVA 1.1 Body weight gain at 1st fortnight

ANOVA 1.1 Body weight gain at 1st fortnight

Source of Variance	*df*	*SS*	*MSS*	*F Cal*	*F Tab at 5%*	*F Tab at 1%*	*S/NS at 5%*	*S/NS at 1%*
Replication	4	53.42	13.36	0.63	2.67	3.97	*NS*	*NS*
Treatment	8	708.84	88.61	4.16	2.24	3.13	*Significant*	*Significant*
Error	32	680.80	21.27					
Total	44	1389.64						

SEM±	**2.06**
CD Value	**6.73**
CV	**7.99**

ANOVA 1.2 Body weight gain at 2nd fortnight

Source of Variance	*df*	*SS*	*MSS*	*F Cal*	*F Tab at 5%*	*F Tab at 1%*	*S/NS at 5%*	*S/NS at 1%*
Replication	4	42.76	10.69	0.53	2.67	3.97	*NS*	*NS*
Treatment	8	583.91	72.99	3.62	2.24	3.13	*Significant*	*Significant*
Error	32	644.40	20.14					
Total	44	1228.31						

SEM±	**2.01**
CD Value	**6.54**
CV	**1.76**

ANOVA 1.3 Body weight gain at 3rd fortnight

Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	198.09	49.52	1.00	2.67	3.97	*NS*	*NS*
Treatment	8	118475.91	14809.49	298.35	2.24	3.13	*Significant*	*Significant*
Error	32	1588.40	49.64					
Total	44	120064.31						

SEM±	**3.15**
CD Value	**10.28**
CV	**12.20**

ANOVA 1.4 Body weight gain at 4th fortnight

Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	273.47	68.37	1.07	2.67	3.97	*NS*	*NS*
Treatment	8	10408.31	1301.04	20.43	2.24	3.13	*Significant*	*Significant*
Error	32	2037.60	63.67					
Total	44	12445.91						

SEM±	**3.57**
CD Value	**11.64**
CV	**13.82**

ANOVA 1.5 Body weight gain at 5th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	138.09	34.52	0.45	2.67	3.97	*NS*	*NS*
Treatment	8	53955.51	6744.44	88.79	2.24	3.13	*Significant*	*Significant*
Error	32	2430.80	75.96					
Total	44	56386.31						

SEM±	**3.90**
CD Value	**12.71**
CV	**15.10**

ANOVA 1.6 Body weight gain at 6th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	647.56	161.89	0.66	2.67	3.97	*NS*	*NS*
Treatment	8	181366.98	22670.87	92.50	2.24	3.13	*Significant*	*Significant*
Error	32	7842.80	245.09					
Total	44	189209.78						

SEM±	**7.00**
CD Value	**22.83**
CV	**27.11**

ANOVA 1.7 Body weight gain at 7th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***

Replication	4	183.69	45.92	0.58	2.67	3.97	*NS*	*NS*
Treatment	8	162320.0	20290.0	255.14	2.24	3.13	*Significant*	*Significant*
Error	32	2544.80	79.53					
Total	44	164864.80						

SEM±	**3.99**
CD Value	**13.01**
CV	**5.67**

ANOVA 1.8 Body weight gain at 8th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	336.98	84.24	0.59	2.67	3.97	*NS*	*NS*
Treatment	8	24862.04	3107.76	21.67	2.24	3.13	*Significant*	*Significant*
Error	32	4589.60	143.42					
Total	44	29451.64						

SEM±	**5.36**
CD Value	**17.47**
CV	**20.74**

ANOVA 1.9 Body weight gain at 9th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	906.98	226.74	0.65	2.67	3.97	*NS*	*NS*
Treatment	8	44348.18	5543.52	16.01	2.24	3.13	*Significant*	*Significant*
Error	32	11080.80	346.28					
Total	4							

	4							

SEM±	**8.32**
CD Value	**27.14**
CV	**21.89**

ANOVA 1.10 Body weight gain at 10th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	510.58	127.64	0.36	2.67	3.97	*NS*	*NS*
Treatment	8	102890.58	12861.32	36.44	2.24	3.13	*Significant*	*Significant*
Error	32	11294.0	352.94					
Total	44	114184.58						

SEM±	**8.40**
CD Value	**27.40**
CV	**14.54**

ANOVA 1.11 Body weight gain at 11th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	1596.98	399.24	1.08	2.67	3.97	*NS*	*NS*
Treatment	8	83161.64	10395.21	28.10	2.24	3.13	*Significant*	*Significant*
Error	32	11836.0	369.88					
Total	44	94997.64						

SEM±	**8.60**
CD Value	**28.05**

CV	15.88

ANOVA 1.12 Body weight gain at 12th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	1218.36	304.59	0.89	2.67	3.97	*NS*	*NS*
Treatment	8	66098.40	8262.30	24.07	2.24	3.13	*Significant*	*Significant*
Error	32	10984.40	343.26					
Total	44	77082.80						

SEM±	8.29
CD Value	27.02
CV	10.82

ANOVA 1.13 Body weight gain at 13th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	283.69	70.92	0.28	2.67	3.97	*NS*	*NS*
Treatment	8	16231.11	2028.89	8.01	2.24	3.13	*Significant*	*Significant*
Error	32	8104.80	253.27					
Total	44	24335.91						

SEM±	7.12
CD Value	23.21

CV	**7.27**

ANOVA 1.4 Body weight gain at 14th fortnight

ANOVA TABLE								
Source of Variance	*df*	*SS*	*MSS*	*F Cal*	*F Tab at 5%*	*F Tab at 1%*	*S/NS at 5%*	*S/NS at 1%*
Replication	4	475.87	118.97	0.51	2.67	3.97	*NS*	*NS*
Treatment	8	14475.38	1809.42	7.82	2.24	3.13	*Significant*	*Significant*
Error	32	7405.60	231.43					
Total	44	21880.98						

SEM±	**6.80**
CD Value	**22.19**
CV	**7.57**

ANOVA 1.15 Body weight gain at 15th fortnight

ANOVA TABLE								
Source of Variance	*df*	*SS*	*MSS*	*F Cal*	*F Tab at 5%*	*F Tab at 1%*	*S/NS at 5%*	*S/NS at 1%*
Replication	4	87.87	21.97	0.46	2.67	3.97	*NS*	*NS*
Treatment	8	1981.91	247.74	5.24	2.24	3.13	*Significant*	*Significant*
Error	32	1512.40	47.26					
Total	44	3494.31						

SEM±	**3.07**
CD Value	**10.03**
CV	**4.62**

ANOVA 1.16 Body weight gain at 16th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	79.87	19.97	0.30	2.67	3.97	*NS*	*NS*
Treatment	8	3703.60	462.95	6.98	2.24	3.13	*Significant*	*Significant*
Error	32	2121.60	66.30					
Total	44	5825.20						

SEM±	**3.64**
CD Value	**11.88**
CV	**8.02**

ANOVA 1.17 Body weight gain at 17th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	553.64	138.41	0.54	2.67	3.97	*NS*	*NS*
Treatment	8	118451.51	14806.44	57.27	2.24	3.13	*Significant*	*Significant*
Error	32	8272.80	258.53					
Total	44	126724.31						

SEM±	**7.19**
CD Value	**23.45**
CV	**22.76**

APPENDIX 3 (Feed intake)

ANOVA 3.1 Feed intake at 1st fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	201.64	50.41	0.76	2.67	3.97	*NS*	*NS*
Treatment	8	5908.71	738.59	11.09	2.24	3.13	*Significant*	*Significant*
Error	32	2131.60	66.61					
Total	44	8040.31						

SEM±	**3.65**
CD Value	**11.90**
CV	**3.34**

ANOVA 3.2 Feed intake at 2nd fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	43.46	10.86	1.20	2.67	3.97	*NS*	*NS*
Treatment	8	48158.62	6019.83	662.23	2.24	3.13	*Significant*	*Significant*
Error	32	290.89	9.09					
Total	44	48449.50						

SEM±	**1.35**
CD Value	**4.40**
CV	**0.85**

ANOVA 3.3 Feed intake at 3rd fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	941.91	235.48	1.02	2.67	3.97	*NS*	*NS*
Treatment	8	206041.51	25755.19	111.23	2.24	3.13	*Significant*	*Significant*
Error	32	7409.54	231.55					
Total	44	213451.06						

SEM±	**6.81**
CD Value	**22.19**
CV	**1.87**

ANOVA 3.4 Feed intake at 4th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	2620.82	655.20	0.56	2.67	3.97	*NS*	*NS*
Treatment	8	200280.12	25035.02	21.29	2.24	3.13	*Significant*	*Significant*
Error	32	37631.62	1175.99					
Total	44	237911.74						

SEM±	**15.34**
CD Value	**50.01**
CV	**3.51**

ANOVA 3.5 Feed intake at 5th fortnight

ANOVA TABLE							

Source of Variance	*df*	*SS*	*MSS*	*F Cal*	*F Tab at 5%*	*F Tab at 1%*	*S/NS at 5%*	*S/NS at 1%*
Replication	4	32.4.38	801.09	1.04	2.67	3.97	*NS*	*NS*
Treatment	8	32451.99	4056.50	5.27	2.24	3.13	*Significant*	*Significant*
Error	32	24644.49	770.14					
Total	44	57096.48						

SEM±	**12.41**
CD Value	**40.47**
CV	**2.45**

ANOVA 3.6 Feed intake at 6th fortnight

ANOVA TABLE								
Source of Variance	*df*	*SS*	*MSS*	*F Cal*	*F Tab at 5%*	*F Tab at 1%*	*S/NS at 5%*	*S/NS at 1%*
Replication	4	5102.44	1275.61	0.91	2.67	3.97	*NS*	*NS*
Treatment	8	212908.0	26613.50	18.88	2.24	3.13	*Significant*	*Significant*
Error	32	45098.0	1409.31					
Total	44	258006.0						

SEM±	**16.79**
CD Value	**54.75**
CV	**2.28**

ANOVA 3.7 Feed intake at 7th fortnight

ANOVA TABLE								
Source of Variance	*df*	*SS*	*MSS*	*F Cal*	*F Tab at 5%*	*F Tab at 1%*	*S/NS at 5%*	*S/NS at 1%*
Replication	4	11801.11	2950.28	0.93	2.67	3.97	*NS*	*NS*
Treatment	8	566484	70810	22.4	2.24	3.13	*Significan*	*Significan*

		.44	.56	2			*t*	*t*
Error	32	101078.0	3158.69					
Total	44	667562.44						

SEM±	**25.13**
CD Value	**81.97**
CV	**3.03**

ANOVA 3.8 Feed intake at 8th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	6331.64	1582.91	0.48	2.67	3.97	*NS*	*NS*
Treatment	8	340919.20	42614.90	12.90	2.24	3.13	*Significant*	*Significant*
Error	32	105716.0	3303.63					
Total	44	446635.20						

SEM±	**25.70**
CD Value	**83.83**
CV	**2.96**

ANOVA 3.9 Feed intake at 9th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	3081.42	770.36	0.13	2.67	3.97	*NS*	*NS*
Treatment	8	546029	68253	11.4	2.24	3.13	*Significan*	*Significan*

		.20	.65	4			*t*	*t*
Error	32	190974.0	5967.94					
Total	44	737003.20						

SEM±	**34.55**
CD Value	**112.67**
CV	**3.76**

ANOVA 3.10 Feed intake at 10th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	22949.66	5737.41	1.29	2.67	3.97	*NS*	*NS*
Treatment	8	299228.06	37403.51	8.39	2.24	3.13	*Significant*	*Significant*
Error	32	142606.85	4456.46					
Total	44	441834.91						

SEM±	**29.85**
CD Value	**97.36**
CV	**2.97**

ANOVA 3.11 Feed intake at 11th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	4499.99	1125.0	0.34	2.67	3.97	*NS*	*NS*
Treatment	8	38899.42	48612.43	14.89	2.24	3.13	*Significant*	*Significant*
Error	32	104484.83	3265.15					
Total	44	493384.25						

SEM±	**25.55**
CD Value	**83.34**
CV	**2.57**

ANOVA 3.12 Feed intake at 12th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	15887.69	3971.92	0.98	2.67	3.97	*NS*	*NS*
Treatment	8	319646.40	39955.80	9.90	2.24	3.13	*Significant*	*Significant*
Error	32	129210.40	4037.83					
Total	44	448856.80						

SEM±	**28.42**
CD Value	**92.68**
CV	**2.87**

ANOVA 3.13 Feed intake at 13th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	2202.31	550.58	0.56	2.67	3.97	*NS*	*NS*
Treatment	8	262665.20	32833.15	33.36	2.24	3.13	*Significant*	*Significant*
Error	32	31496.0	984.25					
Total	44	294161.20						

SEM±	**14.03**
CD Value	**45.76**
CV	**1.41**

ANOVA 3.14 Feed intake at 14th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	219.24	54.81	0.10	2.67	3.97	*NS*	*NS*
Treatment	8	261056.80	32632.10	61.55	2.24	3.13	*Significant*	*Significant*
Error	32	16966.0	530.19					
Total	44	278022.80						

SEM±	**10.30**
CD Value	**33.58**
CV	**1.34**

ANOVA 3.15 Feed intake at 15th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	271.24	67.81	0.96	2.67	3.97	*NS*	*NS*
Treatment	8	186459.91	23307.49	330.90	2.24	3.13	*Significant*	*Significant*
Error	32	2254.0	70.44					
Total	44	188713.91						

SEM±	**3.75**
CD Value	**12.24**
CV	**0.51**

ANOVA 3.16 Feed intake at 16th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	2157.47	539.37	0.41	2.67	3.97	*NS*	*NS*
Treatment	8	36029.64	4503.71	3.42	2.24	3.13	*Significant*	*Significant*
Error	32	42161.60	1317.55					
Total	44	78191.24						

SEM±	**16.23**
CD Value	**52.94**
CV	**2.25**

ANOVA 3.17 Feed intake at 17th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	630.58	157.64	0.17	2.67	3.97	*NS*	*NS*
Treatment	8	49217.24	6152.16	6.64	2.24	3.13	*Significant*	*Significant*
Error	32	29660.0	926.88					
Total	44	7887.24						

SEM±	**13.62**
CD Value	**44.40**
CV	**1.91**

ANOVA 3.18 Total mean feed intake

ANOVA TABLE								
Source of Variance	*df*	*SS*	*MSS*	*F Cal*	*F Tab at 5%*	*F Tab at 1%*	*S/NS at 5%*	*S/NS at 1%*
Replication	4	630.58	157.64	0.17	2.67	3.97	*NS*	*NS*
Treatment	8	49217.24	6152.16	6.64	2.24	3.13	*Significant*	*Significant*
Error	32	29660.0	926.88					
Total	44	7887.24						

SEM±	195.12
CD Value	636.32
CV	1.64

APPENDIX- 4 (Feed Conversion Ratio)

ANOVA 1.1 FCR at 1st fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	0.06	0.01	0.37	2.67	3.97	*NS*	*NS*
Treatment	8	3.39	0.42	11.44	2.24	3.13	*Significant*	*Significant*
Error	32	1.19	0.04					
Total	44	4.57						

SEM	**0.09**
CD Value	**0.28**
CV	**6.29**

ANOVA 1.2 FCR at 2nd fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	0.00	0.00	0.90	2.67	3.97	*NS*	*NS*
Treatment	8	0.70	0.09	138.29	2.24	3.13	*Significant*	*Significant*
Error	32	0.02	0.00					
Total	44	0.72						

SEM	**0.01**
CD Value	**0.04**
CV	**1.80**

ANOVA 1.3 FCR at 3rd fortnight

ANOVA TABLE								

Source of Variance	*df*	*SS*	*MSS*	*F Cal*	*F Tab at 5%*	*F Tab at 1%*	*S/NS at 5%*	*S/NS at 1%*
Replication	4	0.03	0.01	1.45	2.67	3.97	*NS*	*NS*
Treatment	8	6.05	0.76	137.37	2.24	3.13	*Significant*	*Significant*
Error	32	0.18	0.01					
Total	44	6.23						

SEM	**0.03**
CD Value	**0.11**
CV	**3.25**

ANOVA 1.4 FCR at 4th fortnight

ANOVA TABLE								
Source of Variance	*df*	*SS*	*MSS*	*F Cal*	*F Tab at 5%*	*F Tab at 1%*	*S/NS at 5%*	*S/NS at 1%*
Replication	4	0.01	0.00	0.35	2.67	3.97	*NS*	*NS*
Treatment	8	1.69	0.21	37.76	2.24	3.13	*Significant*	*Significant*
Error	32	0.18	0.01					
Total	44	1.87						

SEM	**0.03**
CD Value	**0.11**
CV	**3.46**

ANOVA 1.5 FCR at 5th fortnight

ANOVA TABLE								
Source of Variance	*df*	*SS*	*MSS*	*F Cal*	*F Tab at 5%*	*F Tab at 1%*	*S/NS at 5%*	*S/NS at 1%*
Replication	4	0.09	0.02	1.27	2.67	3.97	*NS*	*NS*
Treatment	8	9.45	1.18	65.92	2.24	3.13	*Significant*	*Significant*

Error	32	0.57	0.02					
Total	44	10.02						

SEM	**0.06**
CD Value	**0.20**
CV	**3.50**

ANOVA 1.6 FCR at 6th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	0.13	0.03	0.61	2.67	3.97	*NS*	*NS*
Treatment	8	109.69	13.71	256.44	2.24	3.13	*Significant*	*Significant*
Error	32	1.71	0.05					
Total	44	111.40						

SEM	**0.10**
CD Value	**0.34**
CV	**4.66**

ANOVA 1.7 FCR at 7th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	4.19	1.05	0.70	2.67	3.97	*NS*	*NS*
Treatment	8	1671.28	208.91	138.95	2.24	3.13	*Significant*	*Significant*
Error	32	48.11	1.50					
Total	44	1719.39						

SEM	**0.55**

CD Value	**1.79**
CV	**8.78**

ANOVA 1.8 FCR at 8th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	12.45	3.11	0.53	2.67	3.97	*NS*	*NS*
Treatment	8	522.31	65.29	11.11	2.24	3.13	*Significant*	*Significant*
Error	32	188.0	5.88					
Total	44	710.32						

SEM	**1.08**
CD Value	**3.54**
CV	**15.08**

ANOVA 1.9 FCR at 9th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	315.37	78.84	1.00	2.67	3.97	*NS*	*NS*
Treatment	8	5564.90	695.61	8.78	2.24	3.13	*Significant*	*Significant*
Error	32	2533.94	79.19					
Total	44	8098.85						

SEM	**3.98**
CD Value	**12.98**
CV	**30.31**

ANOVA 1.10 FCR at 10th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	114.94	28.74	0.71	2.67	3.97	*NS*	*NS*
Treatment	8	4582.45	572.81	14.08	2.24	3.13	*Significant*	*Significant*
Error	32	1301.46	40.67					
Total	44	5883.90						

SEM	**2.85**
CD Value	**9.30**
CV	**29.68**

ANOVA 1.11 FCR at 11th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	189.54	47.39	0.81	2.67	3.97	*NS*	*NS*
Treatment	8	6446.33	805.79	13.72	2.24	3.13	*Significant*	*Significant*
Error	32	1879.67	58.74					
Total	44	8326.01						

SEM	**3.43**
CD Value	**11.18**
CV	**34.63**

ANOVA 1.12 FCR at 12th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	7.01	1.75	0.71	2.67	3.97	*NS*	*NS*

Treatment	8	433.60	54.20	22.11	2.24	3.13	*Significant*	*Significant*
Error	32	78.43	2.45					
Total	44	512.03						

SEM	**0.70**
CD Value	**2.28**
CV	**11.41**

ANOVA 1.13 FCR at 13th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MS S***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	0.46	0.11	0.22	2.67	3.97	*NS*	*NS*
Treatment	8	17.36	2.17	4.21	2.24	3.13	*Significant*	*Significant*
Error	32	16.49	0.52					
Total	44	33.86						

SEM	**0.32**
CD Value	**1.05**
CV	**6.98**

ANOVA 1.14 FCR at 14th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MS S***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	1.72	0.43	0.60	2.67	3.97	*NS*	*NS*
Treatment	8	74.61	9.33	12.93	2.24	3.13	*Significant*	*Significant*
Error	32	23.08	0.72					
Total	44	97.69						

SEM	**0.38**
CD Value	**1.24**
CV	**9.68**

ANOVA 1.15 FCR at 15th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	0.44	0.11	0.36	2.67	3.97	*NS*	*NS*
Treatment	8	13.97	1.75	5.73	2.24	3.13	*Significant*	*Significant*
Error	32	9.76	0.30					
Total	44	23.73						

SEM	**0.25**
CD Value	**0.81**
CV	**4.90**

ANOVA 1.16 FCR at 16th fortnight

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	29.21	7.30	1.95	2.67	3.97	*NS*	*NS*
Treatment	8	210.51	26.31	7.02	2.24	3.13	*Significant*	*Significant*
Error	32	119.88	3.75					
Total	44	330.39						

SEM	**0.87**
CD Value	**2.82**
CV	**11.75**

ANOVA 1.17 FCR at 17th fortnight

ANOVA TABLE							

Source of Variance	*df*	*SS*	*MSS*	*F Cal*	*F Tab at 5%*	*F Tab at 1%*	*S/NS at 5%*	*S/NS at 1%*
Replication	4	11473.20	2868.30	1.07	2.67	3.97	*NS*	*NS*
Treatment	8	120946.68	15118.33	5.62	2.24	3.13	*Significant*	*Significant*
Error	32	86149.47	2692.17					
Total	44	207096.15						

SEM	**23.20**
CD Value	**75.67**
CV	**94.25**

APPENDIX- 5 REPRODUCTIVE TRAITS

ANOVA- 5 Reproductive Traits

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	22.36	5.59	1.09	2.67	3.97	*NS*	*NS*
Treatment	8	341.20	42.65	8.34	2.24	3.13	*Significant*	*Significant*
Error	32	163.60	5.11					
Total	44	504.80						

SEM	**1.01**
CD Value	**3.30**
CV	**1.64**

ANOVA 5.2 Weight at first laying

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	513.20	128.30	2.48	2.67	3.97	*NS*	*NS*
Treatment	8	282108.40	35263.55	680.27	2.24	3.13	*Significant*	*Significant*
Error	32	1658.80	51.84					
Total	44	283767.20						

SEM	**3.22**
CD Value	**10.50**
CV	**0.32**

ANOVA 5.3 Clutch Period

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	0.04	0.01	0.30	2.67	3.97	*NS*	*NS*
Treatment	8	0.88	0.11	3.32	2.24	3.13	*Significant*	*Significant*
Error	32	1.06	0.03					
Total	44	1.93						

SEM	**0.08**
CD Value	**0.26**
CV	**4.25**

ANOVA 5.4 Total egg production

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	17.11	4.28	1.24	2.67	3.97	*NS*	*NS*
Treatment	8	477.60	59.70	17.30	2.24	3.13	*Significant*	*Significant*
Error	32	110.40	3.45					
Total	44	588.00						

SEM	**0.83**
CD Value	**2.71**
CV	**3.20**

ANOVA 5.5 Age at first laying

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	27.24	6.81	1.12	2.67	3.97	*NS*	*NS*
Treatment	8	1463.38	182.92	29.99	2.24	3.13	*Significant*	*Significant*
Error	32	195.20	6.10					
Total	44	1658.58						

SEM	**1.10**
CD Value	**3.60**
CV	**1.79**

APPENDIX 6 (PERFORMANCE INDEX)

ANOVA- PERFROMANCE INDEX

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	346.53	86.63	0.39	2.67	3.97	*NS*	*NS*
Treatment	8	168404.18	21050.52	94.33	2.24	3.13	*Significant*	*Significant*
Error	32	7140.80	223.15					
Total	44	175544.98						

SEM	**6.68**
CD Value	**21.79**
CV	**0.45**

APPENDIX 7 HAEMATOLOGICAL PARAMETERS)

ANOVA- 7 HAEMATOLOGICAL PARAMETERS

ANOVA- 7.1 RBC AT 2ND MONTH

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	0.01	0.00	0.78	2.67	3.97	*NS*	*NS*
Treatment	8	0.06	0.01	3.95	2.24	3.13	*Significant*	*Significant*
Error	32	0.07	0.00					
Total	44	0.13						

SEM	**0.02**
CD Value	**0.07**
CV	**1.89**

ANOVA- 7.2 RBC AT 4th MONTH

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	0.69	0.17	1.72	2.67	3.97	*NS*	*NS*
Treatment	8	2.90	0.36	3.63	2.24	3.13	*Significant*	*Significant*
Error	32	3.19	0.10					
Total	44	6.09						

SEM	**0.14**
CD Value	**0.46**

CV	**10.62**

ANOVA- 7.3 RBC AT 6th MONTH

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	0.06	0.01	0.39	2.67	3.97	*NS*	*NS*
Treatment	8	1.14	0.14	3.89	2.24	3.13	*Significant*	*Significant*
Error	32	1.17	0.04					
Total	44	2.31						

SEM	**0.09**
CD Value	**0.28**
CV	**7.13**

ANOVA- 7.4 WBC AT 2nd MONTH

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	275.47	68.87	2.29	2.67	3.97	*NS*	*NS*
Treatment	8	1073.60	134.20	4.46	2.24	3.13	*Significant*	*Significant*
Error	32	963.20	30.10					
Total	44	2036.80						

SEM	**2.45**
CD Value	**8.00**
CV	**2.32**

ANOVA- 7.5 WBC AT 4th MONTH

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	23.17	5.79	1.23	2.67	3.97	*NS*	*NS*
Treatment	8	7693.89	961.74	203.45	2.24	3.13	*Significant*	*Significant*
Error	32	151.27	4.73					
Total	44	7845.16						

SEM	**0.97**
CD Value	**3.17**
CV	**0.98**

ANOVA- 7.6 WBC AT 6th MONTH

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	9.12	2.28	0.12	2.67	3.97	*NS*	*NS*
Treatment	8	4650.38	581.30	31.16	2.24	3.13	*Significant*	*Significant*
Error	32	596.93	18.65					
Total	44	5247.31						

SEM	**1.93**
CD Value	**6.30**
CV	**1.84**

APPENDIX-8 (BIOCHEMICAL PARAMETERS)

ANOVA-8 BIOCHEMICAL PARAMETERS

ANOVA- 8.1 CHOLESTEROL at 2nd month

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	26.61	6.65	0.19	2.67	3.97	*NS*	*NS*
Treatment	8	1936.08	242.01	6.74	2.24	3.13	*Significant*	*Significant*
Error	32	1148.25	35.88					
Total	44	3084.33						

SEM	2.68
CD Value	8.74
CV	4.05

ANOVA- 8.2 CHOLESTEROL at 4th month

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	15.20	3.80	0.62	2.67	3.97	*NS*	*NS*
Treatment	8	6301.13	787.64	128.70	2.24	3.13	*Significant*	*Significant*
Error	32	195.84	6.12					
Total	44	6496.96						

SEM	**1.11**
CD Value	**3.61**
CV	**1.84**

ANOVA- 8.3 CHOLESTEROL at 6th month

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	85.70	21.43	1.27	2.67	3.97	*NS*	*NS*
Treatment	8	3798.55	474.82	28.18	2.24	3.13	*Significant*	*Significant*
Error	32	539.26	16.85					
Total	44	4337.81						

SEM	**1.84**
CD Value	**5.99**
CV	**2.74**

ANOVA- 8.4 HDL CHOLESTEROL at 2nd month

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	28.08	7.02	0.82	2.67	3.97	*NS*	*NS*
Treatment	8	1260.17	157.52	18.38	2.24	3.13	*Significant*	*Significant*
Error	32	274.22	8.57					
Total	44	1534.39						

SEM	**1.31**
CD Value	**4.27**
CV	**3.70**

ANOVA- 8.2 HDL CHOLESTEROL at 4th month

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	15.83	3.96	0.65	2.67	3.97	*NS*	*NS*
Treatment	8	1467.69	183.46	30.19	2.24	3.13	*Significant*	*Significant*
Error	32	194.46	6.08					
Total	44	1662.16						

SEM	**1.10**
CD Value	**3.60**
CV	**3.41**

ANOVA- 8.2 HDL CHOLESTEROL at 6th month

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	46.69	12.42	2.09	2.67	3.97	*NS*	*NS*
Treatment	8	148.58	18.57	3.13	2.24	3.13	*Significant*	*Significant*
Error	32	190.00	5.94					
Total	44	338.58						

SEM	**1.09**
CD Value	**3.55**
CV	**4.61**

ANOVA- 8.2 LDL CHOLESTEROL at 2nd month

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***

Replication	4	30.62	7.66	0.80	2.67	3.97	*NS*	*NS*
Treatment	8	767.14	95.89	10.02	2.24	3.13	*Significant*	*Significant*
Error	32	306.37	9.57					
Total	44	1073.51						

SEM	**1.38**
CD Value	**4.51**
CV	**7.22**

ANOVA- 8.2 LDL CHOLESTEROL at 4th month

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	10.75	2.69	0.64	2.67	3.97	*NS*	*NS*
Treatment	8	4349.40	543.68	129.18	2.24	3.13	*Significant*	*Significant*
Error	32	134.68	4.21					
Total	44	4484.09						

SEM	**0.92**
CD Value	**2.99**
CV	**5.67**

ANOVA- 8.2 LDL CHOLESTEROL at 6th month

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	65.34	16.33	1.25	2.67	3.97	*NS*	*NS*

Treatment	8	569.44	71.18	5.45	2.24	3.13	*Significant*	*Significant*
Error	32	418.02	13.06					
Total	44	987.45						

SEM	**1.62**
CD Value	**5.27**
CV	**4.73**

ANOVA- 8.2 TRIGLYCERIDES at 2nd month

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	24.48	6.12	0.31	2.67	3.97	*NS*	*NS*
Treatment	8	8755.98	1094.50	55.68	2.24	3.13	*Significant*	*Significant*
Error	32	628.99	19.66					
Total	44	9384.96						

SEM	**1.98**
CD Value	**6.47**
CV	**3.54**

ANOVA- 8.3 TRIGLYCERIDES at 4th month

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	3.68	0.92	0.38	2.67	3.97	*NS*	*NS*
Treatment	8	10539.61	1317.45	548.70	2.24	3.13	*Significant*	*Significant*
Error	32	76.83	2.40					
Total	44	10616.44						

SEM	**0.69**
CD Value	**2.26**
CV	**1.26**

ANOVA- 8.4 TRIGLYCERIDES at 6th month

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	58.15	14.54	0.74	2.67	3.97	*NS*	*NS*
Treatment	8	659.57	82.45	4.20	2.24	3.13	*Significant*	*Significant*
Error	32	628.44	19.64					
Total	44	1288.01						

SEM	**1.98**
CD Value	**6.46**
CV	**3.30**

ANOVA- 8.5 TOTAL SERUM PROTEIN at 2nd month

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	0.25	0.06	0.24	2.67	3.97	*NS*	*NS*
Treatment	8	17.55	2.19	8.49	2.24	3.13	*Significant*	*Significant*
Error	32	8.27	0.26					
Total	44	25.82						

SEM	**0.23**

CD Value	**0.74**
CV	**10.62**

ANOVA- 8.6 TOTAL SERUM PROTEIN at 4th month

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	0.12	0.03	0.14	2.67	3.97	*NS*	*NS*
Treatment	8	6.26	0.78	3.71	2.24	3.13	*Significant*	*Significant*
Error	32	6.76	0.21					
Total	44	13.02						

SEM	**0.21**
CD Value	**0.67**
CV	**11.15**

ANOVA- 8.7 TOTAL SERUM PROTEIN at 6th month

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	0.02	0.00	0.41	2.67	3.97	*NS*	*NS*
Treatment	8	1.26	0.16	16.00	2.24	3.13	*Significant*	*Significant*
Error	32	0.32	0.01					
Total	44	1.58						

SEM	**0.04**
CD Value	**0.14**
CV	**2.59**

ANOVA- 8.8 AMINO ACID (LYSINE at 2nd month)

ANOVA TABLE								

Source of Variance	*df*	*SS*	*MSS*	*F Cal*	*F Tab at 5%*	*F Tab at 1%*	*S/NS at 5%*	*S/NS at 1%*
Replication	4	80.53	20.13	0.84	2.67	3.97	*NS*	*NS*
Treatment	8	742.31	92.79	3.87	2.24	3.13	*Significant*	*Significant*
Error	32	768.00	24.00					
Total	44	1510.31						

SEM	**2.19**
CD Value	**7.14**
CV	**4.55**

ANOVA- 8.9 AMINO ACID (LYSINE at 4th month)

ANOVA TABLE								
Source of Variance	*df*	*SS*	*MSS*	*F Cal*	*F Tab at 5%*	*F Tab at 1%*	*S/NS at 5%*	*S/NS at 1%*
Replication	4	117.91	29.48	1.48	2.67	3.97	*NS*	*NS*
Treatment	8	733.60	91.70	4.59	2.24	3.13	*Significant*	*Significant*
Error	32	639.20	19.98					
Total	44	1372.80						

SEM	**2.00**
CD Value	**6.52**
CV	**4.61**

ANOVA- 8.9 AMINO ACID (LYSINE at 6th month)

ANOVA TABLE								

Source of Variance	*df*	*SS*	*MS S*	*F Cal*	*F Tab at 5%*	*F Tab at 1%*	*S/NS at 5%*	*S/NS at 1%*
Replication	4	144.58	36.14	1.59	2.67	3.97	*NS*	*NS*
Treatment	8	679.51	84.94	3.73	2.24	3.13	*Significant*	*Significant*
Error	32	728.40	22.76					
Total	44	1407.91						

SEM	**2.13**
CD Value	**6.96**
CV	**5.18**

ANOVA- 8.2 AMINO ACID (METHIONINE at 2nd month)

ANOVA TABLE								
Source of Variance	*df*	*SS*	*MS S*	*F Cal*	*F Tab at 5%*	*F Tab at 1%*	*S/NS at 5%*	*S/NS at 1%*
Replication	4	127.69	31.92	1.81	2.67	3.97	*NS*	*NS*
Treatment	8	847.20	105.90	6.01	2.24	3.13	*Significant*	*Significant*
Error	32	563.60	17.61					
Total	44	1410.80						

SEM	**1.88**
CD Value	**6.12**
CV	**11.97**

ANOVA- 8.2 AMINO ACID (METHIONINE at 4th month

ANOVA TABLE								
Source of Variance	*df*	*SS*	*MS S*	*F Cal*	*F Tab at 5%*	*F Tab at 1%*	*S/NS at 5%*	*S/NS at 1%*
Replication	4	114.36	28.59	1.77	2.67	3.97	*NS*	*NS*
Treatment	8	891.11	111.39	6.90	2.24	3.13	*Significant*	*Significant*

Error	32	516.80	16.15					
Total	44	1407.91						

SEM	**1.80**
CD Value	**5.86**
CV	**13.03**

ANOVA- 8.9 AMINO ACID (LYSINE at 6th month)

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MS S***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	81.69	20.42	1.31	2.67	3.97	*NS*	*NS*
Treatment	8	980.71	122.59	7.89	2.24	3.13	*Significant*	*Significant*
Error	32	497.20	15.54					
Total	44	1477.91						

SEM	**1.76**
CD Value	**5.75**
CV	**15.13**

APPENDIX- 9 (CARCASS PARAMETERS)

ANNOVA- 9 (CARCASS PARAMETERS)

ANOVA- 9.1 GIZZARD

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MS S***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	50.98	12.74	2.49	2.67	3.97	*NS*	*NS*
Treatment	8	434.04	54.26	10.61	2.24	3.13	*Significant*	*Significant*
Error	32	163.60	5.11					
Total	44	597.64						

SEM	**1.01**
CD Value	**3.30**
CV	**6.67**

ANOVA- 9.2 LIVER

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MS S***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	19.42	4.86	0.94	2.67	3.97	*NS*	*NS*
Treatment	8	949.20	118.65	22.87	2.24	3.13	*Significant*	*Significant*
Error	32	166.00	5.19					
Total	44	1115.20						

SEM	**1.02**
CD Value	**3.32**
CV	**3.68**

ANOVA- 9.3 SPLEEN

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	0.19	0.05	0.41	2.67	3.97	*NS*	*NS*
Treatment	8	17.57	2.20	18.85	2.24	3.13	*Significant*	*Significant*
Error	32	3.73	0.12					
Total	44	21.30						

SEM	**0.15**
CD Value	**0.50**
CV	**6.55**

ANOVA- 9.4 HEART

ANOVA TABLE								
Source of Variance	***df***	***SS***	***MSS***	***F Cal***	***F Tab at 5%***	***F Tab at 1%***	***S/NS at 5%***	***S/NS at 1%***
Replication	4	3.86	0.96	2.19	2.67	3.97	*NS*	*NS*
Treatment	8	116.97	14.62	33.12	2.24	3.13	*Significant*	*Significant*
Error	32	14.13	0.44					
Total	44	131.10						

SEM	**0.30**
CD Value	**0.97**
CV	**5.67**

REFERENCES

REFERENCES

Aftab, U., Ashraf, M., and Jiang, Z. 2006. Low protein diets for broilers. *World's Poultry Science Journal*, **62** (4) : 688-701.

Ahmed, H.A., Medhi, A.K., Brahma, M.L. and Medhi, D. 2009. Effect of dietary protein and energy levels on the performance of indigenous chicken of Assam. *Indian Journal of Animal Nutrition.* **26** (3) : 283-286.

Aletor, V.A., Hamid, I.I., Niess, E. and Pfeffer, E. 2000. Low-protein amino acid-supplemented diets in broiler chickens:effects on performance, carcass characteristics, whole-body composition and efficiencies of nutrient utilisation. *Journal of the Science of Food and Agriculture.* **80** (5) : 547-554.

Azizi, B., Sadeghi, G., Karimi, A. and Abed, F. 2011. Effects of dietary energy and protein dilution and time of feed replacement from starter to grower on broiler chickens performance. *Journal of Central European Agriculture*. **12** (1) :44-52.

Baba, I., Singh, Y., Sheikh, I. and Thirumurugan, P. 2015. Performances and organoleptic quality of Vanaraja chicken under different rearing systems. *Indian Journal of Animal Production and Management.* **31** (3-4) : 23-27.

Banday, M.T., Baba, I.A., Adil, S. and Sheikh, I.U. 2013. Performance and carcass characteristics of broilers fed graded levels of protein. *Indian Journal of Poultry Science.* **48** (3) : 400-402.

Banday, M. T. 2014. Economic production of poultry. **In**: Avain (poultry) production a text book (eds. Sapcota, D., Narahari, D. and Mahanta, J. D.) New India Publishing Agency, pp 99 – 112.

Barteczko, J. and Lasek, O. 2008. Effect of varied protein and energy contents in mixture on meat quality of broiler chicken. *Slovak Journal of Animal Science.* **41** (4) :173-178.

Bartov, I. 1995. Differential effect of age on metabolisable energy content of high protein-low energy and low protein-high energy diets in young broiler chicks. *British Poultry Science.* **36** (4) : 631-643.

Beski, S.S., Swick, R.A. and Iji, P.A. 2015. Specialized protein products in broiler chicken nutrition: A review. *Animal Nutrition.* **1** (2) : 47-53.

Bhagat, V.R., Mishra, R.K., Patel, A.B., Rajpura, R.M., Bhagora, N.J. and Savaliya, F.P. 2020. Effect of varying levels of dietary protein and energy on performance of commercial broiler chicken. *Indian Journal of Veterinary Sciences and Biotechnology.* **16** (2, 3, 4) : 81-85.

Bird, H. R. 1955. Performance Index of growing chickens. *Poultry Science*. **34** (5) : 1163-1164.

Brandejs, V., Kupcikova, L., Tvrdon, Z., Hampel, D. and Lichovnikova, M. 2022. Broiler chicken production using dietary crude protein reduction strategy and free amino acid supplementation. *Livestock Science.* **258** : 104879.

Bregendahl, K., Sell, J.L. and Zimmerman, D.R. 2002. Effect of low-protein diets on growth performance and body composition of broiler chicks. *Poultry Science.* **81** (8) : 1156-1167.

Cheng, T.K., Hamre, M.L. and Coon, C.N. 1997. Responses of broilers to dietary protein levels and amino acid supplementation to low protein diets at various environmental temperatures. *Journal of Applied Poultry Research.* **6** (1) : 18-33.

Chandrasekar, M. (2011). *Practical Physiology Book.* JP Medical Ltd.

Chrystal, P.V.,Greenhalgh, S., Selle, P.H. and Liu, S.Y. 2020. Facilitating the acceptance of tangibly reduced-crude protein diets for chicken-meat production. *Animal Nutrition.* **6** (3) :247-257.

Das, N., Dehuri, P.K., Panda, N., Mishra, S.C. and Mishra, P.K. 2007. Performance of broilers on various levels of dietary protein and energy in summer under hot humid condition. *Indian Journal of Poultry Science.* **42** (2) : 161-164.

De Cesare, A., do Valle, I.F., Sala, C., Sirri, F., Astolfi, A., Castellani, G. and Manfreda, G. 2019. Effect of a low protein diet on chicken ceca microbiome and productive performances. *Poultry Science.* **98** (9) :3963-3976.

Deepak, N., Preetam, V.C., Rajkumar, U., Prakash, M.G. and Alexander, G. 2017. Evaluation of dietary energy and protein requirements of an improved backyard chicken variety (Rajasri) in its juvenile phase. *Indian Journal of Animal Nutrition.* **34** (2) : 208-213.

Dehury, P.K., Panda, N., Das, N., Mishra, S.C., Mishra, P.K. and Das, S.K. 2008. Evaluation of energy and protein requirement of broiler finisher in summer under hot humid condition. *Indian Journal of Poultry Science.* **43** (1) : 55-58.

Deo, C., Elangovan, A.V. and Mandal, A.B. 2014. Optimizing energy, protein and amino acid needs in diet of starting and growing

Kadaknath chicks. *Indian Journal of Poultry Science.* **49** (1) : 34-37.

Divya, V., Sankaralingam, S. and Anitha, P. 2023. Influence of varying levels of dietary protein and energy on growth performance of Gramasree cockerels at 12 weeks of age. *The Pharma Journal.* **12** (7S).

Eits, R.M., Kwakkel, R.P., Verstegen, M.W.A. and Emmans, G.C. 2003. Responses of broiler chickens to dietary protein: effects of early life protein nutrition on later responses. *British Poultry Science*. **44** (3) :398-409.

Elangovan, A.Y., Deo, C., Mandal, A.B., Singh, D.P. and Shrivastava, H.P. 2004. Protein requirements of growing (12–20 weeks) Naked neck x CARl-Red (Hitcari) and Frizzle x CARI-Red (Upcari) pullets. *Indian Journal of Poultry Science.* **39** (1) : 61-65.

Ferguson, N.S., Gates, R.S., Taraba, J.L., Cantor, A.H., Pescatore, A.J., Ford, M.J. and Burnham, D.J. 1998. The effect of dietary crude protein on growth, ammonia concentration, and litter composition in broilers. *Poultry Science*. **77** (10) : 1481-1487.

Fraps, G.S. 1943. Relation of the protein, fat, and energy of the ration to the composition of chickens. *Poultry Science*. **22** (6) : 421-424.

Geleta, T., & Leta, S. (2015). Effect of dietary energy and protein combination on egg production performance of Fayoumi chickens. *Basic Research Journal of Agricultural Science and Review*, **4** (3): 89-93.

Golian, A., Azghadi, A. and Pilevar, M. 2010. Influence of various levels of energy and protein on performance and humoral immune responses in broiler chicks. *Global Veterinaria*. **4** (5) : 434-440.

Gooch, P., Summers, J.D. and Moran Jr, E.T. 1971. Effect of varying nutrient concentrations on broiler performance using computer formulated rations. In Proc. Univ. Guelph Nutr. Conf. : 11-16.

Griffiths, L., Leeson, S. and Summers, J.D. 1977. Influence of energy system and level of various fat sources on performance and carcass composition of broilers. *Poultry Science*. **56** (3) :1018-1026.

Gulati, A. and Juneja, R. 2023. Poultry Revolution in India: Lessons for smallholder production systems (No. 225). ZEF Working Paper Series.

Gumpha, L. K., Babu, L. K., Kumar, A., Samal, P., and Panda, A. K. 2019. Effect of low protein diets on production performance, egg quality and serum biochemical indices of Vanaraja laying hens. *Animal Nutrition and Feed Technology*. **19** (3) : 349–359.

Gunawardana, P., Roland Sr, D.A. and Bryant, M.M. 2008. Effect of energy and protein on performance, egg components, egg solids, egg quality, and profits in molted Hy-Line W-36 hens. *Journal of Applied Poultry Research*. **17** (4) : 432-439.

Gupta, S. K., Behera, K., Pradhan, C. R., Acharya, A. P., Sethy, K., Behera, D., Lone, S. A., and Shinde, K. P. 2017. Influence of stocking density on the performance, carcass characteristics, hemato-biochemical indices of vanaraja chickens. *Indian Journal of Animal Research*. **51** (5) : 939–943.

Hassan, M. Abdel - Hafeez, Saleh, Elham S. E., Tawfeek, Samar S., Youssef, Ibrahim M. I. and Hemida, Manal B. M. 2016. Effects of high dietary energy, with high and normal protein levels, on broiler performance and production characteristics. *Journal of Veterinary Medical Research*. **23** (1): 94 -108.

Haunshi, S., Doley, S. and Shakuntala, I. 2009. Production performance of indigenous chicken of North Eastern region and improved varieties developed for backyard farming. *Indian Journal of Animal Sciences.* **79** (9): 901–905.

Haunshi, S., Panda, A.K., Padhi, M.K. and Bhanja, S.K. 2015. Effects of Varying Nutrient Densities on Production Performance of Aseel Layers. *Animal Nutrition and Feed Technology*. **15** (1) : 51-58.

Haunshi, S., Panda, A.K., Rajkumar, U., Padhi, M.K., Niranjan, M. and Chatterjee, R.N. 2012. Effect of feeding different levels of energy and protein on performance of Aseel breed of chicken during juvenile phase. *Tropical Animal Health and Production.* **44** (7) : 1653-1658.

Heijmans, J., Duijster, M., Gerrits, W.J.J., Kemp, B., Kwakkel, R.P. and van den Brand, H. 2021. Impact of growth curve and dietary energy-to-protein ratio on productive performance of broiler breeders. *Poultry Science*. **100** (7) : 101131.

Hill, F.W. and Dansky, L.M. 1954. Studies on the energy requirements of chickens. I. The effect of dietary energy level on growth and feed consumption. *Poultry Science.* **33** (1) : 112-119.

Hilliar, M. and Swick, R.A. 2019. Nutritional implications of feeding reduced-protein diets to meat chickens. *Animal Production Science*. **59** (11) : 2069-2081.

Holsheimer, J.P. and Veerkamp, C.H. 1992. Effect of dietary energy, protein, and lysine content on performance and yields of two strains of male broiler chicks. *Poultry Science*. **71** (5) : 872-879.

Hosseini-Vashan, S.J., Jafari-Sayadi, A.R., Golian, A., Motaghinia, G., Namvari, M., & Hamedi, M. (2010). Comparison of growth performance and carcass characteristics of broiler chickens fed diets with various energy and constant energy to protein ratio. *Journal of Animal and Veterinary Advances*, **9** (20): 2565-2570

Hussein, A.S., Cantor, A.H., Pescatore, A.J. and Johnson, T.H. 1996. Effect of dietary protein and energy levels on pullet development. *Poultry Science*. **75** (8) : 973-978.

Infante-Rodriguez, F., Salinas-Chavira, J., Montano-Gomez, M. F., Manriquez-Nunez, O. M., Gonzalez-Vizccara, V. M., Guevera-Florentino, O. F. and Ramirez De Leon., J. A. 2016. Effect of diets with different energy concentrations on growth performance, carcass characteristics and meat chemical composition of broiler chickens in dry tropics. *Springerplus*. **5** (1):1937.

Islam, R., Kalita, N. and Nath, P. 2014. Comparative performance of Vanaraja and Indigenous chicken under backyard system of rearing. *Journal of Poultry Science and Technology*. **2** (1) : 22-25.

ICAR-Directorate of Poultry Research. Vanaraja: meat and egg type coloured bird for rural poultry. http://www.pdonpoultry.org. Accessed on 3 May 2023.

Ivy, R.E. and Gleaves, E.W. 1976. Effect of egg production level, dietary protein and energy on feed consumption and nutrient requirements of laying hens. *Poultry Science*. **55** (6) : 2166-2171.

Izawa, S., Okada, M., Matsui, H. and Horita, Y. J. 1997. Quantitative determination of HDL cholesterol IVD. *Medicine and Pharmaceutical Science*. **37** : 1385 – 1388.

Jackson, S., Summers, J.D. and Leeson, S., 1982. Effect of dietary protein and energy on broiler carcass composition and efficiency of nutrient utilization. *Poultry Science*. **61** (11) : 2224-2231.

Jafarnejad, S. and Sadegh, M., 2011. The effects of different levels of dietary protein, energy and using. *Asian Journal of Poultry Science*, **5** (1) : 35-40.

Jalaluddin, A. 2014. Economic traits in poultry. i**n**: Avain (poultry) production a text book (eds. Sapcota, D., Narahari, D. and Mahanta, J. D.) New india Publishing Agency, New Delhi, pp 61-68.

Kamran, Z., Sarwar, M., Nisa, M., Nadeem, M.A., Ahmad, S., Mushtaq, T., Ahmad, T. and Shahzad, M.A., 2008. Effect of lowering dietary protein with constant energy to protein ratio on growth, body composition and nutrient utilization of broiler chicks. *Asian-Australasian Journal of Animal Sciences*, **21** (11) : 1629-1634.

Kashyap, D. and Goswami, K., 2024. The changing role of the poultry sector in the food and nutritional security of India. In Food Security in a Developing World: Status, Challenges, and Opportunities. Cham: *Springer Nature Switzerland*. **1 :** 153-171

Kato, H., Shimizuike, Y., Yasuda, K., Yoshimatsu, R., Yasuda, K.T., Imamura, Y. and Imai, R., 2022. Estimating production costs and retail prices in different poultry housing systems: conventional, enriched cage, aviary, and barn in Japan. *Poultry Science*. **101** (12) : 102194.

Keshavarz, K. and Nakajima, S., 1995. The effect of dietary manipulations of energy, protein, and fat during the growing and laying periods on early egg weight and egg components. *Poultry Science*. **74** (1) : 50-61.

Kim, J.H., 2014. Energy metabolism and protein utilization in chicken – A review. *Korean Journal of Poultry Science*. **41** (4) : 313-322.

Kumar, M., Dahiya, S. P and Ratwan, P. 2019. Backyard poultry farming in India: A tool for nutritional security and women empowerment. *Biological Rhythem Research.* **52** (10): 1476-1491.

Kumar, U.V., Kumar, R., Rao, S.V., Prince, L.L.L. and Chatterjee, R.N., 2021. Geographical distribution of Vanaraja chicken variety and its impact on poultry sector in India.*Indian Journal of Poultry Science.* **56**(3):261-266.

Kumaravel, V., Mohan, B., Natarajan, A., Murali, N., Selvaraj, P. and Vasanthakumar, P., 2023. Effect on growth performance, carcass traits, and myostatin gene expression in Aseel chicken fed varied levels of dietary protein in isocaloric energy diets. *Tropical Animal Health and Production,* **55** (2) : 82.

Kumari, A.V. and Rao, M.K. 2023. Production and economics of poultry farming in India and Andhra Pradesh. *Journal of Management and Entrepreneurship. **17*** (2):47-53.

Kumari, P., Chandramoni, Kumar, K. and Kumar, S. 2014. Effect of dietary supplement of sugar beet, neem leaf, linseed and coriander on growth performance and carcass trait of Vanaraja chicken. *Veterinary World*. **7** (9): 639–643.

Kumari, P., Chandramoni, Singh, P. K., Dey, A. and Sheetal, S. K. 2014. Effect of different dietary supplementation on nutrient balance and economics in vanaraja chicken. *Environment and Ecology*. **33** (3A): 1285-1288.

Leeson, S., Caston, L. and Summers, J.D., 1996. Broiler response to diet energy. *Poultry Science*. **75** (4) : 529-535.

Liu, S.Y., Selle, P.H., Raubenheimer, D., Gous, R.M., Chrystal, P.V., Cadogan, D.J., Simpson, S.J. and Cowieson, A.J., 2017. Growth performance, nutrient utilisation and carcass composition respond to dietary protein concentrations in broiler chickens but responses are modified by dietary lipid levels. *British Journal of Nutrition*. **118** (4) : 250-262.

Lotha, R. K. and Vidyarthi, V. K. 2020. Addition of aloe vera pulp dried powder in the diet on performance of vanaraja birds. *Livestock Research International*. **8** (4):186-192.

Mallick, P., Muduli, K., Biswal, J.N. and Pumwa, J., 2020. Broiler poultry feed cost optimization using linear programming technique. *Journal of Operations and Strategic Planning*. **3** (1) : 31-57.

Mandal, A.B., Elangovan, A.V. and Deo, C., 2016. Optimizing energy, protein and amino acid needs in diet of starting and growing Aseel chicks. *Indian Journal of Poultry Science*. **51** (1) : 24-28.

Marcu, A., Văcaru-opriş, I. and Marcu, A., 2009. The influence of feed protein and energy level on meat chemical composition from different anatomical regions at “Cobb 500” Hybrid. *Scientific Papers Animal Science and Biotechnologies*. **42** (2) : 147-147.

Marcu, A., Vacaru-Opriș, I., Dumitrescu, G., Marcu, A., Petculescu, C.L., Nicula, M., Dronca, D. and Kelciov, B., 2013. Effect of diets with different energy and protein levels on breast muscle characteristics of broiler chickens. *Animal Science of Biotechnology*. **46** (1) : 1-7.

Marcu, A., Vacaru-Opriș, I., Marcu, A., Nicula, M., Dronca, D., Dumitrescu, G. and Kelciov, B., 2011. The influence of feed protein and energy level on meat chemical composition at Arbor Acres hybrid. *Luc. Şt., Seria Zootehnie, USAMV Iaşi*. **55** (16) : 458-463.

Marcu, A.D.E.L.A., Vacaru-Opriș, I., Marcu, A., Nichita, I.L.E.A.N.A., Nicula, M.A.R.I.A., Dronca, D. and Kelciov, B., 2011. Influence of energy and protein level of the feed on carcass characteristics and meat quality at hybrids "Ross 308" and "Arbor Acres". **44 (1)** : 151-157.

Maynard, C.J., Maynard, C.W., Jackson, A.R., Kidd, M.T., Rochell, S.J. and Owens, C.M., 2023. Characterization of growth patterns and carcass characteristics of male and female broilers from four commercial strains fed high or low density diets. *Poultry Science*. **102** (3) : 102435.

Melesse, A., Dotamo, E., Banerjee, S., Berihun, K. and Beyan, M., 2013. Studies on carcass traits, nutrient retention and utilization of Koekoeck chickens fed diets containing different protein levels with Iso-Caloric ration. *Journal of Animal Science Advanced*. **3** (10) : 532-543.

Mehala, C. and Moorthy, M., 2008. Production performance of broilers fed with Aloe vera and Curcuma longa (Turmeric). *Int. J. Poult. Sci*, **7** (9), pp.852-856.

Miah, M.Y., Chowdhury, S.D. and Bhuiyan, A.K., 2016. Effects of varying levels of dietary protein and energy on growth performance and carcass yield of indigenous chicks in Bangladesh. *Indian Journal of Animal Nutrition*. **33** (3) : 305-313.

Mishra, S.K., 2005. Comparative evaluation of black rock birds intensive and extensive system of rearing. *Indian Journal of. Poultry. Science.* **40** (3) : 288-290.

Mraz, F.R., Boucher, R.V. and McCartney, M.G. 1958. The influence of dietary energy and protein on growth response in chickens. *Poultry Science*. **37** (6) : 1308-1313.

Nahashon, S.N., Adefope, N., Amenyenu, A. and Wright, D., 2005. Effects of dietary metabolizable energy and crude protein concentrations on growth performance and carcass characteristics of French guinea broilers. *Poultry Science*. **84** (2) : 337-344.

Nawaz, H., Mushtaq, T. and Yaqoob, M., 2006. Effect of varying levels of energy and protein on live performance and carcass characteristics of broiler chicks. *The Journal of Poultry Science*. **43** (4) : 388-393.

Neto, M.G., Pesti, G.M. and Bakalli, R.I., 2000. Influence of dietary protein level on the broiler chicken's response to methionine and betaine supplements. *Poultry Science*. **79** (10) : 1478-1484.

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

Van Nguyen, T. and Bunchasak, C., 2005. Effects of dietary protein and energy on growth performance and carcass characteristics of Betong chicken at early growth stage. *Growth*, *27*(6), p.1172.

Niranjan, M., Sharma, R.P., Rajkumar, U., Chatterjee, R.N., Reddy, B.L. and Bhattacharya, T.K., 2008b. *International Journal of. Poultry. Science.* **7** : 1128.

Ojewola, G.S. and Longe, O.G., 1999. Protein and energy in broiler starter diets: effects on growth performance and nutrient utilization. *Nigerian Journal of Animal Production.* **26**: 23-28

Panda, A.K., Rama Rao, S.V., Raju, M.V.L. N. and Shyam Sunder, G. 2011. Response of Vanaraja breeder (male line) chicks to dietary concentrations of lysine and methionine. *Animal Nutrition and Feed Technology.* 11: 1-8.

Panda, A.K., Sahoo, B. and Kumar, A., 2020. Effect of low nutrient density diets on performance of vanaraja laying hens in intensive system of production. *Indian Journal of Animal Nutrition*, **37** (4) : 335-339.

Panigrahy, K. K., Behera, K., Mohapatra, M. L., Acharya, P. A., Sethy, K., Panda, S. and Gupta, K. S. 2017. Sex-related differences in hemato-biochemical indices of adult Vanaraja chickens during summer and winter seasons. *Veterinary World.* **10** (2): 176–180.

Perween, S., Kumar, K., Kumar, S., Singh, P.K. and Kumar, A., 2017. Influence of Different Levels of Energy and Protein in the Diet on Performance, Haemato-biochemical Indices and Carcass Characteristics in Vanaraja Chicken. *Indian Journal of Animal Nutrition*. **34**(3):316-322.

Perween, S., Kumar, K., Kumar, S., Singh, P.K., Kumar, M. and Dey, A., 2016. Effect of feeding different dietary levels of energy and protein on growth performance and immune status of Vanaraja chicken in the tropic. *Veterinary world*. **9** (8) : 893.

Perween, S., Kumar, K., Sanjay, K., Chandramoni, Singh, P. K and Kumar, A. 2017. Influence of Different Levels of Energy and Protein in the Diet on Performance, Haemato-biochemical Indices and Carcass Characteristics in Vanaraja Chicken. *Indian Journal of Animal Nutrition.* **34** (3):316 **-** 322.

Rabie, M.H., Sherif, Kh. El., Abd El-Khalek, A. M. and El-Gamal, A. A. A. 2017. Effect of Dietary Energy and Protein on Growth Performance and Carcass Traits of Mamourah Cockerels. *Asian Journal of Veterinary and Animal Sciences*. **12** (3): 142-151.

Rajwesra, H.N., Naikand, J. and Nagaraja, C.S., 2017. Effect of Varied Levels of Dietary Crude Protein and Metabolizable Energy on Growth Performance in Giriraja Chicken. *Indian Journal of Veterinary Sciences & Biotechnology*. **12** (4) : 75-78.

Rama Rao, S.V., Panda, A.K., Raju, M.V.L.N., Poonam, N.S., 2007. Effect of dietary methionine concentration on performance of Vanaraja chicks. *Animal Nutrition and Feed Technology.* **7** : 241-246.

Rama Rao, S.V., Panda, A.K., Raju, M.V.L.N., Sharma, S.R., Shyam Sunder, G. and Sharma, R.P., 2006. Performance of Vanaraja chicks fed diets containing different levels of protein. *Indian Journal of Animal Nutrition*. **23** (2) : 83-87.

Rama Rao, S.V., Ravindran, V., Raju, M.V.L.N., Srilatha, T. and Panda, A.K., 2014. Effect of different concentrations of metabolisable energy and protein on performance of White Leghorn layers in a tropical climate. *British poultry science*. **55** (4) : 532-539.

Rao, Ch. V. S. Chandra Sekhara, Rao, G. Narasimha, Sharma, R. P. and Reddy, B. L. N. 2004. Genetic study on juvenile traits of vanaraja chickens. *The Indian Journal of Animal Sciences*.**74** (12): 1229 – 1231.

Rao, S.V., Panda, A.K., Raju, M.V.L.N., Sunder, G.S., Bhanja, S.K. and Sharma, R.P., 2005. Performance of Vanaraja chicken on diets containing different concentrations of metabolizable energy at constant ratio with other essential nutrients during juvenile phase. *Indian Journal of Poultry Science*. **40** (3) : 245-248.

Richmond, W. 1973. Qualitative determination of cholesterol in serum or plasma by enzymatic method. *Clinical Chemistry*. **19** (12) : pp 1350.

Sadegh, M and Jafarnejad, S. 2011. The Effects of Different Levels of Dietary Protein, Energy and Using Fat on the Performance of Broiler Chicks at the end of the Third Weeks. *Asian Journal of Poultry Science.* **5***:*35-40.

Salih, R., Tesfaye, E., Tamir, B. and Singh, H., 2016. Effects of feed restriction on production performance and carcass characteristics of Koekoek chickens in Ethiopia. *Poultry Science Journal*. **4** (1) : 55-61.

Shiblee, A.S., 2018. Effects of supplementing different levels of meat and bone meal on productive performance, carcass characteristics and hematobiochemical parameters in broiler (Doctoral dissertation, A thesis submitted in partial of the requirements for the fulfillment of the degree of Master of Science in Animal and Poultry Nutrition Department of Animal Science and Nutrition Faculty of Veterinary Medicine Chittagong Veterinary and Animal Sciences University, Khulshi, Chittagong, Bangladesh).

Snedecor, G. W. and Cochran, W. G. 1998. Statistical Methods. 6th Edition Oxford and IBH Publishing Company, Kolkata, India.

Sterling, K.G., Pesti, G.M. and Bakalli, R.I., 2006. Performance of different broiler genotypes fed diets with varying levels of dietary crude protein and lysine. *Poultry Science*. **85**(6):1045-1054.

Sugandi, D., Bird, H.R. and Atmadilaga, D., 1975. The effect of different energy and protein levels on the performance of laying hens in floor pens and cages in the tropics. *Poultry Science*. **54**(4), pp.1107-1114.

Summers, J.D., Slinger, S.J., Sibbald, I.R. and Pepper, W.F., 1964. Influence of protein and energy and growth and protein utilization in the growing chicken. *The Journal of Nutrition*. **82** (4) : 463-468.

Summers, J.D., Spratt, D. and Atkinson, J.L., 1992. Broiler weight gain and carcass composition when fed diets varying in amino acid balance, dietary energy, and protein level. *Poultry Science*. **71** (2) : 263-273.

Sunde, M.L., 1956. A relationship between protein level and energy level in chick rations. *Poultry Science*. **35** (2) : 350-354.

Swain, B.K., Korikanthimath, V.S. and Chakurkar, E.B., 2008, March. Backyard poultry (Vanaraja) farming in coastal ecosystem of Goa. In Seminar on Sustainable poultry production: rural and commercial approach. March 3, 2008, Project Directorate on Poultry (PDP), Rajendranagar, Hyderabad, India.52-55.

Tikate, K., Wade, M., Ranade, A.S., Patodkar, V.R., Dhaygude, V.S. and Bhalerao, S.M., 2021. Influence of dietary multiple phase feeding on growth performance of commercial broiler chicken. *Indian Journal of Animal Research*. **55** (1) : 66-70.

Toppo, S., Mandal, A.B. and Elangovan, A.V., 2004. Dietary energy and protein requirements of egg type (CARI Sonali) starting chicks. *Animal Nutrition and Feed Technology*. **4** (1) : 17-22.

Torne, D.J., Bade, R.N. and Deshmukh, S.V., 2016. Optimization of dietary protein level through amino acids balancing on performance and economics of commercial broiler chicken production. *Indian Journal of Animal Nutrition*. **33** (4) : 471-474.

Temim, S., Chagneau, A.M., Guillaumin, S., Michel, J., Peresson, R. and Tesseraud, S., 2000. Does excess dietary protein improve growth performance and carcass characteristics in heat-exposed chickens?. *Poultry Science, 79*(3), pp.312-317.

Van Emous, R.A., Kwakkel, R.P., Van Krimpen, M.M. and Hendriks, W.H., 2015. Effects of dietary protein levels during rearing and dietary energy levels during lay on body composition and reproduction in broiler breeder females. *Poultry Science*. **94** (5) : 1030-1042.

Varadharajan, K., Mohan, B., Natarajan, A., Murali, N., Selvaraj, P. and Vasanthakumar, P., 2022. Effect on Growth Performance, Carcass Traits and Myostatin Gene Expression in Aseel Chicken Fed Varied Levels of Dietary Protein in Isocaloric Energy Diets.

Van Nguyen, T. and Bunchasak, C., 2005. Effects of dietary protein and energy on growth performance and carcass characteristics of Betong chicken at early growth stage. *Growth*. **27** (6) : 1172.

Vetrivel, S.C. and Chandrakumarmangalam, S. 2013. The role of poultry industry in Indian economy. *Brazilian Journal of Poultry Science*. **15** : 287-293.

Waldroup, P.W., Jiang, Q. and Fritts, C.A., 2005. Effects of supplementing broiler diets low in crude protein with essential and nonessential amino acids. *International. Journal of. Poultry. Science.* **4** (6) : 425-431.

Wieland, H. and Seidel, D. 1983. A simple specific method for precipitation of low density lipoproteins. *Journal of Lipid Research*. **24** (7) : 904 – 909.

Yunana, Y. L., Kabir, M. and Mallam, I. 2019. Effect of varying levels of energy and protein on performance of Ross breeds broiler chickens. *Nigerian Journal of Animal Science.* **21** (2): 253-259.