CRUDE FIBRE UTILIZATION AND NUTRIENT AVAILABILITY IN INDIGENOUS LAYER DUCKS (*Anas platyrhynchos*)

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THESIS

Submitted in partial fulfilment of the requirement for the degree of

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DECLARATION

I hereby declare that this thesis entitled **"CRUDE FIBRE UTILIZATION AND NUTRIENT AVAILABILITY IN INDIGENOUS LAYER DUCKS** (*Anas platyrhynchos*)" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that the thesis entitled **"CRUDE FIBRE UTILIZATION AND NUTRIENT AVAILABILITY IN INDIGENOUS LAYER DUCKS (*Anas platyrhynchos*)"** is a record of research work done independently by Dr. P. Anitha, under my guidance and supervision and it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

Introduction

1. INTRODUCTION

The poultry industry in India is mainly oriented towards chicken production. Ducks are the second important species among poultry with a population of 24.48 million in the year 1994. The indigenous varieties contribute more than 90 per cent of the total duck population in the country and are being reared extensively under free range and backyard conditions.

The leading states in duck population are West Bengal, Assam, Bihar, Kerala, Andhra Pradesh, Orissa and Tamil Nadu. Kerala, the south peninsular region of India, has a unique system of duck rearing. The vast stretch of paddy fields after harvest forms a potential and sustainable feed resource for the ducks in the State under the foraging system of rearing. In Kerala, duck production is primarily oriented for egg production and the meat from drakes and spent ducks is secondary. More than 80 per cent of the duck population in the State is concentrated in Alappuzha, Ernakulam, Kottayam and Thrissur districts. Plenty of backwaters, lagoons and canals with intermittent paddy fields form the natural feeding places for ducks, and this might be the reason for high concentration of this species in these regions.

Ducks are managed under foraging system by feeding them in post harvest paddy fields and canals during day time. The types of feed resources available from the above places are diverse and are mainly paddy grains, crabs and snails. The availability of nutrients from their natural feeding places may be insufficient in certain periods to support optimum production of eggs, as reflected by fluctuations in egg production. Moreover, the availability of nutrients, especially crude protein and crude fibre, from the natural feed resources vary widely between regions. Preliminary studies conducted to assess the nutrient availability of foraging ducks revealed high level of fibrous feeds in their crop (Anon, 2002).

Haque *et al.* (1994) reported that the feeds of scavenging ducks were either deficient in crude protein or excess in crude fibre. Rashid *et al.* (1995) opined that supplementation of feed items with additives markedly improves egg production and body weight in desi ducks.

The presence of anti nutritional factors at significant levels limits the use of unconventional and agricultural byproducts in poultry diets. The dietary supplementation of enzymes currently addresses such problems at varying degrees and allows more economic utilization of agricultural byproducts in chicken diets. It is well documented that enzyme supplementation breaks the polymeric chains of Non Starch Polysaccharides (NSPs) in to smaller pieces, reducing the viscosity in gut and consequently improves the nutritive value of such feed stuffs.

Dietary fibre is composed predominantly of the Non Starch Polysaccharides (NSPs) and lignin. The Neutral Detergent Fibre (NDF), the major component of NSP, in the most commonly used feed ingredient maize is about 12 per cent and that of de-oiled rice bran is 45 per cent. This indicates that considerable amounts of nutrients are unavailable to poultry due to the lack of enzymes needed to digest them. Ketaren (1998) reported that ducks had a better ability to utilize rice bran than chickens. Rice bran could be included in the duck diet up to 75 per cent without affecting live weight gain, feed intake and feed conversion ratio, while 60 per cent rice bran in the chicken diet reduced the growth rate significantly. Studies on dietary supplementation of enzymes in layer duck feed are scarce and any effort in improving the crude fibre utilization in layer ducks will help to enhance the productivity of indigenous ducks.

The use of insecticides and herbicides in paddy fields reduce the snail population. The farmers often complain about marked drop in egg production and sudden mortality among flocks of foraging ducks in paddy fields. Ketaren (1998) reported increased mortality and morbidity in foraging ducks associated with the application of insecticides and pesticides in rice fields.

Insecticides include a vast variety of compounds, of which Organochlorine (OC) forms a major part with diverse chemical nature and adverse biological activities. They are very persistent in the environment because of their resistance to chemical and microbial decomposition especially when protected by deep layers of soil. The OC compounds are more immunosuppressive than other classes of pesticides. The body fat, being the main storage area for pesticides, retains the compounds in the body for an extra ordinary length of time. At present, the use of pesticides is alarmingly increasing for paddy cultivation in the State.

Considering the above facts, the present investigation was conceived with the following objectives:

i) To study the effects of multi enzyme (Polyzyme) supplementation in high fibre ration of indigenous layer ducks under intensive system of rearing

ii) To estimate the nutrient composition of the crop contents and thereby assessing nutrient availability of foraging ducks

iii) To compare the physiological profile of foraging ducks with that reared under intensive system

and

iv) To estimate the organochlorine residues in the crop contents and body fat of foraging ducks.

Review of Literature

2. REVIEW OF LITERATURE

Available literature indicated that comprehensive studies on nutritional management are lacking in ducks. The role of enzymes as feed additives in poultry nutrition has been documented well by several researchers. Studies on supplementation of enzymes targeting Non Starch Polysaccharide (NSP) in layer ducks are scanty. Nutrient availability of scavenging ducks in Bangladesh was studied by few authors. The data pertaining to such studies in indigenous ducks in India are not available. Therefore an investigation was under taken to study the effect of enzyme supplementation on production performance of indigenous layer ducks fed with high fibre diet in intensive system. A study on foraging ducks was also carried out to assess the nutritional and physiological status of foraging ducks in Kerala. A review of the available literature on various parameters has been attempted in this chapter.

2.1 BODY WEIGHT

Andrews *et al.* (1984) reported that 20^{th} week body weight was 1438 and 1443 g in desi ducks under the intensive and semi intensive system of management respectively when both groups were fed with a diet containing 17.30 per cent CP and 2650 Kcal ME/kg. The authors also reported that body weight at 44 weeks was 1311 g in intensive system and 1281 g in semi intensive system of rearing.

Hamid *et al.* (1988) reported a body weight of 1703.89 g in indigenous ducks, 1788.44 g in Khaki Campbell ducks and 1743.28 g in Indian Runner at 20 weeks of age.

In a survey on duck farming in Andhra Pradesh, Rithamber *et al.* (1986) recorded body weight at sexual maturity of desi ducks ranging from 1250 to 1500 g.

Gajendran *et al.* (1990) studied the performance of desi and Khaki Campbell ducks under deep litter system of rearing in maritime monsoon type of climate and reported that body weight recorded at 20 weeks of age were of 1465 ± 2.387 g for desi ducks and 1402 ± 1.335 g for Khaki Campbell ducks and there was no significant difference between the genetic groups.

Jeroch *et al.* (1995) observed improved live weight gain in starter phase by 3-16 per cent with the supplementation of glycosidase-containing enzyme in barley based diets in male Muscovy ducks. Carcass of ducks fed the enzyme supplemented diet contained more adipose tissue compared to that fed basal diet.

Rashid *et al.* (1995) reported average body weight of 1.5 to 2.0 kg in indigenous ducks of Bangladesh.

Dadashko and Sirvidis (1996) studied the effect of enzyme preparation (MEK-GPL containing beta-glucanase, amylase and lysozyme activity) in crossbred ducks with two types of diets, one based mainly on maize and wheat and the other on barley. In the feeding trial, ducks were grouped in to 5 groups of 100 each and the groups 1 and 2 (controls) were given the diet based mainly on maize and wheat, and that based on barley respectively. Groups 3, 4 and 5 were supplemented with 0.1, 0.3 and 0.5 per cent MEK-GPL premix respectively. Live weight at six months for males and females was 2893 and 2900 g for group 1, and 2806 and 2903 g for group 2. Ducks given the premix were heavier than controls, 2956 to 3123 g for males, and 2979 to 2989 g for females. Differences between controls and test groups were significant. Ducks given premix showed better development of reproductive organs compared to controls.

Mahanta (1997) reported the body weights of two varieties of indigenous ducks of Kerala viz., Chara and Chemballi. The body weights at 20, 40 and 52 weeks of age were 1538.15, 1494.07 and 1335.24 g in Chara ducks and 1497.51, 1475.45 and 1328.81 g in Chemballi ducks respectively under semi intensive system of rearing.

Farrel and Martin (1998) conducted three experiments to test the efficacy of two enzyme preparations targeting the NSPs in rice bran. In experiment I, rice bran 40 per cent decreased growth rate and feed intake in chicks. In second experiment, rice bran 20 or 40 per cent did not alter growth rate, feed intake or feed conversion ratio of ducklings from 3 to 17 days of age. In the third experiment rice bran 30 per cent increased duck growth from 19 to 35 days of age while rice bran 60 per cent decreased growth rate but not feed intake. In all experiments, enzyme preparations had no beneficial effects. They concluded that NSPs were not a significant factor in suppressing the nutritive value of rice bran and therefore the use of enzyme preparations was unlikely to be beneficial.

While evaluating the effect of addition of fibrolytic enzyme (Nutrizyme) in layer diets from 26 to 45 weeks of age with four different energy levels, Mohan *et al.* (2001) could not observe any significant difference in body weight due to enzyme supplementation.

Anon (2002) reported a body weight of 1466 g at 20^{th} week and 1354 g at 40^{th} week in indigenous ducks of Kerala under cage system of rearing. There was no significant difference between the body weight at 20 and 40 weeks of age.

Ravi (2002), while studying the dietary calcium and phosphorus requirements of indigenous layer ducks with three levels of calcium and three levels of phosphorus, observed that the mean body weight of ducks at 20^{th} week ranged from 1400 to 1465 g among the nine treatment groups with an overall mean of 1431 g. It was also reported that the 40th week mean body weight ranged from 1473 to 1579 g among nine treatment groups with an overall mean of 1544 g.

Kavitha *et al.* (2003) studied the effect of exogenous enzyme containing alpha amylase, xylanase, beta glucanase, cellulase and pectinase on the degradation of NSP in corn-soyabean diet both in-vitro and in-vivo on Cobb broilers. The body weight in enzyme treated groups was found better with an overall increment of 65 g (1.59 ± 0.18) against that of control (1.53 ± 0.17).

Nageswara *et al.* (2003) compared the performance of local ducks of Andhra Pradesh under extensive system with traditional management with that of improved management practices from 1 to 58 weeks of age. The improved production packages followed were standard brooding up to 4 weeks of age, supplementation of trace minerals and vitamins, vaccination against duck plague, deworming and litter management. The body weights of ducks in traditional and improved management practices at 22 weeks were 1284 and 1290g and at 58 weeks of age were 1242 and 1240g respectively.

2.2 EGG PRODUCTION

Mostageer *et al.* (1971) reported the egg production of 58.22, 198.59 and 87.12 eggs in desi ducks, Khaki Campbell and their crosses respectively up to 72 weeks of age.

In a survey, Ramachandran and Ramakrishnan (1982) reported that duck farmers of Kerala claimed an average egg production of about 200 eggs per bird per annum for indigenous ducks.

Ramakrishnan *et al.* (1982) conducted preliminary studies on productive efficiency of cross bred (Khaki Campbell x desi) duck under intensive farm condition. They recorded the egg number as 38.7 ± 2.92 up to 100 days from first egg and 47.4 ± 2.80 up to 300 days of age as.

Zombade *et al.* (1982) observed significantly higher hen-day egg production in White Leghorn layers when maize was substituted with paddy at 50, 75 and 100 per cent levels in the diet for a laying period of 120 days from sexual maturity.

Andrews *et al.* (1984) compared the performance of desi ducks under intensive and semi intensive systems of rearing and reported the duck-day egg production of 14.9 and 12.6 per cent in intensive and semi intensive system of management respectively during the period from 21 to 44 weeks of age.

Ravindran *et a*l. (1984) conducted a survey to assess the status of duck farming in Kerala and reported an average egg production in indigenous ducks as 130-140 eggs per duck per year.

Eswaran *et al.* (1985) reported 35.13 eggs in desi ducks and 61.50 eggs in Khaki Campbell ducks for a period of 100 days production from age at first egg. The egg number up to 280 days of age was 51.66 and 60.16 with a per cent duck housed production of 42.70 and 65.70 in desi and Khaki Campbell ducks, respectively.

In a survey study by Rithamber *et al.* (1986) the annual egg production reported in desi ducks of Andhra Pradesh was 150 to 200 eggs in the first two years of laying and peak production was recorded at 6 to 11 months of age.

In Khaki Campbell and local ducks of Tamil Nadu, egg number reported up to 40 weeks of age was 25.10 ± 2.96 and 53.16 ± 10.49 respectively (Gajendran *et al.*, 1990).

Kenzyme, a multienzyme which contained alpha-amylase, beta-glucanase and protease tested in laying hens by Adams (1991) showed 7.2 per cent increase in egg production.

Baruah *et al.* (1991) assessed the productivity of indigenous Pati ducks of Assam, Khaki Campbell and their crosses under farm condition. The study revealed that the total egg number of Pati, Khaki Campbell and their crosses up to 364 days of age averaged 51.57, 109.49 and 80.32 eggs respectively.

Haque and Hussain (1991) evaluated production potential of Khaki Campbell and desi ducks of Bangladesh under scavenging system of management. They found per cent duck-day egg production of Khaki Campbell and desi ducks as 22.4 and 16.8 respectively with corresponding per cent duck-housed egg production of 18.1 and 13.2.

Chen (1992) reported 218 eggs per duck up to 360 days of age in native ducks of Indonesia.

Prakash and Devegowda (1993) studied the effect of cellulase and protease enzymes singly and in combination in the high fibre diet of laying chicken containing fibrous feed stuffs like deoiled sunflower cake and deoiled rice bran. They reported that the cellulase supplementation to high fibre diet with low energy significantly ($P<0.01$) improved the egg production in comparison with control diet.

Sharma and Katoch (1993) obtained a numerical increase in egg production when 'Novozyme' SP-243, a fibre degrading enzyme was supplemented in the diet of 26 weeks old chicken layers.

Rashid *et al.* (1995) studied the performance of desi, Khaki Campbell and their crosses with and without extra feeding under rural conditions of Bangladesh and reported that egg production up to 300 days of age was 41, 67 and 110 eggs respectively when the ducks were fed without supplementary feeding. When the ducks were fed with supplementary feeding, the egg production recorded were 71, 92 and 166 eggs per duck respectively.

While evaluating the influence of 0.06 per cent cellulase and 0.02 per cent protease in a standard layer diet (18 per cent CP and 2600 kcal ME/kg) and less dense layer diet (16 per cent CP and 2500 kcal/kg) Satyamoorthy (1995) noted a numerical improvement in per cent hen-housed and hen-day egg production in enzyme treated groups, but the increase was not statistically significant.

Ponnuvel (1996) reported that 0.06, 0.12 and 0.18 per cent cellulase supplementation in a diet containing 12 per cent fibre caused a numerical increase in hen-housed and hen-day egg production in white Leghorn. However, cellulase supplementation did not have any significant influence on egg production.

Mahanta (1997) reported that the cumulative egg number per duck up to 52 weeks of age was 116.09 in Chara and 124.95 in Chemballi ducks of Kerala under semi intensive system of rearing.

Ketaren (1998) reported that the egg production rate was increased from 38.3 to 48.9 eggs by supplementing concentrated feed to herded ducks. He also reported that, Alabio ducks produced on an average of 248 eggs per year at the laying rate of 67.9 per cent.

Das *et al.* (2000) studied the egg production in desi ducks, Khaki Campbell and their crosses under field conditions in Assam and reported an average egg production of 19.45, 71.98 and 34.20 in desi, Khaki Campbell and their crosses respectively up to 40 weeks of age. Egg production reported up to 56 weeks of age was 42.33 for desi, 140.62 for Khaki Campbell and 64.68 for the cross between them.

Mohan *et al.* (2001) conducted a feeding trial to evaluate the effect of supplementation of a fibrolytic enzyme containing xylanase, pectinase and cellulase on layer performance. Improvement in egg production was observed by 0.1 per cent enzyme supplementation.

Anon (2002) reported the duck housed number of 80.64 eggs per duck up to 40 weeks of age in indigenous ducks of Kerala, under cage system of rearing with duck-housed percentage of 57.60.

While studying the effect of varying levels of calcium and phosphorus in the diet on the performance of indigenous layer ducks, Ravi (2002) reported that the cumulative mean egg number from 21 to 40 weeks of age was 70.4 eggs per duck and that from 25 to 40 weeks of age was 68.2 eggs per duck. The overall mean per cent duck housed production from 21 to 40 weeks was 50.0 and from 25 to 40 weeks was 60.7 among the treatment groups.

Nageswara *et al.* (2003) reported the duck day egg production of local ducks of Andhra Pradesh under extensive system with traditional management as 42 and that with improved management practices as 46 from 22 to 58 weeks of age.

Anon (2004) reported that significant improvement in egg production was noticed in groups of indigenous layer ducks fed a diet having 12 per cent crude fibre and supplemented with 0.1 and 0.2 per cent polyzyme during 27 to 44 weeks of age. The duck housed egg production recorded was 83.67 and 80.44 for the 0.1 and 0.2 per cent enzyme supplemented groups respectively as against 71.67 in unsupplemented group.

2.3 EGG WEIGHT

Reddy *et al.* (1981) studied the egg weight in Khaki Campbell ducks on feeding graded levels of crude protein viz., 15, 17 and 19 per cent with constant level of 2.75 per cent calcium and 0.55 per cent available phosphorus and the egg weight recorded were 59.38, 60.67 and 56.68 g respectively.

Andrews *et al.* (1984) reported that the mean egg weight of desi ducks reared in the intensive system was 60.4 g and 60.7 g in the semi-intensive system, when both the groups were fed a diet with 17.30 per cent crude protein, 2650 Kca/kg of ME, 3.31 per cent calcium and 1.17 per cent total phosphorus.

Eswaran *et al.* (1985) reported the egg weight of 71.40 ± 0.95 g in desi ducks and 62.41 ± 0.50 g in Khaki Campbell ducks at 280 days of age.

Patra *et al.* (1989) reported the egg weight of 66 to 70 g at the age of 40 weeks in Khaki Campbell ducks.

Mahanta *et al.* (1993) studied the physical quality and component parts of Pati (indigenous) and Khaki Campbell duck eggs and reported the mean egg weight of 60.55 ± 0.29 and 56.44 ± 0.38 g in indigenous and Khaki Campbell ducks respectively.

Satyamoorthy (1995) reported that cellulase (0.06 per cent) or protease (0.02 per cent) supplementation in standard layer or less dense layer ration did not have any significant influence on egg weight in layers.

Ponnuvel (1996) did not observe any significant influence on mean egg weight in White Leg horn layers when supplemented 0.06, 0.12 and 0.18 per cent cellulase in high fibre diet containing 12 per cent crude fibre.

Zang Su Min *et al.* (1996) found that compound enzyme preparation containing protease, alpha-amylase, cellulase and pectylase supplemented in layer basal diet increased the average egg weight by 18.18 per cent ($P<0.01$) along with laying rate.

Mahanta (1997) reported the weight of first egg as 61.27 g in Chara and 61.87 g in Chemballi ducks of Kerala. The mean egg weight at 40 weeks of age was 69.94 g in Chara and 68.94 g in Chemballi ducks under semi intensive system of rearing.

Ketaren (1998) reported that egg weight increased from the average of 66.9 to 71.1 g by supplementing 24 g prawn head meal per duck to the laying herded duck diet during non harvest season in Indonesia.

Mohan *et al.* (2001) did not observe any significant effect on egg weight while evaluating the effect of fibrolytic enzyme containing xylanase, pectinase and cellulase (Nutrizyme) in layer diets.

Anon (2002) reported the mean egg weight of 57.42 g in indigenous layer ducks of Kerala, under cage system of rearing from 21 to 40 weeks of age.

Ravi (2002) while studying the influence of different dietary levels of calcium and available phosphorus in indigenous layer ducks reported that the overall cumulative mean egg weight from 25-40 weeks of age ranged from 57.3 ± 0.88 to 61.5 ± 0.97 g with an over all mean of 59.60 ± 0.33 g. He also found that the mean egg weight decreased significantly ($P<0.01$) as the level of calcium increased in the diet.

Nageswara *et al.* (2003) reported the egg weight of local ducks of Andhra Pradesh under traditional and improved management practices from 22 to 58 weeks of age as 65.4 and 65.6g respectively.

Anon (2004) reported an egg weight of 67.50 and 66.90 g in indigenous layer ducks fed with 12 per cent CF diet supplemented with 0.1 and 0.2 per cent polyzyme respectively during 34 to 44 weeks of age. The egg weight in enzyme unsupplemented group with 8 per cent CF diet was 65.10 g and that with 12 per cent CF diet was 63.90g.

Dalibard *et al.* (2004) studied the effects of the use of a multiple enzyme preparation (Rovabio Excel) as a supplement in maize plus soybean poultry feeds. The use of Rovabio resulted in an increase in egg mass of 1.6, 3.9 and 3.7

per cent respectively for an unspecified number of laying hens, turkeys and ducks.

2.4 FEED CONSUMPTION

Bulbule (1982) stated that the feed consumption was varied in Khaki Campbell ducks from 135 to 170 g/duck/day depending up on the rate of production. He also stated that the Khaki Campbell ducks consumed 12.63 kg feed up to the age of 20 weeks and 16.25 kg feed up to 24 weeks, under confinement.

Andrews *et al.* (1984) reported that the desi ducks consumed an average of 191 and 185 g of feed per day in the intensive and semi-intensive system of rearing respectively when both groups were fed with the diet containing 17.30 per cent crude protein and 2650 Kcal ME/kg diet, during the period from 21 to 44 weeks of age.

Eswaran *et al.* (1985) reported that desi ducks consumed 181 to 184 g feed per duck/day.

Gajendran *et al.* (1990) studied the feed consumption pattern in desi and Khaki Campbell ducks from 21 to 40 weeks of age when fed a layer mash containing 13 per cent crude protein and 2475 Kcal ME/kg diet and reported that the mean daily feed consumption was 155 g in desi ducks and 165 g in Khaki Campbell ducks.

Baruah *et al.* (1991) reported the average daily feed consumption for eight laying periods as 190.06 g in Pati duck, 174.29 g in Khaki Campbell and 178.01 g in the crossbred between Pati and Khaki Campbell.

Anon (2002) reported the mean daily feed consumption of 171.88 g from 21 to 40 weeks of age in indigenous layer ducks of Kerala, under cage system of rearing.

2.5 FEED CONVERSION RATIO

Reddy *et al.* (1981) reported the feed conversion ratio of 2.08 in Khaki Campbell ducks when fed with a layer diet containing 19 per cent crude protein and 2400 Kcal ME/Kg from 21 to 52 weeks of age.

In desi ducks, Andrews *et al.* (1984) reported the feed efficiency of 19.5 and 22.7 in intensive and semi intensive system respectively when fed with a diet containing 17.30 per cent crude protein and 2650 Kcal ME/kg diet during the period from 21 to 44 weeks of age.

Eswaran *et al.* (1985) reported an over all feed efficiency of 13.54 ± 8.85 for desi ducks and 11.68 ± 4.77 for Khaki Campbell from 21 to 44 weeks of age.

Narahari and Sundararasu (1988) reported that, there was no significant difference in feed efficiency between dry and wet mash feeding in desi and Khaki Campbell ducks from 21 to 40 weeks of age.

Gajendran *et al.* (1990) reported the mean feed efficiency of 4.88 ± 0.58 (kg feed per dozen eggs) in desi ducks and 10.05 ± 0.75 (kg feed per dozen eggs) in Khaki Campbell ducks from 21 to 40 weeks of age.

Supplementation of a multi enzyme preparation, 'Avizyme' significantly improved feed conversion ratio in barley and oat based diets fed to laying hens (Aimonen and Nazi, 1991).

Baruah *et al.* (1991) stated the feed conversion ratio in the order of 10.87, 5.01 and 6.91 respectively in Pati, Khaki Campbell and their crosses for eight laying periods of 28-day each..

In an investigation, Satyamoorthy (1995) reported that feed efficiency for egg production (egg number) was significantly higher in chicken fed standard layer ration with cellulase and protease enzymes than those on the control.

Anon (2002) reported the mean FCR (per dozen eggs) of 3.6 from 21 to 40 weeks of age and 3.35 from 25 to 40 weeks of age in indigenous ducks of Kerala, under cage system of rearing.

Ravi (2002) reported that the feed conversion ratio per dozen eggs from in indigenous layer ducks during 25 to 40 weeks of age as influenced by different levels of calcium and available phosphorus in the diet ranged from 2.4 to 3.1 with an over all mean value of 2.8. At the same time the mean feed conversion ratio per kg egg mass from 25 to 40 weeks ranged from 3.6 to 4.3 with an over all mean value of 3.9. The dietary calcium and available phosphorus levels did not significantly influence the feed conversion ratios, both per dozen eggs and per kg egg basis.

Anon (2004) reported that the FCR per dozen eggs in indigenous layer ducks during 27-44 weeks of age was 3.10 and 3.07 in groups fed with 8 per cent and 12 per cent CF diet respectively. When the 12 per cent CF diet was supplemented with 0.1 and 0.2 per cent polyzyme and fed to groups of ducks the FCR was found considerably reduced to 2.85 and 2.98 respectively.

2.6 BLOOD PARAMETERS

2.6.1 Hemoglobin

A study on the normal haematology of Khaki Campbell ducks was under taken by Sreenivasan and Rao (1965). The mean value of Hb in 8 months old ducks was found as 12.60 g/dl with a range varying from 10.50 to 14.25 g/dl.

Surendranathan *et al.* (1968) studied the haematological constituents of desi ducks and reported that the Hb value in adult females was 12.30 ± 0.26 g per cent and that in adult male was 13.27 ± 0.52 g per cent ml which was apparently due to the enhanced erythrocyte count in them.

Sreeraman *et al.* (1979) reported that the average haemoglobin values in male and female ducks were 13.83 and 12.2 g per cent respectively.

Datta *et al.* (1996) compared the blood parameters of desi and Khaki Campbell ducks at normal, high and low ambient temperature and reported that the values were lower in desi than Khaki Campbell ducks at all temperatures. At normal ambient temperatures, the Hb was reported as 13.63 and 14.16 g/dl in desi and Khaki Campbell female ducks and that in males was 14.38 and 15.16 g/dl respectively.

Mahanta and Jalaludeen (1999) reported the haemoglobin content of Chara layers as 13.06 ± 0.25 g/dl and that of Chemballi layers as 13.86 ± 0.21 g/dl. They also pointed out that the Hb values in males of Chara and Chemballi were comparatively higher than females.

Sethu (2003) conducted an experiment in Austra White male chicken from 8 to 32 weeks of age to evaluate the effect of supplementing blue green algae (*Spirulina platensis*) on haematological, biochemical and fertility parameters. The Hb value reported at 8^{th} month of age was 12.37 ± 0.22 g/dl in control group and that in spirulina supplemented group was higher.

2.6.2 Plasma Total Protein

Defalco (1942) conducted a serological study and stated that the total serum protein for duck (*Anas platyrhynchos*) was 3.50 g/100 ml.

Werner (1944) found total serum protein of 6.44 g/100 ml in ducks (*Anas platyrhynchos*) for both sexes.

Brandt *et al.* (1951) while studying the effect of age and degree of maturity on the serum proteins in chicken observed that the total protein value decreased with age.

Nirmalan and Robinson (1971) while studying the haematology of ducks noted that the total serum protein value decreased with age.

While studying the dietary protein and energy requirements of White Pekin ducks for growth, Peethambaran (1991) has reported that the serum protein levels ranged from 3.68 to 4.32 g/100 ml at eighth week of age.

Plasma chemistry values were determined in 14 healthy adult (50-60 wk old) and 10 healthy young (8-10 wk old) Nigerian ducks by Olayemi *et al.* (2002). Plasma protein values (g/dl) were reported as 5.95±0.36 in young and 5.91±0.29 g/dl in adult ducks. The authors opined that age did not influence the plasma protein levels.

Shibi (2003) conducted an experiment to evaluate the effect of supplementation of probiotic in White Pekin ducks at 0.025 and 0.05 per cent levels. It was reported that at 8^{th} week of age the serum protein values were 3.27, 3.83 and 4.03 g/dl for control group, 0.025 and 0.05 per cent probiotic supplemented groups respectively in case of male ducks and 3.50, 3.94 and 4.29 g/dl in case of female ducks.

Sethu (2003) conducted an experiment in Austra White male chicken with the objective of evaluating the effect of supplementing blue green algae (*Spirulina plantesis*) on haematological, biochemical and fertility parameters for a period of 24 weeks (8-32 weeks of age). The total plasma protein value was ranging from 4.59 to 5.09 g/dl from fifth to eighth month of age for control group. He also observed that the total protein value was significantly higher in spirulina fed groups.

2.6.3 Plasma Cholesterol

Landauer *et al.* (1941) reported the total cholesterol levels in plasma of male Pekin ducks as 450-500 mg/100 ml and of Mallard as 730 mg/100 ml.

Abdulrahim *et al.* (1996) while studying the influence of *Lactobacillus acidophilus* and zinc bacitracin on performance of layer chicken and their plasma chemistry, observed that plasma cholesterol level was significantly lower in *Lactobacillus acidophilus* supplemented group and the group supplemented with combination of lactobacillus acidophilus and zinc bacitracin, but not in the group supplemented with zinc bacitracin alone. The values corresponding to the above groups were 65.2, 80.7 and 152.6 mg/100 ml respectively.

Sethu (2003) reported that plasma cholesterol level was significantly lower when Austra White male chicken were fed with *Spirulina platensis* in the feed compared to control group. In the control group the values recorded at 20 and 32 weeks of age were varied from 132.12 to 146.19 mg/dl.

Shibi (2003) carried out a study to evaluate the effect of supplementation of probiotic at 0.025 and 0.05 per cent levels in White Pekin ducks and reported that the serum cholesterol values at the end of eighth week were 174.28, 161.26

and 156.27 mg per cent for the control, 0.025 and 0.05 per cent supplemented groups in male ducks and that in female ducks were 164.56, 153.91 and 140.48 mg per cent respectively.

2.6.4 Plasma Total Lipids

While evaluating the effect of dietary supplementation of *Spirulina platensis* on hematological and biochemoical parameters in Austra White male chicken, Sethu (2003) observed low plasma lipid level in spirulina fed groups compared to that of control group. The value of total lipids was ranged from 502.09 to 512.97 mg/dl from fifth to eighth month of age in control group.

Rekhate *et al.* (2004) conducted an experiment to assess the effect of Shatavari root powder on the performance of broilers. The blood biochemical profile revealed that the total lipid value was better in Shatavari treated birds even though the difference between groups was non significant. The values for total lipids were ranged from 457.87 ± 3.36 to 463.43 ± 2.25 mg/dl.

2.7 NUTRIENT DIGESTIBILITY

Potter *et al.* (1965) determined the digestibility coefficients of western grown barley in chicks influenced by fungal enzyme or water treatment. They noticed that either presence of enzyme or water treatment of barley improved the digestibility of protein, fat and nitrogen free extract.

Petterson and Aman (1989) conducted an experiment on broiler chicken fed with diets containing rye and wheat in equal proportion with increasing level of 0, 0.011, 0.022, 0.088 per cent of enzyme preparation containing pentosanase and beta-glucanase. They observed that enzyme preparation generally increased the digestibility of organic matter, crude protein and starch.

Addition of multi enzyme 'Avizyme', in oat based diet fed to laying hens improved the apparent ME, apparent digestibility of crude fat, carbohydrate and hemicellulose. The effect was more pronounced when the ration contained more than 8 per cent fibre content (Aimonen and Nasi, 1991).

Friesen *et al.* (1991) reported that addition of cellulase enzyme (*Trichoderma viridae*) in 60 per cent rye based broiler diet resulted in an increase in the dietary metabolizable energy by 23 per cent and apparent protein digestibility by 12 per cent when compared with unsupplemented control diet.

Swain and Johri (1994) conducted a 4x3 factorial experiment with broilers to assess the influence of enzyme supplements containing amylase, cellulase, protease and lipase in four basal diets containing unautoclaved or autoclaved rice bran with low fibre and high fibre content, wheat bran and sun flower cake. Three test diets from each of the basal diet were prepared by addition of 0, 0.1 and 0.15 per cent enzyme. They found significant increase in metabolizable energy of various low fibre and high fibre diets due to inclusion of enzyme at 0.1 and 0.15 per cent. The retention of protein was found to be higher on diet containing 0.15 per cent

Satyamoorthy (1995) opined that enzyme supplementation resulted in an apparent improvement in the digestibility of crude protein and energy utilization in laying chicken.

Ponnuvel (1996) reported significant improvement in apparent protein and ether extract digestibility in layers supplemented with cellulase enzyme in high fibre diets. He also observed numerical increase in acid detergent fibre and neutral detergent fibre digestibility values in enzyme fed groups compared to the control groups.

Jamroz *et a*l. (1998) compared the digestibility of non starch polysaccharides (NSP) from a diet high in maize and wheat (control diet) with that of a diet high in 'triticale' in two breeds of chicken, ducks and geese. Effect of supplementation of enzyme preparation (Roxazyme) in the digestibility of

NSP in the triticale ration was also investigated. Ducks and geese have slightly higher digestibility of NSP (60 per cent) than chicken (about 55 per cent). Xylose as a component of NSP was markedly less digestible than other sugars in NSP. Supplementation of enzyme did not increase digestibility of NSP in the triticale ration except Xylose which was significantly increased in the triticale plus enzyme group.

2.8. CHEMICAL COMPOSITION OF DUCK MEAT

Scott *et al.* (1957) reported that the duck carcass fat content was negatively correlated and moisture content was positively correlated with the types of feed. The authors also reported that the CP in the duck carcass on fresh basis ranged from 12.70 to 14.70 per cent.

Poultry meat consists of 75 per cent moisture, 18 per cent protein, 3 per cent fat and 0.7 per cent inorganic salts (Varadarajulu, 1973).

Zaniecka and Bobrowska (1981) stated that protein per cent in lean meat plus skin in male pekin ducks was 17.0 and that in female ducks was 16.5.

Khanna and Panda (1984) studied the effect of storage on quality of duck sausages and reported that moisture, protein, fat and ash averaged 62.81, 23.35, 10.72 and 2.74 per cent respectively in fresh product.

Kriz *et al.* (1984) observed that in three groups of Pekin ducks viz. mixed sexes, males and females, the percentages of moisture in the muscle averaged 72.9, 73.0 and 71.8 and that of protein averaged 18.2, 18.5 and 18.1 per cent respectively at 50 days of age.

Panda and Mohapatra (1989) reported that moisture, protein and fat contents of raw duck meat at eight weeks of age averaged 52.7, 19.9 and 35.8 per cent respectively.

Smith *et al.* (1993) conducted studies on 42 week old Pekin duck and reported that the per cent moisture, protein, fat and ash averaged 77.7, 19.50, 2.34 and 1.09 respectively.

To determine the optimal culling age for laying Tsaiya ducks, females culled at different ages were used to measure carcass and meat characters by Wang and Wan (1995). They found that lean meat from breast had higher moisture and protein contents, but was low in fat and lean meat from thigh contained more fat than the breast. The chemical composition of meat was similar to that of culled laying fowls.

Sangilimadan and Narayanankutty (1998) stated that desi spent duck meat sticks contained 71.94 per cent moisture, 18.03 per cent protein, 5.86 per cent fat and 3.88 per cent total ash.

2.9. STUDIES ON FORAGING DUCKS

2.9.1. Nutrient Availability

The nutritional status of laying ducks under scavenging conditions in Bangladesh was studied using the oesophageal crop method during different seasons by Haque *et al.* (1994). The observations made in the report were that crude protein and crude fibre content of diets vary in different areas in different seasons and calcium and phosphorus ratio in the diet was unbalanced. Rice polishings, snails and weeds were the most common feeds in the crop and gizzard. It was concluded that feed available for scavenging ducks were deficient in CP and excessive in CF.

In Tanzania, Mwalusanya *et al.* (2002) reported that the mean dry weight of crop contents were 20.5 and 14.5 g for scavenging indigenous chicken layers and growers respectively which did not vary with seasons. They also observed that the overall physical contents of crop varied with season, but not with the type of bird. The occurrence of 37.4 per cent cereal grains and 19.2 per cent bran was much higher during the long rainy season than in the short rainy season where it was 13.5 and 11.5 per cent respectively. Whereas the occurrence of green forages were 33.7 per cent and insects/worms were 17.9 per cent which were much higher during the short rainy season than in long rainy season (28.6 and 5.8 per cent respectively). The contents of bran, grains, green forages, insects/worms and kitchen wastes in chicken crops were approximately 19.2, 38.4, 22.7, 5.8 and 14 per cent respectively.

Nutritional status of scavenging chickens with special emphasis on energy and protein supplementation under rural conditions in Bangladesh was assessed by Rashid (2003). It was concluded that the nutrient concentrations of feed scavenged by indigenous scavenging chickens were less than the recommended nutritional levels, which varied with season and type of bird. He also recommended that supplementation of feed is crucial during non- harvesting season particularly where scavenging feed resource base is limited.

Rashid *et al.* (2004) conducted a study to assess the chemical composition of the crop contents of local scavenging chicken layers and growers in the rural areas of Bangladesh and found that the mean weight of the dried crop contents was 19.9g for layers and 13.4 g for growers. The mean dry matter percentage of crop contents was 45.5 and 48.9 for layers and growers respectively. The mean crude protein, ether extract, crude fibre, ash, nitrogen-free extract, calcium and total phosphorus of the crop contents were 11.7 ± 2.53, 2.07 ± 0.954, 6.04 ± 2.98, 12.4 ± 5.51, 68.3 ± 7.80, 1.32 ± 0.793 and 0.459 ± 0.177 per cent respectively for layers and were 9.89 ± 1.59, 2.11 ± 2.21, 6.40 ± 4.30, 12.3 ± 6.71, 69.3 ± 7.95, 0.761 ± 0.406 and 0.336 ± 0.200 per cent respectively for growers. They reported that the concentrations of chemical components of feeds scavenged by local chickens were less than the recommended nutritional levels which varied with the type of chicken.

The chemical composition of crop and gizzard contents of scavenging chickens and ducks are tabulated below:

Country	Birds	DM %	CP %	EE %	CF %	Ash %	NFE %	ME kcal/kg	References
Bangladesh	layer	-	9.62						Ali (2002)
Bangladesh	Duck	-	-	-	-	-	-	2456	Ukil (1992)
Bangladesh	Duck	-	8.7-10.2	1.2--1.61.	8-10.6	8.8-14.8	50-58.7	-	Haque *et al.* (1994)
Bangladesh (In winter)	Duck	-	8.74	1.43	9.9	9.9	57.1	-	Haque *et al.* (1994)
India	Hen	-	11.3	8.13	9.74	-	-	-	Prawirokusumo (1988)
Sri Lanka	Hen	34.4	9.4	9.2	5.4	16	-	2280	Gunaratne *et al.* (1993)
Ethiopia	Hen	52.3	8.8	1.9	10.2	-	-	2844	Tadelle and Ogle (1996)
Tanzania*	Mean of hen and grower	43.1	10.4	6.1	5.8	12.5	65.2	-	Mwalusanya *et al.* (2002)

* Crop only

Chemical composition of crop contents of indigenous chickens scavenging in various seasons

Country	Season	DM %	CP %	EE %	CF %	Ash %	NFE %	Ca %	P %	References
Bangladesh	Non-harvest-ing	44.3	10.2	1.49	4.71	13.7	70.0	.97	.39	Rashid (2003)
	Harvest-ing	51.4	10.9	2.6	8.13	11.3	67.4	.94	.35	
Tanzania	Short rain	42.5	12.3	6.8	5.88	13.7	-	.67	.48	Mwalusanya *et al.* (2002)
	Long rain	43.7	8.57	5.4	5.77	11.4	-	.65	.24	
Bangladesh*	Winter	-	7.92	7.3	9.64	12.6	56.3	3.8	.40	Haque (1999)

* Crop and gizzard

2.9.2. Pesticide Residue (Organochlorines)

Smith *et al.* (1969) carried out an experiment in which mature Japanese Quails were fed 0, 100, 200 and 400 ppm of Dichloro Diphenyl Trichloroethane(DDT) in the diet for 60 days and its effect on egg production, mortality, fertility, hatchability and pesticide content of yolks were determined. The levels of DDT fed had no effect on average egg production and there were no differences in mortality, hatchability or fertility between the 0, 100 and 200 ppm DDT groups.

Japanese quails were fed with diet containing 100 ppm of p, p'-DDT or p, p'-DDE (Primary derivatives of DDT) for a period of three months. Reduction in the carbonic anhydrase enzyme activity to about 16 to 19 per cent in the shell forming glands and 22 to 44 per cent in the blood of the treatment groups was observed (Bitman *et al.*, 1970).

DDT was daily fed to laying hens at 0.05, 0.1 and 1.0 ppm levels in feed and the residue of the insecticide was determined in eggs, fat, breast meat, thigh meat and skin after 6 to 12 weeks by Singh *et al.* (1970). Fat was found to contain the maximum amount of DDT residue as compared to other tissues. The average DDT residue after 6 and 12 weeks of intake of 1.0 ppm level was 3.24 and 3.37 ppm respectively. An increase in the insecticide intake caused a proportionate increase in its residue in the tissue.

Miller *et al.* (1976) noted that DDT was responsible for increased frequency of breakage of eggs in birds as it inhibits Ca^{2+}-ATPase enzyme necessary for calcification of eggs.

Day old chicks were fed with sub acute doses of DDT (10 mg of 5 per cent W.P/bird) by Ramalingam (1987). Degenerative changes were seen in liver and renal tubules of kidney. The absorptive layers of intestine were also disrupted.

Frank et al (1990) analyzed samples of abdominal fat collected from avian, bovine, caprine, ovine and porcine species together with hen eggs for organochlorine and organophosphorus pesticides. The compounds identified in animal tissues were DDE, Dieldrin, Lindane, PCB, Pentachlorophenol and Tetrachlortophenol. Pentachlorophenol was the most frequently found contaminant, DDE was the second. Forty three per cent of sample had non-detectable residues. The highest combined residue ranged between 0.1 and 1.0 mg/kg and was present in 2.8% of samples. Residues of Chlordane and its metabolites, heptachlor and its epoxides, endosulphan and its sulphate metabolites, dicofol, HCB and mirex were below their detection limits in all samples.

Administration of DDT to 4 week old cockerels at 12.5, 25 and 37.5 mg/kg body weight for 24 weeks produced testicular atrophy in all treated birds (Balasubrahmaniam and Sundararaj (1993).

In an experiment to study the level of DDT in poultry, (George and Sundararaj, 1995), found that the residues of DDT and its metabolites were highest in adipose tissue followed by liver, kidney, heart, fat of meat, blood, spleen, testes, brain, egg yolk and semen. They also stated that poultry has a higher capacity of bioaccumulation of pesticides in their tissues and are deficient in certain enzymes which aid in detoxification compared to mammals.

Botero *et al.* (1996) estimated concentrations of 12 organochlorine compounds in samples of breast muscle, associated skin and subcutaneous fat of mallards (*Anas platyrhynchos*) collected in Wisconsin during 1984-1989. It was reported that all examined OCs were found to be below concentrations known to affect reproduction in water fowl. Polychlorinated biphenyls (PCBs) were most often detected in mallards, and those compounds were detected in 47 per cent of the samples collected.

Blus *et al.* (1997) observed significant egg-shell thinning in captive American Kestrels (*Falco sparverius*) and wild brown pelicans (*Pelicanus occidentalus*) fed with a DDT contaminated feed. High dietary concentration of DDE caused extreme egg shell thinning and mortality in adult mallards (*Anas platyrhynchos*). No significant effect was seen in the size, mass and shape of eggs.

Report on the Australian National residue survey 2000-2001 (Anon, 2001) indicated the Maximum Residue Level (MRL) of various OC pesticides in poultry fat was 0.2 ppm for endosulfan, aldrin and dieldrin, 0.3 ppm for HCH, 0.7 ppm for lindane and 5 ppm for DDT and its metabolites.

Laying hens were administered orally with a single dose of p, p'-DDT (1mg/kg body weight) by Furusawa (2002). The concentrations (µg/g) of DDT and its metabolites were determined in the main tissues involved in egg formation (blood, liver, ovary and oviduct) and egg yolk by normal-phase High performance liquid chromatography (HPLC). In extractable fats from the above tissues and egg yolk, DDT and DDE were transferred / distributed through out the tissues and egg yolk. DDT was found only in liver. Among the four tissues and yolk fats examined, the DDT levels were high in the ovary, oviduct and egg yolk; the DDE levels were high in the liver, ovary and oviduct and lowest in the yolk ($P<0.01$).

The Pesticide Manufacturers and Formulators Association of India (PMFAI) Statistics (2006) on MRL values of Pesticides (mg/kg) on food commodities indicated the following:

Pesticide	Food commodity	MRL (ppm)
DDT	Poultry and fish	7.0
	Eggs	0.5
HCH (Gamma isomer)	Meat and poultry	2.0
Aldrin, Dieldrin	Meat	0.2
	Eggs	0.1
Ethion	Meat and eggs	0.2

Materials and Methods

3. MATERIALS AND METHODS

An investigation was carried out in the Department of Poultry Science, College of Veterinary and Animal sciences, Kerala Agricultural University utilizing indigenous Kuttanad ducks of Kerala. The study comprised of two parts; a biological trial at the farm level and the other on foraging ducks maintained in the field.

Biological trial

Two hundred (200) female ducks of 18 weeks of age procured from Kuttanad region were used for the trial. They were leg banded and were housed as two ducks per cage in California type cages. The dimensions of the cages were 60x45x40 cm. A floor area of 1350 cm^2 per duck was provided during the experiment.

At 20th week of age, the ducks were randomly divided in to five treatment groups viz., T1, T2, T3, T4 and T5 with four replicates in each treatment consisting of ten ducks in each replicate. A low fibre (LF) layer ration containing 8 per cent crude fibre and a high fibre (HF) ration with 12 per cent crude fibre were prepared. The HF ration was supplemented with Polyzyme at the rate of 0, 0.06, 0.12 and 0.18 per cent to form T2, T3, T4 and T5 respectively. The group T1 formed the control group.

The levels of CP and ME in the experimental rations were maintained at 18 per cent and 2550 Kcal respectively. The energy content of the rations was reduced in this experiment as the ducks were reared in the cage system. Shrivastava and Panda (1982) had suggested 18 per cent CP and 2650 Kcal ME/ Kg to laying ducks. The ingredient composition of the diets is presented in

Experimental ducks in cages

Plate 1

Table 1. Paddy grains, the natural feeding material of foraging ducks were incorporated to maintain 12 per cent of crude fibre.

The ducks in each treatment were assigned to each of the five rations and the three levels of enzymes viz., 0.06, 0.12, and 0.18 per cent were present in the rations as out lined below.

Dietary treatment	T1 (LF)	T2 (HF)	T3 (HF+E)	T4 (HF+E)	T5 (HF+E)
Crude Fibre %	8	12	12	12	12
Polyzyme %	0	0	0.06	0.12	0.18

The enzyme used in this study was 'Polyzyme' a multicellulolytic enzyme supplement, manufactured and marketed by M/S Zeus Biotech pvt. Ltd., Mysore. It contained Endoxylanase, Beta glucanase, Cellulase, Alpha amylase, Pectinase, Protease, Phytase, Alpha galactosidase and Beta galactosidase as indicated by manufacturer.

The experiment consisted of nine periods of 28 days each, from 21 to 56 weeks of age. Measured feed was given as wet mash two times daily. Drinking water was provided *ad lib*. The routine management practices were followed through out the experimental period. No artificial light was provided in the shed.

The body weight of ducks was recorded individually at 20, 40 and 52 weeks of age in order to ascertain the variations in body weight during the laying period. The egg production of ducks under different treatment groups was recorded daily during the entire period of the experiment. From these data, the egg number and per cent production were calculated week wise and period wise on duck-housed and duck-day basis. The feed intake was measured replicate wise

Table 1. Per cent inclusion of feed ingredients and chemical composition of the experimental diets

Ingredients	**Low Fibre Diet (8%) T1**	**High Fibre Diet (12%) T2**
Yellow maize	36.00	22.00
Rice polish	12.00	8.00
Rice bran (Deoiled)	8.00	12.00
Wheat bran	10.00	8.00
Soyabean meal	10.00	10.00
Gingelly oil cake	4.00	4.00
Unsalted dried fish	9.00	8.00
Shell grit	4.00	4.00
Mineral mixture	1.75	1.75
Salt	0.25	0.25
Paddy	5.00	22.00
Analyzed values		
Crude protein	18.03	17.92
Crude fibre	8.03	12.01
Ether extract	4.08	3.96
Calculated values		
ME (Kcal/kg)	2552	2435
Calcium	3.00	3.05
Available phosphorus	0.48	0.50
Lysine	0.77	0.76
Methionine	0.35	0.36
Supplements		
Indomix (A, B2, D3), g*	20	20
Alusil Premix, g**	200	200

* Indomix A, B_2, D_3 (Nicholas Primal India Ltd., Mumbai), containing Vit A 40000 IU, Vit B_2 20 mg, Vit D_3 5000 IU per gram was added to 100 kg diet.

** Alusil Premix (Stallen South Asia Pvt. Ltd.), containing SiO_2 400-500 mg, Al_2O_3 320-400 mg, Fe_2O_3 3-10 g, MgO 5-20 g, CaO 30-50 g, Na_2O 25-45 g, K_2O 5-10 g and ingredients made upto 1000 g was added to 100 kg diet.

at the end of each period and calculated as mean daily feed consumption in each period.

Feed efficiency was calculated based on egg number as well as egg mass and represented as Feed Conversion Ratio (FCR) per dozen eggs and per kilogram eggs.

The mean egg weight in each treatment was arrived at based on the individual egg weight of three consecutive eggs recorded at 0.1mg accuracy at the end of each 28-period.

Blood samples were collected from the wing vein of 6 ducks from each treatment group with anticoagulant sodium salt of ethylene diamine tetra acetate (2mg/ml blood) at 20, 40 and 52 weeks of age. Part of the blood was used for the estimation of hemoglobin and the remaining blood was centrifuged at 3000 rpm for 30 minutes to separate plasma. Plasma samples were aliquoted in labeled tubes and stored at -20^{0}C for estimation of total protein, cholesterol and lipids.

The concentration of hemoglobin was estimated by acid haematin method as described by Fieldman *et al.* (2000).

Total plasma protein was estimated by Biuret method as suggested by Henry *et al.* (1957) using Ecoline kit (M/s Merck India Ltd-Mumbai).

Concentration of plasma total lipids was estimated by Phosphovanilline method as described by Zeoliner (1962) using Lab kit (M/s.Labkit spain).

The total cholesterol was estimated by cholesterol phenol amino antipyrine (CHOD PAP) method as suggested by Stockbridge *et al.* (1989) using Ecoline kit (M/s.E.Merck India Limited, Mumbai).

At the end of the experimental period a digestibility trial was conducted using three birds each randomly selected from each treatment group. Total collection method was employed. The total amount of feed consumed and excreta voided were recorded for each day. The excreta of individual bird was collected in polythene bags, sealed and stored in deep freezer for further analysis.

The chemical composition and fibre fractions of the different rations used in the experiment and excreta collected during the digestibility trial were analysed and estimated as per the procedure of AOAC (1990) and Van-Soest and Wine (1967) respectively. The meat samples of six ducks from each group were subjected to proximate analysis.

Studies on Foraging Ducks

Nutrient availability of foraging ducks was studied utilizing 30 ducks of 38-44 weeks of age, 10 each from three regions viz., Kuttanad, Palakkad and Thrissur. The birds were procured immediately after foraging in paddy fields and their crop, blood samples and fat tissue were collected for further studies. The samples collected were stored in deep freezer for further analysis. The crop contents were subjected to visual examination. Further, the contents were weighed separately and processed for chemical analysis and estimation of pesticide residue. The fat samples were also subjected to further processing for estimation of pesticide residue. The blood samples collected were used for hemoglobin estimation and biochemical tests viz., plasma total protein, cholesterol and lipids.

Meat samples collected from foraging ducks were also subjected to proximate analysis.

Pesticide residue analysis

Specific cleanup procedures were carried out for complete removal of interfacing impurities and extraction of pesticide residues from the collected samples before introduction in to the Gas liquid chromatograph.

Residue extraction from the crop contents

Samples collected were dried and powdered and two grams of the sample was taken in an extraction thimble. The thimble was introduced in to a soxhlet extraction unit and extracted with 200 ml petroleum ether for six hours. This extract was concentrated in a vacuum flash evaporater to 10 ml and quantitatively transferred to a 100 ml separating funnel. Fifteen milliliter acetonitrile saturated with petroleum ether was added and shaken well and the layers were allowed to separate. The bottom layer containing pesticide was transferred to a one litre separating funnel having 600 ml water, 100 ml petroleum ether and 40 ml saturated sodium chloride solution. Extraction with acetonitrile was repeated for two more times and the bottom layer was collected in the same one litre separating funnel, shaken well and allowed to separate. The bottom aqueous layer was transferred to another one litre separating funnel containing 100 ml petroleum ether. It was also shaken well and allowed to separate. The aqueous layers were discarded and the petroleum ether layers from the two were pooled, washed with 100 ml of distilled water three times and dried with anhydrous sodium sulphate, then vacuum flash evaporated.

Five gram anhydrous sulphate was placed at the bottom of a glass column of size 30 mm x 450 mm and 25g of activated florisil was added to the top of sodium sulphate. Another 10 g of sodium sulphate was added above the florisil. After wetting the column with petroleum ether, transferred the acetonitrile clean up sample using small quantities of petroleum ether. Eluted the column first with 200 ml of 6 per cent diethyl ether in petroleum ether, followed by 200 ml of 15 per cent diethyl ether in petroleum ether. The elutes were pooled together and evaporated to dryness in vacuum flash evaporator. The dry matter obtained was taken in two millilitre petroleum ether for injection in to GLC.

Residue extraction from fat tissue

Approximately two grams of fat tissue was weighed and homogenized with anhydrous sodium sulphate and this powder was transferred to a column pre wetted with petroleum ether and the fat was carefully extracted with 200 ml petroleum ether. The extract was then subjected to further clean up procedures in the same method as done for crop content samples.

Analysis on gas liquid chromatography

Quantification of pesticide residues in the collected samples were done using gas liquid chromatography as per the method specified by Sharma (1979) and FDA (1977). GLC analysis was performed on a Hewlett-Packard Agilent 6890 series GC with electron capture detector (ECD) having ^{63}Ni as the radioactive source and equipped with HP enhanced integrator algorithm.

Detection and estimation

The chromatograph of samples and pesticides standard were obtained under identical conditions of GLC. Residues were detected by the combination of their retention time with the standard and the quantity by comparing the area with the standard using the HP enhanced integrator algorithm. Sum total of pesticides in the samples were quantified by the formula

$$\text{Pesticide residue in ppm} = \frac{X}{V_1} \times \frac{V}{M} \times \frac{1}{10^3}$$

X = Integrator reading in picogram

V_1 = µl of the sample injected

V = Total volume of cleaned up sample in ml

M = Weight (g) of sample taken for extraction

The data collected from various parameters were subjected to statistical analysis by One-way ANOVA using Statistical Package for Social Sciences (Field, 2000).

Results

4. RESULTS

The results of the study conducted to evaluate the effect of dietary supplementation of commercial enzyme preparation on production performance of indigenous layer ducks fed high fibre diet and the nutritional and physiological status of foraging ducks from three different regions of Kerala are presented in this chapter.

4.1 BODY WEIGHT

The mean body weight of ducks in different treatment groups at 20, 40 and 52 weeks of age are presented in Table 2 and graphically represented in Figure 1.

The body weight of ducks at 20th week of age in different treatment groups ranged from 1532.5 to 1663.0 g and at 40th week it ranged from 1649.75 to 1682.25 g, while at 52 weeks of age the values were in a range of 1647.0 to 1799.25 g. The mean body weight among the treatment groups was 1607.35, 1662.85 and 1724.10 g at 20, 40 and 52 weeks of age, respectively.

At 20 weeks of age, the birds in the group ear marked for feeding 0.18 per cent polyzyme supplemented diet T5 showed highest body weight (1663.0g) whereas the birds grouped for feeding 0.12 per cent enzyme diet T4 recorded lowest body weight (1532.5g). The body weight recorded among birds fed standard ration (T1), high fibre ration (T2) and 0.06 per cent enzyme supplemented diet (T3) were 1617.25, 1604.25 and 1619.75g respectively. However, the difference between the highest and lowest groups were non significant.

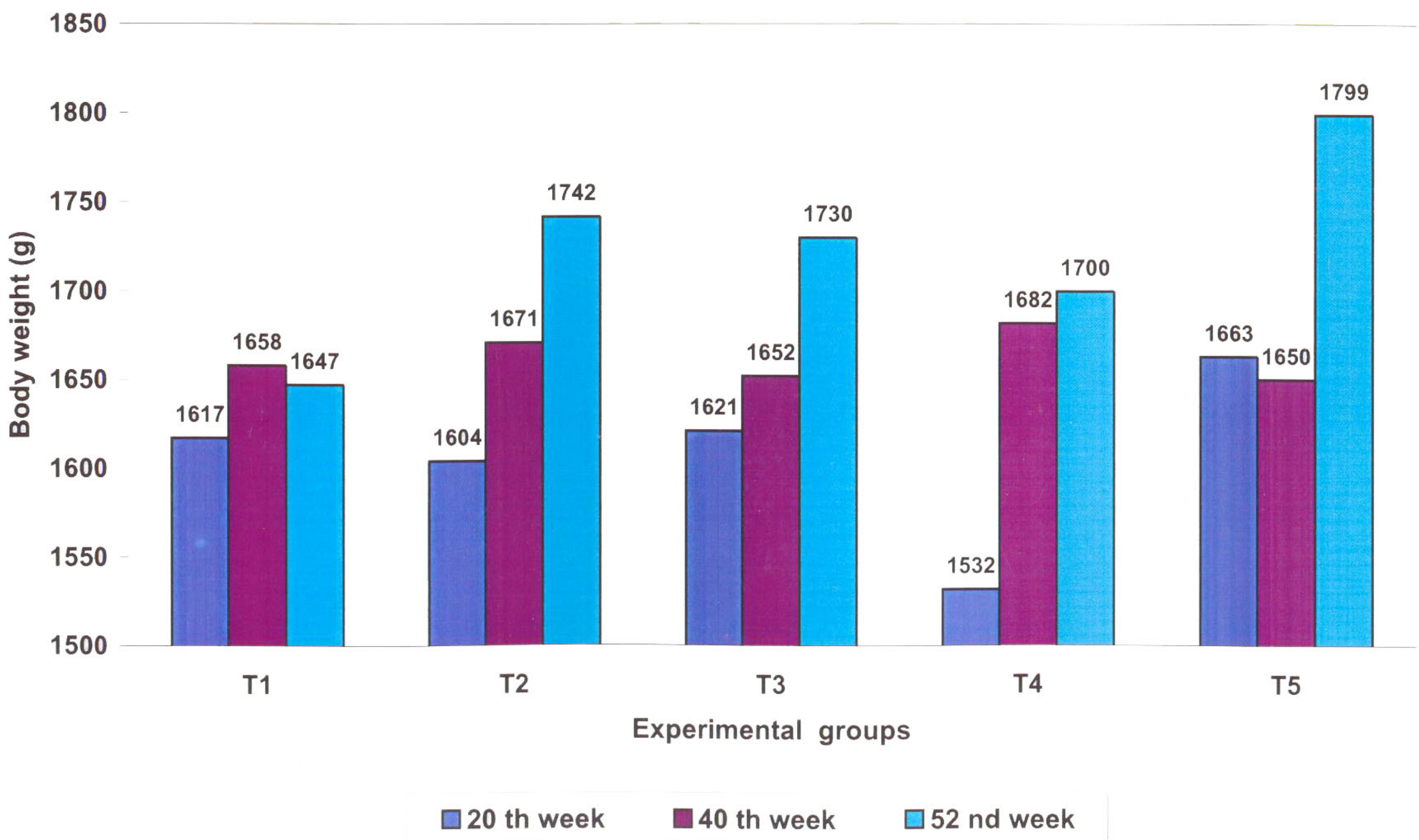
At 40th week of age the mean body weight for groups T1, T2, T3, T4 and T5 were 1658.50, 1671.50, 1652.25, 1682.25 and 1649.75 g respectively with no

Table 2. Mean body weight (g) at 20, 40 and 52 weeks of age in indigenous layer ducks as influenced by CF levels and enzyme supplementation in experimental diets

Age in weeks	Experimental Diets / CF per cent / Enzyme per cent					Overall mean
	T_1 8 0	T_2 12 0	T_3 12 0.06	T_4 12 0.12	T_5 12 0.18	
20	1617.25 ± 25.70	1604.25 ±13.75	1619.75 ±23.38	1532.50 ±57.25	1663.00 ±62.68	1607.35 ±13.63
40	1658.50 ±22.17	1671.50 ±18.29	1652.25 ± 46.11	1682.25 ± 41.82	1649.75 ± 46.94	1662.85 ± 15.03
52	1647.00^{a} ± 11.34	1742.25^{ab} ±37.05	1730.50^{ab} ±24.22	1710.50^{ab} ± 41.43	1799.25^{b} ± 21.62	1724.10 ±16.31

Note: Mean values bearing the same superscript within the row did not differ significantly ($P<0.01$)

Fig. 1 Mean body weight (g) of indigenous layer ducks at 20, 40 and 52 weeks of age as influenced by CF levels and enzyme supplementation in experimental diets



significant difference among the groups. The highest body weight recorded group at 20 weeks of age became the lowest body weight group at 40th week and vice versa.

At 52 weeks of age considerable increase in body weight was recorded in all groups except T1 where a decline of 11.50 g was recorded. The body weight recorded was 1647.0, 1742.25, 1730.50, 1710.50 and 1799.25g respectively among treatment groups T1, T2, T3, T4 and T5. Body weight in group T5 was significantly ($P<0.01$) higher than T1 group, while the other three groups were homogenous and comparable with T1 and T5.

4.2 EGG PRODUCTION

4.2.1 Duck Housed Number (DHN) – Period wise

The egg production measured on duck housed basis represented as duck housed number (DHN) per duck in each 28-day period for different treatment groups are presented in Table 3 and graphically represented in Figure 2.

The results revealed that in period 1, from 21 to 24 weeks of age, the mean DHN in groups T1, T2, T3, T4 and T5 was 3.93, 5.90, 3.60, 5.75 and 4.33 eggs respectively, with an overall mean of 4.70 eggs among the groups put together. The egg number in the first period was the lowest in group T3 and the highest in group T2 and the differences between the treatment groups were non significant.

In period II, the duck housed egg number in dietary groups T1, T2, T3, T4 and T5 was 14.60, 18.40, 15.78, 15.80 and 17.93 respectively with an overall mean of 16.51. The lowest DHN was in the group fed the control ration containing 8 per cent crude fibre (T1) and the highest DHN was in the group fed diet containing 12 per cent crude fibre (T2). The difference in egg number of 3.80 between these two groups was significant ($P<0.05$). The mean egg number in other groups of ducks fed 12 per cent crude fibre supplemented with polyzyme (T3, T4 and T5) were intermediary and the difference among them was non significant. The mean values in the polyzyme supplemented groups were statistically comparable with both the mean values of unsupplemented groups T1 and T2.

In period III, the lowest egg production (16.80) was in the control group (T1) showing similar trend as in the previous period, while the highest DHN (21.00) was recorded in the group fed 12 per cent crude fibre ration (T3) supplemented with 0.06 per cent polyzyme. The difference of 4.20 eggs between the mean values of T1 and T3 was significant (P<0.05). The mean egg production in other groups T2, T4 and T5 were 19.68, 18.83, and 19.45 respectively. These values were comparable with both the values in T1 and T3. The overall mean egg yield in the period III was 19.15 eggs.

In period IV, the difference in egg production among treatment groups was highly significant (P<0.01). The DHN in all the high fibre (HF) rations containing 12 per cent crude fibre was significantly higher (P<0.01) than that of the control diet (T1) containing 8 per cent crude fibre. The highest egg production (22.45) was recorded in the group T3 and the lowest in the group T1 (14.55). The DHN in treatment groups T2, T4 and T5 were, 19.53, 19.00 and 19.75 respectively. The variations between these groups were not very wide. However, the differences among the enzyme supplemented dietary groups were also significant (P<0.05). The DHN in 0.06 per cent enzyme supplemented group was significantly higher than that in 0.12 per cent enzyme fed group, while 0.18 per cent enzyme group was comparable with both the above. The overall mean egg out put in the period IV was 19.06.

The overall mean egg yield was only 17.50 in period V and a drastic decline in egg production was noticed in all the groups except the group T5 wherein the decrease in egg output was slight. The DHN recorded in treatment groups T1, T2, T3, T4 and T5 were 12.90, 17.55, 21.05, 16.38 and 19.63

respectively. The lowest egg production in group T1 with 8 per cent crude fibre was consistently low in this period also and was significantly (P<0.05) lower than all other groups. The highest DHN was in the HF ration supplemented with 0.06 per cent polyzyme (T3) followed by groups T5, T2 and T4 in that order. This trend was similar to the pattern observed in the previous period.

Interestingly, the groups T3, T5 were in a homogenous group and were significantly higher (P<0.05) than that of T4 and T1 and the latter was significantly (P<0.05) lower than the former.

In period VI, the DHN in groups T3 and T5 were significantly higher than that of T1 (P<0.01). The egg production recorded in treatment groups T1, T2, T3, T4 and T5 was 15.78, 17.10, 19.63, 17.43 and 19.20 respectively. The overall mean of 17.83 was slightly higher than that in the previous period (17.50). The egg production recorded was the lowest in group T1 in this period also. DHN was the highest in T3 group followed by the groups T5, T4 and T2 in that order. Thus in periods IV, V and VI, the DHN was significantly higher with the diet containing 12 per cent crude fibre supplemented with 0.06 per cent polyzyme (P<0.01).

In periods VII and VIII, the differences in DHN between treatments were significant (P<0.05) and that in period IX, it was non significant. In period VII, the egg production recorded in treatment groups T1, T2, T3, T4 and T5 was 12.30, 11.85, 13.08, 10.10 and 10.70 respectively with an overall mean of 11.61 for groups put together .The egg production recorded was significantly lower (P<0.05) in the group T4 and higher in T3. The treatment groups T1, T2 and T5 were in homogenous group. The diet T3 was significantly higher (P<0.05) than that of T4.

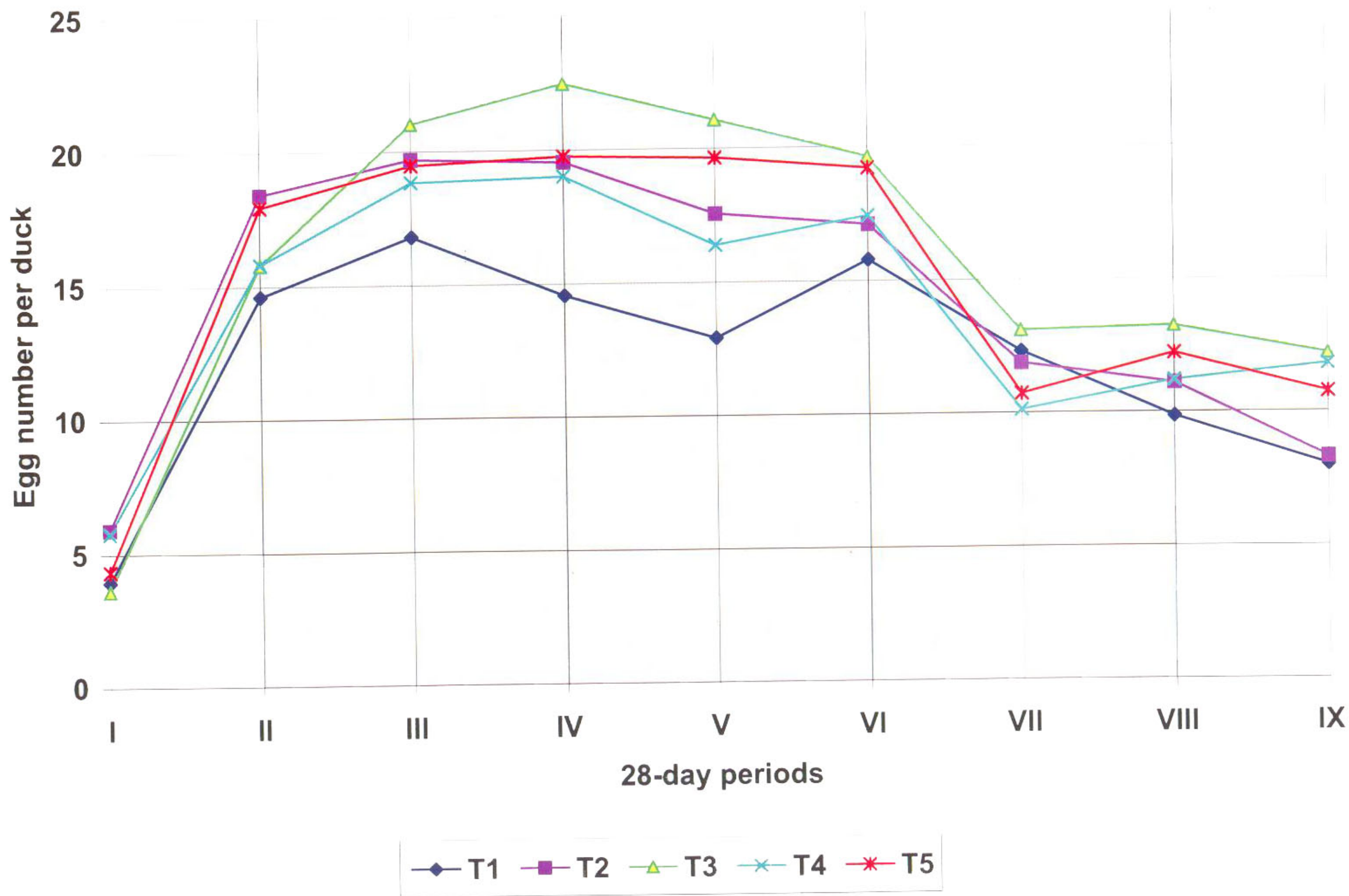
The DHN in treatment groups T1, T2, T3, T4 and T5 was 9.83, 11.08, 13.23, 11.18 and 12.20 respectively with an overall mean of 11.50 in period VIII.

Table 3. Period wise duck housed number (DHN) in indigenous layer ducks as influenced by CF levels and enzyme supplementation in experimental diets.

Period	Age in weeks	Experimental Diets / CF per cent / Enzyme per cent					Overall mean
		T_1 8 0	T_2 12 0	T_3 12 0.06	T_4 12 0.12	T_5 12 0.18	
I	21-24	3.93 ± 1.49	5.90 ±0.81	3.60 ±1.28	5.75 ±0.84	4.33 ±0.73	4.70 ±0.48
II	25- 28	14.60^{a} ±0.84	18.40^{b} ±1.12	15.78^{ab} ± 1.37	15.80^{ab} ± 1.01	17.93^{ab} ± 0.85	16.51 ±0.54
III	29-32	16.80^{a} ±0.89	19.68^{ab} ± 0.70	21.00^{b} ±0.86	18.83^{ab} ± 0.39	19.45^{ab} ± 1.65	19.15 ±0.50
IV**	33-36	14.55^{a} ±1.42	19.53^{b} ±0.83	22.45^{c} ±0.65	19.00^{b} ±0.26	19.75^{bc} ± 0.99	19.06 ±0.69
V	37- 40	12.90^{a} ±0.91	17.55^{bc} ±1.01	21.05^{d} ±0.45	16.38^{b} ±0.60	19.63^{cd} ±1.27	17.50 ±0.74
VI**	41- 44	15.78^{a} ±0.71	17.10^{ab} ±0.69	19.63^{c} ±0.69	17.43^{abc} ± 0.73	19.20^{bc} ± 0.90	17.83 ±0.44
VII	45- 48	12.30^{ab} ±0.40	11.85^{ab} ± 1.15	13.08^{b} ±0.96	10.10^{a} ±0.91	10.70^{ab} ± 0.46	11.61 ±0.41
VIII	49-52	9.83^{a} ±0.68	11.08^{ab} ± 0.65	13.23^{b} ±0.69	11.18^{ab} ± 0.60	12.20^{ab} ± 0.96	11.50 ±0.46
IX	53-56	8.00 ±2.32	8.30 ±2.63	12.18 ±2.12	11.78 ±1.36	10.73 ±1.39	10.20 ±0.90
Cumulative Egg Number	21-40	62.78^{a} ±21.99	81.10^{b} ±39.43	78.13^{b} ±56.24	75.75^{b} ±16.05	81.08^{b} ±9.00	75.77 ±21.91
	21-56	108.68^{a} ± 40.03	129.43^{bc} ± 45.01	141.98^{c} ± 46.36	126.23^{b} ± 33.98	133.90^{bc} ± 65.47	128.04 ± 31.54

Note: Mean values bearing the same superscript within the row did not differ significantly (P<0.05)
** Significant (P<0.01)

Fig. 2 Period wise mean DHN (21 to 56 weeks) in indigenous layer ducks as influenced by CF levels and enzyme supplementation in experimental diets



The lowest was in the group T1 and the highest in T3 and the difference between these groups were statistically significant ($P<0.05$).

In period IX, the egg production recorded in treatment groups T1, T2, T3, T4 and T5 was 8.00, 8.30, 12.18, 11.78 and 10.73 respectively with an overall mean of 10.20. DHN was the lowest in the group T1 and the highest in T3. The DHN was numerically higher in all diets supplemented with polyzyme but the differences between the mean values were non significant.

The cumulative DHN in different treatment groups for 21 to 56 weeks of age is shown in the Table 3 and Fig.3. During 21 to 56 weeks of age, the highest egg number was registered with T3 (0.06% enzyme group) which was significantly ($P<0.05$) higher than T4 (0.12% enzyme group) and both these groups were significantly higher than T1 (low fibre diet group). The other two groups T2 and T5 were homogenous and intermediary between T3 and T4. Egg number up to 56 weeks of age was 108.68, 129.43, 141.98, 126.23 and 133.90 for the groups T1 to T5 in that order with a mean value of 128.04 among the treatment groups.

4.2.2 Duck Day Number (DDN)

The duck day number in each 28-day period for different treatment groups is presented in Table 4. Since there were three mortality each occurred at 38th, 40th and 44th week in treatment groups T5, T2 and T1 respectively, the DDN differed from DHN only in the above three groups from the respective periods onwards. The cumulative duck day egg number was 109.44, 130.65 and 135.78 in T1, T2 and T5 respectively. Since only slight difference existed among DHN and DDN in these groups, statistical difference among the treatment groups remained same as in the case of DHN.

Fig. 3 Cumulative egg number per duck from 21 to 56 weeks of age as influenced by CF levels and enzyme supplementation in experimental diets

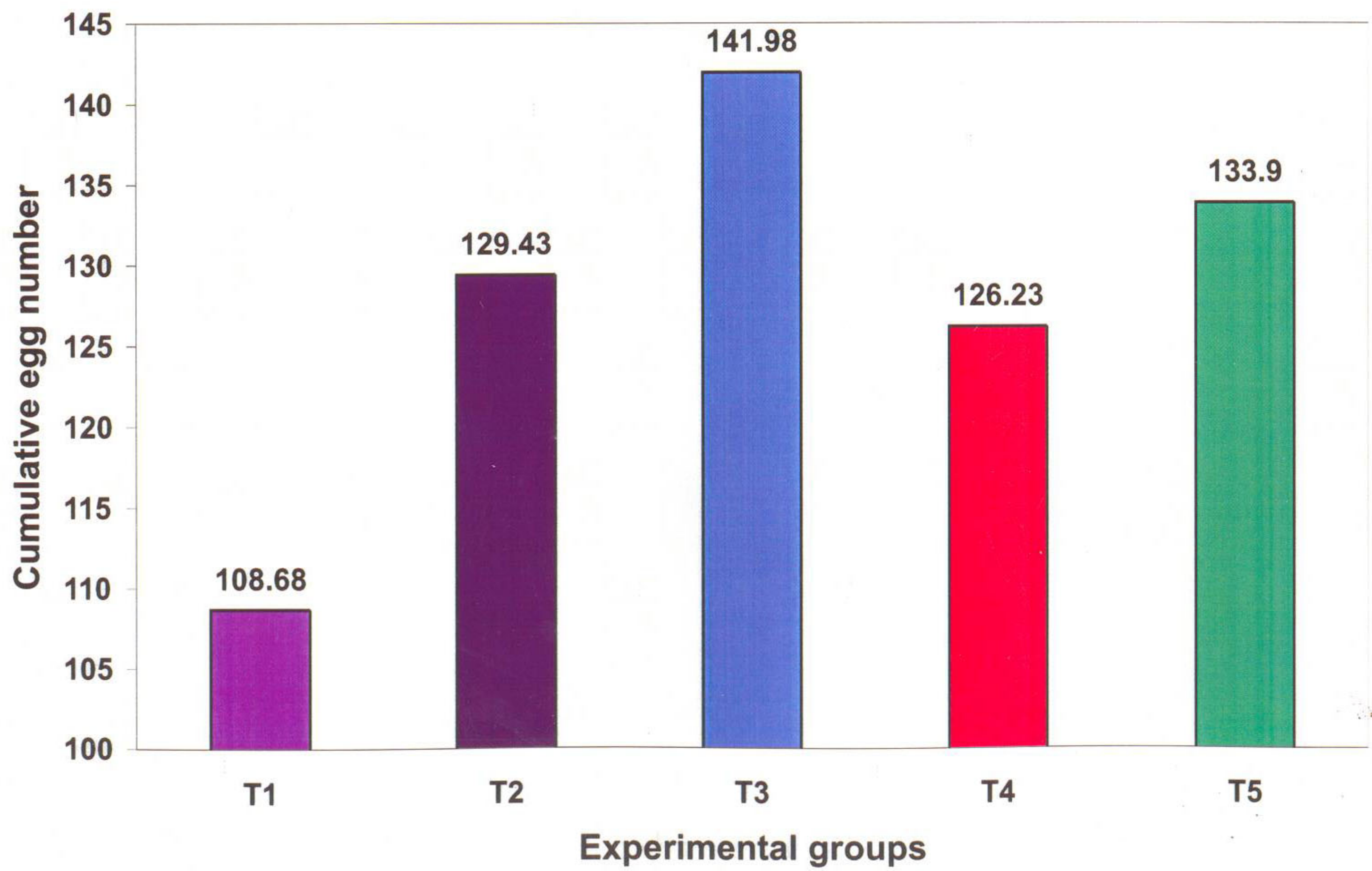


Table 4. Period wise duck day number (DDN) of eggs in indigenous layer ducks as influenced by CF levels and enzyme supplementation in experimental diets

Period	Age in weeks	Experimental Diets / CF per cent / Enzyme per cent					Overall mean
		T_1 8 0	T_2 12 0	T_3 12 0.06	T_4 12 0.12	T_5 12 0.18	
I	21-24	3.93 ±1.49	5.90 ±0.81	3.60 ±1.28	5.75 ±0.84	4.33 ±0.73	4.70 ±0.48
II	25-28	14.60^{a} ±0.84	18.40^{b} ±1.12	15.78^{ab} ±1.37	15.80^{ab} ± 1.01	17.93^{ab} ±0.85	16.51 ±0.54
III	29-32	16.80^{a} ± 0.89	19.68^{ab} ± 0.70	21.00^{b} ±0.86	18.83^{ab} ± 0.39	19.45^{ab} ±1.65	19.15 ±0.50
IV	33-36	14.55^{a} ±1.42	19.53^{b} ±0.83	22.45^{c} ±0.65	19.00^{b} ±0.26	19.75^{bc} ±0.99	19.06 ±0.69
V	37-40	12.90^{a} ±0.91	17.62^{bc} ± 1.01	21.05^{d} ±0.45	16.38^{b} ±0.60	20.03^{cd} ±1.27	17.60 ±0.74
VI	41-44	15.86^{a} ±0.71	17.60^{ab} ± 0.69	19.63^{c} ±0.69	17.43^{abc} ± 0.73	19.71^{bc} ±0.90	18.04 ±0.44
VII	45-48	12.63^{ab} ±0.40	12.20^{ab} ± 1.15	13.08^{b} ±0.96	10.10^{a} ±0.91	11.02^{ab} ±0.46	11.80 ±0.41
VIII	49-52	10.05^{a} ±0.68	11.35^{ab} ± 0.65	13.23^{b} ±0.69	11.18^{ab} ± 0.60	12.52^{ab} ±0.96	11.66 ±0.46
IX	53-56	8.12 ±2.32	8.37 ±2.63	12.17 ±2.12	11.78 ±1.36	11.04 ±1.39	10.29 ±0.90
Cumulative Egg Number	21-56	109.44^{a} ± 40.05	130.65^{bc} ±45.03	141.98^{c} ± 46.36	126.23^{b} ± 33.98	135.78^{bc} ± 65.25	128.82 ± 31.50

Note: Mean values bearing the same superscript within the row did not differ significantly ($P<0.05$)

4.2.3 Duck Housed (DH) and Duck Day (DD) Per Cent Production – Period wise

The per cent egg production measured on duck housed and duck day basis represented as Duck Housed Per Cent (DHP) and Duck Day Per cent (DDP) in each 28-day period for different treatment groups are presented in Tables 5 and 6 respectively.

The values were same for DHP and DDP up to period V in respective groups, but varied afterwards in groups T5, T2 and T1 due to mortality of one duck each in these groups at 38th, 40th and 44th week of age respectively. The statistical difference remained in the same pattern among groups both for DHP and DDP.

The mean Duck Day Per Cent (DDP) Production in groups T1, T2, T3, T4 and T5 (Table 6) was 14.03, 21.05, 12.84, 20.53 and 17.95 per cent respectively with an overall mean of 17.28 per cent in period 1, from 21 to 24 weeks of age. The mean values due to the crude fibre levels and supplementation of polyzyme did not differ significantly among diets.

The per cent production registered in period II ranged from 52.15 to 65.88, the lowest being the group fed the ration containing 8 per cent crude fibre (T1) and the highest with that fed 12 per cent crude fibre diet without enzyme (T2). The difference between these two groups was 13.73 per cent and was significant ($P<0.05$). In the 12 per cent crude fibre diets supplemented with polyzyme, the DDP were 56.33, 56.43 and 64.00 in groups T3, T4 and T5 respectively and the difference was non significant among each other. These three groups were statistically comparable with the highest and lowest groups (T2 and T1) also. The overall mean DDP was 58.96 per cent in the second period.

In period III, the DDP ranged from 60.00 to 75.03 per cent, the lowest was registered in the control group (T1) showing same trend as in the second period, while the highest mean value recorded with the ration supplemented with

0.06 per cent polyzyme (T3). The difference between the mean values were statistically significant (P<0.05). The egg production in other groups T2, T4 and T5 were 70.28, 67.23, and 69.48 per cent respectively. These values were intermediary and were comparable with both the mean values in T1 and T3. The overall mean egg yield during the period III was 68.40 per cent, an increase of 9.44 per cent in comparison to that in period II.

In period IV, the duck day per cent (DDP) production with all diets containing 12 per cent CF was significantly higher (P<0.01) than that of 8 per cent CF level. The production in the group T1 showed a declining trend (51.95%) while the DDP recorded in T3 was the highest (80.18 per cent). The groups T2, T4 and T5 registered a production of 69.73, 67.88 and 70.55 per cent respectively and were intermediary and statistically comparable. The differences in DDP among the enzyme supplemented dietary groups showed that T3 supplemented with 0.06 per cent polyzyme was significantly higher (P<0.05) than that of diet T4 and diet T2. The overall mean egg out put in the period IV (68.06 per cent) was almost same as that observed in period III (68.40 per cent).

In period V, the overall mean per cent production was reduced to 62.85 than the previous period and a decline in egg production was noticed in all the groups except group T5 wherein there was a slight increase of 1.08 per cent in egg output reaching the mean value of 71.63 per cent. The egg production recorded in treatment groups T1, T2, T3 and T4 were 46.05, 62.93, 75.18 and 58.48 per cent respectively. Therefore, the groups T3 and T5 formed a homogenous group with higher egg production. The diet T1 was consistently poor in this period also. The highest DDP was in the ration supplemented with 0.06 per cent polyzyme (T3) followed by groups T5, T2 and T4. All the high fibre diet groups registered significantly higher egg production than that of T1 (P<0.05).

In period VI, the per cent Duck Day Production (DDP) in groups T3 and T5 were high and almost similar. It was significantly higher than that of T1

(P<0.01). The egg production recorded in groups T1, T2, T3, T4 and T5 was 56.63, 63.28, 70.08, 62.15 and 70.40 per cent respectively. The overall mean per cent production in this period (64.51) was slightly higher than that in the previous period (62.85). The egg production recorded was the lowest with 8 per cent crude fibre diet in this period. It was high with diets containing 0.18 and 0.06 per cent polyzyme supplemented groups (T5 and T3) followed by T2 and T4.

From period VII onwards, there was marked reduction in egg production and the overall mean out put was 42.16, 41.67 and 36.76 per cent in periods VII, VIII and IX respectively. The DDP was significant between diets (P<0.05) only in periods VII and VIII.

In period VII, the mean egg production was 45.10, 43.55, 46.70, 36.08 and 39.35 per cent in groups T1, T2, T3, T4 and T5 respectively. Significantly higher (P<0.05) egg production was noticed in T3 group and lower with T4. T1, T2 and T5 formed a homogenous group and were statistically comparable with T3 and T4.

In period VIII the Duck Day Per cent (DDP) Production in treatment groups T1, T2, T3, T4 and T5 was 35.90, 40.55, 47.25, 39.90 and 44.73 respectively, the lowest was in the group T1 and the highest in T3. The difference between these groups was statistically significant (P<0.05). In the last period covering 53-56 weeks of age the DDP in treatment group T1 was 28.98 and that in T2 was 29.88 only. The DDP in T3, T4 and T5 was 43.48, 42.08 and 39.40 respectively. The production was the lowest in T1 and the highest in T3 and the DDP was numerically higher in all diets supplemented with polyzyme but the differences between the mean values were non significant.

The overall duck day per cent production for the period from 21 to 56 weeks of age presented in Table 6 revealed that it was significantly higher with all the diets containing 12 per cent crude fibre than that of the control diet containing 8 per cent crude fibre (P<0.05). The DDP were 43.4, 51.9, 56.3, 50.1

Table 5. Period wise duck-housed per cent (DHP) production in indigenous layer ducks as influenced by CF levels and enzyme supplementation in experimental diets

Period	Age in weeks	Experimental Diets / CF per cent / Enzyme per cent					Overall mean
		T_1 8 0	T_2 12 0	T_3 12 0.06	T_4 12 0.12	T_5 12 0.18	
I	21-24	14.03 ±5.30	21.05 ±2.89	12.84 ±4.54	20.53 ±3.02	17.95 ±1.25	17.28 ±1.65
II	25-28	52.15[a] ±2.99	65.88[b] ±4.01	56.33[ab] ± 4.90	56.43[ab] ±3.60	64[ab] ±3.03	58.96 ±1.91
III	29-32	60.00[a] ±3.20	70.28[ab] ± 2.50	75.03[b] ±3.05	67.23[ab] ±1.40	69.48[ab] ± 5.89	68.4 ±1.80
IV	33-36	51.95[a] ±5.06	69.73[b] ±2.97	80.18[c] ±2.32	67.88[b] ±0.90	70.55[bc] ± 3.55	68.06 ±2.46
V	37-40	46.05[a] ±3.24	62.68[bc] ± 3.59	75.18[d] ±1.60	58.48[b] ±2.17	70.09[cd] ± 4.54	62.49 2.63
VI	41-44	56.33[a] ±2.54	61.05[ab] ± 2.46	70.08[c] ±2.49	62.15[abc] ±2.54	68.57[bc] ± 3.22	63.63 ±1.57
VII	45-48	43.93[ab] ±1.43	42.30[ab] ± 4.12	46.70[b] ± ±3.42	36.08[a] ±3.25	38.23[ab] ± 2.49	41.45 ±1.56
VIII	49-52	35.08[a] ±2.42	39.58[ab] ± 2.30	47.25[b] ±5.48	39.9[ab] ±2.14	43.60[ab] ± 3.42	41.08 ±1.64
IX	53-56	28.55 ±8.30	29.67 ±9.39	43.50 ±7.59	42.08 ±4.86	38.33 ±4.97	36.47 ±3.22
Cumulative mean	21-40	44.84[a] ±4.58	57.97[b] ±2.81	59.91[b] ±2.63	54.11[b] ±1.15	58.41[b] ±3.11	55.04 ±4.56
	21-56	43.12[a] ±1.39	51.36[bc] ±1.73	56.34[c] ±1.85	50.10[b] ±1.34	53.4[bc] ±2.10	50.90 ±1.35

Note: Mean values bearing the same superscript within the row did not differ Significantly ($P<0.05$)

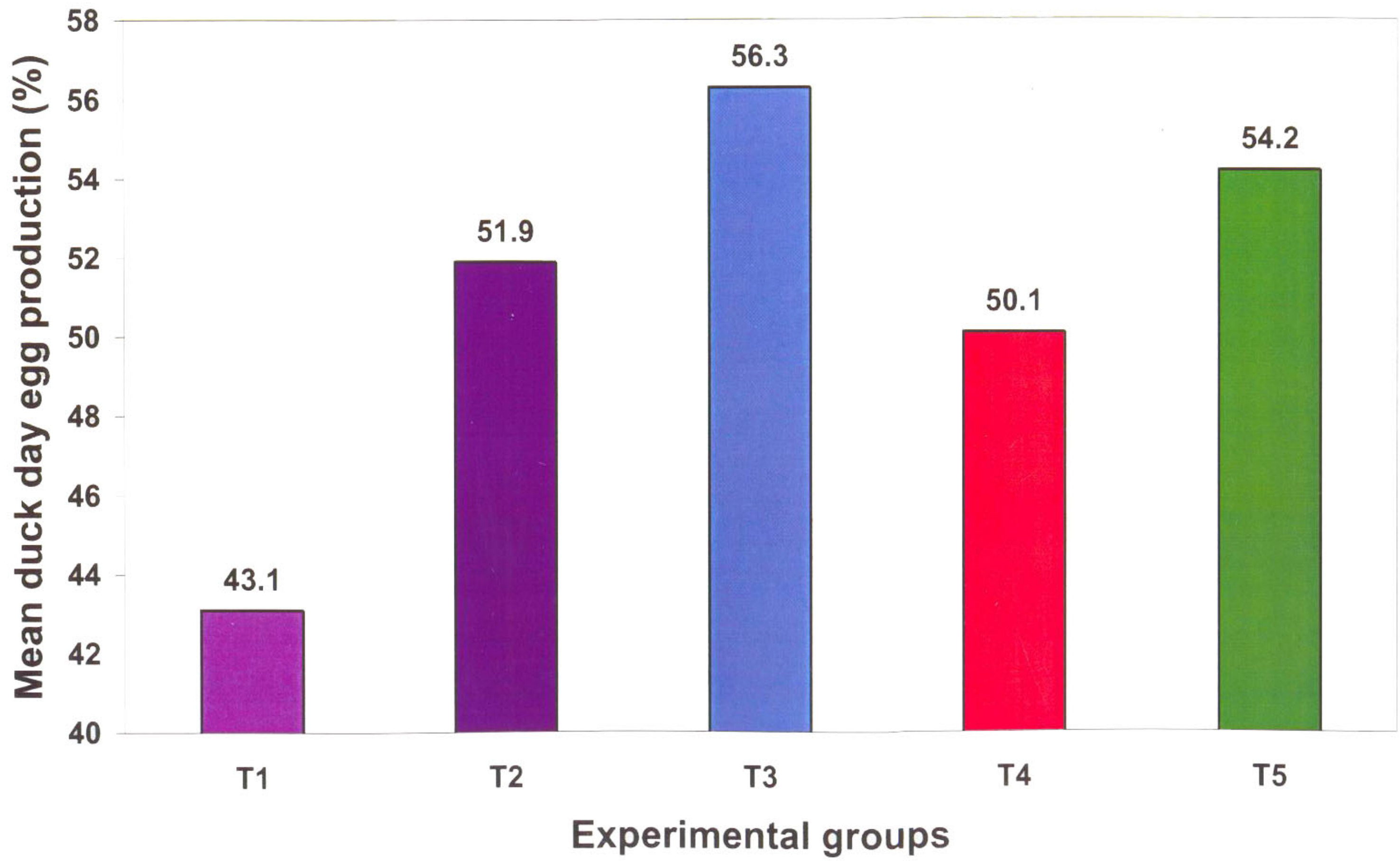
Table 6. Period-wise duck-day per cent (DDP) production in indigenous layer ducks as influenced by CF levels and enzyme supplementation in experimental diets

Period	Age in weeks	Experimental Diets / CF per cent / Enzyme per cent					Overall mean
		T_1 8 0	T_2 12 0	T_3 12 0.06	T_4 12 0.12	T_5 12 0.18	
I	21-24	14.03 ±5.30	21.05 ± 2.89	12.84 ±4.54	20.53 ±3.02	17.95 ±1.25	17.28 ±1.65
II	25-28	52.15^{a} ±2.99	65.88^{b} ± 4.01	56.33^{ab} ± 4.90	56.43^{ab} ±3.60	64.00^{ab} ±3.03	58.96 ±1.91
III	29-32	60.00^{a} ±3.20	70.28^{ab} ± 2.5	75.03^{b} ±3.05	67.23^{ab} ±1.4	69.48^{ab} ±5.89	68.40 ±1.80
IV**	33-36	51.95^{a} ±5.06	69.73^{b} ± 2.97	80.18^{c} ±2.32	67.88^{b} ±0.90	70.55^{bc} ±3.55	68.06 ±2.46
V	37-40	46.05^{a} ±3.24	62.93^{bc} ± 3.71	75.18^{d} ±1.6	58.48^{b} ±2.17	71.63^{cd} ±4.68	62.85 ±2.70
VI**	41-44	56.63^{a} ±2.47	63.28^{ab} ± 3.74	70.08^{b} ±2.49	62.15^{ab} ±2.54	70.40^{b} ±3.27	64.51 ±1.67
VII	45-48	45.10^{ab} ±1.62	43.55^{ab} ± 4.53	46.70^{b} ±3.42	36.08^{a} ±3.25	39.35^{ab} ±2.49	42.16 ±1.56
VIII	49-52	35.90^{a} ±1.88	40.55^{ab} ± 1.88	47.25^{b} ±5.48	39.90^{ab} ±2.14	44.73^{ab} ±3.29	41.67 ±1.58
IX	53-56	28.98 ±8.07	29.88 ± 9.24	43.48 ±7.58	42.08 ±4.86	39.40 ±5.16	36.76 ±3.18
Cumulative mean	21-56	43.40^{a} ±1.47	51.90^{bc} ±1.76	56.30^{c} ±1.85	50.10^{b} ±1.35	54.20^{bc} ±2.53	51.20 ±1.25

Note: Mean values bearing the same superscript within the row did not differ significantly ($P<0.05$)

** Significant ($P<0.01$)

Fig. 4 Mean per cent duck day egg production (21-56 weeks of age) as influenced by CF levels and enzyme supplementation in experimental diets



and 54.2 with diets T1, T2, T3, T4, and T5 respectively. Among the high fibre diets, the diet T3 supplemented with 0.06 per cent polyzyme was better than other diets but was statistically comparable with T2 and T5.

4.2.4 Duck Housed Production – Week wise

The effect of polyzyme supplementation in high fibre diets in indigenous layer ducks was evaluated critically based on the pattern of week-wise egg production from 21 to 56 weeks of age. The effect due to season in this experiment, which commenced on May 21, 2002 and terminated on 27th January 2003, was also explored.

The weekly DH number and per cent production per duck from 23 to 56 weeks of age in 8 and 12 per cent CF diets and the latter supplemented with three levels of polyzyme are presented in Table 7.

Since egg laying was not started at 21 weeks of age in groups T1 and T5 and as the egg production in all groups were less than 10 per cent at 22 weeks of age, the data pertaining to this trait for 21 and 22 weeks of age were not considered for statistical analysis.

The cumulative mean DHN for 23 to 56 weeks of age were 107.25, 128.83, 140.51, 125.33 and 133.84 eggs in T1, T2, T3, T4 and T5 respectively and it was the highest in diet T3 followed by T5, T2, T4 and T1 in that order. The corresponding per cent production during the entire period of experiment was 45.07, 54.15, 59.04, 52.66 and 56.26 over a period of 34 weeks (238 days of production).

The weekly DHN in T1 was found to be less in comparison with all other diet groups. The rate of production in T1 was low throughout the experiment except at 45, 46, 47, 50 and 56 weeks of age compared to other groups. It was evidently low in almost all weeks until 43 weeks of age that ended on 29th

October 2002. The slight edge in production, but non significant, in the T1 group over the other groups was exhibited only at 50 and 56 weeks of age. Thus it can be surmised that the 8 per cent CF diet was poorly utilized in comparison with 12 per cent CF diet. The CF utilization was also higher in the enzyme supplemented high fibre diets.

The weekly pattern of egg production in the diet containing 12 per cent CF (T2) showed that it was superior to all other diets during early periods from 24 to 27 weeks of age. The egg production was consistently high in all weeks during 30 to 43 weeks of age, which fell during the period from July to middle of October 2002.

From 45 weeks onwards, which coincided with last week of October 2002, a drop in egg production was evident in all groups irrespective of the differences in CF levels and various polyzyme levels of supplementation. A sharp decline in egg production was observed particularly in all the polyzyme supplemented groups at 46th week, while in the unsupplemented groups (T1 and T2) it was at 47th week, which coincided with middle of November. Thereafter production was better in all groups for two weeks towards the end of November and in early December. This was immediately followed with decline in per cent production in all groups irrespective of CF and polyzyme levels.

When the first four weeks are not considered, the egg production in T3, T4 and T5 was the lowest at 46th week in comparison with other groups, so also at 47th week in T4 and T5. The very low egg yield in the group T4 (19.29 per cent) and T5 (20.14 per cent) at 46th week and T2 (19.71 per cent) at 56th week was the lowest within the groups during the entire period from 25 to 56 weeks of age.

At 48 weeks of age, the egg production increased by more than double in comparison to that in 47th week production in all diets containing 12 per cent CF. The lowest egg production in T1 group was recorded at 52 weeks of age (9.57 per cent). Around this period the egg yield was low in all other groups. This period coincided with the shortest day length in tropics. At 56 weeks of age, the egg production in all groups was low except T1 wherein there was little increase in egg yield.

4.2.4.1 Peak Production

The peak production of 64.71 per cent occurred in T1 at 32 weeks of age. At the same age the T2 and T4 also registered the peak production (76.86 and 76.43 per cent respectively). At this age T3and T5 recorded 80.00 and 69.29 per cent egg production respectively. The highest egg production level of 83.29 per cent was observed in T3 on a latter age at 35 weeks. T5 also showed its highest yield of 73.57 per cent in 35th week. A second peak of 63.43 per cent was observed in T1 at 44th week, while it was observed at 43rd week in T2 and T4 and T5 as 67.71, 65.71 and 76.57 per cent respectively. In T3 group the second peak of 79.00 per cent was observed at 39th week.

4.2.4.2 Persistency of production

The DH per cent was above 60 per cent in T1 at 32, 43 and 44 weeks of age. In T2, production was above 60 per cent for a longer period continuously from 26 to 39 weeks and also at 41, 43 and 44 weeks of age. While in the T3 group, the production was excellent and was above 70 per cent from 28 to 43 weeks of age and at 48th week. However, at 41st week it was only 69.71 per cent. DH per cent was 80 and above at 32, 35 and 36 weeks of age.

The group T4 was inferior to other polyzyme supplemented groups with respect to per cent egg production. In that group above 60 per cent production was observed from 29 to 37 weeks and also at 42 to 44 weeks. Above 70 per cent production was obtained only at 32 and 34 weeks. In the 0.18 per cent polyzyme supplemented group T5, above 60 per cent DH production was registered from 25 to 44 weeks and at 48th and 49th week. In this group, above 70 per cent was

Table 7. Weekly mean DHN and DHP production in indigenous layer ducks as influenced by CF levels and enzyme supplementation in experimental diets

	Mean DH egg no. per duck per week					Percent production per duck per week					
Age in Weeks	T1	T2	T3	T4	T5	Age in Weeks	T1	T2	T3	T4	T5
23	1.33	1.78	1.00	2.03	1.15	23	19.00	25.43	14.29	29.00	16.43
24	1.93	3.48	1.93	3.00	3.08	24	27.57	49.71	27.57	42.86	44.00
25	2.66	4.08	2.73	3.60	4.25	25	38.00	58.29	39.00	51.43	60.71
26	3.75	4.95	3.80	4.03	4.55	26	53.57	70.71	54.29	57.57	65.00
27	4.08	4.95	4.30	4.15	4.68	27	58.29	70.71	61.43	59.29	66.86
28	4.10	4.48	4.95	4.03	4.45	28	58.57	64.00	70.71	57.57	63.57
29	4.03	5.13	4.93	4.53	4.83	29	57.57	73.29	70.43	64.71	69.00
30	4.05	4.48	5.18	4.40	4.98	30	57.86	64.00	74.00	62.86	71.14
31	4.20	4.70	5.30	4.55	4.80	31	60.00	67.14	75.71	65.00	68.57
32	4.53	5.38	5.06	5.35	4.85	32	64.71	76.86	80.00	76.43	69.29
33	3.08	4.93	5.38	4.85	5.08	33	44.00	70.43	76.86	69.29	72.57
34	3.63	4.95	5.53	5.00	4.70	34	51.86	70.71	79.00	71.43	67.14
35	3.45	5.05	5.83	4.40	5.15	35	49.29	72.14	83.29	62.86	73.57
36	3.60	4.60	5.73	4.53	4.83	36	51.43	65.71	81.86	64.71	69.00
37	3.85	4.68	5.43	4.25	4.85	37	55.00	66.86	77.57	60.71	69.29
38	2.88	4.80	5.05	4.13	5.26	38	41.14	68.57	72.14	59.00	75.14
39	2.83	4.30	5.53	4.18	5.05	39	40.43	61.43	79.00	59.71	72.14
40	3.35	3.87	5.05	3.83	4.85	40	47.86	55.29	72.14	54.71	69.29
41	3.43	4.44	4.88	3.98	5.05	41	49.00	63.43	69.71	56.86	72.14
42	3.65	4.10	5.15	4.48	4.85	42	52.14	58.57	73.57	64.00	69.29
43	4.38	4.74	5.03	4.60	5.36	43	62.57	67.71	71.86	65.71	76.57
44	4.44	4.26	4.58	4.35	4.44	44	63.43	60.86	65.43	62.14	63.43
45	3.74	3.51	2.40	3.13	3.38	45	53.43	50.14	34.29	44.71	48.29
46	3.59	2.54	2.03	1.35	1.41	46	51.29	36.29	29.00	19.29	20.14
47	2.56	2.03	2.45	1.70	1.74	47	36.57	29.00	35.00	24.29	24.86
48	2.72	4.08	5.33	3.93	4.44	48	38.86	58.29	76.14	56.14	63.43
49	4.08	3.46	4.45	3.23	4.21	49	58.29	49.43	63.57	46.14	60.14
50	3.41	2.54	3.10	2.60	3.00	50	48.71	36.29	44.29	37.14	42.86
51	1.92	2.74	2.90	2.28	2.67	51	27.43	39.14	41.43	32.57	38.14
52	0.67	2.62	2.78	3.08	2.64	52	9.57	37.43	39.71	44.00	37.71
53	1.18	2.49	2.95	3.70	2.79	53	16.86	35.57	42.14	52.86	39.86
54	2.18	2.62	3.55	3.53	3.79	54	31.14	37.43	50.71	50.43	54.14
55	2.08	2.03	3.10	2.40	2.44	55	29.71	29.00	44.29	34.29	34.86
56	2.77	1.38	2.58	2.15	1.97	56	39.57	19.71	36.86	30.71	28.14
23-56 weeks	**107.25**	**128.83**	**140.51**	**125.33**	**133.84**	**Mean**	**45.07**	**54.15**	**59.04**	**52.66**	**56.26**

observed at 30, 33, 35, 38, 39, 41 and 43 weeks of age, which is at three weeks and alternate week intervals. This phenomenon was not noted with the 0.12 per cent polyzyme supplemented group.

4.3 EGG WEIGHT

4.3.1 Mean Egg Weight (EW) – Period wise

The mean egg weight worked out on the basis of all eggs weighed individually during three days consecutively towards the end of each 28-day periods from I to IX in different treatment groups are presented in Table 8 and graphically represented in Fig.5. These data represent the mean EW at four week intervals from 24th week onwards.

At 24th week of age, the highest EW of 65.1 g recorded with 0.06 per cent polyzyme (T3) was significantly higher ($P<0.05$) than that of 59.7 g observed in T1, 61.3 g in T2 and 60.9 g in T5. In period II, the mean EW ranged from 60.7 (T1) to 63.0 g (T5) and did not differ significantly between treatments. It was comparatively uniform in T2, T3 and T4 (61.7, 61.5, 61.9 g respectively). The overall mean EW was 61.9 and 61.8 g at 24th and 28th week of age respectively. At 32 weeks of age, EW was increased in all treatment groups. It was 66.0, 63.6, 65.9, 66.9 and 66.0 g in T1, T2, T3, T4 and T5 respectively with an overall mean of 65.7 g. The egg weight of birds fed diet T4 was significantly higher than that of T2 ($P<0.05$).

Subsequently, the mean EW did not differ significantly at 36, 40 and 44 weeks of age, among treatment groups. The overall mean egg weights at these ages were 66.8, 69.0 and 70.3 g respectively.

At 36 weeks of age, the mean EW in T1 and T4 was the same (67.3 g) and in other groups it was almost similar (66.4, 66.8 and 66.3 g for T2, T3 and T5 respectively). At 40 weeks of age, the magnitude of difference between the lowest and highest mean EW was only 1.8 g ranging from 68.1g in T1 and 69.9 g in T5. At 44 weeks of age, the mean EW was uniformly high in all groups. The mean egg weight at this age was 70.4, 70.4, 70.7, 70.2 and 69.8 g respectively for T1, T2, T3, T4 and T5.

The overall mean EW was increased to 71.2 g at 48 weeks of age. However, there was a reduction in egg weight in the group fed diet T1 with 8 per cent CF (65.9 g). The birds fed a diet having 12 per cent CF laid significantly heavier eggs than control birds (69.9 g). Supplementation of Polyzyme in high fibre diets resulted significantly heavier eggs in T3, T4 and T5 (74.4, 70.8 and 74.7 g respectively) and formed a homogenous group. The egg weight between T2 and T4 was statistically comparable. At 52 weeks of age, the overall mean EW reduced to 69.6 g showing a decline in the T1 group. The mean EW in the corresponding groups of T1 to T5 was 60.2, 69.8, 72.6, 72.5 and 72.8 g respectively. The EW in all diets containing 12 per cent CF were significantly higher ($P<0.01$) in comparison with the control group.

There was further increase in EW at 56 weeks of age in all groups including diet T1. The mean EW with diet T3 (78.1g) was significantly higher ($P<0.05$) than diet T1 (73.4 g). The mean egg weight in groups T2, T4 and T5 were also relatively high (76.0, 75.5 and 77.1 g respectively) and were statistically comparable. The overall mean EW was 76.0 g at 56 weeks of age.

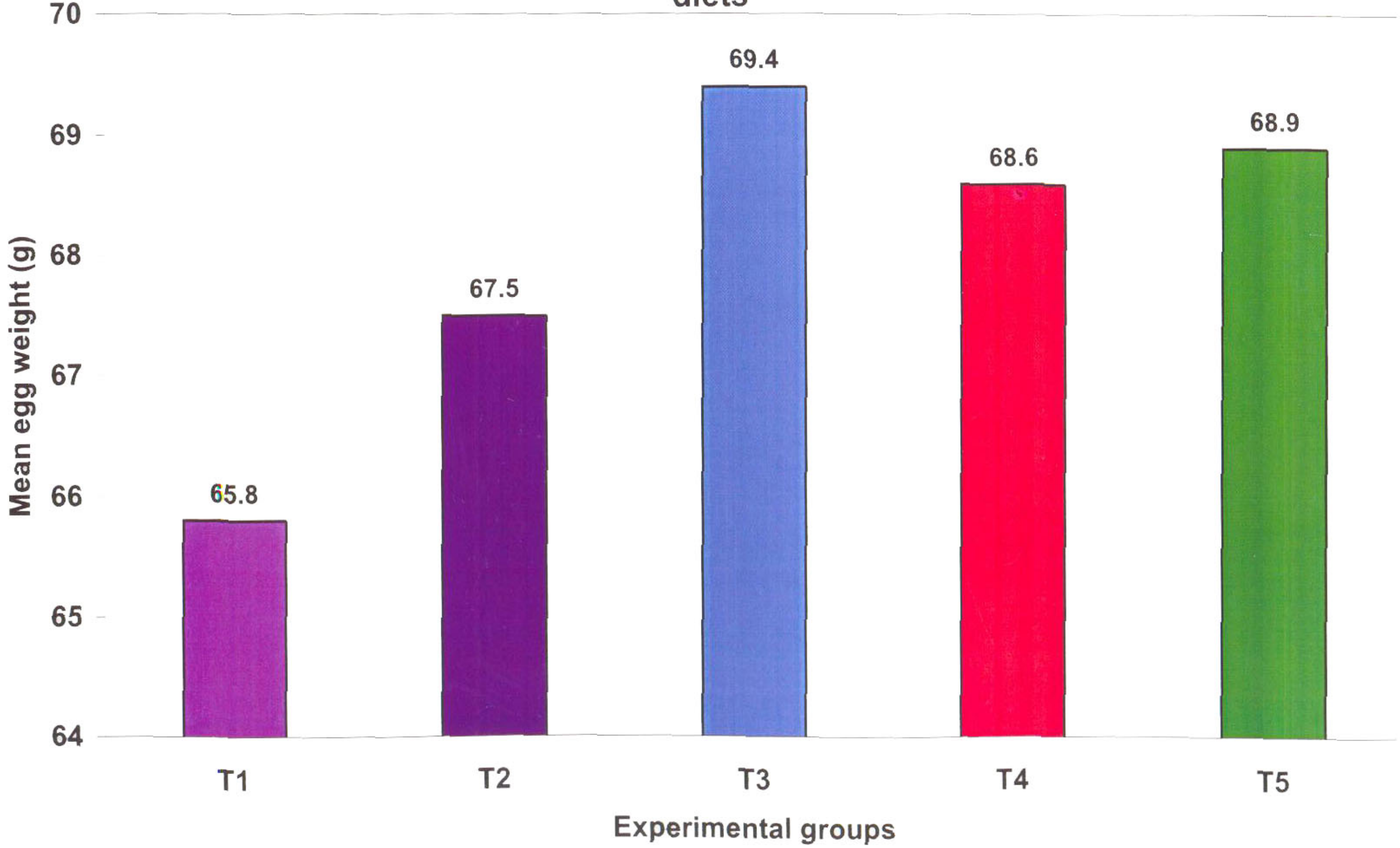
Cumulative mean egg weight from 21 to 56 weeks of age was significantly ($P<0.05$) higher in all enzyme supplemented diet groups than control group with 8 per cent CF diet (T1). Egg weight in enzyme unsupplemented high fibre diet group T2 was intermediary. The cumulative mean egg weight for groups T1, T2, T3, T4 and T5 was 65.8, 67.5, 69.4, 68.6 and 68.9g respectively with an overall mean value of 68.0g.

Table 8. Mean egg weight at four week intervals in indigenous layer ducks as influenced by CF levels and enzyme supplementation in experimental diets

Period	Age in weeks	Experimental Diets / CF per cent / Enzyme per cent					Overall mean
		T_1 8 0	T_2 12 0	T_3 12 0.06	T_4 12 0.12	T_5 12 0.18	
I	24	59.7[a] ±0.96	61.3[a] ±0.73	65.1[b] ±0.33	62.3[ab] ±1.68	60.9[a] ±1.04	61.9 ±0.59
II	28	60.7 ±0.67	61.7 ±0.42	61.5 ±1.08	61.9 ±0.74	63.0 ±0.56	61.8 ±0.34
III	32	66.0[ab] ±0.44	63.6[a] ±0.67	65.9[ab] ±1.82	66.9[b] ±0.41	66.0[ab] ±0.93	65.7 ±0.47
IV	36	67.3 ± ±0.81	66.4 ±0.73	66.8 ±1.33	67.3 ±1.12	66.3 ±0.41	66.8 ±0.39
V	40	68.1 ± ±0.25	68.3 ±0.44	69.2 ±1.53	69.6 ±1.06	69.9 ±0.25	69.0 ±0.38
VI	44	70.4 ± ±0.13	70.4 ±0.86	70.7 ±1.03	70.2 ±0.84	69.8 ±0.92	70.3 ±0.33
VII	48	65.9[a] ±1.63	69.9[b] ±1.12	74.4[c] ±1.33	70.8[bc] ±1.39	74.7[c] ±0.85	71.2 ±0.90
VIII	52	60.2[a] ±1.97	69.8[b] ±0.91	72.6[b] ±2.15	72.5[b] ±3.07	72.8[b] ±2.02	69.6 ±1.39
IX	56	73.4[a] ±0.88	76.0[ab] ±1.81	78.1[b] ±1.69	75.5[ab] ±0.52	77.1[ab] ±1.62	76.0 ±0.67
Cumulative mean EW	21-40	64.3 ±0.32	64.3 ±0.47	65.7 ±1.15	65.6 ±0.90	65.2 ±0.41	65.0 0.32
	21-56	65.8[a] ±0.23	67.5[ab] ±0.64	69.4[b] ±1.25	68.6[b] ±0.82	68.9[b] ±0.67	68.0 ±0.43

Note: Mean values bearing the same superscript within the row did not differ significantly ($P<0.05$)

Fig. 5 Mean egg weight in indigenous layer ducks(21-56 weeks of age) as influenced by CF levels and enzyme supplementation in experimental diets



4.3.2 Egg Mass

Total egg mass and egg mass per duck (kg) recorded weekly in the different treatment groups from 23 to 56 weeks of age are presented in Table 9. The total weekly egg mass ranged from 1.63 to 12.13 kg in group T1, 4.27 to 13.54 in T2, 2.53 to 15.81 in T3, 3.27 to 13.82 in T4, 3.23 to 14.96 in T5 during 23 to 56 week period. Egg mass per duck in Tl ranged from 0.04 to 0.31in T1, 0.11 to 0.34 in T2, 0.06 to 0.40 in T3, 0.08 to 0.35 in T4 and 0.09 to 0.38 in T5 group.

Cumulative egg mass from 23 to 56 weeks in groups T1, T2, T3, T4 and T5 were 286.43, 340.67, 386.97, 338.87 and 366.79 kg respectively and the cumulative egg mass per duck was 7.22, 8.61, 9.67, 8.47 and 9.25 kg respectively (Fig 6). Egg mass was highest in 0.06 per cent enzyme group (T3), followed by 0.18 per cent enzyme group (T5), enzyme unsupplemented high fibre diet group (T2), 0.12 per cent enzyme group (T4) and lastly the enzyme unsupplemented low fibre group (T1). It was evident that 1.39 kg more egg mass per duck was obtained in the group fed high fibre diet compared to that fed low fibre diet.

4.4. FEED CONSUMPTION

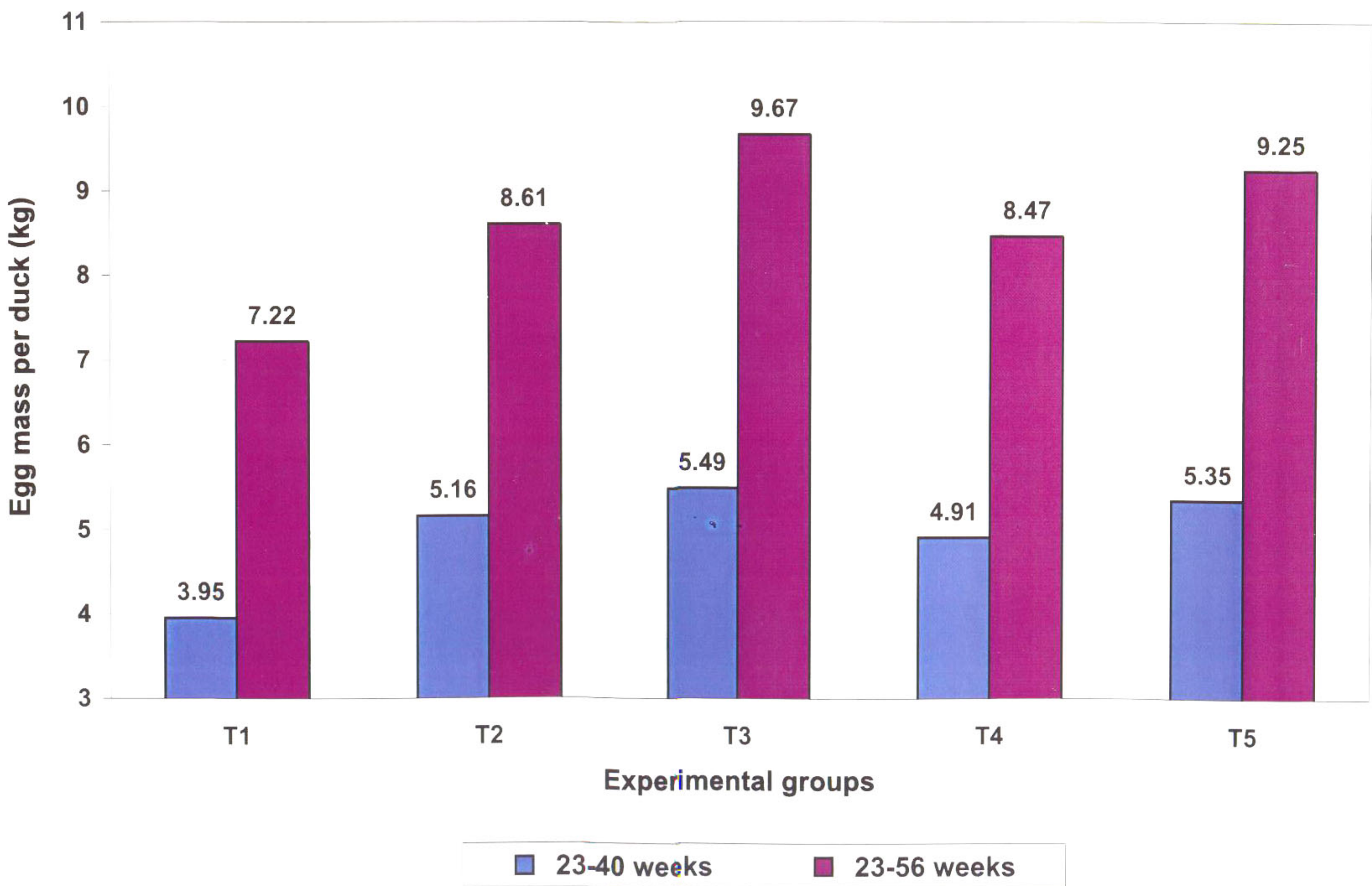
The period wise mean daily feed consumption (FC) in different treatment groups from 21 to 56 weeks of age is presented in Table 10.

The results revealed that, the mean daily feed consumption in the polyzyme-supplemented diets (T3, T4 and T5) was comparable among each other in all periods except period VIII, wherein FC with the diet containing 12 per cent crude fibre supplemented with 0. 18 per cent polyzyme (T5) was significantly higher ($P<0.05$) than T3 and T4.

Table 9. Weekly egg mass in indigenous layer ducks as influenced by CF levels and enzyme supplementation in experimental diets

Age in Weeks	Weekly egg mass (kg)					Egg mass (kg) /duck				
	T1	**T2**	**T3**	**T4**	**T5**	**T1**	**T2**	**T3**	**T4**	**T5**
23	3.11	4.59	2.53	5.17	3.55	0.08	0.11	0.06	0.13	0.09
24	4.77	8.63	5.44	7.39	7.53	0.12	0.22	0.14	0.18	0.19
25	6.25	10.33	7.13	9.18	10.88	0.16	0.26	0.18	0.23	0.27
26	9.00	12.59	9.78	10.38	11.86	0.23	0.31	0.24	0.26	0.30
27	9.73	12.34	11.13	10.56	12.04	0.24	0.31	0.28	0.26	0.30
28	9.75	10.97	12.06	10.09	11.13	0.24	0.27	0.30	0.25	0.28
29	10.08	12.56	12.61	11.34	12.29	0.25	0.31	0.32	0.28	0.31
30	10.16	11.06	13.13	11.10	12.68	0.25	0.28	0.33	0.28	0.32
31	10.52	11.62	13.35	11.48	12.21	0.26	0.29	0.33	0.29	0.31
32	11.85	13.54	14.58	13.82	12.90	0.30	0.34	0.36	0.35	0.32
33	9.91	12.50	14.18	12.67	13.48	0.25	0.31	0.35	0.32	0.34
34	9.64	13.01	14.74	13.45	12.66	0.24	0.33	0.37	0.34	0.32
35	8.93	13.16	15.81	11.85	13.97	0.22	0.33	0.40	0.30	0.35
36	9.69	11.87	15.18	12.64	12.89	0.24	0.30	0.38	0.32	0.32
37	10.23	12.37	14.60	11.52	13.19	0.26	0.31	0.36	0.29	0.33
38	7.71	12.89	14.15	11.40	14.51	0.19	0.32	0.35	0.29	0.33
39	7.57	11.70	15.53	11.74	13.81	0.19	0.29	0.39	0.29	0.35
40	9.10	10.55	13.88	10.50	13.26	0.23	0.27	0.35	0.26	0.34
41	9.45	12.00	13.81	10.99	13.80	0.24	0.31	0.35	0.27	0.35
42	10.37	11.30	14.61	12.94	13.78	0.26	0.29	0.37	0.32	0.35
43	12.13	13.15	14.58	13.14	14.96	0.30	0.34	0.36	0.33	0.38
44	12.11	11.51	12.78	12.26	11.93	0.31	0.30	0.32	0.31	0.31
45	10.23	9.07	8.53	8.22	8.78	0.26	0.23	0.21	0.21	0.23
46	9.73	6.12	5.11	3.27	3.23	0.25	0.16	0.13	0.08	0.08
47	6.67	4.65	6.24	4.22	4.28	0.17	0.12	0.16	0.11	0.11
48	6.84	10.89	15.52	11.03	12.54	0.18	0.28	0.39	0.28	0.32
49	11.51	9.69	13.31	9.35	12.37	0.30	0.25	0.33	0.23	0.32
50	9.49	7.02	9.25	7.43	8.76	0.24	0.18	0.23	0.19	0.22
51	5.25	7.25	8.26	6.31	7.45	0.13	0.19	0.21	0.16	0.19
52	1.63	7.12	8.19	8.81	7.30	0.04	0.18	0.20	0.22	0.19
53	2.96	6.99	8.77	10.64	8.14	0.08	0.18	0.22	0.27	0.21
54	6.21	7.59	10.74	10.49	11.29	0.16	0.19	0.27	0.26	0.29
55	5.88	5.86	9.57	7.34	7.54	0.15	0.15	0.24	0.18	0.19
56	8.02	4.27	7.96	6.22	5.86	0.21	0.11	0.20	0.16	0.15
23-56	**286.43**	**340.67**	**386.97**	**338.87**	**366.79**	**7.22**	**8.61**	**9.67**	**8.47**	**9.25**

Fig. 6 Cumulative mean egg mass (kg) in indigenous layer ducks as influenced by CF levels and enzyme supplementation in experimental diets



Likewise, the FC with all high fibre diet groups irrespective of enzyme supplementation was comparable in all periods except period V where T3 was significantly higher (P<0.05) than that of T2. The FC with diet T1 was significantly lower in periods1, 2, 4, 5, 6 and 8. The feed intake among the treatment groups was statistically non significant during periods III, VII and IX. The effects of various diets at different ages are explained below.

The results revealed that in period 1, from 21 to 24 weeks of age, the mean daily feed consumption in the group T1 was very low (137.05 g) in comparison with moderately high feed intake with all other diets ranging from 151.00 to 154.29 g showing non significant differences among each other. Statistical analysis revealed that FC of group fed a diet containing 8 per cent crude fibre was significantly lower than rest of the groups (P<0.01). The overall mean feed intake in this period was 149.23 g.

In period II, the FC in dietary group T1 was 138.25 g, almost same as that in the previous period. The FC in group T2 was 158.90 g and in the polyzyme supplemented groups T3, T4 and T5, the FC were 163.30, 163.96 and 166.75 g respectively. The FC in all diets with 12 per cent CF was significantly higher than that of diet T1 (P<0.05) and the difference of 28.50 g between T5 and T1 was highly significant (P<0.01).

In period III the diet T1 showed marked increase of 19.83 g in feed consumption to 158.08 g than the previous period, whereas proportionate increase was not observed with other diets and that slight reduction was observed in T4 and T5. The feed intake in T4 was only 159.42 g and that in T5 was165.21 g. The FC did not differ significantly among experimental diets from 29 to 32 weeks of age. However, it was numerically higher with rations T3 and T5 (167.89 and 165.21 respectively) and almost similar in T2 and T4 (161.72 and 159.42 g) respectively.

The overall mean feed intake in periods III and IV was almost same (162.46 and 162.95 g respectively). But the differences in FC between diets in period IV were significant. The mean daily feed consumption in the group T1 was 151.14 g. The feed intake recorded with all the polyzyme-supplemented groups T3, T4 and T5 (169.87, 168.26 and 163.67 g respectively) was significantly higher than that of diet T1 (P<0.05) and the difference between T1 and T3 was highly significant (P<0.01). While, the FC in the diet T2 (161.81 g) was intermediary and statistically comparable with all other diets.

The overall mean FC increased to 171.86 g in period V (37 to 40 weeks) and it was higher than the previous periods. The FC in groups T1, T2, T3, T4 and T5 was 159.36, 166.55, 182.88,169.59 and 180.91 g respectively. The magnitude of difference (23.52 g) between T1 and T3 was significant (P<0.01). The significantly higher feed intake noted with diet T3 in comparison to diet T2 (P<0.05) is a peculiarity in this period. The groups T1 and T4 were comparable while the difference between T1 and T5 was significant (P<0.05).

The overall mean FC in the period VI from 41 to 44 weeks of age was 160.58 g. The diet T1 showed a drastic reduction in mean daily feed consumption to 129.06 g. The reduction was to the tune of 30.30 g per duck compared to the previous period. The reduction in feed intake to this extent was not reflected in other groups and was not very severe. Therefore, the low feed intake in T1 was highly significant (P< 0.01) in comparison with diet T2 (160.66 g) and with all polyzyme supplemented diets wherein the FC was 171.13, 171.22 and 170.83 g in T3, T4 and T5 respectively.

In period VII the group T1 showed a sharp increase in feed intake to 162.99 g registering an increase of 33.93 g per duck compared to the previous period and the difference among treatment groups did not differ significantly. The overall mean FC in the period was 166.06 g. Another appreciable difference was fairly uniform feed intake with other groups compared to the previous period except in T4 wherein a reduction in FC to a tune of 10.32 g was recorded. The

FC in diet T2 was 162.96 g while that in diets T3 and T5 was 172.15 and 171.28 g respectively, almost same as that in the previous period.

The lowest period wise overall mean feed intake was the feature in period VIII. It was reduced to the level of 142.89 g that was lower than the overall mean intake observed in the first period (149.23 g). All groups registered reduction in the daily feed consumption during 8th period (49 to 52 weeks of age), at varying rates of 40.06 g in T1 and 38.22 g in T3. In groups T2, T4 and T5, the reduction in relation with the previous period was 11.07, 22.92 and 3.56 g respectively. The reduction was marked with diets T1 and T3 but was slight with diet T5. The feed consumption was the lowest in diet T1 (122.93 g) and was the highest with diet T5 (167.72g) and the difference between T1 and T5 was highly significant ($P<0.01$). Among the polyzyme supplemented groups, feed intake in T5 was significantly higher ($P<0.05$) than that of T3 and T4. The mean feed intake in T2, T3 and T4 was 151.89, 133.93 and 137.98 g respectively. The period wise feed intake in T1 and T3 and T4 was the lowest in this period.

In period IX, the FC recorded in treatment groups T1, T2, T3, T4 and T5 was 149.14, 167.79, 158.07, 160.52 and 164.98 g respectively with an overall mean of 160.10 g. The differences in feed intake between the treatment groups were non significant.

Statistical analysis of the data on mean cumulative feed consumption for total period of experiment among different treatment groups indicated that feed consumption in group T1 was significantly lower ($P<0.01$) than all other groups which were comparable each other. The mean daily feed consumption for treatment groups T1 to T5 for 21 to 56 week period were 145.33, 160.40, 163.72, 160.31 and 162,82g respectively (Fig 7) and the cumulative feed consumption per duck in treatment groups T1, T2 T3, T4 and T5 were 36.63, 40.42, 41.26, 40.41 and 42.10 kg respectively (Fig. 8).

Table 10. Mean period-wise daily feed consumption (g) in indigenous layer ducks as influenced by CF levels and enzyme supplementation in experimental diets

Period	Age in weeks	Experimental Diets / CF per cent / Enzyme per cent					Overall mean
		T_1 8 0	T_2 12 0	T_3 12 0.06	T_4 12 0.12	T_5 12 0.18	
I	21-24	137.05[a] ±3.09	151.39[b] ±1.24	154.29[b] ±2.19	151.0[b] ±2.67	152.40[b] ±2.27	149.23 ±1.71
II	25-28	138.25[a] ±9.50	158.90[b] ±3.0	163.30[b] ±5.90	163.96[b] ±3.14	166.75[b] ±5.73	158.23 ±3.34
III	29-32	158.08 ±2.87	161.72 ±3.72	167.89 ±4.81	159.42 ±1.70	165.21 ±6.84	162.46 ±1.92
IV	33-36	151.14[a] ±4.65	161.81[ab] ± 2.82	169.87[b] ±3.56	168.26[b] ±2.87	163.67[b] ±4.50	162.95 ±2.13
V	37-40	159.36[a] ±1.04	166.55[ab] ± 2.84	182.88[c] ±2.57	169.59[abc] ± 5.69	180.91[bc] ± 8.65	171.86 ±2.83
VI	41-44	129.06[a] ±5.98	160.66[b] ±3.96	171.13[b] ±3.44	171.22[b] ±2.90	170.83[b] ±8.67	160.58 ±4.31
VII	45-48	162.99 ±4.54	162.96 ±5.40	172.15 ±3.98	160.90 ±5.03	171.28 ±9.02	166.06 ±2.57
VIII	49-52	122.93[a] ±6.67	151.89[bc] ± 9.83	133.93[ab] ± 1.70	137.98[ab] ± 10.73	167.72[c] ±4.70	142.89 ±4.64
IX	53-56	149.14 ±5.71	167.79 ±6.01	158.07 ±5.74	160.52 ±4.76	164.98 ±6.89	160.10 ±2.76
Mean daily consumption (g)	21-56	145.33[a] ±1.37	160.40[b] ±1.46	163.72[b] ±1.23	160.31[b] ±0.80	162.82[b] ±4.69	158.50 ±1.81
Cumulative feed intake/ duck (kg)	21-56	36.63[a] ±0.35	40.42[b] ±0.37	41.26[b] ±0.32	40.41[b] ±0.20	42.10[b] ±1.14	40.16 ±0.49

Note: Mean values bearing the same superscript within the row did not differ significantly ($P<0.05$)

Fig. 7 Mean daily feed intake (g) (21-56 weeks) in indigenous layer ducks as influenced by CF levels and enzyme supplementation in experimental diets

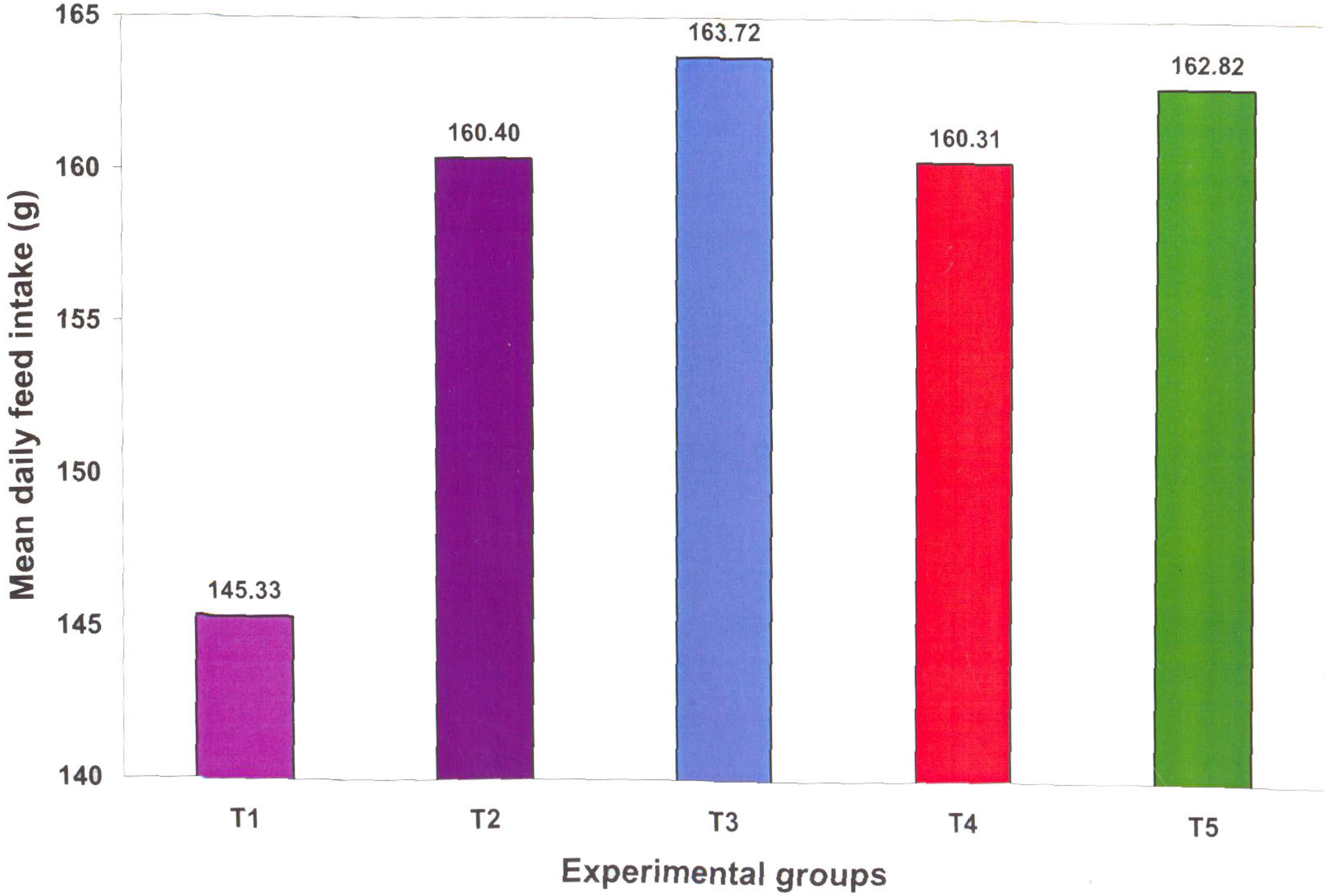
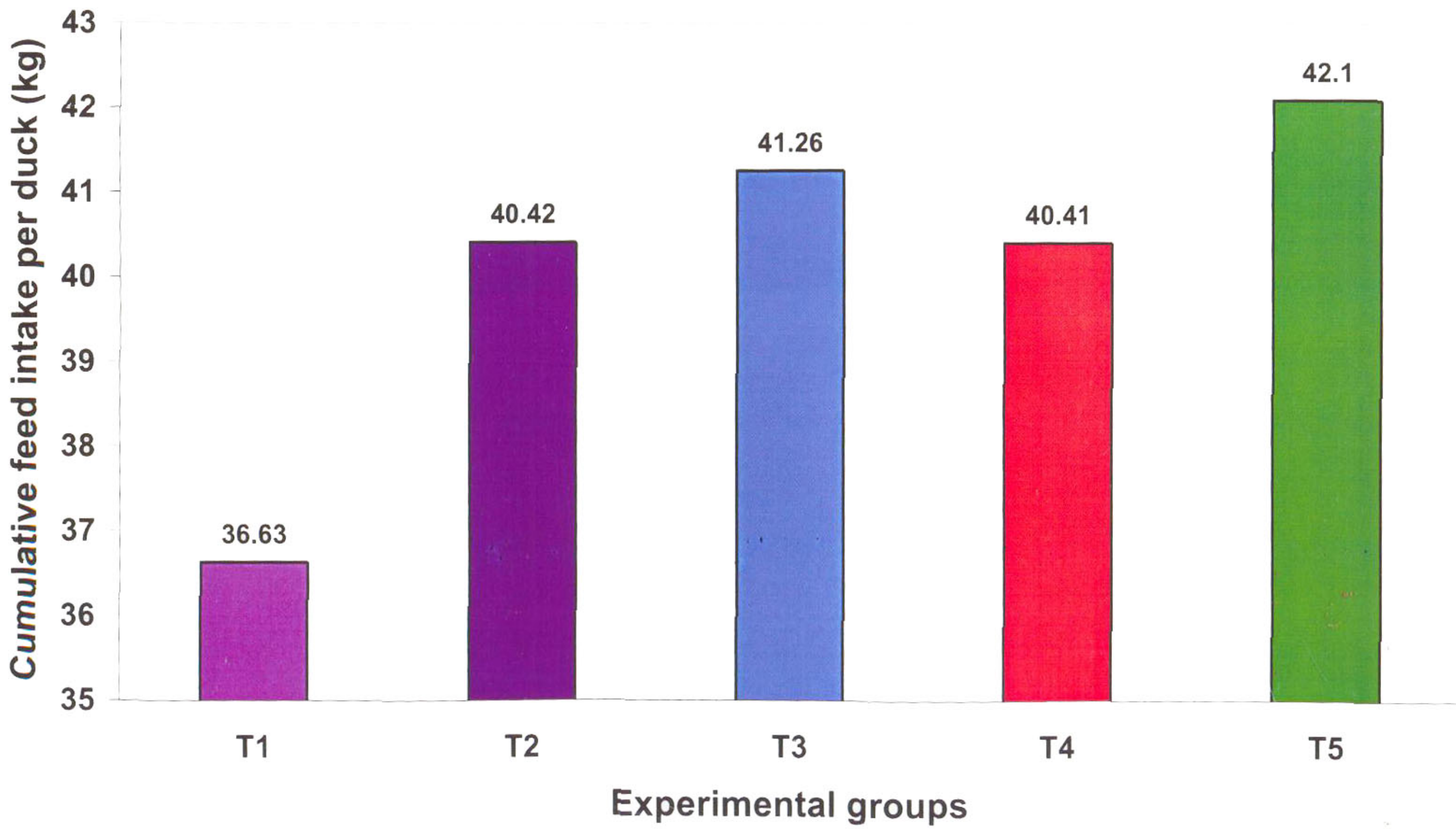


Fig . 8 Cumulative feed intake per duck (21 to 56 weeks of age) in indigenous layer ducks as influenced by CF levels and enzyme supplementation in experimental diets



4.5 FEED CONVERSION RATIO

4.5.1 Feed Conversion Ratio per Dozen Eggs

Feed Conversion Ratio (FCR) per dozen eggs measured as the ratio of feed consumed (kg) to the number of dozens of eggs produced from 21 to 56 weeks of age for different treatment groups are presented in Table 11.

During the initial period of experiment (21-24 weeks) a wide variation noticed in the feed conversion ratio from 9.47 in T2 group to 24.44 in T1 group. FCR for the groups T3, T4 and T5 were 22.77, 9.76 and 13.21 with an overall mean value of 15.93 for the groups put together. Even though the magnitude of difference between the highest and the lowest groups was 14.90, it did not differ significantly among the groups.

During 25 to 28 weeks, FCR for the groups T1, T2, T3, T4 and T5 were 3.21, 2.89, 3.54, 3.53 and 3.13 with an overall mean value of 3.25. T3 and T4 groups with highest feed conversion ratio were significantly different ($P<0.05$) from T2 groups which had lower FCR. T1 and T5 groups were intermediary and comparable with other groups.

During 29 to 32 weeks the lowest feed conversion ratio was noted in 0.06 per cent enzyme supplemented group (T3) followed by enzyme unsupplemented high fibre diet group T2 which were significantly superior ($P<0.05$) than the low fibre diet group T1. The other two enzyme groups were intermediary and comparable with all other groups. FCR for the treatment groups T1, T2, T3 , T4 and T5 were 3.18, 2.77, 2.69, 2.85 and 2.89 with an over all mean value of 2.88.

During period IV (33-36 weeks) the feed conversion efficiency further improved in T3 group which remained as the superior group and was significantly different ($P<0.01$) from T1 group with lowest efficiency. All the high fibre diet groups T2 to T5 were homogenous and significantly superior to the low fibre diet group T1 (P<0.01). The FCR were 3.61, 2.80, 2.55, 2.97 and 2.80 for the groups T1 to T5 in that order with an over all mean value of 2.94 which was slightly higher than that of the previous period.

During 37-40 weeks (Period V), even though the T3 group remained the superior one, all the high fibre diet groups were statistically comparable and were significantly differed from T1 group. The groups T1 to T5 showed FCR values of 4.22, 3.22, 2.92, 3.48 and 3.12 in that order with an over all mean of 3.39.

During period VI (41-44 weeks), there was a change in the trend with the lowest ratio of 2.69 in group T1 and highest ratio of 3.32 in group T4 which were differed significantly (P<0.05). The other three groups were intermediary and statistically comparable with each other and with all groups. The FCR for groups T2, T3 and T5 were 3.10, 2.93 and 3.02 respectively with an over all mean of 3.01.

During the last three periods of experiment (VII, VIII and IX) there was no significant difference between treatment groups. Here also the numerically lowest value remained in T3 group while the highest value differed among other groups in these three periods. The mean values among the five groups were almost similar in period VII and VIII, but was higher in period IX.

The FCR for the groups T1 to T5 were 4.35, 4.63, 4.35, 5.50 and 5.27 with an over all mean value of 4.82 in VIIth period.

During period VIII, the FCR were 3.95, 4.52, 3.54, 4.20 and 4.58 for groups T1 to T5 in that order with an over all mean value of 4.16.

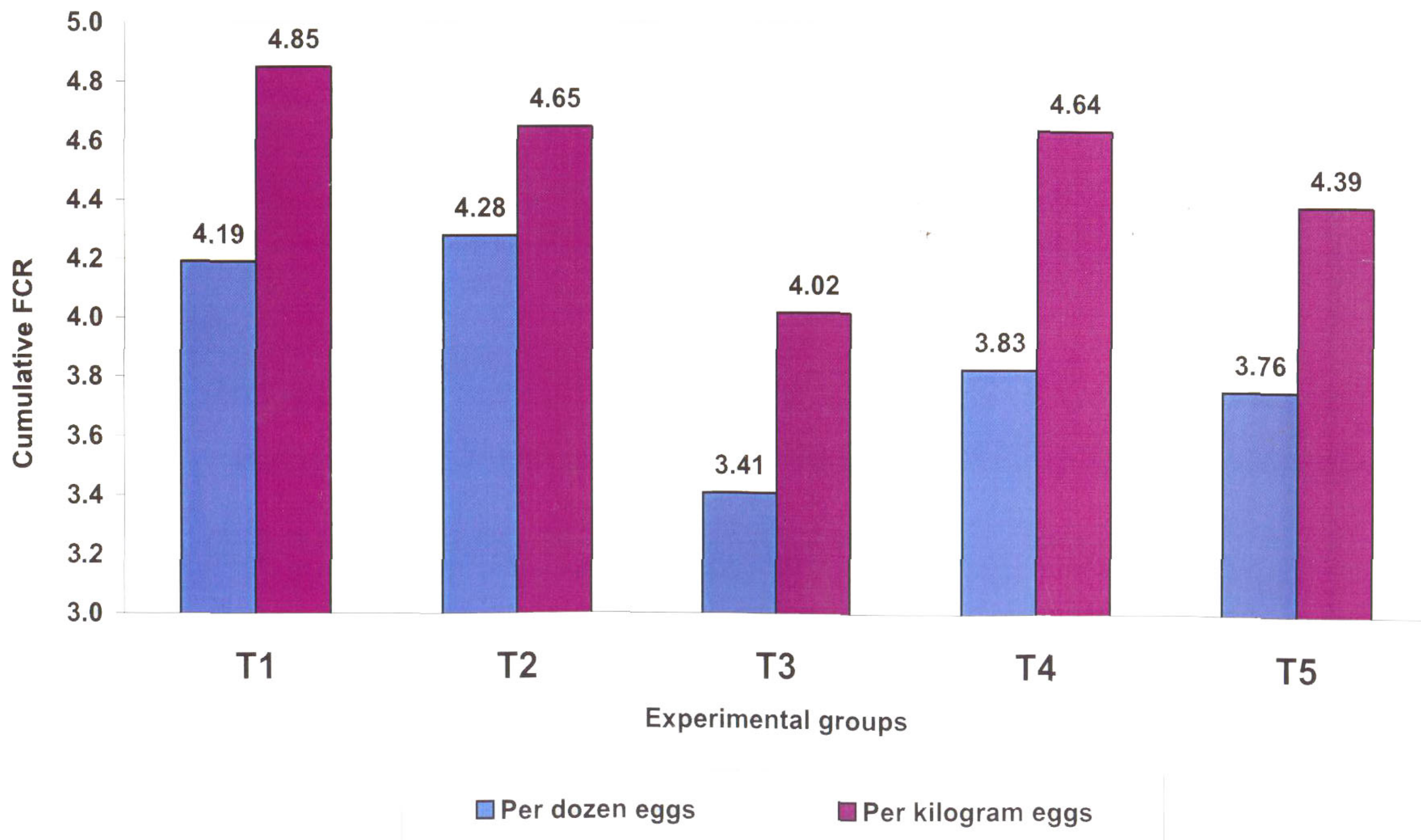
During period IX, the three enzyme supplemented groups did not show much variation, but the other groups showed higher values compared to them. The FCR in T1, T2, T3, T4 and T5 were 8.32, 10.31, 4.73, 4.73 and 5.25 respectively with an over all mean value of 6.67.

Table 11. Mean Feed Conversion Ratio (FCR) per dozen eggs in indigenous layer ducks as influenced by CF levels and enzyme supplementation in experimental diets

Period	Age in weeks	Experimental Diets / CF per cent / Enzyme per cent					Overall mean
		T_1	T_2	T_3	T_4	T_5	
		8 0	12 0	12 0.06	12 0.12	12 0.18	
I	21-24	24.44 ±14.07	9.47 ±1.26	22.77 ±7.91	9.76 ±1.25	13.21 ±2.80	15.93 ±3.23
II	25-28	3.21^{ab} ±0.23	2.89^{a} ±0.09	3.54^{b} ±0.23	3.53^{b} ±0.25	3.13^{ab} ±0.06	3.25 ±0.10
III	29-32	3.18^{b} ±0.13	2.77^{a} ±0.09	2.69^{a} ±0.07	2.85^{ab} ±0.07	2.89^{ab} ±0.16	2.88 ±0.06
IV	33-36	3.61^{b} ±0.41	2.80^{a} ±0.11	2.55^{a} ±0.05	2.97^{a} ±0.04	2.80^{a} ±0.07	2.94 ±0.11
V	37-40	4.22^{b} ±0.33	3.22^{a} ±0.23	2.92^{a} ±0.07	3.48^{a} ±0.05	3.12^{a} ±0.13	3.39 ±0.13
VI	41-44	2.69^{a} ±0.20	3.10^{ab} ±0.19	2.93^{ab} ±0.05	3.32^{b} ±0.17	3.02^{ab} ±0.12	3.01 ±0.08
VII	45-48	4.35 ±0.19	4.63 ±0.50	4.35 ±0.21	5.50 ±0.59	5.27 ±0.37	4.82 ±0.19
VIII	49-52	3.95 ±0.25	4.52 ±0.35	3.54 ±0.38	4.20 ±0.45	4.58 ±0.38	4.16 ±0.17
IX	53-56	8.32 ±2.37	10.31 ±4.35	4.73 ±0.75	4.73 ±0.43	5.25 ±0.57	6.67 ±1.04
Cumulative mean	25-56	4.19 ±0.35	4.28 ±0.51	3.41 ±0.15	3.83 ±0.13	3.76 ±0.09	3.81 ±0.14

Note: Mean values bearing the same superscript within the row did not differ significantly ($P<0.05$)

Fig. 9 Feed Conversion Ratio (per dozen and kg eggs) in indigenous layer ducks as in experimental diets during 25-56 weeks



Since the FCR values were in a wide range during the 1st period of experiment, the cumulative mean values for the treatment groups were calculated by excluding the values in the 1st period. FCR values from 25-56 weeks (Table 11 and Fig.9) indicated that numerically superior values were in the enzyme supplemented diet groups with no significant difference among the different groups.

4.5.2 Feed Conversion Ratio per kg Egg Mass

Feed Conversion Ratio per kg egg mass recorded for 25 to 56 weeks of age in different treatment groups are depicted in Table 12 and Figure 9. In T1 group, superior FCR per kg egg mass (3.19) was recorded during the period of 41-44 weeks. In T2, T3, T4 and T5 groups, the superior values were recorded during 33-36 weeks of age (3.59, 3.18, 3.72 and 3.46 respectively). During the period 25-56 weeks the mean FCR per kg eggs for T1, T2, T3, T4 and T5 groups were 4.85, 4.65, 4.02, 4.64 and 4.39 respectively.

4.6 BLOOD PARAMETERS

4.6.1 Hemoglobin (Hb)

The mean hemoglobin values (g/dl) of experimental layer ducks belonging to five treatment groups at 20, 40 and 52 weeks of age are presented in Table 13.

At 20 weeks of age hemoglobin values of the ducks were in the range of 11.84 to 12.86g/dl. The Hb values of treatment groups T1, T2, T3, T4 and T5 were 12.86, 12.42, 12.36, 11.84 and 12.76 g/dl respectively.

At 40 weeks of age the highest Hb value was recorded in T3 group (13.72g/dl) and lowest in T4 group (12.86g/dl). The Hb values were 13.04, 13.08, 13.72, 12.86 and 13.36 g/dl in the groups from T1 to T5 in that order. Statistical

Table 12. Mean Feed Conversion Ratio per kg of eggs in indigenous layer ducks as influenced by CF levels and enzyme supplementation in experimental diets

Age in weeks	Experimental Diets / CF per cent / Enzyme per cent				
	T1	T2	T3	T4	T5
	8 0	12 0	12 0.06	12 0.12	12 0.18
25-28	4.46	3.85	4.56	4.57	4.07
29-32	4.16	3.71	3.50	3.75	3.70
33-36	4.44	3.59	3.18	3.72	3.46
37-40	5.16	3.92	3.52	4.21	3.71
41-44	3.19	3.66	3.44	3.89	3.55
45-48	5.31	5.78	5.31	6.34	6.06
49-52	4.82	5.29	3.83	4.84	5.05
53-56	7.23	7.40	4.78	5.80	5.48
25-56	**4.85**	**4.65**	**4.02**	**4.64**	**4.39**

analysis did not reveal any significant difference between groups at 20 and 40 weeks of age.

At 52 weeks all enzyme supplemented groups had significantly ($P<0.05$) superior Hb values than the 8% crude fibre diet group (T1), while the 12 per cent crude fibre diet group (T2) was comparable with all groups. The Hb values for T1, T2, T3, T4 and T5 groups were 12.96, 13.34, 13.83, 13.54 and 13.72 g/dl respectively. The overall mean values of hemoglobin content among treatment groups at 20, 40 and 52 weeks were 12.45, 13.01 and 13.48g/dl respectively. Haemoglobin values of ducks in all treatment groups recorded at 20, 40 and 52 weeks were within the normal range.

4.6.2 Plasma Total Protein

Plasma total protein content of experimental groups of ducks at 20, 40 and 52 weeks of age are presented in Table 14.

At 20 weeks of age, the plasma protein values were ranging from 4.16 to 4.38 g/dl with an overall mean value of 4.24 g/dl among the treatment groups. The values for T1, T2, T3 T4 and T5 groups were 4.24, 4.16, 4.19, 4.22 and 4.38 g/dl. Statistically no difference existed in the plasma protein content of different treatment groups.

At 40 weeks of age, plasma protein values increased in all groups. The values were 4.60, 5.05, 5.12, 4.94 and 5.09 g/dl in treatment groups T1, T2, T3, T4 and T5 respectively with an overall mean value of 4.95 g/dl. The difference among treatment groups was non-significant at this age also.

At 52 weeks of age, a slight decline in plasma total protein values were noted in all groups except T1. The values in groups T1, T2, T3, T4 and T5 were 4.63, 4.99, 4.98, 4.83 and 4.90g/dl with an overall mean value of 4.87 g/dl. At 52

Table 13. Mean hemoglobin value (g/dl) of indigenous layer ducks as influenced by CF levels and enzyme supplementation in experimental diets

Age in weeks	T_1	T_2	T_3	T_4	T_5	Overall mean
	CF%- 8 Enzyme- 0	12 0	12 0.06	12 0.12	12 0.18	
20	12.86 ±1.12	12.42 ±0.46	12.36 ±0.23	11.84 ±0.88	12.76 ±0.58	12.45 ±0.42
40	13.04 ±0.17	13.08 ± 0.20	13.72 ±0.82	12.86 ±0.22	13.36 ±0.15	13.01 ±0.12
52	12.96[a] ±0.02	13.34[ab] ±0.16	13.83[b] ±0.12	13.54[b] ±0.11	13.72[b] ±0.15	13.48 ±0.02

Mean values bearing the same superscript within the row did not differ significantly (P<0.05)

Table 14. Mean plasma total protein content (g/dl) of indigenous layer ducks as influenced by CF levels and enzyme supplementation in experimental diets

Age in weeks	T_1	T_2	T_3	T_4	T_5	Overall mean
	CF%- 8 Enzyme- 0	12 0	12 0.06	12 0.12	12 0.18	
20	4.24 ±0.32	4.16 ±0.26	4.19 ±0.35	4.22 ±0.38	4.38 ±0.33	4.24 ±0.14
40	4.60 ±0.22	5.05 ± 0.15	5.12 ±0.13	4.94 ±0. 04	5.09 ±0.15	4.95 ±0.02
52	4.63 ±0.05	4.99 ±0.26	4.98 ±0.02	4.83 ±0.04	4.90 ±0.03	4.87 ±0.16

Non-Significant

weeks of age also the magnitude of difference in plasma protein between groups did not show any significant difference.

4.6.3 Plasma Cholesterol

Plasma cholesterol content of experimental ducks at 20, 40 and 52 weeks of age are presented in Table 15.

At 20 weeks of age, plasma cholesterol content of ducks in treatment groups T1 and T5 were high (205.67 and 207.33mg/dl), while in the other three groups T2, T3 and T4, the mean cholesterol content were 181.83, 184.17, and 189.50mg/dl respectively. The groups T1 and T5 were significantly ($P<0.05$) higher than other three groups. The overall mean value among treatment groups was 193.70mg/dl.

Plasma cholesterol values decreased in all groups at 40 weeks of age. The highest value of 185.75 mg/dl was recorded in 0.12 per cent enzyme supplemented group (T4) and the lowest value of 179.85 in 0.18 per cent enzyme group (T5). The cholesterol value of T2 (180.34 mg/dl) was very close to that of T5 (179.85). The values in T1 (8% CF diet) and T4 (0.12% enzyme group) were similar (185.05 and 185.75 mg/dl respectively). The value in T3 group was 183.54 mg/dl. Statistical analysis revealed no significant difference in plasma cholesterol values at 40th week of age.

At 52 weeks of age, plasma cholesterol values were 167.80, 165.20, 165.50, 162.02 and 163.53 mg/dl for the groups T1, T2, T3, T4 and T5 respectively with an overall mean value of 164.81. Statistically there was no significant difference existed among treatment groups at this age.

4.6.4 Plasma Total Lipids

Plasma total lipid content of indigenous layer ducks in different treatment groups at 20, 40 and 52 weeks of ages are shown in the Table 16. At 20weeks of

Table 15. Mean plasma cholesterol content (mg/dl) of indigenous layer ducks as influenced by CF levels and enzyme supplementation in experimental diets

Age in weeks	T_1	T_2	T_3	T_4	T_5	Overall Mean
	CF%- 8 Enzyme- 0	12 0	12 0.06	12 0.12	12 0.18	
20	205.67[b] ±4.51	181.83[a] ±3.18	184.17[a] ±3.12	189.50[a] ±2.75	207.33[b] ±3.84	193.70 ±2.48
40	185.05 ±2.75	180.34 ± 3.08	183.54 ±3.20	185.75 ±2.22	179.85 ±2.53	182.91 ± 2.62
52	167.80 ±3.15	165.20 ±2.23	165.50 ±2.65	162.02 ±2.85	163.53 ±2.29	164.81 ±2.95

Note: Mean values bearing the same superscript within the row did not differ significantly (P<0.05)

Table 16. Mean plasma total lipid content (mg/dl) of indigenous layer ducks as influenced by CF levels and enzyme supplementation in experimental diets

Age in weeks	T_1	T_2	T_3	T_4	T_5	Over all mean
	CF%- 8 Enzyme- 0	12 0	12 0.06	12 0.12	12 0.18	
20	623.25 ±10.60	638.86 ±13.23	612.50 ±16.51	595.90 ±12.05	610.80 ±12.92	616.30 ± 13.08
40	690.02 ±8.75	712.75 ± 12.08	705.45 ±13.13	716.30 ±9.83	683.42 ±9.85	701.60 ± 10.25
52	785.22 ± 16.08	810.45 ± 15.28	798.64 ± 18.24	826.35 ± 10.87	812.44 ± 13.64	806.60 ± 17.03

Non-Significant

age, the mean plasma lipid content was 623.25, 638.86, 612.50, 595.90 and 610.80 mg/dl for the ducks in the treatment groups T1, T2, T3, T4 and T5 respectively with no significant difference between them. At 40 weeks of age the total plasma lipid values were higher than the values at 20 weeks of age. The highest value was 716.30 in group T4 and the lowest value was 683.42 in group T5. The values for T1, T2 and T3 groups were 690.02, 712.75 and 705.45 mg/dl respectively. At this age also, all the groups were statistically comparable. Further increase in the plasma lipid values of ducks was noticed in all treatment groups at 52 weeks of age. The values for T1, T2, T3, T4 and T5 groups were 785.22, 810.45, 798.64, 826.35 and 812.44 mg/dl respectively. All the groups were statistically comparable at this age also.

4.7 NUTRIENT DIGESTIBILITY

The results of the digestibility trial conducted at the end of experiment at 56 weeks of age are depicted in Table17. The per cent dry matter digestibility among different treatment groups varied from 59.54 in group T1 to 62.17 in 0.06 per cent enzyme supplemented group T3. Dry matter digestibility of treatment groups T2, T4 and T5 were 61.06, 61.86 and 61.15 per cent. Even though numerical increase was noticed in enzyme treated groups, the difference among them was statistically non-significant.

Apparent protein digestibility values for T1, T2, T3, T4 and T5 groups were 61.26, 63.04, 65.28, 64.15 and 65.19 per cent respectively with no significant difference among them.

Ether extract digestibility also varied from 63.06 (T1) to 67.05 (T4) per cent. Ether extract digestibility for other three high fibre diet groups T2, T3 and T5 were 64.71, 66.82 and 66.45 per cent. Statistically all these groups were comparable.

Table 17. Nutrient digestibility in indigenous layer ducks as influenced by CF levels and enzyme supplementation in experimental diets

Nutrient digestibility (%)	T_1	T_2	T_3	T_4	T_5
	CF%- 8 Enzyme- 0	12 0	12 0.06	12 0.12	12 0.18
Dry matter	59.54 ±2.60	61.06 ±3.23	62.17 ±3.51	61.86 ±2.05	61.15 ±2.92
Protein	61.26 ±2.75	63.04 ± 2.08	65.28 ±3.13	64.15 ±3.83	65.19 ±2.85
Ether extract	63.06 ± 2.08	64.71 ± 1.88	66.82 ± 2.15	67.05 ± 3.01	66.45 ± 2.66
Acid detergent fibre (ADF)	19.66 ± 1.73	22.12 ± 2.04	23.32 ± 2.26	22.26 ± 2.47	23.07 ± 2.08
Neutral detergent fibre (NDF)	26.17 ± 1.90	28.06 ± 1.53	30.15 ± 2.82	27.24 ± 1.78	28.10 ± 1.37

N.S

Digestibility of fibre fractions viz., Acid detergent fibre (ADF) and Neutral detergent fibre (NDF) of various diet groups also indicated that digestibility of both fibre fractions were numerically more in the enzyme fed groups compared to the non-enzyme group. ADF digestibility ranged from 19.66 per cent in T1 group to 23.32 per cent in T3 group. T2 and T4 groups were having very close values 22.12 and 22.26, while T5 group had 23.07 per cent digestibility.

NDF digestibility was 26.17, 28.06, 30.15, 27.24 and 28.10 per cent for the groups T1, T2, T3, T4 and T5 respectively. NDF digestibility was also high in 0.06 per cent enzyme group (T3) followed by 0.18 per cent enzyme group (T5) and high fibre non-enzyme groupT2.

4.8 CHEMICAL COMPOSITION OF DUCK MEAT

Chemical composition of duck meat samples collected from different treatment groups at the end of the experiment and also from the foraging ducks are given in Table 18.

Moisture content of the samples among the experimental groups ranged from 73.82 to 75.96 per cent and that of foraging ducks was 73.38 per cent. Crude protein content varied from 17.58 to 18.81 per cent among the experimental groups, while it was 17.03 per cent in the foraging ducks. Values for ether extractives ranged between 2.73 to 4.82 per cent among the experimental groups. The ether extract content of foraging duck was 4.12 per cent. The total ash content of the meat samples was varying from 2.18 to 3.41 per cent among ducks in intensive system, where as a higher value of 3.88 per cent was recorded with ducks in the foraging system. No appreciable difference in the nutrient composition of meat from ducks fed different diets could be observed. Similarly not much variation in the nutrient content of meat between foraging ducks and experimental ducks could be seen.

Table 18. Chemical composition of indigenous layer duck meat

Per cent	Treatment groups in cage system					Foraging ducks
	T1	T2	T3	T4	T5	
Moisture	74.94	75.73	75.96	74.47	73.82	73.38
Crude Protein	17.86	17.81	18.14	17.58	18.81	17.03
Ether Extract	3.23	3.06	2.73	4.82	3.50	4.12
Total Ash	3.41	2.18	3.15	3.06	2.41	3.88

4.9 STUDIES ON FORAGING DUCKS

4.9.1 Nutrient Availability Studies

To assess the nutrient availability of ducks reared under extensive system, studies on crop contents collected from foraging ducks in the harvested paddy fields from three regions of Kerala viz., Kuttanad, Palakkad and Thrissur were carried out. Preliminary examination of the crop contents revealed that the major contents were paddy grains, crabs, snails and worms (Plate 2). The average weight of each item present in the crop and the chemical composition of the crop contents are depicted in Table 19 and 20 respectively. The average fresh weight of crop contents collected from three regions was 41.53 ± 4.23. Some of the crop contained paddy grains, crabs, snails and worms, while some other contained paddy grains alone as major component depending on the foraging area. Among the total crop samples collected, the per cent mean value of paddy grains present accounted to 64.01 ± 4.93. Per cent content of crab was 23.15 ± 4.63, snail 4.07 ± 0.83, worms 2.02 ± 0.48 and other weeds present in the crop was 6.75 ± 1.87.

Analysis of chemical composition of the crop samples (Table 20) revealed that moisture content varied between 41.0-53.0 per cent. The mean crude protein content among samples ranged from 10.20 to 17.5 per cent, crude fibre from 11.30 to 19.80 per cent, fat from 1.8 to 3.7 per cent and total ash between 9.5-17.0 per cent. The mean percentage of fibre fractions viz., Neutral Detergent Fibre (NDF) and Acid Detergent Fibre (ADF) ranged between 28.1 to 39.5 per cent and 12.7 to 23.4 per cent respectively.

4.9.2 Blood Parameters

The blood parameters of foraging ducks of 38-44 weeks of age were analyzed and are presented in Table 21. The mean hemoglobin content of the foraging ducks was 12.85 ± 0.20 g/dl. The biochemical analysis of the plasma showed that the total protein, cholesterol and total lipid values were 3.85 ± 0.12

Crop contents of foraging duck

Plate 2

Table 19. Physical examination of crop contents collected from foraging ducks

Average fresh weight of Crop contents (g)	41.53 ± 4.23
Mean content of paddy grains in the crop (%)	64.01 ± 4.93
Mean content of Crab (%)	23.15 ± 4.63
Mean content of Snail (%)	4.07 ± 0.83
Mean content of worms (%)	2.02 ± 0.48
Mean content of other weeds (%)	6.75 ± 1.87

Table 20. Chemical composition of Crop contents (per cent) collected from foraging ducks

Nutrient	**Per cent**
Moisture	41.0-53.0
Crude protein	10.2-17.5
Crude fibre	11.3-19.8
Ether extract	1.8-3.7
Total ash	9.5-17.0
Neutral detergent fibre	28.1-39.5
Acid detergent fibre	12.7-23.4

g/dl, 184.52 ± 2.46 and 764.15 ± 7.04 mg/dl respectively. A close observation of the individual values of both blood and biochemical parameters among ducks from all regions revealed that much variation did not exist. It also gives a positive indication of the physiological well being of foraging ducks in different areas of the state.

4.9.3 Pesticide Residue Analysis

The pesticide mixed standard contained isomers of Hexa chloro cyclohexane (HCH) namely ά, β, γ and δ HCH, isomers of DDT namely o, p'-DDE, p, p'-DDE, o, p'- DDT and p, p'-DDT, ά and β isomers of Endosulphan, Dicofol and dieldrin. Chromatogram of mixed standard depicts separate peaks for these components (Fig.10.)

4.9.3.1 Kuttanad

Organochlorine residue present in the crop contents and body fat of foraging ducks collected from Kuttanad region are presented in Table 22 and chromatogram of representative samples for crop content and fat are depicted in Figure 11 and 12 respectively. The results presented in Table 22 revealed that the residues of organochlorine compounds namely ά, β, γ and δ isomers of HCH, isomers of DDT namely o, p'-DDE, o, p'-DDT , Dicofol and ά –Endosulphan residues were present in very minute quantities ranging from 0.00014 to 0.00044 ppm in the crop content and 0.00011 to 0.0089 ppm in the fat of foraging ducks collected from Kuttanad. The combined residue of all components present in the crop and fat were 0.0018 and 0.0117 ppm which were not exceeding their Maximum Residue Levels (MRL) in poultry.

4.9.3.2 Palakkad

Organochlorine residues estimated in the crop content and fat of foraging ducks from Palakkad (Table 23) revealed that almost all components of pesticides

Table 21. Mean hematological and plasma biochemical values of foraging ducks of 38-44 weeks of age

Hemoglobin(g/dl)	12.85 ± 0.20
Plasma Total Protein (g/dl)	3.85 ± 0.12
Plasma Cholesterol (mg/dl)	184.52 ± 2.46
Plasma Total lipids (mg/dl)	764.15 ± 7.04

Table 22. Mean organochlorine residues present in the crop content and fat of foraging ducks from Kuttanad

Name of organochlorine	Crop content (ppm)	Fat (ppm)
α –HCH	0.00016	0.00058
β –HCH	0.00044	0.00066
γ –HCH	0.00014	0.0089
δ –HCH	0.00026	0.00011
p, p'-DDE	0.00017	0.00038
o, p'-DDT	0.00028	0.00050
ά –Endosulphan	0.00031	0.0004
Dicofol	0.0000	0.0002
Total	**0.0018**	**0.0117**

in the mixed standard were present in these samples. The pesticide components were ά, β, γ and δ isomers of HCH, isomeras of DDT namely p, p'-DDE and o, p'- DDT, ά- Endosulphan, Dicofol and dieldrin. The residues (ppm) in the crop content were ranging from 0.0002 to 0.0075 ppm and that in fat samples were ranging from 0.00014 to 0.0135 ppm. The combined residues were 0.0152 and 0.0419 ppm in the crop and fat samples respectively. Even though residues for all components were present in theses samples, all these were below the MRL. The Chromatogram for the representative crop and fat samples collected from this region are shown in Figure 13 and 14 respectively.

4.2.3.3 Thrissur

The organochlorine residues estimated in crop contents and fat of foraging ducks from Thrissur (Table 24) showed that ά, β, γ and δ isomers of HCH, o, p'-DDE and p, p'-DDE (isomers of DDT) and ά-Endosulphan were present in the samples. The residues (ppm) in the crop content varied from 0.0001 to 0.0018 ppm with a combined residue of 0.0033 ppm for all the components. In fat samples the residues were ranging from 0.00018 to 0.0042 ppm with a combined residue of 0.0077 ppm. Chromatogram of representative crop and fat samples of ducks collected from Thrissur are depicted in Fig. 15 and 16 respectively.

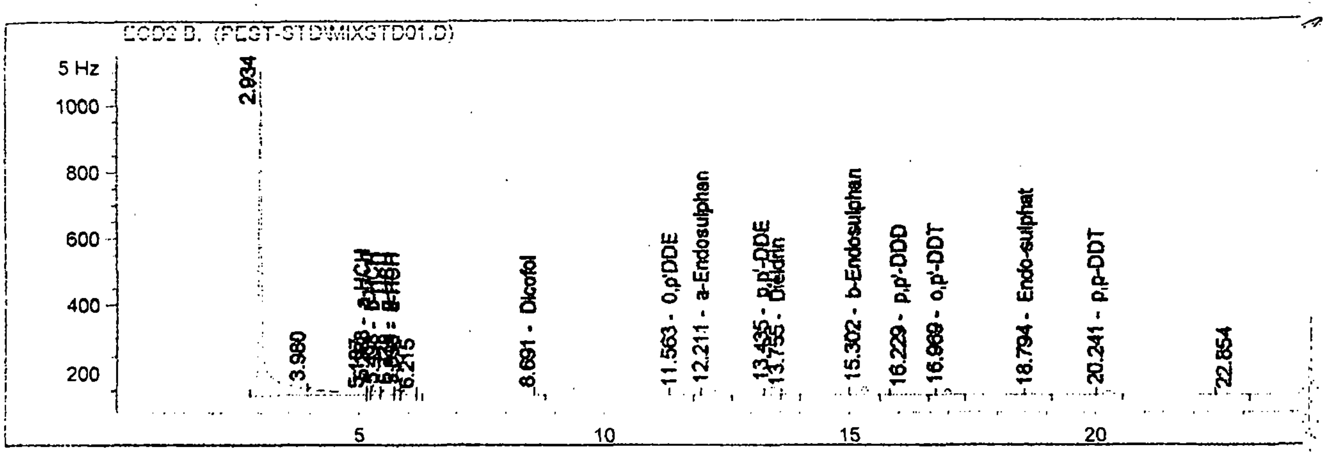
Table 23. Mean organochlorine residue present in the crop content and fat of foraging ducks from Palakkad

Name of organochlorine	Crop content (ppm)	Fat (ppm)
α -HCH	0.00086	0.0021
β -HCH	0.0045	0.0092
γ -HCH	0.0075	0.0135
δ -HCH	0.0019	0.0066
p, p'-DDE	0.0000	0.00014
o, p'-DDT	0.0000	0.00018
ά -Endosulphan	0.00024	0.0004
Dicofol	0.0002	0.009
Dieldrin	0.0000	0.00077
Total	**0.0152**	**0.0419**

Table 24. Mean organochlorine residues present in the crop content and fat of foraging ducks from Thrissur

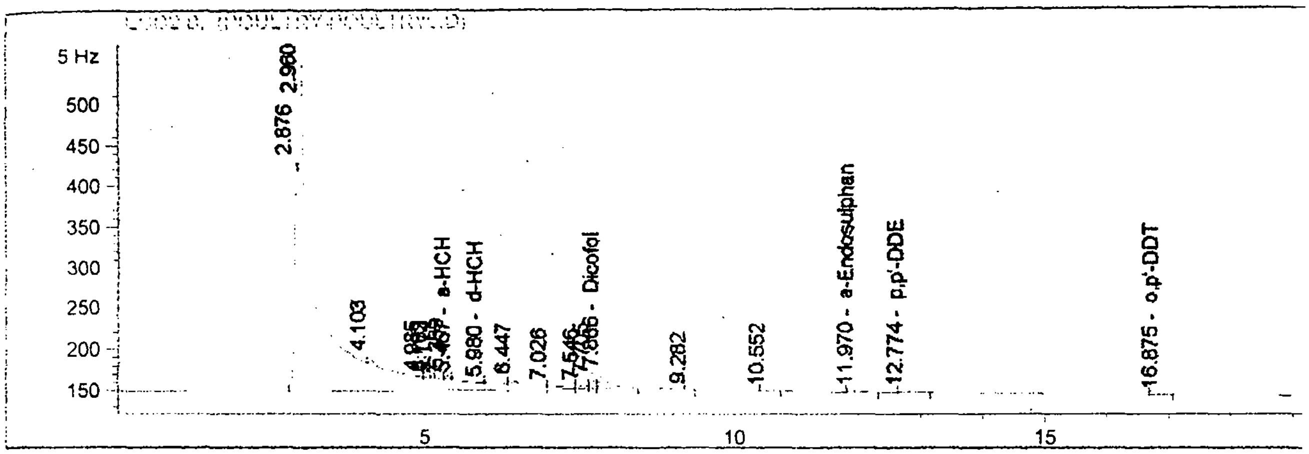
Name of organochlorine	Crop content (ppm)	Fat (ppm)
α -HCH	0.00015	0.00025
β -HCH	0.0006	0.00135
γ -HCH	0.0001	0.0008
δ -HCH	0.0002	0.0006
p, p'-DDE	0.0018	0.0042
o, p'-DDE	0.00014	0.00018
ά -Endosulphan	0.00026	0.00028
Total	**0.0033**	**0.0077**

Fig.10 **Chromatogram of the pesticide mixed standard**



Peak #	Ret. Time (min)	Area	Area %	Amount	Compound Name
1	2.934	5.663e3	71.160	0.000	
2	3.980	798.839	10.038	0.000	
3	5.187	23.578	0.296	0.000	
4	5.288	126.202	1.586	12.620	a-HCH
5	5.498	104.993	1.319	10.499	b-HCH
6	5.779	65.907	0.828	6.591	g-HCH
7	5.898	90.864	1.142	9.086	d-HCH
8	6.215	12.308	0.155	0.000	
9	8.691	32.683	0.411	3.268	Dicofol
10	11.563	43.526	0.547	4.353	0,p'DDE
11	12.211	120.497	1.514	12.050	a-Endosulphan
12	13.435	176.359	2.216	17.636	p,p'-DDE
13	13.755	73.722	0.926	7.372	Dieldrin
14	15.302	196.956	2.475	19.696	b-Endosulphan
15	16.229	66.365	0.834	6.637	p,p'-DDD
16	16.969	137.017	1.722	13.702	o,p'-DDT
17	18.794	84.355	1.060	8.435	Endo-sulphat
18	20.241	121.511	1.527	12.151	p,p-DDT
19	22.854	19.397	0.244	0.000	

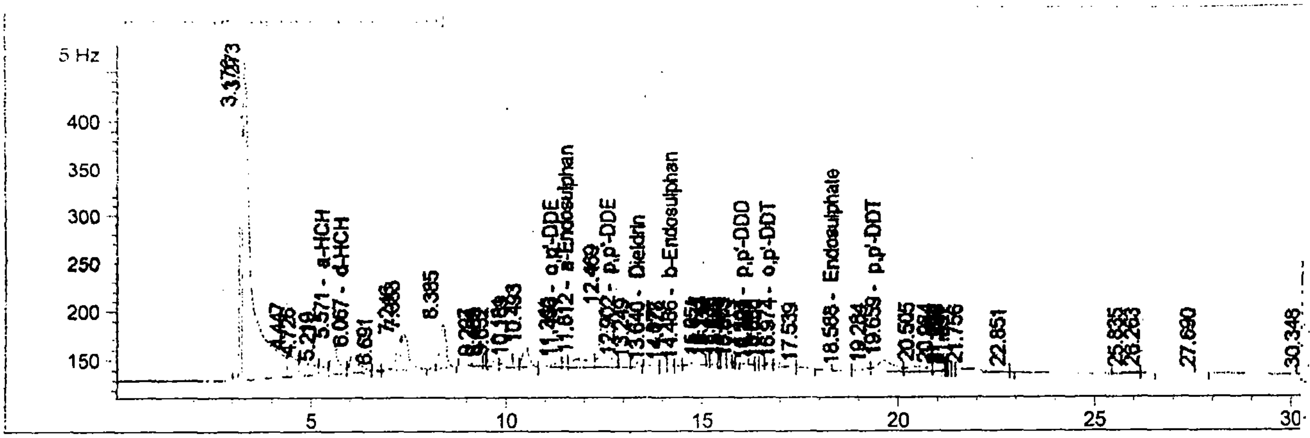
Fig.12 **Chromatogram showing the organochlorine residues in the fat sample of foraging duck from Kuttanad**



Peak #	Ret. Time (min)	Area	Area %	Amount	Compound Name
1	2.876	871.373	8.736	0.000	
2	2.960	6.264e3	62.798	0.000	
3	4.103	1.312e3	13.149	0.000	
4	4.985	99.482	0.997	0.000	
5	5.103	68.178	0.684	0.000	
6	5.174	122.477	1.228	0.000	
7	5.369	117.368	1.177	0.000	
8	5.467	332.041	3.329	0.186	a-HCH
9	0.000	0.000	0.000	0.000	b-HCH
10	0.000	0.000	0.000	0.000	g-HCH
11	5.980	172.228	1.727	0.168	d-HCH
12	6.447	220.033	2.206	0.000	
13	7.026	82.490	0.827	0.000	
14	7.546	37.773	0.379	0.000	
15	7.705	50.345	0.505	0.000	
16	7.866	172.005	1.724	0.180	Dicofol
17	9.282	1.691	0.017	0.000	
18	10.552	1.933	0.019	0.000	
19	0.000	0.000	0.000	0.000	o,p'-DDE
20	11.970	24.911	0.250	0.016	a-Endosulphan
21	12.774	16.865	0.169	0.014	p,p'-DDE
22	0.000	0.000	0.000	0.000	Dieldrin

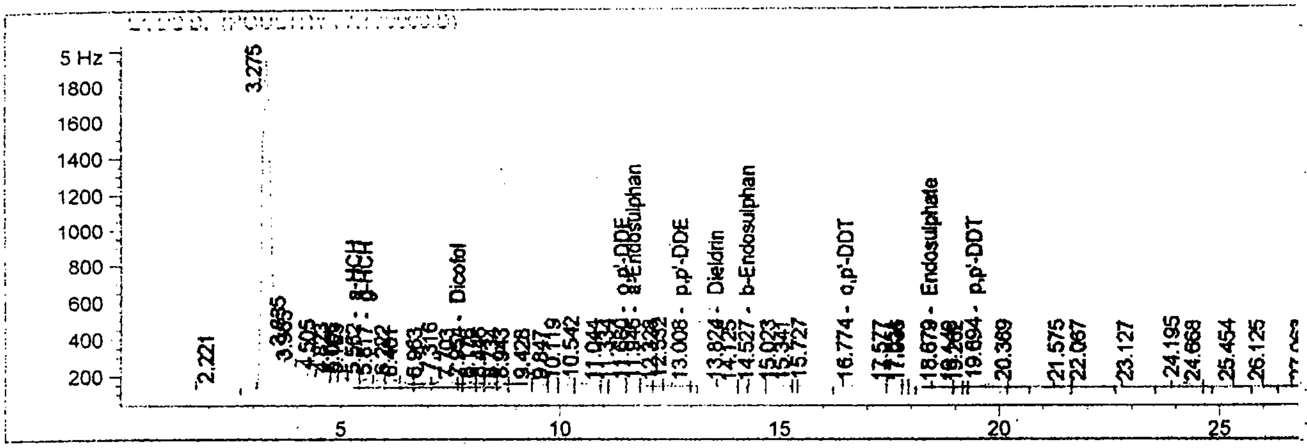
Peak #	Ret. Time (min)	Area	Area %	Amount	Compound Name
23	0.000	0.000	0.000	0.000	b-Endosulphan
24	0.000	0.000	0.000	0.000	p,p'-DDD
25	16.875	5.820	0.058	0.005	o,p'-DDT
26	0.000	0.000	0.000	0.000	Endosulphate
27	0.000	0.000	0.000	0.000	p,p'-DDT
28	21.116	2.173	0.022	0.000	

Fig.13 Chromatogram showing the organochlorine residues in the crop sample of foraging duck from Palakkad



Peak #	Ret. Time (min)	Area	Area %	Amount	Compound Name
1	3.176	1.226e3	9.842	0.000	
2	3.273	5.312e3	42.634	0.000	
3	4.447	337.532	2.709	0.000	
4	4.726	341.536	2.741	0.000	
5	5.219	117.428	0.942	0.000	
6	5.571	409.761	3.289	0.229	a-HCH
7	0.000	0.000	0.000	0.000	b-HCH
8	0.000	0.000	0.000	0.000	g-HCH
9	6.067	298.028	2.392	0.290	d-HCH
10	6.691	16.682	0.134	0.000	
11	7.246	251.681	2.020	0.000	
12	7.383	446.585	3.584	0.000	
13	0.000	0.000	0.000	0.000	Dicofol
14	8.385	466.604	3.745	0.000	
15	9.297	83.627	0.671	0.000	
16	9.465	22.241	0.178	0.000	
17	9.489	11.131	0.089	0.000	
18	9.652	80.772	0.648	0.000	
19	10.131	95.693	0.768	0.000	

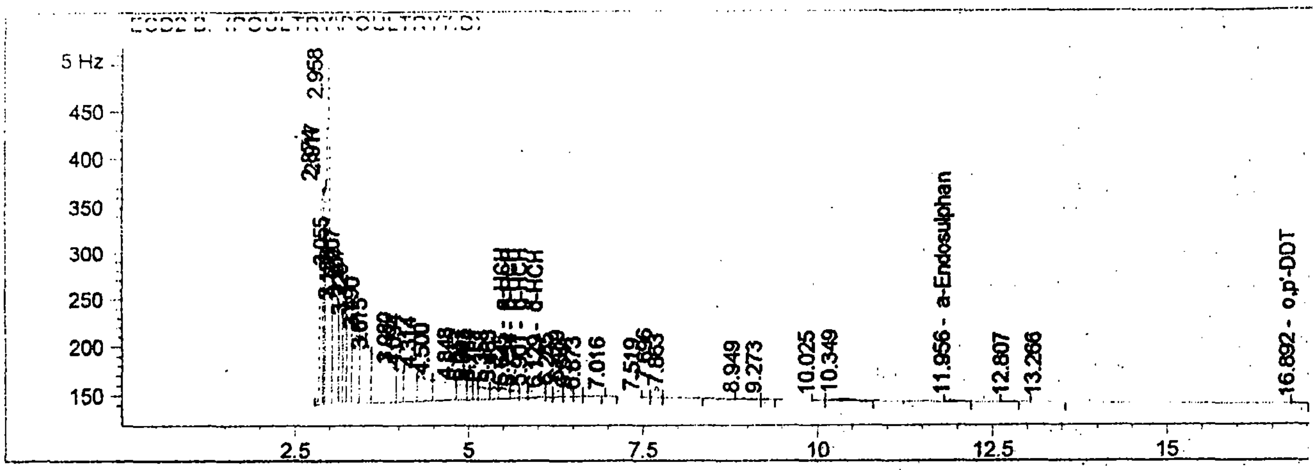
Fig.14 **Chromatogram showing the organochlorine residues in the fat sample of foraging duck from Palakkad**



Peak #	Ret. Time (min)	Area	Area %	Amount	Compound Name
1	2.221	31.658	0.072	0.000	
2	3.275	2.696e4	61.548	0.000	
3	3.835	2.546e3	5.811	0.000	
4	3.985	2.351e3	5.368	0.000	
5	4.505	1.205e3	2.751	0.000	
6	4.823	537.044	1.226	0.000	
7	5.066	644.069	1.470	0.000	
8	5.163	645.629	1.474	0.000	
9	5.562	798.248	1.822	0.660	a-HCH
10	0.000	0.000	0.000	0.000	b-HCH
11	5.817	572.991	1.308	0.100	g-HCH
12	0.000	0.000	0.000	0.000	d-HCH
13	6.222	701.622	1.602	0.000	
14	6.401	462.294	1.055	0.000	
15	6.963	502.358	1.147	0.000	
16	7.316	1.070e3	2.442	0.000	
17	7.703	129.420	0.295	0.000	
18	7.954	393.450	0.898	0.411	Dicofol
19	8.176	192.941	0.440	0.000	
20	8.446	314.449	0.718	0.000	
21	8.734	254.554	0.581	0.000	
22	8.943	537.180	1.226	0.000	

Peak #	Ret. Time (min)	Area	Area %	Amount	Compound Name
23	9.428	267.240	0.610	0.000	
24	9.847	125.498	0.286	0.000	
25	10.119	191.629	0.437	0.000	
26	10.542	330.595	0.755	0.000	
27	11.044	38.005	0.087	0.000	
28	11.334	121.448	0.277	0.000	
29	11.680	117.939	0.269	0.139	o,p'-DDE
30	11.946	100.067	0.228	0.080	a-Endosulphan
31	12.328	47.730	0.109	0.000	
32	12.532	182.004	0.415	0.000	
33	13.008	6.030	0.014	0.005	p,p'-DDE
34	13.824	59.265	0.135	0.100	Dieldrin
35	14.125	2.576	0.006	0.000	
36	14.527	12.879	0.029	0.007	b-Endosulphan
37	15.023	64.335	0.147	0.000	
38	15.341	5.817	0.013	0.000	
39	15.727	193.306	0.441	0.000	
40	0.000	0.000	0.000	0.000	p,p'-DDD
41	16.774	105.544	0.241	0.082	o,p'-DDT
42	17.577	7.258	0.017	0.000	
43	17.851	3.620	0.008	0.000	
44	17.936	2.224	0.005	0.000	
45	18.679	22.095	0.050	0.035	Endosulphate
46	19.149	8.648	0.020	0.000	
47	19.262	6.360	0.015	0.000	
48	19.694	264.023	0.603	0.303	p,p'-DDT
49	20.369	18.613	0.042	0.000	
50	21.575	22.145	0.051	0.000	
51	22.067	97.097	0.222	0.000	
52	23.127	20.127	0.046	0.000	
53	24.195	333.452	0.761	0.000	
54	24.668	2.324	0.005	0.000	
55	25.454	5.246	0.012	0.000	
56	26.125	2.588	0.006	0.000	
57	27.063	44.495	0.102	0.000	
58	27.485	5.134	0.012	0.000	
59	28.052	108.753	0.248	0.000	
60	29.163	8.516	0.019	0.000	

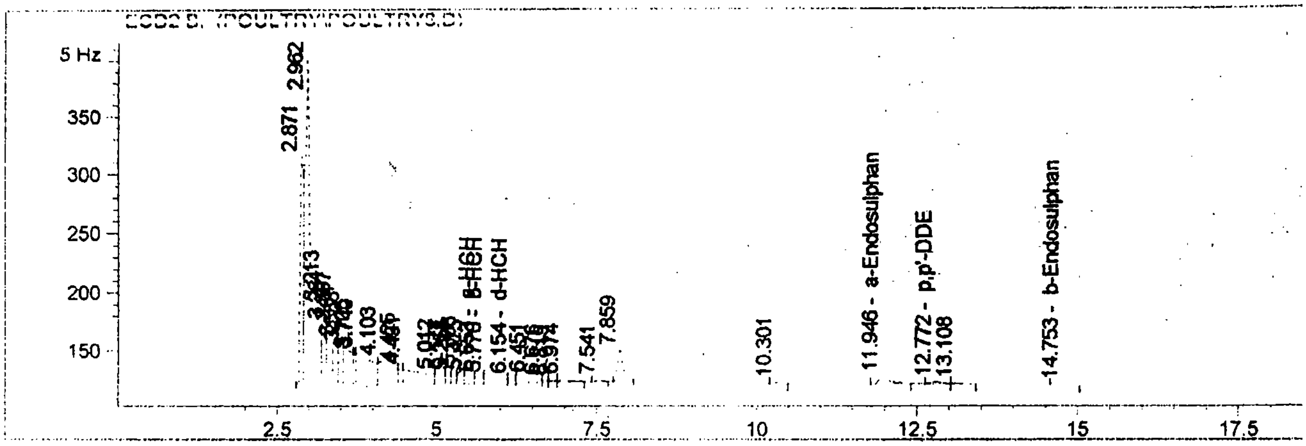
Fig.15 **Chromatogram showing the organochlorine residues in the crop sample of foraging duck from Thrissur**



Peak #	Ret. Time (min)	Area	Area %	Amount	Compound Name
1	2.874	678.295	7.925	0.000	
2	2.917	464.572	5.428	0.000	
3	2.958	1.358e3	15.862	0.000	
4	3.055	694.593	8.116	0.000	
5	3.138	323.731	3.783	0.000	
6	3.207	385.369	4.503	0.000	
7	3.267	400.062	4.674	0.000	
8	3.328	509.426	5.952	0.000	
9	3.490	615.699	7.194	0.000	
10	3.615	898.065	10.493	0.000	
11	3.980	189.728	2.217	0.000	
12	4.094	337.784	3.947	0.000	
13	4.314	308.805	3.608	0.000	
14	4.500	352.361	4.117	0.000	
15	4.848	126.775	1.481	0.000	
16	5.012	62.084	0.725	0.000	
17	5.093	57.868	0.676	0.000	
18	5.164	116.585	1.362	0.000	
19	5.358	72.216	0.844	0.000	
20	5.463	96.455	1.127	0.000	
21	5.645	56.993	0.666	0.029	a-HCH
22	5.754	45.396	0.530	0.064	b-HCH

Peak #	Ret. Time (min)	Area	Area %	Amount	Compound Name
23	5.901	78.567	0.918	0.014	g-HCH
24	6.129	24.334	0.284	0.020	d-HCH
25	6.285	38.969	0.455	0.000	
26	6.439	49.821	0.582	0.000	
27	6.541	21.620	0.253	0.000	
28	6.673	14.605	0.171	0.000	
29	7.016	2.542	0.030	0.000	
30	7.519	1.864	0.022	0.000	
31	7.696	44.842	0.524	0.000	
32	7.863	62.432	0.729	0.000	
33	0.000	0.000	0.000	0.000	Dicofol
34	8.949	5.568	0.065	0.000	
35	9.273	2.368	0.028	0.000	
36	10.025	3.219	0.038	0.000	
37	10.349	38.763	0.453	0.000	
38	0.000	0.000	0.000	0.000	o,p'-DDE
39	11.956	7.320	0.086	0.004	a-Endosulphan
40	0.000	0.000	0.000	0.000	p,p'-DDE
41	12.807	3.732	0.044	0.000	
42	13.266	5.179	0.061	0.000	
43	0.000	0.000	0.000	0.000	Dieldrin
44	0.000	0.000	0.000	0.000	b-Endosulphan
45	0.000	0.000	0.000	0.000	p,p'-DDD
46	16.892	2.349	0.027	0.002	o,p'-DDT
47	0.000	0.000	0.000	0.000	Endosulphate
48	0.000	0.000	0.000	0.000	p,p'-DDT

Fig.16 **Chromatogram showing the organochlorine residues in the fat sample of foraging duck from Thrissur**



Peak #	Ret. Time (min)	Area	Area %	Amount	Compound Name
1	2.871	636.024	10.372	0.000	
2	2.962	2.114e3	34.483	0.000	
3	3.213	280.460	4.574	0.000	
4	3.281	316.928	5.168	0.000	
5	3.397	223.173	3.639	0.000	
6	3.464	162.133	2.644	0.000	
7	3.538	304.295	4.962	0.000	
8	3.705	62.746	1.023	0.000	
9	3.749	459.969	7.501	0.000	
10	4.103	318.402	5.192	0.000	
11	4.425	67.090	1.094	0.000	
12	4.491	324.921	5.299	0.000	
13	5.012	82.737	1.349	0.000	
14	5.177	43.809	0.714	0.000	
15	5.258	39.732	0.648	0.000	
16	5.368	63.328	1.033	0.000	
17	5.475	65.115	1.062	0.000	
18	5.653	47.758	0.779	0.025	a-HCH
19	5.770	95.290	1.554	0.135	b-HCH
20	0.000	0.000	0.000	0.000	g-HCH
21	6.154	24.735	0.403	0.021	d-HCH
22	6.451	72.734	1.186	0.000	

Peak #	Ret. Time (min)	Area	Area %	Amount	Compound Name
23	6.676	11.457	0.187	0.000	
24	6.819	10.695	0.174	0.000	
25	6.974	24.452	0.399	0.000	
26	7.541	11.390	0.186	0.000	
27	7.859	150.429	2.453	0.000	
28	0.000	0.000	0.000	0.000	Dicofol
29	10.301	4.524	0.074	0.000	
30	0.000	0.000	0.000	0.000	o,p'-DDE
31	11.946	76.623	1.250	0.047	a-Endosulphan
32	12.772	23.307	0.380	0.020	p,p'-DDE
33	13.108	9.408	0.153	0.000	
34	0.000	0.000	0.000	0.000	Dieldrin
35	14.753	3.867	0.063	0.003	b-Endosulphan
36	0.000	0.000	0.000	0.000	p,p'-DDD
37	0.000	0.000	0.000	0.000	o,p'-DDT
38	0.000	0.000	0.000	0.000	Endosulphate
39	0.000	0.000	0.000	0.000	p,p'-DDT

Discussion

5. DISCUSSION

5.1 BODY WEIGHT

The mean body weight (BW) of indigenous ducks at 20 weeks of age presented in Table 2 ranged from 1532.50 ± 57.25 g to 1663.0 ± 62.68 g with an overall mean of 1607.35 ± 13.63 g. At the commencement of experiment, the body weight was the lowest in group T4 and the highest in group T5 and the difference between these two groups was 130.5 g and this variation was statistically non significant.

The mean body weight in group T4 is in agreement with body weight of 1538.15 g reported by Mahanta (1997) and that in group T5 is close to the value of 1703.89 g reported by Hamid *et al.* (1988). The mean body weight at 20th week in all experimental groups in the present study fall within the range of 1.5 to 2.0 kg as reported by Rashid *et al.* (1995).

Andrews *et al.* (1984) reported body weight of 1438 g in desi ducks at 20th week under intensive system and 1443 g under semi intensive system of rearing. Lower body weights in desi ducks reported by Rithamber *et al.* (1986), Gajendran *et al.* (1990), Ravi (2002), Anon (2002) and Nageswara *et al.* (2003) were 1250 to 1500, 1465, 1431, 1466 and 1284 to 1290 g respectively. Mahanta (1997) also reported body weight of 1497.51 g in Chemballi variety of desi ducks.

These variations in 20th week body weight reported by various authors can be attributed to the genetic architecture of flocks and changes in the system of rearing and type of feed used prior to the commencement of the experiment.

The 40th week body weight (Table 2) among the experimental groups ranged between 1649.75 and 1682.25 g, the lowest being in group T5 and the highest in group T4. The overall mean body weight was 1662.85 g showing an increase of 55.5 g over a period of 20 weeks. The ducks fed 12 per cent crude fibre diet supplemented with 0.12 per cent enzyme (T4) improved their body weight by increasing 149.75 g and became the highest weight group at 40 weeks of age.

In the other three groups, viz., T1, T2 and T3 an increase in body weight of 41.25, 67.25 and 32.50 g respectively were registered. While, a reduction of 13.25 g was noticed in ducks fed 0.18 per cent enzyme (T5) resulting in lowest weight at 40 weeks of age. However, these variations among groups did not influence 40^{th} week body weight significantly. The phenomenon of increase in body weight of ducks at 40 weeks of age in cage system observed in the present study is in full agreement with the findings of Ravi (2002).

The pattern of increase in weight recorded in the present study resulted in higher body weights at 40 weeks of age. On the other hand various authors reported a decline in body weight with increasing age. Andrews *et al.* (1984) observed a decrease in the body weight at 40^{th} week both in intensive and semi intensive rearing (1311 and 1281 g). Mahanta (1997) indicated the same trend and reported a decrease in body weight to the tune of 44.08 g in Chara ducks and 22.06 g in Chemballi variety of duck at 40^{th} week of age. (Anon 2002) observed a similar trend under cage system of rearing and stated that the body weight of 1466 g at 20 weeks of age, reduced to 1354 g at 40 weeks of age in Kuttanad ducks.

At 52 weeks of age, the mean body weight was the lowest (1647 g) in the control group fed 8 per cent crude fibre and the highest (1799.25 g) in group T5 showing a further increase in all groups fed diets containing 12 per cent crude fibre. The highest increase of 149.5 g was registered with the 0.18 per cent enzyme supplemented group (T5). The increase in feed intake observed with 12 per cent crude fibre diets compared to the 8 per cent crude fibre diet might be the reason for higher body weights at 52 weeks of age in all the groups fed 12 per cent crude fibre. This finding also indicated that cage reared ducks at 52 weeks of age did not exhibit the tendency of loosing weight on optimum feed intake. The overall mean weight at 52 weeks of age showed an overall increase of 61.25 g compared to the mean BW at 40 weeks of age.

A decrease of 11.5 g in body weight observed in the control group (T1) fed 8 per cent crude fibre, could not be attributed to any specific reason and the magnitude of decline was very low. The declining trend in BW observed by Mahanta (1997) was to the tune of 158.8 g in Chara and 146.6 g in Chemballi varieties of desi ducks.

The increase in body weight observed at 52 weeks of age could not be attributed to the enzyme supplementation in the diet as this increase was noted in unsupplemented group also. Farrel and Martin (1998) did not observe any beneficial effect in ducklings by the supplementation of enzyme in diets containing 30 and 60 per cent rice bran. Jeroch *et al.* (1995) observed improved live weight gain in starter phase by the enzyme supplementation in barley based diets in male Muscovy ducks. Improvement in live weight of six months old cross bred ducks given enzyme premix was reported by Dadashko and Sirvidis (1996).

5.2 EGG PRODUCTION

5.2.1 Duck Housed Number (DHN) – Period wise

The duck housed number (DHN) of eggs per duck for different treatment groups in nine, 28-day laying periods from 21 to 56 weeks of age is presented in Table 3.

In this study egg number recorded in the 8 per cent fibre diet (T1) was low throughout the experimental period and the cumulative egg production was the lowest (108.68 eggs per duck) in the control group. Lower feed intake was observed in this group in all periods.

During the initial period, high egg production was recorded in 12 per cent dietary fibre group (T2) and this trend continued in the second period also. The effect of enzyme supplementation in 12 per cent CF diet on egg production was more pronounced from third period onwards till the end of experiment in 0.06 and 0.18 per cent levels (T3 and T5).

During the initial three, 28-day periods from 21 to 32 weeks of age, the egg production in 0.12 per cent enzyme supplemented group T4 was comparable with other two enzyme supplemented groups, but it was significantly low in IV^{th} and V^{th} period. Comparatively low hemoglobin content of ducks at 40 weeks of age could be attributed to the low egg production in this group.

The egg production in ducks fed 12 per cent dietary fibre was higher than the 8 per cent dietary fibre in all the periods except period VII. This might be due to the better utilization of fibre by the ducks.

The highest cumulative egg production of 141.98 eggs per duck during the period from 21 to 56 weeks of age (Table 3) was recorded with diet containing 12 per cent crude fibre supplemented with 0.06 per cent enzyme (T3). Significantly higher egg production was recorded in group T3 from third to sixth and during eighth period. After 40 weeks of age, the magnitude of reduction in egg yield was comparatively low leading to the highest cumulative egg production up to 56 weeks of age in group T3.

In the present study, the egg number up to 40 weeks of age ranged from 62.78 to 81.10 between the lowest and highest groups (Table 3).

The results of the present study is in agreement with the production performance of desi ducks of Kerala reported by Mahanta (1997), but was comparatively higher than the production reported by other authors (Mostageer *et al.* 1971, Ramakrishnan *et al.* 1982, Andrews *et al.* 1984, Eswaran *et al.* 1985, Gajendran *et al.* 1990, Baruah *et al.* 1991, Rashid *et al.* 1995 and Nageswara *et al.* 2003). The egg number recorded in this experiment was better than the egg production of desi ducks under field conditions in Assam as reported by Das *et al.* (2000), which were 19.45 and 42.33 up to 40 and 56 weeks of age respectively. In cage system of rearing the egg number up to 40 weeks of age were 70.4 and 80.64 as in the reports of Ravi (2002) and Anon (2002) respectively. The present study was also in cage system and the results are comparable with the above results.

Among the five treatment groups, egg production per duck up to 56 weeks of age was significantly higher in 0.06 per cent enzyme supplemented diet (T3) and this increase was 12.55 eggs more than the 0 per cent enzyme supplemented high fibre diet group (T2). A numerical increase of 4.47 eggs was accounted in 0.18 per cent enzyme supplemented group (T5) also. The beneficial effect of enzyme in increasing egg production was noticed in group T3 consistently up to 52 weeks of age. Higher egg production in layer chicken fed with fibre degrading enzymes was observed by Prakash and Devegowda (1993), Sharma and Katoch (1993), Satyamoorthy (1995), Ponnuvel (1996) and Mohan *et al.* (2001). Anon (2004) reported increased egg production in desi ducks with 0.1 and 0.2 per cent dietary supplementation of polyzyme from 27 to 44 weeks of age. The present finding agrees with the above reports.

5.2.2 Duck day number (DDN)

Among the treatment groups, T1, T2 and T5 showed 2.5 per cent mortality during the entire period of experiment. This resulted in cumulative duck day number of 109.44, 130.65 and 135.78 in groups T1, T2 and T5 respectively, which was higher than the corresponding values of duck housed number. Since only slight difference existed among DHN and DDN in these groups, statistical difference among the treatment groups remained same.

5.2.3 Duck Housed (DH) and duck day (DD) Per cent Production – period wise

Period wise Duck housed and Duck day per cent production from 21 to 56 weeks of age for different treatment groups are presented in Tables 5 and 6 respectively.

The overall mean per cent duck housed egg production for the five treatments T1 to T5 in that order was 43.12, 51.36, 56.34, 50.10 and 53.40 for nine, 28-day laying periods (252 days). The overall mean duck day production per cent were differed from DHP in T1, T2 and T5 by an increase of 0.28, 0.54 and 0.80 per cent respectively due to the mortality occurred in these groups.

The overall per cent duck housed production for 224 days of production in Chara and Chemballi varieties as reported by Mahanta (1997) were 41.78 and 42.91 per cent respectively. In the present study, the lowest value recorded for T1 group was higher than that recorded by him. In all other groups significantly ($P<0.05$) higher per cent production were recorded due to the higher utilization of fibre and other nutrients by enzyme supplementation. Cage system of rearing might have helped the ducks to maintain their production even with low feed intake as recorded in the control group T1 compared to the production in semi intensive system of rearing reported by him.

The per cent production reported by many authors in desi ducks were below the present values. Andrews *et al.* (1984) reported the duck-day egg production of 14.9 and 12.6 per cent in intensive and semi intensive system of management respectively from 21 to 44 weeks of age, while Eswaran *et al.* (1985) reported duck housed production of 42.70 up to 280 days of age. Duck housed and duck day egg production in desi ducks of Bangladesh reported by Haque and Hussain (1991) was 13.2 and 16.8 per cent respectively. Anon (2002) and Ravi (2002) reported the per cent duck housed production of 57.60 and 50.0 respectively from 21 to 40 weeks of age in cage system of rearing.

Per cent duck housed production from 21 to 40 weeks of age was 44.84, 57.97, 59.91, 54.11 and 58.41 respectively for treatments T1, T2, T3, T4 and T5. All the values except for T1 were higher than that reported by Ravi (2002) up to 40 weeks of age and comparable with that reported by Anon (2002).

5.2.4 Duck housed production-week wise

The mean weekly egg number and per cent production per duck in the treatment groups up to 56 weeks of age presented in Table 7 revealed that the weekly egg production fluctuate markedly. While studying the egg production trait of two varieties of desi ducks in Kerala, Mahanta (1997) also observed similar trends.

On analysis of the weekly egg production data it was also observed that there were two peaks in egg production in all groups.

The present finding of two peaks in the egg production cycle of desi ducks was in agreement with the earlier report of Ramakrishnan *et al.* (1982) and Mahanta (1997). The latter observed the first peak at 30th week and second peak at 35th and 37th week in Chara and Chemballi varieties respectively. The first peak observed in the present study was varying from 32 to 35 weeks of age among the five treatment groups and the second peak between 39 and 44 weeks of age. However, the occurrence of two peaks in the production cycle observed in this study could not be attributed to any treatment effect as this phenomenon was reported in earlier studies in indigenous layer ducks in Kerala.

The weekly per cent egg production also indicated that the peak production was as high as 83.29 in T3 group. Except in T1, group it was more than 70 per cent in all other groups. These production records were in par with the highest production (70 per cent) reported by Ramakrishnan *et al.* (1982), who opined that desi ducks of Kerala have the genetic potential for high egg production although the peak production was maintained only for a very short duration.

Egg production in all treatment groups dropped considerably during 45 to 48 weeks of age in period VII due to moulting in the whole flock. Another reason might be the environmental factor, as this period coincided with the shorter day length which caused the insufficient day light for egg production. More over, no artificial lighting was provided in the experimental shed.

5.3 EGG WEIGHT

5.3.1 Mean Egg Weight-Period wise

The data on egg weight (Table 8) represent the mean egg weight at four week intervals from 24 week onward which was calculated based on the individual egg weight recorded during the last three consecutive days at the end of each 28 day periods.

The egg weight recorded at 24^{th} week was highest in 0.06 per cent enzyme supplemented group (T3) and it was significantly ($P<0.05$) higher than all other groups except T4 (0.12 per cent enzyme group). At 28^{th} week the egg weight in T3 group reduced by 3.6 g and was comparable with all other groups. But the overall mean egg weight was similar in these two periods. At 32^{nd} week the mean egg weight increased to 65.7 g with corresponding increase in all treatment groups. At 36, 40 and 44 weeks also there was considerable improvement in egg weight in all groups, but the differences among groups was non significant. At 48^{th} week, further increase in egg weight was noted in enzyme supplemented groups only.

At 52 weeks of age egg weight decreased in all groups except T2 and T4 resulting in a decrease of 1.6 g in the overall mean egg weight compared to 48^{th} week of age.

During the 56^{th} week, egg weight increased considerably in all groups with a highest value of 78.1 g in T3 group and was significantly ($P<0.05$) higher than T1 group (73.4g). Mean egg weight in the other three high fibre diet groups were homogenous and were intermediary. The overall mean egg weight also increased from 69.6 to 76.0 g from the period VIII to IX.

When the overall mean egg weight calculated from 21 to 56 week of age, the highest egg weight was observed in treatment T3 and was significantly ($P<0.05$) higher than the 8 per cent CF diet group (T1). Statistical analysis of the mean egg weight data revealed that Polyzyme supplementation in high fibre diets resulted significantly ($P<0.05$) heavier eggs. Egg weight was significantly lower in 8 per cent CF diet group. The egg weight in ducks fed 12 per cent fibre diet without enzyme supplementation was intermediary.

The present results on egg weight were superior to that mentioned by Andrews *et al.* (1984) who reported an egg weight of 60.4 g under intensive system and 60.7 g under the semi intensive system among indigenous ducks of Kerala. Eswaran *et al.* (1985) reported an egg weight of 62.41 g at 40 weeks of age in desi ducks and Mahanta *et al.* (1993) reported an egg weight of 60.55 g in Pati ducks. The overall mean egg weight recorded among experimental ducks at 40^{th} week in the present study (69.0 g) was similar to the mean egg weight in Chara and Chemballi ducks at 40^{th} week of age (69.9 and 68.9 g respectively) reported by Mahanta (1997).

Under cage system of rearing, Anon (2002) reported the mean egg weight of 57.42 g in indigenous ducks of Kerala from 21 to 40 weeks of age. Ravi (2002) also reported the overall cumulative mean egg weight from 25 to 40 weeks of age among treatment groups as 59.60 g in indigenous layer ducks under cage system. Both these values were below the overall mean value of egg weight recorded among the five groups from 21 to 40 weeks of age in the present study (65.0 g).

Among the nine periods, significant difference in egg weight was noticed only during five periods. At 24th week, egg weight in T3 (0.06 per cent enzyme) was significantly ($P<0.05$) higher than enzyme unsupplemented groups T1 and T2 while at 48th week, 0.06 and 0.18 per cent enzyme groups T3 and T5 were significantly higher than T1 and T2. This trend was observed in T3 group at 56th week also when compared to T1. The cumulative mean egg weight data from 21 to 56 weeks of age indicated that the three levels of enzyme supplementation significantly influenced the egg weight. This finding support the result of Zang Su Min *et al.* (1996) who reported that compound enzyme preparation supplemented in layer basal diet increased average egg weight by 18.18 per cent. But Satyamoorthy (1995), Ponnuvel (1996) and Mohan (2001) could not observe any significant effect on egg weight in chicken layers supplemented with fibrolytic enzymes. On reviewing the literatures, studies on multi enzyme supplementation on egg weight in layer ducks could not be seen. Therefore the effect of enzyme supplementation on egg weight cannot be interpreted reliably based on the present study alone.

5.3.2 Egg Mass

The data on weekly egg mass per duck in each treatment group from 21 to 56 weeks of age are presented in Table 9. The total egg mass per duck up to 56 weeks of age was the highest (9.67 kg) in the 12 per cent CF diet with 0.06 per cent enzyme supplementation and the lowest (7.22 kg) in 8 per cent CF diet group (T1). The values were 8.61, 8.47 and 9.25 kg for T2 (12% CF diet), T4 (12% CF + 0.12 per cent enzyme) and T5 (12% CF + 0.18 per cent enzyme) groups respectively. The high egg mass values in enzyme groups T3 and T5 were due to high egg number. The low egg mass in 0.12 per cent enzyme group T4 was due to the low egg number without adversely affecting the egg weight. The increased egg mass recorded in the enzyme supplemented groups T3 and T5 supports the finding of Dalibard *et al.* (2004) who observed 3.7 per cent increase in egg mass when duck feed was supplemented with multi enzyme preparation.

5.4 FEED CONSUMPTION

Mean period-wise daily feed consumption (g) presented in Table 10 indicated that feed consumption was low in T1 group (8% CF diet) throughout the experimental period except in period VII (45-48 week). This might have caused the lower egg number in this group during all periods. The lowest feed intake in T1 group was 122.93 g during VIIIth period and highest feed intake was 162.99 g during VIIth period. This lower feed intake also caused the lower mean body weight in this group at 52 weeks of age which was significantly lower than that in all other treatment groups. The difference in feed consumption among treatment groups was non significant during periods III, VII and IX. The feed consumption in all 12 per cent crude fibre dietary groups (T2 to T5) was comparable among each other.

When the mean daily feed consumption per duck was considered for the whole experimental period (21 to 56 weeks), the overall mean was 145.33 g in T1 group and varied from 160.31 to 163.72 g among other four groups. T1 was significantly ($P<0.01$) lower than all other groups. The cumulative feed consumption per duck for 21 to 56 weeks was 36.63, 40.42, 41.26, 40.41 and 42.10 kg respectively for treatments T1 to T5 in that order. The enzyme supplementation did not influence the feed consumption throughout the experiment. The higher feed intake in the 12 per cent dietary groups might be due to the high dietary inclusion of paddy, which is the natural feed material for the foraging ducks. As the experimental ducks were procured from field, they might have accustomed with the foraging feed material during growing period.

Bulbule (1982) recorded feed consumption of 135 to 170 g in desi ducks under confinement. Higher feed intake was reported by Andrews *et al.* (1984) under intensive (191 g) and semi intensive (185 g) systems of management. Eswaran *et al.* (1985) reported an average daily feed intake of 181 to 184 g under semi intensive system of rearing. Gajendran *et al.* (1990) reported daily feed intake of 155 g in desi ducks and 165 g in Khaki Campbell ducks from 21 to 40 weeks of age. The average daily feed consumption was 190.06 g in Pati ducks, 174.29 g in Khaki Campbell ducks and 178.01 g in their crosses (Baruah *et al.*, 1991). Studies with desi ducks of Kerala, Anon (2002) reported mean daily feed intake of 171.88 g per duck during 21 to 40 weeks of age. The present results are very close to the observations made by the above authors but higher than that reported by Ravi (2002) who stated lower feed consumption of 130.2 g for 21 to 40 weeks of age under cage system. The higher feed consumption obtained in the present study might be due to the higher body weight of the ducks in all the treatment groups in comparison with the lower body weight observed by Ravi (2002). The higher feed intake might have caused a higher mean egg weight in cage rearing in the present study.

5.5. FEED CONVERSION RATIO

5.5 .1 Feed Conversion Ratio (FCR) per Dozen Eggs

Mean feed conversion ratio per dozen eggs (Table 11) during first laying period ranged widely from 9.47 to 24.44 with an overall mean value of 15.93. During the initial period, egg production was very low in T1, T3 and T5 groups which resulted in the high feed conversion ratio in this period.

During the second period (25 to 28 weeks) egg production improved in all the groups and the FCR reached to superior values ranging from 2.89 to 3.54 with an overall mean of 3.25. Superior FCR noted in T2 (12% CF diet group) was due to the highest egg production recorded in this group. During period III, further improvement in FCR was observed in all enzyme supplemented groups with the superior value of 2.69 in 0.06 per cent enzyme group (T3). It was significantly ($P<0.05$) better than T1 group and was comparable with all other groups. This trend continued in period IV (33-36 weeks) and V (37-40 weeks) also. The superior FCR in T1 group during 41 to 44 weeks (VIth period) was due to the considerable increase in egg production in this group during this period. During the last three periods of experiment, the differences among treatment groups were non significant.

Since the FCR values were very high and varying widely in the period I, it was excluded and not considered for statistical analysis. When FCR was calculated for 25 to 56 week period, it was numerically better in T3 group (3.41), followed by T5 and T4 (3.76 and 3.83 respectively). The differences existed between the groups were non significant. Among the enzyme supplemented groups, even though the egg number was significantly lower in 0.12 per cent enzyme group (T4), the FCR per dozen eggs was comparable in all enzyme supplemented groups.

Majority of the reports available on FCR per dozen eggs in desi ducks are based on the study conducted up to 40 and 44 weeks of age. The values reported for 21 to 40 weeks of age by Andrews *et al.* (1984) and Gajendran (1990) were higher than the values obtained in the present study. The value reported by Baruah *et al.* (1991) for desi ducks in Assam for 8, 28-day laying periods was also higher(10.87) compared to the result in the present study. However, the FCR values for 25-56 weeks of age in the present study is comparable to the values reported by Anon (2002) and Ravi (2002) for 21 to 40 weeks of age and Anon (2004) for 27 to 44 weeks of age.

FCR expressed based on the number of eggs produced alone may not reflect the feed efficiency. FCR based on kg eggs produced will help to reveal the actual relationship between mean egg weight, egg mass and feed consumption. Hence FCR based on kg eggs was also calculated.

5.5.2 Feed Conversion Ratio (FCR) per kg Egg Mass

Feed Conversion Ratio based on egg mass during 25-56 weeks of age (Table 12) was better in T3 group (4.02), followed by T5 group (4.39), almost similar in T2 and T4 groups (4.65 and 4.64 respectively), and comparatively poor in T1 group (4.85). The higher egg mass in T3 and T5 groups resulted in the superior FCR values in these groups. Even though the feed consumption was low in T1 group, the lowest egg mass resulted in poor FCR value in T1. The FCR per kilogram eggs reported in indigenous layer ducks by Ravi (2002) ranged from 3.6 to 4.3 for 25 to 40 weeks of age. In the present study FCR per kg eggs for 25-56 weeks of age, with a range of 4.02 to 4.85, are close to the values reported by Ravi (2002), even with the comparatively low egg production after 40 weeks of age.

5.6 BLOOD PARAMETERS

5.6.1 Hemoglobin

The mean hemoglobin values of experimental ducks under cage system of housing (Table 13) were within the normal range. The mean hemoglobin values reported in eight months old ducks by Sreenivasan and Rao (1965) was 12.61g/dl with a range of 10.50 to 14.25 g/dl. In the present study, the values were without much variation at 20th week of age in all the groups and it increased slightly at 40 and 52 weeks of age. The values recorded at different ages were within the range of values reported by various authors. Surendranathan *et al.* (1968) and Sreeraman *et al.* (1979) also reported similar values in adult desi female ducks. Mean hemoglobin values obtained in the present study at 40 and 52 weeks of age (13.01and 13.48 g/dl) are very close to the hemoglobin values reported by Datta *et al.* (1996) and Mahanta and Jalaludeen (1999) in female desi ducks. It indicated that either 12 per cent crude fibre inclusion or enzyme supplementation in the diet did not adversely affect the hemoglobin content in the ducks.

The lower hemoglobin content of ducks in T4 (0.12 per cent enzyme diet) group at 20th week could not be attributed to dietary effect as it occurred at the start of experiment, but the ducks in this group had lower body weight at 20 weeks of age. Higher hemoglobin value of ducks in T3 (0.06 per cent enzyme diet) group at 40th week can be attributed to the better physiological status of ducks in this group resulting in better performance of the group with respect to egg production. At 52 weeks of age, all enzyme supplemented groups were having significantly higher hemoglobin values than 8 per cent crude fibre diet group (T1). The value in T2 was comparable with all other groups. This might be due to the higher feed intake of ducks in 12 per cent crude fibre diet groups compared to the lower feed intake in the control group T1.

5.6.2 Plasma Total Protein

The plasma protein values of ducks (Table 14) indicated that the values ranged from 4.16 to 4.38 g/dl at 20 weeks, 4.60 to 5.12 g/dl at 40 weeks and 4.63 to 4.99 g/dl at 52 weeks of age. The overall mean values were 4.24, 4.95 and 4.87 g/dl at 20, 40 and 52 weeks of age respectively.

The results of the present study are comparable with the values reported by various authors.

Defalco (1942) observed a lower value of serum total protein for ducks (3.5g/dl), while Werner (1944) reported higher value (6.44g/dl). The total protein values recorded in ducks fed 12 per cent fibre diets at 40 weeks of age in the present study are comparatively closer to the value reported by Olayemi *et al.* (2002) in 50 to 60 week old ducks (5.91g/dl), who observed similar value in 8 to 10 week old ducks also. The overall mean plasma protein value obtained in ducks at 20 weeks of age in the present study are close to the serum total protein values reported in eight week old White Pekin ducks by Peethambaran (1991) and Shibi (2003).

The mean plasma protein value observed at 20 and 40 weeks of age (4.24 and 4.95 g/dl respectively) in ducks in the present study are in line with the values observed at 20 and 32 weeks of age (4.59 and 5.09 g/dl respectively) in Austra White male chicken by Sethu (2003).

In the present study the total protein values increased at 40 weeks of age. The value decreased at 52 weeks of age which agrees with the observations by

Brandt *et al.* (1951) and Nirmalan and Robinson 1971) in chicken and ducks respectively. However, many factors like stage of dehydration or hydration, hemorrhage, level of protein nutrition, sex and stage of development influence the protein level of plasma in birds (Laveille and Sauberlich, 1961).

5.6.3 Plasma Cholesterol

The plasma cholesterol values of ducks at three ages (Table 15) indicated that the values were ranging from 181.83 to 207.33mg/dl at 20 weeks, 179.85 to 185.75 mg/dl at 40 weeks and 162.02 to 167.80 mg/dl at 52 weeks of age.

The plasma cholesterol values recorded in T1 and T5 groups were significantly higher at the start of experiment. During this period, egg production has not been started in these groups, while in the other three groups duck housed egg number was 0.13/duck at 21st week of age. The birds in T1 and T5 groups started laying from 22nd week onwards. The delay in maturity might be the reason for high plasma cholesterol in these two groups.

At 40 weeks of age, the ducks in all the groups have attained their first peak in their production cycle. The plasma cholesterol level at this age ranged from 179.85mg/dl to 185.75mg/dl among treatment groups.

Literature on plasma cholesterol values in indigenous layer ducks are scanty for comparison.

Plasma cholesterol levels of male Pekin ducks and Mallards reported by Landauer *et al.* (1941) were high as 450-500mg/dl and 730mg/dl respectively.

The mean plasma cholesterol value of ducks at 52 weeks of age in the present study (164.81mg/dl)is close to the value reported by Shibi (2003) in White Pekin female ducks in the control group (164.56 mg/dl).

5.6.4 Plasma Total Lipids

The mean plasma total lipid values at 20, 40 and 52 weeks of age among the experimental ducks were 616.3, 701.6 and 806.6 mg/dl respectively (Table 16). Literature on plasma total lipid values of layer ducks is not available to corroborate the results of the present study. The values reported in Austra White male chicken by Sethu (2003) were 502 and 512 mg/dl at 20 and 32 weeks of age, while in broilers the value reported by Rekhate *et al.* (2004) was 457-463 mg/dl. Further studies in this area are needed for deriving conclusion.

5.7 NUTRIENT DIGESTIBILITY

Nutrient digestibility of experimental ducks belonging to five treatment groups carried out at the end of the experiment was shown in Table 17. Dry matter digestibility of the ducks fed various diets ranged from 59.54 to 62.17 per cent with no significant difference among the groups. Protein digestibility was numerically higher in the enzyme supplemented groups with maximum value in 0.06 per cent enzyme group (65.28 per cent) and similar value in the group fed 0.18 per cent enzyme (65.19 per cent). Digestibility value for ether extract was highest in 0.12 per cent enzyme supplemented group (T4) and lowest in 8 per cent crude fibre diet group (T1). The values in all the enzyme supplemented groups were similar. Numerically superior protein and ether extract digestibility in the enzyme treated groups might be responsible for the increased egg weight in these groups than in the other groups.

Digestibility of Acid detergent fibre fractions was also higher in the enzyme supplemented groups. However, the digestibility values of both Neutral detergent fibre and Acid detergent fibre were very close in 12 % CF diets. This indicates the ability of the ducks to digest NSPs more compared to chicken as reported by Jamroz *et al.* (1998). Effect of enzyme supplementation on digestibility of nutrients was studied in broilers and laying hens by several authors, but the studies on ducks are scanty. Increased digestibility of protein and energy was reported in broilers by Petterson and Aman (1989), Friesen *et al.* (1991) and Swain and Johri (1994) with NSP degrading enzymes. The positive effect of fibre degrading enzymes on laying hens was reported by Aimonen and Nasi (1991), Satyamoorthy (1995) and Ponnuvel (1996). The present findings agree with the observations of Ponnuvel (1996) who reported significant improvement in protein and ether extract digestibility and numerical increase in digestibility of fibre fractions in laying hens supplemented with cellulase in 12 per cent fibre diets.

5.8 CHEMICAL COMPOSITION OF MEAT

The moisture content of the layer duck meat at 56 weeks of age among the experimental ducks in cages and that of foraging ducks at 38-44 weeks of age (Table 18) were almost similar. The values were in the range of 73.38 to 75.96 per cent. These values were very close to the values reported by Varadarajulu (1973) and Sangilimadan and Narayanankutty (1998). These results are also in line with the values reported by Kriz et *al.* (1984) and Smith *et al.* (1993) in Pekin ducks, but higher than the value reported by Panda and Mohapatra (1989) in raw duck meat at eight weeks of age.

The protein content was also varying from 17.03 to 18.81 per cent among the samples collected from the experimental and foraging ducks. These values are also very close to the values reported by Varadarajulu (1973), Kriz *et al.* (1984) and Sangilimadan and Narayanankutty (1998). The fat content also ranged from 2.73 to 4.82 per cent among the samples. The fat content was higher than that reported by Smith *et al.* (1993) in 42 week old Pekin ducks (2.34 per cent) and lower than that reported by Khanna and Panda (1984) in duck sausages (10.72 per cent), but almost similar to the value shown by Sangilimadan and Narayanankutty (1998) in meat sticks prepared from spent desi ducks (5.86 per cent).

Total ash values of duck meat in the present study (2.18 to 3.88 per cent) are also more or less similar to the value reported by Sangilimadan and Narayanankutty (1998), but higher than that reported in 42 week old Pekin ducks (1.09 per cent) by Smith *et al.* (1993).

5.9 STUDIES ON FORAGING DUCKS

5.9.1 Nutrient Availability Studies

The nutritional status of foraging ducks from three different regions of Kerala was studied by crop content analysis and the mean percentage of different items present in the crop is listed in Table 19. Among the crop samples examined, the main item found was paddy grains which was 64.01 ± 4.93 per cent. The next major item was crab 23.15 ± 4.63 per cent, while that of snails, worms and other weeds was 4.07 ± 0.83 and 2.02 ± 0.48 and 6.75 ± 1.87 per cent respectively. Chemical composition of crop contents varied widely depending on the nature of items present in it. Crop samples contained paddy and other weeds had high fibre content, while those contained crab, snails, worms etc. had more protein content. Thus it is evident that foraging ducks meet the requirement of energy, protein and other nutrients from paddy grains, crab, snails and other weeds. Similar study was conducted in laying ducks under scavenging conditions in Bangladesh during different seasons by Haque *et al.* (1994) and observed that rice polishings, snails and weeds were the common feeds in the crop and gizzard. Mwalusanya *et al.* (2002) and Rashid (2003) reported that the overall physical contents of crop in chicken varied with season. They found that whole paddy rice was a major grain in the crop of chicken during the paddy harvest season.

5.9.2 Chemical Composition of Crop Contents

The chemical composition of crop contents of foraging ducks (Table 20) revealed that the dry matter content varied from 41 to 53 per cent. As ducks consume more water than hen, the dry matter content will be lower compared to hen. Earlier works in ducks are not available for comparison. However, the values are similar to that reported in non-harvesting season (44.3 per cent) and in harvesting season (51.4 per cent) by Rashid (2003) in hen. The dry matter per cent in the crop of laying hen reported by Gunaratne *et al.* (1993), Tadelle and Ogle (1996) and Mwalusanya *et al.* (2002) were 34.4, 52.3 and 43.1 per cent respectively.

The crude protein values reported by the above authors varied from 8.8 to 10.4 per cent, ether extract 1.9 to 9.2 per cent, crude fibre 5.4 to 10.2 per cent and total ash from 12.5 to 16.0 per cent. Crude protein (10.2 to 17.5 per cent) and crude fibre (11.3 to 19.8 per cent) values of the crop contents in the present study are higher than values reported by Haque *et al.* (1994) in scavenging ducks while the values for ether extract (1.8 to 3.7 per cent) and total ash (9.5 to 17 per cent) are close to those reported by the same author in ducks (1.2 to 1.61 and 8.8 to 14.8 per cent respectively).

The chemical composition was carried out in the samples collected from ducks in the post harvested paddy fields only; hence the seasonal effect on the chemical composition of crop contents could not be assessed in this study. The seasonal effect on the chemical composition of crop contents in hen reported by Rashid (2003) revealed that dry matter, ether extract and crude fibre were significantly higher during harvesting season than in non-harvesting season, but other nutrients did not vary. According to Mwalusanya *et al.* (2002), the crude protein, ether extract, crude fibre, total ash, calcium and phosphorus were higher during short rainy season than in long rainy season in Tanzania.

5.9.2 Blood Parameters

Hematological and biochemical analysis of the blood samples collected from foraging ducks revealed that hemoglobin, plasma total protein, cholesterol and total lipid values were within the normal range. However, hemoglobin and total protein values were slightly lower than the values recorded in the experimental ducks in cages at 40 weeks of age. As the age of foraging ducks, from which the blood samples collected, was varied between 38 and 44 weeks of age, the blood parameters were compared with that of the experimental ducks in cages at 40 weeks of age.

5.9.3 Pesticide Residue Analysis

Under foraging system of duck rearing in the harvested paddy fields in Kerala, there is every chance of intake of the pesticides by the ducks due to the in discriminate use of the compounds in paddy cultivation. The nature of pesticides and their residue levels in animal tissues in theses area were not investigated. Therefore, in the present study an attempt was made to assess the residue levels of organochlorine pesticides in the crop content and body fat of foraging ducks from three distinct foraging regions in Kerala.

Organochlorine residue estimated in the crop contents and body fat of foraging ducks collected from Kuttanad, Palakkad and Thrissur are presented in Tables 22, 23 and 24 respectively.

5.9.3.1 Kuttanad

The results of the pesticide residue analysis in the samples collected from foraging ducks from Kuttanad revealed that the organochlorine residues present in the crop content and fat of foraging ducks ranged from 0.00014 to 0.00044 ppm and 0.00011 to 0.0089 ppm respectively. The samples in this region contained ά, β, γ and δ isomers of Hexachloro cyclohexane (HCH), metabolites of Dichloro diphenyl trichloroethane (DDT), Dicofol and ά-Endosulphan. The combined residue of these compounds accounted to 0.0018 and 0.0117 ppm in crop content and fat respectively.

5.9.3.2 Palakkad

The samples from foraging ducks in Palakkad contained ά, β, γ and δ isomers of HCH, isomers of DDT, Dicofol, ά-Endosulphan and Dieldrin. The residue in the crop content was ranging from 0.0002 to 0.0075 ppm and that in fat samples was ranging from 0.00014 to 0.0135 ppm. The combined residues were 0.0152 and 0.0419 ppm in the crop content and fat respectively.

5.9.3.3 Thrissur

The samples estimated in crop contents and fat of foraging ducks from Thrissur showed that only isomers of HCH, primary derivatives of DDT and ά-Endosulphan were present in the samples. The combined residues in these samples were also negligible (0.0033 and 0.0077 ppm in crop and fat samples respectively).

Report on the Australian National Residue survey results (Anon. 2001) indicated that the Maximum Residue Level (MRL) of various organochlorine pesticides in poultry fat are 0.2 ppm for endosulphan, aldrin and dieldrin compounds, 0.3 ppm for HCH and 5.0 ppm for DDT and its metabolites.

MRL specified by Pesticide Manufacturers and Formulators Association of India (PMFAI) are 7.0 ppm for DDT, 2.0 ppm for HCH and 0.2 ppm for aldrin and dieldrin in poultry meat.

The effects of feeding organochlorines on various poultry species have been reported by many authors. The effect of DDT and its derivatives on carbonic anhydrase enzyme activity and reduction in egg shell thickness was reported in chicken and Japanese quails by Miller et al. (1976) and Bitman *et al.* (1970) respectively.

High dietary concentration of DDE caused extreme egg shell thinning and mortality in adult mallards with no significant effect in egg size, mass and shape according to Blus *et al.* (1997).

While determining the residue in laying hens after feeding DDT at different levels, highest residue of DDT and its metabolites were found in adipose tissue than egg yolk, meat, blood and other organs (Singh *et al.*, 1970 and George and Sundararaj, 1995). High levels of DDT were determined in ovary, oviduct and egg yolk than blood and liver, while DDE in liver, ovary and oviduct with the lowest in egg yolk by Furusawa (2002).

The poly chlorinated biphenyls were reported as the most frequent contaminant among the organochlorine residues estimated in the breast muscle, skin and subcutaneous fat of mallards in Wisconsin and abdominal fat of avian species in Ontario (Botero *et al.*, 1996).

Since the organochlorine residues detected in the samples collected from three regions in the study were below their MRL specified in poultry, the eggs and meat from foraging ducks could be considered as safe for human consumption. The results of the present study indicated that the residues from a series of organochlorine compounds are present in the paddy fields in Kerala. The farmers should be made aware about the fact that indiscriminate use of these compounds in the field may lead to the accumulation of the residues in meat in future creating risk and harm to human and animal population.

Summary

6. SUMMARY

An experiment was conducted in the Department of Poultry Science, College of Veterinary and Animal sciences, Kerala Agricultural University to study the effect of supplementation of a multi enzyme in layer duck rations. Experimental diets containing Crude Fibre at 8 and 12 per cent levels and the latter diet supplemented with varying levels of 'Polyzyme' were formulated and fed to indigenous layer ducks, under cage system of management. The experiment started at 20 weeks of age and continued up to 56 weeks of age. The nutritional and physiological status of ducks under extensive system of management was evaluated in foraging ducks procured from three regions viz; Kuttanad, Palakkad and Thrissur in Kerala.

Two hundred (200), indigenous ducks at 18 weeks of age were divided in to five groups of 40 ducks each in five dietary groups T1, T2, T3, T4 and T5 consisting of four replicates each having 10 ducks housed as two ducks per cage. The experimental diets formulated with 18 per cent crude protein and 2550 Kcl ME/kg diet. The control diet T1 contained 8 per cent crude fibre and other diets T2 to T5 contained 12 per cent crude fibre and the diets T3, T4 and T5 were supplemented with Polyzyme at levels 0.06, 0.12 and 0.18 per cent respectively.

The body weight was recorded at 20, 40 and 52 weeks of age. The production performance was recorded from 21 to 56 weeks of age. Egg production was recorded daily and week wise and period wise egg number and per cent production on duck housed and duck day basis were arrived. Individual egg weight was recorded during the last three consecutive days in each 28-day period and the mean periodwise egg weight was calculated. Daily egg mass was recorded in each treatment group from 23 to 56 weeks of age and cumulative egg mass per duck in each group was worked out. Feed consumption in each treatment group was recorded period wise and the mean daily feed intake per bird

was calculated. Feed conversion ratios were calculated per dozen and per kilogram egg basis in each period.

Blood parameters in respect of hemoglobin, plasma total protein and lipids and cholesterol were analyzed in six ducks from each dietary group at 20, 40 and 52 weeks of age. Chemical composition of the meat was estimated in thigh muscle samples collected from six ducks in each dietary group at 56 weeks of age. At the end of the experiment, nutrient digestibility was assessed using three ducks from each treatment group.

Nutritional and physiological status of foraging ducks was assessed by collecting crop, body fat and blood samples from 10 ducks each from three regions, namely Kuttanad, Palakkad and Thrissur and the nutrient availability in the crop contents was estimated. Hemoglobin, plasma total protein and lipids and total cholesterol were analyzed to assess the physiological status of the foraging ducks. The pesticide residue in the crop contents and fat samples were estimated using Gas Chromatography.

The salient results obtained in the present study are summarized below:

1. The mean body weight of indigenous layer ducks ranged from 1532.50 to 1663.0 g at 20 weeks and 1649.75 to 1682.25g at 40 weeks of age. At both these ages, the differences among groups were statistically non significant. Whereas, at 52 weeks of age, in the control group T1 fed 8 per cent CF, the mean body weight (1647.0 g) was significantly lower than that of group T5 (1799.25 g) fed 12 per cent CF supplemented with 0.18 per cent polyzyme ($P<0.01$). The other three high fibre diet groups were homogenous and intermediary between T1 and T5.

2. The cumulative mean duck housed number (DHN) during the period from 21 to 56 weeks of age was the highest in group T3 fed 12 per cent CF

supplemented with 0.06 per cent enzyme (141.98) and the lowest in the 8 per cent crude fibre control group T1 (108.68). The cumulative DHN in all 12 per cent CF diets T2 to T5 were significantly higher than that of control group ($P<0.05$). In 12 per cent CF diet T4 supplemented with 0.12 per cent enzyme level, the DHN (126.23 eggs) was significantly lower than that recorded with diet T3. The enzyme unsupplemented 12 per cent crude fibre diet group T2 was statistically comparable with enzyme supplemented groups.

3. The cumulative mean duck-housed per cent production in dietary group T3 (56.34 per cent) was significantly higher ($P<0.05$) than that of control group T1 (43.12 per cent) and T4 (50.10 per cent). The per cent production in dietary groups T1, T2, T3, T4 and T5 were 43.12, 51.36, 56.34, 50.10 and 53.40 respectively. The per cent production in 12 per cent fibre group T2 was statistically comparable with enzyme supplemented groups.

4. The weekly egg production pattern revealed that there were two peaks in production during the period from 23 to 56 weeks of age. In the control group, the first peak occurred at 32nd week with 64.71 per cent production and next peak occurred at 44 weeks of age with 63.43 per cent production. In other groups, the two peaks occurred between 32 and 44 weeks of age but with higher per cent production compared to that in 8 per cent CF diet. The weekly egg production was the highest (83.29 per cent) in 12 per cent CF diet T3 with 0.06 per cent enzyme supplementation at 35 weeks of age.

5. The overall mean egg weight for 21-56 weeks of age was significantly higher in all enzyme supplemented dietary groups compared to control group ($P<0.05$) and the mean values were 65.8, 67.5, 69.4, 68.6 and 68.9 g in groups T1, T2, T3, T4 and T5 respectively.

6. Total egg mass per duck during 23-56 weeks ranged from 7.22 to 9.67 kg showing the highest egg mass in 0.06 per cent enzyme supplemented group and lowest in the control group.

7. Overall mean daily feed consumption per duck for 21-56 weeks period ranged from 145.33 to 163.72 g with an overall mean value of 158.50g. Mean daily feed intake per duck in the 8 per cent CF diet group was significantly lower than all other dietary groups ($P<0.05$). The cumulative feed intake per duck for 21-56 weeks of age ranged from 36.63 kg in 8 per cent CF diet group to 42.10 kg in 0.18 per cent enzyme supplemented group with an overall mean value of 40.16 kg.

8. Feed Conversion Ratio (FCR) per dozen eggs for 25-56 week period was numerically better in all enzyme-supplemented groups. Among them, 0.06 per cent enzyme supplemented group was superior with a value of 3.41. The cumulative FCR in dietary groups T1, T2, T3, T4 and T5 were 4.19, 4.28, 3.41, 3.83 and 3.76 respectively.

9. FCR per kilogram egg for 25-56 weeks was better in 0.06 per cent enzyme diet group compared to other groups.

10. Physiological profile of indigenous layer ducks indicated that hemoglobin values among the five treatment groups were comparable each other and ranged from 11.84 to 12.86, 12.86 to 13.72 and 12.96 to 13.83 g/dl at 20, 40 and 52 weeks of age respectively. At these ages, total protein and lipids in plasma showed non significant variation among groups. The overall mean values of plasma total protein among the dietary treatment groups at 20, 40 and 52 weeks of age were 4.24, 4.95 and 4.87 mg/dl respectively. The overall mean values of plasma total lipids among the dietary treatment groups at 20, 40 and 52 weeks of age were 616.30, 701.60 and 806.60 mg/dl. The biochemical analysis revealed that Plasma

cholesterol ranged from 181.83 to 207.33, 179.85 to 185.75 and 162.02 to 167.80 mg/dl among the experimental groups at 20, 40 and 52 weeks of age respectively.

11. The results of the digestibility trial conducted at the end of the experiment at 56 weeks of age showed that per cent digestibility of crude protein, ether extract and fibre fractions namely Neutral detergent fibre and Acid detergent fibre were numerically higher in enzyme supplemented groups compared to other groups.

12. The moisture content of the meat from indigenous layer ducks at 56 weeks of age ranged from 73.38 to 75.96 per cent among the experimental groups and foraging ducks. Crude protein value ranged from 17.03 to 18.81, fat from 2.73 to 4.82 and total ash from 2.18 to 3.88 per cent. There was no apparent difference in the nutrient composition of duck meat from experimental ducks and foraging ducks.

13. The livability was 100 per cent in two experimental groups T3 and T4 and 97.5 per cent each in the other three groups.

14. The feed items present in the crop of foraging ducks showed wide variations quantitatively. The contents present in the crop were paddy grains, crab, snail, worms and other weeds in the proportion of 64.01, 23.15, 4.07, 2.02 and 6.75 per cent respectively. The chemical composition of pooled contents in the crop indicated that moisture, crude protein, ether extract, crude fibre and total ash ranged widely between 41.0 to 53.0, 10.2 to 17.5, 1.8 to 3.7, 11.3 to 19.8 and 9.5 to 17.0 per cent respectively. The fibre fractions Neutral detergent fibre and Acid detergent fibre ranged from 28.1 to 39.5 per cent and 12.7 to 23.4 per cent respectively.

15. The mean hemoglobin value of the foraging ducks estimated was 12.85 g/dl. While, the mean plasma total protein, plasma total lipids and plasma total cholesterol were 3.85 g/dl, 764.15 mg/dl and 184.52 mg/dl respectively.

    The mean hemoglobin content of foraging ducks (38-44 weeks) was similar to the mean hemoglobin value of ducks in the 0.12 per cent enzyme group (12.86 g/dl) in the cage system at 40 weeks of age. The mean total protein value of foraging ducks was lower than the value obtained in the experimental ducks in the intensive system at 20, 40 and 52 weeks of ages. The mean plasma cholesterol value in foraging ducks was very close to the values recorded in ducks in T1, T3 and T4 groups. The plasma total lipid value of foraging ducks was higher than the corresponding values obtained for experimental ducks in cages at 40 weeks of age. However, plasma total lipid value was close to the value obtained in experimental ducks fed with 8 per cent crude fibre diet.

16. The pesticide screening in the crop content and fat of foraging ducks from three regions of Kerala, namely Kuttanad, Palakkad and Thrissur indicated that the residues of various isomers of Hexachlorocyclohexane (HCH), primary derivatives of DDT, isomers of endosulphan, dicofol and dieldrin were present in minute quantities both in crop contents and fat. The combined residues for these compounds in the crop contents were 0.0018, 0.0152 and 0.0033 ppm and that in fat samples were 0.0117, 0.0419 and 0.0077 ppm in Kuttanad, Palakkad and Thrissur regions respectively. However, all the values were below the Maximum Residue Level (MRL) specification for these compounds in poultry meat.

Considering the overall performance of the indigenous ducks under the cage system of rearing, it was concluded that 12 per cent crude fibre is superior over the 8 per cent crude fibre in layer duck rations as evidenced by significantly higher egg production in the high fibre diet. The supplementation of polyzyme at 0.06 per cent level in 12 per cent crude fibre diet is proved to be advantageous as this level of enzyme helped to enhance the productivity in respect of cumulative egg number and mean egg weight in ducks. The 0.06 per cent level of polyzyme markedly improved the cumulative FCR in indigenous ducks.

Based on the results obtained in this study, it can be inferred that the crude protein availability from foraging fields are widely variable. The feed of the foraging ducks contained more fibre that can be efficiently utilized by them as evidenced by ability to maintain high egg production in the foraging conditions. Phyiological parameters in respect of hemoglobin, plasma total protein, lipids, and cholesterol in foraging ducks are comparable to that under intensive system of rearing. The residues of a series of organochlorine compounds in the crop contents as well as body fat of foraging ducks are not alarming, since the residues quantified are negligible. As the residue levels are very low to produce any harmful effect on the health and productivity of ducks, it cannot be considered as the cause for the health problems encountered in the foraging ducks as believed by the duck farmers of Kerala.

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CRUDE FIBRE UTILIZATION AND NUTRIENT AVAILABILITY IN INDIGENOUS LAYER DUCKS (*Anas platyrhynchos*)

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ABSTRACT OF THE THESIS

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ABSTRACT

A study was conducted in the Department of Poultry Science, College of Veterinary and Animal Sciences, Kerala Agricultural University to find out the effect of supplementation of a multi enzyme preparation 'Polyzyme' on the production performance of indigenous layer ducks. Diets containing 8 and 12 per cent CF and the high fibre diet supplemented with Polyzyme were fed to ducks from 20 to 56 weeks of age under cage system of rearing. Foraging ducks procured from three different regions of Kerala namely Kuttanad, Palakkad and Thrissur were utilized to evaluate the nutritional and physiological status of foraging ducks in Kerala.

Two hundred, 18 weeks old indigenous layer ducks were housed in cages at the rate of two ducks per cage. They were divided in to five groups viz., T1, T2, T3, T4 and T5 consisting of 40 ducks in each treatment group having four replicates with 10 ducks in each replicate. The control group T1 was allotted with 8 per cent CF diet. The diets with 12 per cent CF, T2, T3, T4 and T5 were supplemented with polyzyme levels at Zero, 0.06, 0.12 and 0.18 per cent respectively. All the diets contained 18 per cent CP and 2550 kcal ME/kg diet.

Nutritional and physiological status of foraging ducks was assessed by collecting crop, body fat and blood samples from 10 ducks each from three regions namely Kuttanad, palakkad and Thrissur. The nutrient availability in the crop contents of the ducks was estimated. The crop contents and fat were screened for pesticide residues using Gas Chromatography. Hemoglobin, plasma total protein, lipids and cholesterol were analyzed to assess the physiological status of the foraging ducks and that under cage system of rearing.

The mean body weight of indigenous layer ducks ranged from 1532.50 to 1663.0 g at 20 weeks, 1649.75 to 1682.25 g at 40 weeks and 1647.00 to 1799.25 g at 52 weeks of age with significant difference (P<0.01) between the lowest and highest groups only at 52 weeks of age.

The cumulative Duck housed egg number during 21 to 56 weeks of age was highest (141.98) in 0.06 per cent enzyme supplemented group (T3) and lowest (108.68) in 8 per cent crude fibre diet group (T1) and the DHN in all the 12 per cent CF dietary groups were significantly higher than that of control group (P<0.05). The mean percent Duck housed production was highest (56.34) in 0.06 per cent enzyme diet group and lowest (43.12) in 8 per cent CF diet group during 21 to 56 weeks period. The highest weekly egg production per cent (83.29) was recorded in 0.06 per cent enzyme dietary group at 35 weeks of age.

The overall mean egg weight for 21 to 56 weeks of age was significantly higher in all enzyme supplemented dietary groups than that of control group (P<0.05). The total egg mass per duck during 23 to 56 weeks was ranged from 7.22 to 9.67 kg showing the highest egg mass in 0.06 per cent enzyme supplemented group and the lowest in control group.

The overall mean daily feed consumption per duck for 21 to 56 weeks period ranged from 145.33 to 163.72 g and significantly higher in all diets contained 12 per cent CF and the mean cumulative feed intake was ranged from 36.63 to 41.26 kg with an overall mean value of 40.16 kg.

Feed Conversion Ratio (FCR) per dozen eggs for 25 to 56 week period was numerically better (3.41) in 0.06 per cent enzyme supplemented group.

Physiological profile of indigenous layer ducks indicated that hemoglobin values ranged from 11.84 to 12.86 g/dl at 20th week, 12.86 to 13.72 g/dl at 40th week and 12.96 to 13.83 g/dl at 52nd week among the five treatment groups. Results of the plasma biochemical analysis revealed that total protein values did not differ significantly either at 20, 40 or 52 weeks of age among the groups. The mean values at 20, 40 and 52 weeks of age were 4.24, 4.95 and 4.87 g/dl respectively. Plasma Cholesterol values at 20 weeks ranged from 181.83 to 207.33 mg/dl among groups. The corresponding values at 40 weeks ranged from 179.85 to 185.75 mg/dl and at 52 weeks from 162.02 to 167.80 mg/dl. The plasma total lipid values at 20, 40 and 52 weeks of age ranged from 595.90 to 638.86, 683.42 to 716.30 and 785.22 to 826.35 mg/dl respectively.

Per cent digestibility of protein, fat and fibre fractions namely Neutral detergent fibre and Acid detergent fibre were numerically higher in enzyme supplemented groups compared to other groups.

The moisture content of the meat from indigenous layer ducks at 56 weeks of age ranged from 73.38 to 75.96 per cent among the experimental groups and foraging ducks. Crude protein value ranged from 17.03 to 18.81, fat from 2.73 to 4.82 and total ash from 2.18 to 3.88 per cent.

The livability was 100 per cent in experimental groups T3 and T4 and 97.5 per cent each in the other three groups.

The chemical composition of the crop contents collected from foraging ducks indicated that moisture content ranged from 41.0 to 53.0 per cent, crude protein 10.2 to 17.5, ether extract 1.87 to 3.7, crude fibre 11.3 to 19.8 and total ash 9.5 to 17.0 per cent.

The mean hemoglobin and plasma biochemical values of foraging ducks between 38 to 44 weeks of age were within the normal range and were comparable with that of ducks in intensive system.

The organochlorine residue estimated in the crop content and fat of foraging ducks from three regions of Kerala namely Kuttanad, Palakkad and

Thrissur indicated that the residues detected in the samples were below the Maximum Residue Level of OC compounds in poultry. The combined residue level of all organochlorine compounds in the crop content of foraging ducks from Kuttanad, Palakkad and Thrissur were 0.0018, 0.0152 and 0.0033 ppm respectively. The combined residue in the fat of foraging ducks were higher than those values observed in crop contents at Kuttanad, Palakkad and Thrissur region and were 0.0117, 0.0419 and 0.0077 ppm respectively.

Based on the present study it was concluded that 12 per cent crude fibre can be included advantageously in the diet of indigenous layer ducks. Supplementation of 0.06 per cent polyzyme in 12 per cent fibre diet will help to enhance the production performance of indigenous layer ducks.

Results from the studies on foraging ducks revealed that nutrient availability from foraging fields are widely variable. Physiological parameters in respect of hemoglobin, plasma total protein, lipids and cholesterol in foraging ducks are comparable to that under intensive system of management. Organochlorine residues in the crop content and fat of foraging ducks from Kuttanad, Palakkad and Thrissur are below the Maximum Residue Levels of the compounds in poultry.