Ph.D. DRUSILLA JISHING RENGMA 2024 LPM 2024

INCLUSION OF LINSEED (*Linum usitatissimum)* MEAL ON THE PERFORMANCE OF VANARAJA BIRDS

Thesis

submitted to

NAGALAND UNIVERSITY

in partial fulfillment of requirements for the Degree

of

Doctor of Philosophy

in

Livestock Production and Management

by

DRUSILLA JISHING RENGMA

Admn. No. Ph – 245/18 Regn. No. Ph.D/LPM/00234

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School of Agricultural Sciences,
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DECLARATION

I, **Drusilla Jishing Rengma**, hereby declare that the subject matter of this thesis is the record of work done by me, that the contents of this thesis did not form the basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and that the thesis had not been submitted by me for any research degree in any other university/institute.

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

Date:
Place: SAS, Medziphema Campus, NU

DRUSILLA JISHING RENGMA

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Supervisor

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CERTIFICATE – I

This is to certify that the thesis entitled **"INCLUSION OF LINSEED (*Linum usitatissimum)* MEAL ON THE PERFORMANCE OF VANARAJA BIRDS"**submitted to Nagaland University in partial fulfillment of the requirements for the award of degree of Doctor of Philosophy (Agriculture) in **Livestock Production and Management** is the record of research work carried out by Ms. **Drusilla Jishing Rengma** Registration No. **Ph.D/LPM/00234** under my personal supervision and guidance.

The results 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 **“Inclusion of Linseed (Linum usitatissium) Meal on the Performance of Vanaraja Birds”** submitted by **Ms. Drusilla Jishing Rengma** Admission No. Ph-245/18 Registration No. **Ph.D/LPM/00234** 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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1. Dr. Razouneinuo Zuyie (Supervisor & Chairman)	…………………………..
2. Prof. K. Sarjan Rao (External examiner)	…………………………..
3. Pro Vice-Chancellor Nominee (Dean, SAS)	……………………………
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Date:

Place: SAS, Medziphema Campus, NU **Drusilla JishingRengma**

ABSTRACT

The present study entitled **"Inclusion of Linseed (*Linum isitatissimum*) on the Performance of Vanaraja Birds"** was carried out with the objective to study the productive and reproductive performance, blood constituents and economics of rearing Vanaraja birds as influenced by dietary inclusion of linseed meal. The study was conducted at the poultry unit of the department. A total of 120 numbers of female Vanaraja chicks were reared for a period of nine months which were randomly divided into four treatment groups T_1, T_2 T_3 and T_4 of 30 birds each having five replications per treatment following Randomized Block Design and were subjected to four dietary levels of linseed meal containing 0 per cent, 4 per cent, 8 per cent and 12 per cent, respectively. The birds were reared under deep litter system up to 8 weeks of age and thereafter in cages following standard management practices. They were fed with starter ration from 0-8 weeks, grower ration from 8-20 weeks and layer ration after 20 weeks. Initial body weight was recorded at day old and thereafter it was recorded fortnightly. While feed intake and egg production was recorded daily. At 4^{th} and 9^{th} month, blood was collected for evaluation of blood constituents. Linseed meal had significant effect on the overall mean body weight, gain in weight, feed intake and feed conversion efficiency. The overall mean body weight (1870.50 g/bird) was found to be significantly ($P<0.05$) higher in T_1 followed by T_2, T_4 and least in T_3 (1778.10 g/bird). Similarly, gain in body weight was found to be significantly higher in T_1 (144.2g) followed by T_2, T_4 and least in T_3 (139.3g) while feed intake was significantly ($p<0.05$) lower at (T_2) 4 per cent linseed meal as compared to control group. Best mean Feed Conversion Ratio of 9.2 was observed in T_2. Mortality was nil in groups fed with linseed meal. Best performance index was observed in T_2 (11.1) as compared to the control (8.8). Lower body weight and egg weight at onset of production was observed in linseed fed groups. Control group had higher egg production, clutch size and egg weight. Higher yolk weight, albumen weight and yolk cholesterol was recorded in T_3 while group T_4 had the maximum HU. Least cholesterol and triglycerides was recorded T_4 while the highest HDL and lowest LDL was observed in control group. Cost of production was higher in T_4 and lower in T_2 while higher net profit per bird and net profit per gain was recorded in T_3 as compared to the control group.

On the basis of the above findings, it may be concluded that groups fed with linseed meal performed better in terms of egg quality traits, blood constituents and net return. Considering the economy of production and blood constituents, use of linseed meal up to 8 per cent may be advocated to increase production and enhance quality for maximum net return.

Key words: Vanaraja birds, body weight, linseed meal, blood constituents, net profit.

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LIST OF ABBREVIATION

ABBREVIATIONS	FULL FORM
@	at the rate of
%	Per cent
ALA	Alpha-linolenic acid
ANOVA	Analysis of variance
ad libitum	Freely; as much as
BIS	Bureau of Indian Standards
BW	Body weight
BWG	Body weight gain
df	Degree of freedom
FCE	Feed Conversion Efficiency
FCR	Feed conversion ratio
Fig	Figure
g	gram
g/dl	gram per deciliter
LDL	Low Density Lipo Protein
LO	Linseed oil
HDL	High Density Lipo protein
HU	Haugh Unit

ICAR	Indian Council of Agricultural Research
i.e.	that is
INR	Indian Rupee
IMARC	International Market Analysis Research and Consulting Group
Kg	kilogram
mg/dl	milligram per deciliter
NCCLS	National Committee for Clinical Laboratory Standard
NEH	North Eastern Hill
ml	milliliter
mm	Millimeter
MSS	Mean Sum of Square
PFAs	Phytogenic Feed Additives
PI	Performance Index
SDG	Seceisolariciresiroldiglucoside
SEM	Standard Error of Mean
SO	Soya bean oil
SOV	Sources of Variance
SS	Sum of Square
VLDL	Very low density Lipo protein

CHAPTER-1

INTRODUCTION

INTRODUCTION

Poultry holds a very important place both in urban and rural sector in terms of nutrition, livelihood, and job creation and as an industry. Poultry meat and eggs and meat are highly nutritious as they are rich in protein, minerals and vitamins. Besides, it also provides valuable manure for food production. Moreover, since poultry products are free from religious prejudices, it constitutes the most popular non-vegetarian food for majority of the population in India. Since chicken eggs and meat are affordable, readily available even in rural areas and nutritious, it helps to fight malnutrition and provides nutritional security to the rural masses. Besides, poultry provides a major avenue for income generation activity and employment for farmers, entrepreneurs and unemployed youths.

Recently, there has been a surge in production and demand for functional food that are distinct with respect to safety, health benefits, freshness, taste, colour and the like. Further, there is also a growing concern for coronary heart diseases and other life threatening diseases due to the consumption of food containing high cholesterol and saturated fatty acids. In view of this, experts have recommended daily consumption of diet which is rich in n-3 polyunsaturated fats, low in trans-fatty acids, saturated fatty acid and cholesterol.

Through nutritional intervention substances that are beneficial to health are added while components that are detrimental are either removed or reduced in order to produce functional food. As a result designing the nutritional profile of poultry eggs and meat through dietary approaches is a reasonably simple and affordable way to improve consumers' health and nutritional condition. Eggs can be created by dietary methods, such as the addition of particular nutrients, herbs, or medications with specialized medicinal and functional qualities.

Lipids or fats are important factors which determined the growth of birds. It is known that the source of fat in diet particularly in monogastric species such as poultry, determines the fatty acid profile of the meat and fat. The fatty acid composition in meat, quantity and quality of lipids are determined by several internal (age, gender, genotype and castration) and external (feeding) factors (Masek *et al*., 2013). Nutritional diets of birds influence meat qualities in terms of nutritive value, acceptability, human health and processing (Sahoo and Jena, 2014). Basic components of eggs like water, protein and carbohydrates and major minerals cannot be altered. However, it is well known that the composition of their lipids, vitamins and trace elements can be altered to some extent through their diet Wang *et al*. (2010) have also advocated successful enrichment of minor egg composition through nutritional intervention. Avian eggs are also capable of accumulating several nutrients and non nutrient like pigments, herbal active principles, flavouring compounds, antioxidant, immunomodulators and other components present in the feed.

In tropical and subtropical region, linseed (*Linum usitatissimum*), often known as flaxseed, is widely cultivated. With evidence of cultivation going back to thousands of years, it is one of the oldest crops in the world (Newkirk, 2015). According to the Food and Agriculture Organisation of the United Nations Statistics Division (2015), Canada produces 712,000 metric tonnes of linseed annually, making it the world's top producer at the moment. Linseed is largely grown for its fibre, seed, and oil and by- products. Due to its high energy level, linseed has historically been used for both human and animal consumption, particularly during the winter. Linseed oil is mostly utilized in the manufacturing of paint and other industrial products. Linseed as rich source of alpha-linolenic acid, high quality protein, soluble fiber and phenolic compounds had been reported by several researchers (Martinchik *et al*., 2012; Kajla *et al*., 2015 and Soni *et al.,* 2016). Dietary supplementation of flax seed had revealed potential health benefits in conditions related with heart, terminal diseases and other metabolic diseases (Katare *et al*., 2012 and Soni *et al.,* 2016). Use of linseed contributes to healthy feathers or a lustrous coat as well as increased joint mobility. Besides, the by-products of linseed (cake and meal) is used as a source of protein and energy (Ahmad *et al*., 2012) in animal ration. Researchers such as (Pisal, 2019) and had reported better performance and higher net return due to the inclusion of flax seed in poultry diet. Linseed had been successfully used in poultry feed to improve their growth performance, positive change in the blood constituents and fatty acid profiles of the eggs (Ahmad *et al*., 2017; Promila, 2017; Adangale, 2018; Pisal, 2019 and Tamasgen *et al*.,2021). Besides, replacing the conventional energy and protein sources, use of linseed in poultry diet can enrich the end product and also increase profitability. Moreover, considering the nutritional value and the positive effects of flaxseed, use of this oil seed can be popularized for the benefit of the local poultry growers in the state. This will also help the farmers to produce quality eggs and meat and satisfy consumers demand.

Despite its benefits, linseed can also cause negative impact on the performance of the birds as it contains several anti-nutritional factors such as trypsin inhibitors, phytates, mucilages, cyanogenic glycosides and including water soluble non-starch glycans. Hence, it is important to consider the form and the safe level of inclusion when added in the diet.

Small scale poultry farming by local farmers, SHGs, youths, housewives and even employed people is gaining popularity in the region with more preference for improved birds. One such strain of bird is Vanaraja which has the resemblance of the native birds and are able to thrive well even in free range. It has become a choice bird for meeting the domestic need and for livelihood activities. Vanaraja is a dual-purpose, multi-coloured synthetic bird which was developed by the Project Directorate of Poultry, Hyderabad (ICAR) and has gained more significance in rural areas due to its higher adaptability and productivity.

Given the positive effects of linseed, a thorough and systematic investigation using different levels of linseed meal in poultry diet will help to generate useful data regarding the performance of the birds and also establish the optimum levels of inclusion for onward recommendation. Changes in productive and reproductive traits and blood constituents are important parameters in assessing the response and performance of the birds. Hence, the present study entitled "Inclusion of linseed (*Linum usitatissimum)* meal on the performance of Vanaraja birds" was carried out to examine the influence of different levels of linseed meal on the economic traits of Vanaraja birds with the following objectives:

1. To study the productive and reproductive performance of Vanaraja birds fed with linseed meal.
2. To determine the economics of production of Vanaraja birds feed with linseed meal.
3. To study the biochemical constituents of blood and egg of Vanaraja birds fed with linseed meal.

CHAPTER - 2

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Linseed is a potential nutritional food because of its exceptionally high content of bioactive compounds such as alpha-linolenic acid (ALA), dietary fiber and high quality protein. It is also an excellent source of fiber, lecithin, vitamins and minerals. Dietary supplementation of linseed in poultry had shown positive benefits on the productive and reproductive performance and blood constituents of the poultry birds. Several studies have been carried out using this oilseed to explore the possibility of replacing the conventional feed stuff to reduce feed cost, improve performance, enhance the quality of the product and maximize profit. Relevant literatures on supplementation of linseed in poultry diet by different researchers were thoroughly reviewed and are presented below under different sub-heads.

2.1 Linseed and its Chemical Composition

Linseed contains 40 per cent oil, 30 per cent diet and fiber, 20 per cent protein, 4 per cent ash and 6 per cent moisture (Wang *et al.,* 2008).

The oil content and fatty acid composition in different cultivars of linseed was assessed by Bayrak *et al.* (2010). They observed that the oil content ranged from 23.28 to 40.36 per cent while saturated and unsaturated fatty acids was found to be 10.02 per cent and 89.91 per cent of the total oil, respectively.

Flax being a good source of alpha-linolenic acid, lignans, high quality protein, soluble fiber and phenolic compounds continues to grow in its recognition as a potential functional food (Pradhan *et al*.,2010; Katoch and Singh, 2021)

Dietary supplementation of flax seed had revealed potential health benefits in conditions like cardiovascular disease, certain types of cancers and other metabolic disorders (Katare*et al*., 2012).

Martinchik *et al*. (2012) reported that three compounds viz; PUFA omega-3 family, dietary fibers and phytoestrogen lignans determine the hypolipidemic and antiatherogenic actions of flaxseed. They observed that flaxseeds contains 20-30 per cent protein and 35-45 per cent oil of which 9-10 per cent constitutes saturated fatty acids (palmitic and stearic), about 20 per cent monounsaturated fatty acids (mainly oleic acid) and more than 70 per cent alpha-linolenic fatty acids.

As per Popa *et al*. 2012, linseed oil was found to contain high levels of linolenic (53.21 per cent) followed by oleic (18.51 per cent) and linoleic (17.25 per cent) while palmitic (6.58 per cent) and stearic (4.43 per cent) were found to be the dominant saturated fatty acids.

Flax (*Linum usitassimum*) also known as linseed is a blue flowering annual herb which belongs to Lineaceae family. It produces small flat oil seeds of golden yellow to reddish brown color which has emerged as a potential nutritional food because of its exceptionally high content of alpha-linolenic acid (ALA), dietary fiber, high quality protein and phytoestrogens (Kajla *et al*., 2015).

Soni *et al*. (2016) stated that flaxseed is widely cultivated in the world for several purposes such as fiber, oil medicinal and nutritional product. They reported that it contains good amount of á-Linolenic Acid (ALA), omega-3 fatty acid, protein, dietary fiber, lignan specifically Secoisolariciresinoldiglucoside (SDG). In agreement with other researchers, they have also advocated that flaxseed added food products can have good consumer acceptability besides its nutritional benefits stating that ALA is considered to be beneficial for infant brain development, reducing blood lipids and cardiovascular diseases.

Ahmad *et al*. (2017) mentioned that linseed is one of the richest vegetable sources of omega-3 (PUFA) which has been successfully used in poultry feed to fortify chicken eggs with omega-3 PUFA.

As per Pirmohammadi *et al*. (2019) linseed can exert negative impact on growth performance due to its lower digestibility and higher viscosity of jejuna digesta. They further stated that it contains several anti-nutritional factors, such as mucilage from hulls, linatine, cyanogenic glycosides, trypsin inhibitors, phytic acid and water-soluble non-starch polysaccharides.

The amino acid pattern of flax protein is similar to that of soybean protein Raghuwanshi *et al*. (2019)

2.2 Effect of linseed meal of poultry birds on the productive and reproductive traits

2.2.1 Body weight and growth rate

Parmentier *et al*. (1997) observed that linseed meal supplementation adversely affected body weight gain in pullets, specifically a line of White Leghorn pullets.

Gonzalez-Esquerra *et al.* (2000) observed that hens consuming either 10 or 20 per cent linseed experienced a depression in body weight and weight gain.

Pietras *et al.* (2000) reported that including 60 or 150 g/kg linseed into broiler diets had no negative effect on body weight gain.

Newman *et al.* (2002) reported no adverse effects on weight gain of broilers when fed with 8 per cent levels of fish oil, sunflower oil and tallow.

Shen *et al.* (2005) observed lower body weight gain in the birds fed with linseed supplemented diet as compared to canola or extruded full fat soybean based diets.

Pekel *et al*. (2009) reported lower body weight of birds fed with linseed diets with copper supplementation.

Arshami*et al.* (2010) reported that there was decrease in body weight gain in pullets which were subjected to diet containing 10 per cent linseed as compared to control group.

Al Daraji*et al.* (2011) reported that dietary supplementation with 3 per cent fish oil and linseed oil resulted in significant improvement in body weight of quail.

Mridula *et al.* (2011) reported that the body weight declined progressively with the increase in the level of flaxseed supplementation from 5 to 15 per cent.

As per Rahimi *et al.* (2011), there was decrease in body weight gain when broilers were fed with linseed (7.5–15 per cent).

Lopes *et al*. (2013) reported that with partial or total substitution of soya bean oil (S0) with linseed oil (LO) showed no significant differences in body weight and body weight gain.

As per Duarte *et al.* (2014), quardratic improvement in body weight gain was seen when different levels of linseed oil was included in iso-energy diets in broiler chicken.

Kumari *et al.* (2014) reported that body weight and weight gain was seen higher in the treatment groups than the control group.

Starcevic *et al.* (2014) observed comparable body weight gain in broiler chicken due to supplementation of linseed oil at a rate of 5 per cent in the diet.

Ayed *et al.* (2015) reported that inclusion of soybean oil and palm oil in broiler ration did not have any adverse effects on body weight.

Mridula *et al.* (2015) observed that birds fed on 10 per cent linseed showed a reduction of 10.08 per cent in body weight as compared to the control group.

Panda *et al.* (2015) concluded that dietary replacement of sun flower oil (2 per cent in starter and 3 per cent in finisher diets) with linseed oil at levels 33, 67 and 100 per cent did not show any adverse effect on body weight gain.

Mangesh (2017) observed maximum body weight in groups fed with 4 per cent linseed powder supplementation.

Promila *et al.* (2017) reported that body weight gain of laying hens increased linearly with the increase in the dietary supplementation of linseed oil.

Shunthwal*et al.* (2017) reported that there was no significant difference in body weight and body weight gain of birds when fed with different levels of linseed oil.

Adangale (2018) recorded that broilers fed with linseed showed significantly higher body weight gain in control group in comparison to the treatment groups.

Chiroque *et al.* (2018) observed significant (p<0.05) increase in the final live weight and improved feed:gain ratio in guinea fowls as a result of feeding linseed and pumpkin seed meals. They also stated that use of these oilseeds can replace conventional energy and protein sources in diets and increase profitability.

Pisal (2019) reported that the birds fed with 3 per cent linseed oil showed higher body weight and weight gain as compared to the control group.

Gosh (2020) reported that there was no significant difference in body weight gain when white leghorn laying chickens were fed with linseed oil supplemented diet.

There was decrease in body weight as a result of feeding flaxseed with chromium supplementation (Mir *et al.,* 2021).

In a study conducted by Tamasgen *et al.* (2021) replacing 0, 25, 50, 75 and 100 per cent soybean meal with linseed meal, the difference in final body weight, change in weight and weight gain was found to be significantly lower at 100 per cent level between 1-22 days as compared to the control. However at 1-44 days, irrespective of the groups, these parameters were found to be uniform.

Rathur *et al*. (2022) observed significant ($p<0.05$) effect of linseed on the body weight gain of broiler chicken and the weight gain was found to be higher in birds fed with 0 per cent linseed followed by those which were fed with linseed at the rate of 2.5, 5, 7.5 and 10 per cent.

2.2.2 Feed intake and feed conversion efficiency

Balevi and Coskun (2000) reported that feeding broiler with different fat sources (corn oil, linseed oil and tallow) significantly affected the feed conversion ratio.

Schumann *et al.* (2000) reported that there was no change in feed intake in laying hens up to 4 per cent of linseed oil dietary supplementation.

Crespo and Esteve-Gracia (2001) reported that addition of linseed oil at the rate of 5 or 10 per cent in the diet reduced the feed intake in broiler chickens however, feed efficiency was observed to be significantly better in birds subjected to 10 per cent of linseed oil.

Grobas *et al.* (2001) reported decrease in feed intake with improved feed efficiency when hen's were fed 5 or 10 per cent of linseed oil.

Lopez-Ferrer *et al.* (2001) observed that birds fed with linseed oil diets had higher feed intake than the control group but had no improvement in feed efficiency.

Novak and Scheideler (2001) reported that increase feed intake in hens when linseed was added in their diets.

Raes *et al.* (2002) reported reduced in feed intake but with improved feed efficiency in hens when kept on diets with linseed oil fortification.

Sari *et al.* (2002) reported lower feed consumption in the experimental bird groups receiving feed with 5, 10 and 15 per cent common flax seed.

Bean and Leeson (2003) reported that feed intake was reduced when hens were fed with 10 per cent flax seed.

Ansari *et al.* (2006) reported increase in feed conversion ratio due to linseed supplementation at the rate of 15 per cent.

Augustyn *et al.* (2006) observed that inclusion of linseed oil in experimental diets of the birds decreased feed intake up to 14 per cent with an improved feed efficiency.

Celebi and Utlu (2006) reported that the feed intake of the hens receiving diets supplemented with 4 per cent linseed oil was lower than the hens in the control group with no change in feed efficiency.

Zelenka *et al.* (2006) observed better feed intake and feed conversion ratio in broiler chicks receiving 5 and 7 per cent of linseed oil as compared with those receiving 1 and 3 per cent.

Haug *et al.* (2007) reported that rapeseed oil or rapeseed oil plus linseed oil did not influence feed intake or feed conversation ratio in broilers.

Febal *et al.* (2008) reported that supplementation of linseed oil at the level of 3 per cent in the diet did not produce any visible effect on feed intake of broiler birds.

Hayat *et al.* (2009) reported a reduction in feed intake as a result of linseed feeding.

Najib *et al.* (2010) reported that feed consumption of birds fed with flaxseed increased significantly then the control group however the feed conversion ratio did not show any significant difference.

Wang *et al.* (2010) reported poorer feed conversion efficiency in comparison to the control as a result of feeding whole linseed at the rate of 15 per cent.

Kirubakaran *et al.* (2011) reported that there was decrease in feed intake in birds fed with linseed based diet.

Rahimi *et al.* (2011) reported that control group showed better performance in FCR than those fed with linseed (7.5–15 per cent).

Ahmad *et al.* (2013) reported that the increase in the levels (5, 10, and 15 per cent) of linseed in diet showed decrease in feed intake.

Al-Zuhairy and Alasadi (2013) reported significant improvement in feed conversion ratio in groups fed with linseed based diet as compared to the control group.

Lopes *et al*. (2013) reported that with partial or total substitution of soya bean oil with linseed oil showed no significant differences in feed intake and feed to gain ratio of the broiler birds.

Poorghasemi *et al.* (2013) did not observe any significant effect on feed conversion ratio of broiler chicks due to dietary replacement of sunflower oil or mustard oil.

Duarte *et al.* (2014) observed that effect of inclusion of different levels of linseed oil in iso-energy diets on broiler chicken showed quadratic improvement in feed intake and feed conversion ratio.

Starcevic *et al.* (2014) observed comparable feed intake and feed efficiency reported in broiler chicken supplemented with 5 per cent of linseed oil or sunflower oil.

Panda *et al.* (2015) reported that dietary replacement of sunflower oil with linseed oil did not show any adverse effect on feed intake and feed conversion ratio.

Promila (2016) reported that adding of 3, 3,5, and 4% linseed oil to the meal caused layers to consume much less feed. However, adding 2.5 and 4 per cent linseed oil greatly increased the feed conversion ratio.

Mangesh (2017) reported that supplementation of linseed powder to Giriraja birds had significant effect on feed intake and feed conversion ratio.

Promila *et al.* (2017) reported that the hens fed with 5 or 10 per cent linseed oil showed a decrease in feed intake.

Shunthwal *et al.* (2017) revealed that feed intake and FCR did not differ significantly between different dietary treatments when linseed oil was added in the broiler chicken feed.

Adangale (2018) reported that inclusion of linseed to the broiler diet showed non-significant differences in all the treatment groups. He also reported that feed intake in all the treatment groups was comparable to each other when linseed was included in the diet of white leghorn layers and better FCR was recorded in control group compared to other treatments.

Karnani *et al*. (2019) reported that effect of linseed on FCR in broiler was found to be non- significant while feed conversion ratio was significantly ($P<0.05$) improved due to dietary supplementation of linseed oil at 2 and 3 per cent level.

Mohammad *et al*. (2019) reported that supplementation of 3 per cent linseed showed better performance in feed intake and feed conversion ratio.

Pisal (2019) reported that supplementation of 2 per cent of linseed oil in the feed of Giriraja birds showed higher feed intake comparing to other levels in the treatment groups and lower FCR was seen in treatment groups.

Ghosh (2020) reported that supplementation of linseed oil at the rate of 1.5 per cent showed significant increase in feed intake of the birds but showed no significant effect on feed conversion ratio.

Rathaur *et al*. (2022) reported that feed intake in broilers was unaffected when they were fed with diet supplemented with linseed at the of 0, 2.5, 5, 7.5 and 10 per cent while poorer feed conversion was observed in groups fed with linseed.

2.2.3 Mortalityand Performance Index

Kumari *et al.* (2014) observed higher ($p<0.01$) performance index (750.89b±24.98) of Vanaraja chicken due to dietary supplementation of linseed as compared to control groups .

Kakade (2015) reported that mortality was seen slightly higher in treatment group when detoxifiedgossypol of cotton seed cake and its value addition was used in poultry diet.

Kate (2015) reported that mortality in all groups was seen well within the limits when dietary soybean meal protein was replaced by various levels of rapeseed meal in broilers.

Shunthwal *et al.* (2017) found that there was no mortality of the broilers in either of the dietary treatment groups subjected to 0, 25, 50, 75 and 100 percent linseed oil (except one in treatment group fed with 50% of linseed oil) by replacing sunflower oil.

Karnani (2019) reported significant reduction in mortality rate due to supplementation of different levels of linseed oil in broiler chickens.

Pisal (2019) reported that there was no mortality when Giriraja birds were fed with linseed oil.

2.2.4 Reproductive traits

Schumann *et al.* (2000) observed that the egg production reduced continuously as the trial proceeded however there was no change in egg weight in laying hens at 4 per cent linseed oil in the diet.

Galabart *et al.* (2001) reported comparable egg weight and Haugh unit value in hens fed with 5 per cent linseed oil as compared to the controls. Further, there was no influence on the egg production of hens.

Grobas *et al.* (2001) similar Haugh unit value, egg weight, egg yolk weight and number of eggs when hens were fed with 5 to 10 per cent linseed however there was increase in albumen weight in linseed supplemented group.

Novak and Scheideler (2001) reported that the overall egg weight from 21 to 57 weeks of age unaffected by linseed based diet. However, during 49 to 57 week period linseed fed hens produced eggs that were much heavier than the control group. They further stated that though there was no significant difference in egg production between the chicken receiving 10 per cent flax seed and those receiving 0 per cent linseed there was reduction in yolk percentage and significant increase in albumen percentage in linseed fed hens.

Raes *et al.* (2002) reported that linseed oil in the diet of layers did not affect egg weight.

Sari *et al.* (2002) reported that when 5, 10, and 15 per cent common flax seed was added in poultry diet, there was 84 per cent increase in egg-laying performance while the yolk weight decreased significantly.

Basmacioglu *et al.* (2003) reported that egg production increased on average by 4 per cent in hens fed with common flax seed .

Bean and Leeson (2003) reported the hens fed with linseed produced eggs with a smaller ($p<0.05$) percentage of wet yolk compared to the control birds.

Beyen (2004) discovered that hens fed with linseed produced eggs with a smaller ($p<0.05$) percentage of wet yolk compared to the control birds.

Mazalli *et al.* (2004) reported that addition of PUFA substances such fish oil, linseed oil, sunflower oil, canola oil and tallow in commercial layer diets did not affect egg production.

Anasri *et al.* (2006) indicated that the 15 per cent linseed in the diet was associated with a decrease in egg production in the laying hens.

Augustyn *et al.* (2006) reported that there was 4 per cent improvement in egg production in the groups of hens fed with common flax seed based diet. They also found that eggs laid by birds fed linseed oil were 4 per cent smaller with lesser albumen than those laid by the control group however, there was no change in yolk weight.

Celebi and Utlu (2006) observed significant variation in egg weight in laying hens due to the influence of linseed and an increase ($p < 0.05$) in egg production when hens were fed with 4 per cent linseed oil in the diet.

Silke *et al.* (2008) reported that adding two dietary fats namely soybean oil and linseed oil in the ration of laying hens showed no difference in egg production and egg weight in layers .

Svedova *et al.* (2008) observed a decrease in egg production but increase in egg weight in hens fed with 3 per cent linseed oil.

Hayat *et al.* (2009) reported that dietary supplementation of common flax seed at the rate of 10 per cent did not show any significant effect on egg production, egg weight, yolk weight, albumen weight, Haugh units and egg cholesterol content.

Arshami *et al.* (2010) observed a decline in egg production with 10 per cent linseed in diet however at 22 weeks of age, the egg production of control and birds fed with 7.5 per cent flax was found to be at par.

Hazim *et al.* (2010) revealed that linseed supplementation in laying hens diet resulted in significant increase in egg weight, haugh unit and albumin weight.

Huthail and Yousef (2010) observed no significant difference in haugh unit at 10 per cent linseed in bird's diet.

Najib and Al-Yousef (2010) determined that adding 10 per cent flax seed to feed helps produce quality eggs.

Wang and Hugo (2010) observed no significant difference in the egg production and egg weight with 4 to 15 per cent dietary level of linseed. The haugh unit of linseed group was numerically higher than the control.

Al Daraji *et al.* (2011) reported that feeding laying quails with different levels of flax seed (2, 4 or 6 per cent) caused significant improvement in most of the egg quality parameters. Hence, they advocated adding of flax seed for improving the productive performance of Japanese quail.

Ceylan *et al.* (2011) reported that laying hens were fed diets containing sunflower, fish, linseed and rapeseed oil with 2 levels of inclusion (1.5 and 3.0 per cent) for 12 weeks, egg production and egg and cholesterol content were unaffected by the treatment.

Kirubakaran *et al.* (2011) reported that diet containing flaxseed, sardines and pearl millet significantly increased the egg weight of Single Comb White Leghorn birds while egg production was observed to be unaffected.

Mridula *et al.* (2012) reported that hen-day eggs production was found improved with linseed supplementation in layer diet.

Ahmad *et al.* (2013) reported that feeding linseed to the laying hens had no detrimental effect on egg characteristics like egg weight and yolk weight but had suppressive effects on egg production.

Halle and Schöne. (2013) reported that supplementation of linseed meal at the rate of 15 per cent in the diet of young Lohmann brown hens caused a reduction in egg production.

Yassein *et al.* (2015) reported that supplementation of dietary flax seed had no negative effects on egg quality standards or laying performance but resulted in increased amount of unsaturated fatty acids and lower cholesterol in egg yolks. They opined that flax seed can be a useful supplement to obtain yolks with adequate amounts of beneficial fatty acids.

Promila (2016) reported that linseed oil was successfully supplemented at the rate of 2.5 per cent in layers diet which had beneficial effect by enhancing egg quality parameters such as lowering of egg yolk cholesterol level in hens.

Adangale (2018) reported that the overall egg production and overall hen day egg production of white leghorn laying hens was significantly improved when subjected to diet supplemented with 7.5 per cent linseed while the internal and external qualities of eggs were unaffected.

Gosh (2020) laying chickens in treatment group showed a significant increase in egg production, egg weight, higher albumen weight, similarly significant higher haugh unit was observed in linseed oil groups as compared to control group, and improved egg yolk in hens diet.

2.3. Biochemical Blood Constituents

Febel *et al.* (2008) reported lower plasma total cholesterol and LDL cholesterol level in broilers fed with linseed oil supplemented.

Azad *et al.* (2009) observed no significant effect on serum total cholesterol and triglycerides concentration with inclusion of mustard seed (7.5 or 15 per cent), linseed (7.5 or 15 per cent) or combination of both (each at 10 per cent) in broiler chicken diets when compared to control group.

Aguilar *et al.* (2011) evaluated the effect of dietary inclusion of squash seed meal in broiler diet. They reported that addition of squash seed meal reduced the abdominal fat, serum levels of total cholesterol, very low density (VLDL) and low density (LDL) lipoproteins, triglycerides, glucose and atherogenic index but increased the serum levels of beneficial lipids. They further stated that blood constituents such as triglycerides, total cholesterol, phospholipids and low- and high density lipoproteins can be strongly influenced by the chemical composition of feeds.

Hazim *et al.* (2011) observed that omega-3 fatty acids helped lower the blood cholesterol and triglycerides level.

Najib and Al-Yousef (2011) observed that feeding flax seed to layers marginally increased the amount of cholesterol than the control group.

Lopes *et al.* (2013) studied the effect of dietary replacement of sunflower oil with linseed oil at graded levels of 0, 25, 50, 100 per cent on serum lipid profile. They observed no significant ($P>0.05$) difference in serum triglycerides, total cholesterol and HDL cholesterol levels. However, significant ($P<0.05$) effect of collection day of serum at different intervals of 21, 28 and 34 days was observed.

Wang *et al.* (2013) observed that the inclusion of 5 per cent linseed or sunflower oil did not affect serum triglycerides, LDL and HDL level while cholesterol level was lower in birds fed with linseed oil.

Starcevic *et al.* (2014) reported that dietary replacement of sunflower oil (5 per cent of diet) with linseed oil had significantly ($P<0.05$) reduced the serum total cholesterol concentration in broiler chicken, however they observed it did not show any effect on HDL cholesterol, LDL cholesterol and triglycerides concentrations.

Yassin *et al*. (2015) observed that diets containing 15 per cent flax seed significantly decreased the serum cholesterol and triglycerides concentrates as compared to the control group.

Mangesh (2017) reported that 5 per cent linseed powder effectively reduced serum total cholesterol, LDL and triglyceride and increased HDL respectively.

Kanakri *et al*. (2017) have stated that essential fatty acids are incorporated in poultry diet to reduce the harmful lipids (cholesterol and triglycerides).

Shunthwal *et al.* (2017) observed that LDL, total cholesterol and triglyceride level was significantly decreased in all the groups fed with linseed oil based diet.

As per Shunthwal and Sheoran (2017), flaxseed supplementation in the diets of broiler chicks reduced the blood cholesterol and LDL while HDL level was increased.

Adangale (2018) observed that the serum cholesterol, triglycerides and LDL levels decreased as the level of linseed increased in the ratio of broiler chicken.

Chiroque *et al.* (2018) reported that feeding of helmeted guinea fowls with linseed and pumpkin seed decreased ($p<0.05$) the mystic, palmitic and octadecanoic acid levels as well as increased the linolic, a-linolenic, eicosapentanoic and docosahexanoic acids ($p<0.05$).

Gosh (2020) reported that the serum cholesterol and triglycerides concentration was significantly decreased when hens were fed with diets supplemented with black cumin, garlic and turmeric powder in combination with different levels of linseed oil as compared to control group in laying chickens.

Rathaur *et al.* (2022) studied the dietary supplementation of linseed on the growth performance and lipid profile of broiler chickens. They observed that the addition of linseed decreased cholesterol, triglyceride, low density lipoprotein and very low density lipoprotein levels while high density lipoprotein increased significantly.

2.4 Economics of Rearing

El-Latif *et al.* (2002) reported that the inclusion of herbal feed additives in Japanese quail diet resulted in the least feed cost/kg gain and the highest percentage of economical efficiency compared with the control diet.

Sujatha (2002) observed 50 per cent higher production cost due to the use of flaxseed and fish oil as compared to oil-rich fish.

Hassan *et al.* (2004) reported that economical efficiency value at 7 weeks of age was improved in chicks fed with diets supplemented with the herbal feed additives as compared with the supplemented ones.

Ceylan *et al.* (2011) reported that feed cost did not show any significant difference between types of dietary fats, but increased by higher level of oil inclusion in the diet of laying hens.

Hazim *et al.* (2011) observed that inclusion of flax seed at different levels in Japanese quail during the laying period resulted in higher income efficiency.

Promila (2016) observed 50 per cent higher production cost due to the use of flaxseed and fish oil as compared to oil-rich fish.

Mangesh (2017) reported that dietary supplementation of linseed powder at the rate of 5 per cent significantly improved the economical returns.

Promila *et al.* (2017) reported that feed cost value of dozen egg production decreased in treatment groups T_4 (5 per cent linseed oil) in comparison to T_1 (non supplementedmaize based control diet). Thus, the highest net profit was obtained in hens under T_4.

Shunthwal *et al.* (2017) reported that there was no compromise with the cost of production using linseed oil in the ration of broiler chicks.

Pisal (2019)) observed that feeding linseed oil diet at the rate of 3 and 2 per cent instead of 5 per cent was most beneficial which showed higher net return.

Tamasgen *et al*. (2021) evaluated the effect of replacing soybean meal with graded levels of linseed meal at the rate of 0 per cent, 25 per cent, 50 per cent, 75 per cent and 100 per cent in broiler chicken. They reported higher initial body weight, lower feed cost and higher net return at 50 per cent level of replacement.

CHAPTER – 3

MATERALS AND METHODS

MATERIAL AND METHODS

The present experiment was carried out to study the growth performance, feed intake, feed conversion rate, mortality, performance index, reproductive traits, egg quality traits, biochemical constituents and economics of rearing Vanaraja birds provided with diet replaced with different levels of linseed meal following scientific and standard management practices.

3.1 Location of work

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

3.2 Experimental Birds and Diet:

A total of 120 day - old healthy Vanaraja chicks (female chicks) were used for the experiment, which was procured from ICAR Research Complex for NEH Region, Nagaland Centre, Medziphema, Nagaland.

Good quality feed ingredients were procured from a reputed commercial feed supplier M/S Amar Mill, Golaghat Road, Dimapur while whole linseed was procured from the local farmers.

The experimental birds were subjected to four dietary treatments. Group (T_1) served as control which was provided basal diet without linseed meal while groups T_2, T_3 and T_4 were provided the same basal diet but added with linseed meal replacing GNC at the rate of 4 per cent, 8 per cent and 12 per cent, respectively.

3.3 Experimental Design:

The experiment was carried out in Randomized Block Design. The experimental birds were divided into four treatment groups designated as T_1 (

control), T_2,T_3 and T_4 with thirty (30) birds each which was replicated five times having six (6) birds in each replicate. The birds were reared for a period of 9 months (273 days).

3.4 Test material and Feed preparation:

Linseed meal was prepared by milling the whole linseed into fine powder which was then properly stored in a dry place to be used later. The experimental feed was formulated according to the nutritional requirement recommended by ICAR (2011). Experimental diet was prepared by replacing GNC with linseed meal at the rate of 0 per cent (T_1), 4 per cent (T_2), 8 per cent (T_3) and 12 per cent (T_4). The birds were provided with three phase diet standard starter feed from 0 to 8 weeks, grower feed from 9 to 20 weeks and layer feed from 20 weeks onwards as shown in Table 3.1 to Table 3.3.

Table 3.1 Chick ration (0-8 weeks):

Ingredients	**Level of Linseed meal (%)**			
	0	**4**	**8**	**12**
Maize	40	41	39	37.5
Wheat bran	15	12	12	13
Rice polish	14	13	14.5	13
Fish meal	6	6	6	6
GNC	20.5	19.5	16	14
Linseed meal	0	4	8	12
Min. Mixture	2	2	2	2
Di-calcium phosphate	0.5	0.5	0.5	0.5
Calcite	1.5	1.5	1.5	1.5
Common salt	0.5	0.5	0.5	0.5
Total	100	100	100	100

CP (%)	20.16	20.43	20.42	20.32

Table 3.2 Grower ration (8 to 20 weeks):

Ingredients	**Level of Linseed meal (%)**			
	0	**4**	**8**	**12**
Maize	32.5	32.5	33	33.5
Wheat bran	15	14	14	14
Rice polish	31	31	28	25.5
Fish meal	4	4	4	4
GNC	10	6	5.5	3.5
Linseed meal	0	4	8	12
Min. Mixture	2	2	2	2
Di-calcium phosphate	0.5	0.5	0.5	0.5
Calcite	4.5	4.5	4.5	4.5
Common salt	0.5	0.5	0.5	0.5
Total	100	100	100	100
CP (%)	16.58	16.10	16.56	16.62

Table 3.3 Layer ration (After 20 weeks):

Ingredients	**Level of Linseed meal (%)**			
	0	**4**	**8**	**12**
Maize	29.0	29	29	28
Wheat bran	15	15	15	13
Rice polish	30	28.0	27	28.0
Fish meal	5	5	5	5
GNC	13	11	8	6
Linseed meal	0	4	8	12

Min. Mixture	2	2	2	2
Di-calcium phosphate	0.5	0.5	0.5	0.5
Calcite	5	5	5	5
Common salt	0.5	0.5	0.5	0.5
Total	100	100	100	100
CP (%)	18.07	18.17	18.11	18.05

3.5 Preparation of the brooder house:

Before the arrival of chicks, the brooder house was properly cleaned and disinfected through proper disposal of the waste materials, washing of the floor and white washing of the walls. Brooders, feeders and drinkers were cleaned and sundried. Adequate ventilation and lighting was ensured. At the entrance of the brooder house, the footbath was filled with water mixed with potassium permanganate. Four temporary partitions of uniform sizes were made to rear the chicks on the floor up to eight weeks. After liming of the floor, saw dust was spread keeping a depth of 4-5 inches. Newspaper was place above the litter material to prevent the chicks from picking the litter material and protect them from the dust.

Four hover brooders fixed with 60 watts bulbs (3-4 nos. each) were used for brooding. Brooder lights were kept on before the arrival of chicks to keep the house warm.

3.5.1 Brooding and Rearing

Brooding and rearing was done as per standard practices. The birds were randomly distributed in the compartments treatment wise and were reared on deep litter from day-old to eight weeks of age. Recommended brooding temperature was maintained for successful brooding. The chicks were regularly monitored.

The drinkers were checked daily for spillage and leakage of water on the litter material. After the completion of 8 weeks, the birds were transferred to the layer cages as per treatment and replications and were reared in cages till the end of the trial period.

3.5.2 Feed, watering and health

Upon arrival, the chicks were weighed, fed with glucose water and then released into the brooding unit. After placing the chicks in the brooder, maize grits was sprinkled on the newspaper to encourage them to eat which was stopped after they started eating from the regular feeders. To encourage the chicks to eat, the feeders were kept full initially but reduced to half its volume after the chicks learnt to eat. Two drinkers and two linear feeders were provided in each compartment and the birds received feed and fresh water *ad libitum* during the experimental period. Starter feed was provided from 0-8weeks, grower feed from 9-20weeks and layer feed after 20 weeks. Measured quantity of feed was given daily at 6 a.m. and 2 p.m. The leftover feed was measured the next day to calculate daily feed consumption of the birds. The birds were vaccinated against Ranikhet disease, Infectious bursal disease and fowl pox as per the recommended vaccination schedule.

3.6 Experimental Procedure

3.6.1 Body Weight and Growth Rate:

Initial body weight of the day- old chicks was recorded. Thereafter, the average body weight of the Vanaraja birds were recorded at fortnightly intervals which were taken in the morning hours prior to feeding and watering. A digital weighing balance having a maximum capacity of 10 kg was used for the entire experiment for weighing the birds. During the first four weeks, the average weight of the chicks was recorded in groups of 5-10. This was done by placing the chicks in a pre – weighed bamboo basket or cartoon. After the 8th week, the birds were weighed individually at fortnightly intervals till the end of the trial period.

3.6.2 Feed Intake and Feed Conversion Ratio

The amount of feed supplied to the birds was recorded daily and the feed residue, if any, was recorded the next morning. Feed intake was calculated by offering weighed quantity of feeds according to the treatments with the help of a precise digital weighing balance and expressed in gram. The leftover feed collected the next morning was subtracted from the total amount of feed supplied the previous day to arrive at the exact quantity of feed consumed by the birds per day. From these data, the average and weekly feed consumption was calculated for each bird in each group and expressed in grams. The feed conversion ratio (FCR) was calculated by adopting the following formula: Banday, (2014):

$$\text{Feed Conversion Ratio (FCR)} = \frac{\text{Quantity of feed consumed (g)}}{\text{Total body weight gain (g)}}$$

3.6.3 Mortality/Liveability and Performance Index

Mortality was recorded throughout the experimental period and was expressed in percentage using the following formula:

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

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

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

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

3.7 Reproduction traits

3.7.1 Age at Sexual Maturity

Age at first egg was considered as the age of sexual maturity as egg production starts when the birds attain sexual maturity. Collection of eggs was done thrice a day i.e. morning, afternoon and evening. The collected eggs were filled in the egg trays and stored at room temperature.

3.7.2 Body weight at 1st egg, age at first egg and Egg weight at 1st laying

To record the body weight at first egg, the day when the birds laid its first egg, body weight of that particular bird was recorded. Age at first egg was calculated by counting the number of days starting from day- old to the day of first egg while the weight of first egg was measured by using a digital weighing balance.

3.7.3 Clutch size and total egg production up to 39 weeks of age

A clutch is a group of eggs laid by a hen on consecutive days which is followed by a rest period of about a day or more. Daily egg production was recorded daily upto 39 weeks of age (9 months) to calculate the total egg production.

3.7.4 Egg quality traits

Egg quality traits were determined by randomly selecting 2 eggs from each replicate. The main parameters to determine the quality of the eggs were egg weight, yolk weight, albumen weight, Haugh unit and yolk cholesterol. For the measurement of egg weight, yolk weight, albumen weight, a digital balance was used. After weighing the egg, it was broken on a flat surface. The albumen height was measured using a tripod micrometer. The yolk was separated and weighed. Similarly, the egg white was collected and weighed.

3.7.5 Haugh unit

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

$$HU = 100 \log (H+7.6-1.7W0.37)$$

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

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

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

3.7.6 Yolk cholesterol

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

Procedures

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

For cholesterol assay standard kit was procured from DIATEK healthcare Pvt. Ltd. Composition of the reagent in the cholesterol standard kit is given in table 3.4 and protocol for cholesterol analysis is given in Table 3.5.

Table 3.4 Composition of the reagent in the cholesterol standard kit

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

Cholesterol Standard: 200 mg/dl

Table 3.5 Protocol for cholesterol analysis

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

End Point Method:

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

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

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

3.8 Blood parameters

At 4th month and 9th month of age, three birds in each treatment were randomly selected from any three replicate groups for blood collection. The blood was collected from the wing vein of the birds by sterilizing and numbing an area of the wing with disinfectant and cotton wool and then collecting about 2 ml of blood with the use of sterile needles into well labeled sterilized tubes containing Heparin as anticoagulant. Biochemical profiles such as Cholesterol, triglyceride, low density lipoprotein (LDL) and high density lipoprotein (HDL) were determined using different procedure.

3.8.1 Cholesterol

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

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

Procedure

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

The values obtained were calculated as per the method described by Richmond (1973).

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

3.8.2 Triglycerides

The serum was separated out into a clean plastic screw-cap vial from the collected whole blood sample and neatly labeled. Triglycerides are also lipids that circulate in the blood. Triglycerides concentration was expressed in mg/dl.

Procedure

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

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

3.8.3 High-density lipoproteins (HDL)

The serum was separated out into a clean plastic screw-cap vial from the collected whole blood sample and neatly labeled. High density lipoprotein or good cholesterol absorbs cholesterol and carries it back to the liver. High density lipoprotein concentration was expressed in mg/dl.

Procedure

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

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

3.8.4 Low density lipoproteins (LDL)

The serum was separated out into a clean plastic screw-cap vial from the collected whole blood sample and neatly labeled. Low density lipoprotein sometimes called bad cholesterol, makes up most of the body's cholesterol. Low density lipoprotein concentration was expressed in mg/dl.

Procedure

1. Each test tube was marked as per the sample numbers and two other test tubes marked as B (blank) and S (standard).
2. In all the test tubes except S, 450µl of reagent (R1) was taken.
3. In the test tube marked for standard 6 µl of the calibrator was added.

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

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

3.9 Economics of Feeding Linseed Meal

The economics of feeding linseed meal based diet by replacing GNC at the rate of 0 per cent, 4 per cent, 8 per cent and 12 per cent was calculated on the basis of overall cost of inputs, i.e. the cost of chicks, feeds, labor, medicines and other miscellaneous cost. The live weight of the bird at the end of experiment was considered to calculate the gross return per bird and net profit per bird.

3.10 Statistical Analysis:

The experimental data collected was statistically analyzed using ANOVA in a randomized block design as described by Snedecor and Cochran (1998). The results are given as means, standard error and $p<0.05$.

Day old chicks

Brooding of chicks

Plate 1 Vaccination of chicks

Whole linseed

Plate 2 Preparation of feed and mixing of linseed meal

Rearing of birds in deep litter system (1-8 weeks)

Plate 3 Rearing of birds in cages (after weeks)

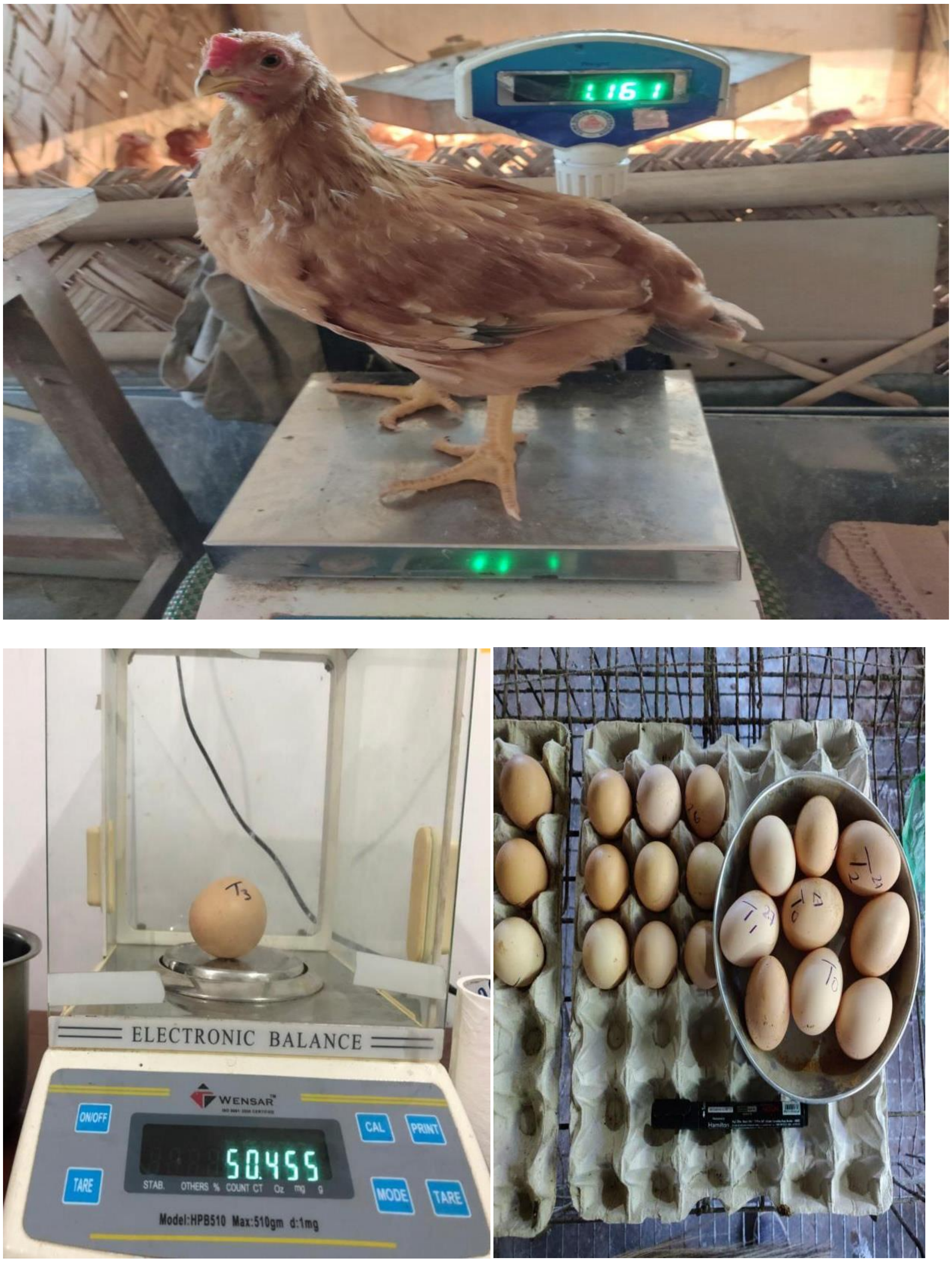

Plate 4 Weighing of birds and eggs

Plate 5 Egg quality traits and biochemical, blood constituent analysis

CHAPTER – 4

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

The present study was carried out with 120 numbers of female Vanaraja chicks which were reared for a period of 39 weeks. The birds were subjected to four dietary treatments containing 0, 4, 8 and 12 per cent of linseed meal. Data on the performance of the birds in terms of body weight, body weight gain, feed intake, feed conversion efficiency, mortality, liveability, performance index, egg quality traits, biochemical parameters and economy of rearing as influenced by the dietary treatments was recorded. All recorded data were analyzed statistically and presented in tables and illustrated by graphs in order to depict the salient findings. The findings from the present study are discussed in this chapter under the following heads.

4.1 Productive traits

4.1.1 Body weight

The observation on variation in body weight of different treatment groups from day-old to 39 weeks of age are presented in Table 4.1 and are graphically presented in Fig 4.1.1 Their mean statistical analyses are shown in Appendix 1 (BODY WEIGHT)

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

Fortnight	Treatment				SEM ±	CD
	T_1	T_2	T_3	T_4		
0	40.0	30.0	38.0	40.0	2.4	NS
1st	297.0	301.0	297.0	308.0	14.4	NS
2nd	550.9^{a}	565.0^{ab}	593.0^{b}	554.0^{a}	5.8	17.9
3rd	706.0^{ab}	691.9^{a}	734.0^{b}	670.0^{a}	5.2	16.2
4th	982.0	1009.0	1002.0	979.0	8.2	NS
5th	1397.0^{c}	1164.6^{b}	1134.0^{ab}	1011.0^{a}	13.4	41.5
6th	1522.0^{b}	1351.0^{a}	1421.0^{a}	1365.0^{a}	5.3	16.5
7th	1745.0^{c}	1655.0^{a}	1692.0^{ab}	1712.0^{bc}	13.1	40.5
8th	1988.0^{b}	1845.0^{a}	1866.0^{a}	1826.0^{a}	6.2	19.2
9th	2100.0^{b}	2023.0^{a}	1968.0^{a}	1982.0^{a}	8.5	26.3
10th	2201.0^{b}	2102.0^{a}	2048.2^{a}	2089.0^{a}	17.1	52.8
11th	2263.0^{c}	2199.0^{b}	2129.0^{a}	2178.0^{ab}	11.8	36.6
12th	2327.0^{b}	2298.0^{b}	2230.0^{a}	2245.0^{a}	7.5	23.3
13th	2418.0^{b}	2349.0^{a}	2310.0^{a}	2344.0^{a}	5.0	15.5
14th	2493.0^{b}	2400.0^{a}	2391.0^{a}	2412.0^{a}	6.4	19.8
15th	2553.0^{a}	2462.0^{a}	2445.0^{a}	2485.0^{b}	6.4	19.9
16th	2603.0^{c}	2524.0^{ab}	2485.0^{a}	2541.0^{b}	7.3	22.6
17th	2671.0^{b}	2583.0^{a}	2562.0^{a}	2601.0^{a}	5.7	17.6
18th	2739.0^{b}	2629.0^{a}	2601.0^{a}	2689.0^{b}	10.1	31.3
19th	2801.0^{b}	2722.0^{a}	2693.0^{a}	2715.0^{a}	14.3	44.0
20th	2884.0^{c}	2776.0^{b}	2701.0^{a}	2785.0^{b}	10.2	31.5
TOTAL	39280.9^{b}	37679.5^{a}	37340.2^{a}	37531.0^{a}	267.13	823.19
MEAN	1870.5^{d}	1794.3^{c}	1778.1^{a}	1787.2^{b}	2.14	6.60

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

As per the Table 4.1.1 the initial body weight of the treatments groups T_1, T_2, T_3 and T_4 was observed to be 40.0g, 30.0g, 38.0g and 40.0 g, respectively and the corresponding body weight at 20th fortnight was observed to be 2884.0, 2776.0, 2701.0 and 2785.0g. The overall mean body weight was found to be 1870.5, 1794.3, 1778.1 and 1787.2 g for T_1, T_2, T_3 and T_4, respectively.

The statistical analysis had revealed that there was significant effect of dietary supplementation of linseed meal on the body weight of Vanaraja birds. Body at day-old was found to be non-significant, however, the final body weight at the end of the trial was significantly ($p<0.05$) different among the treatment groups. The overall trend in body particularly from 5th fortnight to 20th fortnight was consistently higher ($p<0.01$) in control group as compared to the linseed fed groups.

The overall mean body weight was significantly higher in control group T_1 followed by T_2, T_4 and the least was in T_3. The results of the current study corroborated with the findings of Mridula *et al.* (2011) ; Arshami *et al.* (2010) and Mohammad *et al.* (2019), who found that adding flaxseed in the diet had reduced the body weight of the pullets and quails. Starcevic *et al*. (2014) illustrated that supplementation of 5 per cent linseed oil to chicken broiler diets had no significant difference on the body weight. On the other hand, Shunthwal *et al.* (2017) and Ceylana *et al.* (2011) found that feeding laying hens with various dietary oil sources had no effect on their body weight. This finding was at odds with that of Kumari *et al* (2014), Mangesh (2017) and Pisal (2019) who claimed that birds provided with linseed meal or linseed oil showed considerably higher body weight than the control group.

Decrease in body weight might be due to the negative impact of the anti nutritional factors present in linseed meal. Primohammadi*et al.* (2019) had reported that mucilage, linatine, cyanogenic glycosides, trypsin inhibitors, phytic acid, and water-soluble non-starch polysaccharides can reduce the nutrient digestibility and utilization and consequently reduce the growth rate of the birds. Furthermore, difference in the findings could be due to the varying levels and type or form of linseed utilised, variations in strains, feed ingredients, agro-climatic conditions and other factors.

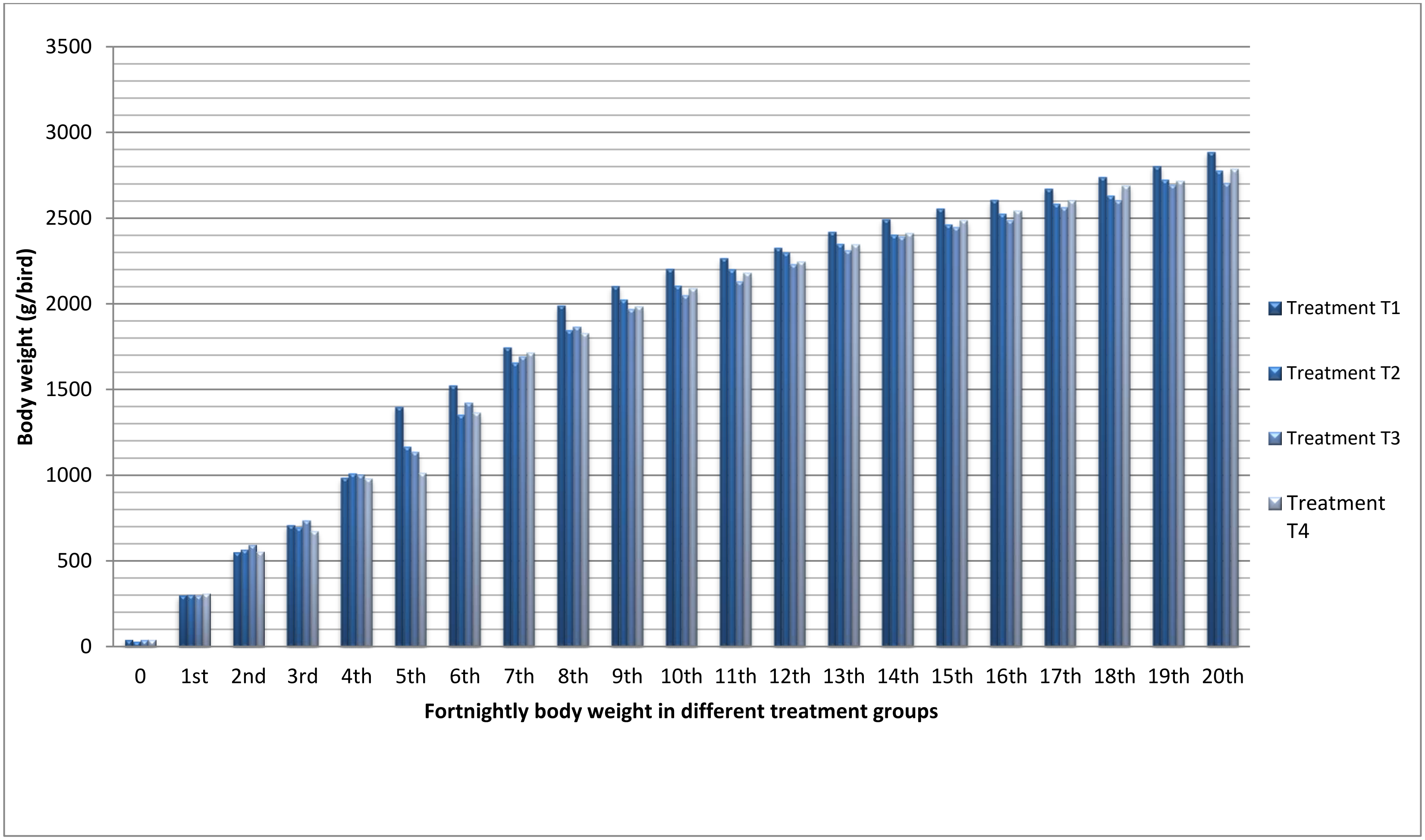

Fig 4.1.1: Average body weight (g/bird/fortnight) of Vanaraja in different treatment groups

4.1.2 Gain in body weight

The average fortnightly gain in body weight for different treatment groups are shown in Table 4.1.2 and are graphically presented in Fig 4.1.2. Their mean statistical analyses are shown in Appendix 2 (GAIN IN BODY WEIGHT)

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

Fortnight	Treatment				SEM ±	CD
	T_1	T_2	T_3	T_4		
1st	257.0	263.0	259.9	268.0	15.0	NS
2nd	253.9^{a}	264.0^{ab}	295.1^{b}	246.0^{a}	11.4	35.1
3rd	155.1^{c}	126.9^{ab}	141.0^{bc}	116.0^{a}	6.1	18.9
4th	276.0^{ab}	317.1^{c}	267.9^{a}	309.0^{bc}	10.9	33.6
5th	415.0^{c}	155.6^{b}	132.0^{b}	32.0^{a}	13.5	41.5
6th	125.0^{a}	186.4^{b}	287.0^{c}	354.0^{d}	12.9	39.9
7th	223.0^{a}	304.0^{b}	271.0^{ab}	347.0^{c}	15.6	48.1
8th	243.0^{c}	190.0^{b}	174.0^{b}	114.0^{a}	14.3	44.0
9th	112.0^{a}	178.0^{b}	102.0^{a}	156.0^{b}	10.1	31.1
10th	276.0^{ab}	317.1^{c}	267.9^{a}	309.0^{bc}	10.9	33.6
11th	62.0	97.0	80.8	89.0	22.6	NS
12th	64.0^{a}	99.0^{b}	101.0^{b}	67.0^{a}	10.4	32.0
13th	91.0^{b}	51.0^{a}	80.0^{b}	99.0^{b}	8.6	26.6
14th	75.0^{b}	51.0^{a}	81.0^{b}	68.0^{ab}	6.9	21.2
15th	60.0	62.0	54.0	73.0	11.6	NS
16th	50.0	62.0	40.0	56.0	9.4	NS
17th	68.0	59.0	77.0	60.0	10.2	NS
18th	68.0^{ab}	46.0^{a}	39.0^{a}	88.0^{b}	9.6	29.8
19th	62.0^{ab}	93.0^{b}	92.0^{b}	26.0^{a}	13.2	40.6
20th	83.0^{b}	54.0^{b}	12.2^{a}	70.0^{b}	11.2	34.4
TOTAL	3019.0^{b}	2976.1^{b}	2854.8^{a}	2947.0^{ab}	32.35	99.71

MEAN	144.2^b	138.8^a	135.1^a	139.3^a	1.41	4.35

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

As per Table 4.1.2 the total gain weight was 3019.0, 2976.1, 2854.8 and 2947.0 for T_1, T_2, T_3 and T_4 respectively. Meanwhile, the overall mean body weight gain for the treatment groups was recorded to be 144.2, 138.8, 135.1 and 139.3 g per bird, correspondingly.

The statistical analysis recorded that there was significant effect of linseed meal on the body weight gain of the birds and the gain in weight was found to be significantly higher in control group T_1 followed by T_4, T_2 and least in T_3. However, the difference in body weight gain among the treatment groups T_2, T_3, T_4 was found to be non-significant.In consistent with the present finding, Rahimi *et al*. (2011) and Adangle (2018), the control group performed better in terms of body weight growth than those birds which were fed with diet supplemented with linseed while Kirubakaran *et al*. (2011) observed that layer birds fed with flaxseed did not exhibit any significant difference in the body weight gain. On the contrary, it was noted by Kumari *et al*. (2014) and Pisal (2019) that dietary supplementation of linseed meal resulted in the increase in the body weight gain and they have claimed that the body weight gain in the laying hens increased with increasing linseed oil levels.

According to Shunthwal *et al*. (2017), there was no significant difference in body weight gain of birds when fed with different levels of linseed oil. Similiarly, Starcevic *et al*. (2014) observed comparable body weight gain in broiler chicken due to supplementation of linseed oil at the rate of 5 per cent in the diet. According to Gosh (2020), linseed oil based diet had no discernible impact on the weight gain of white leghorn chickens. Poor gain in weight might have been due to the negative impact on growth performance exerted by the anti-nutritional factors in linseed as reported by Pirmohammadi *et al*. (2019). The disparity in the results could also be caused due to variations in strains, feed ingredients, varying levels of linseed meal, agro climatic conditions and other environmental factors.

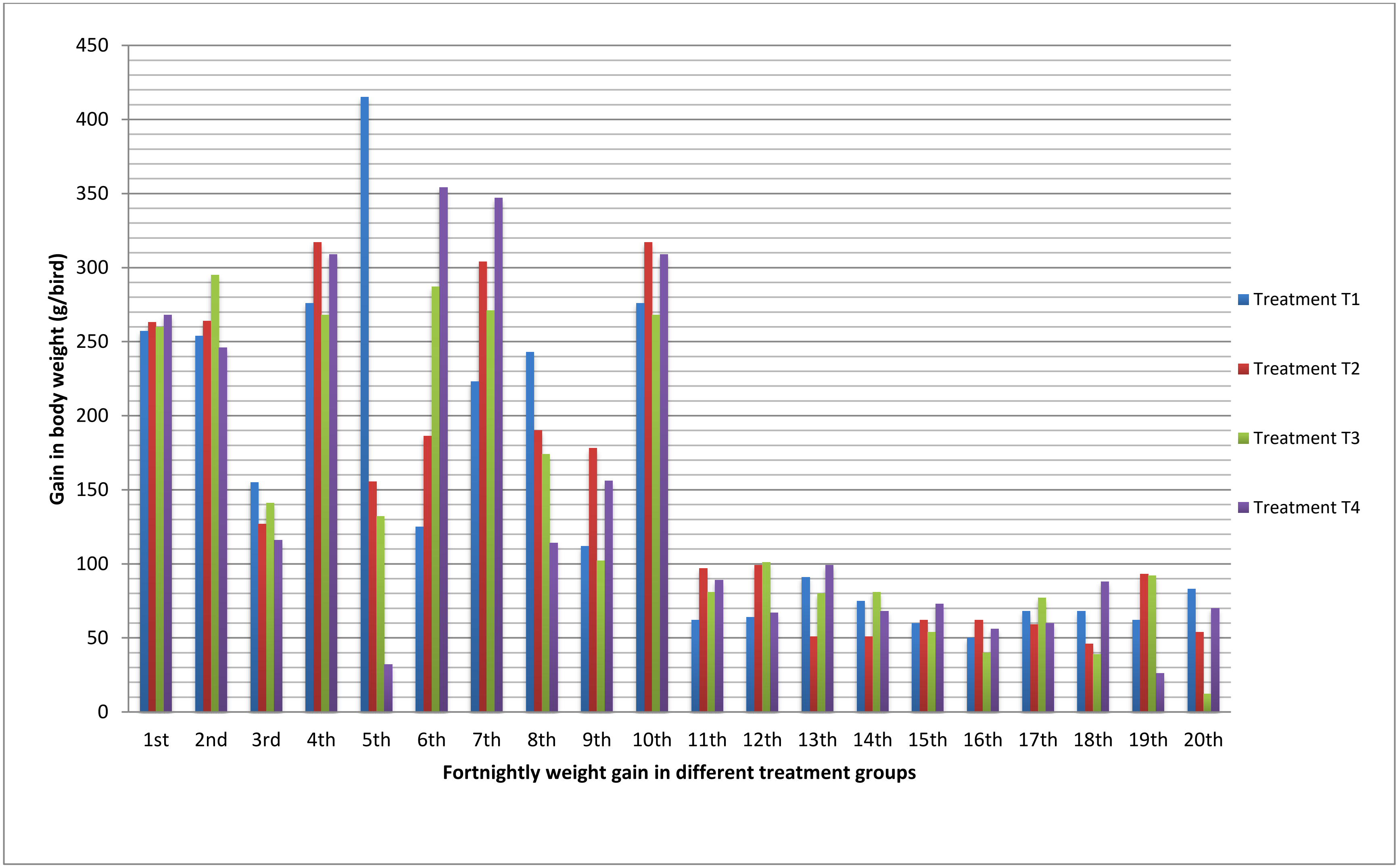

Fig 4.1.2: Average gain in body weight (g/bird/fortnight) of Vanaraja in different treatment groups

4.1.3 Feed intake

The average fortnightly feed intake for different treatment groups are shown in Table 4.1.3 and are graphically presented in Fig 4.1.3. The mean statistical analyses are shown in Appendix 3 (FEED INTAKE)

Table 4.1.3 Average feed intake (g/bird/fortnight) of Vanaraja birds in different treatment groups

Fortnight	Treatment				SEM ±	CD
	T_1	T_2	T_3	T_4		
1st	233.4	248.0	241.0	249.2	7.8	NS
2nd	682.0	678.6	674.0	686.6	5.5	NS
3rd	965.0	964.2	964.0	963.0	6.0	NS
4th	845.4^{c}	754.4^{a}	791.2^{b}	838.4^{c}	5.7	17.7
5th	530.0^{b}	373.2^{a}	309.4^{a}	307.0^{a}	28.4	87.5
6th	847.2^{c}	759.0^{b}	663.8^{a}	946.2^{d}	7.3	22.6
7th	963.2^{b}	875.0^{a}	866.0^{a}	1019.2^{c}	5.6	17.5
8th	833.4^{b}	793.0^{a}	794.0^{a}	990.0^{c}	6.4	19.9
9th	963.6^{a}	1217.0^{b}	1220.0^{b}	1213.0^{b}	4.0	12.4
10th	1494.6^{c}	1378.6^{a}	1384.4^{a}	1426.4^{b}	4.9	15.3
11th	1184.0^{c}	840.8^{a}	1130.6^{b}	1134.0^{b}	7.4	22.8
12th	1061.2^{c}	429.2^{a}	925.2^{b}	927.0^{b}	4.9	15.3
13th	1018.8^{d}	422.4^{a}	798.2^{b}	838.6^{c}	7.2	22.2
14th	877.6^{c}	429.4^{a}	780.6^{b}	766.6^{b}	6.2	19.3
15th	1059.4^{c}	792.8^{a}	928.6^{b}	759.8^{a}	41.9	129.0
16th	1122.6^{c}	961.0^{a}	987.4^{b}	1001.6^{b}	5.8	18.0
17th	1047.8^{a}	964.4^{a}	920.8^{a}	2490.4^{b}	52.9	163.0
18th	1178.9^{c}	1100.9^{b}	1074.2^{a}	1166.4^{c}	7.6	23.7
19th	1301.6^{b}	1234.8^{a}	1201.8^{a}	1330.6^{b}	18.7	57.7
20th	706.6^{b}	596.8^{a}	711.8^{b}	694.6^{b}	6.0	18.6
TOTAL	18916.3^{c}	15813.5^{a}	17367.0^{c}	19748.6^{d}	60.85	187.51

MEAN	945.8^{c}	790.7^{a}	868.4^{b}	987.4^{d}	6.37	19.63

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

The total feed intake from 1^{st} to 20^{th} fortnight for T_1, T_2, T_3 and T_4 that is from the beginning to the end of the trial was recorded to be 18916.3g, 15813.5g, 17367.0g and 19748.6g, respectively while the corresponding overall mean feed intake was recorded to be 945.8g, 790.7g, 868.4g and 987.4g.

As per the statistical analysis there was significant effect of linseed meal supplementation on feed consumption of Vanaraja birds and the mean feed intake per fortnight was found to be significantly higher in T_4 followed by T_1, T_3 and T_2. Similiar to the present findings, Najib and Al-Yousef (2010) and Ghosh (2020) had reported significantly higher feed intake in birds fed with flax seed. According to Hayat *et al*. (2009) showed that feeding of flax showed positive effect on the feed intake of the birds. Similiarly, Celebi and Utlu (2006) and Mohammad *et al*. (2019) also discovered variation in feed intake due to inclusion of linseed in the diet.

On the contrary, Haug *et al.* (2007) reported that addition of rapeseed oil or rapeseed oil plus linseed oil did not influence feed intake in broilers. Likewise, Febel *et al.* (2008) also reported that supplementation of linseed oil at the level of 3 per cent in the diet did not produce any visible effect on feed intake of broiler birds. According to Lopes *et al.* (2013) reported that with partial or total substitution of soya bean with linseed oil there was no significant difference in feed intake of the broiler birds.

The higher feed intake at higher level might be due to the enhancement of palatability as a result of linseed while the reason for variation in the findings could be the difference in level and form in which linseed was used and the strain of bird.

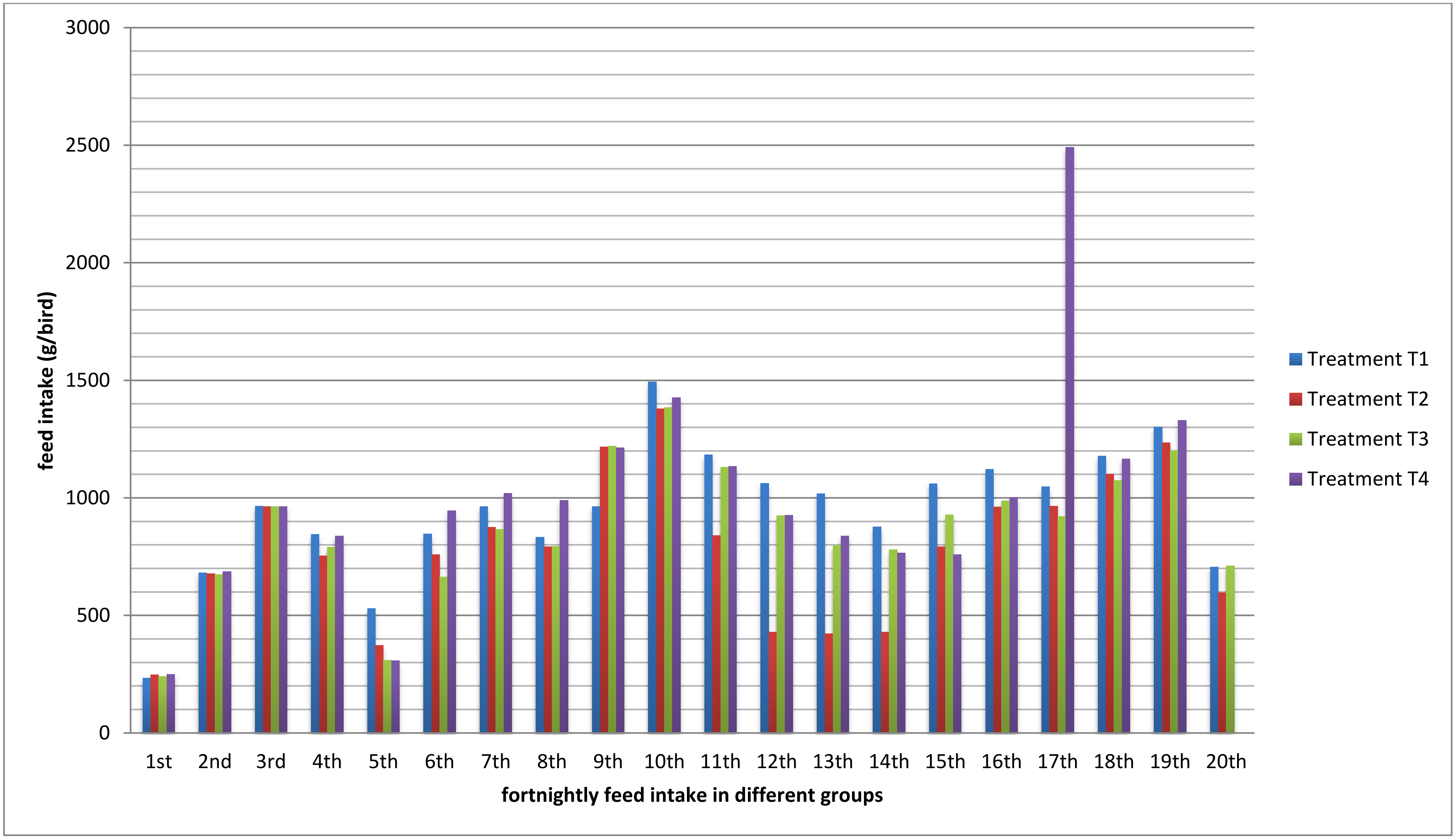

Fig 4.1.3: Average feed intake (g/bird/fortnight) of Vanaraja in different treatment groups

4.1.4 Feed conversion raio

The average fortnight feed conversion ratio observed from 1st fortnight to 20th fortnight in different treatment groups is presented in Table 4.1.4 and are graphically illustrated in Fig 4.1.4 Their mean statistical analyses are shown in Appendix 4 (FEED CONVERSION RATIO)

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

Fortnight	Treatment				SEM ±	CD
	T_1	T_2	T_3	T_4		
1st	0.9	0.9	0.9	0.9	0.7	NS
2nd	2.7	2.6	2.3	2.8	0.2	NS
3rd	6.3^{a}	7.7^{bc}	6.9^{ab}	8.4^{c}	0.3	1.0
4th	3.1^{a}	2.4^{a}	3.0^{b}	2.7^{ab}	0.1	0.3
5th	1.3^{a}	2.6^{a}	2.4^{a}	12.5^{b}	1.7	5.4
6th	7.5^{b}	4.1^{a}	2.3^{a}	2.7^{a}	0.6	2.0
7th	4.3^{b}	2.9^{a}	3.2^{a}	3.0^{a}	0.1	0.5
8th	3.5^{a}	4.2^{a}	4.7^{a}	9.4^{b}	0.6	2.0
9th	8.9^{a}	6.9^{a}	12.8^{b}	7.9^{a}	0.9	3.0
10th	5.5^{b}	4.3^{a}	5.2^{b}	4.6^{a}	0.1	0.5
11th	26.9	15.2	26.9	18.0	9.6	NS
12th	21.2^{c}	4.5^{a}	9.5^{ab}	16.4^{bc}	3.6	11.2
13th	12.1	8.9	10.3	8.9	1.2	NS
14th	12.3	11.0	11.2	11.9	2.0	NS
15th	20.2	15.5	38.5	11.6	11.6	NS
16th	28.1	16.0	36.1	22.6	8.7	NS
17th	17.3^{a}	17.4^{a}	13.2^{a}	56.5^{b}	10.6	32.7
18th	18.9^{ab}	26.5^{b}	34.8^{c}	15.8^{a}	2.6	8.0
19th	23.0^{a}	15.6^{a}	16.9^{a}	93.4^{b}	15.1	46.5
20th	8.9^{a}	14.5^{a}	58.9^{b}	20.8^{a}	7.0	21.9

TOTAL	232.9^{b}	183.7^{a}	300.0^{c}	330.8^{d}	4.83	14.88
MEAN	11.6^{b}	9.2^{a}	15.0^{c}	16.5^{d}	0.09	0.29

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

In Feed conversion ratio as per the table 4.1.4 the mean feed conversion ratio was recorded to be 11.6g, 9.2g, 15.0g and 16.5g for T_1, T_2, T_3 and T_4 respectively.

From the Table 4.1.4, the mean FCR was found to be in the range of 0.9 to 28.1, 0.9 to 26.5, 0.9 to 58.9 and 0.9 to 93.4 for T_1, T_2, T_3 and T_4 ,respectively meanwhile the mean FCR for the respective group was observed to be 11.6, 9.2, 15.0 and 16.5.

It is evident from Table 4.1.4 that inclusion of linseed in diet of Vanaraja birds had significant effect on feed conversion ratio among the groups. The diet replaced with 4 per cent level of linseed showed significantly better feed conversion ratio than the rest of the groups T_1, T_3 and T_4. This might be due to better utilization of feed within this level and the improvement in growth due to the bio active compounds present in linseed. Similar to the present findings, Mangesh (2017) had also reported significant effect of linseed powder on feed conversion ratio in Giriraja birds. Kumari *et al*. (2014) and Najib *et al*. (2010) also found that feeding of full-fat flaxseed showed significant difference in layer hens. Similiarly, Zelenka *et al.* (2006) and Karnani *et al*. (2019) have also reported better FCR in broilers receiving 3 to 7 per cent of linseed oil. On the contrary, many authors like Najib *et al*. (2010), Lopes *et al*. (2013) and Shuntwal *et al*. (2017) observed no significant difference in FCR among linseed supplemented group and control group.

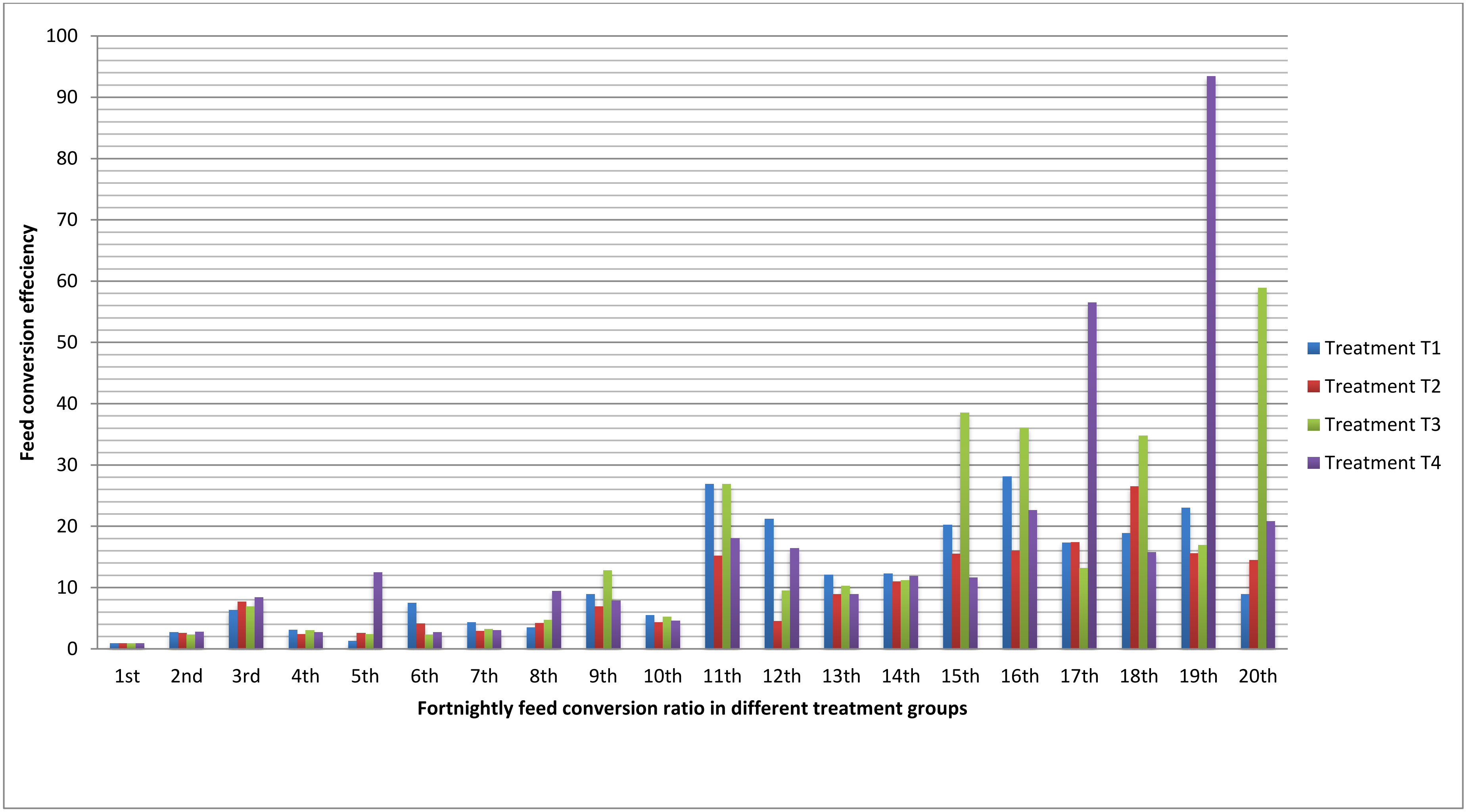

Fig 4.1.4: Average feed conversion ratio (g/bird/fortnight) of Vanaraja in different treatment group

4.1.5 Mortality/Liveability and Performance Index

The average mortality, liveability and performance index till the end of the trial period are shown in Table 4.1.5 and has been graphically plotted in Fig 4.1.5

Table 4.1.5 Mortality/ liveability and Performance Index of Vanaraja birds in different treatment groups.

Treatment groups	Mortality (%)	Liveability (%)	Performance Index
T_1	3.4	96.6	8.8
T_2	0.0	100.0	11.1
T_3	0.0	100.0	6.6
T_4	0.0	100.0	6.2

As per Table 4.1.5, the rate of mortality of Vanaraja birds during the trial period was recorded to be 3.4 per cent for the control group T_1 while it was nil for T_2, T_3 and T_4. Hence, liveability percentage was recorded as 96.6, 100.0, 100.0 and 100.0, respectively. The values for performance index were 8.8, 11.1, 6.6 and 6.2 for T_1, T_2, T_3 and T_4, respectively.

As evident from the findings that the inclusion level of linseed meal for the present study did not have any adverse effect on the survivability of the birds as the mortality was recorded to be nil. Though mortality rate of 3.4 per cent was observed in control group, it was well within the normal range. Low or nil mortality could be due to the favourable climatic condition, proper care and good management of the birds.

The present finding was in agreement with Pisal (2019) reported that feeding of linseed oil to the Giriraja poultry birds during the experimental period was zero. On the contrary, Kakade (2015) had reported higher mortality due to feeding detoxified gossypol of cotton seed cake and its value addition.

Higher performance index was observed in T_2 as compared to the control T_1 which corroborated with the findings of Kumari *et al*. (2014) who had also reported higher performance index due to dietary linseed supplementation. Better performance observed in group T_2 in the present study might be attributed to better FCR at this level of the linseed meal which is a good source of quality protein and other beneficial bioactive compounds.

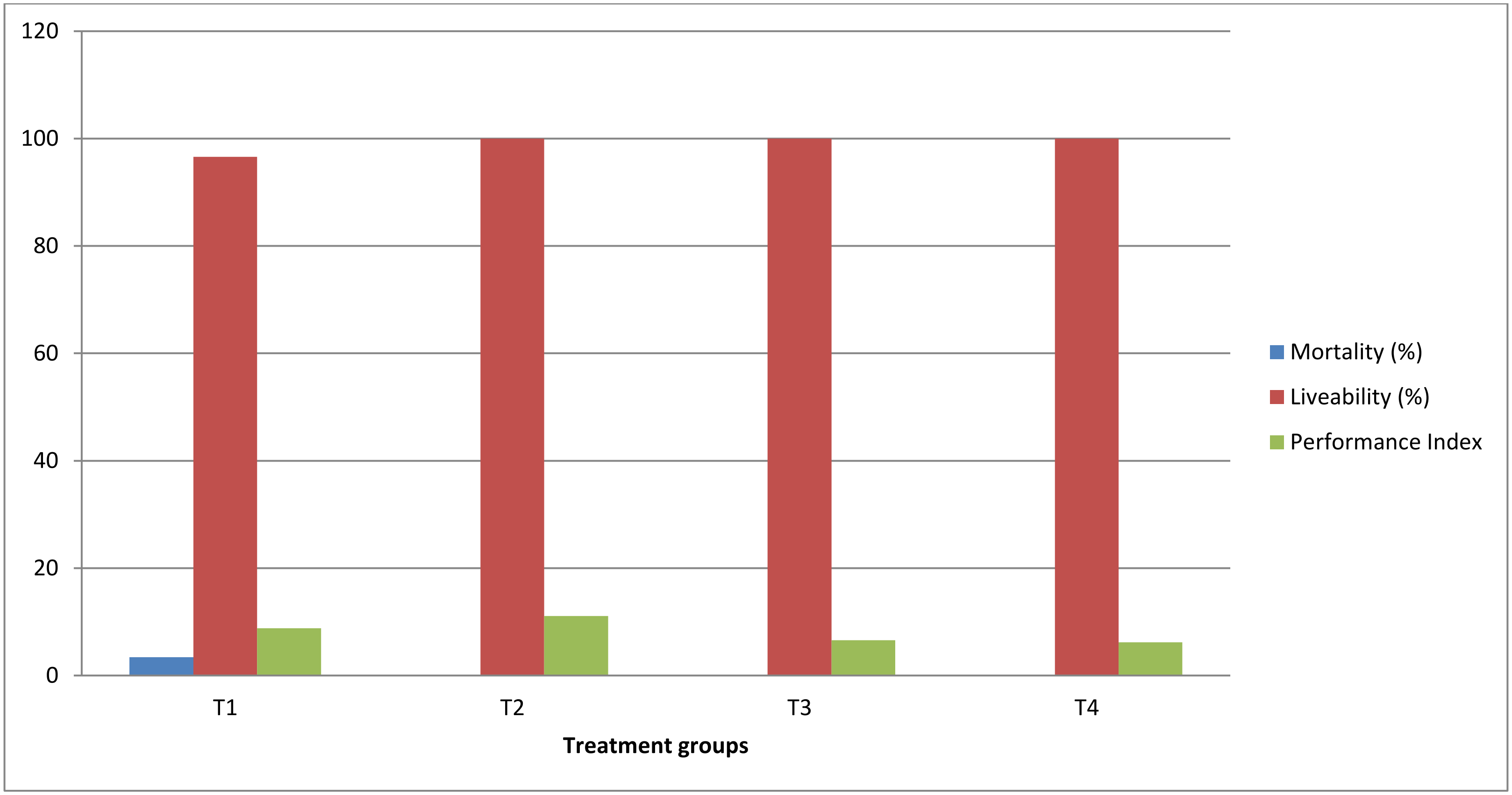

Fig 4.1.5: Mortality, liveability and performance index of Vanaraja birds in different treatment groups

4.2 Reproductive traits

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

Age at sexual maturity, body weight and egg weight at onset of egg production was calculated and are presented in Table 4.2.1. They are graphically represented in Fig 4.2.1 and their mean statistical analyses are shown in Appendix 5 (REPRODUCTIVE TRAITS)

Table 4.2.1 Effect of linseed meal on age at sexual maturity, body weight and egg weight at onset of egg production of Vanaraja birds in different treatment groups

Treatment groups	Age at sexual maturity(days)	Body weight at onset of egg production (g/bird)	Egg weight at onset of egg production(g/egg)
T_1	140.8	2198.0^{d}	41.2^{c}
T_2	141.4	2100.0^{c}	34.2^{a}
T_3	141.2	2039.0^{a}	40.8^{bc}
T_4	141.0	2080.0^{b}	38.2^{b}
Mean	141.1	2104.2	38.6
SEM	0.3	6.6	0.8
CD Value (0.05)	NS	20.00	2.60

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

*Figures bearing no superscripts in a column did not differ significantly (P>0.05)

According to the Table 4.2.1 age at sexual maturity was found to be 140.8, 141.4, 141.2 and 141.0 for T_1, T_2, T_3 and T_4, respectively. Body weight at onset of egg production was observed to be 2198.0, 2100.0, 2039.0 and 2080.0 g for T_1, T_2, T_3 and T_4, respectively. The egg weight at onset of egg production (g/egg) for the respective group was 41.2, 34.2, 40.8, and 38.2.

Analysis of variance had revealed that, inclusion of linseed meal in the diet had significant effect on the body weight and egg weight at the onset of production. Lowered body weight at onset of egg production and lower egg weight was observed in groups subjected to linseed meal based diet. Researchers such as Ahmad *et al.* (2013) and Yassein *et al.* (2015) had reported that supplementation of dietary flax seed had no detrimental effects on egg quality standards or laying performance. However, on the other hand contradictory findings were reported by Hazim *et al.* (2010); Al Daraji *et al.* (2011) and Kirubakaran *et al.* (2011) who had reported that linseed supplementation in laying hens diet resulted in significant increase in egg weight and improvement in egg quality parameters. The reasons for variation in the findings could be the difference in level of linseed used, form of linseed used, type of feed and the strains of birds.

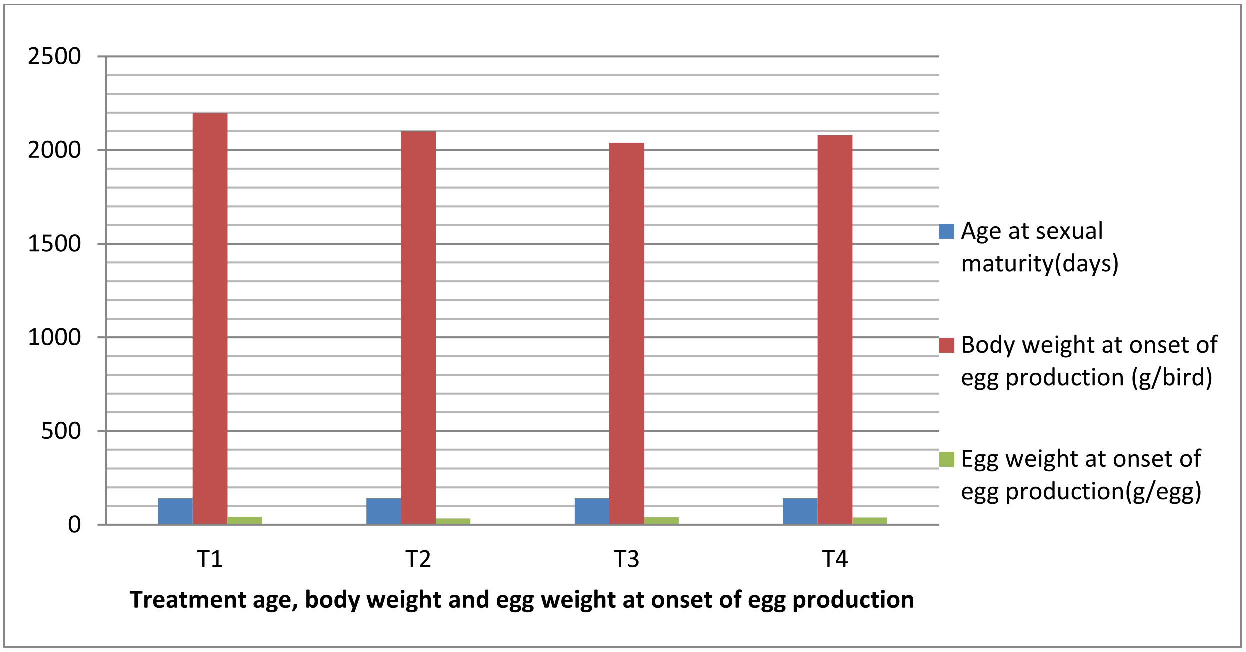

Fig 4.2.1: Effect of dietary supplementation of linseed meal on age at sexual maturity (day/bird), body weight (g/bird) and egg weight (g) at onset of egg production in Vanaraja birds.

4.2.2 Egg production and Egg quality traits

The total egg production per bird, clutch size and egg quality traits for the different treatment groups are presented in the Table 4.2.2.They are graphically represented in Fig 4.2.2 and their mean statistical analyses are shown in Appendix 6 (EGG PRODUCTION and EGG QUALITY TRAITS)

Table 4.2.2 Effect of linseed meal on the egg production and egg quality traits of Vanaraja birds in different treatment

Treatment group	Total egg production (nos./bird)	Clutch size (nos.)	Egg weight (g)	Yolk weight (g)	Albumen weight (g)	Haugh Unit	Yolk cholesterol (mg/g yolk)
T_1	94.5^c	6.4^b	55.2^c	16.1^b	25.1^b	85.7^b	10.8
T_2	73.43^a	5.5^a	52.0^b	14.6^a	27.1^b	82.9^b	10.9
T_3	83.8^b	5.8^a	46.0^a	16.3^b	27.5^b	67.6^a	11.3
T_4	86.8^b	6.4^b	53.4^{bc}	13.7^a	21.7^a	93.7^c	11.1
Total	338.3	24.1	206.6	60.7	101.4	329.9	44.1
Mean	84.5	6.0	51.7	15.2	25.4	82.5	11.0
SEM ±	1.2	0.18	0.9	0.4	0.9	0.9	0.17
CD Value (0.05)	3.9	0.6	2.7	1.4	2.8	2.8	NS

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

As per the Table 4.2.2, the total egg production (nos/bird) per bird for T_1,T_2, T_3 and T_4 was recorded as 94.5, 73.43, 83.8 and 86.8, respectively. Meanwhile the respective egg size per clutch was recorded as 6.4, 5.5, 5.8 and 6.4 numbers. The egg weight, yolk weight and albumen weight for the different treatment T_1, T_2, T_3 and T_4 was 55.2, 52.0, 46.0 and 53.4g; 16.1, 14.6, 16.3 and 13.7g and 25.1, 27.1, 27.5 and 21.7g, respectively. The value of Haugh unit was recorded as 85.7, 82.9, 67.6 and 93.7g for T_1, T_2, T_3 and T_4, respectively.The corresponding value for yolk cholesterol (mg/g yolk) was 10.8, 10.9, 11.3 and 11.0.

Statistical analysis had revealed significant effect of dietary linseed supplementation on total egg production and clutch size. As evident from Table 4.2.2, there was decrease in egg production and clutch size in the linseed supplemented group as compared to control. Total egg production was significantly higher in control group (T_1) followed by T_4, T_3, T_2 group. Similar clutch size was observed between the groups T_1 and T_4 and the groups T_2 and T_3.

Similar to the present findings, Ahmad *et al.* (2013) and Halle and Schone (2013) had also reported that inclusion of linseed meal had suppressive effects on egg production. However, on the contrary, Mridula *et al*. (2012), Adangale (2018) and Gosh (2020) observed higher egg production due to linseed supplemention.

With regards to the egg quality traits, statistical analysis had revealed that linseed meal had significant effect on all the egg quality traits except the yolk cholesterol. From Table 4.2.2 .egg weight was found to be significantly higher in T_1 followed by T_4, T_2 and the least in T_3. However, the difference between the treatment group T_1 and T_4 and the treatment groups T_2 and T_4 was found to be non-significant. Though T_3 had the least egg weight, the values for yolk weight and albumen weight in this group was found to be significantly higher than the other groups, while the least was recorded in T_4. The higher the value of Haugh unit, the better is the quality of eggs of which it was found to be highest in T_4 followed by T_1, T_2 and the least in T_3. Irrespective of the groups, effect of linseed meal on yolk cholesterol was found to be non- significant.

The present findings was in agreement with the findings of Hazim *et al.* (2010) and Gosh (2020) who have reported significant increase in albumen weight and Haugh unit. Similarly, significant improvement in most of the egg quality traits was reported by Al Daraji *et al.* (2011). However, Hayat *et al.* (2009); Huthail and Yousef (2010); Ceylan (2011) and Adangale (2018) have reported that feeding of linseed did not affect the egg weight, yolk weight, albumen weight and Haugh units.

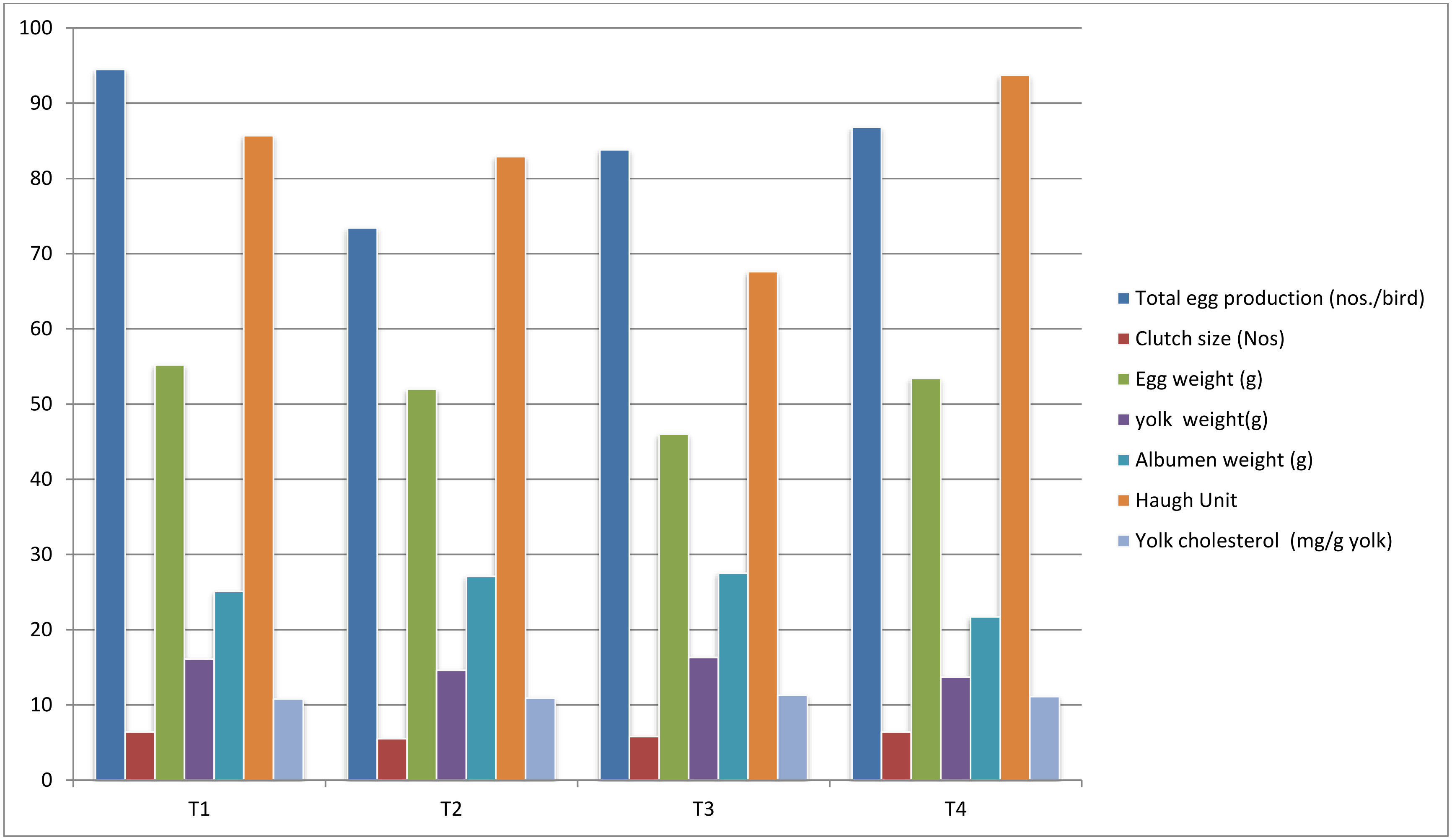

Fig: 4.2.2 Effect of linseed meal on the egg production and egg quality traits of Vanaraja birds in different treatment

4.3 Biochemical blood constituents

The biochemical constituents of blood in different treatment groups are presented in the Table 4.3. They are graphically represented in Fig 4.3 and their mean statistical analyses are shown in Appendix 7 (BLOOD CONSTITUENTS)

Table 4.3 Effect of linseed meal on blood constituents of Vanaraja birds at different age in different treatment groups.

Treatment	Cholesterol mg/dl		HDL mg/dl		LDL mg/dl		Triglycerides mg/dl	
	4th month	9th month	4th month	9th month	4th month	9th Month	4th month	9th month
T_1	164.2[d]	146.5[c]	26.2	36.9[b]	56.7	23.6[a]	409.7[b]	426.9[d]
T_2	152.6[c]	135.0[b]	22.5	33.7[a]	51.1	36.2[b]	392.5[b]	318.2[c]
T_3	148.5[b]	140.4[c]	20.8	36.5[b]	74.4	54.1[d]	250.8[a]	239.1[b]
T_4	138.5[a]	113.1[a]	24.1	36.5[b]	76.4	45.8[c]	204.8[a]	106.3[a]
Mean	86.2	76.4	13.3	20.5	36.9	22.8	179.6	155.7
SEM ±	1.0	1.8	1.9	0.3	9.7	1.6	3.69	5.1
CD Value (0.05)	3.2	6.1	NS	1.1	NS	4.9	113.6	15.8

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

Supplementation of linseed meal was found to have significant effect on the blood constituents of Vanaraja birds. As per the Table 4.2.3, the cholesterol level at 4 and 9 months of age was found to be significantly higher in control group T_1 and the least was in T_4 (12 per cent). Similarly, the values for HDL both at 4 months and 9 months of age were observed to be higher in control group T_1 while the least values for HDL at 4 months and 9 months of age was observed at 8 per cent and 4 per cent linseed supplementation. LDL was observed to be unaffected when GNC was replaced with linseed meal up to 4 months. However, it was found to be higher ($p<0.05$) with at 8 per cent dietary linseed at 9 months of age and the least was observed in control group.

Triglyceride was found to be significantly higher in control group both at 4 and 9 months while T_4 had the lowest triglyceride. Hence, inclusion of linseed showed positive effect on the cholesterol and triglycerides.

The present finding was in line with Yassein*et al*. (2015) and Shunthwal *et al.* (2017) who had reported that dietary supplementation of flax seed showed significant effect on cholesterol, LDL and triglycerides. Decreased level of cholesterol and triglyceride was reported by Gosh (2020) and Rathaur *et al*. (2022) as a result of feeding linseed based diet.

Contrary to the above findings, Azad *et al.* (2009), Lopes *et al.* (2013) and Starcevic *et al*. (2014) reported that the blood constituents viz; serum triglycerides, total cholesterol, HDL and LDL cholesterol, were unaffected when birds were subjected to dietary treatments containing linseed or mustard seed meal.

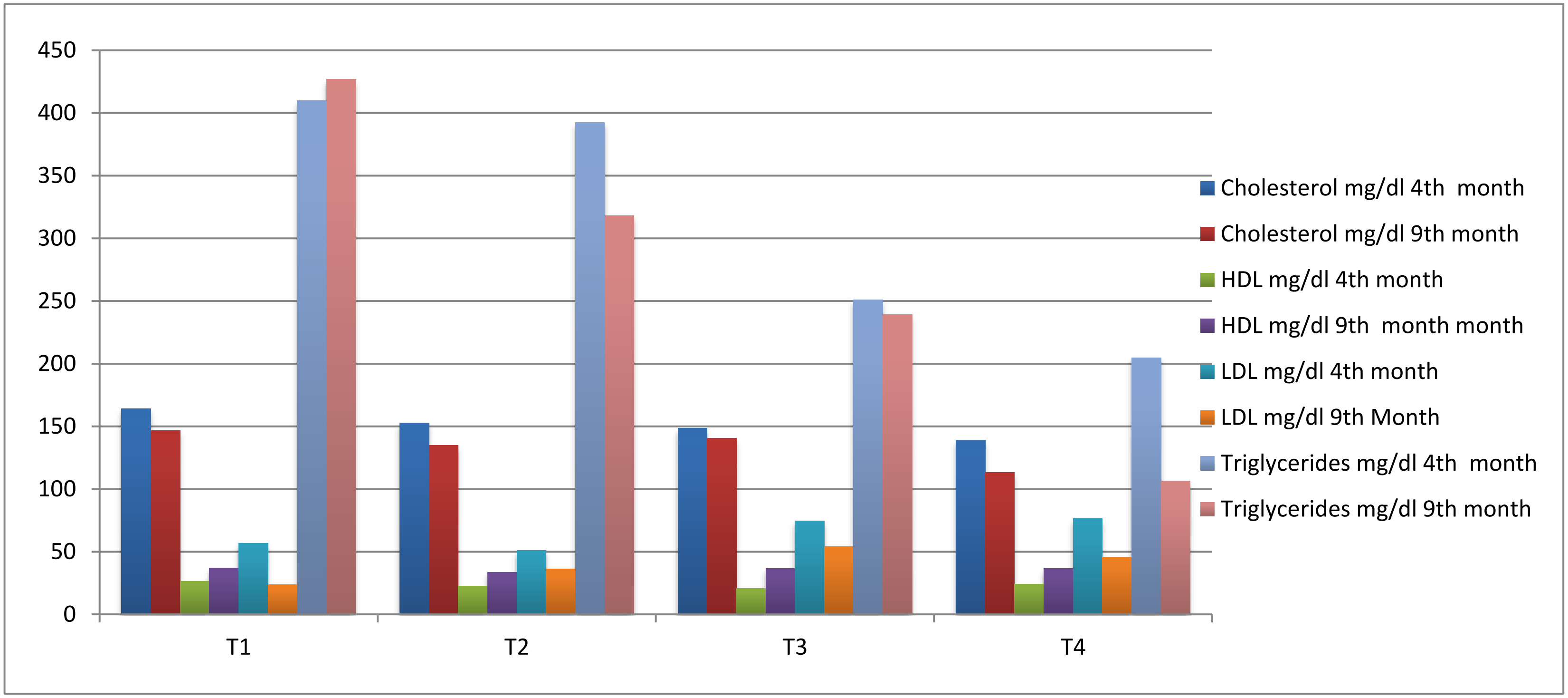

Fig 4.3: Effect of dietary supplementation of linseed meal on Biochemical constituents of blood of Vanaraja birds at different ages (month) in different treatment groups

4.4 Economics

The effect of linseed meal on the economics of Vanaraja bird production in different treatment groups are presented in the Table 4.4.

Table 4.4 Effect of linseed meal on the economics of Vanaraja bird's production

Particulars	Treatment			
	T_1	**T_2**	**T_3**	**T_4**
Cost of bird (Rs/bird)	40	40	40	40
Feed cost (Rs)	1095.2	896.6	880.5	1048.6
Cost of Linseed (Rs)	0	31.6	69.5	118.5
Cost of medicine (Rs)	12.5	12.5	12.5	12.5
Cost of labour (Rs)	70	70	70	70
Miscellaneous cost (Rs)	33.3	33.3	33.3	33.3
Cost of production (Rs)	1251.0	1084.0	1105.8	1322.9
Average Weight of bird (Kg)	2.9	2.8	2.7	2.8
Production cost per kg live wt. (Rs)	431.37	387.14	409.55	472.46
Sale of one live bird @Rs. 250 per kg	725	700	675	700
Sale of eggs @9.3 per egg	10.1	7.9	9	9.3
Sale of gunny bags @Rs.20/bag	14.2	12.6	13.8	16
Total receipt (Rs)/bird	1643.5	1395.5	1468.4	1532.2
Net profit (Rs)/bird	329.5	311.5	362.6	209.3
Net profit per kg live weight (Rs)	113.62	111.25	134.29	74.75
Benefit-cost ratio	1.31	1.28	1.32	1.15

As per the Table 4.4, average cost of production per bird for T_1, T_2, T_3 and T_4 was 1251.0, 1084.0, 1105.8 and 1322.9rupees, respectively. The corresponding values for cost of production per kg live weight were 431.37, 387.14, 409.55,and 472.46 respectively. The net profit per bird for T_1, T_2, T_3 and $T_4$was 329.5, 311.5,362.6, 209.3 rupees; respectively while the corresponding net profit per kg live weight was 113.62, 111.25, 134.29, 74.75 rupees. The maximum (1.32)and minimum (1.15) benefit cost ratio was observed in T_3 and $T_{4,}$ respectively.

From the given data, the highest and the lowest net profit per bird was obtained from T_3 and $T_{4,}$ respectively. Similarly, net profit per kg live weight was observed to be maximum in T_3 and the least in T_4. In terms of economy, linseed meal at the rate of 8 per cent resulted in higher net income and benefit- cost ratio while the least was in T_4. Similar to the present findings, Hazim *et al.* (2011), Mangesh (2017) and Pisal (2019) reported higher income generation as a result of feeding poultry birds with linseed oil or linseed powder based diet.

CHAPTER – 5

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

Poultry holds a very important place both in urban and rural sector in terms of nutrition, livelihood, and job creation and as an industry. Poultry and poultry production being readily available even in rural areas, it provides nutritional security to the rural masses. Further, it creates avenue for income generation activity and employment for farmers, entrepreneurs and unemployed youths.

Small scale poultry farming by local farmers, SHGs, youths, housewives and even employed people is gaining popularity in the region. Rearing of poultry birds particularly improved birds have gained significance in rural areas due to its higher adaptability and productivity. Vanaraja is an innovative bird for the farmers which has the resemblance of the native birds and are able to thrive well even in free range and able to meet the domestic need and support livelihood activities.

Recently, there has been a surge in production and demand for functional food that is safe and has health benefits particularly with the growing concern for coronary heart diseases and other life threatening diseases. There is possibility of changing the nutritional profile of poultry eggs and meat through dietary approaches such as the addition of particular nutrients, herbs, or medications with specialised medicinal and functional qualities which is reasonably simple and affordable to improve consumers' health and nutritional condition.

Linseed (*Linum usitatissimum*), often known as flaxseed, is widely cultivated oil seed which is largely grown for its fibre, seed, oil and by- products. It is known to be a rich source of alpha-linolenic acid, high quality protein, soluble fiber and phenolic compounds. Linseed had been successfully used in poultry feed to improve their growth performance, positive change in the blood constituents and fatty acid profiles of the eggs. A thorough and systematic investigation using different levels of linseed meal in poultry diet will not only help to generate useful data on the performance of the birds but enable low cost enrichment of poultry products. Hence, the present study entitled "Inclusion of linseed (*Linum usitatissimum*) meal on the performance of Vanaraja birds" was carried out with the following objectives:

4. To study the productive and reproductive performance of Vanaraja birds fed with linseed meal.
5. To determine the economics of production of Vanaraja birds feed with linseed meal.
6. To study the biochemical constituents of blood and egg of Vanaraja birds fed with linseed meal.

To carry out the study, a total of 120 numbers of female Vanaraja chicks were reared for a period of nine months which were randomly divided into four treatment groups T_1, T_2 T_3 and T_4 of 30 birds each having five replications per treatment following Randomized Block Design and were subjected to four dietary levels of linseed meal containing 0 per cent, 4 per cent, 8 per cent and 12 per cent, respectively. The birds were reared under deep litter system up to 8 weeks of age and thereafter in cages following standard management practices. They were fed with starter ration from 0-8 weeks, grower ration from 8-20 and layer ration after 20 weeks. Initial body weight was recorded at day old and thereafter it was recorded fortnightly. While feed intake and egg production was recorded daily. Egg quality traits were measured. Blood was collected at four months and nine months of age, to evaluate the blood constituents.

5.1 Productive traits

5.1.1 Body weight

At the end of the 20th fortnight, the average body weight for the various treatment groups was 2884.0g, 2776.0g, 2701.0g, and 2785.0g per bird for the T_1, T_2, T_3, and T_4 groups, respectively. The statistical analysis had revealed significant effect of dietary supplementation of linseed meal on the body weight of Vanaraja birds. The body weight was found to be significantly ($p<0.05$) higher in control group T_1 followed by T_2, T_4 and the least was in T_3.

5.1.2 Body Weight gain

The overall mean body weight gain for the treatment groups T_1, T_2, T_3 and T_4, was recorded to be 144.2, 138.8, 135.1 and 139.3 g per bird, respectively. Linseed meal had significant ($p<0.05$) effect on the body weight gain of the birds and the gain in weight was found to be significantly higher in control group T_1 followed by T_4, T_2 and least in T_3.

5.1.3 Feed Intake

The mean feed intake for the groups T_1, T_2, T_3, and T_4 was 945.8g, 790.7g, 868.4g, and 987.4g per bird, respectively. The mean feed intake per fortnight was found to be significantly ($p<0.05$) higher in T_4 followed by T_1, T_3 and T_2.

5.1.4 Feed conversion ratio

Across all treatment groups, the mean feed conversion ratio of Vanaraja birds was 11.6, 9.2, 15.0, and 16.5 for T_1, T_2, T_3, and T_4 groups, respectively. The diet replaced with 4 % level of linseed showed significantly better feed conversion ratio than the rest of the groups T_1, T_3 and T_4.

5.1.5 Mortality/Liveability and Performance Index

The mortality percentage was 3.4 for the treatment group T_1 and nil for the rest of the groups. Hence, for the various treatment groups $T_{1,}$ $T_{2,}$ T_3 and T_4 was 3.4, 0.0, 0.0 and 0.0 proportionately, liveability per cent was 96.6, 100.0, 100.0, and 100.0 percent for T_1, T_2, T_3, and $T_{4,}$ respectively.

The performance indices for the treatment groups were 8.8, 11.1, 6.6, and 6.2, respectively. Group T_2 out- performed the other treatment groups.

5.2 Reproductive traits

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

Age at sexual maturity was 140.8, 141.4, 141.2, and 141.0 days, for the various treatment groups T_1, T_2, T_3, and $T_{4,}$ respectively which was found to be non- significant ($p>0.05$).

The body weights at the onset of egg production for the various treatment groups were 2198.0g, 2100.0g, 2039.0g, and 2080g, for T_1, T_2, T_3, and $T_{4,}$ respectively. Initial egg weight for the various treatment groups was 41.2g, 34.2g, 40.8g, and 38.2g/egg. Lower body weight and lower egg weight at onset of egg production was observed in groups subjected to linseed meal based diet.

5.2.2 Egg production and Egg quality traits

There was decrease ($p<0.05$) in egg production and clutch size in the linseed supplemented group as compared to control. Total egg production was significantly higher in control group (T_1) followed by T_4,T_3, T_2 group.

Statistical analysis have revealed that linseed meal supplementation showed significant ($p<0.05$) effect on all the egg quality traits except the yolk cholesterol. Egg weight was found to be significantly higher in T_1 followed by T_4, T_2 and the least in T_3. Though T_3 had the least egg weight, the values for yolk weight and albumen weight in this group was found to be significantly higher while the least was recorded in T_4.

Haugh unit was found to be highest ($p<0.05$) in T_4 followed by T_1, T_2 and the least in T_3. Irrespective of the groups, effect of linseed meal on yolk cholesterol was found to be non- significant ($p>0.05$).

5.3 Biochemical parameters

Supplementation of linseed meal was found to have significant effect on the blood constituents of Vanaraja birds. The cholesterol level at 4 and 9 months was found to be significantly higher in control group T_1 and the least was in T_4 (12 per cent).

Similarly, the values for HDL both at 4 months and 9 months of age were observed to be higher in control group T_1 while the least values for HDL were observed at 8 per cent and 12 per cent linseed supplementation.

LDL was found to be significantly ($p<0.05$) higher at 12 % and 8% dietary linseed at 4 and 9 months of age, respectively.

Triglycerides were found to be significantly ($p<0.05$) higher in control group both at 4 and 9 months while T_4 had the lowest triglyceride. Hence, inclusion of linseed showed positive effect on the cholesterol and triglycerides.

5.4 Economics

Total cost of production per bird and per kg live weight was highest in group T_4 (472.46) followed by T_1, T_3 and least in T_2 (387.14). Highest net profit per bird and net profit per kg weight gain was recorded in T_3 followed by T_1, T_2 and the least in T_4. Linseed meal at the rate of 8 per cent resulted in higher net income and benefit- cost ratio while the least was in T_4.

5.5 Conclusions:

1. Body weight was significantly higher in T_1 (1870.5g) followed by T_2, T_4 and least in T_3 (1778.1g).
2. There was significant ($p<0.05$) difference in overall body weight gain amongst the treatment groups due to linseed meal supplementation and the highest value was seen in T_1 (144.2g)
3. Feed intake was significantly ($p<0.05$) lower in T_2 (790.7g) followed by T_3, T_1 and the highest in T_4 (987.4g).
4. Best mean FCR was observed in group T_2 (9.2).
5. Mortality rate was (3.4) in T_1 group while it was nil in groups fed with linseed.
6. Best performance index was observed in T_2. (11.1).
7. Age at sexual maturity was found to be non- significant ($p>0.05$).
8. Lower body weight and lower egg weight at onset of egg production was observed in groups subjected to linseed meal based diet.
9. Egg production was significantly higher in control group (94.5nos.) followed by T_4, T_3 and the least in T_2 (73.43 nos.) and higher egg weight was recorded in T_1 (55.2).
10. Clutch size was significantly ($p<0.05$) higher in control group (6.4nos.) however it did not differ with T_4.
11. Yolk weight (16.3g) and albumen weight (27.5g) was found to be higher in T_3 and least was in T_4 group.
12. Haugh unit was found to be maximum (93.7) in T_4 among the treatment groups.

13. No significant difference was seen in yolk cholesterol.
14. The serum cholesterol level at 4 and 9 months of age was found to be significantly higher in control group T_1 and the least was in T_4.
15. The values for HDL both at 4 months and 9 months of age were observed to be higher in control group T_1 (36.9)while the least values for HDL was observed at 4 per cent linseed supplementation group.
16. LDL was found to be significantly higher at T_3 (8 per cent) dietary linseed at 4, 9 months of age.
17. Triglyceride was found to be significantly higher in control group both at 4 and 9 months while T_4 had the lowest triglyceride.
18. Highest net profit per bird and net profit per kg weight gain was recorded in T_3 and least in T_4.

On the basis of the above findings, it may be concluded that groups fed with linseed meal performed better in terms of egg quality traits, blood constituents and net return. Considering the economy of production, use of linseed meal upto 8 per cent may be advocated to increase production and enhance quality for maximum net return.

5.6 Future plan

1. Further studies using different levels of linseed meal on productive and reproductive traits for longer duration can be carried.
2. Further investigation on the haemato-biochemical blood constituents and egg parameters can be done.
3. In-depth studies on the enrichment of meat and eggs with linseed meal can be carried out.

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APPENDICES

APPENDIX-1 (BODY WEIGHT)

ANOVA-1 BODY WEIGHT

ANOVA 1.1 Body weight at day-old

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value					
					Calculated	Tabulation	LOGIC		CV%	13.77
1	Block/Rep	4.0	130.0	32.5	1.1	3.3	NS		SEM	2.40
2	Treatment	3.0	20.0	6.7	0.2	3.5	NS		CD	7.40
3	Error	12.0	346.0	28.8						
4	Total									

ANOVA 1.2 Body weight at 1st fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value					
					Calculated	Tabulation	LOGIC		CV%	10.73
1	Block/Rep	4.0	525.2	131.3	0.1	3.3	NS		SEM	14.45
2	Treatment	3.0	374.4	124.8	0.1	3.5	NS		CD	44.52
3	Error	12.0	12523.0	1043.6						
4	Total									

ANOVA 1.3 Body weight at 2nd fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value					
					Calculated	Tabulation	LOGIC		CV%	2.30
1	Block/Rep	4.0	216.1	54.0	0.3	3.3	NS		SEM	5.81
2	Treatment	3.0	5503.1	1834.4	10.9	3.5	SIGNIFICANT		CD	17.91
3	Error	12.0	2027.8	169.0						
4	Total									

ANOVA 1.4 Body weight at 3rd fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value					
					Calculated	Tabulation	LOGIC		CV%	1.68
1	Block/Rep	4.0	1739.7	434.9	3.1	3.3	NS		SEM	5.27
2	Treatment	3.0	10781.8	3593.9	25.9	3.5	SIGNIFICANT		CD	16.23
3	Error	12.0	1664.6	138.7						
4	Total									

ANOVA 1.5 Body weight at 4th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value					
					Calculated	Tabulation	LOGIC		CV%	1.86
1	Block/Rep	4.0	1411.0	352.8	1.0	3.3	NS		SEM	8.28
2	Treatment	3.0	3270.0	1090.0	3.2	3.5	NS		CD	25.51
3	Error	12.0	4113.0	342.8						
4	Total									

ANOVA 1.6 Body weight at 5th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value					
					Calculated	Tabulation	LOGIC		CV%	2.56
1	Block/Rep	4.0	3150.8	787.7	0.9	3.3	NS		SEM	13.47
2	Treatment	3.0	389791.4	129930.5	143.2	3.5	SIGNIFICANT		CD	41.51
3	Error	12.0	10888.4	907.4						
4	Total									

ANOVA 1.7 Body weight at 6th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value					
					Calculated	Tabulation	LOGIC		CV%	0.85
1	Block/Rep	4.0	386.5	96.6	0.7	3.3	NS		SEM	5.38
2	Treatment	3.0	90403.8	30134.6	208.1	3.5	SIGNIFICANT		CD	16.58
3	Error	12.0	1737.5	144.8						
4	Total									

ANOVA 1.8 Body weight at 7th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value					
					Calculated	Tabulation	LOGIC		CV%	1.73
1	Block/Rep	4.0	3580.0	895.0	1.0	3.3	NS		SEM	13.15
2	Treatment	3.0	21270.0	7090.0	8.2	3.5	SIGNIFICANT		CD	40.54
3	Error	12.0	10382.0	865.2						
4	Total									

ANOVA 1.9 Body weight at 8th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value					
					Calculated	Tabulation	LOGIC		CV%	0.74
1	Block/Rep	4.0	1789.0	447.3	2.3	3.3	NS		SEM	6.25
2	Treatment	3.0	79973.8	26657.9	136.4	3.5	SIGNIFICANT		CD	19.26
3	Error	12.0	2345.0	195.4						
4	Total									

ANOVA 1.10 Body weight at 9th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	0.95
1	Block/Rep	4.0	689.5	172.4	0.5	3.3	NS		SEM	8.55
2	Treatment	3.0	52723.8	17574.6	48.1	3.5	SIGNIFICANT		CD	26.35
3	Error	12.0	4388.5	365.7						
4	Total									

ANOVA 1.11 Body weight at 10th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	1.82
1	Block/Rep	4.0	9276.2	2319.1	1.6	3.3	NS		SEM	17.14
2	Treatment	3.0	63026.2	21008.7	14.3	3.5	SIGNIFICANT		CD	52.83
3	Error	12.0	17632.6	1469.4						
4	Total									

ANOVA 1.12 Body weight at 11th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	1.21
1	Block/Rep	4.0	2715.5	678.9	1.0	3.3	NS		SEM	11.89
2	Treatment	3.0	46273.8	15424.6	21.8	3.5	SIGNIFICANT		CD	36.65
3	Error	12.0	8488.5	707.4						
4	Total									

ANOVA 1.13 Body weight at 12th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	0.74
1	Block/Rep	4.0	2828.5	707.1	2.5	3.3	NS		SEM	7.56
2	Treatment	3.0	30790.0	10263.3	35.9	3.5	SIGNIFICANT		CD	23.3
3	Error	12.0	3429.5	285.8						
4	Total									

ANOVA 1.14 Body weight at 13th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	0.48
1	Block/Rep	4.0	1325.0	331.3	2.6	3.3	NS		SEM	5.01
2	Treatment	3.0	30753.8	10251.3	81.5	3.5	SIGNIFICANT		CD	15.5
3	Error	12.0	1509.0	125.8						
4	Total									

ANOVA 1.15 Body weight at 14th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	0.59
1	Block/Rep	4.0	2637.5	659.4	3.2	3.3	NS		SEM	6.42
2	Treatment	3.0	32850.0	10950.0	53.1	3.5	SIGNIFICANT		CD	19.8
3	Error	12.0	2476.5	206.4						
4	Total									

ANOVA 1.16 Body weight at 15th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation			
							LOGIC	CV%	0.58
1	Block/Rep	4.0	732.5	183.1	0.9	3.3	NS	SEM	6.45
2	Treatment	3.0	33733.8	11244.6	54.1	3.5	SIGNIFICANT	CD	19.9
3	Error	12.0	2495.5	208.0					
4	Total								

ANOVA 1.17 Body weight at 16th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation			
							LOGIC	CV%	0.65
1	Block/Rep	4.0	2584.0	646.0	2.4	3.3	NS	SEM	7.33
2	Treatment	3.0	36193.8	12064.6	45.0	3.5	SIGNIFICANT	CD	22.6
3	Error	12.0	3220.0	268.3					
4	Total								

ANOVA 1.18 Body weight at 17th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation			
							LOGIC	CV%	0.49
1	Block/Rep	4.0	260.0	65.0	0.4	3.3	NS	SEM	5.71
2	Treatment	3.0	33513.8	11171.3	68.5	3.5	SIGNIFICANT	CD	17.6
3	Error	12.0	1958.0	163.2					
4	Total								

ANOVA 1.19 Body weight at 18th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation			
							LOGIC	CV%	0.85
1	Block/Rep	4.0	2410.5	602.6	1.2	3.3	NS	SEM	10.1
2	Treatment	3.0	57215.0	19071.7	37.0	3.5	SIGNIFICANT	CD	31.3
3	Error	12.0	6177.5	514.8					
4	Total								

ANOVA 1.20 Body weight at 19th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation			
							LOGIC	CV%	1.17
1	Block/Rep	4.0	6706.0	1676.5	1.6	3.3	NS	SEM	14.3
2	Treatment	3.0	33343.8	11114.6	10.9	3.5	SIGNIFICANT	CD	44.0
3	Error	12.0	12234.0	1019.5					
4	Total								

ANOVA 1.21 Body weight at 20th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	0.82
1	Block/Rep	4.0	1461.5	365.4	0.7	3.3	NS		SEM	10.2
2	Treatment	3.0	84645.0	28215.0	54.0	3.5	SIGNIFICANT		CD	31.5
3	Error	12.0	6274.5	522.9						
4	Total									

APPENDIX-2 (BODY WEIGHT GAIN)

ANOVA-2 BODY WEIGHT GAIN

ANOVA 2.1 Body weight gain at 1st fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	12.8
1	Block/Rep	4.0	306.5	76.6	0.1	3.3	NS		SEM	15.0
2	Treatment	3.0	333.2	111.1	0.1	3.5	NS		CD	46.2
3	Error	12.0	13471.7	1122.6						
4	Total									

ANOVA 2.2 Body weight gain at 2rd fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	9.63
1	Block/Rep	4.0	2426.4	606.6	0.9	3.3	NS		SEM	11.4
2	Treatment	3.0	6952.5	2317.5	3.6	3.5	SIGNIFICANT		CD	35.1
3	Error	12.0	7799.0	649.9						
4	Total									

ANOVA 2.3 Body weight gain at 3th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	10.2
1	Block/Rep	4.0	1932.6	483.1	2.6	3.3	NS		SEM	6.12
2	Treatment	3.0	4331.5	1443.8	7.7	3.5	SIGNIFICANT		CD	18.9
3	Error	12.0	2249.8	187.5						
4	Total									

ANOVA 2.4 Body weight gain at 4th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	Tabulation				
							LOGIC		CV%	8.33
1	Block/Rep	4.0	1031.2	257.8	0.4	3.3	NS		SEM	10.9
2	Treatment	3.0	8774.1	2924.7	4.9	3.5	SIGNIFICANT		CD	33.6
3	Error	12.0	7115.5	593.0						
4	Total									

ANOVA 2.5 Body weight gain at 5th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	Tabulation				
							LOGIC		CV%	16.4
1	Block/Rep	4.0	4967.8	1242.0	1.4	3.3	NS		SEM	13.5
2	Treatment	3.0	399875.4	133291.8	147.1	3.5	SIGNIFICANT		CD	41.5
3	Error	12.0	10871.4	905.9						
4	Total									

ANOVA 2.6 Body weight gain at 6th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	Tabulation				
							LOGIC		CV%	12.2
1	Block/Rep	4.0	1543.3	385.8	0.5	3.3	NS		SEM	12.9
2	Treatment	3.0	156442.6	52147.5	62.3	3.5	SIGNIFICANT		CD	39.9
3	Error	12.0	10043.9	837.0						
4	Total									

ANOVA 2.7 Body weight gain at 7th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	Tabulation				
							LOGIC		CV%	12.2
1	Block/Rep	4.0	2202.5	550.6	0.5	3.3	NS		SEM	15.6
2	Treatment	3.0	41193.8	13731.3	11.3	3.5	SIGNIFICANT		CD	48.1
3	Error	12.0	14597.5	1216.5						
4	Total									

ANOVA 2.8 Body weight gain at 8th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	Tabulation				
							LOGIC		CV%	17.7
1	Block/Rep	4.0	2898.5	724.6	0.7	3.3	NS		SEM	14.3
2	Treatment	3.0	42303.8	14101.3	13.8	3.5	SIGNIFICANT		CD	44.0
3	Error	12.0	12243.5	1020.3						
4	Total									

ANOVA 2.9 Body weight gain at 9th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	16.5
1	Block/Rep	4.0	1096.5	274.1	0.5	3.3	NS		SEM	10.1
2	Treatment	3.0	19460.0	6486.7	12.7	3.5	SIGNIFICANT		CD	31.1
3	Error	12.0	6121.5	510.1						
4	Total									

ANOVA 2.10 Body weight gain at 10th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	8.33
1	Block/Rep	4.0	1031.2	257.8	0.4	3.3	NS		SEM	10.9
2	Treatment	3.0	8774.1	2924.7	4.9	3.5	SIGNIFICANT		CD	33.6
3	Error	12.0	7115.5	593.0						
4	Total									

ANOVA 2.11 Body weight gain at 11th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	61.5
1	Block/Rep	4.0	6171.7	1542.9	0.6	3.3	NS		SEM	22.6
2	Treatment	3.0	3376.4	1125.5	0.4	3.5	NS		CD	69.7
3	Error	12.0	30697.1	2558.1						
4	Total									

ANOVA 2.12 Body weight gain at 12th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	28.0
1	Block/Rep	4.0	3122.0	780.5	1.4	3.3	NS		SEM	10.4
2	Treatment	3.0	5983.8	1994.6	3.7	3.5	SIGNIFICANT		CD	32.0
3	Error	12.0	6460.0	538.3						
4	Total									

ANOVA 2.13 Body weight gain at 13th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	24.0
1	Block/Rep	4.0	2030.0	507.5	1.4	3.3	NS		SEM	8.63
2	Treatment	3.0	6613.8	2204.6	5.9	3.5	SIGNIFICANT		CD	26.6
3	Error	12.0	4466.0	372.2						
4	Total									

ANOVA 2.14 Body weight gain at 14th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	22.4
1	Block/Rep	4.0	1403.5	350.9	1.5	3.3	NS		SEM	6.90
2	Treatment	3.0	2523.8	841.3	3.5	3.5	SIGNIFICANT		CD	21.2
3	Error	12.0	2852.5	237.7						
4	Total									

ANOVA 2.15 Body weight gain at 15th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	41.5
1	Block/Rep	4.0	3423.5	855.9	1.3	3.3	NS		SEM	11.6
2	Treatment	3.0	943.8	314.6	0.5	3.5	NS		CD	35.6
3	Error	12.0	8026.5	668.9						
4	Total									

ANOVA 2.16 Body weight gain at 16th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	40.7
1	Block/Rep	4.0	1178.5	294.6	0.7	3.3	NS		SEM	9.46
2	Treatment	3.0	1320.0	440.0	1.0	3.5	NS		CD	29.2
3	Error	12.0	5369.5	447.5						
4	Total									

ANOVA 2.17 Body weight gain at 17th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	34.4
1	Block/Rep	4.0	2439.5	609.9	1.2	3.3	NS		SEM	10.2
2	Treatment	3.0	1050.0	350.0	0.7	3.5	NS		CD	31.3
3	Error	12.0	6194.5	516.2						
4	Total									

ANOVA 2.18 Body weight gain at 18th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	35.9
1	Block/Rep	4.0	2174.0	543.5	1.2	3.3	NS		SEM	9.68
2	Treatment	3.0	7423.8	2474.6	5.3	3.5	SIGNIFICANT		CD	29.8
3	Error	12.0	5618.0	468.2						
4	Total									

ANOVA 2.19 Body weight gain at 19th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	43.1
1	Block/Rep	4.0	10159.0	2539.8	2.9	3.3	NS		SEM	13.2
2	Treatment	3.0	15003.8	5001.3	5.8	3.5	SIGNIFICANT		CD	40.6
3	Error	12.0	10405.0	867.1						
4	Total									

ANOVA 2.20 Total mean body weight gain

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value					
					Calculated	Tabulation	LOGIC		CV%	45.6
1	Block/Rep	4.0	3033.2	758.3	1.2	3.3	NS		SEM	11.2
2	Treatment	3.0	14208.4	4736.1	7.6	3.5	SIGNIFICANT		CD	34.4
3	Error	12.0	7497.6	624.8						
4	Total									

APPENDIX-3 (FEED INTAKE)

ANOVA-3 Feed intake

ANOVA 3.1 Feed intake at 1st fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value					
					Calculated	Tabulation	LOGIC		CV%	7.21
1	Block/Rep	4.0	1128.8	282.2	0.9	3.3	NS		SEM	7.83
2	Treatment	3.0	797.8	265.9	0.9	3.5	NS		CD	24.1
3	Error	12.0	3683.2	306.9						
4	Total									

ANOVA 3.2 Feed intake at 2nd fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value					
					Calculated	Tabulation	LOGIC		CV%	1.84
1	Block/Rep	4.0	231.2	57.8	0.4	3.3	NS		SEM	5.59
2	Treatment	3.0	425.8	141.9	0.9	3.5	NS		CD	17.2
3	Error	12.0	1877.2	156.4						
4	Total									

ANOVA 3.3 Feed intake at 3rd fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value					
					Calculated	Tabulation	LOGIC		CV%	1.40
1	Block/Rep	4.0	637.7	159.4	0.9	3.3	NS		SEM	6.05
2	Treatment	3.0	10.1	3.4	0.0	3.5	NS		CD	18.6
3	Error	12.0	2193.1	182.8						
4	Total									

ANOVA 3.4 Feed intake at 4th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation	LOGIC		CV%	1.59
1	Block/Rep	4.0	1390.8	347.7	2.1	3.3	NS		SEM	5.75
2	Treatment	3.0	27382.2	9127.4	55.3	3.5	SIGNIFICANT		CD	17.7
3	Error	12.0	1981.6	165.1						
4	Total									

ANOVA 3.5 Feed intake at 5th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation	LOGIC		CV%	16.7
1	Block/Rep	4.0	24814.3	6203.6	1.5	3.3	NS		SEM	28.4
2	Treatment	3.0	164297.8	54765.9	13.6	3.5	SIGNIFICANT		CD	87.50
3	Error	12.0	48373.7	4031.1						
4	Total									

ANOVA 3.6 Feed intake at 6th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation	LOGIC		CV%	2.04
1	Block/Rep	4.0	863.2	215.8	0.8	3.3	NS		SEM	7.35
2	Treatment	3.0	218840.5	72946.8	270.2	3.5	SIGNIFICANT		CD	22.6
3	Error	12.0	3239.2	269.9						
4	Total									

ANOVA 3.7 Feed intake at 7th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation	LOGIC		CV%	1.37
1	Block/Rep	4.0	1388.3	347.1	2.1	3.3	NS		SEM	5.69
2	Treatment	3.0	80884.9	26961.6	166.3	3.5	SIGNIFICANT		CD	17.5
3	Error	12.0	1945.3	162.1						
4	Total									

ANOVA 3.8 Feed intake at 8th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation	LOGIC		CV%	1.69
1	Block/Rep	4.0	291.8	73.0	0.3	3.3	NS		SEM	6.46
2	Treatment	3.0	131167.6	43722.5	209.8	3.5	SIGNIFICANT		CD	19.9
3	Error	12.0	2501.4	208.4						
4	Total									

ANOVA 3.9 Feed intake at 9th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation			
							LOGIC	CV%	0.78
1	Block/Rep	4.0	549.2	137.3	1.7	3.3	NS	SEM	4.02
2	Treatment	3.0	240684.6	80228.2	993.3	3.5	SIGNIFICANT	CD	12.4
3	Error	12.0	969.2	80.8					
4	Total								

ANOVA 3.10 Feed intake at 10th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation			
							LOGIC	CV%	0.78
1	Block/Rep	4.0	811.5	202.9	1.6	3.3	NS	SEM	4.98
2	Treatment	3.0	42917.2	14305.7	115.6	3.5	SIGNIFICANT	CD	15.3
3	Error	12.0	1485.3	123.8					
4	Total								

ANOVA 3.11 Feed intake at 11th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation			
							LOGIC	CV%	1.54
1	Block/Rep	4.0	666.8	166.7	0.6	3.3	NS	SEM	7.40
2	Treatment	3.0	366374.6	122124.9	445.8	3.5	SIGNIFICANT	CD	22.8
3	Error	12.0	3287.2	273.9					
4	Total								

ANOVA 3.12 Feed intake at 12th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation			
							LOGIC	CV%	1.33
1	Block/Rep	4.0	1123.8	281.0	2.3	3.3	NS	SEM	4.95
2	Treatment	3.0	########	387397.4	3156.8	3.5	SIGNIFICANT	CD	15.3
3	Error	12.0	1472.6	122.7					
4	Total								

ANOVA 3.13 Feed intake at 13th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation			
							LOGIC	CV%	2.10
1	Block/Rep	4.0	1452.5	363.1	1.4	3.3	NS	SEM	7.21
2	Treatment	3.0	941137.0	313712.3	1206.8	3.5	SIGNIFICANT	CD	22.2
3	Error	12.0	3119.5	260.0					
4	Total								

ANOVA 3.14 Feed intake at 14th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	1.96
1	Block/Rep	4.0	584.2	146.0	0.7	3.3	NS		SEM	6.25
2	Treatment	3.0	574818.1	191606.0	979.8	3.5	SIGNIFICANT		CD	19.3
3	Error	12.0	2346.6	195.6						
4	Total									

ANOVA 3.15 Feed intake at 15th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	10.6
1	Block/Rep	4.0	24991.3	6247.8	0.7	3.3	NS		SEM	41.9
2	Treatment	3.0	282460.6	94153.5	10.7	3.5	SIGNIFICANT		CD	129.0
3	Error	12.0	105176.7	8764.7						
4	Total									

ANOVA 3.16 Feed intake at 16th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	1.28
1	Block/Rep	4.0	338.3	84.6	0.5	3.3	NS		SEM	5.84
2	Treatment	3.0	76976.9	25659.0	150.5	3.5	SIGNIFICANT		CD	18.0
3	Error	12.0	2045.3	170.4						
4	Total									

ANOVA 3.17 Feed intake at 17th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	8.72
1	Block/Rep	4.0	53682.8	13420.7	1.0	3.3	NS		SEM	52.9
2	Treatment	3.0	8623000.6	2874333.5	205.5	3.5	SIGNIFICANT		CD	163.0
3	Error	12.0	167861.2	13988.4						
4	Total									

ANOVA 3.18 Feed intake at 18th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	1.52
1	Block/Rep	4.0	2007.8	502.0	1.7	3.3	NS		SEM	7.68
2	Treatment	3.0	38383.4	12794.5	43.4	3.5	SIGNIFICANT		CD	23.7
3	Error	12.0	3538.6	294.9						
4	Total									

ANOVA 3.19 Feed intake at 19th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	3.30
1	Block/Rep	4.0	4915.7	1228.9	0.7	3.3	NS		SEM	18.7
2	Treatment	3.0	52649.2	17549.7	10.0	3.5	SIGNIFICANT		CD	57.7
3	Error	12.0	21010.3	1750.9						
4	Total									

ANOVA 3.20 Total mean feed intake

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F Value					
					Calculated	Tabulation	LOGIC		CV%	1.99
1	Block/Rep	4.0	190.7	47.7	0.3	3.3	NS		SEM	6.02
2	Treatment	3.0	44140.9	14713.6	81.1	3.5	SIGNIFICANT		CD	18.6
3	Error	12.0	2177.3	181.4						
4	Total									

APPENDIX-4 (FEED CONVERSION EFFICIENCY)

ANOVA-4 Feed conversion efficiency

ANOVA -4.1 Feed conversion efficiency at 1st fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value					
					Calculated	Tabulation	LOGIC		CV%	15.8
1	Block/Rep	4.0	0.0	0.0	0.5	3.3	NS		SEM	0.07
2	Treatment	3.0	0.0	0.0	0.0	3.5	NS		CD	0.20
3	Error	12.0	0.3	0.0						
4	Total									

ANOVA -4.2 Feed conversion efficiency at 2nd fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value					
					Calculated	Tabulation	LOGIC		CV%	19.6
1	Block/Rep	4.0	1.0	0.3	1.0	3.3	NS		SEM	0.23
2	Treatment	3.0	0.7	0.2	0.9	3.5	NS		CD	0.70
3	Error	12.0	3.1	0.3						
4	Total									

ANOVA 4.3 Feed conversion efficiency at 3rd fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value					
					Calculated	Tabulation	LOGIC		CV%	10.6
1	Block/Rep	4.0	5.1	1.3	2.1	3.3	NS		SEM	0.35
2	Treatment	3.0	12.1	4.0	6.7	3.5	SIGNIFICANT		CD	1.07
3	Error	12.0	7.3	0.6						
4	Total									

ANOVA 4.4 Feed conversion efficiency at 4th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation	LOGIC			
1	Block/Rep	4.0	0.1	0.0	0.2	3.3	NS		SEM	0.12
2	Treatment	3.0	1.5	0.5	6.4	3.5	SIGNIFICANT		CD	0.38
3	Error	12.0	0.9	0.1						
4	Total									

CV% 9.84

ANOVA 4.5 Feed conversion efficiency at 5th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation	LOGIC		CV%	84.7
1	Block/Rep	4.0	64.8	16.2	1.0	3.3	NS		SEM	1.78
2	Treatment	3.0	408.0	136.0	8.6	3.5	SIGNIFICANT		CD	5.47
3	Error	12.0	189.2	15.8						
4	Total									

ANOVA 4.6 Feed conversion efficiency at 6th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation	LOGIC		CV%	35.0
1	Block/Rep	4.0	6.5	1.6	0.8	3.3	NS		SEM	0.65
2	Treatment	3.0	82.6	27.5	13.1	3.5	SIGNIFICANT		CD	2.00
3	Error	12.0	25.3	2.1						
4	Total									

ANOVA 4.7 Feed conversion efficiency at 7th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation	LOGIC		CV%	11.6
1	Block/Rep	4.0	0.1	0.0	0.2	3.3	NS		SEM	0.17
2	Treatment	3.0	6.7	2.2	14.7	3.5	SIGNIFICANT		CD	0.54
3	Error	12.0	1.8	0.2						
4	Total									

ANOVA 4.8 Feed conversion efficiency at 8th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation	LOGIC		CV%	26.7
1	Block/Rep	4.0	9.5	2.4	1.1	3.3	NS		SEM	0.65
2	Treatment	3.0	108.5	36.2	17.1	3.5	SIGNIFICANT		CD	2.00
3	Error	12.0	25.3	2.1						
4	Total									

ANOVA 4.9 Feed conversion efficiency at 9th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation	LOGIC		CV%	24.3
1	Block/Rep	4.0	15.9	4.0	0.8	3.3	NS		SEM	0.99
2	Treatment	3.0	100.8	33.6	6.8	3.5	SIGNIFICANT		CD	3.05
3	Error	12.0	58.9	4.9						
4	Total									

ANOVA 4.10 Feed conversion efficiency at 10th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	8.47
1	Block/Rep	4.0	0.4	0.1	0.6	3.3	NS		SEM	0.19
2	Treatment	3.0	3.8	1.3	7.4	3.5	SIGNIFICANT		CD	0.57
3	Error	12.0	2.1	0.2						
4	Total									

ANOVA 4.11 Feed conversion efficiency at 11th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	99.0
1	Block/Rep	4.0	712.2	178.0	0.4	3.3	NS		SEM	9.64
2	Treatment	3.0	548.6	182.9	0.4	3.5	NS		CD	29.7
3	Error	12.0	5573.4	464.4						
4	Total									

ANOVA 4.12 Feed conversion efficiency at 12th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	63.3
1	Block/Rep	4.0	312.0	78.0	1.2	3.3	NS		SEM	3.64
2	Treatment	3.0	815.7	271.9	4.1	3.5	SIGNIFICANT		CD	11.2
3	Error	12.0	797.1	66.4						
4	Total									

ANOVA 4.13 Feed conversion efficiency at 13th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	27.1
1	Block/Rep	4.0	50.9	12.7	1.7	3.3	NS		SEM	1.22
2	Treatment	3.0	33.8	11.3	1.5	3.5	NS		CD	3.76
3	Error	12.0	89.1	7.4						
4	Total									

ANOVA 4.14 Feed conversion efficiency at 14th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	39.2
1	Block/Rep	4.0	157.7	39.4	1.9	3.3	NS		SEM	2.03
2	Treatment	3.0	5.4	1.8	0.1	3.5	NS		CD	6.26
3	Error	12.0	247.7	20.6						
4	Total									

ANOVA 4.15 Feed conversion efficiency at 15th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value					
					Calculated	Tabulation	LOGIC		CV%	121.4
1	Block/Rep	4.0	3413.0	853.2	1.3	3.3	NS		SEM	11.6
2	Treatment	3.0	2121.8	707.3	1.0	3.5	NS		CD	35.9
3	Error	12.0	8136.7	678.1						
4	Total									

ANOVA -4.16 Feed conversion efficiency at 16th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value					
					Calculated	Tabulation	LOGIC		CV%	76.5
1	Block/Rep	4.0	1151.9	288.0	0.7	3.3	NS		SEM	8.79
2	Treatment	3.0	1087.1	362.4	0.9	3.5	NS		CD	27.1
3	Error	12.0	4633.5	386.1						
4	Total									

ANOVA -1.17 Feed conversion efficiency at 17th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value					
					Calculated	Tabulation	LOGIC		CV%	90.8
1	Block/Rep	4.0	2505.4	626.3	1.1	3.3	NS		SEM	10.6
2	Treatment	3.0	6235.8	2078.6	3.7	3.5	SIGNIFICANT		CD	32.7
3	Error	12.0	6735.7	561.3						
4	Total									

ANOVA -1.18 Feed conversion efficiency at 18th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value					
					Calculated	Tabulation	LOGIC		CV%	24.2
1	Block/Rep	4.0	74.6	18.7	0.6	3.3	NS		SEM	2.60
2	Treatment	3.0	1085.0	361.7	10.7	3.5	SIGNIFICANT		CD	8.00
3	Error	12.0	404.2	33.7						
4	Total									

ANOVA -1.19 Feed conversion efficiency at 19th fortnight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value					
					Calculated	Tabulation	LOGIC		CV%	90.7
1	Block/Rep	4.0	3505.7	876.4	0.8	3.3	NS		SEM	15.1
2	Treatment	3.0	21191.8	7063.9	6.2	3.5	SIGNIFICANT		CD	46.5
3	Error	12.0	13639.3	1136.6						
4	Total									

ANOVA 1.20 Total mean feed conversion efficiency

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value					
					Calculated	Tabulation	LOGIC		CV%	61.5
1	Block/Rep	4.0	505.4	126.4	0.5	3.3	NS		SEM	7.09
2	Treatment	3.0	7666.4	2555.5	10.2	3.5	SIGNIFICANT		CD	21.9
3	Error	12.0	3017.8	251.5						
4	Total									

APPENDIX-5 (REPRODUCTIVE TRAITS)

ANOVA-5 Reproductive traits

ANOVA 5.1 Age at sexual maturity (days)

	Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
								LOGIC		CV%	0.4905
	1	Block/Rep	4	1.25	0.3125	0.652174	3.259167	NS		SEM	0.3096
	2	Treatment	3	0.9375	0.3125	0.652174	3.490295	NS		CD	0.9540
	3	Error	12	5.75	0.479167						
	4	Total									

ANOVA 5.2 Body weight at onset of egg production

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	0.704828
1	Block/Rep	4	1729.875	432.4688	1.966046	3.259167	NS		SEM	6.632778
2	Treatment	3	68263.75	22754.58	103.4446	3.490295	SIGNIFICANT		CD	20.43938
3	Error	12	2639.625	219.9688						

ANOVA 5.3 Egg weight at onset of egg production

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value Calculated	F Value Tabulation				
							LOGIC		CV%	4.96
1	Block/Rep	4.0	5.3	1.3	0.4	3.3	NS		SEM	0.86
2	Treatment	3.0	155.6	51.9	14.2	3.5	SIGNIFICANT		CD	2.64
3	Error	12.0	43.9	3.7						
4	Total									

APPENDIX-6 (EGG PRODUCTION AND EGG QUALITY TRAITS)

ANOVA 6.1 total egg production per bird

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F Value					
					Calculated	Tabulation	LOGIC		CV%	3.35E+00
1	Block/Rep	4.0	29.8	7.5	0.9	3.3	NS		SEM	1.27E+00
2	Treatment	3.0	1065.2	355.1	44.3	3.5	SIGNIFICANT		CD	3.9E+00
3	Error	12.0	96.2	8.0						
4	Total									

ANOVA 6.2 Clutch size

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F Value					
					Calculated	Tabulatior	LOGIC		CV%	6.85E+00
1	Block/Rep	4.0	0.7	0.2	1.0	3.3	NS		SEM	1.85E-01
2	Treatment	3.0	3.0	1.0	5.9	3.5	SIGNIFICANT		CD	5.69E-01
3	Error	12.0	2.0	0.2						
4	Total									

ANOVA 6.3 Egg weight at the end of the experiment

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value					
					Calculated	Tabulatior	LOGIC		CV%	3.90
1	Block/Rep	4.0	9.3	2.3	0.6	3.259167	NS		SEM	0.90
2	Treatment	3.0	238.6	79.5	19.6	3.490295	SIGNIFICANT		CD	2.78
3	Error	12.0	48.7	4.1						
4	Total									

ANOVA 6.4 Yolk weight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value					
					Calculated	Tabulatior	LOGIC		CV%	7.06
1	Block/Rep	4.0	4.6	1.2	1.0	3.3	NS		SEM	0.48
2	Treatment	3.0	24.3	8.1	7.1	3.5	SIGNIFICANT		CD	1.48
3	Error	12.0	13.8	1.1						
4	Total									

ANOVA 6.5 Albumen weight

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value					
					Calculated	Tabulatior	LOGIC		CV%	8.07
1	Block/Rep	4.0	11.7	2.9	0.7	3.3	NS		SEM	0.92
2	Treatment	3.0	103.3	34.4	8.2	3.5	SIGNIFICANT		CD	2.82
3	Error	12.0	50.3	4.2						
4	Total									

ANOVA 6.6 Haugh unit

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value					
					Calculated	Tabulation	LOGIC		CV%	2.48
1	Block/Rep	4.0	3.1	0.8	0.2	3.3	NS		SEM	0.91
2	Treatment	3.0	1793.7	597.9	143.1	3.5	SIGNIFICANT		CD	2.82
3	Error	12.0	50.1	4.2						
4	Total									

ANOVA 6.7 Yolk cholesterol

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of	F Value					
					Calculated	Tabulation	LOGIC		CV%	3.52
1	Block/Rep	4	0.107	0.02675	0.177055	3.259167	NS		SEM	0.17
2	Treatment	3	0.842	0.280667	1.857694	3.490295	NS		CD	0.54
3	Error	12	1.813	0.151083						
4	Total									

APPENDIX-7 (BIOCHEMICAL PARAMETERS)

ANOVA-8 Biochemical parameters

ANOVA 8.1 Total cholesterol at 4th month

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F Value				
					Calculated	Tabulation	LOGIC	CV%	1.55E+00
1	Block/Rep	4.0	54.6	13.7	2.5	3.3	NS	SEM	1.04E+00
2	Treatment	3.0	1704.2	568.1	104.2	3.5	SIGNIFICANT	CD	3.22E+00
3	Error	12.0	65.4	5.4					
4	Total								

ANOVA 8.2 Total cholesterol at 8th month

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F Value				
					Calculated	Tabulation	LOGIC	CV%	3.06E+00
1	Block/Rep	4.0	80.2	20.0	1.2	2.9	NS	SEM	1.83E+00
2	Treatment	5.0	122396.0	24479.2	1458.3	2.7	SIGNIFICANT	CD	6.17E+00
3	Error	20.0	335.7	16.8					
4	Total								

ANOVA 8.3 HDL Cholesterol at 4th month

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F Value				
					Calculated	Tabulation	LOGIC	CV%	1.83E+01
1	Block/Rep	4.0	82.5	20.6	1.1	3.3	NS	SEM	1.91E+00
2	Treatment	3.0	82.0	27.3	1.5	3.5	NS	CD	5.90E+00
3	Error	12.0	220.0	18.3					
4	Total								

ANOVA 8.4 HDL Cholesterol at 8th month

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.40E+00
1	Block/Rep	4.0	2.7	0.7	0.9	3.3	NS	SEM	3.86E-01
2	Treatment	3.0	32.0	10.7	14.3	3.5	SIGNIFICANT	CD	1.19E+00
3	Error	12.0	8.9	0.7					
4	Total								

ANOVA 8.5 LDL Cholesterol at 4th month

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F Value				
					Calculated	Tabulation	LOGIC	CV%	3.38E+01
1	Block/Rep	4.0	1113.7	278.4	0.6	3.3	NS	SEM	9.77E+00
2	Treatment	3.0	2402.1	800.7	1.7	3.5	NS	CD	3.01E+01
3	Error	12.0	5722.6	476.9					
4	Total								

ANOVA 8.6 LDL Cholesterol at 8th month

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F Value				
					Calculated	Tabulation	LOGIC	CV%	8.95E+00
1	Block/Rep	4.0	30.0	7.5	0.6	3.3	NS	SEM	1.60E+00
2	Treatment	3.0	2570.8	856.9	67.1	3.5	SIGNIFICA	CD	4.92E+00
3	Error	12.0	153.2	12.8					
4	Total								

ANOVA 8.7 Triglycerides at 4th month

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.62E+01
1	Block/Rep	4.0	65131.2	16282.8	2.4	3.3	NS	SEM	3.69E+01
2	Treatment	3.0	156277.0	52092.3	7.7	3.5	SIGNIFICANT	CD	1.136E+02
3	Error	12.0	81595.0	6799.6					
4	Total								

ANOVA 8.8 Triglycerides at 8th month

Sl.No	Source of Variation	Degree of Freedom	Sum of Square	Mean Sum of Square	F Value				
					Calculated	Tabulation	LOGIC	CV%	4.21E+00
1	Block/Rep	4.0	391.1	97.8	0.7	3.3	NS	SEM	5.13E+00
2	Treatment	3.0	273329.6	91109.9	692.3	3.5	SIGNIFICA	CD	1.58E+01
3	Error	12.0	1579.2	131.6					
4	Total								