# UTILISATION OF DRIED CUTTLE FISH *(Sepia officialis)* WASTE SILAGE IN JAPANESE QUAIL *(Coturnix coturnix japonica)* LAYER RATION

**LEKSHMY. M.A.**

**Department of Poultry Science**

**COLLEGE OF VETERINARY AND ANIMAL SCIENCES**

MANNUTHY, THRISSUR – 680 651

KERAKA, INDIA.

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# DECLARATION

I hereby declare that this thesis, entitled "**UTILISATION OF DRIED CUTTLE FISH (*Sepia officialis*) WASTE SILAGE IN JAPANESE QUAIL (*Coturnix coturnix japonica*) LAYER RATION**" 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.

Mannuthy,
.08.05

**LEKSHMY M.A.**

## CERTIFICATE

Certified that this thesis, entitled "**UTILISATION OF DRIED CUTTLE FISH (*Sepia officialis*) WASTE SILAGE IN JAPANESE QUAIL (*Coturnix coturnix japonica*) LAYER RATIONS**" is a record of research work done independently by **Lekshmy M.A.**, under my guidance and supervision and it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

Dr. A. Jalaludeen
Director i/c and Head
Centre for Advanced
Studies in Poultry Science
College of Veterinary and
Animal Sciences, Mannuthy

## CERTIFICATE

We, the undersigned members of the Advisory Committee of **Lekshmy M.A.,** a candidate for the degree of Master of Veterinary Science in Poultry Science, agree that this thesis entitled **"UTILISATION OF DRIED CUTTLE FISH (*Sepia officialis*) WASTE SILAGE IN JAPANESE QUAIL (*Coturnix coturnix japonica*) LAYER RATION"** may be submitted by Lekshmy M.A., in partial fulfilment of the requirement for the degree.

**Dr. A. Jalaludeen**

(Chairman, Advisory committee)
Director i/c and Head
Centre for Advanced Studies in Poultry Science
College of Veterinary and Animal Sciences
Mannuthy

**Dr. Leo Joseph**

Associate Professor and Head
University Poultry and Duck Farm
College of Veterinary and
Animal Sciences, Mannuthy
(Member)

**Dr. K. Narayanankutty**

Senior Scientist
AICRP on Poultry for Eggs
College of Veterinary and
Animal Sciences, Mannuthy
(Member)

**Dr. A.D. Mercy**

Associate Professor
Department of Animal Nutrition
College of Veterinary and Animal sciences
Mannuthy
(Member)

**External Examiner**

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*Lekshmy.M.A*

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# ***Introduction***

# 1. INTRODUCTION

Japanese quail (*Coturnix coturnix japonica*) is a domesticated avian species and is a popular table delicacy since olden times. Its unique characteristics like faster growth rate, early sexual maturity, high rate of production, short generation interval, hardy nature, simple rearing procedures and quicker returns on investment has opened a new area and an alternative for farmers interested in poultry production. There is immense potential for quails in providing gainful employment and supplementary source of income and as a valuable source of meat and egg. Many countries have recognized the nutritional and economic value of Japanese quails and started rearing them commercially. In order to minimize the cost of production of quail, research has been carried out round the globe, on various aspects of quail production.

Quails were introduced for the first time in India at Central Avian Research Institute, (CARI), Izatnagar. Quail hatching eggs were obtained from University of California, USA in 1974 under United Nations Development Project. The consistent support of Central Avian Research Institute with respect to the availability of improved quail germ plasm has resulted in the establishment of quail production units in public and private sectors all over the country.

Similar to other avian species, feed is the single major factor that determines the cost of production of quail egg and meat. The conventional feed ingredients used in quail rations compete with human food as well as other livestock feed items. Therefore, economic formulation of quail rations with better quality and cheaper ingredients is the need of the hour. Protein content of ration is critical in determining the efficiency of quail production. For efficient production, protein quality and quantity in the ration should be well balanced.

Fish meal is the main source of animal protein in poultry rations under Indian conditions but availability of good quality fish meal is inadequate to meet the growing demands of poultry industry. Moreover, there are several restrictions by local administrations against fish meal plants as they cause environmental problems.

Fisheries is a well flourished industry in India owing to its long coastal belt. Seafood export is one of the major sources of foreign exchange in our country. Among the Indian states, Kerala is blessed with a long coastal stretch of about 500 kilometers. There are several seafood processing units functioning in the state which generate tonnes of fish wastes every day. In almost all species of fish nearly 40 to 50 per cent is thrown away as wastes, which is as rich in protein content as the parts separated for edible purposes. This may cause serious environmental pollution as well as economic loss. Conversion of these fish wastes into silage is an alternative with low investment to tackle this problem. Fish silage can be prepared by acid digestion or microbial fermentation. The main drawback of fish silage is its liquid consistency, which makes it difficult to handle as a feed ingredient. To overcome this condition co-drying the silage with agro-industry byproducts such as rice bran or cassava root meal as filler material was tried by many researchers with favourable results.

Nearly one lakh tonnes of cephalopods are processed annually in India generating more than 30,000 tonnes of waste with high moisture content and unpleasant appearance. Disposal of this waste is a major problem faced by all concerned. The Central Institute of Fisheries Technology (CIFT), Kochi has developed a product utilizing this waste, cuttle fish waste silage. The silage was sun- dried with rice-bran as filler material and the final product having 26 per cent crude protein has been utilised in animal rations.

The information regarding the use of cuttle fish waste silage in poultry rations is scanty. Hence an experiment was planned with the objective of determining the effect of replacing unsalted dried fish with cuttle fish waste silage as protein supplement in quail layer ration. The economics of replacement of driedfish with cuttle fish waste silage will also be also worked out.

# ***Review of literature***

# 2. REVIEW OF LITERATURE

Fish silage preparation is a cheaper means of utilizing fish waste when conventional fish meal is expensive or unavailable. It can be prepared either from ground fish or its by products by the addition of organic or mineral acids or a carbohydrate source for fermentation. This can replace more conventional source of protein for pigs, chicken, ducks, sheep, cow, beef cattle and even camels. Biological trials and literatures on utilization of fish waste silage in Japanese quail appeared to be scanty. Hence, the available literatures on other species have also been reviewed.

## 2.1 PREPARATION OF FISH SILAGE

Whittemore and Taylor (1976b) prepared deoiled herring offal silage by adding formic acid at the rate of 35 kg per tonne of filleted herring fish. The liquefied silage was heated to 75°C and centrifuged. The effluent was again heated to 70°C and fractions obtained other than oil were mixed to make deoiled herring silage. They observed that the gross energy and nitrogen in the herring silage diet was more digestible than that in the fish meal when 25 per cent silage was included in swine ration.

Kumar and Sampath (1979) made use of *Lactobacillus plantarum* cultures, molasses and water to prepare fish waste silage from cannary waste. Deoiled rice bran was mixed with silage in the ratio of 1:4 to make a final protein content of 31.8 per cent.

Johnsen and Skrede (1981) preserved fish viscera of cod and haddock by mixing minced viscera with formic acid (0.75 per cent) and propionic acid (0.75

per cent) to make concentrated and non concentrated fish silage. The autolysed material was heated to 95°C and fat was removed by centrifugation.

Strom and Eggum (1981) prepared fish viscera silage from cod and saithe fish by adding a mixture of formic acid and propionic acid (1:1) to minced viscera. They conducted an experiment in rats and reported that the nutritional value of fish silage has been improved by lipid removal and storage.

Samuels *et al*. (1982) ensiled crab or fish waste with either maize stover or groundnut hulls alone and added 5 per cent dry molasses or 1 per cent formic acid. The wastes were also ensiled with johnson grass with or without molasses.

Batterham *et al*. (1983) prepared acid fish silage from selected fish species or prawn offal by adding 38 g per kg of 0.85 per cent formic acid to obtain a final pH of less than 4 and investigated the nutritive value of fish silage prepared from ocean perch nannygai for grower pigs.

Lindgren and Pleje (1983) ensiled baltic herring offal by mixing cereals pre-fermented with *Pedicoccus acidilactii* and *Lactobacillus plantarum* cultures using sorbic and propionic acids as antifungal additives. The rapid fall in pH eliminated fish pathogens.

Johnson *et al*. (1985) prepared acid fish silage by adding formic acid (3.5 litre per 100 kg filleted fish waste) and fermented fish silage by adding molasses and *Lactobacillus plantarum* cultures. In both cases wheat bran was used as filler material.

Ward *et al*. (1985) ensiled the ground viscera of white fish, northern pike tullibee and walleye by adding 7.5 kg formic acid and 7.5 kg propionic acid at pH 4.5.

Hassan and Heath (1986) evaluated the biological fermentation of whole fish, viscera and heads using *lactobacillus plantarum* cultures and suggested that a minimum amount of 5 per cent lactose is necessary for successful fermentation and an antimycotic agent must be added to arrest mould growth.

Green *et al*. (1988) prepared oily fish silage by mixing mackerel fish waste with 85 per cent formic acid at a rate of 35 g per kg wet weight. The mean pH value maintained was 3.38 during 105 days storage period.

Strasdine *et al*. (1988) prepared silage from dog fish offal by adding 1.3 per cent of formic acid and concluded that the biological value of dog fish silage was lower than that of the more traditional protein source. An experiment with rats showed reduction in palatability.

Espe *et al*. (1990) prepared acid fish silage from herring fish, saithe fish, capelin and norway pout, respectively and observed a reduction in the digestibility of silage stored for more than three months.

Machin *et al*. (1990) produced high oil fish silage and low oil fish silage from mackerel and herring, respectively, using 85 per cent formic acid and ground cassava meal was used as filler material. They suggested that the reduced performance of chicks fed on fish silages dried on substrate was due to lipid oxidation.

Espe *et al*. (1992) showed that fish silage could be prepared from frozen saithe by adding 25 g per kg formic acid (85 per cent), 2 g per kg potassium sorbate and 0.2 g per kg ethoxyquin. They conducted a trial in broiler chicks and concluded that the replacement of dietary fish meal with fish silage did not reduce dietary quality of the feed for young growing chicken.

Bello *et al*. (1993) prepared microbial fish silage from under-utilised fish by mixing with fruit waste and juice (papaya and pineapple) at 35°C. The addition of fruit was related to silage liquefaction or hydrolysis and addition did not have any effect on pH.

Fagbenro and Jauncey (1994) prepared fermented fish silage by mixing 300 g of minced Tilapia fish waste with 45 g molasses, corn flour or tapioca flour and utilizing 15 g *Lactobacillus plantarum* as inoculum. It was kept at 39°C for 30 days anaerobically and soybean meal was used as filler material.

According to Rose *et al*. (1994) acid fish silage could be prepared by mixing with formic acid (76 ml per 100kg) and fermented fish silage could be prepared by adding *Lactobacillus plantarum* and P*ediococcus acidilactica* cultures to a mixture of barley, dried malt and water and conducted a trial in pigs with diet that contained 0, 6, 8, 10 or 12 per cent dry matter of acid fish silage or same levels of fermented fish silage. They concluded that fish silage reduced the productive performance of young pigs compared with the diets containing fish meal.

According to Perez (1995) the fish silage prepared using organic or mineral acids are known as acid fish silage and those which require the addition of carbohydrate and anaerobic storage conditions are known as fermented fish silage and both the types can replace conventional source of protein in pigs, ducks, sheep, cow and camel rations.

Hammoumi *et al.* (1998) prepared fish silage from chopped pilchard waste by adding 15 per cent molasses using *Lactobacillus plantarum* cultures and conducted a growth trial in broilers using the silage incorporated with bran and barley.

White *et al*. (1998) prepared acid dog fish silage by adding 25 per cent w/w of 85 per cent concentrated formic acid and 200 mg per kg ethoxyquin as anti-oxidant to raw ground dog fish and fermented silage was prepared by adding a commercial bio preservative Marisil[@] and extruded wheat to the same batch of ground fish.

Kjos *et al*. (1999) fed grower pigs with salmon byproduct silage preserved by 15 to 25 g per kg wet weight of formic acid and found no significant difference in growth performance or carcass quality.

Magana *et al*. (1999) prepared formic hydrochloric acid silage and formic sulphuric acid silage from tuna by-products by adding hydrochloric acid and sulphuric acid, respectively, to get pH 2 and then formic acid was added to make the final pH 3 and dried with sorghum. An experiment was conducted in broilers using this silage at 0, 5, 10 and 15 per cent levels replacing soybean meal.

White *et al*. (1999) preserved silver hake fish by ensiling with 85 per cent formic acid added at the rate of 2.5 per cent w/w using 200 ppm ethoxyquin as anti oxidant to make acid fish silage and then prepared fermented fish silage by adding 15 per cent extruded wheat, then 1 per cent Marisil[@] (bio preservative) and 1 per cent w/w of formic acid.

Borin *et al*. (2000) fed pigs with fresh water fish silage prepared by mixing partly eviscerated fish, sugar palm syrup and rice bran in the ratio 50:10:40 on fresh basis and packed tightly to maintain an anaerobic environment.

Lien *et al*. (2000) prepared acid fish silage by mixing ground whole fish with 2 per cent of formic acid or 3 per cent by weight of formic acid-sulphuric acid mixture and utilized it in swine ration replacing 0, 50 and 100 per cent of crude protein from fish meal of control diet.

Ngoan *et al*. (2000) reported that shrimp by-product silage could be prepared by mixing with sugar cane molasses in the ratio of 3:1 (wet weight basis) or with cassava root meal in the ratio of 1:1 (wet weight of shrimp by-product to air dry weight of cassava meal) but the proportion of cassava meal reduced the crude protein concentration.

## 2.2 CHEMICAL COMPOSITION OF FISH SILAGE

### 2.2.1 Proximate Composition

Vedhanayagam *et al*. (1976) reported the percentage chemical composition of fish silage prepared from thrash fish. The crude protein, crude fibre, total ash, ether extract, nitrogen free extract, insoluble ash, calcium and phosphorus were 63.90, 0.08, 18.01, 5.84, 12.17, 0.49, 4.28 and 4.28 per cent, respectively.

Whittemore and Taylor (1976a) determined the chemical composition of fish silage on dry matter basis and observed the protein, ether extract, ash and total dry matter per cent as 67.50, 3.75, 16.50 and 22.40, respectively.

Tatterson (1982) observed the per cent moisture, oil, ash and protein content of various fish silages as 69.4 to 80.8, 0.5 to 13.0, 2.2 to 4.2 and 13.5 to 17.4, respectively.

Johnsen and Skrede (1981) estimated the proximate composition of concentrated fish silage on dry matter basis. The per cent dry matter, crude protein, ether extract and ash were 43.4 to 46.6, 72.3 to 74.5, 4.6 to 7.3 and 8.6, respectively. They also estimated the drymatter, crude protein, ether extract and ash content of unconcentrated silage as 13.1 to 15.1, 16.9 to 76.3, 3.8 to 13.9 and 8.6 to 10.0 per cent, respectively.

Johnson *et al.* (1985) determined the nutritive value of acid and fermented fish silages mixed with wheat bran. The dry matter, crude protein, ether extract, calcium and total phosphorus of acid and fermented fish silages were 93.6 and 62.5, 37.1 and 32.3, 21.0 and 20.3, 2.69 and 2.58, 1.66 and 1.34 per cent, respectively.

Green *et al.* (1988) estimated the proximate composition of the oily fish silage, prepared from mackerel fish. The crude protein, ether extracts and ash contents were 43.5, 4.4 and 6.7 per cent, respectively.

Rose *et al.* (1994) analysed the chemical composition of two fish silages preserved by formic acid and natural fermentation and reported the dry matter content as 21.7 and 30.8 per cent, respectively. The crude protein, ash and ether extract content on dry matter basis were 55.8 and 35.5, 12.7 and 10.3, 14.3 and 8.2 per cent in formic silage and naturally fermented silage, respectively.

Hammoumi *et al.* (1998) conducted an experiment in broilers with pilchard waste silage with an average dry matter, ash, fat, protein, fibre and reducing sugar content of 38.38, 7.94, 6.12, 11.34, 0.08 and 10.79 per cent, respectively.

White *et al.* (1999) reported that the acid fish silage from silver hake contained 21.8 per cent dry matter, 19.1 per cent ash, 66.5 per cent crude protein, 13.4 per cent crude fibre and 1.0 per cent carbohydrate whereas that from fermented fish silage contained 32.9 per cent dry matter, 17.5 per cent ash, 43.9 per cent crude protein, 9.3 per cent crude fibre and 29.3 per cent carbohydrate.

Ngoan *et al.* (2001) replaced fish meal in swine ration with ensiled shrimp by product. The per cent dry matter, crude protein, ether extract, ash, calcium and phosphorus were 28.0, 26.9, 2.8, 21.0, 6.5 and 1.0 per cent, respectively.

According to Sakthivel (2003) the dry matter, crude protein, ether extract, crude fibre, total ash, nitrogen free extract and acid insoluble ash of cuttle fish waste silage prepared by adding formic acid were 84.88, 25.32, 2.8, 15.04, 17.38, 39.46 and 9.38 per cent, respectively.

## 2.3 FATTY ACID COMPOSITION

Machin *et al*. (1990) assessed the performance of broiler chicks fed on low and high oil fish silages in relation to changes taking place in lipid and protein com- ponents and reported that the losses of unsaturated fatty acids especially $C_{18-3}$, $C_{18-4}$, $C_{20-3}$, $C_{20-4}$, $C_{20-5}$ and $C_{22-6}$ were more in high oil fish silage than fish meal.

Nwokola and Sim (1990) compared the nutritive value of fermented fish wastes, fermented whole herring and herring fish meal and observed that the fatty acids, $C_{14:0}$, $C_{20:4\omega3}$, $C_{20:5\omega3}$ and $C_{22:6\omega3}$ were higher in fermented products than fish meal. $C_{18:2}$ was rich in herring products than fish scraps.

## 2.4 OTHER MARINE WASTES UTILISED IN ANIMAL RATION

Ayyaluswami *et al*. (1979) reported that prawn shell meal with 36.0 per cent crude protein and 13.73 per cent crude fibre can replace fish meal with 40.24 per cent crude protein and 2.34 per cent crude fibre at 5 per cent levels in pig ration.

Rosenfield *et al*. (1997) conducted a trial in broilers replacing 0, 10, 20, 30 and 40 per cent of the crude protein contributed by soybean meal in their diet by shrimp meal and observed that shrimp meal can replace soybean meal partially or completely in their diets.

Narahari *et al.* (1991) observed no significant difference in weight gain and livability of broilers when chitin was included in the ration at 0, 2, 4 and 6 per cent levels.

Ochetim (1992) fed broilers and layers with locally produced fish waste meal replacing meat and bone meal. No significant difference was observed in both the cases and he concluded that fish waste meal was as good as meat and bone meal for egg and meat type birds.

Mohan (1999) conducted a trial in egger-type chicks by including squilla meal at 0, 25, 50, 75 and 100 per cent levels replacing fish meal protein and suggested 25 per cent replacement as economical without altering egg production or quality.

Periyasamy (2004) fed broilers with sardine fish head meal at 0, 5, 7.5, and 10 per cent levels in maize-soyabean based diets and reported 7.5 per cent inclusion level as advantageous.

Reddy *et al.* (2004) included squilla meal in White Leghorn layer diets at 0, 4, 4.5, 8.89 and 13.34 per cent levels replacing fish meal and concluded that it can be included upto 8.89 per cent levels without affecting egg production.

2.5.1 BODY WEIGHT

### 2.5.2 Effect of Fish Meal on Body Weight of Japanese Quails

Babu *et al*. (1987) observed the body weight of Japanese quails at sixth week as 123.1g when fed with a ration containing 6 per cent fish meal. The net crude protein content of feed was 26 per cent and ME 2450 kcal/kg.

According to Elangovan *et al*. (2002) the live weight gain (g per bird) in Japanese quails fed a standard diet containing 186.1 g per kg crude protein and 11.27 MJ/kg metabolisable energy was 26.2 g from 7-20 weeks of age. The birds were maintained on a ration containing 72 per cent basal mixture, which contained 5 per cent fish meal.

Erener *et al*. (2003) reported the eighth week body weight as 181.4 g and recorded a gain of 43.2 g from 8 to 20 weeks of age in Japanese quails fed with a ration that contained 3 per cent fish meal and an overall crude protein content of 24 per cent.

### 2.5.2 Effect of Fish Silage on Growth and Body Weight in Chicken

Vedhanayagam *et al*. (1976) fed White Leghorn chicks with starter ration containing fish silage prepared from trash fish and suggested that the body weight of chicks fed fish silage was higher than those fed fish meal. Silage was included at 7 and 10 per cent levels as a substitute for fish meal.

Johnson *et al.* (1985) observed no significant difference in live weight or live weight gain of broiler chicks fed acid or fermented fish silage in a trial where acid fish silage and fermented fish silage were incorporated into wheat–based diets at 25, 50 and 100 per cent levels at the expense of soybean meal.

In a trial, White Leghorn male chicks from 0 to 4 weeks of age were fed high protein diets where fish silage contributed 5, 10, 20 and 40 per cent of crude protein and reported that the chicks maintained on 20 per cent protein from concentrated viscera silage showed higher body weight than those fed the reference diet (Krogdahl, 1985a).

Krogdahl (1985b) conducted experiments in meat–type chicks where fish silage constituted 0, 10, 20 or 40 per cent of dietary crude protein and in ducks where fish viscera silage constituted 0, 20 or 40 per cent of dietary crude protein. A higher weight gain was observed in birds fed silage diets than those fed with reference diet.

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Machin *et al.* (1990) observed that the gain of chicks fed on balanced diet containing 4.7 or 9.4 per cent crude protein from high oil fish silage (9.8 and 19.6 per cent of dietary dry matter) and 5.2 or 10.4 per cent crude protein from low oil fish silage (6.8 and 13.5 per cent of dietary dry matter) were 99 and 85 per cent and 98 and 91 per cent respectively, of the gains achieved with corresponding fish meal.

Rodriguez *et al*. (1990) conducted a biological test in broilers to evaluate fish silage at two inclusion levels (2.5 and 5 per cent). They recorded the weight gain and feed consumption and observed best biological response in broilers fed 5 per cent shrimp fish silage.

Tanaka *et al*. (1990) fed White Leghorn chicks of 4 weeks of age with diet containing 0 (control), 0.2, 0.5, 1.0 or 2.0 per cent fermented chub mackerel (CME). They observed improved body weight gain with CME supplemented groups.

Espe *et al.* (1992) found no significant weight gain in chicken when herring offal silage was substituted for 0, 50, 100, 200, 300 and 400 g per kg of fish meal protein. Chicken fed fish meal showed significantly lower weight gain when saithe offal silage substituted 150 and 300 g per kg of fish meal protein.

Ochetim (1992) observed no significant difference in the body weight of layer and broiler birds when meat and bone meal was replaced by locally produced fish waste meal in an isocaloric and isonitrogenous ration.

Ahmed and Mahendrakar (1996) fed broilers with an isonitrogenous and isocaloric diet replacing 25 and 50 per cent of fish meal in the ration by fish viscera silage. A five per cent reduction in growth was noticed as the feed consumption was lower for silage fed groups but this difference was not statistically significant.

Raj *et al*. (1996) recorded the live weight in broilers fed fermented fish silage as 2.296 kg and those fed fish meal as 1.984 kg at 8 weeks of age in a trial where 50 per cent of the fish meal was replaced by fish viscera silage.

Hammoumi *et al*. (1998) conducted a biological trial in broilers and observed a net increase in the weight of birds fed fish silage supplemented with barley flour and bran than those fed with commercial feed.

Magana *et al*. (1999) observed no significant difference between treatments when fish silage mixed with sorghum was fed to broilers at 5, 10 and 15 per cent levels but a slighter weight gain was noticed at 5 per cent level.

Mohan (1999) replaced fish meal with squilla meal protein in egger type chick rations at 0, 25, 50, 75 and 100 per cent levels. The body weight gain in these levels was 511.3, 494.8, 509.5, 475.4, 476.4 g, respectively. He also reported that body weight gain was not affected when squilla meal replaced fish meal in egger type chicks.

## 2.6 FEED CONSUMPTION

### 2.6.1 Effect of Fish Silage on Feed Consumption in Japanese Quails

Singh *et al.* (1999) reported the feed consumption in Japanese quail layers fed with a basal ration containing 10 per cent fish meal as 21.4 g per bird per day.

Elangovan *et al.* (2002) observed an average feed intake of 27 g per bird per day during 7-20 weeks period in Japanese quails when fed with a ration containing 5 per cent fish meal.

Erener *et al*. (2003) reported that the average feed intake of Japanese quails fed a basal diet containing 12.5MJ/kg of ME and 20 per cent crude protein was 43.2 g per bird per 112 days. The level of inclusion of fish meal was 3 per cent in the basal diet.

### 2.6.2 Effects of Fish Silage on Feed Consumption in Chicken

Vedhanayagam *et al*. (1976) incorporated fish silage at 0, 7 or 10 per cent levels in chick ration instead of fish meal and observed an increased feed consumption in White Leghorn chicks fed fish silage than those given fish meal.

Johnson *et al*. (1985) could not observe any significant effect in feed intake of broiler chicken fed 0, 25, 50 or 100 per cent acid or fermented fish silage than those fed fish meal when incorporated into wheat based diet at the expense of soybean meal.

Krogdahl (1985a) observed no difference in feed intake when fish viscera silage contributed 0 or 40 per cent of crude protein in high protein diets of White Leghorn birds.

Espe *et al*. (1992) found no significant difference in feed consumption of chicken when 0, 50,100, 200, 300 and 400 g per kg of fish meal protein was substituted by herring offal silage.

In a study, Ochetim (1992) could not observe any significant difference in the feed intake of both layer and broiler birds when meat and bone meal was replaced by locally available fish waste. The feed to gain ratio was numerically better in birds fed locally available fish waste than those on meat and bone meal for broilers.

Ahmed and Mahendrakar (1996) replaced 25 and 50 per cent of fish meal in an isocaloric and isonitrogenous diet with fermented fish silage and observed no significant difference in feed intake of broilers fed fish silage than those fed fish meal but the feed intake was apparently lower in fish silage fed groups. They suggested that 50 per cent or lower amount of fish meal could be replaced by fish silage.

Raj *et al*. (1996) conducted an experiment on broilers replacing 50 per cent of fish meal in the diet with fermented fish silage and observed a higher feed consumption for fish silage fed birds. Feed consumption of silage group was more by 19.4 per cent compared to control. Feed conversion efficiency was also better in silage fed group.

Magana *et al*. (1999) reported that the feed intake of broilers fed tuna fish waste silage mixed with sorghum (silage-sorghum ratio of 70:30) showed no significant difference between treatments when included at 5, 10 and 15 per cent levels.

According to Kjos *et al.* (2001) the feed intake was not affected when fish silage replaced fish meal in layer ration. There was significant reduction in the feed intake when fish silage was given along with different levels of fish fat.

Reddy *et al*. (2004) concluded that feed consumption was not affected in White Leghorn layers when squilla meal was included in the diet at 0, 4.45, 8.89 and 13.34 per cent levels, replacing fish meal.

## 2.7 EGG PRODUCTION

### 2.7.1 Effect of Fish Meal on Egg Production in Japanese Quails

Shrivastav *et al*. (1993) observed the per cent hen day egg production as 65.02 in Japanese quails when fed with a ration containing 7 per cent fish meal.

Singh *et al*. (1999) observed that the egg production was not affected by the partial or complete replacement of fish meal with sundried poultry excreta in the diet of Japanese quail layers. The inclusion level of fish meal was 10 per cent.

Elangovan *et al*. (2002) reported an average hen day egg production of 88.9 per cent during 7-20 weeks production period when fed with a basal diet containing 5 per cent fish meal.

Erener *et al*. (2003) fed Japanese quails with a basal diet containing 2 per cent fish meal from 8 to 20 weeks of age. The overall egg production reported was 88.3 per cent.

### 2.7.2 Effect of Fish Silage on Egg Production in Chicken

According to Krogdahl (1985a) the total egg production and laying rate in chicken fed 20 per cent protein from concentrated fish viscera silage was as high as the hens fed the reference diet with fish meal. There was a drop in the egg production of group fed 40 per cent protein from fish viscera silage during the ninth period.

Ochetim (1992) found no significant difference in total egg production when locally available fish waste replaced meat and bone meal in layer ration.

The hen housed production percentage was 61.9 and 62.2 in meat and bone meal and locally available fish waste meal based diets, respectively.

Kjos *et al*. (2001) observed that the egg production in White Leghorn layers was not affected when fish silage replaced fish meal at a level of 12 per cent of dietary protein. The hen day egg production observed was 91.5 and 92.1 for fish meal and fish silage groups, respectively.

## 2.8 EGG WEIGHT

### 2.8.1 Effect of Fish Meal on Egg Weight in Japanese Quail

According to Shrivastav *et al*. (1993) the average egg weight was 10.28 g in breeding Japanese quails when fed with a ration containing 7 per cent fish meal.

Elangovan *et al*. (2002) recorded an average egg weight of 11.6 g when 5 per cent fish meal was included in Japanese quail layer ration.

Erener *et al*. (2003) reported the egg weight in Japanese quails as 11.5 g when fed with a ration containing 2 per cent fish meal.

### 2.8.2 Effect of Fish Silage and Fish Wastes on Egg Weight in Chicken

Krogdahl (1985a) observed no significant difference in egg weight of White Leghorn layers when 0, 20 or 40 per cent of dietary protein was contributed by fish silage.

Ochetim (1992) replaced meat and bone meal with locally available fish waste meal in layer ration and observed no significant difference in the egg weight between diets. The average egg weight was 56.2 and 58.7 g for meat and bone meal and fish waste groups, respectively.

Mohan (1999) found no significant difference in the egg weight among treatment groups when squilla meal was included at 0, 25, 50, 75 and 100 per cent levels replacing fish meal in layer ration.

Kjos *et al*. (2001) observed no significant difference in egg weight between treatments when fish meal was replaced by fish silage in layer rations. A significant reduction in egg weight was observed when fish silage was given along with added levels of fish fat.

## 2.9 EGG QUALITY

### 2.9.1 Effect of Fish Meal on Egg Quality in Japanese Quails

Das and Dash (1989) observed no significant difference in egg components and the proportionate component yields of egg except albumen weight and volume when fish meal was replaced by earthworm meal in Japanese quail diets.

According to Shrivastav *et al*. (1993) the shape index, albumen index and yolk index of Japanese quail eggs fed 7 per cent fish meal were 77.79, 0.107 and 0.447, respectively.

Singh *et al*. (1999) observed that the egg quality traits like albumen index, yolk index and internal quality unit were not significantly affected by the partial or complete replacement of fish meal with sun dried poultry excreta in the diet of Japanese quails.

Elangovan *et al.* (2002) recorded the shape index, albumen index, yolk index, internal quality unit and shell thickness in Japanese quails fed with a basal diet containing 5 per cent fish meal as 77.9, 0.129, 0.478, 62.3 and 0.193 mm, respectively.

According to Erener *et al.* (2003) the shape index and shell thickness of Japanese quail eggs were 80.47 and 186.2 µm, respectively, when fed with a diet containing 2 per cent fish meal from 8 to 20 weeks of age.

### 2.9.2 Effect of Fish Waste and Fish Silage on Egg Quality in Chicken

Mohan (1999) concluded that the egg quality parameters except yolk index and yolk colour did not differ significantly among the squilla meal protein fed groups in egger type layers.

Kjos *et al*. (2001) observed the albumen thickness as 7.5 and 8.07 mm and the Haugh unit scores as 87 and 90 in fish meal and fish silage fed groups, respectively. No significant difference in egg quality was noticed when fish silage replaced fish meal in layer diets.

According to Reddy *et al.* (2004) egg quality parameters did not show any specific trend when fish mixture was replaced by squilla meal in White Leghorn layers.

## 2.10 FATTY ACID PROFILE

### 2.10.1 Fatty Acid Profile in Japanese Quails

Durairaj and Martin (1975) suggested that myristic, palmitic, palmitoleic, stearic, oleic, linoleic, eicosatrienoic and arachidonic acid constitute 95 per cent of fatty acids in Japanese quail carcass.

Adachi *et al.* (1978) reported that the principle fatty acids in Japanese quail egg yolk as $C_{18:1}$, $C_{16:0}$, $C_{16:1}$, $C_{18:0}$ and $C_{18:2}$ with predominance of $C_{18:1}$ and $C_{16:1}$.

According to Choi *et al*. (2001) the palmitic, oleic, linoleic and linolenic acid content of quail egg yolk was 27.4, 8.30, 44.5, 9.1 and 0.2 per cent when maintained on commercial grain based diets.

Aydin and Cook (2004) analysed the fatty acid profile of quail yolk and liver in birds maintained on corn soya canola diets. They reported the myristic, palmitic, oleic and linoleic acid content of quail liver as 0.36, 24.99, 33.28 and 15.90 per cent, respectively and the palmitic, stearic, oleic, linoleic and linolenic acid content of quail yolk as 29.54, 11.66, 42.20, 9.99 and 0.50 per cent, respectively.

### 2.10.2 Effect of Fish Silage on Fatty Acid Profile in Chicken

Krogdahl (1985a) observed that the $C_{16:1}$ and $C_{18:2}$ content was higher and $C_{22:1}$ was lower in yolk and abdominal fat of chicken fed fish viscera silage high in fat than those fed with the reference diet that contained herring fish meal.

According to Kjos *et al*. (2001) the White Leghorn birds fed fish silage based diets showed lower $C_{22:1}$ content in egg yolk than those fed fish meal. Other fatty acids did not differ significantly.

## 2.11 LIVABILITY

Johnson *et al*. (1985) observed no significant difference in the livability pattern of broilers when acid or fermented fish silages were incorporated into wheat-based diets at 0, 25, 50 or 100 per cent levels at the expense of soybean meal.

Ochetim (1992) fed broilers and layers with locally available fish waste meal replacing meat and bone meal. In both the cases there was no significant difference in the livability of birds.

Ahmed and Mahendrakar (1996) replaced fish meal with 25 and 50 per cent levels of fish silage in an isocaloric and isonitrogenous broiler diet. The livability pattern was 10 per cent for fish meal group and 15 and 12.5 per cent in 25 and 50 per cent fish silage groups, respectively.

## 2.12 ECONOMICS

Vedhanayagam *et al*. (1976) observed that the cost of feed per kilogram gain in body weight was lower in broiler chicken fed 7 per cent and 10 per cent trash fish silage than those fed 10 per cent fish meal. This was due to the better feed efficiency in silage fed groups.

Mohan (1999) fed squilla meal to egger type birds at 0, 25, 50 and 100 per cent levels replacing fish meal. The feed cost per egg was 79 paise for fish meal and 25 per cent replacement groups. Other inclusion levels resulted in economic loss.

# *Materials and methods*

# 3. MATERIALS AND METHODS

An experiment was carried out at the Department of Poultry science, College of Veterinary and Animal Sciences, Kerala Agricultural University, Mannuthy, to study the effect of inclusion of dried cuttle fish waste silage in Japanese quail layer ration.

## 3.1 EXPERIMENTAL MATERIALS

### 3.1.1 Birds

A total of 240 Japanese quail pullets received from University Poultry Farm, Mannuthy were utilized for the study. The birds were housed at five weeks of age for cage adaptation.

### 3.1.2 Rations

Quail layer rations with crude protein 22 per cent and metabolisable energy 2650 kcal per kg feed formed the experimental rations. Cuttle fish waste silage was added to the control diet replacing dried fish to form isocaloric and isonitrogenous diets. The details of treatment groups and experimental diets are given below.

$T_1$ = Control ration containing unsalted dried fish at a level of 8 per cent as animal protein source.

$T_2$ = Ration in which 50 per cent of crude protein from unsalted dried fish was replaced with dried cuttle fish waste silage.

$T_3$ = Ration in which 100 per cent of crude protein from unsalted dried fish was replaced with dried cuttle fish waste silage.

The ingredient composition of the rations is given in Table 1. Chemical composition of cuttle fish waste silage and the formulated rations was determined AOAC, (1990) and are presented in Tables 2 and 3, respectively.

### 3.1.3 Dried Cuttle Fish Waste Silage

Dried cuttle fish waste silage was obtained from Central Institute of Fisheries Technology (CIFT), Cochin under National Agricultural Technology Project (NATP).

#### *3.1.3.1 Preparation of cuttle fish waste silage*

The waste left after the commercial processing of cuttle fish excluding its bones were heated with commercial grade formic acid at the rate of 3 per cent v/w. Thorough mixing was done to maintain the pH below 4 and the silage took 4-7 days for liquefaction. The liquid silage thus obtained was mixed with rice bran in the ration 2:1 and dried under sunlight.

## 3.2 EXPERIMENTAL DESIGN

The experiment was conducted during the laying phase of Japanese quails from six to twenty six weeks of age. Two hundred and forty Japanese quail pullets were wing banded, weighed individually and distributed randomly to three treatments groups with four replicates of twenty birds in each.

Each replicate was housed in separate cage of dimension 60x60x20cm, maintaining uniform standard management conditions. The birds were fed experimental feed *ad libitum* and clean drinking water was provided throughout the experimental period. Data collection was done for five periods of twenty eight days each from six to twenty six weeks of age.

The following observations were recorded during the course of the experiment.

### 3.2.1 Body Weight

Body weight of all birds at sixth and twenty sixth week of age was recorded ($BW_6$ and $BW_{26}$).

### 3.2.2 Age at Sexual Maturity

The age at first egg, 10 per cent production and 50 per cent production (days) were recorded in each replicate and from this data mean age at sexual maturity was determined.

### 3.2.3 Egg Production

Egg production was recorded daily from seven to twenty six weeks of age replicate wise and expressed as hen housed and hen day egg production.

### 3.2.4 Egg Weight

At the end of each twenty eighth day laying period all the eggs laid from the treatment groups were collected for three consecutive days, weighed individually with 0.01g accuracy. Based on these data mean egg weight was worked out.

### 3.2.5 Feed Consumption

The weight of feed issued was recorded replicate wise in each period and the balance feed available in the feeders at the end of each period was measured. From this data mean daily feed consumption per bird was calculated.

### 3.2.6 Egg Quality

At the end of each twenty eighth day period five eggs were randomly collected from each replicate for egg quality study. Shape, albumen and yolk indices, internal quality unit and shell thickness were measured. The heights of albumen and yolks were measured using Ame's tripod stand micrometer. The widths of yolk and albumen were measured by using hand slide calipers. The shell thickness was measured using Mitutoyo digimatic micrometer.

The formulae applied for calculating shape, albumen and yolk indices were

$$\text{Shape index} = \frac{\text{Greatest width of the egg (mm) X 100}}{\text{Greatest length of the egg (mm)}}$$

$$\text{Albumen index} = \frac{\text{Maximum height of thick albumen (mm)}}{\text{Maximum width of thick albumen (mm)}}$$

$$\text{Yolk index} = \frac{\text{Maximum height of yolk (mm)}}{\text{Maximum diameter of yolk (mm)}}$$

The internal quality unit of quail egg was calculated (Kondaiah *et al*., 1981) by using the formula.

$$\text{Internal quality unit (IQU)} = 100 \log (H+4.18-0.8989W^{0.6674})$$

Where, H stands for height of the albumen in millimeters and W for weight of egg in gram.

### 3.2.7 Livability

The period-wise per cent livability was recorded based on the number of birds alive for each period after recording the mortality of birds from different treatment groups. Post mortem examination was conducted in each case to find out cause of death.

## 3.3 FATTY ACID PROFILE

At the end of the trial five yolks from each replicate was pooled and a sample was taken for fatty acid profile analysis. Similarly, livers of two birds were collected from each replicate, pooled and subjected for the analysis. Fatty acid methyl esters were prepared from yolk samples (Wang et al., 2000) and liver lipids were extracted from triturated samples (Folch et al., 1957) and then esterified to fatty acid methyl esters. The esterified samples were loaded in Gas chromatograph equipped with flame ionization detector, Column;SP$^{TM}$- 2380 capillary column, 30m x 0.25 x 0.2 µm film thickness.

## 3.4 ECONOMICS

The cost advantage of raising Japanese quail by incorporating cuttle fish waste silage replacing dried fish in layer diet was calculated based on the prevailing cost of the feed ingredients and quail eggs during the study period.

## 3.5 STATISTICAL ANALYSIS

Data collected on various parameters were statistically analysed by Completely Randomised Design (CRD) as described by Snedecor and Cochran (1985). Means were compared by Least Significant Difference (LSD) test using MSTAT-C.

Table 1. Ingredient composition of experimental rations, %

| Ingredients | T1 | T2 | T3 |
|---|---|---|---|
| Maize | 45.50 | 44.00 | 39.00 |
| Wheat bran | 5.25 | 1.00 | - |
| Soybean meal | 34.00 | 35.25 | 36.50 |
| Dry fish | 8.00 | 4.00 | - |
| Cuttle fish waste silage | - | 8.50 | 17.00 |
| Shell grit | 5.50 | 5.50 | 5.75 |
| Mineral mixture* | 1.50 | 1.50 | 1.50 |
| Salt | 0.25 | 0.25 | 0.25 |
| TOTAL | 100 | 100 | 100 |
| Nicomix A+B+D3+K** | 10 g | 10 g | 10 g |
| Nicomix BE*** | 20 g | 20 g | 20 g |
| Toxiroak**** | 50 g | 50 g | 50 g |

Mineral mixture*: Supermin P mineral mixture without salt (Kwality Agrovet industries, Salem) Composition: Calcium: 30.0 %, Phosphorus: 9.0 %, Iron: 0.2 %, Iodine: 0.01 %, Zinc: 0.05 %, Manganese: 0.4 %, Copper: 0.4 %, Flourine (max): 0.05 %, Acid Insoluble Ash (max): 2.5 % and Moisture: 3 %.

Nicomix A+B+D3+K** (Nicholas Primal India Ltd., Mumbai)

Composition per gram: Vitamin A: 82,000 IU, Vitamin D3: 12,000 I,
Vitamin B2: 50 mg, Vitamin K: 10 mg

Nicomix BE***: Vitamin B1–4 mg, Vitamin B6–8 mg,Vitamin B12–40 mcg, Niacin 60 mcg, Calcium pantothenate 40 mg and Vitamin E 40

Toxiroak****: Hydrated sodium, calcium, aluminium silicate and herbal ingredients.

Table 2. Chemical composition of dried cuttle fish waste silage, %
(on dry matter basis)

| Components | Composition |
|---|---|
| Dry matter | 90.02 |
| Crude protein | 22.54 |
| Ether extract | 2.76 |
| Crude fibre | 16.43 |
| NFE | 40.65 |
| Total ash | 17.62 |
| Acid insoluble ash | 7.51 |
| Calcium | 0.45 |
| Phosphorus | 1.62 |

Table 3. Chemical composition of Japanese quail layer rations, %
(on dry matter basis)

| Components | T1 | T2 | T3 |
|---|---|---|---|
| Dry matter | 90.77 | 91.05 | 90.39 |
| Crude protein | 22.07 | 21.98 | 22.01 |
| Ether extract | 5.74 | 3.56 | 3.45 |
| Crude fibre | 3.79 | 5.23 | 5.67 |
| NFE | 56.51 | 57.22 | 56.01 |
| Total ash | 11.87 | 12.01 | 12.86 |
| Acid insoluble ash | 3.63 | 3.92 | 4.57 |
| Calcium | 3.18 | 3.23 | 3.02 |
| Phosphorus | 0.67 | 0.72 | 0.63 |
| ME (Kcal/ kg)* | 2698.35 | 2689.85 | 2652.4 |

- Calculated values

# ***Results***

# 4. RESULTS

The results of an experiment carried out to study the effect of dietary inclusion of dried cuttle fish waste silage replacing dried fish on production performance of Japanese quails are presented in this chapter.

## 4.1 BODY WEIGHT

Data on mean body weight at six weeks and twenty six weeks of age as influenced by different dietary treatments viz., control ration (T1), quail layer ration replacing 50 per cent dried fish with dried cuttle fish waste silage (T2) and quail layer ration replacing 100 per cent dried fish with dried cuttle fish waste silage (T3) are presented in Table 4.

The mean body weight of birds belonging to the treatments T1, T2 and T3 at six weeks of age was 160.05, 159.67 and 160.58 g, respectively. The corresponding values at twenty six weeks of age were 204.77, 201.42 and 199.43 g, respectively.

The body weight of quails in different treatments was comparatively uniform at the beginning of the experiment. But at the end of twenty-six weeks the birds maintained on control ration T1, recorded numerically higher body weight when compared to other treatment groups. However, the statistical interpretation of the results showed no significant difference among the treatments at both ages.

The data on mean body weight of birds at sixth and twenty-sixth week of age as influenced by dietary inclusion of dried cuttle fish waste silage replacing dried fish is graphically represented in Fig. 1.

Table 4. Mean (± S.E.) body weight and body weight gain of Japanese quails as Influenced by dietary inclusion of dried cuttle fish waste silage from 7 to 26 weeks of age, g

| Parameter | Dried cuttle fish waste silage (%) in experimental diets | | |
|---|---|---|---|
| | 0 (T1) | 8.5 (T2) | 17 (T3) |
| Body weight at 6 weeks | 160.05±0.94 | 159.67±0.63 | 160.58±0.99 |
| Body weight at 26 weeks | 204.77±1.88 | 201.42±4.01 | 199.43±3.9 |
| Body weight gain 7 to 26 weeks | 44.73±2.61 | 41.76±4.4 | 38.85± 4.7 |

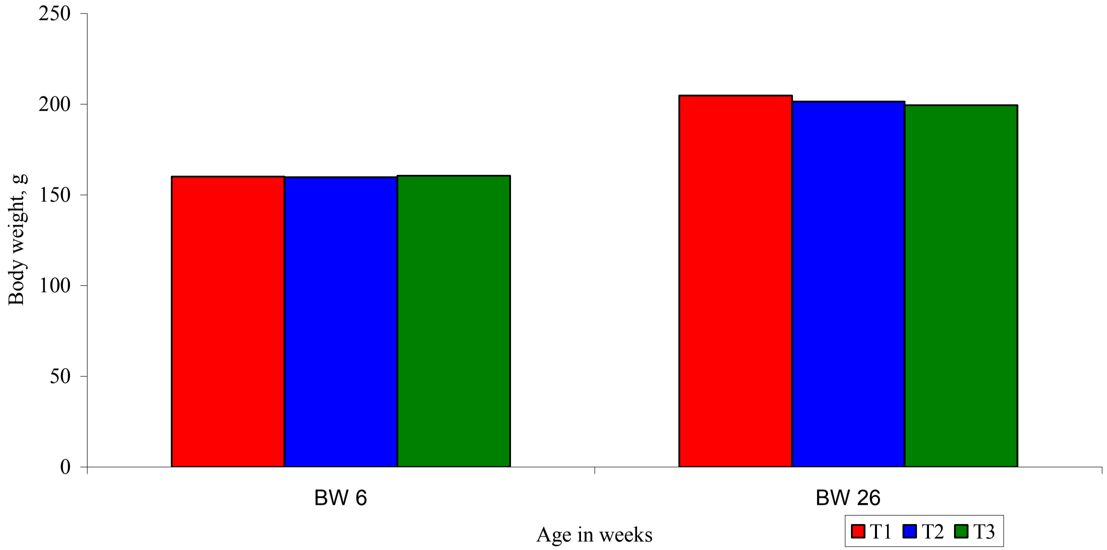


Fig. 1. Mean body weight of Japanese quails as Influenced by dietary inclusion of dried cuttle fish waste silage from 7 to 26 weeks of age, g

## 4.2 BODY WEIGHT GAIN

The mean body weight gain of birds during the twenty weeks laying period among different dietary groups is presented in Table 4.

The mean body weight gain of Japanese quail was 44.73, 41.76 and 38.85 g, for the groups T1, T2 and T3, respectively. The gain in weight was proportionately less with increasing levels of dried cuttle fish waste silage in quail rations. However, the statistical analysis of the data revealed that the magnitude of difference between treatments was not significant.

## 4.3 AGE AT FIRST EGG

The mean age at first egg recorded in the treatment groups were 45.25, 43.50 and 46.25 days for T1, T2 and T3, respectively (Table 5). The birds belonged to group T2 attained sexual maturity first followed by the control group T1. There was a slight delay for group T3 in attaining sexual maturity. The statistical interpretation of the results showed that group T2 differed significantly from group T3. The mean age at first egg was statistically similar between groups T1 and T2. Likewise, there was no significant difference between groups T1 and T3. The mean age at first egg is graphically depicted in Fig. 2.

## 4.4 AGE AT 10 PER CENT AND 50 PER CENT PRODUCTION

The data pertaining to mean age at 10 per cent and 50 per cent production as influenced by the dietary inclusion of dried cuttle fish waste silage are presented in Table 5 and is graphically represented in Fig. 2.

Table 5. Mean (±S.E.) age at first egg, 10 and 50 per cent production of Japanese quails as influenced by dietary inclusion of dried cuttle fish waste silage, days

| Parameter | Dried cuttle fish waste silage (%) in experimental diets | | |
|---|---|---|---|
| | 0 (T1) | 8.5 (T2) | 17 (T3) |
| Age at first egg | 45.25±1.03 [ab] | 43.50±0.29 [b] | 46.25±0.48 [a] |
| Age at 10 per cent production | 49.21±1.93 | 45.50±1.19 | 51.25±1.32 |
| Age at 50 per cent production | 62.50±1.19 | 65.75±2.18 | 71.75±3.93 |

a,b Means within a row with no common superscripts differ significantly ($p<0.01$)

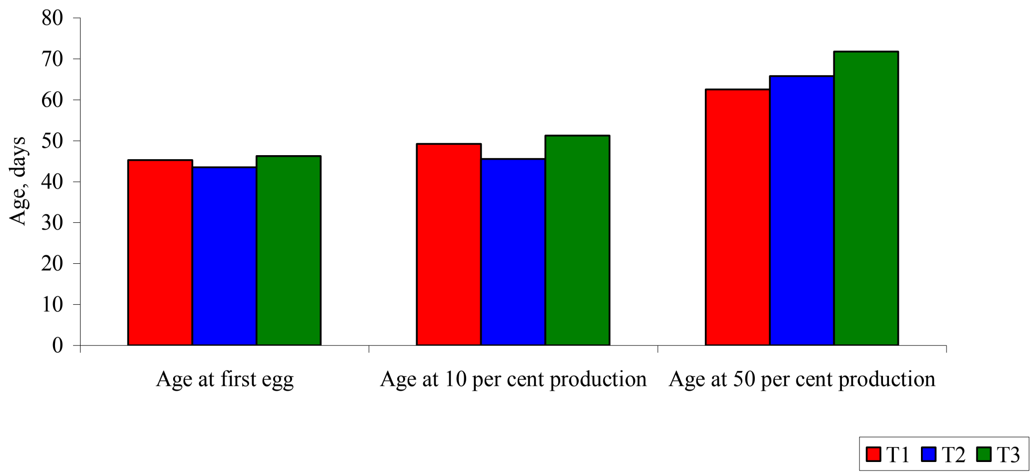


Fig. 2. Mean age at first egg, 10 and 50 per cent production (days) of Japanese quails as influenced by dietary inclusion of dried cuttle fish waste silage from 7 to 26 weeks of age

The mean age at 10 per cent production showed that the birds under group T2 attained 10 per cent production earlier (45.50 days), than control group T1(49.21 days). The birds maintained on T3 diet attained 10 per cent production on a later date (51.25 days).

The mean age at 50 per cent production for the groups T1, T2 and T3 were 62.50, 65.75 and 71.75 days, respectively. It could be seen that the group T1 attained 50 per cent production first followed by T2 and then T3.

The statistical analysis of the data on age at 10 per cent and 50 per cent production showed no significant difference among three dietary treatment groups.

## 4.5 FEED CONSUMPTION

The period wise mean daily feed consumption of Japanese quails as influenced by dietary inclusion of dried cuttle fish waste silage from seven to twenty six weeks of age are presented in Table 6.

The mean daily feed consumption per bird among different dietary treatments T1, T2 and T3 were 24.71, 24.99 and 22.77 g, respectively, from seven to ten weeks of age. The corresponding figures during the period from eleven to fourteen weeks were 25.42, 25.05, 24.15 g, respectively. The mean daily feed intake for the period from fifteen to eighteen weeks, nineteen to twenty two weeks and twenty three to twenty six weeks were 29.90, 30.08 and 29.08 g; 31.42, 31.63 and 29.49 g and 33.52, 29.26 and 29.60 g, respectively.

The statistical analysis of the data showed that control group (T1) and the group in which fifty per cent of dried fish protein was replaced by cuttle fish waste silage (T2) showed no significant difference between them in feed intake up to fourth period (seven to twenty two weeks of age) whereas the feed intake of

Table 6. Mean (± S.E.) feed consumption per bird per day of Japanese quails as influenced by dietary inclusion of dried cuttle fish waste silage from 7 to 26 weeks of age, g

| Age in weeks | Dried cuttle fish waste silage (%) in experimental diets | | |
|---|---|---|---|
| | 0 (T1) | 8.5 (T2) | 17 (T3) |
| 7-10 | $24.71 \pm 0.37^{a}$ | $24.99 \pm 0.25^{a}$ | $22.77 \pm 0.26^{b}$ |
| 11-14 | $25.42 \pm 0.15^{a}$ | $25.05 \pm 0.17^{a}$ | $24.15 \pm 0.12^{b}$ |
| 15-18 | $29.90 \pm 0.28^{A}$ | $30.08 \pm 0.17^{A}$ | $29.08 \pm 0.28^{B}$ |
| 19-22 | $31.42 \pm 0.33^{a}$ | $31.63 \pm 0.59^{a}$ | $29.49 \pm 0.57^{b}$ |
| 23-26 | $33.52 \pm 0.39^{a}$ | $29.26 \pm 0.41^{b}$ | $29.60 \pm 0.71^{b}$ |
| 7-26 (Overall) | $29.00 \pm 0.14^{A}$ | $28.15 \pm 0.25^{B}$ | $27.02 \pm 0.20^{C}$ |

A, B, C Means within a row with no common superscripts differ significantly ($p<0.05$)
a, b Means within a row with no common superscripts differ significantly ($p<0.01$)

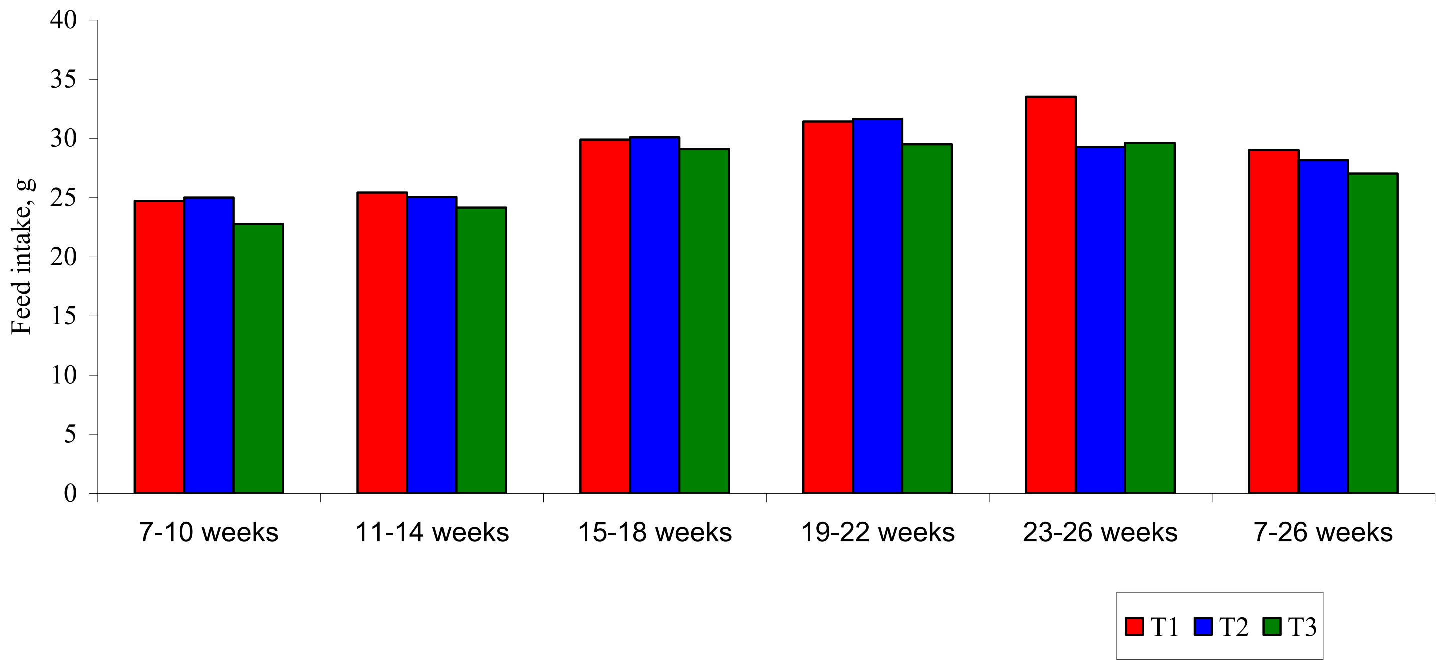


Fig. 3. Mean feed consumption per bird per day of Japanese quails as influenced by dietary inclusion of dried cuttle fish waste silage from 7 to 26 weeks of age, g

group T3 was significantly lower than groups T1 and T2. During the last period of 23 to 26 weeks of age T2 showed a sudden reduction in feed intake and it was, statistically comparable with T3. In the last period the feed intake in the control group T1 was statistically higher.

The mean daily feed intake of Japanese quails from seven to twenty six weeks of age as influenced by the dietary inclusion of cuttle fish waste silage was 29.00, 28.15, and 27.02 g for the groups T1, T2 and T3, respectively. The mean daily feed intake was highest in the control group T1 followed by T2 and then T3. The differences were statistically significant ($p<0.01$). The mean daily feed intake of Japanese quails from seven to twenty six weeks of age as influenced by dietary treatments is graphically represented in Fig. 3.

## 4.6 FEED EFFICIENCY

The mean feed efficiency values expressed as feed per dozen eggs due to incorporation of dried cuttle fish waste silage in Japanese quails from seven to twenty six weeks of age are presented in Table 7 and depicted in Fig. 4. Statistical analysis revealed significant differences in feed efficiency due to dietary inclusion of cuttle fish waste silage replacing dried fish.

The mean cumulative feed conversion efficiency for the groups T1, T2 and T3 were 0.53, 0.53 and 0.61, respectively. The feed efficiency of the group T3 (0.61) was significantly inferior ($P<0.01$) as compared to treatment groups T1 and T2 (0.53).

Table 7. Mean (± S.E.) feed efficiency of Japanese quails as influenced by dietary inclusion of dried cuttle fish waste silage from 7 to 26 weeks of age, (kg of feed/dozen eggs)

| Age in weeks | Dried cuttle fish waste silage (%) in experimental diets | | |
|---|---|---|---|
| | 0 (T1) | 8.5 (T2) | 17 (T3) |
| 7-10 | $1.19\pm0.02^{c}$ | $1.38\pm0.03^{b}$ | $1.80\pm0.03^{a}$ |
| 11-14 | $0.44\pm0.02^{b}$ | $0.46\pm0.02^{b}$ | $0.58\pm0.02^{a}$ |
| 15-18 | $0.46\pm0.01^{B}$ | $0.48\pm0.05^{AB}$ | $0.52\pm0.02^{A}$ |
| 19-22 | $0.47\pm0.01^{b}$ | $0.48\pm0.01^{b}$ | $0.61\pm0.03^{a}$ |
| 23-26 | $0.48\pm0.01^{a}$ | $0.42\pm0.01^{b}$ | $0.47\pm0.02^{ab}$ |
| 7-26 (Overall) | $0.53\pm0.01^{b}$ | $0.53\pm0.02^{b}$ | $0.61\pm0.01^{a}$ |

A, B, C Means within a row with no common superscripts differ significantly ($p<0.05$)

a, b Means within a row with no common superscripts differ significantly ($p<0.01$)

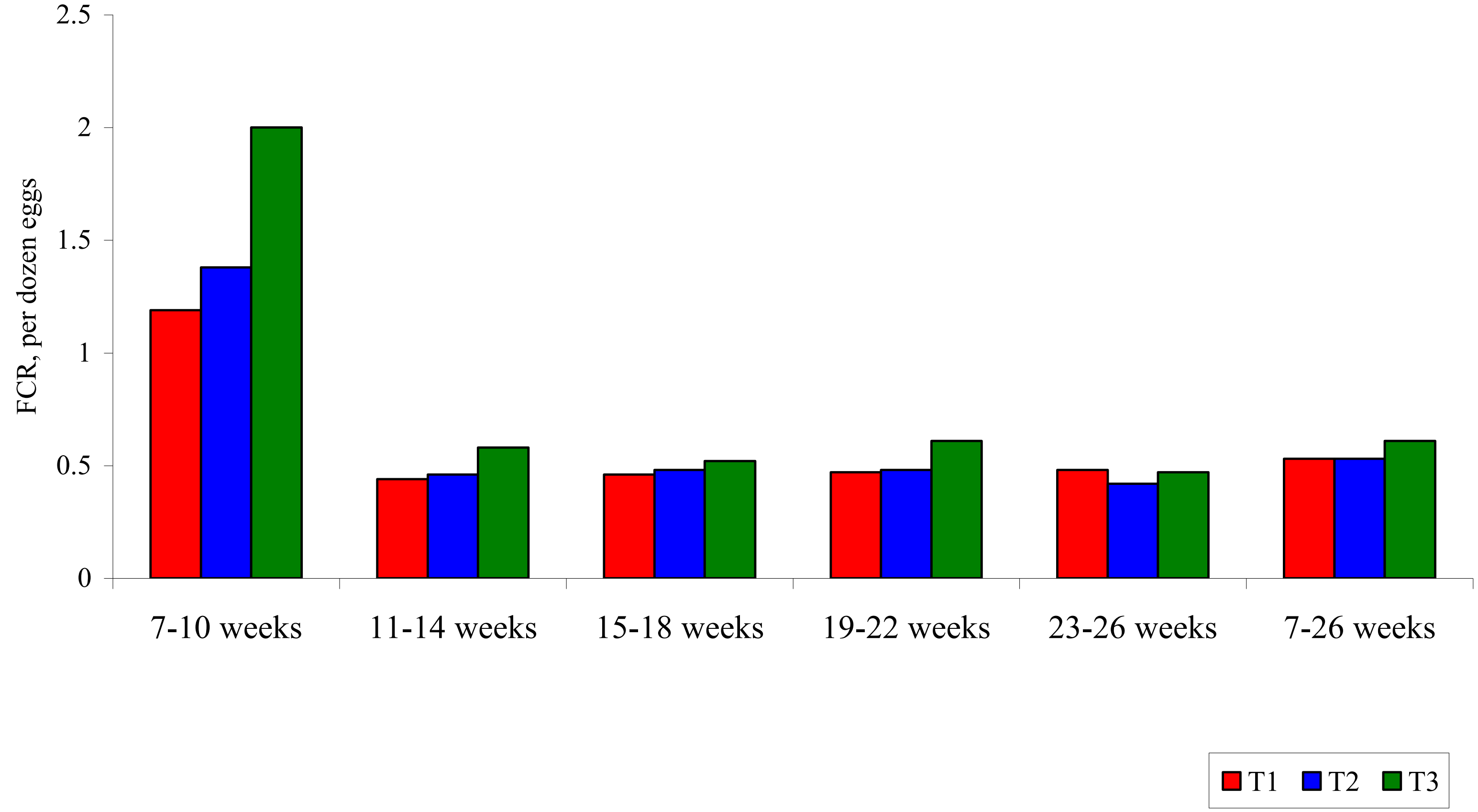


Fig. 4. Mean feed efficiency of Japanese quails as influenced by dietary inclusion of dried cuttle fish waste silage from 7 to 26 weeks of age, kg of feed/ dozen eggs

## 4.7 EGG PRODUCTION

The data on mean hen housed and hen day egg number (eggs per bird) and per cent hen housed and hen day egg production from seven to twenty six weeks of age among the treatment groups T1, T2 and T3 are presented in Table 8, 9, 10 and 11, respectively.

### 4.7.1 Hen Housed Egg Production

In this study, the birds in group T1 recorded the highest hen housed egg production (eggs/bird) (90.32) followed by birds in group T2 (88.52) and T3 (74.06). The hen housed egg production of Japanese quail layers showed significant difference among treatment groups in all the periods and overall study period except 15 to 18 weeks of age. The hen housed egg production was highly significant ($P<0.01$) during the periods seven to ten weeks, 19 to 22 weeks and 23 to 26 weeks. But the difference was significant ($P<0.05$) during 11 to 14 weeks of age. The overall hen housed egg production from seven to twenty six weeks of age showed highly significant ($P<0.01$) difference among treatment groups. Hen housed egg production of birds in the control group T1 and those maintained on a diet supplemented with 50 per cent cuttle fish waste silage replacing dried fish were statistically comparable. Complete replacement of fish meal with cuttle fish waste silage resulted in a reduction in hen housed egg number.

The mean per cent hen housed egg production as influenced by varying dietary treatments also showed similar trends to that of hen housed egg number. However, the statistical analysis of this data on mean per cent hen housed egg production for the period from seven to twenty six weeks of age showed no significant difference among the treatment groups. The mean per cent hen housed egg production were 64.38, 63.21 and 52.94 for the treatment groups T1, T2 and T3, respectively.

### 4.7.2 Hen Day Egg Production

The overall mean hen day egg number for the treatments T1, T2 and T3 were 93.52, 91.98 and 76.80, respectively. Statistical analysis of the data showed highly significant differences among the treatments throughout the experimental period. The hen day egg number was significantly more with T1 and T2 as compared to T3 ($p<0.01$).

The data on mean per cent hen day egg production of Japanese quail from seven to twenty six weeks of age revealed that the birds in group T1 (control) recorded highest egg production (66.86 per cent) followed by birds in group T2 (65.34 per cent) and T3 (54.89 per cent). Statistical analysis of the per cent hen day egg production revealed that significant differences existed among the treatment groups in all the periods. Control birds recorded significantly higher egg production in all the periods. Per cent hen day egg production was significantly inferior with group T3 throughout the experiment period ($p<0.01$). The egg production among birds in group T2 was statistically comparable with control group except during the period seven to ten weeks of age. However, when the magnitude of difference in mean per cent hen day egg production for the period from seven to twenty six weeks of age was tested statistically it failed to show any significant difference. The graphical representation of the data is given in Fig. 6.

Table 8. Mean (± S.E.) hen housed egg production of Japanese quails as influenced by dietary inclusion of dried cuttle fish waste silage from 7 to 26 weeks of age, eggs/bird

| Age in weeks | Dried cuttle fish waste silage (%) in experimental diets | | |
|---|---|---|---|
| | 0 (T1) | 8.5 (T2) | 17 (T3) |
| 7-10 | 6.99±0.05[a] | 6.18±0.05[b] | 4.26±0.05[c] |
| 11-14 | 18.98±0.79[A] | 18.08±0.93[A] | 14.75±0.58[B] |
| 15-18 | 20.77±0.56 | 20.72±0.58 | 18.65±0.66 |
| 19-22 | 21.30±0.20[a] | 21.24±0.47[a] | 16.60±0.64[b] |
| 23-26 | 21.24±0.47[a] | 22.3±0.42[a] | 20.24±0.28[b] |
| 7-26 (Overall) | 90.32±0.48[a] | 88.52±2.26[a] | 74.06±1.56[b] |

A, B Means within a row with no common superscripts differ significantly ($p<0.05$)

a, b, c Means within a row with no common superscripts differ significantly ($p<0.01$)

Table 9. Mean (± S.E.) hen day egg production of Japanese quails as influenced by dietary inclusion of dried cuttle fish waste silage from 7 to 26 weeks of age, eggs/bird

| Age in weeks | Dried cuttle fish waste silage (%) in experimental diets | | |
|---|---|---|---|
| | 0 (T1) | 8.5 (T2) | 17 (T3) |
| 7-10 | 7.04±0.04[a] | 6.02±0.05[b] | 4.29±0.03[c] |
| 11-14 | 19.29±0.77[a] | 18.95±0.42[a] | 15.06±0.73[b] |
| 15-18 | 21.30±0.51[a] | 21.26±0.19[a] | 19.30±0.29[b] |
| 19-22 | 22.35±0.26[a] | 21.27±0.55[a] | 16.82±0.46[b] |
| 23-26 | 23.43±0.10[a] | 23.6±0.11[a] | 21.33±0.44[b] |
| 7-26 (Overall) | 93.52±0.60[a] | 91.98±0.43[a] | 76.80±0.63[b] |

a , b, c Means within a row with no common superscripts differ significantly ($p<0.01$)

Table 10. Mean (± S.E.) hen housed egg production of Japanese quails as influenced by dietary inclusion of dried cuttle fish waste silage from 7 to 26 weeks of age, %

| Age in weeks | Dried cuttle fish waste silage (%) in experimental diets | | |
|---|---|---|---|
| | 0 (T1) | 8.5 (T2) | 17 (T3) |
| 7-10 | 25.00±0.14$^{a}$ | 22.03±0.17$^{b}$ | 15.18±0.15$^{c}$ |
| 11-14 | 67.7±2.82$^{A}$ | 64.55±3.57$^{A}$ | 52.68±2.06$^{B}$ |
| 15-18 | 74.19±1.97 | 73.98±2.04 | 66.62±2.33 |
| 19-22 | 76.08±0.70$^{a}$ | 75.87±1.67$^{a}$ | 57.73±2.30$^{b}$ |
| 23-26 | 78.88±0.48$^{A}$ | 79.64±1.48$^{A}$ | 72.48±0.98$^{B}$ |
| 7-26 (Overall) | 64.38 | 63.21 | 52.94 |

A, B Means within a row with no common superscripts differ significantly ($p<0.05$)

a, b, c Means within a row with no common superscripts differ significantly ($p<0.01$)

Table 11. Mean (± S.E.) hen day egg production of Japanese quails as influenced by dietary inclusion of dried cuttle fish waste silage from 7 to 26 weeks of age, %

| Age in weeks | Dried cuttle fish waste silage (%) in experimental diets | | |
|---|---|---|---|
| | 0 (T1) | 8.5 (T2) | 17 (T3) |
| 7-10 | 25.0±0.13[a] | 22.12±0.17[b] | 15.28±0.90[c] |
| 11-14 | 69.29±3.12[a] | 65.90±2.35[a] | 53.78±2.01[b] |
| 15-18 | 76.06±1.80[a] | 75.90±0.69[a] | 69.21±1.28[b] |
| 19-22 | 80.64±0.55[a] | 78.47± 0.21[a] | 60.06±1.64[b] |
| 23-26 | 83.31±0.37[a] | 84.29±0.38[a] | 76.16±1.55[b] |
| 7-26 (Over all) | 66.86 | 65.34 | 54.89 |

a, b, c Means within a row with no common superscripts differ significantly ($p<0.01$)

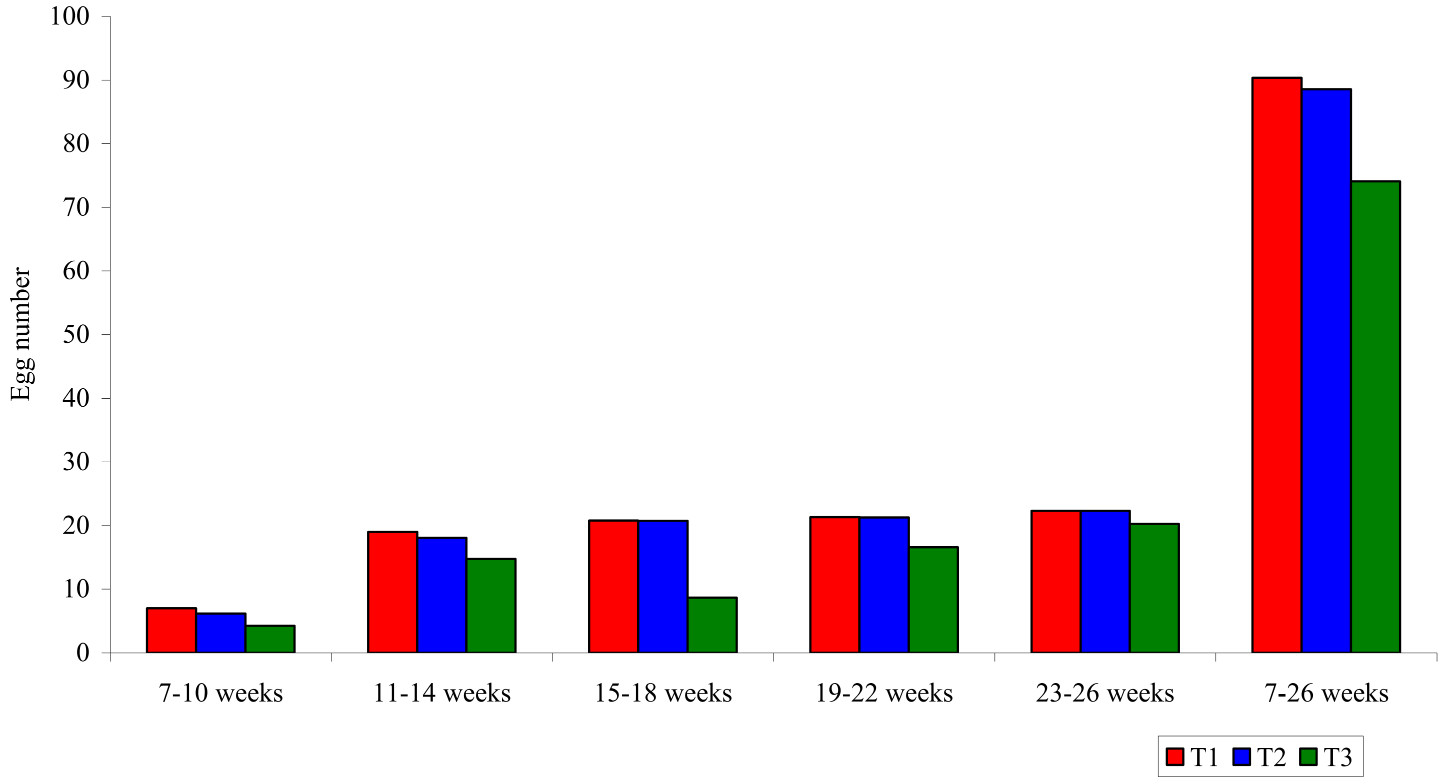


Fig. 5. Mean hen housed egg production of Japanese quails as influenced by dietary inclusion of dried cuttle fish waste silage from 7 to 26 weeks of age, eggs/bird

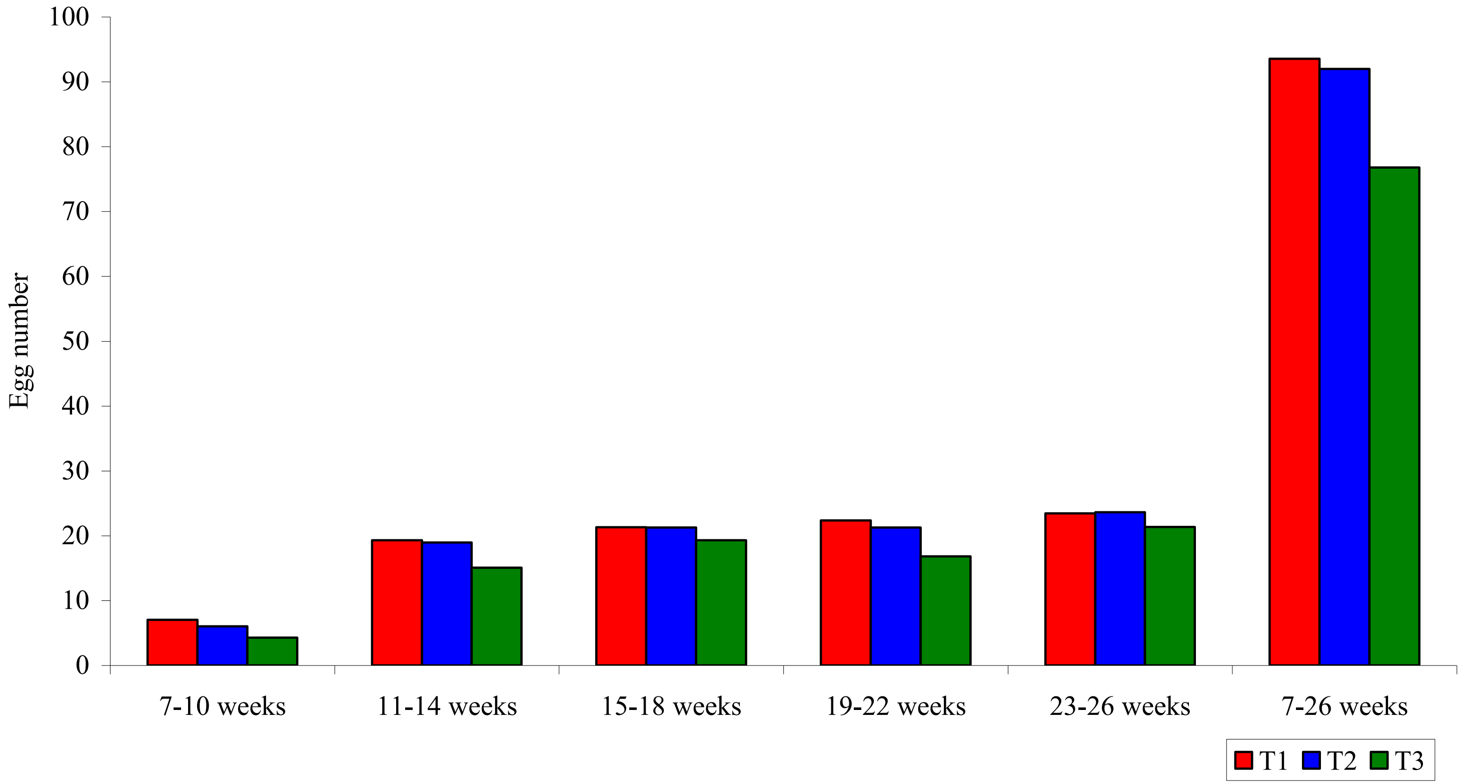


Fig. 6. Mean hen day egg production of Japanese quails as influenced by dietary inclusion of dried cuttle fish waste silage from 7 to 26 weeks of age, eggs/bird

## 4.8 EGG WEIGHT

The mean egg weight (g) of birds as influenced by dietary inclusion of dried cuttle fish waste silage from seven to twenty six weeks of age are given in Table 12 and is represented graphically in Fig. 7.

The mean egg weight was 10.82, 10.81 and 10.73 g in treatment groups T1, T2 and T3, respectively. Statistical analysis of the data showed no significant difference between the treatment groups.

The period wise egg weight ranged from 10.47 to 10.99, 10.41 to 11.07 and 10.14 to 11.03 g in T1, T2 and T3, respectively. Statistical interpretation of the results showed no significant difference between treatment groups in any of the periods.

## 4.9 EGG QUALITY CHARACTERISTICS

### 4.9.1 Shape Index

The mean shape index values of eggs obtained from quail layers as influenced by different dietary treatments from seven to twenty six weeks of age are presented in Table 13.

The mean shape index values for the treatment groups T1, T2 and T3 were 78.89, 78.61 and 78.55, respectively. There was no significant difference due to dietary treatments on shape index throughout the period of study.

Table 12. Mean (± S.E.) egg weight of Japanese quails as influenced by dietary inclusion of dried cuttle fish waste silage from 7 to 26 weeks of age, g

| Age in weeks | Dried cuttle fish waste silage (%) in experimental diets | | |
|---|---|---|---|
| | 0 (T1) | 8.5 (T2) | 17 (T3) |
| 7-10 | 10.47±0.19 | 10.41±0.23 | 10.14±0.23 |
| 11-14 | 10.81±0.09 | 10.71±0.22 | 10.92±0.19 |
| 15-18 | 10.71±0.16 | 10.88±0.20 | 10.87±0.22 |
| 19-22 | 10.99±0.12 | 11.07±0.20 | 11.03±0.22 |
| 23-26 | 10.98±0.16 | 10.99±0.23 | 10.78±0.19 |
| 7-26 (Overall) | 10.82±0.12 | 10.81±0.20 | 10.73±0.18 |

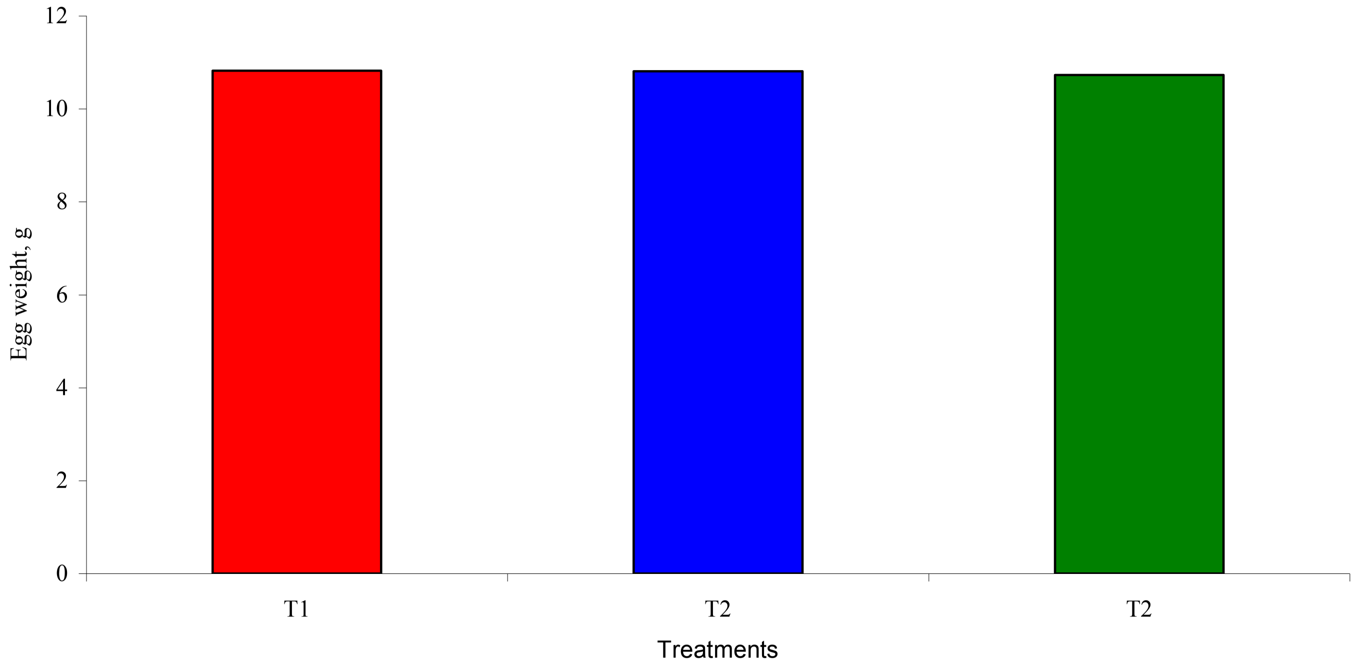


Fig. 7. Mean egg weight of Japanese quails as influenced by dietary inclusion of dried cuttle fish waste silage from 7 to 26 weeks of age, g

### 4.9.2 Albumen Index

The mean albumen index values in eggs collected from Japanese quail as influenced by the dietary inclusion of dried cuttle fish waste silage from seven to twenty six weeks of age are presented in Table 14.

The mean albumen index for the treatment groups T1, T2 and T3 were 0.131, 0.138 and 0.136, respectively. The statistical analysis failed to reveal any significant difference among albumen index values due to dietary treatments.

### 4.9.3 Yolk Index

The mean yolk index in eggs of Japanese quails as influenced by the dietary inclusion of dried cuttle fish waste silage from seven to twenty six weeks of age are presented in Table 15.

In the study period of seven to twenty six weeks of age the mean yolk index values were 0.456, 0.470 and 0.469 for the treatment groups T1, T2 and T3, respectively. The statistical analysis revealed no significant difference in yolk index of treatment groups in any of the period.

### 4.9.4 Internal Quality Unit (IQU)

The mean internal quality unit in eggs of Japanese quail as influenced by the dietary incorporation of dried cuttle fish waste silage from seven to twenty six weeks of age are presented in Table 16.

Table 13. Mean (± S.E.) shape index of Japanese quails as influenced by dietary inclusion of dried cuttle fish waste silage from 7 to 26 weeks of age

| Age in weeks | Dried cuttle fish waste silage (%) in experimental diets | | |
|---|---|---|---|
| | 0 (T1) | 8.5 (T2) | 17 (T3) |
| 7-10 | 79.78±0.44 | 79.32±0.32 | 79.23±0.47 |
| 11-14 | 79.39±0.37 | 79.03±0.22 | 79.02±0.45 |
| 15-18 | 79.97±0.30 | 78.62±0.39 | 78.53±0.35 |
| 19-22 | 78.22±0.27 | 78.11±0.17 | 78.09±0.24 |
| 23-26 | 78.08±0.33 | 77.97±0.19 | 77.88±0.17 |
| 7-26 (Overall) | 78.89±0.33 | 78.61±0.26 | 78.55±0.26 |

Table 14. Mean (± S.E.) albumen index of Japanese quails as influenced by dietary inclusion of dried cuttle fish waste silage from 7 to 26 weeks of age

| Age in weeks | Dried cuttle fish waste silage (%) in experimental diets | | |
|---|---|---|---|
| | 0 (T1) | 8.5 (T2) | 17 (T3) |
| 7-10 | 0.117±0.00 | 0.142±0.02 | 0.122±0.01 |
| 11-14 | 0.124±0.01 | 0.129±0.00 | 0.130±0.01 |
| 15-18 | 0.133±0.01 | 0.133±0.00 | 0.136±0.01 |
| 19-22 | 0.142±0.01 | 0.139±0.01 | 0.143±0.01 |
| 23-26 | 0.146±0.00 | 0.147±0.00 | 0.147±0.00 |
| 7-26 (Overall) | 0.131±0.01 | 0.138±0.00 | 0.136±0.00 |

Table 15. Mean (± S.E.) yolk index of Japanese quails as influenced by dietary inclusion of dried cuttle fish waste silage from 7 to 26 weeks of age

| Age in weeks | Dried cuttle fish waste silage (%) in experimental diets | | |
|---|---|---|---|
| | 0 (T1) | 8.5 (T2) | 17 (T3) |
| 7-10 | 0.424±0.01 | 0.419±0.01 | 0.431±0.01 |
| 11-14 | 0.438±0.01 | 0.449±0.01 | 0.450±0.02 |
| 15-18 | 0.450±0.01 | 0.480±0.01 | 0.470±0.01 |
| 19-22 | 0.466±0.01 | 0.498±0.00 | 0.494±0.01 |
| 23-26 | 0.504±0.01 | 0.505±0.01 | 0.503±0.01 |
| 7-26 (Overall) | 0.456±0.01 | 0.470±0.02 | 0.469±0.01 |

Table 16. Mean (± S.E.) internal quality unit of Japanese quails as influenced by dietary inclusion of dried cuttle fish waste silage from 7 to 26 weeks of age

| Age in weeks | Dried cuttle fish waste silage (%) in experimental diets | | |
|---|---|---|---|
| | 0 (T1) | 8.5 (T2) | 17 (T3) |
| 7-10 | 57.34±0.32 | 58.33±0.30 | 57.83±0.22 |
| 11-14 | 59.43±0.31 | 59.38±0.29 | 59.20±0.41 |
| 15-18 | 60.47±0.50 | 60.60±0.29 | 60.13±0.24 |
| 19-22 | 61.18±0.33 | 61.56±0.23 | 61.29±0.25 |
| 23-26 | 62.4±0.22 | 62.52±0.26 | 62.28±0.30 |
| 7-26 (Overall) | 60.16±0.86 | 60.45±0.75 | 60.14± 0.77 |

Table 17. Mean (± S.E.) shell thickness of Japanese quails as influenced by dietary inclusion of dried cuttle fish waste silage from 7 to 26 weeks of age, mm

| Age in weeks | Dried cuttle fish waste silage (%) in experimental diets | | |
|---|---|---|---|
| | 0 (T1) | 8.5 (T2) | 17 (T3) |
| 7-10 | 0.194±0.01 | 0.191±0.01 | 0.190 ±0.01 |
| 11-14 | 0.191±0.01 | 0.187±0.01 | 0.185±0.01 |
| 15-18 | 0.183±0.00 | 0.184±0.01 | 0.183±0.01 |
| 19-22 | 0.179±0.00 | 0.181±0.00 | 0.180±0.01 |
| 23-26 | 0.175±0.00 | 0.178±0.00 | 0.177±0.00 |
| 7-26 (Overall) | 0.184±0.00 | 0.184±0.00 | 0.183±0.00 |

The internal quality unit of eggs of Japanese quail from seven to twenty six weeks of age for the treatment groups T1, T2 and T3 were 60.16, 60.45 and 60.14, respectively. The statistical analysis revealed no significant difference among treatment groups.

### 4.9.5 Shell Thickness

The mean shell thickness values in eggs of Japanese quails as influenced by the dietary inclusion of dried cuttle fish waste silage from seven to twenty six weeks of age are presented in Table 17.

The mean egg shell thickness for the treatment groups T1, T2 and T3 were 0.184, 0.184 and 0.183 mm, respectively. On statistical analysis, shell thickness did not differ significantly among different dietary treatments.

## 4.10 FATTY ACID PROFILE

### 4.10.1 Quail Liver

The mean fatty acid composition of Japanese quail liver as influenced by the dietary inclusion of dried cuttle fish waste silage is given in Table 18. The mean per cent composition of saturated fatty acids for T1, T2 and T3 were 32.36, 33.87 and 33.49 per cent and the corresponding poly-unsaturated fatty acid contents were 22.13, 21.57 and 21.15 per cent, respectively. The monounsaturated fatty acid content was highest in T3 (44.76 per cent) followed by T2 (43.73 per cent) and T1 (41.99 per cent). Statistical analysis of the data showed no significant difference between treatments with respect to saturated fatty acid (SFA) and polyunsaturated fatty acid (PUFA) composition. On the other hand, monounsaturated fatty acid (MUFA) content of T3 was statistically higher than T1 ($p<0.01$).

The statistical interpretation of the results on individual fatty acids, myristic, palmitic, linolenic, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) showed no significant difference among treatment groups but the oleic acid content was significantly higher in group T3 than T1.

The per cent composition of unidentified fatty acids content was statistically higher in the liver of birds fed control ration T1 (3.53) than T2 (0.83) and T3 (0.87).

### 4.10.2 Quail Yolk

The mean egg yolk fatty acid profile of Japanese quail as influenced by the dietary inclusion of dried cuttle fish waste silage are presented in Table 19.

The per cent composition of palmitic, stearic, oleic, linoleic, linolenic, EPA and DHA contents did not exhibit any statistical difference among treatment groups. The same trend was noticed with respect to total saturated and unsaturated fatty acid composition. Similar to liver tissues, the unidentified fraction of fatty acids in the egg yolk of quail birds fed control ration T1 (3.21 percent) was statistically higher than T2 (1.72 per cent) and T3 (0.81 per cent).

## 4.11 LIVABILITY

The mean livability percentage of Japanese quails from seven to twenty six weeks of age, as influenced by dietary inclusion of dried cuttle fish waste silage are presented in Table 20.

Table 18. Mean (± S.E.) liver fatty acid profile of Japanese quails as influenced by dietary inclusion of dried cuttle fish waste silage, %

| Fatty acids | $T_1$ | $T_2$ | $T_3$ |
|---|---|---|---|
| Myristic | 0.62±0.17 | 0.70±0.10 | 0.40±0.08 |
| Palmitic | 31.74±1.50 | 33.17±0.47 | 33.09±0.89 |
| Oleic | 41.99±0.59$^{b}$ | 43.73±0.41$^{ab}$ | 44.76±0.74$^{a}$ |
| Linoleic | 15.57±0.82 | 15.01±0.30 | 15.45±0.85 |
| *EPA | 3.99±0.59 | 3.63±0.17 | 3.28±0.33 |
| **DHA | 2.58±0.41 | 2.93±0.24 | 2.41±0.25 |
| ***SFA | 32.36±1.41 | 33.87±0.57 | 33.49±0.93 |
| ****MUFA | 41.99±0.59$^{b}$ | 43.73±0.41$^{ab}$ | 44.76±0.74$^{a}$ |
| *****PUFA | 22.13±1.72 | 21.57±0.27 | 21.15±0.80 |
| Unidentified | 3.53±0.51$^{a}$ | 0.83±0.45$^{b}$ | 0.87±0.32$^{b}$ |

a, b, c Means within a row with no common superscripts differ Significantly ($p<0.01$)

*EPA: Eicosapentanoic acid ** DHA: Docosahexanoic acid
***SFA: Saturated fatty acids **** MUFA: Monounsaturated fattyacids
*****PUFA: Polysaturated fatty acids

Table 19. Mean (± S.E.) egg yolk fatty acid profile of Japanese quails as influenced by dietary inclusion of dried cuttle fish waste silage, %

| Fatty acids | $T_1$ | $T_2$ | $T_3$ |
|---|---|---|---|
| Palmitic | 24.94±1.37 | 25.51±1.00 | 26.94±0.95 |
| Stearic | 14.52±1.60 | 15.42±0.39 | 14.59±0.55 |
| Oleic | 38.54±0.23 | 39.42±0.88 | 39.78±0.82 |
| Linoleic | 8.16±0.65 | 7.39±0.32 | 8.62±0.84 |
| Linolenic | 1.21±0.36 | 1.19±0.27 | 0.93±0.36 |
| EPA | 4.13±0.33 | 4.91±0.65 | 4.78±0.77 |
| DHA | 4.29±0.37 | 4.45±0.57 | 3.56±0.87 |
| SFA | 39.46±0.80 | 40.93±0.86 | 41.53±0.85 |
| MUFA | 38.54±0.23 | 39.42±0.88 | 39.78±1.82 |
| PUFA | 17.72±1.29 | 17.39±0.34 | 17.8±1.33 |
| Unidentified | 3.21±0.49[a] | 1.72±1.00[b] | 0.81±0.15[b] |

*EPA: Eicosapentanoic acid ** DHA: Docosahexanoic acid

***SFA: Saturated fatty acids **** MUFA: Monounsaturated fattyacids

*****PUFA: Polysaturated fatty acids

Table 20. Mean livability of Japanese quails as influenced by dietary inclusion of dried cuttle fish waste silage from 7 to 26 weeks of age, %

| Age in weeks | Dried cuttle fish waste silage (%) in experimental diets | | |
|---|---|---|---|
| | 0 (T1) | 8.5 (T2) | 17 (T3) |
| 7-10 | 98.75 | 97.50 | 97.50 |
| 11-14 | 97.50 | 97.50 | 97.50 |
| 15-18 | 96.25 | 96.25 | 97.50 |
| 19-22 | 95.00 | 95.00 | 97.50 |
| 23-26 | 93.75 | 93.75 | 96.25 |

*EPA: Eicosapentanoic acid
**DHA: Docosahexanoic acid
***SFA: Saturated fatty acids
****MUFA: Monounsaturated fattyacids
*****PUFA: Polysaturated fatty acids

Table 20. Mean livability of Japanese quails as influenced by dietary inclusion of dried cuttle fish waste silage from 7 to 26 weeks of age, %

| Age in weeks | Dried cuttle fish waste silage % in experimental diets | | |
|---|---|---|---|
| | 0 (T1) | 8.5 (T2) | 17 (T3) |
| 7-10 | 98.75 | 97.50 | 97.50 |
| 11-14 | 97.50 | 97.50 | 97.50 |
| 15-18 | 96.25 | 96.25 | 97.50 |
| 19-22 | 95.00 | 95.00 | 97.50 |
| 23-26 | 93.75 | 93.75 | 96.25 |

Only a total of 14 birds died within the 20 weeks experimental period. The livability percentage among treatment groups T1, T2 and T3 at the end of the experiment were 93.75, 93.75, and 96.25, respectively.

## 4.12 ECONOMICS

The economics of egg production (Margin over feed cost) in Japanese quail as influenced by supplementation of cuttle fish waste silage are presented in Table 21.

The total number of eggs produced by the groups T1, T2 and T3 during the 20 weeks experimental period were 7226, 7084 and 5925, respectively. The corresponding total feed consumption were 324.577, 314.941 and 302.585 kg, respectively. The cost of one kg feed for T1, T2 and T3 were Rs. 9.11, 8.83 and 8.53 respectively. The feed cost for treatments T2 and T3 was less since the cost of dried cuttle fish waste silage was not as high as dried fish. The cost of feed per egg was lowest in T2 (39.25 paise) followed by T1 (40.92 paise) and T3 (43.56 paise). The net profit per egg over feed cost was higher in T2 (30.75 paise), followed by T1 (29.08 paise) and T3 (26.44 paise)

Table 21. Economics of egg production (Margin over feed cost) of Japanese quails as influenced by dietary inclusion of dried cuttle fish waste silage from 7 to 26 weeks of age

| Sl No. | Particulars | Dried cuttle fish waste silage (%) in experimental diets | | |
|---|---|---|---|---|
| | | 0 (T1) | 8.5 (T2) | 17 (T3) |
| 1 | Feed intake (kg) | 324.577 | 314.941 | 302.585 |
| 2 | Total number of eggs produced | 7226.00 | 7084.00 | 5925.00 |
| 3 | Feed consumed per egg (g) | 44.92 | 44.45 | 51.07 |
| 4 | Cost of feed (Rs per kg) | 9.11 | 8.83 | 8.53 |
| 5 | Cost of feed per egg (Paise) | 40.92 | 39.25 | 43.56 |
| 6 | Margin per* egg over feed cost (paise) | 29.08 | 30.75 | 26.44 |

* Egg cost – 70 paise per egg

# *Discussion*

# 5. DISCUSSION

The results obtained from the study to find out the effect of inclusion of dried cuttle fish waste silage replacing dried fish in Japanese quail layer ration on the production performance are discussed in this chapter.

## 5.1 BODY WEIGHT

Mean body weight of Japanese quails at six weeks of age for the treatment groups T1, T2 and T3 were 160.05, 159.67, and 160.58 g, respectively, indicating that the birds utilised for the study were of uniform body weight. Perusal of the data on body weight at six weeks of age presented in Table 4 showed no significant difference between treatment groups.

The body weight at twenty six weeks of age showed that birds belonged to the control group T1 recorded the maximum body weight (204.77 g), followed by T2 (201.42 g) and then T3 (199.43 g). There was a numerical decrease in body weight with increased inclusion levels of dried cuttle fish waste silage. Replacement of dried fish at 50 per cent and cent per cent levels with dried cuttle fish waste silage caused only a reduction in body weight of 3.35 and 5.34 g, respectively during the entire experimental period. The statistical analysis of the data showed no significant difference among treatment groups. The results of this study revealed that feeding of dried cuttle fish waste silage did not have any adverse effect on body weight of Japanese quails.

The above findings are in line with Johnson *et al.* (1985), who reported that there was no significant effect in the growth of broilers when acid or fermented fish silage was included in their ration. Ochetim (1992) also observed similar findings in meat type birds when meat and bone meal were replaced by locally available fish waste. Similarly, Mohan (1999) also could not observe any significant effect in the body weight when squilla meal was used to replace fish meal in egger type birds.

## 5.2 BODY WEIGHT GAIN

On perusal of the data presented in Table 4, it could be seen that the mean weight gain during the 20 weeks experimental period was statistically similar among three dietary treatments. However, the mean weight gain showed a numerical reduction with increased inclusion levels of cuttle fish waste silage. The body weight gain in the control group T1, in which dried fish was the sole animal protein source, was 44.73 g as against 41.76 g in the group in which 50 per cent of dried fish was replaced with dried cuttle fish waste silage (T2) and 38.85 g in which dried fish was completely replaced with dried cuttle fish waste silage (T3). The slight reduction in the weight gain of quail birds in group T2 and T3 might be due to reduced feed intake observed in these groups.

The present results are in close agreement with the observations of Krogdahl (1985b) who could not observe any significant difference in weight gain when fish viscera silage was included in broiler ration. The result observed in this study is also in agreement with the findings of Espe *et al.* (1992) who reported no significant difference in weight gain when herring fish silage was used to replace fish meal in broiler ration. Magana *et al.* (1999) also observed no significant difference in the weight gain when fish silage mixed with sorghum was included in broiler ration.

This observation suggested that the dried cuttle fish waste silage could be incorporated in quail layer ration without sacrificing body weight gain.

## 5.3 AGE AT FIRST EGG

The data on mean age at first egg presented in Table 5 indicated that the group T2, in which cuttle fish waste silage replaced 50 per cent fish meal protein attained age at first egg earlier than the control group T1 and the 100 per cent replacement group T3. The mean age at first egg was 45.25, 43.50 and 46.25 days for the groups T1, T2 and T3, respectively. The group T2 attained sexual maturity 1.75 days earlier than T1 and 2.75 days earlier than T3. The difference in age at first egg between T2 and T3 were statistically significant ($P<0.01$). However, both the treatment groups T2 and T3 were statistically similar with the control group T1 with respect to this trait.

As the experimental diets were offered at the end of sixth week of age, the result on this trait could not be considered as the treatment effect. However, it could be stated that the inclusion of dried cuttle fish waste silage did not impart any adverse effect on the age at first egg of Japanese quails.

## 5.4 AGE AT 10 PER CENT AND 50 PER CENT PRODUCTION

The mean age at 10 per cent production recorded in the dietary treatments viz., T1, T2 and T3 were 49.21, 45.50 and 51.25 days, respectively (Table 5). The treatment group T2 reached 10 per cent production 3.71 days earlier than T1 and 5.75 days earlier than T3.

After attaining sexual maturity the groups T1, T2 and T3 took 17.25, 22.25 and 25.5 days, respectively to attain 50 per cent egg production. Even though group T2 was first to attain sexual maturity and also 10 per cent production, the control group, T1 (62.50days) attained 50 per cent production at a faster rate than T2 (65.75 days). The T3 group attained 50 per cent production 9.25 days later than the control group. However, no statistical difference existed among the treatment groups with respect to ages at 10 per cent and 50 per cent production.

On screening the literature, references are not available to corroborate this finding.

## 5.5 FEED CONSUMPTION

The mean daily feed intake per bird among treatment groups during the different periods ranged from 24.71 to 33.52 g in T1, 24.99 to 31.63 g in T2 and 22.77 to 29.60 g in T3.

The mean daily feed consumption showed a numerical increase from first to fifth period (seven to twenty six weeks) in all the treatments groups except for T2 in the fifth period.

The mean daily feed consumption of group T1 (control) during the study period was 29.00 g which was highest among the treatment groups. The lowest daily feed intake of 27.02 g was noted with the group T3. The daily feed intake value of group T2 was medium (28.15 g).

Statistical analysis of the mean daily feed consumption data indicated significant differences among the treatments. The mean daily feed intake during the periods seven to ten weeks, 11 to 14 weeks, 19 to 22 weeks and 23 to 26 weeks of age were highly significant ($P<0.01$). On the other hand, that during 15 to 18 weeks and seven to twenty six weeks was significant at 5 per cent levels ($P<0.05$). In all the periods from seven to twenty six weeks of age, birds in the control group (T1) consumed significantly more feed. The mean daily feed intake of birds in group T2 in different periods were statistically comparable with control group except during 23 to 26 weeks. On the other hand, the mean daily feed intake of birds under T3 group was significantly lower than T1 and T2 groups in all the periods except 23 to 26 weeks for T2.

When the whole experimental period of seven to twenty six weeks of age was considered, linear reduction ($P<0.05$) in mean daily feed intake was observed with increasing levels of dried cuttle fish waste silage in quail feed.

On reviewing literature, it was observed that the results relating this trait seem to be contradictory. Vedhanayagam *et al.* (1976) incorporated fish silage at 0, 7 or 10 per cent levels in chick ration instead of fish meal and observed an increased feed consumption in chicks fed fish silage than those given fish meal. Similarly, Raj *et al.* (1996) replaced 50 per cent of fish meal in broiler diet with fermented fish silage and observed a higher feed consumption for fish silage fed birds. The results are contradictory to the findings of present study.

On the contrary, Krogdahl (1985a), Ahmed and Mahendrakar (1996), Magana *et al.* (1999), Kjos *et al.* (2001) and Reddy *et al.* (2004) could not observe any difference in feed consumption consequent to supplementation of fish viscera silage in White Leghorn layer birds, fermented fish silage in broiler chicken, tuna fish waste in broilers, fish silage in layers and squilla meal in White Leghorn layers, respectively.

Wide differences in the nutrient composition of fish silages prepared from different sources of fishes and differences in the method of preparation of fish silages might be the reason for this type of erratic results.

The fibre content of the control ration was 3.79 and that of T2 and T3 were 5.23 and 5.67, per cent respectively. This increased fibre content might have resulted in the lower feed intake.

## 5.6 FEED EFFICIENCY

Mean feed efficiency (kg of feed/dozen eggs) of Japanese quails as influenced by the dietary inclusion of dried cuttle fish waste silage from seven to twenty six weeks of age presented in Table 7, indicated that significant differences existed among the treatments.

The cumulative feed efficiency (per dozen eggs) at the end of the experiment was 0.53, 0.53 and 0.61 for the treatment groups T1, T2 and T3, respectively. Numerically similar feed efficiency values were obtained for T1 and T2 groups (0.53), whereas feed efficiency for birds in the group T3 was significantly ($P<0.01$) inferior when compared to T1 and T2.

During the first period of seven to ten weeks of age the feed efficiency was generally poor for all the treatment groups. It was 1.19, 1.38 and 1.80 for the groups T1, T2, and T3, respectively. This was due to the lower egg production during that period as the birds were in the start of laying. In the subsequent periods the egg production was improved with the result better feed efficiency among three treatment groups were recorded.

From second period to fifth period the feed efficiency was within acceptable limits. Significantly lower feed efficiency noted with group T2 in the first period of seven to ten weeks of age was improved in the subsequent periods and was statistically comparable with T1 upto 26 weeks of age.

In the last period of twenty three to twenty six weeks of age a significant ($P<0.01$) improvement in feed efficiency was noticed in T2 (0.42) and the group topped the list followed by T3 (0.47) and then T1 (0.48). The improvement noticed in T2 was higher than the control group T1. This could be due to the significantly ($P<0.01$) lower feed intake observed in this group during this period together with comparable egg production. But group T3 was significantly inferior to T1 and T2 in all periods except third period in which feed efficiency was statistically similar to T2.

Review of references showed that research works on utilisation of fish waste silage in Japanese quails are not available. Ochetim(1992) reported that the feed to gain ration was numerically better in broiler chicken fed locally available fish waste than those on meat and bone meal. Similarly, Raj *et al*. (1996) conducted an experiment on broilers replacing fifty per cent of fish meal in the diet with fermented fish silage and observed better feed efficiency in silage fed groups. Based on the present experiment it is clear that the dried cuttle fish waste silage could be used to replace 50 per cent of fish meal protein from Japanese quail layer ration without any adverse effect on feed conversion efficiency.

## 5.7 EGG PRODUCTION

The mean hen housed and hen day egg production (eggs/bird and per cent) of Japanese quails as influenced by the dietary inclusion of dried cuttle fish waste silage from seven to twenty six weeks of age presented in Tables 8, 9, 10 and 11, respectively indicated comparatively similar trends except during 15 to 18 weeks period with respect to mean hen housed production (egg/bird and per cent) and seven to twenty six weeks period for per cent hen day and hen housed egg production.

The pattern of egg production during the five laying periods showed that during the initial period of laying (seven to ten weeks of age), group T1 topped in production followed by T2 and T3. In the subsequent periods, birds in group T2 picked up production and became statistically similar to that of control group, T1.

The hen housed egg number was comparatively low in the first period. The control group T1 recorded the maximum (6.99) egg number followed by T2

(6.18) and T3 (4.26). The magnitude of difference observed among treatments was statistically significant ($P<0.01$).

From the second period onwards the hen housed egg number of the groups T1 and T2 were statistically similar and were significantly different ($P<0.01$ and $P<0.05$) from T3 except during third period in which hen-housed egg number was statistically similar among treatment groups.

Perusal of data on mean cumulative hen housed egg number revealed that the partial replacement of fish meal protein by dried cuttle fish waste silage did not have any adverse effect on egg production. The cumulative hen housed egg number for the groups T1, T2 and T3 were 90.32, 88.52 and 74.06, respectively. Statistical analysis showed that cumulative hen housed egg number was more ($P<0.01$) in T1 and T2 groups as compared to T3. The mean cumulative hen day egg number among the treatment groups also showed similar trend.

Per cent hen housed egg production in the group T2 during the whole experimental period was less to a level of 1.17 as compared to control, wheares complete replacement of dried fish with cuttle fish waste silage resulted in 11.44 per cent reduction. In all the five periods from seven to twenty six weeks of age per cent hen day egg production was significantly ($P<0.01$) more with the control group T1. The mean per cent hen day egg production among birds in the group T2 was statistically comparable with group T1 from the second period to fifth period. However, in all the periods, hen day egg production was significantly lower with birds in group T3 ($p<0.01$). But the magnitude of differences in per cent hen day and hen housed egg production for the whole experimental period from seven to twenty six weeks of age was analysed statistically, it failed to show any significant difference.

The per cent hen day egg production in the control group (T1) fed with dried fish was 66.86. The replacement of 50 per cent of fish protein with cuttle fish waste silage protein caused only a reduction of 1.52 per cent in egg production. On the other hand 100 per cent replacement of fish protein with cuttle fish waste silage protein resulted in 11.97 per cent reduction in egg production. This finding confirms that replacing fish protein with cuttle fish waste silage protein at 50 per cent level could be able to cater the aminoacid requirements for optimum egg production in Japanese quails.

The results of the study clearly indicated that partial replacement of dried fish with cuttle fish waste silage can be advocated without compromising the egg production profile of Japanese quails. Krogdahl (1985a) also reported that the total egg production and laying rate in chicken fed 20 per cent protein from concentrated fish viscera silage was as high as the hens fed the reference diet with fish meal. However replacement with 40 per cent protein from fish viscera waste caused a drop in egg production. This might be due to the quality of fish viscera used in that study. Similarly, Ochetim (1992) could not observe any significant difference in total egg production when locally available fish waste replaced meat and bone meal in layer ration. Kjos *et al*. (2001) also observed that the egg production in White Leghorn layers was not affected when fish silage replaced fish meal at a level of 12 per cent of dietary protein.

The significantly lower egg production among birds in group T3 showed that complete replacement of fish with dried cuttle fish waste silage is not feasible.

## 5.8 EGG WEIGHT

The mean egg weight (g) of Japanese quails as influenced by supplementation of dried cuttle fish waste silage from seven to twenty six week of age given in Table 12 indicated that the differences in egg weight among the treatment groups were very low. Statistical analysis of the data revealed no significant difference between them. The mean egg weight was 10.82, 10.81 and

10.73 g for groups T1, T2 and T3, respectively. Group T1 recorded the highest egg weight numerically and was higher than T2 and T3 by 0.01 g and 0.09 g, respectively. The egg weight obtained during the first period covering seven to ten weeks of age was comparatively lower than other periods in all the treatment groups.

The mean egg weight obtained in this study was in line with the findings of Shrivastav *et al*. (1993) who observed the mean egg weight in Japanese quails as 10.28 g when 7 per cent fish meal was included in their ration. All the three treatment groups showed maximum egg weight in the fourth period.

The findings of this study is in close agreement with the reports of Krogdahl (1985a) and Kjos *et al.* (2001) who observed no significant difference in egg weight when fish silage was used to replace fish meal protein in layer diet.

The results of this study clearly indicated that partial as well as complete replacement of fish protein with cuttle waste fish silage did not have any adverse effect on egg weight of Japanese quail.

5.9 EGG QUALITY

On perusal of the data presented in Tables 13, 14, 15, 16 and 17 it was revealed that the egg quality traits, viz., shape index, albumen index, yolk index, internal quality unit and shell thickness did not show any significant difference due to partial or complete replacement of dried fish with cuttle fish waste silage in quail layer diet.

The mean shape indices of eggs of Japanese quails from seven to twenty six weeks of age for T1, T2 and T3 were 78.89, 78.61 and 78.55, respectively. Shrivastav *et al.* (1993) and Elangovan *et al*. (2002) observed the mean shape index in Japanese quails as 77.79 and 77.90 when fish meal was included at 7 per cent and 5 per cent levels, respectively. On the other hand, Erener *et al.* (2003) reported a shape index of 80.47 when 2 per cent fish meal was included in quail ration. The results obtained in this study falls within this range.

The mean albumen index values for the groups T1, T2 and T3 were 0.131, 0.138 and 0.136, respectively. Shrivastav *et al.* (1993) and Elangovan *et al.* (2002) observed lower albumen index values in Japanese quails, fed with a diet containing fish meal. However, Kondiah *et al.* (1981) reported the albumen index as 0.130 in Japanese quail.

The mean yolk index values for the group T1, T2 and T3 were 0.456, 0.470 and 0.469, respectively. The mean yolk indices obtained in this study are in close agreement with that of Shrivastav *et al.* (1993) and Elangovan *et al.* (2002).

The mean internal quality units observed among different dietary treatments were 60.16, 60.45 and 60.14 for T1, T2 and T3, respectively. Kondiah *et al.* (1983) observed the mean internal quality unit as 62.12 in Japanese quails and results of the present study falls within the range reported by him.

The mean shell thickness values during the entire experimental period for T1, T2 and T3 were 0.184, 0.184 and 0.183 mm, respectively. The mean values are in close line with that of Elangovan *et al.* (2002) and Erener *et al.* (2003) who observed the mean shell thickness of Japanese quail egg as 0.193 mm and 0.186 mm, respectively

The results of this study is in close agreement with the findings of Kjos *et al*. (2001) who observed no significant difference in egg quality traits when fish silage was used to replace fish meal in chicken layer diets. Similarly, Reddy *et al.* (2004) observed no significant difference in egg quality traits when fish meal was replaced by squilla meal in layer birds.

## 5.10 FATTY ACID PROFILE

The liver fatty acid profile of Japanese quails as influenced by supplementation of dried cuttle fish waste silage, presented in Table 18 revealed that various dietary treatments did not have any significant influence on the composition of various fatty acids except oleic acid. Oleic acid content was significantly ($P<0.01$) more with the group T3 (44.76 per cent). There was no significant difference between the cuttle fish waste silage added groups (T2 and T3) with respect to liver oleic acid content. Though, the control group T1 showed significantly lower oleic acid contents (41.99 per cent) than T3, it was comparable with the group T2 (43.73 per cent). The oleic acid content of cuttle fish was 8.3 per cent (Anon 2004), which may be higher than the oleic acid content of dried fish utilised in the experimental ration. This might have resulted in the higher oleic acid content of quail liver. The birds maintained on a diet which contained both unsalted dried fish as well as dried cuttle fish waste silage (T2) showed an intermediary value.

The unidentified group of fatty acid was significantly more ($P<0.01$) in the liver of birds fed the control diet containing dry fish. It was significantly lower with the groups offered cuttle fish waste silage. The dried fish used in this experiment might have contributed these fatty acid as the other ingredients used were similar in all the three rations.

Mean egg yolk fatty acid picture as influenced by different dietary treatments given in Table 19 showed that the total saturated fatty acid content of egg yolk was numerically lower in T1 than T2 and T3. However there was no significant difference between them. Similar to that of quail liver, oleic acid content of egg yolk was highest in T3 (39.78 per cent) and lowest in T1 (38.54 per cent) but again T2 showed an intermediary value (39.42). However, this difference was not statistically significant. The unidentified fatty acid content was also significantly higher in T1.

The per cent composition of the quail egg yolk fatty acids viz., palmitic, stearic, oleic and linoleic acid contents were in line with the findings of Choi *et al.* (2001). But the linolenic, EPA and DHA values obtained in the present study was higher than the values cited by him. This might be due to the superior quality of feed ingredients used in this experiment.

Considering the fatty acid composition of quail liver and yolk, the oleic acid constituted the major fraction among all other fatty acids. This agrees with the findings of Adachi *et al.* (1978) who reported oleic acid as the principle fatty acid in quail egg yolk. The mean fatty acid per cent of both liver and yolk obtained in the present study were in agreement with the findings of Aydin and Cook (2004).

As specific studies are not reported to elucidate the effect of feeding cuttle fish waste silage in quail layer ration on fatty acid profile of quail liver and yolk, the findings of the present study could not be corroborated with similar works.

The results obtained in this study indicate that cuttle fish waste silage can be safely incorporated in quail layer ration replacing dried fish.

## 5.10 LIVABILITY

The data on livability percentage of birds under different dietary treatment groups revealed that it ranged from 93.75 to 96.25 per cent. During the entire course of the experiment covering 20 weeks, only 14 birds died. Post mortem report of the dead birds revealed no reasons attributable to treatment effect.

The results agrees with the findings of Johnson *et al.* (1985) who observed no significant difference in the livability pattern of broilers fed fish meal, acid fish silage or fermented fish silage. On the contrary Ahmed and Mahendrakar (1996) observed slightly higher livability pattern in fish silage fed groups than those fed on fish meal diets.

## 5.11 ECONOMICS

The cost of three dietary isonitrogenous and isocaloric rations were Rs. 9.11, 8.83 and 8.53 per kg for T1, T2 and T3, respectively. The low cost of T2 and T3 rations were due to the inclusion of low priced dried cuttle fish waste silage. The feed intake was also lower in T2 and T3 viz., 314.941 and 302.585 kg when compared to 324.577 kg of the control group. But the feed consumed per egg was 44.92, 44.45 and 51.07 g in T1, T2 and T3, respectively. The feed required per egg was highest in T3 group though their feed intake was significantly ($P<0.01$) lower. The egg production in T3 was also low according to the feed intake and thus required more feed to produce an egg. The cost of feed per egg was 40.92, 39.25 and 43.56 paise for T1, T2 and T3, respectively. The net profit per egg over feed cost was highest in T2 (30.75 paise) followed by T1 (29.08 paise) and T3 (26.44 paise). Dried cuttle fish waste silage, being a low protein source compared to unsalted dried fish, was required in larger quantities to maintain the isonitrogenous diet and thus resulted in high cost of production per egg. The result in the present study is in agreement with the findings of Vedhanayagam *et al.* (1976) who observed that the cost of feed per kilogram gain in body weight gain was lower in broilers fed fish silage and Sakthivel (2003) also observed low cost of feed per kg gain when dried cuttle fish waste silage was fed to growing pigs.

# *Summary*

## SUMMARY

An experiment was carried out at the Department of Poultry science, College of Veterinary and Animal Sciences, Kerala Agricultural University, Mannuthy, to study the effect of inclusion of dried cuttle fish waste silage in Japanese quail layer ration. The experiment was conducted during the laying phase of Japanese quails from six to twenty six weeks of age. Two hundred and forty Japanese quail pullets were wing banded, weighed individually and distributed randomly to three treatments groups with four replicates of twenty birds in each. Quail layer rations with crude protein 22 per cent and metabolisable energy 2650 kcal per kg feed formed the experimental rations. Cuttle fish waste silage was added to the control diet replacing dried fish to form isocaloric and isonitrogenous diets. The details of treatment groups and experimental diets are given below.

$T_1$ = Control ration containing unsalted dried fish at a level of 8 per cent as animal protein source.

$T_2$ = Ration in which 50 per cent of crude protein from unsalted dried fish was replaced with dried cuttle fish waste silage.

$T_3$ = Ration in which 100 per cent of crude protein from unsalted dried fish was replaced with dried cuttle fish waste silage.

Each replicate was housed in separate cages maintaining uniform standard management conditions. The mean initial body weight at the sixth week and the final body weight at the end of the twenty six weeks of age were recorded. Egg production was recorded daily from seven to twenty six weeks of age replicate wise and expressed as hen housed and hen day egg production. Data collection were done for five periods of 28 days each from seven to twenty six weeks of age. At the end of each period all the eggs collected for three consecutive periods were weighed to calculate the mean egg weight and five eggs randomly picked from each replicate was utilised for egg quality analysis. The shape index,

albumen index, yolk index, internal quality unit and shell thickness were recorded. Economics over feed cost was calculated based on the prevailing cost of feed ingredients and quail eggs during the period. At the end of the trial five yolks from each replicate was pooled and a sample was taken for fatty acid profile analysis. Similarly, livers of two birds were collected from each replicate, pooled and subjected for the analysis.

The results obtained from the trial are summarized below

The mean body weight of birds belonging to the treatments T1, T2 and T3 at six weeks was 160.05, 159.67 and 160.58 g, respectively. The corresponding values at twenty six weeks of age were 204.77, 201.42 and 199.43 g, respectively. The statistical interpretation of the results showed no significant difference among the treatments at both ages.

The mean body weight gain of Japanese quail was 44.73, 41.76 and 38.85 g, for the groups T1, T2 and T3, respectively. The gain in weight was proportionately less with increasing levels of dried cuttle fish waste silage in quail rations. However, the statistical analysis of the data revealed that the magnitude of difference between treatments was not significant.

The age at first egg recorded in the treatment groups were 45.25, 43.50 and 46.25 days for T1, T2 and T3, respectively. The birds belong to group T2 attained sexual maturity first followed by the control group T1. The statistical interpretation of the results showed that group T2 differed significantly from group T3. The mean age at 10 per cent production showed that the birds under group T2 attained 10 per cent production earlier (45.50 days), than control group T1 (49.21 days) and T3 (51.25 days). The mean age at 50 per cent production for the groups T1, T2 and T3 were 62.50, 65.75 and 71.75 days, respectively. The statistical analysis of the data on age at 10 per cent and 50 per cent production showed no significant difference among three dietary treatment groups.

The mean daily feed intake of Japanese quails from seven to twenty six weeks of age were 29.00, 28.15, and 27.02 g for the groups T1, T2 and T3, respectively. The mean daily feed intake was highest in the control group T1 followed by T2 and T3. The difference was statistically significant.

The mean cumulative feed conversion efficiency for the groups T1, T2 and T3 were 0.53, 0.53 and 0.61, respectively. The feed efficiency of the group T3 (0.61) was significantly inferior ($P<0.01$) as compared to treatment groups T1 and T2 (0.53).

In the overall study period, the birds in group T1 (90.32) recorded the highest hen housed egg production (eggs/bird) followed by birds in group T2 (88.52) and T3 (74.06). The hen housed egg production of Japanese quail layers showed significant difference among treatment groups in all the periods and overall study period except 15 to 18 weeks of age. The mean per cent hen housed egg production were 64.38, 63.21 and 52.94 for the treatment groups T1, T2 and T3, respectively. The statistical analysis of the data on mean per cent hen housed egg production for the period from seven to twenty six weeks of age showed no significant difference among the treatment groups.

The overall mean hen day egg number for the treatments T1, T2 and T3 were 93.52, 91.98 and 76.80, respectively. The hen day egg number was significantly more with T1 and T2 as compared to T3 ($p<0.01$). The data on per cent hen day egg production of Japanese quail from seven to twenty six weeks of age revealed that the birds in group T1 (control) recorded highest egg production (66.86 per cent) followed by birds in group T2 (65.34 per cent) and T3 (54.89 per cent). The statistical analysis of the data on mean per cent hen day egg production for the period from seven to twenty six weeks of age showed no significant difference among the treatment groups.

The mean egg weight was 10.82, 10.81 and 10.73 g in treatment groups T1, T2 and T3, respectively. Statistical analysis of the data showed no significant difference between the treatment groups.

The egg quality characteristics recorded viz, shape index, albumen index, yolk index, internal quality unit and shell thickness did not differ significantly between treatments in any of the periods.

There was no significant difference in the egg yolk fatty acid composition of birds among the three dietary groups. Among liver fatty acids the oleic acid content was significantly higher in T3 than T1 while that of T2 was comparable with T3 and T1.

The livability percentage among treatment groups T1, T2 and T3 at the end of the experiment were 93.75, 93.75, and 96.25, respectively.

The cost of one kg feed for T1, T2 and T3 were Rs. 9.11, 8.83 and 8.53 respectively. The feed cost for treatments T2 and T3 was less since the cost of dried cuttle fish waste silage was not as high as dried fish. The cost of feed per egg was lowest in T2 (39.25 paise) followed by T1 (40.92 paise) and T3 (43.56 paise). The net profit per egg over feed cost was higher in T2 (30.75 paise), followed by T1 (29.08 paise) and T3 (26.44 paise).

Overall evaluation of the results of this study reveal that dried cuttle fish waste silage can be used as protein supplement in Japanese quail layer ration to replace 50 per cent protein from unsalted dried fish without any adverse effect on growth, production and egg quality.

Table 22. Effect of dietary inclusion of dried cuttle fish waste silage on production performance as well as economics over feed cost in Japanese quail layers from 7-26 weeks of age

| Parameters | Dried cuttle fish waste silage (%)in experimental diets | | |
|---|---|---|---|
| | 0 (T1) | 8.5 (T2) | 17 (T3) |
| Initial body weight | 160.05±0.94 | 159.67±0.63 | 160.58±0.99 |
| Final body weight (g) | 204.77±1.88 | 201.42±4.01 | 199.43±3.9 |
| Age at first egg | 45.25±1.03$^{ab}$ | 43.50±0.29$^{b}$ | 46.25±0.48$^{a}$ |
| Age at 10% production | 49.21±1.93 | 45.50±1.19 | 51.25±1.32 |
| Age at 50% production | 62.50±1.19 | 65.75±2.18 | 71.75±3.93 |
| Mean feed consumption (g/bird/day) | 29.00±0.14$^{A}$ | 28.15±0.25$^{B}$ | 27.02±0.20$^{C}$ |
| Cumulative feed efficiency (per dozen eggs) | 0.53±0.010$^{b}$ | 0.53±0.02$^{b}$ | 0.61±0.01$^{a}$ |
| Cumulative hen housed egg number (eggs/bird) | 90.32±0.48$^{a}$ | 88.52±2.26$^{a}$ | 74.06±1.56$^{b}$ |
| Cumulative hen day egg number (eggs/bird) | 93.52±0.60$^{a}$ | 91.98±0.00$^{a}$ | 76.80±0.00$^{b}$ |
| Livability | 93.75 | 93.75 | 95.00 |
| Cost of feed per egg (paise) | 40.92 | 39.25 | 43.56 |
| Margin of profit over feed cost per egg (paise) | 28.08 | 30.75 | 26.44 |

A, B, C Means within a row with no common superscripts differ significantly ($p<0.05$)

a, b, c Means within a row with no common superscripts differ significantly ($p<0.01$)

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**ABSTRACT**

An experiment was conducted in Japanese quail layers from six to 26 weeks of age by replacing unsalted dried fish with cuttle fish waste silage on crude protein basis. The objective was to assess the production performance as well as the economics of feed cost over production. Two hundred and forty Japanese quail pullets of six weeks age were divided randomly into twelve groups of 20 birds each. They were randomly allotted into three treatment groups, T1, T2 and T3 and maintained on isonitrogenous and isocaloric diet. The unsalted dried fish content in the control ration (T1) was replaced by cuttle fish waste silage at 50 and 100 per cent levels in T2 and T3, respectively. The initial and final body weight were recorded. Data collection was done for five periods of twenty eight days each from seven to twenty six weeks. At the end of the trial pooled yolk samples and two liver samples from each replicate were analysed for fatty acid profile.

The initial and final body weight and the body weight gain during experimental period for different dietary treatments did not differ significantly. The birds belonged to group T2 attained sexual maturity first followed by the control group T1. There was a slight delay for group T3 in attaining sexual maturity ($P<0.01$). The age at 10 and 50 per cent production did not differ significantly between treatments. The period wise mean daily feed consumption was lower in T3 than T1 and T2 ($P<0.01$). The mean feed intake was highest in T1 followed by T2 and T3 and the treatments differed significantly ($P<0.05$). The cumulative feed conversion efficiency was superior inT1 and T2 ($P<0.01$) than T3. The cumulative hen housed and hen day egg number of T1 and T2 were significantly higher ($p<0.01$) than T3. Though the per cent hen housed and hen day egg production of birds in treatments T1 and T2 were significantly higher in all the periods, the overall mean values did not show any significant difference. The egg quality traits recorded viz., shape index, albumen index, yolk index, internal quality unit and shell thickness did not differ significantly between

treatments in any of the periods (P>0.05). The oleic acid content of quail liver was significantly higher in T3 than T1 but no significant difference was noticed among the egg yolk fatty acids. The cost of feed per egg was lowest in T2 followed by T1 and T3.

Overall evaluation of the study reveals that the cuttle fish waste silage could be used economically to replace 50 per cent of crude protein from unsalted dried fish on protein basis in Japanese quail layer rations, without any adverse effect on growth, production and egg quality and feed cost.