NUTRITIVE EVALUATION OF SQUILLA (*Oratosquilla nepa*) MEAL IN BROILER CHICKEN DIETS

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled **"Nutritive evaluation of squilla (*Oratosquilla nepa*) meal in broiler chicken diets"** 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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Dedicated to my beloved

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INTRODUCTION

INTRODUCTION

Poultry industry registered a phenomenal growth in India during the last three decades. The total produce from poultry in 1993 was estimated to be 24,000 million eggs and 454,000 tonnes of poultry meat from 150 million layers and 235 million broilers respectively (Anon, 1994). An annual growth rate of 8-9 per cent in layers and 12-15 per cent in broilers shows the immense potential of the industry.

One of the crucial inputs that would determine successful and sustainable development in poultry industry is the availability of quality feed in required quantity. As feed accounts for 70-75 per cent of total production cost of poultry (Panda and Mohapatra, 1989), efficient use of feed is extremely important to poultry producers. The poultry industry has always encountered the problem of obtaining feed ingredients of reasonably good quality, free of toxin, and antimetabolites and of adequate nutritional quality to support efficient growth. Since the feeds of plant origin commonly used for compounding rations for poultry are deficient in one or more essential amino acids, the supply of all essential aminoacids in proper proportions and amounts is ensured by the inclusion of a good quality animal protein source mainly fish meal and meat meal.

A conservative inclusion level of 8 per cent of fish meal requires 4,24,000 tonnes of fish meal for poultry feed alone, as the total poultry feed production in India during 1994 was 5.3 million tonnes (Anon, 1994). Recently the demand for marine protein has increased further because of the sudden upsurge in aquaculture. The availability of fin fish meal on dry matter basis is only about 1,76,563 tonnes in India (Ali *et al.*, 1995) and considerable part of it is used in prawn feed preparations.

The high cost of fish meal coupled with the nonavailability of good quality material to bridge the shortfall in poultry feed makes it imperative to find out alternate animal protein sources of low cost that can substitute conventional protein sources for economic poultry farming. One such untapped animal protein source is squilla, a marine crustacean which is caught in large quantities along with fish and prawns during trawling and are thrown as waste after recovery of edible fish/ prawn (Ranjhan, 1993).

Squilla is estimated to be available to the tune of 57,942 tonnes per annum in India forming nearly 15 per cent of total marine proteins. Karnataka state is leading in its landing of squilla (14,760 tonnes) followed by Gujarat, Maharastra, Tamil Nadu, Goa, Kerala and Andhra Pradesh (Ali *et al.*, 1995).

Squilla is inedible to human beings and is reported to contain about 34 per cent of crude protein on dry matter basis. The protein is deficient in lysine, methionine and threonine but cheaper when compared to fish meal (Reddy *et al.*, 1997). The material has also a high content of chitin which may limit its use in poultry diets. So far, very little work seems to have been carried out to assess the nutritive value of squilla meal in broiler rations. The meagre work reported indicates that squilla meal is inferior to fish meal as an animal protein source for broiler chicken. The lesser nutritive value reported is evidently due to the deficiency of lysine and methionine.

Considering the high protein content, available at low cost, squilla meal needs further investigation especially at the wake of shortage of fish meal. The present study is to evaluate the feeding value of squilla meal supplemented with lysine and methionine in broiler chicken diets.

REVIEW OF LITERATURE

Squilla (*Oratosquilla nepa*), a stomatopod crustacean is abundantly available in Indian coasts as well as in China, Thailand, Malaysia and the Philippines (Nair *et al.*, 1987). It is also called as mantis shrimp. Squilla inhabits in burrows in the sand or mud at the bottom of the sea (Ayyar, 1968) and they feed on small fishes. The body length of squilla ranges from 8-11 cm and the weight ranges from 5-15 g.

Squilla is inedible to human beings but is found to be rich in crude protein, calcium, phosphorus, chitin and total ash content. The information available on the utilisation of squilla meal as a feed ingredient for poultry is scanty. Hence the available literature on nutrient content and feeding value of squilla meal is reviewed and presented below.

2.1 Chemical composition

2.1.1 Proximate composition, calcium and phosphorus content

The figures on proximate composition of squilla meal reported by various authors (Anon, 1976-77, Reddy *et al.*, 1997, Mohan, 1999) revealed that crude protein content varies from 33.97 to 38.23, crude fibre 10.80 to 13.92, ether extractives 1.86 to 4.80, NFE 3.15 to 11.94 and total ash 38.31 to 43.32, calcium 7.28 to 10.0 and phosphorus 1.72 to 2.0 per cent.

On comparison of the figures reported for chemical composition of squilla meal with those for shrimp meal (Rosenfeld *et al.*, 1997), squid meal (Hulan *et al.*, 1979) and fish meal (Panda *et al.*, 1990) following differences were observed:

The per cent crude protein content of squilla meal (33.9) was found to be lower when compared to that of fish meal (43.1), shrimp meal (61.77) and squid meal (64.5) where as the per cent crude fibre content was higher in squilla meal

(13.92) than fish meal (3.6) and shrimp meal (10.83). The per cent ether extract content in squilla meal (1.86) was the lowest when compared to shrimp meal (4.3), fish meal (7.66) and squid meal (22.8). However, the total ash content was higher in squilla meal (38.31%) than fish meal (37.5%), squid meal (18.83%) and shrimp meal (18.99%). The calcium content of squilla meal (7.28%) was almost similar to that of fish meal (7.16%), but higher than that of shrimp meal (6.32%) and squid meal (2.28%) but the phosphorus content (1.72%) was lower when compared to shrimp meal (1.78%) and squid meal (3.2%).

2.1.2 Amino acid composition of squilla meal

The amino acid composition of squilla meal has been analysed by Mathew *et al.* (1982) and Reddy *et al.* (1997).

The content of amino acids in squilla meal as reported by Reddy *et al.* (1997) was lower than that reported by Mathew *et al.* (1982) with regard to threonine, valine, methionine, isoleucine, leucine, tyrosine, phenyl alanine and lysine. The content of methionine and lysine reported by Reddy *et al.* (1997) were about half of that reported by Mathew *et al.* (1982), the methionine and lysine contents in squilla meal (Reddy *et al.*, 1997) and fish meal (Panda *et al.*, 1990) being 1.86 and 3.6 and 6.74 and 7.1 per cent respectively.

In general, the data on amino acid composition as reported by Reddy *et al.* (1997) revealed that squilla meal is inferior to fish meal in regard to all amino acids especially the most limiting amino acids, lysine and methionine.

2.1.3 Metabolisable energy content of squilla meal

Reddy *et al.* (1997) reported the apparent metabolisable energy content of squilla meal as 1704 kcal/kg which was lower than that of fish meal (1930 kcal/kg) reported by the same workers and 1834 kcal/kg reported by Panda *et al.* (1990).

Apparent metabolisable energy of 2115 kcal/kg reported by Mohan (1999) for squilla meal was also lower than that of 2257 kcal/kg reported by him for fish meal. It was observed that wide variations existed in the values reported for squilla meal and fish meal by the above workers.

Higher metabolisable energy values have been reported for by-products of other aquatic crustaceans. Rosenfeld *et al.* (1997) have observed a high true metabolisable energy value of 2910 kcal/kg for shrimp meal and Hulan *et al.* (1979) reported a value of 4132 kcal/kg for squid meal.

2.1.4 Gross protein value of squilla meal

Reddy *et al.* (1997) in their studies with squilla meal reported the gross protein value of squilla meal as 68 per cent which was found to be lower than the value for fish meal (72.02%).

2.1.5 Protein digestibility of squilla meal

A lower digestibility of 66 per cent has been reported for squilla meal by Reddy *et al.* (1997) in comparison to that of fish meal (74%). Mohan (1999) also reported a lower digestibility for squilla meal protein (87.10) when compared to that of fish meal protein (92.21).

2.2 Safety of squilla protein

Nair *et al.* (1991) evaluated the safety of squilla protein for reproductive performance in rats. They fed weanling rats, diets containing squilla protein at 10 and 20 per cent for 24 weeks and observed that the fertility of the groups fed 20 per cent squilla protein was comparable to that of control group fed 10 per cent casein protein while that of the 10 per cent squilla protein group was lower. Average number of pups born alive was lower in the 10 per cent squilla protein fed group

REVIEW OF LITERATURE

than the other two groups. Significant differences could be observed in the gestation index and lactation index between the experimental and control animals. The average weight of pups at birth and at 21st day for control and 20 per cent squilla protein groups were similar while it was lower in 10 per cent squilla protein group. No adverse changes in appearance, behaviour and survival of the rats on experimental diets were also reported by the above workers. The overall results indicated that the consumption of squilla protein upto 20 per cent level by rats did not cause any deleterious effect on reproductive performance.

2.3 Feeding value of squilla meal and marine protein supplements for broiler chicken

2.3.1 Weight gain

a) Effect of squilla meal

Reddy *et al.* (1997) included squilla meal at 0, 41.7, 83.4, 125.1 and 166.8 g/kg levels in broiler diets replacing a fish mixture (620 g fish meal, 130 g starch, 24.8 g dicalcium phosphate, 54.7 g shell grit, 15.8 g sodium chloride and 154.7 g/kg saw dust). They observed that when squilla meal replaced 0, 25, 50, 75 and 100 per cent of nitrogen in the fish mixture, there was no significant difference in weight gain at the end of 42nd day. Though not statistically significant, numerically higher and lower gains were observed in birds fed diets incorporating squilla meal included at 41.7 g (1372 g) and 166.8 g/kg (1250 g) compared to control (1347 g) diet.

Mohan (1999) in his studies with squilla meal replacing fish meal in broiler diets for six weeks observed significantly higher weight gain in control group fed 10 per cent fish meal, the weight gain recorded for various groups fed rations incorporating squilla meal at 0, 5, 7.5 and 10 per cent being 1356.16, 1270.33, 1221.83 and 1083.18 g respectively.

b) Effect of processed squilla meal

Reddy *et al.* (1997) in another study to evaluate the effect of autoclaving squilla meal on its nutritive value included autoclaved squilla meal (1.09kg/cm^2 for 5 min) in broiler chicken rations at three levels viz., 83.4, 125.1, 166.8 g/kg replacing fish mixture.

It was observed that complete replacement of fish mixture by raw squilla meal resulted in significant reduction in body weight of the birds, the reduction in body weight in the other groups being not significant.

Birds fed ration containing autoclaved squilla meal recorded significantly lower mean weight gain as compared to the control group. Further, a negative correlation existed between the level of autoclaved squilla meal in the ration and the final weight of the birds. The authors opined that the lower performance of the birds fed autoclaved squilla meal compared to those fed raw squilla meal could be due to the loss of critical amino acids like lysine during autoclaving.

The effect of enzymes on the utility of squilla meal was also studied by adding bacterial proteases (10,000 units/g) at 0.5, 1.0 and 2.0 g/kg to each of the three diets containing the raw squilla meal.

The addition of bacterial proteases at levels of 0.5 and 1.0 g/kg resulted in a better performance of the birds than those fed fish mixture based ration. However, an increase in the concentration (2.0 g/kg) of enzymes beyond 1.0 g/kg was not able to enhance the performance further.

c) Replacement of fish meal crude protein by squilla meal protein

Mohan (1999) replaced fish meal protein at 0, 25, 50, 75 and 100 per cent level with squilla meal true protein (calculated by substracting chitin nitrogen) in broiler diets and observed no significant difference in weight gain between the different groups fed varying levels of squilla meal protein, the weight gain recorded for the different groups being 1432.9, 1388.9, 1354.1, 1368.9 and 1361.9 g respectively.

d) Effect of squid meal

Hulen *et al.* (1979) in their studies including squid meal in broiler diets at different levels viz., 50, 100 and 150 g/kg as against a control containing fish meal (50 g/kg). Higher body weight was observed in group fed squid meal at 150 g/kg level compared to the other levels. The lowest body weight gain was noticed in group fed the ration without squid meal.

e) Effect of shrimp meal

Rosenfeld *et al.* (1997) substituted soyabean meal crude protein with shrimp meal crude protein at 0, 10, 20, 30 and 40 per cent level in broiler diets. At the end of 49th day they observed no significant difference in the body weight (2325, 2363, 2354, 2314 and 2338 g respectively) as the level of shrimp meal substitution increased from 0 to 40 per cent.

f) Effect of chitin

Nair *et al.* (1987) in their study to evaluate the effect of inclusion of chitin at 0.5 per cent level in commercial broiler ration observed that the weight gain at 25 days of age was significantly higher in chitin fed group. The same trend continued till the 60th day and resulted in 10 per cent extra weight gain over the control birds. Similar results have been reported by the authors in another study incorporating chitin in broiler diets (Nair *et al.*, 1993). They opined that the conversion of chitin to glucosamine by the chitinolytic enzymes in the chicks could have contributed to the better performance of chitin fed groups. Further, it was reported that n-acetyl glucosamine functions as a growth factor when added to baby foods (Kent and

White House, 1955 and Gyorgy *et al.*, 1955). Spreen *et al.* (1984) have reported that chitinous material in the intestinal tract of chicks supported the growth of Bifidobacterium, which is reported to be a beneficial organism.

However, Narahari *et al.* (1991) reported that addition of chitin to broiler diets at 0, 0.2, 0.4 and 0.6 per cent levels resulted in no significant difference in weight gain at the end of 6 weeks.

Razdan and Petterson (1994) also could not observe any significant difference in body weight in broilers at the end of 18 days by supplementing chitin at 3 per cent level.

g) Effect of supplementation of lysine and methionine

Raju *et al.* (1999) in their study to evaluate the effect of supplemental lysine and methionine on soya meal based low protein diets in broilers observed weight gain comparable to that of soya-fish meal based control diets in marginally protein deficient group but significantly lower weight gain in the severely deficient diet. The birds were fed with diets containing protein levels of starter and finisher viz., 23:20, 21:18 and 19:16 with and without supplementation of amino acids (lysine and methionine) in the low protein groups. The weight gain recorded at 49 days of age were 2052, 2006, 1903, 1904 and 1891 g respectively for the different groups.

Rosenfeld *et al.* (1997) substituted soyabean meal crude protein with shrimp meal crude protein at 0,60,80 and 100 per cent level and lysine was supplemented at a level comparable to that of 100 per cent soyabean control diet. There was a significantly higher weight gain in the 100 per cent shrimp meal group compared to the other groups, the weight gains recorded at six weeks being 1939, 2020, 1952 and 2065 g respectively. The authors opined that the better performance was due to the better quality of amino acids in shrimp meal and the synthetic lysine added to compensate the deficiency of lysine when compared to soyabean meal.

2.3.2 Feed intake and feed efficiency

a) Effect of squilla meal

Reddy *et al.* (1997) observed that both feed intake and efficiency of feed utilisation were not significantly influenced by the rate of inclusion of squilla meal replacing fish mixture in broiler diets at 0, 41.7, 83.4, 125.1 and 166.8 g/kg, the feed intake of birds at six weeks fed rations containing different levels being 2905, 3143, 3195, 3079 and 3058 g/bird respectively. Though the live weight indicated a curvilinear trend, a linear decrease in feed efficiency was observed at all levels of inclusion of squilla meal compared to that of control diet, which was attributed to the increasing concentration of chitin with higher levels of squilla meal.

Mohan (1999) in his study to evaluate the effect of squilla meal in broiler diets incorporated at 0, 5, 7.5 and 10 per cent level for six weeks reported a significant reduction in the feed intake of birds at 10 per cent inclusion level. He also reported a higher feed efficiency in zero per cent group (2.12) compared to 5 per cent (2.26), 7.5 per cent (2.37) and 10 per cent (2.45) squilla meal group.

b) Effect of processed squilla meal

Reddy *et al.* (1997) reported that efficiency of feed utilization was lower in birds fed with diets containing raw and autoclaved squilla meals irrespective of the dietary concentration, compared to the control group. They further observed that enzyme supplementation to raw squilla diet at levels of 0.5, 1 and 2 g/kg improved efficiency of feed utilization significantly.

c) Effect of replacement of fish meal protein by squilla meal protein

Mohan (1999) recorded almost similar feed intake and feed efficiency at six weeks in birds fed diets containing squilla meal protein replacing fish meal protein at 0, 25, 50, 75 and 100 per cent levels, the feed intake and feed efficiency being 3271.80, 3196.20, 3268.40, 3260.10, 3126.50 g and 2.28, 2.30, 2.41, 2.38, 2.30 respectively.

d) Effect of squid meal

Hulan *et al.* (1979) included squid meal at 50, 100 and 150 g/kg in broiler diet compared to 50 g fish meal in the control diet for a period of 48 days. They reported a significant linear improvement in feed conversion ratio (2.05, 1.97 and 1.91 vs 2.05) as the level of squid meal in the ration was increased.

e) Effect of shrimp meal

Rosenfeld *et al.* (1997) in their study substituted soyabean meal crude protein with shrimp meal crude protein at 0, 10, 20, 30 and 40 per cent levels in broiler diet and observed that the feed consumption at the end of 49th day was 4783, 5100, 4804, 4816 and 4693 g respectively, the numerical difference in feed intake among the various groups being not statistically significant. The feed efficiency was apparently the highest in 40 per cent group (2.00) followed by zero per cent (2.05), 30 per cent (2.09), 20 per cent (2.10) and 10 per cent (2.12).

f) Effect of chitin

Nair *et al.* (1987) found that addition of 0.5 per cent chitin to commercial broiler diet resulted in higher feed intake compared to that of control group (4200 g vs 4000 g) at the end of 60th day. The feed efficiency was also better (2.38 vs 2.50) due to improved weight gain. Similar results were reported by the same authors in their latter experiment (Nair *et al.*, 1993).

Razdan and Petterson (1994) reported that at the end of 18th day the feed intake and feed efficiency of broiler birds did not vary when 3 per cent chitin was supplemented to a basal diet.

Narahari *et al.* (1991) supplemented chitin at 0, 0.2, 0.4 and 0.6 per cent levels in broiler diet and reported that feed consumption was gradually reduced as the level of chitin supplementation increased. Birds fed diets supplemented with 0.4 per cent and 0.6 per cent chitin had significantly lower feed intake than those fed with zero per cent or 0.2 per cent chitin levels. The reduction in feed intake resulted in a significantly better feed efficiency in 0.4 per cent (3.26) and 0.6 per cent(3.16) groups compared to zero per cent (3.86) and 0.2 per cent (3.78) groups.

g) Effect of supplementation of lysine and methionine

Raju *et al.* (1999) observed no significant effect on feed intake when lysine and methionine were supplemented to low protein broiler diets. The birds were fed diet containing soya-fish meal control and soya meal based low protein diets viz. 23:20, 21:18 and 19:16 with and without supplemental amino acids in the low protein groups for seven weeks. The feed intakeswere 4328, 4293, 4186, 4353 and 4343 g respectively. However, the feed conversion efficiency was significantly higher in the control (2.20) and amino acid supplemented low protein groups (2.24 and 2.30) compared to unsupplemented low protein groups (2.39 and 2.45). The authors opined that lower feed efficiency with the low protein groups was due to the imbalance between essential and nonessential amino acids.

Rosenfeld *et al.* (1997) substituted soyabean meal crude protein with shrimp meal crude protein at 0, 60, 80 and 100 per cent levels and lysine was supplemented at a level comparable to that of 100 per cent soyabean control diet.

The feed intake upto 42 days of age was 3767, 3727, 3717 and 3815 g respectively and did not significantly differ between the groups. But the feed efficiency was better in birds fed diets with shrimp meal included at levels of 60 per cent (1.84) followed by 100 per cent (1.85) and 80 per cent (1.90) levels when compared to zero per cent group (1.97). The authors opined that the better performance was due to the better quality of amino acids in shrimp meal and the synthetic lysine added to compensate the deficiency when compared to soyabean meal.

2.4 Slaughter studies and gut morphology

2.4.1 Dressing percentage

Reddy *et al.* (1997) in their study to evaluate the effect of squilla meal inclusion in the diet of broiler chicken by replacing fish mixture at levels of 0, 41.7, 83.4, 125.1, 166.8 g/kg observed no significant difference in the dressing percentage of birds fed the different diets.

Mohan (1999) recorded a significantly higher dressing percentage in birds fed diet containing 5 per cent squilla meal (69.55%) compared to 10 per cent (66.12%) squilla meal. The author opined that the reduced dressing percentage in birds fed 10 per cent squilla meal diet may be due to increased weight of feathers (3.99 g % Vs 5.66 g %) compared to control birds. However, in another trial when squilla meal protein replaced fish meal protein he could not observe any significant difference in the dressing percentage.

2.4.2 Length of intestine

Reddy *et al.* (1997) in their study reported a linear increase in the length of intestines (duodenum, jejunum, ileum and caeca) as the dietary level of squilla meal was increased. Regression analysis indicated a significant linear effect for caecal length and duodenal length. Further histological studies revealed a slight increase in the number of goblet cells and thickening in the intestinal mucosa in all the test groups.

2.4.3 Abdominal fat

Zikakis *et al.* (1982) evaluated the effect of inclusion of 20 per cent whey along with or without 2 per cent chitin in commercial broiler diets. They reported that the abdominal fat pad in birds was smaller when 2 per cent chitin was supplemented to a 20 per cent whey diet. The same finding was confirmed by them in a second experiment, where birds fed with 20 per cent whey with 2 per cent chitin produced significantly less abdominal fat without reduction in body weight in comparison to chicken raised on commercial broiler ration.

2.4.4 Organoleptic studies

Mohan (1999) while evaluating the effect of inclusion of squilla meal on the taste of broiler chicken meat reported a reduction in consumer preference as the level of squilla meal increased in the diet. However, in another trial he observed similar acceptability when fish meal protein was replaced with squilla meal protein at 0, 5, 7.5 and 10 per cent levels.

2.5 Livability

Studies carried out in broiler chicken to evaluate the effect of incorporation of squilla meal replacing fish meal over a period of six weeks by Mohan (1999) revealed 4.4 per cent mortality. However, no specific lesion was observed by him on post-mortem of the birds.

2.6 Ration digestibility

2.6.1 Moisture content in faeces

Mohan (1999) reported a significantly lower moisture content in faeces of chicken fed squilla meal at 10 per cent level compared to those fed at 7.5 per cent and zero per cent level replacing fish meal. He opined that chitin did not increase the moisture content of the faeces, instead reduced the moisture content significantly at higher levels of inclusion.

However, the same worker (Mohan, 1999) in another trial to evaluate the effect of squilla meal protein replacing fish meal protein reported a significantly higher moisture content in the faeces of all birds fed squilla meal protein compared to the control group fed fish meal protein.

2.6.2 Dry matter digestibility

A significantly lower dry matter digestibility was observed by Mohan (1999) in birds fed squilla meal at 10 per cent level compared to zero per cent level. However, the same worker in another trial where the squilla meal protein replaced fish meal protein at 0, 25, 50, 75 and 100 per cent level, could notice no significant difference in the dry matter digestibility though there was a marginal reduction in the dry matter digestibility as the level of squilla meal protein increased.

2.6.3 Crude protein digestibility

Mohan (1999) reported a crude protein digestibility of 66.74, 68.19, 60.54 and 64.20 per cent when squilla meal was included in the rations of broilers at 0, 5, 7.5 and 10 per cent level respectively replacing fish meal. The crude protein digestibility was found to be significantly higher in control group and 5 per cent squilla meal group compared to 7.5 per cent group. But crude protein digestibility in birds fed 10 per cent squilla meal did not differ significantly when compared with the other groups. However, no significant difference was recorded by the same worker in the crude protein digestibility between the various groups of birds fed diets in which squilla meal protein replaced fish meal protein at various levels.

2.6.4 Ration metabolisability

Mohan (1999) reported no significant difference in the metabolisability of the rations when squilla meal and squilla meal protein replaced fish meal and fish meal protein respectively, in his study to evaluate the effect of squilla meal in broiler chicken diets.

2.7 Cost effectiveness

2.7.1 Effect of chitin

Supplementation of broiler diets with chitin at 0, 0.2, 0.4 and 0.6 per cent levels eventhough increased the cost per kg of feed, the feed cost per kg body weight diminished with increase in the dietary chitin level due to improved feed efficiency (Narahari *et al.*, 1991). The authors observed that feeding diets having 0.4 and 0.6 per cent levels of chitin resulted in 12.6 and 13.9 per cent net savings in the feed cost to produce one kg live body weight, when compared to the control. The broiler farm economy index also suggested better economy in favour of 0.4 and 0.6 per cent dietary chitin levels (0.453 and 0.498) as against 0.2 per cent chitin and the control without chitin (0.390 and 0.387).

Similar results were also observed by Nair *et al.* (1993) who supplemented 0.5 per cent chitin to broiler feed and found that the profit per bird doubled when compared to the control birds (Rs.3.27 Vs 1.46).

2.7.2 Effect of squilla meal

Mohan (1999) in his study to evaluate squilla meal replacing fish meal reported a loss of 48, 98 and 128 paise to produce 1 kg live weight gain in broilers fed diets with 5, 7.5 and 10 per cent squilla meal respectively inspite of the lower feed cost with squilla meal ration. The reason attributed to the loss is due to the decreased feed efficiency recorded as the level of squilla meal increased in the ration.

The same author also reported a higher expenditure in birds fed diets in which squilla meal protein replaced fish meal protein, the expenditure on feed to produce one kg weight gain in broilers being higher by 11, 85, 71 and 19 paise in birds fed diets with 25, 50, 75 and 100 per cent squilla meal protein compared to those on control ration.

2.7.3 Effect of supplementation of lysine and methionine

Raju *et al.* (1999) in their study to evaluate the effect of supplemental amino acids on low protein diets observed that the cost per kg of live weight was lowest in birds fed on low protein diets (Rs.12.50 and 12.24) compared to control (Rs.14.23) and amino acid supplemented low protein diets (Rs.14.65 and 15.47). They opined that increase in the level of crude protein in the diets and supplementation of amino acid to the feed added to the cost of diets with no proportionate increase in the performance of birds and favoured low protein diets without supplementation of amino acids as a viable proposition in broilers for the present.

MATERIALS AND METHODS

MATERIALS AND METHODS

An experiment was conducted in the Department of Animal Nutrition, College of Veterinary and Animal Sciences, Mannuthy to evaluate the feeding value of squilla meal as an animal protein source replacing unsalted dried fish in the broiler chicken diets.

3.1 Experimental materials

3.1.1 Experimental birds

One hundred and eighty, day-old straight-run-broiler chicks (Varna) procured from the revolving fund hatchery of the Centre for Advanced Studies in Poultry Science, Kerala Agricultural University, Mannuthy formed the experimental subjects.

3.1.2 Rations

Squilla meal and soya meal required for the study were procured from the market. The other feed ingredients were procured from the University Poultry Farm, Mannuthy.

Four experimental rations were formulated as per BIS (1992), viz.

1) control containing 10 per cent unsalted dried fish (T_1)
2) T_1 in which 50 per cent crude protein from dried fish is replaced with squilla meal crude protein (T_2)
3) T_1 in which 100 per cent crude protein from dried fish is replaced with squilla meal crude protein (T_3)
4) T_3 supplemented with adequate lysine and methionine to balance the levels of these amino acids as per BIS specifications.

All the rations were made iso-proteimic and iso-caloric. The ingredient composition and the chemical composition of the four different starter and finisher rations are presented in Table 1, 2, 3 and 4 respectively. Broiler starter diets were fed upto six weeks of age and then switched over to broiler finisher diets till the end of eight weeks.

3.1.3 Chemical analysis

The chemical composition of squilla meal and the different experimental rations were estimated as per the procedures described in AOAC (1990).

3.1.3.1 Chitin content

Chitin content in squilla meal was estimated as per the procedure of Madhavan *et al.* (1986).

Deproteinization: Two grams of finely ground squilla meal was mixed with 100 ml of 3 per cent sodium hydroxide solution and was boiled for 10 min. The solution was cooled and filtered. The residue was made free of alkali after washing with distilled water.

Demineralisation: This procedure was performed to remove the calcium carbonate. The residue was treated with 100 ml of 4 per cent hydrochloric acid for 2 h. at room temperature. Later the clear solution was filtered and the residue was washed free of chlorides and then was rinsed with alcohol and dried at 100°C for 2 h. The final residue obtained was chitin.

3.2 Experimental methods

3.2.1 Housing of birds

The experimental house, feeders, waterers and other equipment were cleaned thoroughly and disinfected one week before the chicks were housed. The straight-run day-old chicks procured for the experiment were weighed individually, vaccinated against Ranikhet and wing banded before housing. The experimental birds were housed in the deep litter system. The birds in each replicate were housed in individual pens.

3.2.2 Experimental design

The chicks were randomly divided into twelve groups of fifteen chicks each. The groups were allotted randomly to four treatments viz. T_1, T_2, T_3 and T_4 with three replicates in each treatment. The details of treatments are presented in Table 5.

3.2.3 Management

Feed and water were provided *ad libitum* throughout the experiment and the litter material was added regularly to keep it dry. Standard managemental procedures were adopted during the entire experimental period. Duration of experiment was eight weeks.

3.2.4 Body weight

The body weight of individual birds was recorded at fortnightly intervals from day old to study the pattern of body weight gain under different feeding regimes.

3.2.5 Feed consumption

Feed intake of the birds was recorded replicate-wise at the end of each week. From this data the average feed intake per day was calculated for various treatment groups.

3.2.6 Feed efficiency

Feed conversion efficiency (kg of feed/kg body weight) was calculated based on the data on body weight and feed intake.

3.2.7 Metabolism trial

Towards the end of the experiment a three day metabolism trial was conducted using six birds selected randomly from each treatment group for both starter and finisher ration. During the trial period, measured quantity of feed was offered on an *ad libitum* basis and the intake was recorded. Water was provided *ad libitum*. The total excreta voided by each bird was collected daily and was stored in air tight containers in a deep freezer for analysis.

3.2.8 Slaughter studies

At the end of the experiment, one male and one female bird from each replicate were randomly selected and sacrificed to study the processing yields and losses as per the procedure described by BIS (1973). Percentages of dressed yield, giblet yield, abdominal fat yield and ready to cook yield were calculated from the data.

3.2.9 Duodenal length

During the slaughter studies, the duodenal length of the birds was recorded (cm).

3.2.10 Livability

The mortality of birds from different treatment groups was recorded and post-mortem was conducted to assess the cause of death.

3.2.11 Chemical analysis

The chemical composition of excreta collected during the metabolism trial was estimated as per the procedures described in AOAC (1990). The content of nitrogen of the excreta was determined in fresh material.

3.2.12 Metabolisable energy

The gross energy in feed and excreta samples were estimated using an adiabatic digital bomb calorimeter. From the values the apparent metabolisable energy of different rations were calculated.

3.2.13 Cost-benefit analysis

The cost benefit analysis was worked out from the cost of feed, live weight produced and the quantity of feed consumed by birds in each treatment group.

3.2.14 Statistical analysis

Data collected on various parameters were statistically analysed as per the methods described by Snedecor and Cochran (1980).

Table 1. Percentage ingredient composition of starter rations

Ingredient	Inclusion level			
	T_1	T_2	T_3	T_4
Dried fish*	10.00	5.0	-	-
Squilla meal		5.0	10.0	10.0
Soya meal	12.0	12.0	12.0	12.0
Groundnut cake	9.0	9.0	9.0	9.0
Gingelly oil cake	18.0	18.0	19.0	19.0
Yellow maize	40.0	42.0	44.0	44.0
Wheat bran	10.0	8.0	5.0	5.0
Mineral mixture[1]	1.0	1.0	1.0	1.0
Added per 100kg of feed				
Lysine (g)	-	-	-	310.0
Methionine (g)	-	-	-	92.0
Choline chloride (g)	50	50	50	50
Vitamin mixture[2] (g)	10	10	10	10
Coccidiostat[3] (g)	50	50	50	50
Toxin binder[4] (g)	300	300	300	300
Salt (g)	250	250	250	250

* Fish [illegible] contained crude protein similar to that of squilla meal

1 Composition of Keyes mineral mixture for poultry: Moisture 3%, Calcium 32%, Phosphorus 6%, Manganese 0.27%, Iodine 0.01%, Zinc 0.26%, Copper (ppm) 100, Iron (ppm) 1000, Fluorine (max) 0.03%.

2 Composition of Vitamin (INDOMIX) mixture
Each gram contains: Vitamin A 82,500 IU, Vitamin B_2 50mg, Vitamin D_3 12,000 IU and Vitamin K 10mg.

3 Composition of coccidiostat (DOT)
Each gram contains:Dinitrotoluamide 250mg

4 Composition of toxin binder (ULTRASIL)
Blend of alumino silicates a derivative of natural zeolites with organic acids like propionic, acetic, 2,4 hexadienoic benzene carboxylic acid, isobutyric acid together with gentian violet and 1,2 dihydroxy propane.

Table 2. Percentage ingredient composition of finisher rations

Ingredients	Inclusion level			
	T_1	T_2	T_3	T_4
Dried fish*	10.00	5.0	-	-
Squilla meal	-	5.0	10.0	10.0
Soya meal	12.0	12.0	12.0	12.0
Groundnut cake	5.0	4.0	5.0	5.0
Gingelly oil cake	11.0	13.0	12.0	12.0
Yellow maize	43.0	43.0	40.0	40.0
Rice polish	12.0	14.0	20.0	20.0
Wheat bran	6.0	3.0	-	-
Mineral mixture[1]	1.0	1.0	1.0	1.0
Added per 100 kg of feed				
Lysine (g)	-	-	-	293.0
Methionine (g)	-	-	-	84.0
Choline chloride (g)	50	50	50	50
Vitamin mixture[2] (g)	10	10	10	10
Coccidiostat[3] (g)	50	50	50	50
Toxin binder[4] (g)	300	300	300	300
Salt (g)	250	250	250	250

* Fish meal contained crude protein similar to that of squilla meal

1 Composition of Keyes mineral mixture for poultry: Moisture 3%, Calcium 32%, Phosphorus 6%, Manganese 0.27%, Iodine 0.01%, Zinc 0.26%, Copper (ppm) 100, Iron (ppm) 1000, Fluorine (max) 0.03%.

2 Composition of Vitamin (INDOMIX) mixture
Each gram contains: Vitamin A 82,500 IU, Vitamin B_2 50mg, Vitamin D_3 12,000 IU and Vitamin K 10mg.

3 Composition of coccidiostat (DOT)
Each gram contains Dinitrotoluamide 250mg

4 Composition of toxin binder (ULTRASIL)
Blend of alumino silicates a derivative of natural zeolites with organic acids like propionic, acetic, 2,4 hexadienoic benzene carboxylic acid, isobutyric acid together with gentian violet and 1,2 dihydroxy propane.

Table 3. Percentage chemical composition of starter diets (on dry matter basis)*

Nutrient	T_1	T_2	T_3	T_4
Moisture	11.00±0.07	10.90±0.06	10.40±0.15	10.30±0.11
Crude protein	23.10±0.19	23.10±0.13	23.10±0.12	23.00±0.12
Crude fibre	4.50±0.08	5.10±0.16	5.80±0.15	4.90±0.41
Ether extract	5.10±0.46	5.50±0.21	5.20±0.41	5.10±0.21
NFE	54.00±0.66	53.00±0.34	54.00±0.28	54.90±0.29
Total ash	13.30±0.18	13.30±0.20	11.90±0.13	12.10±0.09
Acid insoluble ash	2.60±0.04	2.90±0.20	2.20±0.02	2.10±0.05
Calcium	2.23±0.02	2.25±0.19	2.20±0.13	2.30±0.16
Phosphorus	0.83±0.02	0.81±0.01	0.81±0.02	0.80±0.02
Calculated chemical composition				
Crude protein	23.07	22.97	23.05	23.05
ME Kcal/kg	2808.00	2797.00	2804.00	2804.00
Lysine	1.173	1.016	0.863	1.173
Methionine	0.574	0.522	0.482	0.574

* Average of six values

Table 4. Percentage chemical composition of finisher diets (on dry matter basis)*

Nutrient	T_1	T_2	T_3	T_4
Moisture	10.80±0.07	10.00±0.13	10.70±0.21	10.20±0.07
Crude protein	20.00±0.08	20.00±0.19	20.20±0.21	20.10±0.24
Crude fibre	6.00±0.12	6.10±0.14	5.90±0.17	6.00±0.13
Ether extract	5.20±0.26	5.60±0.32	5.40±0.51	5.80±0.35
NFE	54.90±0.62	54.60±0.51	55.40±0.80	55.00±0.44
Total ash	13.90±0.15	13.70±0.20	13.10±0.18	13.10±0.28
Acid insoluble ash	2.70±0.05	2.70±0.07	2.70±0.03	2.50±0.08
Calcium	2.00±0.11	2.26±0.08	2.33±0.09	2.21±0.10
Phosphorus	0.89±0.01	0.86±0.01	0.90±0.00	0.91±0.02
Calculated chemical composition				
Crude protein	20.02	20.01	20.03	20.03
ME Kcal/kg	2908.00	2910.00	2902.00	2902.00
Lysine	1.077	0.931	0.784	1.077
Methionine	0.495	0.464	0.411	0.495

* Average of six values

Table 5. Distribution of dietary treatments

Dietary treatment	No. of replicate	No. of birds	Rations	Amino acid supplementation level (%)			
				Starter		Finisher	
				Lysine	Methionine	Lysine	Methionine
T_1	3	45	Broiler diets with 10 per cent dried fish	-	-	-	-
T_2	3	45	Broiler diets with 50 per cent crude protein from dried fish replaced with squilla meal protein	-	-	-	-
T_3	3	45	Broiler diets with 100 per cent crude protein from dried fish replaced with squilla meal crude protein	-	-	-	-
T_4	3	45	T_3 supplemented with adequate lysine and methionine as per BIS (1992)	0.310	0.092	0.293	0.084

RESULTS

RESULTS

The effect of replacement of fish meal with squilla meal as an animal protein source on the performance of broiler chickens was assessed by conducting a feeding trial and the results obtained are presented in this chapter.

4.1 Proximate composition of squilla meal

Data on chemical composition of squilla meal utilized for the experiment are presented in Table 6.

4.2 Body weight

The results on the mean values of body weight of birds as influenced by treatments T_1, T_2, T_3 and T_4 at fortnightly intervals are presented in Table 7, their statistical analysis in Table 8 and graphically represented in Fig.1.

4.3 Body weight gain

The data on mean fortnightly body weight gain and cumulative weight gain of birds maintained on different dietary treatments are presented in Table 9 and the statistical analysis in Tables 10 and 11. The weight gains are graphically represented in Fig.2 and 3.

4.4 Feed consumption

The mean daily feed intake of the birds are presented in Table 12 and the statistical analysis is given in Table 13.

Data on mean fortnightly and cumulative feed intake of the birds during the eight week period in the different treatment groups are set out in Table 14.

Tables 15 and 16 give statistical analysis of the same and Fig.4 and 5 their graphic representation.

4.5 Feed conversion efficiency

The data on fortnightly feed conversion efficiency and cumulative feed conversion efficiency of birds at sixth and eighth weeks of age in the different dietary treatment groups are set out in Table 17 and their statistical analysis in Tables 18 and 19. The results are graphically represented in Fig.6 and 7.

4.6 Protein intake and protein efficiency ratio

Tables 20 and 22 present the data on protein intake and protein efficiency ratio respectively and their statistical analysis are charted out in Tables 21 and 23. Figures 8 and 9 represent the same graphically.

4.7 Slaughter studies

The results of processing yield and length of duodenum of birds slaughtered from the different groups are presented in Table 24 and their statistical analysis in Table 25. The same is graphically represented in Fig.10 and 11.

4.8 Metabolism trial

The data on faecal moisture content and apparent metabolisable energy value of different diets and the daily protein retention of birds in the different groups are presented in Table 26 and their statistical analysis in Table 27. Figures 12 and 13 graphically represent the same.

4.9 Livability

The total number of birds died during the experimental period was three, one each from group T_1, T_2 and T_4. The livability percentage for different treatment groups were 97.8, 97.8, 100 and 97.8 for T_1, T_2, T_3 and T_4 respectively.

4.10 Economics of gain

Data on the cost of production (Rs) per kg live weight gain of birds maintained on the four dietary treatments T_1, T_2, T_3 and T_4 are charted out in Table 28. Their statistical analysis is presented in Table 29 and graphic representation in Fig.14.

Table 6. Percentage chemical composition of squilla meal (on dry matter basis)*

Nutrient	
Moisture	9.60±0.07
Crude protein	34.10±1.11
Crude fibre	12.1±0.21
Ether extract	1.60±0.04
NFE	13.80±1.18
Total ash	38.40±0.28
Acid insoluble ash	7.00±0.17
Calcium	7.40±0.20
Phosphorus	1.73±0.02
Chitin	9.97±0.10

*Average of six values

Table 7. Body weight (g) of birds fed different dietary levels of squilla meal at fortnightly intervals

Treatment		Age in weeks				
		0	2	4	6	8
	R_1	42.50	235.70	702.70	1290.70	1836.70
T_1	R_2	42.60	221.00	699.20	1270.00	1788.00
	R_3	42.80	219.20	696.90	1300.00	1828.70
Mean		42.60	225.30^{a}	699.60^{a}	1286.90^{a}	1817.80^{a}
±SE		0.13	6.57	13.24	20.19	33.38
	R_1	42.80	233.50	680.90	1262.00	1749.30
T_2	R_2	42.70	217.20	652.00	1248.00	1794.00
	R_3	42.90	237.50	699.30	1294.70	1812.70
Mean		42.80	229.40^{a}	677.40^{ab}	1268.20^{ab}	1785.30^{ab}
±SE		0.21	5.40	13.22	21.06	33.88
	R_1	42.90	182.50	563.40	1112.00	1664.70
T_3	R_2	41.80	211.90	635.50	1191.30	1629.30
	R_3	42.30	221.00	643.00	1206.70	1674.00
Mean		42.30	205.10^{b}	614.00^{c}	1170.00^{c}	1656.00^{c}
±SE		0.22	5.56	14.53	24.98	27.83
	R_1	42.40	228.20	665.70	1208.70	1691.30
T_4	R_2	42.10	227.10	645.70	1200.00	1726.00
	R_3	42.70	228.70	646.20	1225.30	1728.00
Mean		42.40	228.00^{a}	652.50^{b}	1211.30^{bc}	1715.10^{bc}
±SE		0.22	4.80	12.66	19.42	28.01
CD		-	15.69	37.47	60.08	86.30

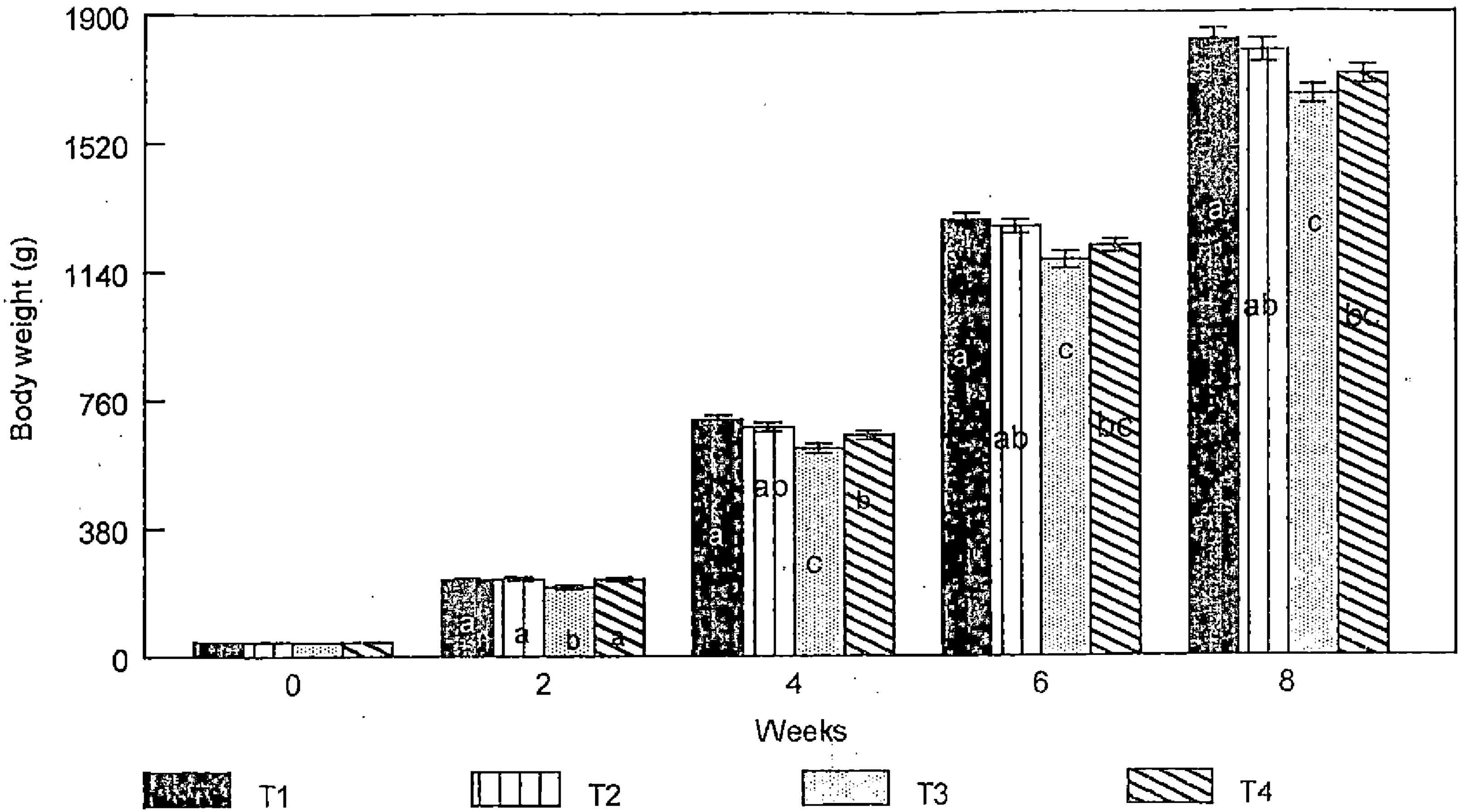
Means bearing different superscript within the same column differ significantly ($P < 0.01$)

Table 8. Body weight (g) of birds fed different dietary levels of squilla meal at fortnightly intervals - ANOVA

Week	Source	d.f	SS	MSS	F value
	Treatment	3	6.26	2.09	1.145^{NS}
0	Error	176	320.43	1.82	
	Total	179	326.69		
	Treatment	3	17384.51	5794.84	4.077**
2	Error	176	250148.22	1421.30	
	Total	179	267532.73		
	Treatment	3	182000.42	60666.81	7.482**
4	Error	176	1427026.89	8108.11	
	Total	179	1609027.31		
	Treatment	3	386015.56	128671.85	6.172**
6	Error	176	3669092.22	20847.12	
	Total	179	4055107.78		
	Treatment	3	707822.22	235940.74	5.485**
8	Error	176	7570102.22	43011.94	
	Total	179	8277924.44		

** Significant (P<0.01)
NS - Not significant

Fig.1 Body weight (g) of birds maintained on different dietary treatments



a,b,c means with different letters differ (P < 0.01)

Table 9. Fortnightly and cumlative body weight gain (g) of birds fed different dietary levels of squilla meal

Treatment		Age in weeks				Cumulative body weight gain (g)	
		1-2	3-4	5-6	7-8	Sixth week	Eighth week
	R_1	193.2	467.0	588.0	546.0	1248.2	1794.2
T_1	R_2	178.4	478.2	570.8	518.0	1227.4	1745.2
	R_3	176.4	477.7	603.1	528.7	1257.2	1785.9
Mean		182.7^a	474.3^a	587.3	530.9	1244.3^a	1775.2^a
± SE		6.54	8.20	11.37	17.43	20.15	33.35
	R_1	190.7	447.5	581.1	487.3	1219.2	1706.5
T_2	R_2	174.5	434.8	596.0	546.0	1205.3	1751.3
	R_3	194.7	461.8	595.3	518.0	1251.8	1769.8
Mean		186.6^a	448.0^{ab}	590.8	517.11	1225.4^{ab}	1742.5^{ab}
± SE		5.36	9.46	12.55	17.45	21.00	30.87
	R_1	139.6	380.9	548.6	552.7	1069.1	1621.8
T_3	R_2	170.2	423.5	555.9	438.0	1149.6	1587.6
	R_3	178.7	422.0	563.7	467.3	1164.4	1631.7
Mean		162.8^b	408.8^c	556.0	486.0	1127.7^c	1613.7^c
± SE		5.54	10.50	12.65	12.73	24.94	27.75
	R_1	185.8	437.5	543.0	482.7	1166.3	1649.0
T_4	R_2	185.0	418.6	554.3	526.0	1157.9	1683.9
	R_3	186.0	417.5	579.1	502.7	1182.6	1685.3
Mean		185.6^a	424.5^{bc}	558.8	503.8	1168.9^{bc}	1672.7^{bc}
± SE		4.79	9.67	12.6	14.64	19.40	27.98
CD		15.61	26.50	-	-	59.96	86.16

Means bearing different superscript within the same column differ significantly ($P < 0.01$)

Table 10. Fortnightly body weight gain (g) of birds fed different dietary levels of squilla meal - ANOVA

Week	Source	d.f	SS	MSS	F value
	Treatment	3	16924.9	5641.64	4.007**
1-2	Error	176	247800.0	1407.96	
	Total	179	264724.9		
	Treatment	3	110199.3	36733.10	9.055**
3-4	Error	176	713976.4	4056.68	
	Total	179	824175.8		
	Treatment	3	45446.6	15148.88	2.223[NS]
5-6	Error	176	1199347.6	6814.48	
	Total	179	1244794.2		
	Treatment	3	49517.8	16505.93	1.490[NS]
7-8	Error	176	1950176.7	11080.55	
	Total	179	1999694.4		

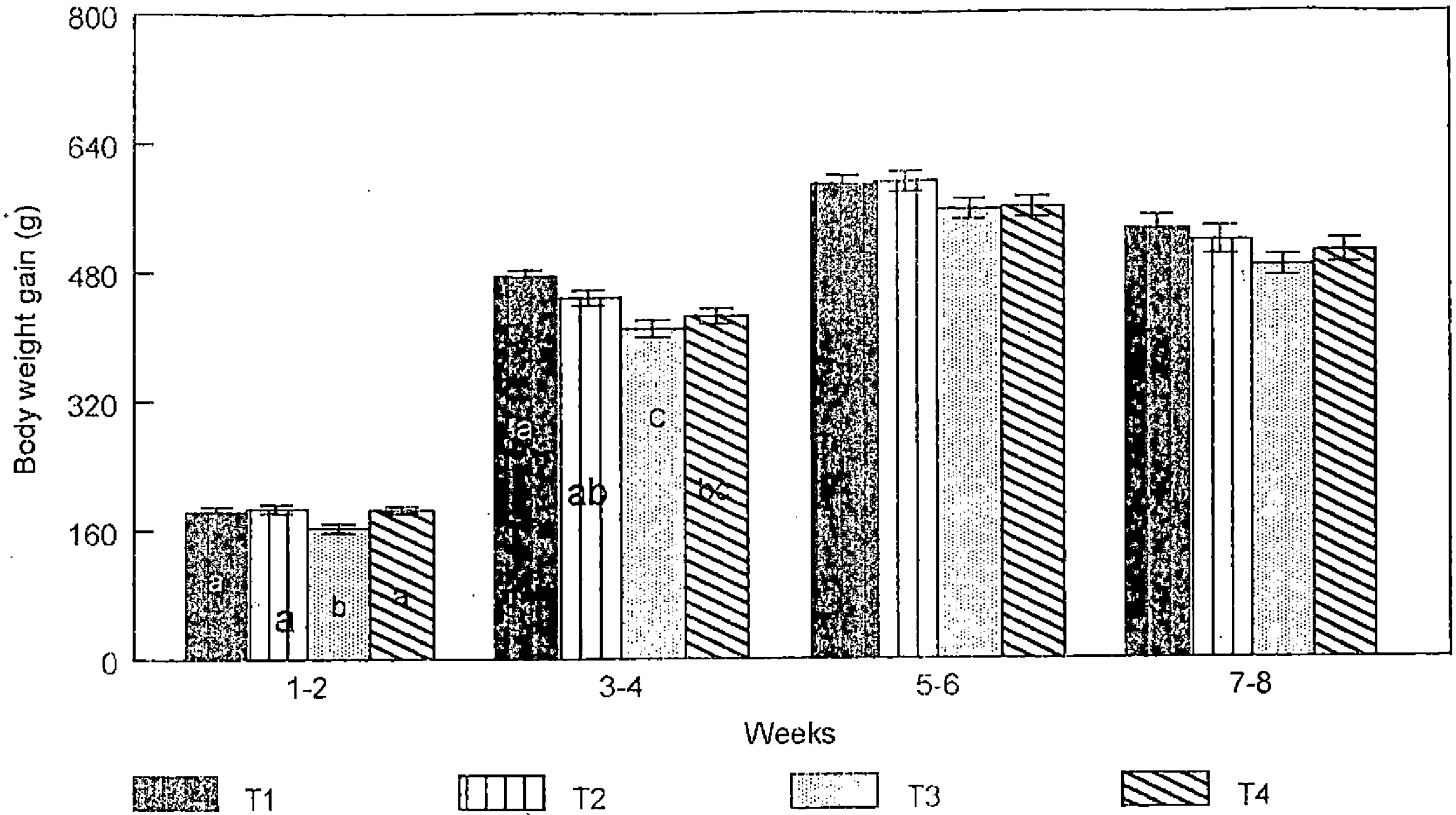
** Significant (P<0.01)
NS - Not significant

Table 11. Cumulative body weight gain (g) of birds fed different dietary levels of squilla meal - ANOVA

Week	Source	d.f	SS	MSS	F value
	Treatment	3	383262.6	127754.18	6.151**
6	Error	176	3655754.7	20771.33	
	Total	179	4039017.2		
	Treatment	3	704183.6	234727.87	5.474**
8	Error	176	7547504.7	42883.55	
	Total	179	8251688.3		

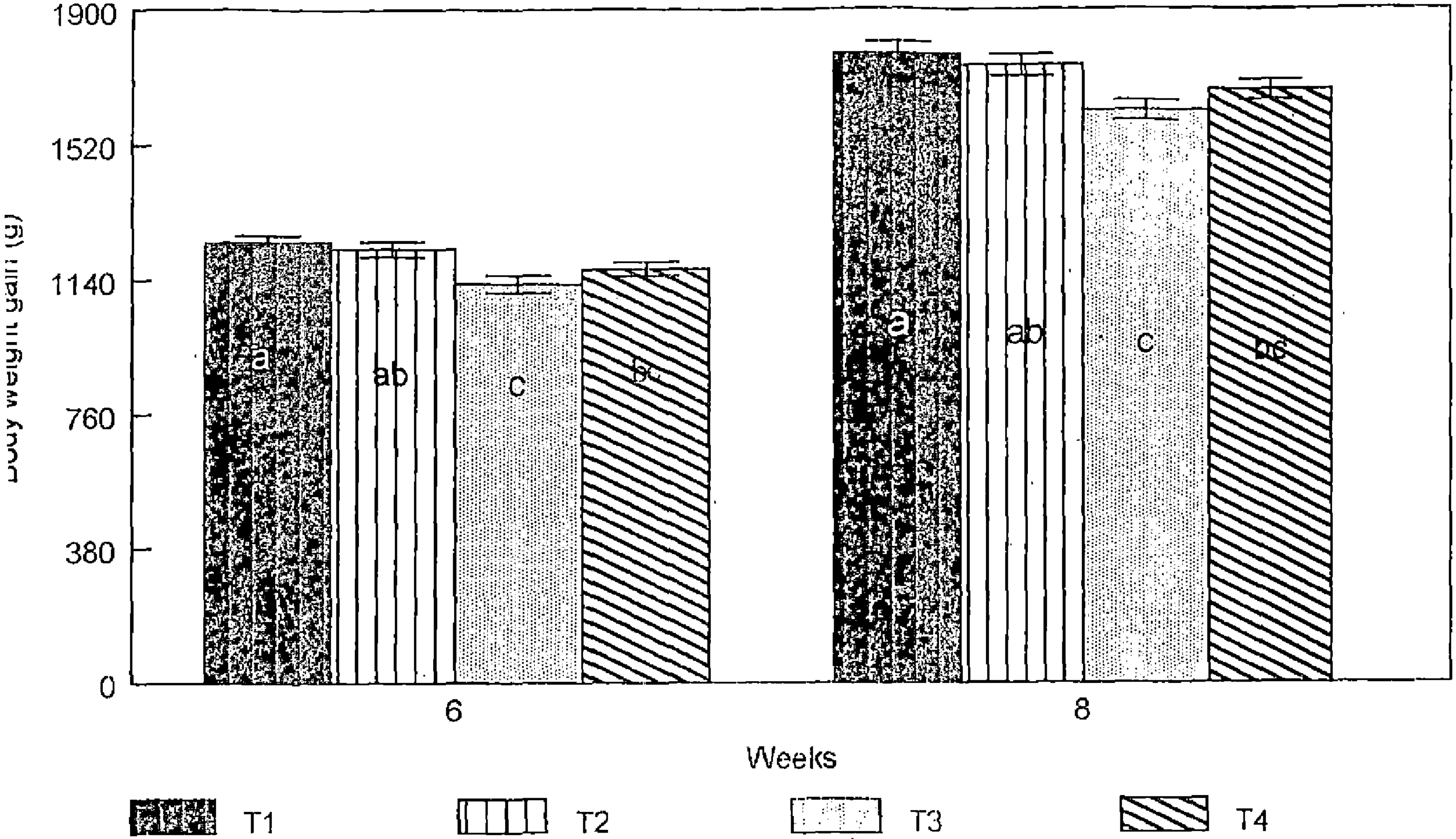
** Significant (P<0.01)

Fig. 2. Fortnightly body weight gain (g) of birds maintained on different dietary treatments



a,b,c means with different letters differ (P<0.01)

Fig. 3. Cumulative body weight gain (g) of birds maintained on different dietary treatments



a,b,c means with different letters differ (P <0.01)

Table 12. Mean daily feed intake (g) of birds fed different dietary levels of squilla meal

Treatment		Age in weeks 1	2	3	4	5	6	7	8
T_1	R_1	16.19	39.05	70.48	91.43	97.14	109.52	132.38	141.90
	R_2	15.24	37.14	69.52	95.24	104.76	109.52	118.10	125.71
	R_3	15.24	37.14	73.33	96.19	104.76	116.19	125.71	131.43
Mean		15.56	37.78	71.11	94.29	102.22	111.74	125.40	133.01
± SE		0.32	0.63	1.14	1.45	2.54	2.22	4.13	4.74
T_2	R_1	16.19	40.95	70.48	92.38	102.86	109.52	115.24	122.85
	R_2	14.29	38.10	66.67	94.29	102.86	117.14	118.10	139.05
	R_3	18.10	38.10	72.38	94.29	106.67	120.95	123.81	129.52
Mean		16.19	39.05	69.84	93.65	104.13	115.87	119.05	130.47
± SE		1.10	0.95	1.68	0.64	1.27	3.36	2.52	4.70
T_3	R_1	15.27	38.10	67.62	92.38	106.67	114.29	120.95	130.48
	R_2	17.14	37.14	72.38	95.27	97.14	109.52	112.38	121.90
	R_3	24.76	38.10	66.67	92.38	99.05	110.48	119.05	127.62
Mean		19.05	37.78	68.89	93.33	100.95	111.43	117.46	126.67
± SE		2.91	0.32	1.77	0.95	2.91	1.45	2.60	2.52
T_4	R_1	16.19	37.14	67.62	94.29	102.86	114.29	114.29	119.05
	R_2	17.14	38.10	77.14	96.19	97.14	101.90	121.90	127.62
	R_3	19.04	40.95	73.33	92.38	98.10	106.67	116.19	128.57
Mean		17.46	38.73	72.70	94.29	99.37	107.62	117.46	125.08
± SE		0.85	1.14	2.77	1.10	1.77	3.61	2.29	3.03
Statistical significance		NS	NS	NS	NS	NS	NS	NS	NS

NS - Not significant (P >0.05)

Table 13. Mean daily feed intake (g) of birds fed different dietary levels of squilla meal - ANOVA

Week	Source	d.f	SS	MSS	F value
	Treatment	3	21.35	7.12	0.906^{NS}
1	Error	8	62.84	7.86	
	Total	11	84.19		
	Treatment	3	3.86	1.29	0.631^{NS}
2	Error	8	16.32	2.04	
	Total	11	20.18		
	Treatment	3	24.44	8.15	0.729^{NS}
3	Error	8	89.40	11.18	
	Total	11	113.85		
	Treatment	3	2.04	0.68	0.196^{NS}
4	Error	8	27.84	3.48	
	Total	11	29.88		
	Treatment	3	36.52	12.17	0.825^{NS}
5	Error	8	118.00	14.75	
	Total	11	154.52		
	Treatment	3	102.32	34.11	1.449^{NS}
6	Error	8	188.24	23.53	
	Total	11	290.56		
	Treatment	3	128.49	42.83	1.616^{NS}
7	Error	8	212.07	26.51	
	Total	11	340.56		
	Treatment	3	116.82	38.94	0.864^{NS}
8	Error	8	360.57	45.07	
	Total	11	477.39		

NS - Not significant

Table 14. Fortnightly and cumulative feed intake (g) of birds fed different dietary levels of squilla meal

Treatment		Age in weeks				Cumulative intake (g)	
		1-2	3-4	5-6	7-8	Sixth week	Eighth week
	R_1	386.7	1133.3	1446.7	1920.0	2966.7	4886.7
T_1	R_2	366.7	1153.3	1500.0	1706.7	3020.0	4726.7
	R_3	366.7	1186.7	1546.7	1800.0	3100.0	4900.0
Mean		373.3	1157.8	1497.8	1808.9	3028.9	4837.8
±SE		6.67	15.55	28.89	61.74	38.75	55.68
	R_1	400.0	1140.0	1486.7	1666.7	3026.7	4693.3
T_2	R_2	366.7	1126.7	1540.0	1800.0	3033.3	4833.3
	R_3	393.3	1166.7	1593.3	1773.3	3153.3	4926.7
Mean		386.7	1144.4	1540.0	1746.7	3071.1	4817.8
±SE		10.18	11.76	30.79	40.74	41.15	67.81
	R_1	373.3	1120.0	1546.7	1760.0	3040.0	4800.0
T_3	R_2	380.0	1173.3	1446.7	1640.0	3000.0	4640.0
	R_3	440.0	1113.3	1466.7	1726.7	3020.0	4647.7
Mean		397.8	1135.6	1486.7	1708.89	3020.0	4728.9
±SE		21.2	18.99	30.55	35.76	11.55	47.04
	R_1	373.3	1133.3	1520.0	1633.3	3026.7	4660.0
T_4	R_2	386.7	1213.3	1393.0	1747.0	2993.0	4740.0
	R_3	420.0	1160.0	1433.0	1713.3	3013.3	4726.7
Mean		393.3	1168.9	1448.7	1697.9	3011.0	4708.9
±SE		13.88	23.52	37.49	33.71	9.79	24.75
Statistical significance		NS	NS	NS	NS	NS	NS

NS - Not significant (P >0.05)

Table 15. Fortnightly feed intake (g) of birds fed different dietary levels of squilla meal - ANOVA

Week	Source	d.f	SS	MSS	F value
1-2	Treatment	3	1021.87	340.62	0.575[NS]
	Error	8	4740.82	592.60	
	Total	11	5762.69		
3-4	Treatment	3	1937.25	645.75	0.666[NS]
	Error	8	7762.28	970.29	
	Total	11	9699.53		
5-6	Treatment	3	12711.15	4237.05	1.371[NS]
	Error	8	24728.23	3091.03	
	Total	11	37439.38		
7-8	Treatment	3	22590.00	7530.00	1.273[NS]
	Error	8	47323.04	5915.38	
	Total	11	69913.04		

NS - Not significant

Table 16. Cumulative feed intake (g) of birds fed different dietary levels of squilla meal - ANOVA

Week	Source	d.f	SS	MSS	F value
6	Treatment	3	6366.05	2122.02	0.826[NS]
	Error	8	20544.37	2568.05	
	Total	11	26910.42		
8	Treatment	3	36770.21	12256.74	1.553[NS]
	Error	8	63141.99	7892.75	
	Total	11	99912.20		

NS - Not significant

Fig. 4. Fortnightly feed intake (g) of birds maintained on different dietary treatments

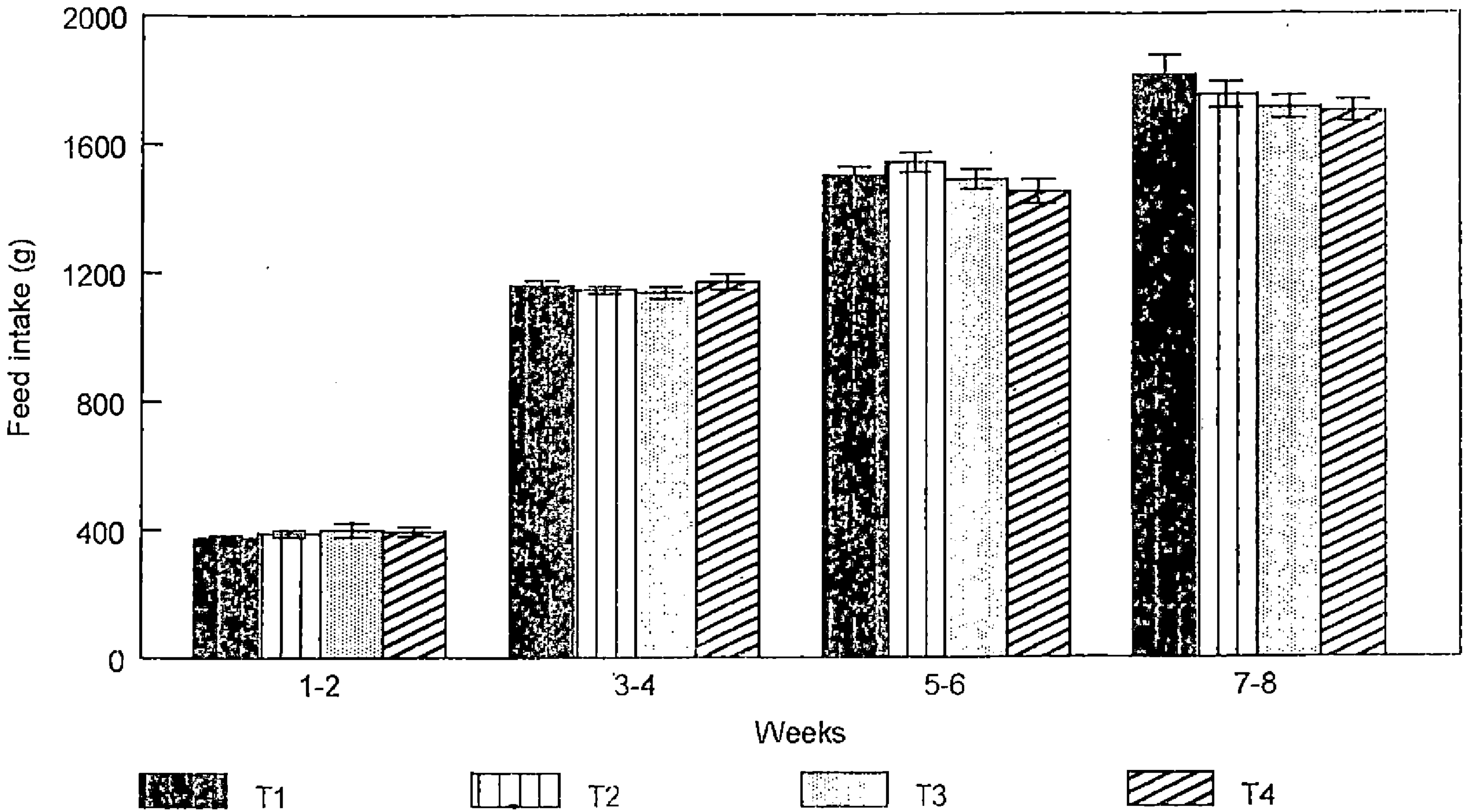


Fig. 5. Cumulative feed intake (g) of birds maintained on different dietary treatments

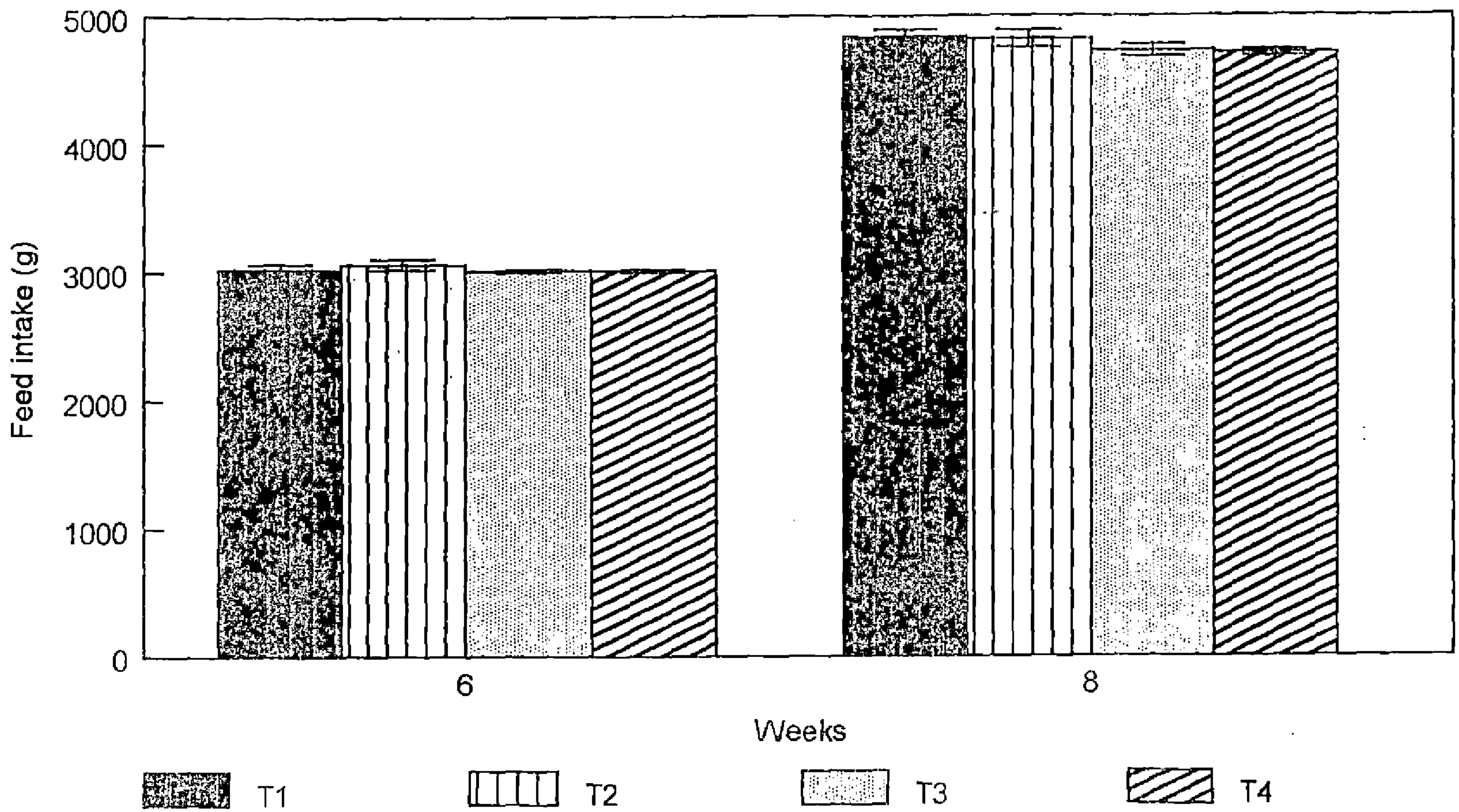


Table 17. Fortnightly and cumulative feed conversion efficiency of birds fed different dietary levels of squilla meal

Treatment		Age in weeks				Cumulative feed conversion efficiency	
		1-2	3-4	5-6	7-8	Sixth week	Eighth week
	R_1	2.00	2.43	2.46	3.51	2.38	2.72
T_1	R_2	2.06	2.41	2.63	3.29	2.46	2.71
	R_3	2.08	2.48	2.56	3.40	2.47	2.74
Mean		2.047^{b}	2.440^{c}	2.550	3.40	2.437^{c}	2.723^{d}
±SE		0.02	0.02	0.05	0.06	0.03	0.01
	R_1	2.10	2.55	2.56	3.42	2.48	2.75
T_2	R_2	2.10	2.59	2.58	3.30	2.52	2.76
	R_3	2.02	2.53	2.68	3.42	2.52	2.78
Mean		2.073^{b}	2.557^{bc}	2.607	3.38	2.507^{bc}	2.763^{c}
±SE		0.03	0.02	0.03	0.04	0.01	0.01
	R_1	2.67	2.94	2.82	3.18	2.84	2.96
T_3	R_2	2.23	2.77	2.60	3.74	2.61	2.92
	R_3	2.46	2.64	2.60	3.69	2.59	2.91
Mean		2.453^{a}	2.783^{a}	2.673	3.537	2.68^{a}	2.930^{a}
±SE		0.13	0.09	0.08	0.18	0.08	0.02
	R_1	2.02	2.59	2.80	3.38	2.60	2.83
T_4	R_2	2.09	2.90	2.51	3.32	2.58	2.81
	R_3	2.26	2.78	2.47	3.41	2.55	2.80
Mean		2.123^{b}	2.757^{ab}	2.593	3.37	2.577^{ab}	2.813^{b}
±SE		0.07	0.09	0.10	0.06	0.02	0.01
CD		0.2455	0.2063	-	-	0.1458	0.3646

Means bearing different superscript within the same column differ significantly ($P < 0.05$)

Table 18. Fortnightly feed conversion efficiency of birds fed different dietary levels of squilla meal - ANOVA

Week	Source	d.f	SS	MSS	F value
	Treatment	3	0.321	0.107	6.334*
1-2	Error	8	0.135	0.017	
	Total	11	0.456		
	Treatment	3	0.243	0.081	6.569*
	Error	8	0.099	0.012	
3-4	Total	11	0.341		
	Treatment	3	0.023	0.008	0.522^{NS}
	Error	8	0.120	0.015	
5-6	Total	11	0.143		
	Treatment	3	0.054	0.018	0.629^{NS}
	Error	8	0.230	0.029	
7-8	Total	11	0.284		

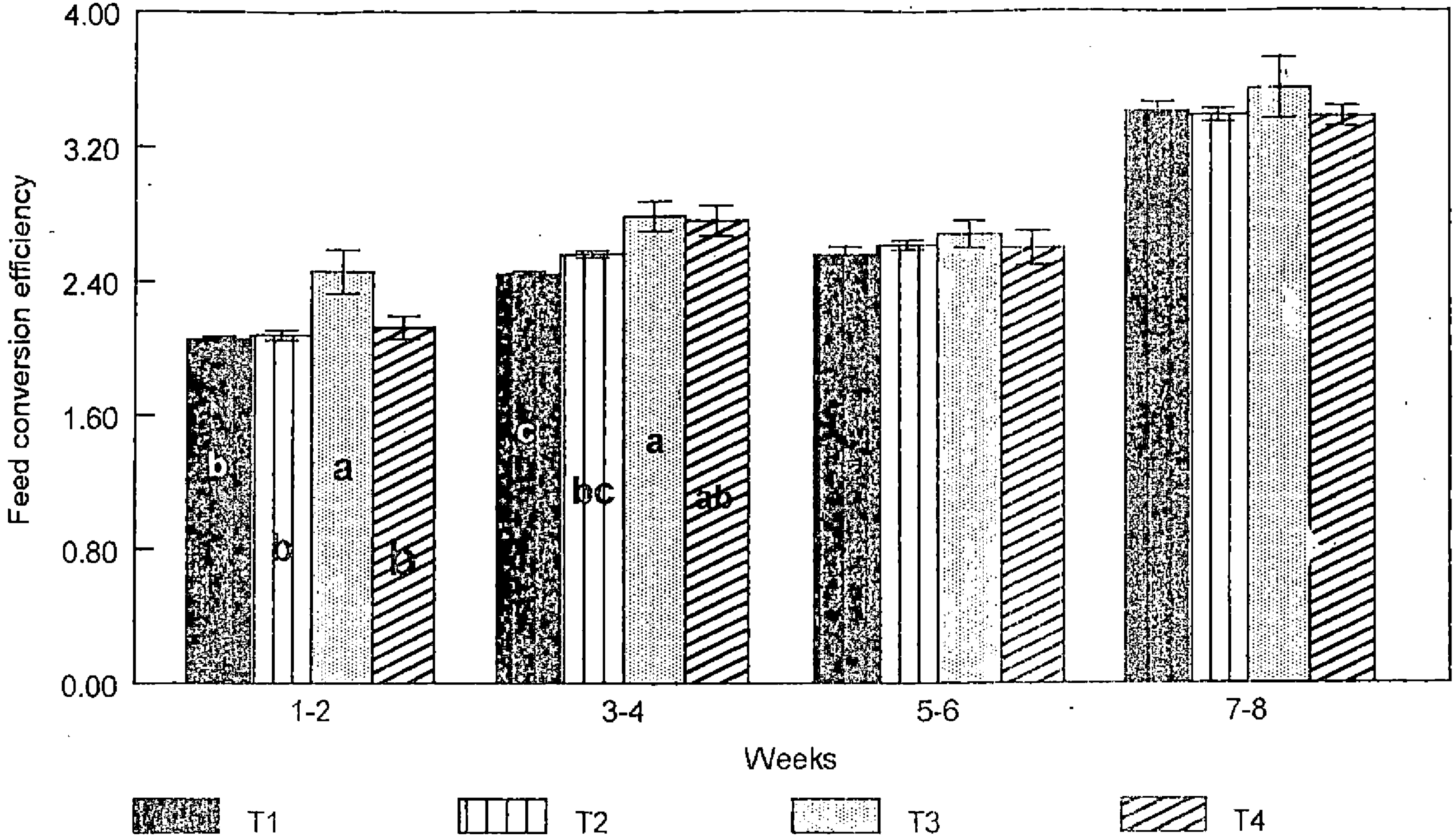
* Significant (P <0.05)
NS - Not significant

Table 19. Cumulative feed conversion efficiency of birds fed different dietary levels of squilla meal - ANOVA

Week	Source	d.f	SS	MSS	F value
	Treatment	3	0.097	0.032	5.648*
6	Error	8	0.046	0.006	
	Total	11	0.143		
	Treatment	3	0.072	0.027	68.786**
8	Error	8	0.003	0.000375	
	Total	11	0.075		

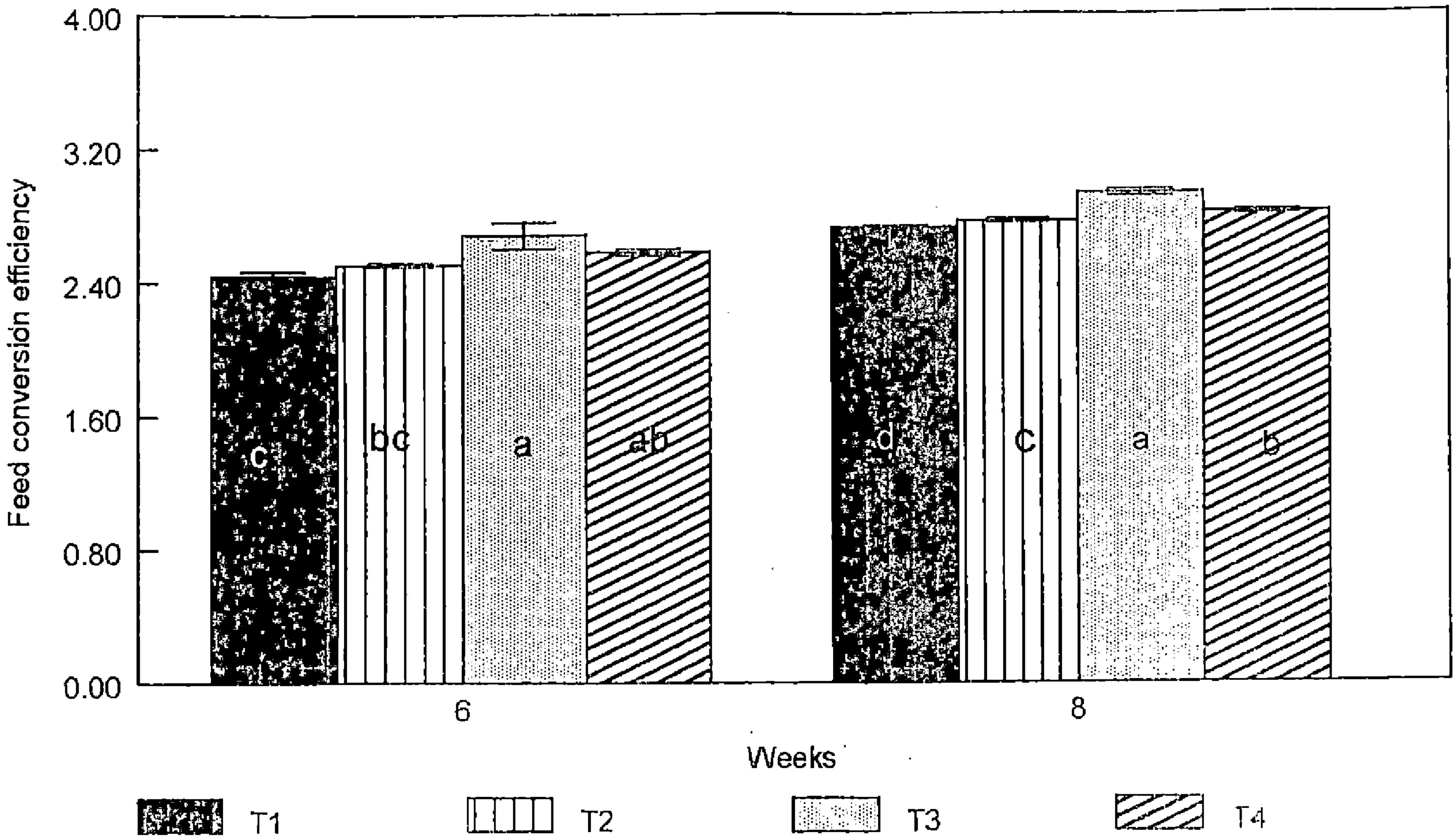
* Significant (P <0.05)
** Significant (P <0.01)

Fig. 6. Fortnightly feed conversion efficiency of birds maintained on different dietary treatments



a,b,c means with different letters differ ($P < 0.05$)

Fig. 7. Cumulative feed conversion efficiency of birds maintained on different dietary treatments



a,b,c,d means with different letters differ (P < 0.05)

Table 20. Protein intake (g) of birds fed different dietary levels of squilla meal

Treatment		Age in weeks			
		2	4	6	8
	R_1	89.2	350.8	684.7	1068.7
T_1	R_2	84.6	350.8	697.0	1038.4
	R_3	84.6	358.4	715.5	1075.5
Mean		86.2	353.3	699.1	1060.9
±SE		1.54	2.55	8.94	11.41
	R_1	92.4	355.7	699.2	1032.5
T_2	R_2	84.7	344.9	700.7	1060.7
	R_3	90.9	360.4	728.4	1083.1
Mean		89.3	353.7	709.4	1058.8
±SE		2.35	4.59	9.51	14.64
	R_1	86.1	344.7	701.0	1055.8
T_3	R_2	87.6	358.2	691.8	1022.0
	R_3	101.5	358.2	696.4	1044.5
Mean		91.7	353.6	696.4	1040.8
±SE		4.88	4.61	2.66	9.94
	R_1	86.0	347.0	697.0	1024.9
T_4	R_2	89.1	368.5	689.4	1040.4
	R_3	96.7	363.9	693.9	1038.3
Mean		90.6	359.8	693.4	1034.50
±SE		3.20	6.53	2.23	8.79
Statistical significance		NS	NS	NS	NS

NS - Not significant (P >0.05)

Table 21. Protein intake (g) of birds fed different dietary levels of squilla meal - ANOVA

Week	Source	d.f	SS	MSS	F value
2	Treatment	3	51.82	17.27	0.548^{NS}
	Error	8	252.00	31.50	
	Total	11	303.82		
4	Treatment	3	88.06	29.35	0.428^{NS}
	Error	8	548.82	68.60	
	Total	11	636.88		
6	Treatment	3	435.14	145.05	1.060^{NS}
	Error	8	1094.33	136.79	
	Total	11	1529.47		
8	Treatment	3	1536.90	512.30	1.462^{NS}
	Error	8	2803.35	350.42	
	Total	11	4340.25		

NS - Not significant

Fig. 8. Protein intake (g) of birds maintained on different dietary treatments

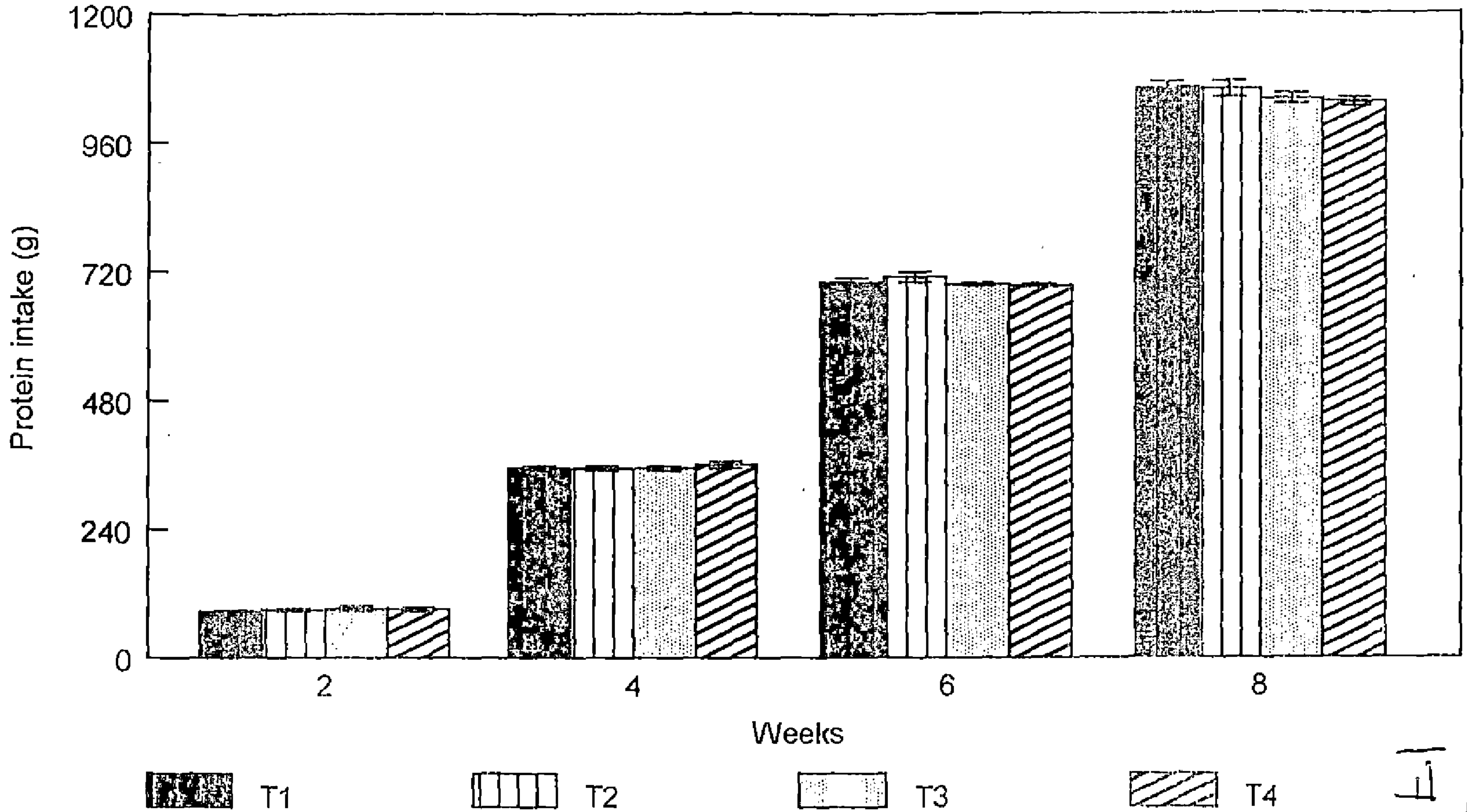


Table 22. Protein efficiency ratio of birds fed different dietary levels of squilla meal

Treatment		Age in weeks			
		2	4	6	8
	R_1	2.16	1.88	1.82	1.68
T_1	R_2	2.10	1.87	1.76	1.68
	R_3	2.08	1.82	1.76	1.66
Mean		2.113^{a}	1.857^{a}	1.78^{a}	1.673^{a}
±SE		0.02	0.02	0.02	0.01
	R_1	2.06	1.79	1.74	1.65
T_2	R_2	2.06	1.77	1.72	1.65
	R_3	2.14	1.82	1.72	1.63
Mean		2.087^{a}	1.793^{ab}	1.727^{ab}	1.643^{b}
±SE		0.03	0.02	0.01	0.01
	R_1	1.62	1.51	1.52	1.53
T_3	R_2	1.94	1.66	1.66	1.55
	R_3	1.76	1.68	1.67	1.56
Mean		1.773^{b}	1.617^{c}	1.617^{c}	1.547^{d}
±SE		0.09	0.05	0.05	0.01
	R_1	2.15	1.79	1.67	1.61
T_4	R_2	2.08	1.64	1.68	1.61
	R_3	1.92	1.66	1.70	1.62
Mean		2.05^{a}	1.697^{bc}	1.683^{bc}	1.613^{c}
±SE		0.07	0.05	0.01	0.01
CD		0.1975	0.1191	0.0842	0.02105

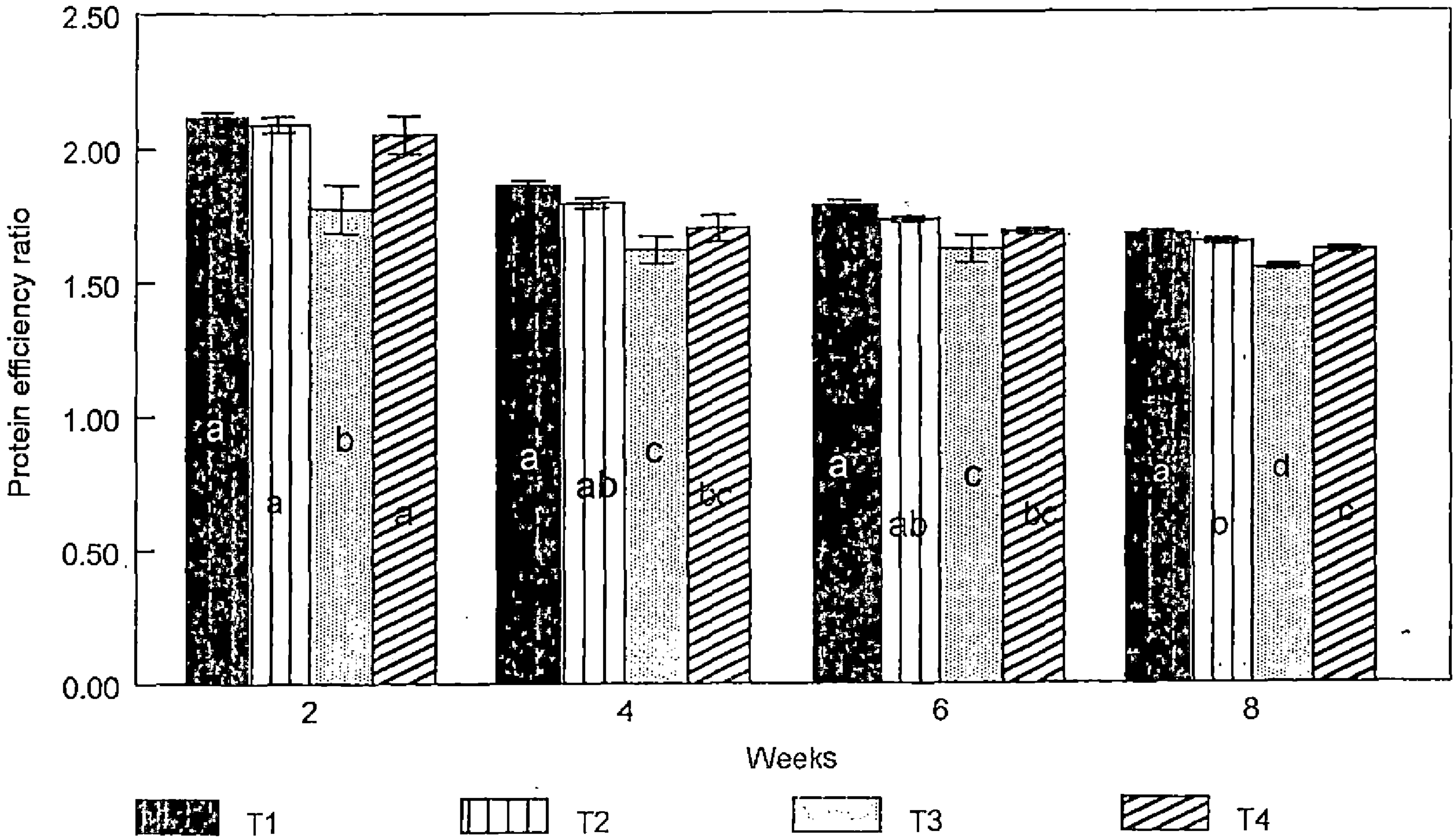
Means bearing different superscript within the same column differ significantly. ($P < 0.05$)

Table 23. Protein efficiency ratio of birds fed different dietary levels of squilla meal - ANOVA

Week	Source	d.f	SS	MSS	F value
2	Treatment	3	0.222	0.074	6.814*
	Error	8	0.087	0.011	
	Total	11	0.309		
4	Treatment	3	0.101	0.034	7.923**
	Error	8	0.034	0.004	
	Total	11	0.135		
6	Treatment	3	0.043	0.014	6.662*
	Error	8	0.017	0.002	
	Total	11	0.060		
8	Treatment	3	0.026	0.009	66.063**
	Error	8	0.001	0.000125	
	Total	11	0.027		

* Significant (P <0.05)
** Significant (P <0.01)

Fig.9. Protein efficiency ratio of birds maintained on different dietary treatments



a,b,c,d means with different letters differ (P < 0.05)

Table 24. Processing yield and length of duodenum of birds fed different dietary levels of squilla meal

Treatment		Percent of live weight				Length of duodenum (cm)
		Dressing yield[1]	Abdominal fat	Giblet yield	Ready to cook	
	R_1	92.42	1.92	4.65	66.72	30.50
T_1	R_2	93.33	2.28	4.70	67.65	27.75
	R_3	91.95	2.34	4.58	67.97	31.00
Mean		92.72	2.18^{a}	4.64	67.44^{ab}	29.75
±SE		0.24	0.25	0.08	0.52	1.22
	R_1	92.87	1.44	4.45	68.68	28.0
T_2	R_2	92.76	1.91	4.95	67.32	32.0
	R_3	93.44	1.97	5.08	68.33	28.5
Mean		93.02	1.77^{ab}	4.83	68.17^{a}	29.50
±SE		0.85	0.31	0.13	0.45	0.96
	R_1	89.76	1.25	9.45	61.54	30.5
T_3	R_2	92.47	1.38	5.47	68.49	29.0
	R_3	88.03	1.38	4.79	63.97	28.0
Mean		90.09	1.33^{bc}	4.99	65.60^{bc}	29.17
±SE		1.49	0.05	0.2	1.52	0.65
	R_1	91.61	1.10	5.46	65.09	30.75
T_4	R_2	91.07	1.31	5.65	64.93	30.50
	R_3	88.41	1.02	4.68	64.30	31.25
Mean		90.37	1.14^{c}	5.26	64.77^{c}	30.83
±SE		0.78	0.12	0.23	0.30	0.59
CD		-	0.6141	-	2.496	-

[1]Weight of birds after removal of feathers only

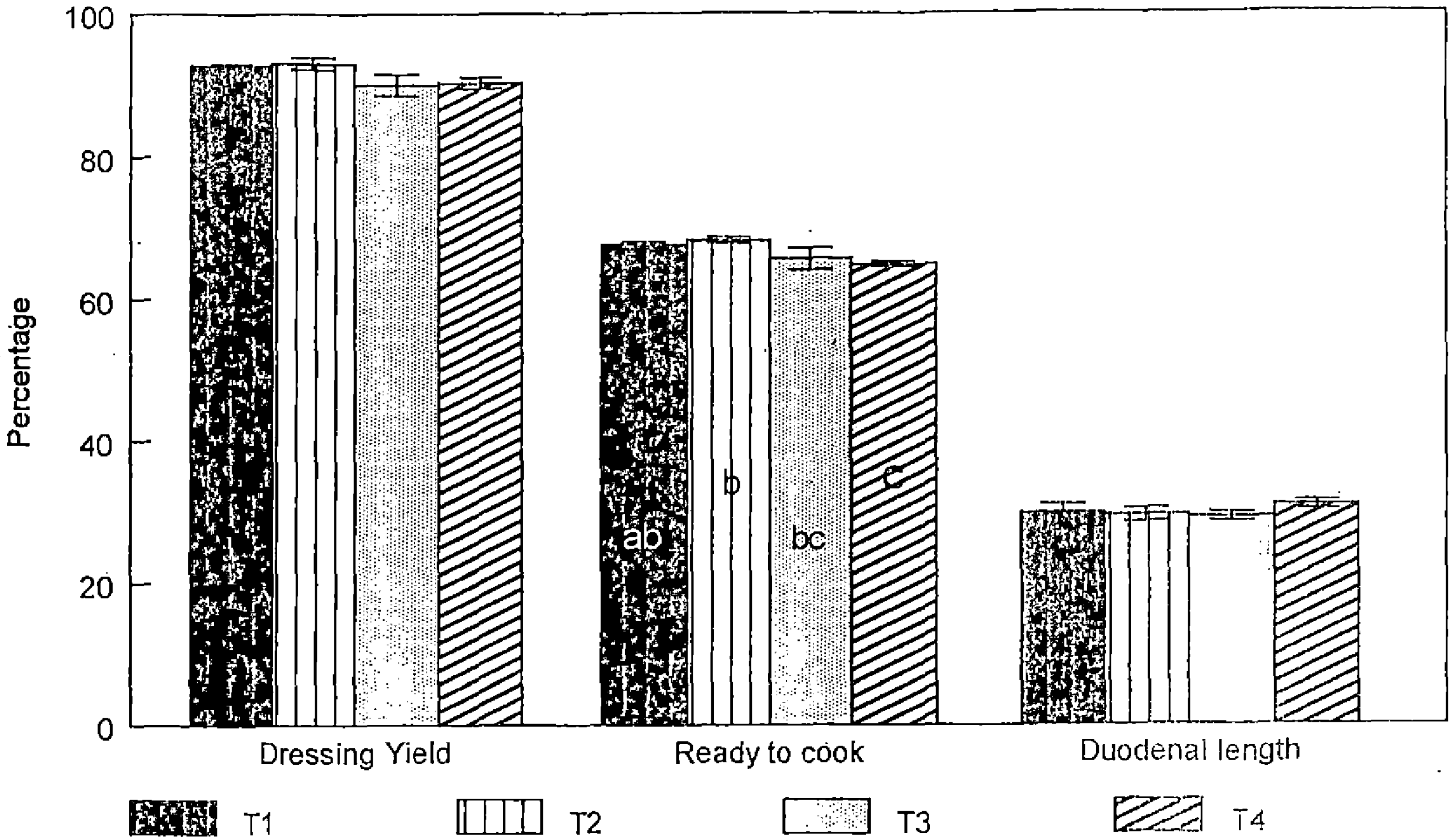
Means bearing different superscript within the same column differ significantly ($P < 0.05$)

Table 25. Processing yield and length of duodenum of birds fed different dietary levels of squilla meal - ANOVA

	Source	d.f	SS	MSS	F value
1. Dressing yield (%)	Treatment	3	42.31	14.10	2.604^{NS}
	Error	20	108.31	5.42	
	Total	23	150.62		
2. Abdominal fat (%)	Treatment	3	3.89	1.30	4.971**
	Error	20	5.21	0.26	
	Total	23	9.10		
3. Giblet weight (%)	Treatment	3	1.25	0.42	2.369^{NS}
	Error	20	3.51	0.18	
	Total	23	4.76		
4. Ready to cook (%)	Treatment	3	45.01	15.0	3.492*
	Error	20	85.93	4.3	
	Total	23	130.94		
5. Length of duodenum (cm)	Treatment	3	9.37	3.12	0.653^{NS}
	Error	20	95.54	4.78	
	Total	23	104.91		

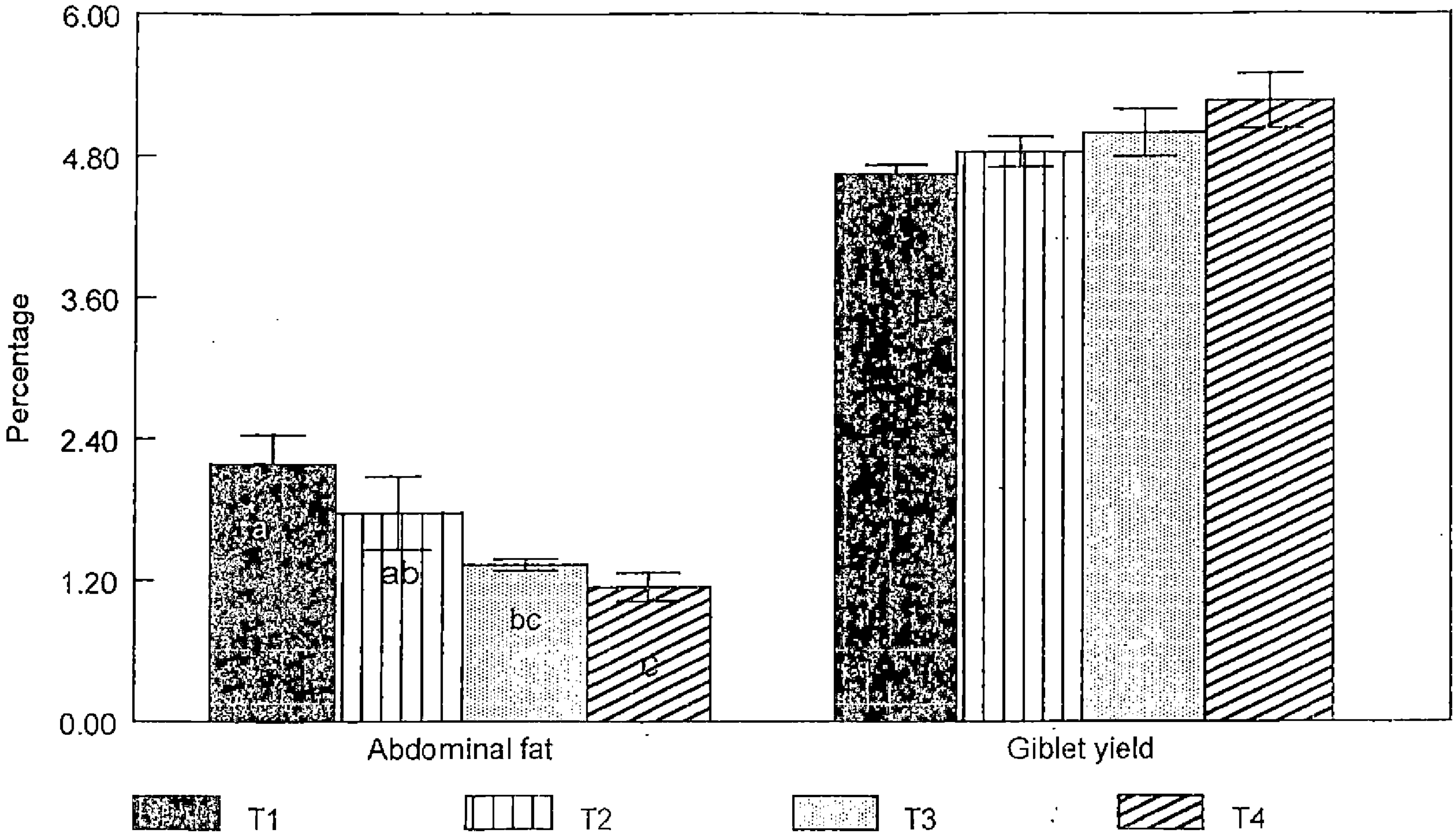
* Significant (P <0.05)
** Significant (P <0.01)
NS - Not significant

Fig.10. Dressing yield, ready-to-cook yield (% of live weight) and length of duodenum (cm) of birds maintained on different dietary treatments



a,b,c means with different letters differ (P < 0.05)

Fig.11. Abdominal fat and giblet yield (% of body weight) of birds maintained on different dietary treatments



a,b,c means with different letters differ (P < 0.01)

Table 26. Influence of squilla meal at different levels in broiler rations on faecal moisture, apparent metabolisable energy content of diets and daily protein retention in birds

Treatment		[1]Faecal moisture (%)		[2]Apparent metabolisable energy (Kcal/kg)		[1]Protein retention (g/day/bird)	
		Starter	Finisher	Starter	Finisher	Starter	Finisher
	R_1	80.89	77.11	2709	2782	4.14	5.03
T_1	R_2	79.80	77.54	2750	2813	2.48	7.62
	R_3	80.20	74.23	2595	2873	1.46	3.78
Mean		80.30	76.29[b]	2684.7	2822.7	2.69	5.48
±SE		0.21	0.66	46.4	26.7	0.53	0.78
	R_1	81.23	78.28	2531	2824	3.57	6.61
T_2	R_2	79.63	80.84	2683	2904	2.48	3.86
	R_3	81.79	78.58	2686	2720	1.31	4.79
Mean		80.88	79.23[a]	2633.3	2816.3	2.45	5.08
±SE		0.42	0.522	51.2	53.3	0.46	0.62
	R_1	84.59	80.77	2738	2829	5.15	4.46
T_3	R_2	82.16	81.15	2453	2727	5.22	6.42
	R_3	80.50	79.01	2647	2932	0.38	4.23
Mean		82.42	80.31[a]	2612.7	2829.3	3.58	5.03
±SE		0.76	0.43	84.0	59.2	1.05	0.45
	R_1	78.07	78.51	2578	2727	0.40	5.44
T_4	R_2	82.16	79.00	2877	2922	8.09	9.52
	R_3	80.89	79.66	2589	2831	6.80	6.19
Mean		80.36	79.05[a]	2681.3	2826.7	5.01	7.05
±SE		0.80	0.23	97.9	56.3	1.56	0.80
CD		-	1.437	-	-	-	-

[1] Mean ±SE average of six values

[2] Mean ±SE average of three values

Means bearing different superscript within the same column differ significantly ($P < 0.01$)

Table 27. Influence of squilla meal at different levels in broiler rations on faecal moisture, apparent metabolisable energy content of diets and daily protein retention in birds - ANOVA

	Source	d.f	SS	MSS	F value
Faecal moisture	Treatment	3	17.55	5.85	2.732^{NS}
Starter	Error	20	42.83	2.14	
	Total	23	60.38		
Finisher	Treatment	3	52.82	17.61	12.362**
	Error	20	28.48	1.42	
	Total	23	81.30		
Protein Retention	Treatment	3	24.08	8.03	1.286^{NS}
Starter	Error	20	124.85	6.24	
	Total	23	148.93		
Finisher	Treatment	3	16.13	5.38	1.948^{NS}
	Error	20	55.22	2.76	
	Total	23	71.35		
AME	Treatment	3	11457.33	3819.11	0.238^{NS}
Starter	Error	8	128482.67	16060.33	
	Total	11	139940.00		
Finisher	Treatment	3	287.58	95.86	0.012^{NS}
	Error	8	61374.67	7671.83	
	Total	11	61662.25		

*Significant (P <0.05)
NS - Not significant

Fig.12. Apparent metabolisable energy (kcal / kg) of starter and finisher diets incorporating different levels of squilla meal

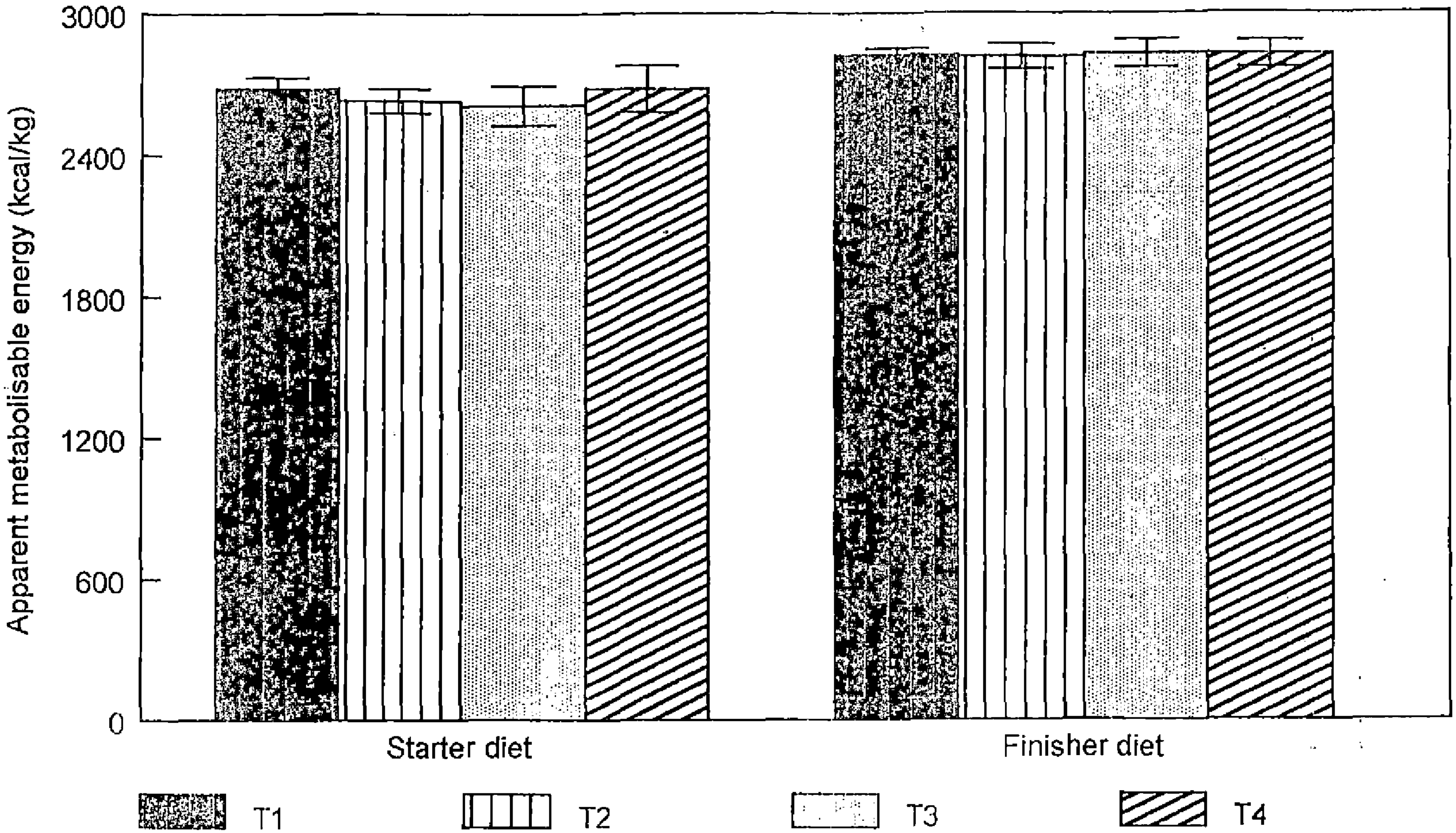


Fig.13. Protein retention (g / day) of birds maintained on different dietary treatments

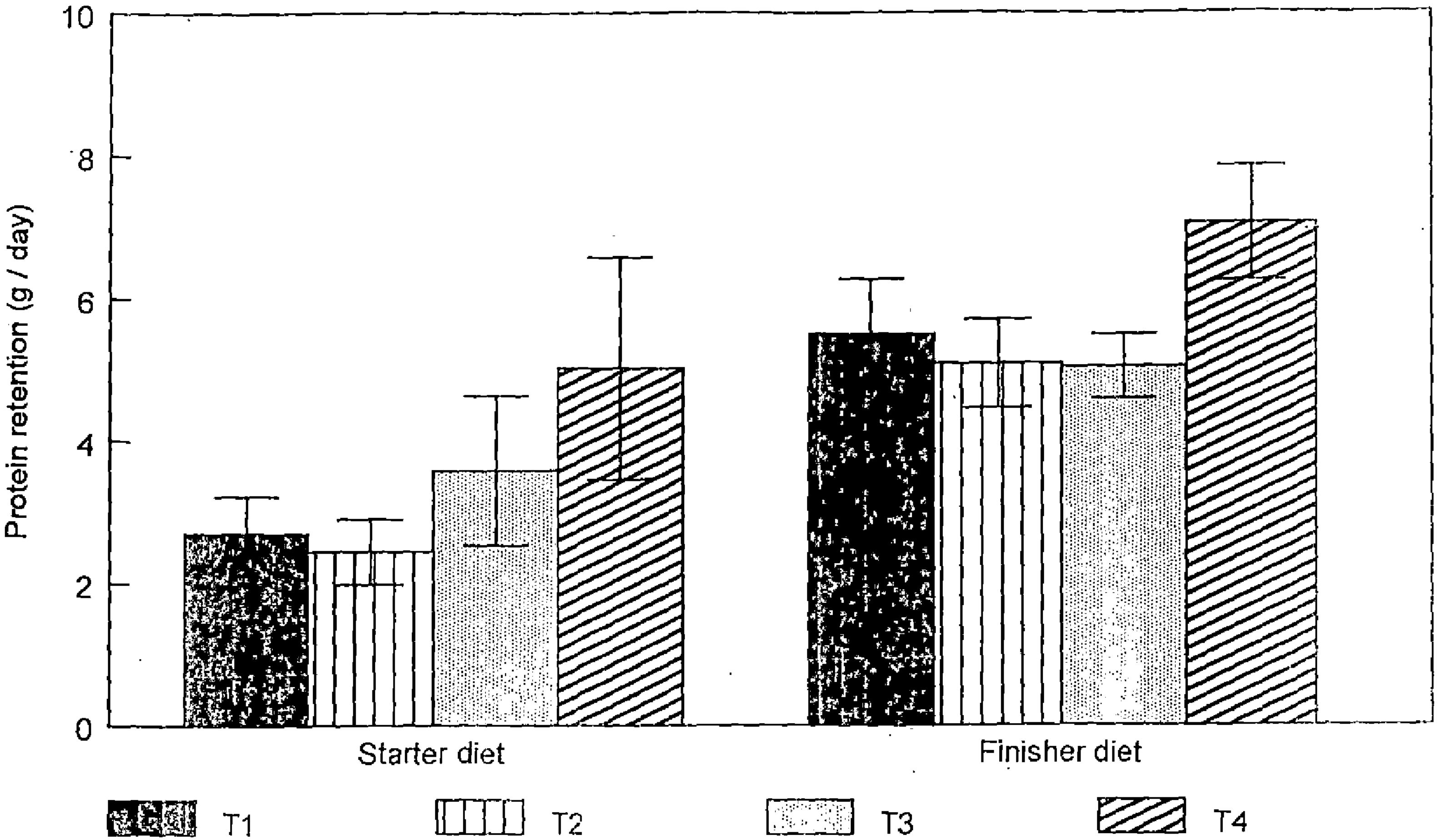


Table 28. Cost of production (Rs.) of birds fed different dietary levels of squilla meal

	T_1	T_2	T_3	T_4
1. Cost of feed/kg (Rs)				
Starter	7.65	7.42	7.21	7.78
Finisher	7.11	6.91	6.65	7.17
2. Feed intake (kg)				
Starter	3.029	3.071	3.02	3.011
Finisher	1.809	1.747	1.709	1.698
3. Live weight of birds (kg)	1.818	1.785	1.656	1.715
4. Cost/kg of live weight (Rs)	26.42^{c} ±0.05	26.24^{c} ±0.03	27.25^{b} ±0.10	27.79^{a} ±0.08

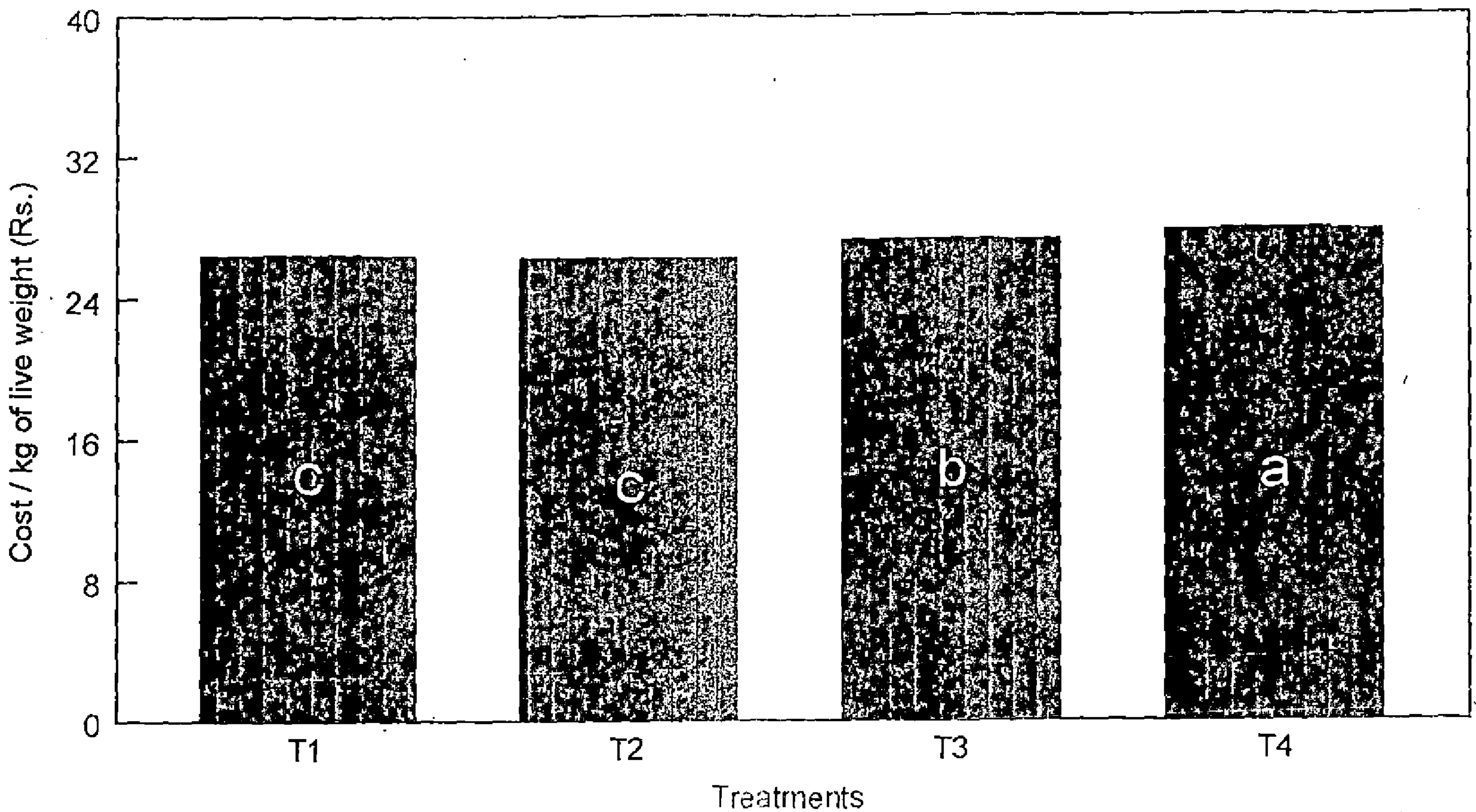
*Means bearing different superscript within the same row differ significantly ($P < 0.01$)

Table 29. Cost of production (Rs.) of birds fed different dietary levels of squilla meal - ANOVA

	Source	df	SS	MSS	F value
Cost/kg of live weight (Rs.)	Treatment	3	4.70	1.566	74.57**
	Error	8	0.17	0.021	
	Total	11	4.87		

** Significant ($P < 0.01$)

Fig.14. Cost of production (Rs) of birds maintained on different dietary treatments



a,b,c means with different letters differ (P<0.01)

DISCUSSION

DISCUSSION

The results obtained during the course of the present investigation are discussed below.

5.1 Chemical composition of squilla meal

The squilla meal used for the study contained 34.1 per cent crude protein, 12.1 per cent crude fibre, 13.8 per cent nitrogen free extract, 1.6 per cent ether extract, 38.4 per cent total ash, 7.0 per cent acid insoluble ash, 7.4 per cent calcium, 1.73 per cent phosphorus and 9.97 per cent chitin on dry matter basis (Table 6).

The crude protein content of the squilla meal observed in the present study was similar to the value reported by Reddy *et al.* (1997), while slightly higher values have been reported by Anon (1976-77) and Mohan (1999).

The figure obtained for the crude fibre content of squilla meal was comparable to the value reported by Anon (1976-77), though slightly higher and lower values were reported by Reddy *et al.* (1997) and Mohan (1999) respectively.

The nitrogen free extract content of the squilla meal obtained in the present study was found to be higher than the value of 11.94 per cent reported by Reddy *et al.* (1997), 9.1 per cent by Anon (1976-77) and 3.15 per cent by Mohan (1999).

The mean ether extract value of 1.6 per cent in squilla meal was close to the value reported by Reddy *et al.* (1997), while higher values have been reported by Anon (1976-77) and Mohan (1999).

The observed value for the total ash for squilla meal was in agreement with the values reported by Reddy *et al.* (1997) and Anon (1976-77) but lower than that reported by Mohan (1999).

The calcium and phosphorus content of squilla meal were 7.40 per cent and 1.73 per cent respectively, which are almost similar to the values reported by Reddy *et al.* (1997). However, higher values have been reported for both calcium and phosphorus by Anon (1976-77) and Mohan (1999).

The chitin content of the squilla meal used in the present study was 9.97 per cent which is in concurrence with the value (9.84%) reported by Mohan (1999). However, a higher value of 13.92 per cent reported by Reddy *et al.* (1997) might be due to the assumption of the authors that the entire crude fibre was represented by chitin only.

5.2 Body weight of experimental birds

The data presented in Table 7 and their statistical analysis in Table 8 reveal that the average fortnightly weights of birds on different dietary treatments differ significantly ($P < 0.01$) from the second week onwards.

The mean body weights of birds in different treatment groups at two weeks of age were 225.3, 229.4, 205.1 and 228.0 g for T_1, T_2, T_3 and T_4 respectively. The weight recorded in group fed ration containing 10 per cent squilla meal (T_3) was significantly ($P < 0.01$) lower than the other three groups.

The mean body weight recorded at the end of four weeks were 699.6, 677.4, 614.0 and 652.5 g for T_1, T_2, T_3 and T_4 respectively, the mean body weight of T_3 group being significantly ($P < 0.01$) lower than T_1, T_2 and T_4. However there was no significant difference between T_2 and T_4 and between T_1 and T_2.

The mean body weight of birds on different dietary treatments recorded at six weeks and eight weeks of age showed a similar trend in their growth except that the body weights of T_3 group are almost comparable to that of T_4.

The observations on the body weight of birds revealed that the growth rate declined with increasing levels of squilla meal in the diet.

Supplementation of 10 per cent squilla meal diet with lysine and methionine (T_4) improved the growth marginally to a level almost similar to that of 5 per cent squilla meal diet. The reduction in growth may be due to lower true protein content in the squilla meal based diets (Mohan, 1999).

5.3 Body weight gain

It could be observed from the data on fortnightly body weight gain of birds recorded in Table 9 that there was no definite trend in body weight gain among the different treatment groups. The first and second fortnightly gain showed that the 100 per cent squilla meal crude protein diet was inferior ($P < 0.01$) to all the other diets in promoting body weight (Table 10). During the second fortnight the weight gain of birds on 50 per cent squilla meal crude protein group was significantly ($P < 0.01$) higher when compared to 100 per cent squilla meal crude protein diet (T_3), the gain being comparable to that of the group supplemented with amino acids (T_4).

There was no statistically significant difference in the mean body weight gain of birds on different dietary treatments during the third and fourth fortnight. However, numerically higher weight gains were observed in T_1 and T_2 group as compared to T_3 and T_4 groups.

A perusal of the mean cumulative body weight gain (Table 9 and 11) of birds at six and eight weeks revealed a similar trend among the different treatment groups. The weight gains recorded were 1244.3, 1225.4, 1127.7 and 1168.9 g at six weeks and 1775.2, 1742.5, 1613.7 and 1672.7 g at eight weeks for T_1, T_2, T_3 and T_4 respectively.

The weight gain of birds in control group (T_1) fed ration with 100 per cent fish meal crude protein was comparable to those of 50 per cent squilla meal crude protein (T_2) replaced group. The weight gain in T_2 group was significantly higher ($P < 0.01$) than T_3 group but almost comparable to T_4 group. Similarly the weight gains in the T_3 and T_4 groups were comparable though numerically higher weight gain was recorded in T_4 group.

The data further revealed that the cumulative weight gain decreased with increasing level of squilla meal in the diet. In the present study replacement of fish meal crude protein upto 50 per cent with squilla meal crude protein had no significant influence on body weight gain. A similar trend in weight gain was also reported by Reddy *et al.* (1997). However they observed no significant difference in weight gain at all levels of fish meal nitrogen replacement with squilla meal nitrogen. Mohan (1999) during his studies with broilers using squilla meal replacing fish meal in the diets reported a significantly ($P < 0.05$) lower weight gain at all levels of squilla meal inclusion (5, 7.5 and 10%) when compared to the control diet containing 10 per cent fish meal.

Supplementation of lysine and methionine to 100 per cent squilla meal protein based diets improved weight gains to a level comparable to that of 50 per cent squilla meal protein diet and it may be due to the better balance of amino acids and better utilisation of protein in squilla meal based diets.

The above observation is in keeping with those reported by Raju *et al.* (1999) who studied the effect of supplemental amino acids on soya based low protein diets compared to fish meal control. They observed that amino acid supplementation improved body weight gain of birds fed marginally protein deficient diets and the weight gains were comparable to those birds fed control diet. However, significantly lower weight gain was reported by the above authors in the birds fed severely protein deficient diets even on amino acid supplementation.

The lowered weight gain on squilla meal based diets may be due to the lower true protein content and imbalance of essential amino acids compared to the fish meal based diet.

5.4 Feed consumption

The data presented in Table 12 and 13 on the daily feed intake of birds indicate that there is no significant difference between the different treatment groups in this regard. The fortnightly intake of birds also revealed no significant difference (Table 14 and 15).

The cumulative feed intake (Table 14) of birds were 3028.9, 3071.1, 3020.0 and 3011 g at six weeks and 4837.8, 4817.8, 4728.9 and 4708.9 g for T_1, T_2, T_3 and T_4 at eight weeks respectively (Fig.5). Though there was no significant difference in the feed intake between the different groups as is evidenced from the statistical analysis given in Table 16, a numerically lower value was observed as the level of squilla meal increased in the diet.

Similar findings were observed by Reddy *et al.* (1997) who reported a curvilinear trend in feed intake as the level of squilla meal increased in the ration. Mohan (1999) also observed no difference in feed intake when squilla meal was included in the diet upto 7.5 per cent. However, a substantial reduction in feed intake was reported by him when squilla meal was included at 10 per cent level in the broiler diet.

The linear reduction in feed intake as level of squilla meal increased in the diet may be due to the higher concentration of the chitin in the diet. Narhari *et al.* (1991) also reported a gradual reduction in feed consumption as the level of chitin supplementation (0 to 0.6%) increased in the diet. However, Nair *et al.* (1987) observed higher feed intake when 0.5 per cent chitin was added to commercial diet.

5.5 Feed conversion efficiency

A perusal of data on the mean fortnightly feed conversion efficiency given in Table 17 and their statistical analysis in Table 18 indicate that the four dietary treatments significantly ($P < 0.05$) influenced the efficiency in the first two fortnights only. The data further revealed that the birds fed diet containing 10 per cent squilla meal had significantly lower feed efficiency when compared to the other three groups in the first fortnight (2.45 vs 2.05, 2.07, 2.12). In the second fortnight even though a similar trend continued, the feed efficiency of birds in T_3 group was comparable to those in T_4 (2.76 vs 2.78), the highest feed efficiency being seen in T_1 (2.44) group of birds (Fig.6).

The cumulative feed conversion efficiency at six weeks of age was significantly ($P < 0.05$) higher in birds in T_1 and T_2 groups when compared to T_3 (2.44 and 2.51 vs 2.68), no significant difference being observable between T_2 and T_4 groups (2.51 vs 2.58) and between T_3 and T_4 (2.68 vs 2.58).

But the cumulative feed conversion efficiency of birds at eight weeks differed significantly ($P < 0.01$) among all the dietary treatments and was higher in

T_1 group (2.72) followed by T_2, T_4 and T_3, the values obtained being 2.76, 2.81 and 2.93 respectively. It was observed that the feed efficiency decreased with increasing levels of squilla meal in the diets (Fig.7).

Reddy *et al.* (1997) reported similar decrease in effective feed utilisation as squilla meal content increased in the diet compared to the fish meal based control diet. Mohan (1999) also reported a higher feed efficiency ($P < 0.01$) in zero per cent squilla meal group (2.12) as compared to 5 per cent (2.26), 7.5 per cent (2.37) and 10 per cent (2.45) squilla meal groups.

Reddy *et al.* (1997) attributed the reduction in effective feed utilisation of birds fed squilla meal diet to the increasing dietary concentration of chitin. On the contrary, Nair *et al.* (1987) and Narahari *et al.* (1991) observed better feed efficiency in chitin fed birds.

Supplementation of lysine and methionine improved the feed conversion efficiency in the 100 per cent squilla meal crude protein (T_4) based diet when compared to the unsupplemented (T_3) group till six weeks of age, a significantly ($P < 0.01$) higher feed efficiency (2.81 vs. 2.93) being observed at the end of eight weeks.

Raju *et al.* (1999) also reported better feed conversion efficiency in birds on amino acid supplementation of low protein diets. Similarly Rosenfeld *et al.* (1997) observed a better feed conversion efficiency on lysine supplementation with shrimp meal. The higher feed efficiency observed in the amino acid supplemented group maybe due to the better utilisation of protein.

5.6 Protein intake and protein efficiency ratio

The data set out in Table 20 and the statistical analysis of protein intake (Table 21) of birds fed different dietary levels of squilla meal revealed no significant difference among them in this regard throughout the experimental period (Fig.8). The intake recorded were 1060.9, 1058.8, 1040.8 and 1034.5 g for T_1, T_2, T_3 and T_4 group of birds respectively. The statistically insignificant reduction in protein intake in all the squilla meal diets was due to reduced feed intake.

From the results presented in Table 22 and their statistical analysis in Table 23 (Fig.9) it can be seen that the protein efficiency ratio in birds on the different dietary treatments differed significantly ($P < 0.05$) from second week onwards, T3 registering the lower value of 1.77 when compared to other groups. The fourth and sixth week protein efficiency values also showed the same trend with T_3 group showing the lowest value but comparable to that of T_4, the control birds (T_1) having the highest and T_2 comparable to that of T_1 and T_4. The values during the eigth week were 1.67, 1.64, 1.55 and 1.61 for T_1, T_2, T_3 and T_4 group respectively and were significantly different ($P < 0.01$). A close look at the protein efficiency values and the weight gain of birds in the various treatment groups reveal that they correlate well with the body weight gain.

5.7 Slaughter studies

5.7.1 Dressing yield

The dressing yield in birds sacrificed from different treatment groups were 92.72, 93.02, 90.09 and 90.37 per cent for T_1, T_2, T_3 and T_4 respectively (Table 24). The statistical analysis (Table 25) of the data revealed no significant difference among the different treatment groups in this regard, a finding which is in concurrence with those reported by Reddy *et al.* (1997). However, Mohan (1999) reported a significantly (P<0.05) lower dressing percentage when squilla meal in broiler diet was increased from 5 to 10 per cent.

5.7.2 Abdominal fat

A perusal of data in Table 24 and 25 revealed that the abdominal fat yield (%) decreased significantly (P <0.01) as the level of squilla meal in the diet increased (Fig.11). The abdominal fat yield recorded for T_1, T_2, T_3 and T_4 groups were 2.18, 1.77, 1.33 and 1.14 per cent respectively. Birds in T_1 group had significantly higher fat than those in T_3 and T_4. However, there was no significant difference between the birds in T_1 and T_2, T_2 and T_3 and T_3 and T_4 in this regard.

The reduction in the abdominal fat in birds fed squilla meal incorporated diet may be due to the increased level of dietary chitin as observed by Zakakis *et al.* (1982) who also reported thin abdominal fat pads in birds fed rations supplemented with 2 per cent chitin.

5.7.3 Giblet yield

From the results given in Table 24 it can be seen that the giblet yield from birds fed rations containing varying levels of squilla meal were 4.64, 4.83, 4.99 and 5.26 per cent for T_1, T_2, T_3 and T_4 respectively (Fig.11). The statistical analysis (Table 25) revealed no significant difference between the various dietary treatments but numerically higher giblet yield was observed as the level of squilla meal increased in the diet. An inverse relationship could also be observed between the giblet yield and the abdominal fat yield.

5.7.4 Ready-to-cook yield

The mean ready to cook yield were 67.44, 68.17, 65.60 and 66.77 per cent from birds in T_1, T_2, T_3 and T_4 groups respectively. The statistical analysis

(Table 25) showed a significantly ($P < 0.05$) low yield in birds fed 10 per cent squilla meal diet (T_3) compared to 5 per cent (T_2) and zero per cent level (T_1) (Fig.10).

5.7.5 Length of duodenum

A perusal of the data presented in Table 24 reveals that the mean length of duodenum in birds sacrificed from different dietary treatments were 29.75, 29.50, 29.17 and 30.83 cm for T_1, T_2, T_3 and T_4 groups respectively. The statistical analysis of the data (Table 25) did not reveal any significant difference between the different dietary treatments in regard to duodenal length. However, Reddy *et al.* (1997) reported a linear increase in the duodenal length of birds as the level of squilla meal increased in the diet.

5.8 Metabolism trial

5.8.1 Faecal moisture

Data set out in Table 26 revealed that the faecal moisture content of faeces from birds fed starter diets were 80.3, 80.88, 82.42 and 80.36 per cent for T_1, T_2, T_3 and T_4 group respectively. The statistical analysis (Table 27) showed no significant difference among the birds in various treatment groups.

The faecal moisture content values from birds fed finisher diets (Table 26) were 76.29, 79.23, 80.31 and 78.72 per cent for T_1, T_2, T_3 and T_4 group respectively. A significantly ($P < 0.01$) lower moisture (Table 27) level was observed in birds fed fish meal based control (T_1) diet.

Contrary to the above observation, Mohan (1999) reported a lower moisture content in faeces of birds fed ration containing 10 per cent squilla meal compared to 5 per cent and zero per cent levels. The higher moisture content observed in faeces from birds fed finisher diet containing squilla meal at various levels cannot be attributed to the presence of chitin in those diets, since no significant difference could be observed in this regard between the various treatment groups fed the starter diets.

5.8.2 Apparent metabolisable energy content

The data presented in Table 26 indicate that the apparent metabolisable energy content of the starter diets T_1, T_2, T_3 and T_4 were 2684.7, 2633.3, 2612.7 and 2681.3 kcal/kg respectively, the estimated energy values being slightly lower than the calculated values.

The apparent metabolisable energy content of finisher diets were 2822.7, 2816.3, 2829.3 and 2826.7 kcal/kg respectively for T_1, T_2, T_3 and T_4. The statistical analysis (Table 27) of the results revealed no significant difference between the starter and finisher diets incorporating squilla meal at different levels replacing dried fish (Fig.12).

The above findings are in agreement with those of Mohan (1999) who also could not observe any significant difference in the metabolisability of broiler rations when squilla meal / squilla meal protein replaced fish meal / fish meal protein respectively at different levels.

5.8.3 Protein retention

From the results given in Table 26 it can be observed that the mean daily protein retention of birds fed on different starter diets were 2.69, 2.45, 3.58 and 5.01 g for T_1, T_2, T_3 and T_4 respectively and those on finisher diets 5.48, 5.08, 5.03 and 7.05 g for T_1, T_2, T_3 and T_4 respectively.

The protein retention of birds fed aminoacid supplemented (T_4) diets were numerically higher than those on the other three diets but the differences between the various groups were not statistically significant (Table 27). The unsupplemented groups (T_1, T_2 and T_3) showed a linear decrease in protein retention with increasing levels of squilla meal with finisher diet. However, a higher retention of protein was noticed in birds on starter diet with 10 per cent squilla meal. The higher protein retention observed in birds fed T_4 diets may be due to the better balance of aminoacids compared to those on the other diets.

5.9 Livability

A total of three birds died out of 180 chicks in all the four treatment groups over an experimental period of eight weeks. The mortality occurred in the first week. The post-mortem examination revealed no detectable abnormalities.

5.10 Economics of gain

The cost of squilla meal was Rs.6.00/kg and that of unsalted dried fish was 10.50/kg. The growth performance of broilers fed diets incorporating squilla meal was comparable only at 50 per cent level of replacement of fish meal, while it was lesser when squilla meal protein completely replaced fish meal protein even with aminoacid supplementation.

A perusal of the data presented in Table 28 reveal that the cost of feed in aminoacid supplemented (T_4) group was more than that of control (T_1) with no corresponding increase in the performance of the birds.

From the results given in Table 28 it can be further seen that the cost of production per kilogram of live body weight of birds maintained on the four dietary treatments T_1, T_2, T_3 and T_4 were Rs. 26.42, 26.24, 27.25 and 27.79 respectively, the cost of production being significantly lower ($P < 0.01$) in T_1 and T_2 groups when compared to T_3 and T_4 and birds on T_4 ration having the highest cost per kg live body weight gain (Table 29 and Fig.14). The lower cost of squilla meal was responsible for the slightly lower cost per kg live weight in T_2 group compared to all the other groups.

A critical evaluation of the results obtained in the present study indicates that squilla meal can be used as a substitute for unsalted dried fish in broiler diets to replace 50 per cent of fish meal crude protein without influencing either the average daily gain, feed conversion efficiency or the cost of production per kilogram of gain.

SUMMARY

SUMMARY

An investigation was carried out in the Department of Animal Nutrition, College of Veterinary and Animal Sciences, Mannuthy to assess the feeding value of squilla (*Oratosquilla nepa*) meal as an animal protein source replacing dried fish in the diet of broiler chicken on their growth performance.

One hundred and eighty day-old commercial broiler chicks (Varna) were randomly distributed into four dietary treatments having three replicates of fifteen birds each. The four dietary treatments viz. T_1 containing 10 per cent unsalted dried fish (control), T_2 in which 50 per cent crude protein from dried fish was replaced with squilla meal protein, T_3 in which 100 per cent crude protein from dried fish was replaced with squilla meal protein and T_4 in which T_3 was supplemented with adequate lysine and methionine as per BIS (1992). The rations were made iso-proteimic and iso-caloric. The birds in each replicate were housed at random in individual but identical pens and were reared under deep litter system of management. Scientific managemental procedures were adopted throughout the experimental period of eight weeks.

Feed and water were provided *ad libitum*, broiler starter diets were fed for six weeks of age and broiler finisher diets from seventh week till the end of the experiment. The body weight of individual birds were recorded at the beginning of the experiment and there after at fortnightly intervals. Replicate wise weekly feed consumption was recorded.

A metabolism trial was carried out towards the end of the experiment using six birds from each treatment. Based on the data obtained from the metabolism trial faecal moisture content, apparent metabolisable energy value of the rations and protein retention of the birds were calculated. At the end of eight weeks two birds from each replicate were randomly selected and sacrificed to assess the

dressed yield, ready-to-cook yield, giblet yield, abdominal fat yield and length of duodenum. Mortality of the birds during the experimental period was also recorded. The economic benefit of incorporating squilla meal was also calculated from the data on feed intake and body weight gain of birds.

The data on chemical analysis of squilla meal used for the experiment indicate that the material was rich in protein (34.1%), calcium (7.4%) and phosphorus (1.73%) and had a chitin content of 9.97 per cent on dry matter basis.

The mean body weight of birds recorded at different ages revealed that the birds on 100 per cent squilla meal protein (T_3) had significantly ($P < 0.01$) lesser body weight than those on the control (T_1) and on 50 per cent squilla meal protein diet (T_2) throughout the experimental period but were comparable to those of the amino acid supplemented 100 per cent squilla protein group (T_4) at six and eight weeks. However, there were no significant differences between T_2 and T_4 and between T_1 and T_2 at six and eight weeks of age in this regard.

The fortnightly body weight gain of birds in the various dietary treatments did not differ significantly after four weeks of age. The cumulative body weight gain of birds at six and eight weeks indicated that birds in 100 per cent squilla meal protein group were inferior ($P < 0.01$) to the control and 50 per cent squilla meal group but were almost comparable to the amino acid supplemented 100 per cent squilla meal protein group (T_4). However, weight gain of birds fed diet (T_4) containing supplemented amino acids was almost similar weight gain to that of 50 per cent squilla meal protein group (T_2), the weight gain recorded for birds on the different dietary treatments at the end of eight weeks being 1775.2, 1742.5, 1613.7 and 1672.7 g for T_1, T_2, T_3 and T_4 respectively.

Data on mean daily, fortnightly and cumulative feed intakes showed no significant difference among the birds in the different dietary treatments.

The cumulative feed conversion efficiency at six and eight weeks differed significantly, the same at six weeks being significantly high ($P < 0.05$) in birds of T_1 and T_2 compared to those in T_3 (2.44 and 2.51 vs 2.68). The feed efficiency values were almost similar in T_2 and T_4 (2.51 vs 2.58) and in T_3 and T_4 groups (2.68 vs 2.58). The feed efficiency was seen decreased with increasing levels of squilla meal in the diet.

Record of protein intake of birds revealed that it did not differ significantly among the birds of different dietary treatments. But the protein efficiency ratio differed significantly ($P < 0.05$) among the various treatment group, with the control group having the highest and the 100 per cent squilla meal protein group having the lowest value.

Results on slaughter studies revealed that there was no significant difference in the dressing yield, giblet yield and length of duodenum among the treatment groups. However, abdominal fat yield in birds decreased ($P < 0.01$) with increasing level of dietary squilla meal, while the ready-to-cook yield was lower in 100 per cent squilla meal protein group ($P < 0.05$).

Metabolism trial with the various starter and finisher diets showed no significant difference in the apparent metabolisable energy values. Daily protein deposition of birds of various treatment groups also did not differ significantly. However, the faecal moisture content was significantly ($P < 0.01$) higher in birds fed on squilla meal based finisher diets.

It was concluded that squilla meal can be used as a substitute for unsalted dried fish in broiler chicken diets to replace 50 per cent of fish meal crude protein without influencing either the average daily gain, feed conversion efficiency or the cost of production per kilogram of live weight gain.

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NUTRITIVE EVALUATION OF SQUILLA (*Oratosquilla nepa*) MEAL IN BROILER CHICKEN DIETS

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ABSTRACT OF A THESIS

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ABSTRACT

An experiment was designed and conducted to assess the nutritive value of squilla (*Oratosquilla nepa*) meal in broiler chicken diet as an animal protein source replacing fish meal protein at three levels viz. zero, 50 and 100 per cent with supplementation of lysine and methionine at 100 per cent level of replacement.

One hundred and eighty one-day old straight-run commercial broiler chicks were divided into four groups each with three replicates of fifteen birds and were allotted to four dietary treatments viz. T_1 containing 10 per cent unsalted dried fish (control), T_2 in which 50 per cent crude protein from dried fish was replaced with squilla meal protein, T_3 in which 100 per cent crude protein from dried fish was replaced with squilla meal protein and T_4 in which T_3 was supplemented with adequate lysine and methionine as per BIS (1992). The rations were made iso-proteimic and iso-caloric. The chicks were reared under standard managemental conditions for a period of eight weeks.

The birds fed on 100 per cent squilla meal protein diet in replacement of fish meal protein attained significantly lower body weight gain ($P < 0.01$) compared to those in the control (T_1) and 50 per cent squilla meal protein (T_2) group at six and eight weeks. Lysine and methionine supplementation in the 100 per cent squilla meal protein diet improved the weight gain of birds to a level comparable to those on 50 per cent squilla meal protein diet.

Feed intake and protein intake of birds on various dietary treatments at different ages did not differ significantly ($P > 0.05$). But the feed conversion efficiency of birds maintained on control diet was significantly higher ($P < 0.05$) at six weeks and eight weeks ($P < 0.01$) than those on 100 per cent squilla meal protein diet (2.437 vs 2.68 and 2.72 vs 2.93). Protein efficiency ratio of birds

differed significantly between different treatment groups and the values correlate well with the body weight gain at different ages.

Slaughter studies revealed no significant difference ($P > 0.05$) between the different groups in dressed yield, giblet yield and length of duodenum. However, the abdominal fat was significantly higher ($P < 0.01$) in control group of birds, while the ready-to-cook yield was significantly less ($P < 0.05$) in 100 per cent squilla meal protein group.

The apparent metabolisable energy content of different rations and daily protein retention of birds showed no significant difference between the different dietary treatments.

The cost of production per kilogram of live weight gain of birds maintained on the four dietary treatments T_1, T_2, T_3 and T_4 were Rs. 26.42, 26.24, 27.25 and 27.79 respectively. Though there was a slight decrease in the cost of production of birds due to incorporation of squilla meal in place of unsalted dried fish at 50 per cent replacement, the difference was insignificant. However, 100 per cent replacement of fish meal protein with squilla meal protein and amino acid supplementation to the same increased the cost of production ($P < 0.01$) with no corresponding increase in performance.

From the results obtained in the present study it was inferred that squilla meal can be effectively included in broiler chicken diets to replace 50 per cent of fish meal protein without affecting growth, feed conversion efficiency and the cost of production.