GROWTH PERFORMANCE OF BROILER CHICKEN FED ON FERMENTED FISH WASTE SILAGE RATION

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Thesis submitted in partial fulfilment of the requirement for the degree of

Master of Veterinary Science

Faculty of Veterinary and Animal Sciences
Kerala Agricultural University, Thrissur

2005

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DECLARATION

I hereby declare that this thesis, entitled **"GROWTH PERFORMANCE OF BROILER CHICKEN FED ON FERMENTED FISH WASTE SILAGE 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.

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Certified that this thesis, entitled **"GROWTH PERFORMANCE OF BROILER CHICKEN FED ON FERMENTED FISH WASTE SILAGE RATION"** is a record of research work done independently by **Ms. Smitha N.F.**, 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.

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ACKNOWLEDGEMENT

*It is with immense pleasure that I record my sincere and heartfelt gratitude to the Chairperson of the Advisory Committee **Dr. A.D. Mercy**, Associate Professor, Department of Animal Nutrition for her meticulous guidance, personal attention, keen interest, affectionate encouragement, persuasion and incessant help offered to me from the initiation of work to the ship shaping of the manuscript. Without her strong support and co-operation the successful completion of this work would not have been possible.*

*To the greatest degree, I am grateful to **Dr. T.V. Viswanathan**, Associate Professor and Head, Department of Animal Nutrition, Member of the Advisory Committee, for his generous encouragement, inspiration, kindness and personal guidance in the pursuit of this work.*

*I am sincerely thankful to **Dr. V.K. Elizabeth**, Associate Professor Department of Poultry Science and **Dr. K. Shyama**, Assistant Professor, Pig Breeding Farm, Members of the Advisory Committee for their whole-hearted co-operation, words of inspiration, incessant encouragement and affection rendered during the entire period of research work.*

*I owe my sincere gratitude to **Dr. K.M. Syam Mohan** and **Dr. K. Ally**, Assistant Professors, Department of Animal Nutrition for their valuable guidance, timely help and moral support.*

*I am grateful to **Dean**, College of Veterinary and Animal Sciences, Mannuthy and Kerala Agricultural University for the facilities provided for this research work.*

*I wish to extend my thanks to **Central Institute of Fisheries Technology (CIFT)**, Cochin under the National Agricultural Technology Project (NATP) for their timely supply of fermented fish waste silage.*

*I express my gratitude to **Dr. Kjos N.P.**, Professor, Department of Animal Sciences and Division of Nutritional Sciences, University of Illinois, Urbana, USA for sending the relevant literature on this topic.*

*I am in short of words to express my deep sense of gratitude to my great friends **Drs. Raja D, Sheena Joseph, Mary Juliet Francis and Smitha Wilson**, without whose tireless help, unconditional support and constant encouragement the successful completion of this research work would not have been possible.*

The generous help, assistance, guidance and support rendered to me by my beloved seniors ***Drs. Anup Kollanoor*** *and* ***Jith John Mathew*** *and other seniors* ***Drs. Shekar M., Suresh M.*** *and* ***T. Hariharan*** *are duly acknowledged. I am greatly thankful to* ***Dr. Sakthivel P.C.*** *for his valuable help in literature collection. A bouquet of thanks to friends and junior colleagues* ***Drs. Smitha R. Pillai, Jasmine Rani*** *and* ***Hareesh P.S.*** *for their help and co-operation.*

Words possess no enough power to reflect my thankfulness for the invaluable help, moral support and affection rendered by my great friends ***Drs. Amrita, Shymaja, Lekshmi, Vandana, Sangeetha, Sheena, Aparna, Rani, Kavi and Jayant.***

I gratefully acknowledge ***Mr. Chandrasekharan****, Associate Professor and Instrumentation Engineer,* ***Mrs. Dhanya****, Research Assistant, Central Instrumentation Laboratory and* ***Ms. Annie Thomas****, ARIS cell for their lots of help rendered. The help given by* ***Ms. Dhanya, Mrs. Bindhu****, Senior Research Fellows and* ***Mrs. Juli, Mr. Shukoor****, Junior Research Fellows is greatly acknowledged.*

I sincerely acknowledge the staff of our department ***Mr. Viswambaran, Mr. Vargheese, Mr. Kochaniyan, Mrs. Rosi, Miss. Madhavi*** *and* ***Miss. Rekha*** *for their timely help.*

I am thankful for the wholehearted help rendered for statistical analysis of data by ***Smt. Sujatha****, Assistant Professor and Head,* ***Smt. K.A. Mercy****, Assistant Professor, Department of Statistics.*

I treasure the invaluable help, concern, encouragement, valuable suggestions, critical comments and moral support rendered by ***Dr. Binoy Joseph.***

No phrase or words in any language can ever express my deep sense of love and gratitude to my beloved ***Appachan and Amma****, beloved sisters* ***Annie*** *and* ***Anju*** *and brother* ***Abie.***

Above all, I bow my head before ***God The Almighty****, for the blessings showered on me... for all the things I have and I don't... for helping me to reach the shore safely... through the love and prayers of my family, friends and teachers.*

Smitha N.F.

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Introduction

1. INTRODUCTION

India has made tremendous progress in broiler production in the last two decades. With an annual output of 1,000 million broilers, which yield 12.5 lakh tonnes of poultry meat, India ranks eighth largest producer of broiler meat in the world (Anon, 2003). The poultry sector provides about 2 percent of the total gross domestic product (GDP) of India.

One of the crucial inputs that would determine successful and sustainable development in poultry industry is the availability of quality feed in required quantity. As feed accounts for 70 to 75 per cent of total production cost of poultry, efficient utilization of feed is extremely important for poultry producers to maximize the profit.

Chicken being monogastric in nature, their diet must be balanced with regard to the essential amino acid contents. In order to balance the amino acid profile of the diet, animal protein source such as fish meal is usually used. But due to the non availability of good quality raw material and escalating cost of production of fish meal, alternative protein sources such as fish and shell fish processing wastes are to be exploited.

Large quantities of wastes are generated from sea food processing industries in India. Disposal of these wastes presents a major problem because of their objectionable odour, high moisture content and disposal regulations. These protein-rich by-products, which are at present discarded, could be converted into useful protein sources for feeding livestock and poultry and there by mitigate the protein deficit and environmental pollution in the country. Conversion of fish processing wastes into meal is not practical because of the high investment involved. Ensiling of fish waste is one of the cheaper alternatives with a very low investment for its utilization as animal feed. Fish silage may be described as a liquid product, which develops when whole fish or parts of fish, are treated with an acid, usually formic or a mineral acid. Liquefaction is caused by enzymes present in the fish, and is accelerated by the acid, which in addition to creating the right conditions for the enzymes to work, helps to break down bone and limits the growth of spoilage bacteria (Tatterson, 1982). Fish waste can also be ensiled by biological fermentation using lactic acid bacteria, which either exist naturally in the raw material or are introduced as starter culture (Rose *et al.*, 1994).

Very few works have been carried out in India to study the effect of incorporation of fermented fish waste silage in the diet of broilers. Thus the present experiment was undertaken to assess the effect of dietary incorporation of fermented fish waste silage on growth, feed efficiency and processing yields of broiler chicken and also to assess the economics of utilization of fermented fish waste silage in broilers.

Review of Literature

2. REVIEW OF LITERATURE

2.1 METHODS OF PRESERVATION OF FISH WASTES

2.1.1 Fermented Fish Silage

Krishnaswamy *et al.* (1965) prepared ensiled fish by fermentation with 1.5 to 2 per cent *Streptococcus lactis* to which commercial lactose, citric acid and yeast extract were added at the rates of 1.0, 0.2 and 0.1 per cent respectively. Lindgren and Pleje (1983) reported that inoculation of minced fish and fish offal with cereals pre-fermented with *Pediococcus acidilactica* and *Lactobacillus plantarum* resulted in a rapid fall in p^H to below 4 to 5 within 30 hours and eliminated the gram-negative fermenters and fish pathogens. They further stated that addition of 0.1 per cent sorbic acid inhibited the growth of yeasts during the initial fermentation period and during storage. Rose *et al.* (1994) also used *Lactobacillus plantarum* and *Pediococcus acidilactica* for the preparation of fish silage along with a mixture of barley, dried malt and water.

Lactobacillus plantarum was used for the production of fermented fish waste silage by Johnson *et al.* (1985), Hassan and Heath (1986), Fagbenro and Jauncey (1994a, b), Lourhzal *et al.* (2002) and Vidotti *et al.* (2003). Faid *et al.* (1997) produced fish silage by incubating fish waste with 25 percent molasses and a starter culture of *Saccharomyces* sp. and *Lactobacillus plantarum* at 22°C, while White *et al.* (1998 and 1999) used a commercial biopreservative Marsil®, (finn sugar) 1 per cent and extruded wheat (15 per cent) for the production of fermented fish silage.

Molasses was added as an additive for fermentation by Johnson *et al.* (1985); Faid *et al.* (1997), Lourhzal *et al.* (2002) and Vidotti *et al.* (2003). Hassan and Heath (1986) used 5 per cent lactose, while, Fagbenro and Jauncey (1994a, b) used molasses, corn flour or tapioca flour as carbohydrate substrates.

Ahmed and Mahendrakar (1996a) carried out fermentation ensiling of fresh water fish viscera with 10 per cent (w/w) molasses, 0.5 per cent (v/w) propionic acid and 0.02 per cent (w/w) ethoxyquin as an antioxidant under micro aerophilic condition. Ngoan *et al.* (2000) ensiled shrimp by-product with molasses in the ratio 6:1, 4:1 and 3:1 on a wet weight basis and with cassava root meal in the ratio 3:1, 2:1 and 1:1 (wet weight of shrimp by product and air dry weight of cassava root meal) and found that shrimp by-product ensiled with cassava had higher organic matter digestibility. Borin *et al.* (2000) ensiled partly eviscerated fish with rice bran and sugar pulp in proportions of 50:10:40.

2.1.2 Acid Preservation of Fish Silage

Formic acid was used for preserving fish and fish waste by several workers. Winter and Javed (1980), Johnson *et al.* (1985) and Green *et al.* (1988) used 3.5 per cent formic acid on wet weight basis. Husain and Offer (1987) prepared fish silage by mixing 20 ml of 90 per cent formic acid per kilogram of minced white fish and fish offal. The acidified mince was divided into 6 parts and to each part 0, 1, 2, 3, 4 or 5 ml of 40 per cent formaldehyde was added and kept for 10 days, while, Machin *et al.* (1990) prepared fish silage by the addition of 3 per cent formic acid to high and low oil content fish on wet weight basis.

Johnsen and Skrede (1981) and Krogdhal (1985a) preserved fish viscera with 0.75 per cent formic acid and 0.75 per cent propionic acid. Gao *et al.* (1992) on the other hand used 0.75 or 1.0 per cent citric acid along with 0.5, 0.75 and 1.0 per cent formic acid and found that at least 50 per cent formic acid could be replaced with citric acid. Acid was added at a rate of 8 to 9 per cent by weight or 5 per cent by volume to raw material (Perez, 1995).

Ethoxyquin (200 ppm) was used along with 2.5 per cent (w/w) formic acid to prepare acid silver hake silage (Espe *et al.*, 1992a and White *et al.*, 1999) and acid dogfish silage (White *et al.*, 1998).

Magana *et al.* (1999) produced formic-hydrochloric acid silage by adding hydrochloric acid to reach p^H 2, then formic acid was added to reach p^H 3, whereas, formic-sulphuric acid silage was produced by adding sulphuric acid to reach p^H 2 then formic acid was added to reach p^H 3.

Lien *et al.* (2000) concluded that the p^H of the silage remained below 4.5 during the 3 months of storage when formic acid was added at 2 per cent and above levels or when a mixture of formic acid and 10 per cent sulphuric acid (1:1) was added at 3 per cent level.

2.1.3 Other Additives

Fish silage was mixed with different filler materials to increase the dry matter content and to enhance drying. De-oiled rice bran was used by Kumar and Sampath (1979), while Johnson *et al.* (1985) used wheat bran. Ali *et al.* (1995) also mixed silage prepared from trash marine fish with wheat bran in the ratio 3:1 before sun drying.

Samuels *et al.* (1991) produced fish silage from finfish and crab processing wastes with ground wheat straw.

Ramachandran *et al.* (1992) ensiled prawn waste with rice bran (1:1 wet basis) with or without tapioca flour and coconut cake. James (1993) ensiled prawn waste with chopped paddy straw in equal proportions (1:1 wet basis) using 10 per cent tapioca flour as additive for a period of 50 days.

Samuels *et al.* (1992) ensiled crab and fish processing wastes with stover or groundnut hulls and with 5 per cent dry molasses or 1 per cent formic acid. They also ensiled seafood wastes with wilted Johnson grass with or without 5 per cent dry molasses. Reys *et al.* (1991) mixed low quality fish in the ratio 85:15 with either sterile molasses (+ 0.25 per cent sorbic acid to inhibit fungi) or tropical fruit waste (mainly papayas and pineapples) or 72.5:12.5:15 with molasses and fruit waste. The mixture was kept at 35, 45, 55, 65 or 75°C for up to 17 days. Bello *et al.* (1993) also used juice and waste fruits (pineapple and papaya) at 35°C for 20 days for producing microbial fish silage from under-utilized fish.

Fagbenro and Jauncey (1994c) added potato extracts at 5 ml per kg silage as proteolytic inhibitor or lipid antioxidant and incubated for 30 days at 30°C.

Fagbenro (1994) blended fermented tilapia silage (1:1 w/w) with soybean meal, poultry by-product meal and oven-dried at 45°C for 48 hours and found that it made a suitable supplement in dry fish diets for tilapia.

Hydrolysed feather meal, poultry by-products meal or soyabean meal was blended with fermented shrimp head silage in the ratio 85:15 (Fagbenro and Bellow-Olusoji, 1997).

Fagbenro and Jauncey (1998) found that the addition of 50 ml of onion extract per kg of fish silage proved effective as lipid antioxidant.

2.2 OTHER SEAFOOD WASTES

Shrimp and fish wastes had high protein contents (44.8 to 64.6 per cent) and their amino acid profiles were similar to that of fish meal. Furthermore, it had a high digestibility of 81 to 96 per cent and biological value 63 to 83 per cent (Afolabi *et al.*, 1980).

Watkins *et al.* (1982) evaluated shrimp and crab processing by-products as feed supplements for mink and concluded that crustacean waste diets generally resulted in lower final weight, weight gain and greater feed consumption than control groups fed a standard diet. Mohan and Sivaraman (1993) also found that the body weight gain and feed conversion efficiency of pigs receiving dried prawn waste replacing 50 and 100 per cent of unsalted dried fish were significantly lower. Rosenfeld *et al.* (1997) reported that shrimp meal could replace soybean meal in broiler diets without negatively affecting their performance.

Anderson and Lunen (1986) concluded that for grower pigs, body weight gain per day was similar among the treatment diets containing 0, 5, 10 and 15 per cent crab meal, while, feed consumed per day and feed to gain ratio were lower when fed 10 and 5 per cent crab meal diets.

Wohlt *et al.* (1994) identified sea clam viscera food processing wastes as potentially low cost alternative protein supplements for growing pigs. Similarly, Abazinge *et al.* (1994) ensiled crab waste and wheat straw mixtures with molasses and produced a palatable silage that was efficiently utilized by wethers.

Ayangbile *et al.* (1998) preserved crab waste with 0.2 per cent sodium hypochlorite and mixed with wheat straw, liquid molasses, water and a microbial inoculant *Streptococcus faecium* and *Lactobacillus plantarum*. They found that feeding crab waste-straw silage did not adversely affect nutrient utilization or performance of ruminants.

2.3 PRESERVATION OF OTHER PROCESSING WASTES

Machin *et al.* (1984) preserved poultry offal by autolysis in the presence of formic acid and subsequent preparation of broiler feed ingredients by drying the hydrolysate on wheat middlings and maize, while, Tibbetts *et al.* (1987) produced poultry offal silage by mixing ground poultry heads, feet and viscera with corn, dried molasses and *Lactobacillus acidophilus* culture. Fagbenro and Fasakin (1996) ensiled defatted poultry viscera with 4 to 5 per cent citric acid and 0.5 per cent propionic acid.

2.4 CHEMICAL COMPOSITION OF SILAGE

2.4.1 Dry Matter

The dry matter content of fish silage ranged between 19 to 30 per cent (Luscombe, 1973; Whittemore and Taylor, 1976b; Tibbetts *et al.*, 1981; Batterham *et al.*, 1983; Ward *et al.*, 1985; Strasdine *et al.*, 1988; Myer *et al.*, 1990; Espe *et al.*, 1992a; Alwan *et al.*, 1993). Fagbenro and Jauncey (1995b), White *et al.* (1998), Hammoumi *et al.* (1998), Ngoan *et al.* (2000) and Lourhzal *et al.* (2002) reported a dry matter content of 30 to 40 percent, while, Ramachandran *et al.* (1992) and Kjos *et al.* (1999) reported a dry matter content of 45 to 50 per cent. A higher dry matter content of 93 per cent was reported by Krishnaswamy *et al.* (1965) and Johnson *et al.* (1985) for fish silage.

2.4.2 Crude Protein

The crude protein content of fish silage ranged between 11 to 30 per cent based on fish used for ensiling (Luscombe, 1973; Tibbetts *et al.*, 1981; Ward *et al.*, 1985; Strasdine *et al.*, 1988; Valdivieso *et al.*, 1992; Alwan *et al.*, 1993; Hammoumi *et al.*, 1998; Magana *et al.*, 1999; Ngoan *et al.*, 2000; Lourhzal *et al.*, 2002). A crude protein of 40 to 60 per cent was reported by Batterham *et al.* (1983), Offer and Husain (1987), Green *et al.* (1988), Espe *et al.* (1992a), Ali *et al.* (1994), Fagbenro and Jauncey (1995b) and White *et al.* (1998) in fish silage. Kumar and Sampath (1979) and Johnson *et al.* (1985) reported the crude protein content of 32 per cent. A higher protein content of 73 to 85 per cent was reported by Krishnaswamy *et al.* (1965), Myer *et al.* (1990) and Kjos *et al.* (1999) in fish silage..

2.4.3 Ether Extract

The ether extract content of fish silage ranged ~~between~~ from 2.5 to 10 per cent (Krishnaswamy *et al.*, 1965; Luscombe, 1973; Kumar and Sampath, 1979; Tibbetts *et al.*, 1981; Ward *et al.*, 1985; Strasdine *et al.*, 1988; Myer *et al.*, 1990; Fagbenro and Jauncey, 1995b; Hammoumi *et al.*, 1998; Magana *et al.*, 1999; Kjos *et al.*, 1999; Ngoan *et al.*, 2000; Lourhzal *et al.*, 2002), while, Whittemore and Taylor (1976a) and White *et al.* (1998) observed 28 per cent ether extract in fish silage.

Whittemore and Taylor (1976a) found that the oil content might fluctuate from 1.5 to 50 percent of dry matter according to season of the year. Similar values were reported by Johnsen and Skrede (1981), Espe *et al.* (1992a), Green *et al.* (1988) and Alwan *et al.* (1993).

2.4.4 Crude Fibre

The crude fibre content of fish silage varied based on the filler material used. Kumar and Sampath (1979) reported a crude fibre content of 10.63 per cent in fish silage, while, Valdivieso *et al.* (1992) found the carbohydrate content of fish silage as 10.71 per cent.

Ramachandran *et al.* (1992) reported the NDF, ADF, cellulose and lignin content in prawn waste-rice bran silage as 33 to 44, 16 to 25, 9.8 to 11.5 and 4.6 to 9.2 per cent, respectively. A lower crude fibre content of 0.08 per cent was reported by Hammoumi *et al.* (1998) and one percent by Magana *et al.* (1999).

2.4.5 Nitrogen Free Extract

The nitrogen free extract content was 28.66 per cent in solid fish silage and 57.64 per cent in liquid fish silage (Kumar and Sampath, 1979). Ali *et al.* (1995) reported that the nitrogen free extract was mainly contributed by wheat bran that was used as the filler material and it ranged from 16.91 to 28.43 per cent. Ramachandran *et al.* (1997) reported the nitrogen free extract content of prawn waste rice bran silage as 37.7 per cent, while, Magana *et al.* (1999) found it as 45.4 per cent.

2.4.6 Total Ash

The total ash content of fish silage ranged between 5 and 15 per cent (Krishnaswamy *et al.*, 1965; Luscombe, 1973; Whittemore and Taylor, 1976a; Strasdine *et al.*, 1988, Myer *et al.*, 1990; Espe *et al.*, 1992a; Ramachandran *et al.*, 1992; Valdivieso *et al.*, 1992; Fagbenro and Jauncey, 1995b; Hammoumi *et al.*, 1998; White *et al.*, 1998; Kjos *et al.*, 1999; Magana *et al.*, 1999; Lourhzal *et al.*, 2002). Total ash content of 21 per cent was observed by Ngoan *et al.* (2000) for shrimp by-product ensiled with molasses.

Ward *et al.* (1985) reported a low total ash content of 1.55 per cent, while, a high total ash content of 51 per cent was reported by Alwan *et al.* (1993) in fish waste silage.

2.4.7 Calcium and Phosphorus

The calcium and phosphorus content of fish silage ranged from 1.3 to 3.5 and 0.5 to 2 per cent, respectively (Whittemore and Taylor, 1976b; Kumar and Sampath, 1979; Tibbetts *et al.*, 1981; Johnson *et al.*, 1985; Myer *et al.*, 1990; Magana *et al.*, 1999; Lourhzal *et al.*, 2002).

Samuels *et al.* (1991) found the calcium content of finfish waste silage and crab waste silage as 7.5 and 12.7 per cent and phosphorus content as 0.71 and 0.35 per cent, respectively.

2.5 AMINO ACIDS IN FISH SILAGE

Krishnaswamy *et al.* (1965) found the available lysine, methionine, cystine and tryptophan of the ensiled fish to be 8.1, 3.6, 1.1 and 1.2 per cent, respectively. Whittemore and Taylor (1976a, b) reported that concentration of lysine, threonine, methionine and cystine in deoiled herring silage as 6.2, 3.0, 1.8 and 0.8 per cent, respectively.

Johnsen and Skrede (1981) reported a 50 per cent reduction of tryptophan in fish viscera silage when compared to unprocessed fish viscera. They further stated that tryptophan is the first limiting amino acid in fish viscera silage followed by sulphur containing amino acids.

The lysine, methionine and cystine concentration in fermented silage meal was 1.1, 0.6 and 0.25 per cent, respectively (Johnson *et al.*, 1985). They further stated that the recovery of amino acids relative to the total crude protein content from fermented silage meal was only 78.7 per cent presumably as a result of maillard reaction products during drying.

Machin *et al.* (1990) found that cystine content of silage was markedly lower and methionine contents slightly lower than those of raw fish. Myer *et al.* (1990) observed a lysine, methionine and threonine content in scallop viscera silage as 5.8, 2.6 and 3.7 per cent, respectively.

Dong *et al.* (1993) prepared silage by adding lactic and sulphuric acids to salmon viscera and separately co-dried with poultry by-product meal (1:1 dry weight basis) and found that methionine was the limiting amino acid.

Perez (1995) obtained higher levels of lysine, threonine and sulphur containing amino acids in fish silage than in fish meal. Consequently, fish silage would appear to be an excellent protein supplement for non-conventional livestock feeding systems.

Magana *et al.* (1999) found that the tryptophan and lysine contents decreased by 39 and 8 per cent, respectively, when formic sulphuric acid silage was stored for 20 days.

Ngoan *et al.* (2000) reported the lysine, methionine, threonine and phenylalanine content of shrimp by-product ensiled with molasses as 1.7, 0.7, 0.9 and 1.3 per cent, respectively.

Vidotti *et al.* (2003) showed that lysine, histidine, methionine, phenylalanine and tyrosine were present in higher concentrations whereas valine and isoleucine were deficient in acid silages and arginine was deficient in fermented silages.

2.6 MICROBIAL PROFILE OF FISH SILAGE

Krishnaswamy *et al.* (1965) found that coliforms, enterococci, salmonella, staphylococci and pathogenic anaerobes were absent in fish silage. Ahmed and Mahendrakar (1996a) reported that coliforms, *Escherichia coli*, enterococci, staphylococci and salmonella were absent from 48 or 72 hours onwards during fermentation at 37 and 26°C and *Clostridium perfringens* was absent after 48 hours and spores after 72 hours of fermentation at both temperatures in fermented fish silage. Faid *et al.* (1997) reported a rapid decrease of coliform and clostridium counts after 5 to 7 days of incubation of fish waste. Magana *et al.* (1999) also found that the contents of aerobic mesophiles, total coliforms, yeasts, and mould were reduced during one month of incubation at 37°C.

2.7 ACCUMULATION OF HEAVY METALS IN FISH SILAGE AND ANIMAL TISSUES

Batterham *et al.* (1983) found that mercury content of fish silage was 1.05 mg per kg. They also found that methyl mercury concentration in pigs fed fish silage and slaughtered at 45 kg live weight was 0.085 mg per kg on wet weight basis.

Myer *et al.* (1990) reported cadmium concentration of 2.5 mg per kg in kidney, 0.9 mg per kg in liver and a lesser concentration of 0.3 mg per kg in masseter muscle on wet basis when 24 per cent scallop viscera silage was included in diet of pigs.

Bello *et al.* (1993) observed low levels of lead, mercury and chrome in dry fish silage.

2.8 EFFECT OF FISH SILAGE ON GROWTH AND FEED EFFICIENCY

2.8.1 Broilers

McNaughton *et al.* (1978) found that adding hydrolysed fish protein to corn-soybean diet of broiler birds improved the feed efficiency but had no effect on 4-week body weight when compared to chicks fed a balanced corn-soybean diet. Krogdahl (1985b) reported that there was no significant difference in weight gain and livability in birds fed different levels of fish viscera silage. He further found that sensory qualities of meat decreased significantly. Johnson *et al.* (1985) also reported that there were no significant effects of inclusion of either acid silage meal or fermented silage meal up to a level of 10 per cent in the diet of broiler chicken. Strasdine *et al.* (1988) reported that waste from the processing of dogfish could be successfully made into fish silage. But when it was fed alone to monogastric animals, biological value was low.

Ochetim (1992) effectively replaced meat and bone meal with local fish waste meal at 15 and 12 per cent levels in the starter and finisher broiler rations, respectively. Espe *et al.* (1992a) evaluated the effect of substituting 0, 5, 10, 20, 30 and 40 per cent of fish meal protein with herring offal silage protein. They found no significant difference in feed intake, weight gain and feed efficiency up to a level of 30 per cent of diet protein from fish silage. Ahmed and Mahendrakar (1996b) evaluated the effect of replacing 25 and 50 per cent fish meal by fermented fish viscera silage in the ration of broiler chicks and they concluded that there were no significant differences in feed consumption and growth rate of chicks fed the control and fish viscera incorporated rations. Magana *et al.* (1999) fed fish silage dried with sorghum (70:30) and found that inclusion upto 15 per cent in the diet did not affect the weight gain, feed intake or feed conversion in broilers. Maigualema and Gernat (2003) studied the effect of replacing soyabean meal with Tilapia by-product meal and concluded that Tilapia by-product meal could be substituted for soyabean meal crude protein upto 50 per cent level without negatively affecting the bird performance and carcass quality.

Fish waste was ground and heated to 55°, 70° and 90°C for 24 hours each and incorporated in diets for broiler chickens at 2.5, 5, 7.5 and 10 per cent levels. The performance of chicken fed 5 per cent fish waste in the diet was significantly increased (Ilian *et al.*, 1985). Hassan and Heath (1987) found that broiler chicks fed a ration containing 5 and 10 per cent fish silage had better feed efficiency than did birds fed a ration with no silage. Results indicated that up to 10 per cent fish silage could be included in broiler rations without adversely affecting feed efficiency or body weight. Similarly, Nwokola and Sim (1990) fed broilers with fermented fish waste or fermented whole herring or herring fish meal at 5 or 10 per cent level and found that the feed gain ratio was highest for chicks fed a diet with 5 per cent fermented herring. Tanaka *et al.* (1990) fed growing chicks with diets containing 0, 0.2, 0.5, 1 or 2 per cent fermented products of chub mackerel (CME) and found that it improved the body weight gain, while, 1 or 2 per cent CME significantly decreased the abdominal fat weight. Machin *et al.* (1990)

concluded that the live weight gain and feed conversion ratio were significantly higher for chicks fed on low oil fish silage than those fed on high oil fish silage.

Rodriguez *et al.* (1990) conducted a biological test in broiler chicks to evaluate the effect of inclusion of fish silage at 2.5 and 5 per cent levels and they concluded that the diet with 5 per cent fish silage gave best results for weight gain, feed consumption and feed conversion ratio. Mahendrakar *et al.* (1991) fed broiler chicks with fish and poultry viscera silages to evaluate their growth performance and they found that between the groups fed with fish viscera autolysate at 15 and 30 per cent levels, the weight gain and feed consumption were higher for 30 per cent fish viscera autolysate diet fed birds. Bello and Fernandez (1995) found an increase in the weight gain and feed consumption in chicken fed 5 to 20 per cent fish silage in their diets. Raj *et al.* (1996) reported that replacement of 50 per cent of fish meal with fermented fish viscera silage improved the growth rate and feed conversion efficiency in broiler chicks. Hammoumi *et al.* (1998) on the other hand reported that the broilers showed a net increase in the live weight when fish silage was supplemented with barley flour and bran.

Broiler chicks fed diets containing fish silage had a greater weight gain, greater feed intake and a lower feed to gain ratio (Kjos *et al.*, 2000). In another experiment, they further found that when diets containing 50 g per kg fish silage and different levels of fish fat were fed to day old chicks, there were no significant differences in weight gain or carcass weight. Lourhzal *et al.* (2002) fed 25 days old broilers with fish silage at 5, 15 and 25 per cent levels and observed no mortalities and no symptoms of malnutrition. They found a net increase in weight of broilers fed on fish silage supplemented with barley flour and bran.

2.8.2 Layers

Krogdahl (1985a) observed no difference in death rates when fish viscera silage was included in the diet of layers. He further found that the egg weight and the laying rate did not differ significantly between treatments. Kjos *et al.* (2001) fed laying hens with diet containing 50 g per kg fish silage and different levels of fish fat and found that fish silage did not affect feed intake, egg production and the sensory quality of eggs, while, increasing levels of fish fat negatively influenced the egg production.

2.8.3 Pigs

Tatterson (1982) reported that when pigs were grown from 30 to 60 kg on fish silage diets their live weight, growth rate and feed conversion efficiency were significantly higher than those on the control diets. Similarly, Batterham *et al.* (1983) found that feeding with fish silage increased growth rate and improved feed conversion in pigs relative to soybean meal or a combination of both during the 20 to 45 kg growth phase, while, Green *et al.* (1988) concluded that growing pigs fed only fish silage grew significantly faster than those given no fish silage as it resulted in an improvement in feed conversion ratio.

Borin *et al.* (2000) reported that the growth rate of cross bred pigs varied between 325 to 476 grams per day with an average of 405 gram per day when they were fed eight kilogram of sugar palm juice, 400 gram of fish silage and 500 gram of rice bran, while, Ngoan *et al.* (2001) concluded that from an economical as well as performance point of view, ensiled shrimp by-product can replace 50 per cent of fish meal in cassava root meal and rice bran based diets for growing pigs with a low genetic growth potential.

Luscombe (1973) reported that there was no significant difference in daily weight gain from 60-120 lb, 120-200 lb or 60-200 lb when fish meal or a combination of fish meal and soybean meal was replaced with fish silage. Ayyaluswami *et al.* (1979) also concluded that replacement of fish meal either with prawn shell or fish silage rice bran mix did not affect body growth or feed efficiency of growing pigs for slaughter. The addition of scallop viscera silage to the diets of growing-finishing pigs had no effect on the resulting back fat thickness or loin eye area (Myer *et al.*, 1990). They also found that the inclusion of silage at 24 per cent did not influence the average daily gain, feed intake and feed per unit gain.

Kjos *et al.* (1999) reported no significant difference in growth performance when 50 gram per kilogram fish silage and different levels of fish fat were included in the diets of growing finishing pigs. Sakthivel (2003) fed growing and finishing swine rations containing dried cuttle fish waste silage replacing dried fish at 50 and 100 per cent levels on protein basis and found no difference in growth rate and feed efficiency between the treatments.

Tibbetts *et al.* (1981) fed 64 weanling and 64 finishing pigs with rations containing 0, 3, 6 and 9 per cent fish silage. They observed no significant differences in average daily gain between treatments but there was a decrease in feed conversion efficiency in animals fed with 6 and 9 per cent fish silage rations. Rose *et al.* (1994) showed that each 1 per cent addition of fish silage to the diets of growing pigs decreased the growth rate by 4 per cent. They further found that the pigs given fermented silage diets had a 12 per cent greater dry matter intake compared with the pigs given formic acid preserved silage.

Perez (1995) reported that the performance was significantly lower when 100 per cent of the fish meal was replaced by silage in growing pigs and this was attributed to the palatability of the ration which significantly affected feed intake. Coates *et al.* (1998) reported gastric ulceration and features of vitamin A toxicosis in two of twelve lame and recumbent growing pigs fed a diet of 50 per cent fish silage produced from the offal of farmed atlantic salmon. Lien *et al.* (2000) fed crossbred growing pigs without or with fish silage replacing 50 or 100 per cent of the crude protein from fish meal in the control diet and found a reduction in feed intake and daily gain in pigs fed fish silage.

2.8.4 Cattle and Sheep

Kumar and Sampath (1979) fed adult bullocks with 2.5 kg solid fish ensilage each day with ragi straw and reported no loss in body weight.

Winter and Javed (1980) concluded that when fish silage was fed to early weaned calves over the 10 week period, the feed consumption, weight gain and feed to gain ratio did not differ significantly as the proportion of fish silage in the diet increased.

Offer and Husain (1987) reported that calves fed on fish silage had significantly depressed feed intake and live weight gain but when fed to wether sheep digestibility of gross energy or organic matter was not reduced.

Samuels *et al.* (1991) reported that both fish and crab waste ensiled with straw were acceptable to sheep and that the nutrients were used efficiently. Similarly, James (1993) fed adult, dry non pregnant cows with grass hay or grass hay plus paddy straw or grass hay plus prawn silage and found that prawn silage can form a potential alternate feed source for cattle when prawn waste was ensiled with paddy straw and tapioca flour as additive.

2.8.5 Ducks

Krogdahl (1985b) found that feeding fish viscera silage improved the feed intake, weight gain and sensory quality of duck meat.

Perez (1995) replaced 50 or 75 per cent of the protein supplement by shrimp head silage and concluded that the silage material could replace 75 per cent of the fish or soybean protein supplement.

Barroga *et al.* (2004) fed fattening ducks on fish silage, tofu cake and sweet potato that comprised upto 50 per cent of the diet and observed no significant difference in final weight.

2.8.6 Rats

Espe *et al.* (1989) concluded that in rats the digestibility and utilization of protein of freshly prepared silage were higher than those of raw materials and silages stored for sometime, while, Espe *et al.* (1992b) determined the effect of storage for upto 1 year on the nutritional value of ensiled cooked and non-cooked minced capelin in growth experiments with young rats. They found that cooked silage was the best after storing for one year showing both better growth and protein efficiency ratio.

Rats fed fish silage at 25 and 50 per cent levels supplemented with barley showed no mortality or any symptoms of malnutrition (Lourhzal *et al.*, 2002). They further observed a net increase in weight gain when fed fermented fish waste supplemented with barley.

2.8.7 Fish

Ali *et al.* (1994) found that when 50, 75 and 100 per cent fish meal was replaced with fish silage prepared from under utilized marine fish, in the diet of major carp, the diet with fish silage showed consistently better performance than the diet with no silage.

Fagbenro and Jauncey (1995a) blended lactic acid fermented fish silage with soybean meal, poultry by-product meal, hydrolysed feather meal and meat and bone meal and the blends were evaluated as protein source for juvenile cat fish (*Clarias gariepinus*). They concluded that it could be used as a suitable protein supplement that could provide upto 50 per cent of dietary protein without affecting feed efficiency, fish growth or health.

Feeding trials and digestibility studies were conducted in recirculatory system to assess the effect of replacing fish meal with 0, 5, 10, 20, 30 and 40 per cent fermented shrimp head waste meal and the results showed no significant variation in apparent digestibility coefficient of nutrients, and protein efficiency ratio and food conversion ratio in fishes fed any of the diets (Nwanna, 2003).

2.8.8 Mink

The digestibility of dry matter, crude protein, crude fibre and gross energy was 86.0, 93.3, 98.1 and 90.4 per cent, respectively, for fermented dogfish silage (White *et al.*, 1998), while, that for fermented silver hake silage was 77.7, 84.5, 99.2 and 86.1 per cent, respectively (White *et al.*, 1999) when fed to mature mink.

2.9 EFFECT OF FISH SILAGE ON CARCASS CHARACTERISTICS

Luscombe (1973) found no significant difference between treatments for length, shoulder fat and loin fat when fish silage was fed as a replacement for fish meal or a combination of fish meal and soybean meal in the ration of pigs. They further found that there was no adverse effect on the fat quality and taste of fat and lean after cooking. Ologhobo *et al.* (1988) concluded that total edible meat, breast cuts and weights of giblets of broilers fed fish meal and neutral maize fish silage diets were not significantly different, but dressed and eviscerated carcass weight were highest in fish meal diets and lowest in acidic maize fish silage and acidic cassava fish silage diets. Rodriguez *et al.* (1990) found that feeding fish silage at 2.5 per cent and 5 per cent levels did not adversely affect the meat flavour and acceptability. Guevara *et al.* (1991) also observed acceptable flavour of meat from chicken fed fish silage. Avdalov *et al.* (1993) reported that there were no significant differences in carcass yield, carcass length and back fat thickness when fish silage was fed to fattening pigs.

Mahendrakar *et al.* (1991) reported fishy taint in muscle when fish viscera autolysate was included in the ration of broilers and this could be overcome by replacing it with commercial diet one week prior to slaughter. Kjos *et al.* (1999) concluded that diets containing 2.5 and 9.5 g per kg fish fat until slaughter caused off-flavour of bacon. Kjos *et al.* (2000) found that the diets containing the highest levels of fish fat caused off-odour and off taste to thigh meat stored at $-16^{o}C$, when diets containing fish silage was fed to broiler chicks.

Barroga *et al.* (2004) observed that dressing percentage, meat yield and carcass meat of ducks fed on fish silage, tofu cake and sweet potato were better than those fed the reference diet.

2.10 EFFECT OF FISH SILAGE ON SERUM CHOLESTEROL AND TRIGLYCERIDE

Tanaka *et al.* (1990) found that 1 or 2 per cent fermented products of chub mackerel in diets of 4 week old chicken decreased the triglyceride and free cholesterol concentrations in plasma.

2.11 DIGESTIBILITY OF FISH SILAGE

Whittemore and Taylor (1976b) concluded that the digestible energy and nitrogen were higher for diets containing fish silage. When growing pigs were fed diets containing 25 per cent deoiled herring silage or 25 per cent fish meal the efficiency of retention of digested nitrogen was 0.42 and 0.37 per cent, respectively.

Strom and Eggum (1981) reported that the digestibility of the protein was high, while, no difference in digestibility could be detected before or after autolysis when fish viscera silage was fed to rats. They further found that the biological value of protein increased after autolysis and de-oiling.

The digestibility coefficient of dry matter and nitrogen free extract when dried prawn waste (DPW) replaced 50 per cent protein from unsalted dried fish (USDF) in weanling pigs was better but that of crude protein was lower when DPW replaced 100 per cent of the USDF (Mohan and Sivaraman, 1993).

Sakthivel (2003) fed growing and finishing pigs with cuttle fish waste silage replacing dried fish at 0, 50 and 100 per cent levels on protein basis and found that the digestibility coefficient of dry matter and crude protein was lower for 50 per cent replacement diets and that of ether extract, crude fibre and nitrogen free extract was similar for all the three treatments.

2.12 BALANCE OF NITROGEN

Belay *et al.* (1993) performed colostomy in broilers and evaluated the urinary and faecal nitrogen excretion of birds exposed to thermoneutral and heat-distressed environment and found that the urine production and composition and overall water and nitrogen balance were strongly impacted by heat-distressed environment.

Bonnet *et al.* (1997) investigated the effect of chronic heat exposure on feed digestibility. They reared male chicken under 22 and 32°C and found that the nitrogen retention was significantly reduced in birds reared at 32°C compared to those at 22°C.

Dozier *et al.* (2001) evaluated the nitrogen and energy utilisation by male and female broilers that were fed adequate or deficient threonine and found that the males receiving adequate threonine had a higher retention of nitrogen than males consuming low threonine diets and females had similar nitrogen utilization at both threonine concentrations.

Kalinowski *et al.* (2003) found the per cent nitrogen retention of 29 day old slow and fast feathering broilers to be in the range of 62 to 64.

Sales and Janssens (2003) reported that the nitrogen retention in pigeons fed corn and pea diet ranged between 2.52 and 4.01 mg per g of diet nitrogen.

Keshavarz and Austic (2004) concluded that the nitrogen and phosphorus excretion of broilers fed diets containing 13 per cent crude protein and 0.2 per cent non phytate phosphorus supplemented with limiting amino-acids and phytase were lower than those fed high protein diets.

2.13 BALANCE OF CALCIUM AND PHOSPHORUS

Summers *et al.* (1976) studied the influence of dietary changes in calcium and phosphorus levels on retention of these nutrients in layers and found that the percent retention of calcium and phosphorus were 53 and 7.39 per cent at 2.96 per cent inclusion and 76.6 and 0.07 per cent at 1.5 per cent inclusion of calcium in their ration. They also found that the per cent retention of calcium and phosphorus were 63.19 and 7.23 per cent at 0.57 per cent inclusion of phosphorus and 66.7 and 0.23 per cent at 0.42 per cent inclusion in their ration.

Belay *et al.* (1992) found that the calcium and phosphorus balance in broilers were 268 and 271 mg per kg body weight per day, respectively, when reared in a thermoneutral environment.

2.14 ECONOMICS

Vedhanayakam *et al.* (1976) concluded that the cost of feed per kilogram gain in body weight was lower in groups where the fish silage replaced completely the fish meal on a nitrogen and quantitative basis. Ologhobo *et al.* (1988) observed that cost of feed per kilogram diet and kilogram body weight gain were lower when fish silage substituted fish meal in broiler feed formulation. Sakthivel (2003) reported that the cost of feed per kilogram gain was lower for growing pigs fed cuttle fish waste silage rations.

Materials and Methods

3. MATERIALS AND METHODS

An experiment was conducted in the Department of Animal Nutrition, College of Veterinary and Animal Sciences, Mannuthy for a period of six weeks to study the growth performance of broiler chicken fed on fermented fish waste silage ration.

3.1 EXPERIMENTAL MATERIALS

3.1.1 Experimental Birds

One hundred and eighty, day-old straight-run commercial broiler chicks (Vencob) procured from Venkateshwara Hatcheries Ltd., Palakkad, Kerala formed the experimental subjects.

3.1.2 Experimental Rations

The experimental broiler rations consisted of starter rations containing 23 per cent crude protein and 2800 kcal of metabolisable energy per kg and finisher rations containing 20 per cent crude protein and 2900 kcal of metabolisable energy per kg. Three isonitrogenous and isocaloric rations were formulated, viz.,

1. T1 (Control) - Standard broiler ration as per BIS (1992) specifications.
2. T2 - 50 per cent protein of unsalted dried fish of the control ration replaced by fermented fish waste silage.
3. T3 - 100 per cent protein of unsalted dried fish of the control ration replaced by fermented fish waste silage.

Birds were fed broiler starter rations up to four weeks of age and then they were switched to broiler finisher rations till the end of the experiment.

The ingredient composition of the three starter and finisher rations are presented in Table 1.

3.1.3 Fermented Fish Waste Silage

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

3.1.3.1 *Method of Preparation*

Fish processing plant waste was mixed with a consortium of bacteria and yeasts (1:1 wet basis) to produce fermented liquor. The clarified supernatant of fermented liquor was mixed with dried fish powder or pulverized fish (1:1 ratio) and heated. To this prawn shell, mollusc shell and other mineral supplements were added to produce fermented fortified fish meal. The final mixture was treated with two percent acetic acid to lower the p^H, dried and again pulverized.

3.2 EXPERIMENTAL METHODS

3.2.1 Housing of Birds

The experimental pens, feeders, waterers and other equipments were properly cleaned and disinfected one week before the chicks were housed. The disinfectant used was Kohrsolin-TH solution, manufactured by Hamburg, Germany, marketed in India by Glaxo SmithKline pharmaceuticals Ltd., Mumbai, the active content being Gluteraldehyde seven grams in 100 ml, the dilutions been done @ 5 ml of the product per 20 litres of water. The straight-run day-old chicks were wing banded, weighed individually and vaccinated against Ranikhet disease before housing.

3.2.2 Experimental Design

The chicks were randomly divided into 15 groups of 12 chicks each. The groups were allotted randomly to three dietary treatments viz., T1, T2 and T3 with five replicates in each treatment.

3.2.3 Management

The birds were provided with feed and water *ad libitum* throughout the experimental period and were maintained under deep litter system of management. The birds were vaccinated against Infectious Bursal Disease at 14 days of age. Standard managemental procedures were adopted identically to all treatments during the entire experimental period of six weeks.

3.2.4 Body Weight

The body weight of individual birds was recorded at weekly intervals from day old to study the pattern of growth rate under different dietary treatments.

3.2.5 Feed Consumption

Feed intake of the birds was recorded replicate wise at weekly intervals. From these data, the average feed intake per bird per day was calculated for various treatment groups.

3.2.6 Feed Conversion Ratio

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

3.2.7 Metabolism Trial

At the end of the experiment, a three-day metabolism trial was conducted using two birds from each replicate selected randomly. They were housed in individual metabolism cages with facilities for feeding, watering and excreta collection. Water was provided *ad libitum*. Excreta was collected over 24 hour period for three consecutive days using total collection method as described by Summers *et al.* (1976). The excreta was weighed each day and samples were taken in airtight containers and were stored in a deep freezer till they were analysed. The total amount of feed consumed was also recorded.

3.2.8 Chemical Analyses

The chemical composition of experimental rations and fermented fish waste silage was determined as per the standard procedures (AOAC, 1990). The nitrogen content of the excreta samples was determined in fresh material as per the procedure described in AOAC (1990). For mineral analyses the diet and excreta samples were subjected to wet digestion, using nitric acid and perchloric acid (2:1). Calcium content of the digested sample was determined using atomic absorption spectrophotometer (Perkin-Elmer Model-AAS 3110) and inorganic phosphorus by colorimetric method (AOAC, 1990) using Spectronic 1001_{plus} spectrophotometer (Milton Roy Co., USA).

From the data obtained on the total intake and outgo of nutrients during the metabolism trial, nitrogen retention and availability of calcium and phosphorus were calculated.

3.2.9 Serum Biochemical Parameters

At the end of sixth week, blood samples were collected from two birds in each replicate by severing the jugular vein for the estimation of serum calcium, phosphorus, cholesterol, triglyceride, glucose, creatinine and uric acid. The serum inorganic phosphorus was estimated colorimetrically using Spectronic 1001_{plus} spectrophotometer by phosphomolybdate method utilizing the kit supplied by M/s Agappe Diagnostics, Maharashtra, India. The serum cholesterol, triglycerides, glucose, creatinine and uric acid were estimated in blood analyzer (MISPA Plus) using the kits supplied by M/s Agappe Diagnostics. The serum calcium was determined using atomic absorption spectrophotometer.

3.2.10 Processing Yields

At the end of sixth week, two birds from each replicate were randomly selected and sacrificed to study the processing yields as per the procedure described by BIS (1973). Percentages of giblet, ready-to-cook and abdominal fat yields were calculated from the slaughter data.

3.2.11 Livability

The mortality of birds from different treatment groups was recorded and per cent livability was calculated.

3.2.12 Economics

Cost of feed/kg live weight gain for different dietary treatments was calculated from cost of feed, live weight gain of birds and quantity of feed consumed by birds in each treatment group.

3.2.13 Statistical Analysis

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

Table 1. Ingredient composition of broiler starter and finisher rations, %

Ingredients	Starter			Finisher		
	T1	T2	T3	T1	T2	T3
Yellow maize	48.00	48.00	48.00	59.00	59.00	59.00
Wheat bran	4.68	4.84	4.98	3.68	3.84	3.98
Soybean meal	35.00	35.00	35.00	25.00	25.00	25.00
Unsalted dried fish	10.00	5.00	0.00	10.00	5.00	0.00
Fermented fish waste silage	0.00	4.84	9.70	0.00	4.84	9.70
Mineral mixture	1.75	1.75	1.75	1.75	1.75	1.75
Common salt	0.25	0.25	0.25	0.25	0.25	0.25
Vitamin mixture[1]	0.02	0.02	0.02	0.02	0.02	0.02
Toxin binder[2]	0.05	0.05	0.05	0.05	0.05	0.05
Coccidiostat[3]	0.10	0.10	0.10	0.10	0.10	0.10
Choline chloride	0.15	0.15	0.15	0.15	0.15	0.15
Total	100.00	100.00	100.00	100.00	100.00	100.00

[1]Vitamin mixture: NICOMIX AB_2D_3K and NICOMIX BE, 1:1 ratio (Nicholas primal India Ltd., India)

Composition per gram:

NICOMIX AB_2D_3K: Vitamin A - 82500 IU, Vitamin B_2 - 50 mg, Vitamin D_3 - 12000 IU, Vitamin K - 10 mg

NICOMIX BE: Vitamin B_1 - 4 mg, Vitamin B_6 - 8 mg, Vitamin B_{12} - 40 µg, Niacin - 60 mg, Vitamin E - 40 mg, Ca pantothenate - 40 mg.

[2]Toxin binder (Toxiwin™):

Contains: Hydrated sodium calcium alumino silicate.

[3]Coccidiostat (Anacox™ 1%):

Each gram contains: Maduramycin ammonium 10 mg.

Results

4. RESULTS

The results obtained in the present study are detailed under the following headings.

4.1 CHEMICAL COMPOSITION

The chemical composition of starter and finisher rations are presented in Table 2. The chemical composition of fermented fish waste silage was estimated. The dry matter, crude protein, ether extract, crude fibre, total ash, nitrogen free extract, acid insoluble ash, calcium and phosphorus content of fermented fish waste silage were 91.91, 46.56, 3.23, 3.14, 24.41, 22.66, 0.53, 7.26, and 2.52 per cent, respectively.

4.2 BODY WEIGHT

The weekly mean body weight of birds is presented in Table 3 and is graphically represented in Fig. 1. The mean body weight of birds belonging to the groups T1, T2 and T3 were 1439, 1479 and 1536 g, respectively, at six weeks of age.

4.3 BODY WEIGHT GAIN

The data on weekly cumulative mean weight gain up to six weeks of age of birds among different dietary treatments are presented in Table 4 and is graphically represented in Fig. 2. The cumulative mean body weight gain of birds belonging to the groups T1, T2 and T3 were 1401, 1434 and 1491 g, respectively, at sixth week.

4.4 FEED CONSUMPTION

Data on weekly average of daily feed intake and cumulative feed intake per bird maintained on different dietary treatments are given in Tables 5 and 6, respectively, and the graphical representation of data on cumulative feed intake in Fig. 3. The cumulative mean feed intake of the birds of T1, T2 and T3 were 2998, 3013 and 3127 g, respectively, at sixth week.

4.5 FEED CONVERSION EFFICIENCY

The data pertaining to mean cumulative feed conversion efficiency (kg feed /kg gain) at weekly intervals for different dietary treatments are set out in Table 7 and are graphically represented in Fig. 4. The mean cumulative feed conversion efficiency of experimental birds was 2.12, 2.08 and 2.09 for the treatments T1, T2 and T3, respectively, at sixth week.

4.6 BALANCE AND RETENTION OF NITROGEN, CALCIUM AND PHOSPHORUS

The data on balance (g/day) and retention (per cent) of nitrogen, calcium and phosphorus of the birds during the metabolism trial are given in Table 8. The data on retention of nitrogen, calcium and phosphorus is graphically represented in Fig. 5.

The percentage retention was 41.48, 43.36 and 40.92 for nitrogen; 28.73, 23.66 and 22.93 for calcium and 31.72, 33.37 and 30.27 for phosphorus for birds in T1, T2 and T3, respectively.

4.7 SERUM BIOCHEMICAL PARAMETERS

The data on serum cholesterol, triglyceride, glucose, creatinine, uric acid, calcium and phosphorus content of experimental birds as influenced by different dietary treatments at six weeks of age are presented in Table 9 and the data on serum cholesterol, triglyceride, glucose, uric acid, calcium and phosphorus content are graphically represented in Fig. 6 and 7.

Serum cholesterol content of birds were 107.36, 104.48 and 101.98 and serum triglyceride content was 123.94, 94.37 and 87.04 mg per cent at six weeks of age for T1, T2 and T3, respectively. Serum glucose content was 166.2, 153.8 and 164.6 mg per cent for T1, T2 and T3, respectively.

The mean serum creatinine and uric acid content of birds were 0.36, 0.35 and 0.36 and 3.35, 2.98 and 2.85 mg per cent at sixth week for T1, T2 and T3, respectively.

The mean serum calcium content of birds was 9.7, 10.4 and 9.4 mg per cent, respectively. Serum inorganic phosphorus content for the treatments T1, T2 and T3 were 5.43, 5.33 and 5.95 mg per cent, respectively.

4.8 PROCESSING YIELDS

Data on per cent ready-to-cook yield, giblet yield and abdominal fat yield of birds maintained on different dietary treatments at six weeks of age are given in Table 10 and are graphically represented in Figs. 8 and 9.

The per cent ready-to-cook yield were 69.07, 67.04 and 65.39; the per cent giblet yield were 4.15, 4.11 and 3.98 and the per cent abdominal fat yield were 0.96, 0.91 and 0.72 at sixth week for T1, T2 and T3, respectively.

4.9 LIVABILITY

During the course of the experiment one bird died from T2. The per cent livability was 100 for T1 and T3 and 98.33 for T2.

4.10 ECONOMICS OF GAIN

Cost of experimental rations and cost of production (Rs.) per kg live weight gain of birds maintained on different dietary treatments are charted out in Table 11. Their graphical representations are given in Fig. 10.

The cost of feed per kg live weight gain of birds maintained on different dietary treatments T1, T2 and T3 were Rs. 18.94, 19.09 and 18.49 for starter ration and Rs. 22.28, 20.16 and 21.10 for finisher ration, respectively.

Table 2. Chemical composition of broiler starter and finisher rations*, %

Items	Starter ration			Finisher ration		
	T1	T2	T3	T1	T2	T3
Dry matter	88.86	87.88	87.14	86.68	86.96	87.32
Crude protein	24.42	24.40	24.54	20.28	21.37	20.83
Ether extract	2.35	1.98	2.02	2.06	1.67	1.59
Crude fibre	6.01	6.09	5.95	4.67	4.38	5.09
NFE	57.23	57.04	58.78	62.89	63.05	64.73
Total ash	9.99	10.49	8.71	10.10	9.53	7.76
Acid insoluble ash	2.76	2.49	1.69	3.23	2.62	1.15
Calcium	0.96	0.75	1.13	0.89	0.82	0.87
Phosphorus	0.73	0.77	0.69	0.63	0.67	0.64

*On dry matter basis

Table 3. Weekly mean body weight of birds maintained on different dietary treatments, g

Age in weeks	Treatments			CD
	T1	T2	T3	
0	43.31±0.68	45.17±0.42	44.20±0.26	-
1	120.10±2.47	122.25±1.77	119.70±1.31	NS
2	303.57±5.33	305.95±3.83	304.47±4.21	NS
3	528.10±12.76	522.98±11.04	537.07±11.71	NS
4	787.73±26.10	781.26±22.86	820.85±30.66	NS
5	1186.56±49.64	1178.23±30.77	1232.01±46.52	NS
6	1438.84±62.03	1479.34±32.02	1535.55±56.97	NS

NS - Non significant

Table 4. Cumulative mean body weight gain of birds maintained on different dietary treatments, g

Age in weeks	Treatments			CD
	T1	T2	T3	
1	75.79±2.29	77.11±2.03	75.49±1.53	NS
2	259.27±5.03	260.78±3.58	258.71±4.97	NS
3	483.66±12.41	477.81±10.66	493.73±11.58	NS
4	743.67±25.35	736.14±22.43	784.73±34.40	NS
5	1140.13±47.64	1137.65±30.08	1191.27±44.01	NS
6	1395.53±58.01	1434.48±31.58	1491.31±56.96	NS

NS - Non significant

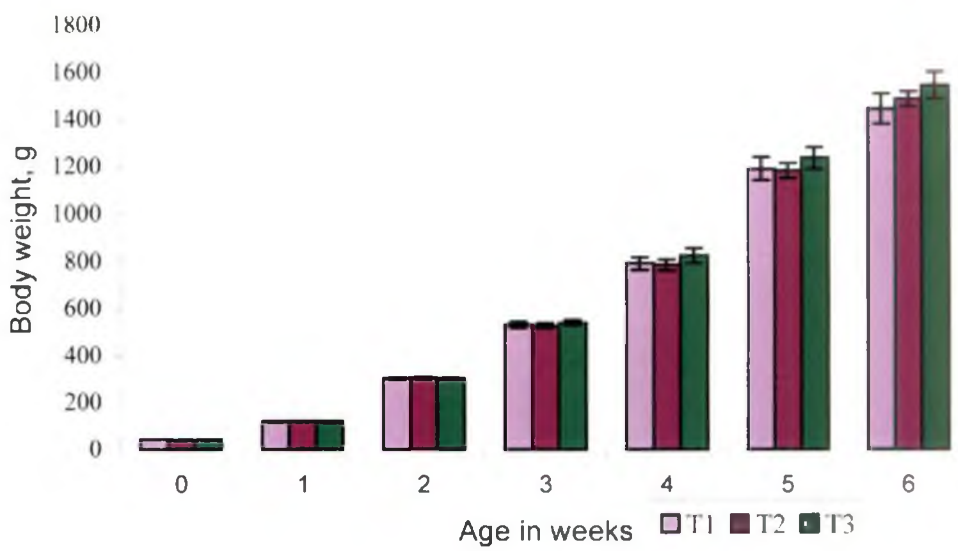


Fig.1.Weekly mean body weight of birds maintained on different dietary treatments

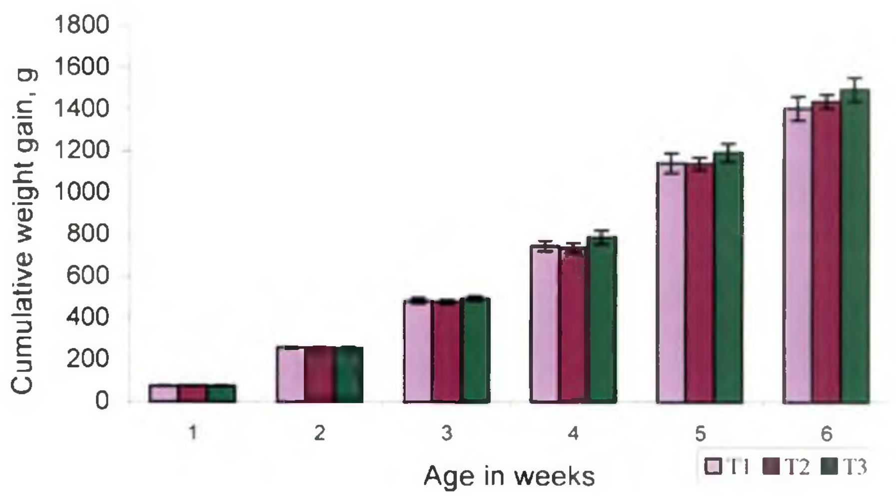


Fig.2. Cumulative mean body weight gain of birds maintained on different dietary treatments

Table 5. Weekly average of daily feed intake of birds maintained on different dietary treatments, g

Age in weeks	Treatments			CD
	T1	T2	T3	
1	12.64±0.40	12.83±0.26	12.74±0.26	NS
2	42.00±0.40	42.46±0.92	41.65±0.42	NS
3	63.13±3.54	68.27±2.30	68.70±2.53	NS
4	86.57±2.60	84.17±2.43	90.58±2.89	NS
5	96.65±3.28	95.46±1.62	97.90±2.45	NS
6	126.79±5.15	127.23±6.16	135.55±7.52	NS

NS - Non significant

Table 6. Cumulative mean feed intake of birds maintained on different dietary treatments, g

Age in weeks	Treatments			CD
	T1	T2	T3	
1	88.46±2.79	89.79±1.83	89.14±1.82	NS
2	382.47±5.08	387.00±5.82	382.66±4.33	NS
3	824.35±24.35	864.87±17.35	863.56±20.36	NS
4	1430.36±40.78	1454.05±28.11	1493.26±20.31	NS
5	2110.04±58.53	2122.30±38.69	2178.53±36.27	NS
6	2997.60±87.35	3012.83±70.71	3127.36±82.67	NS

NS - Non significant

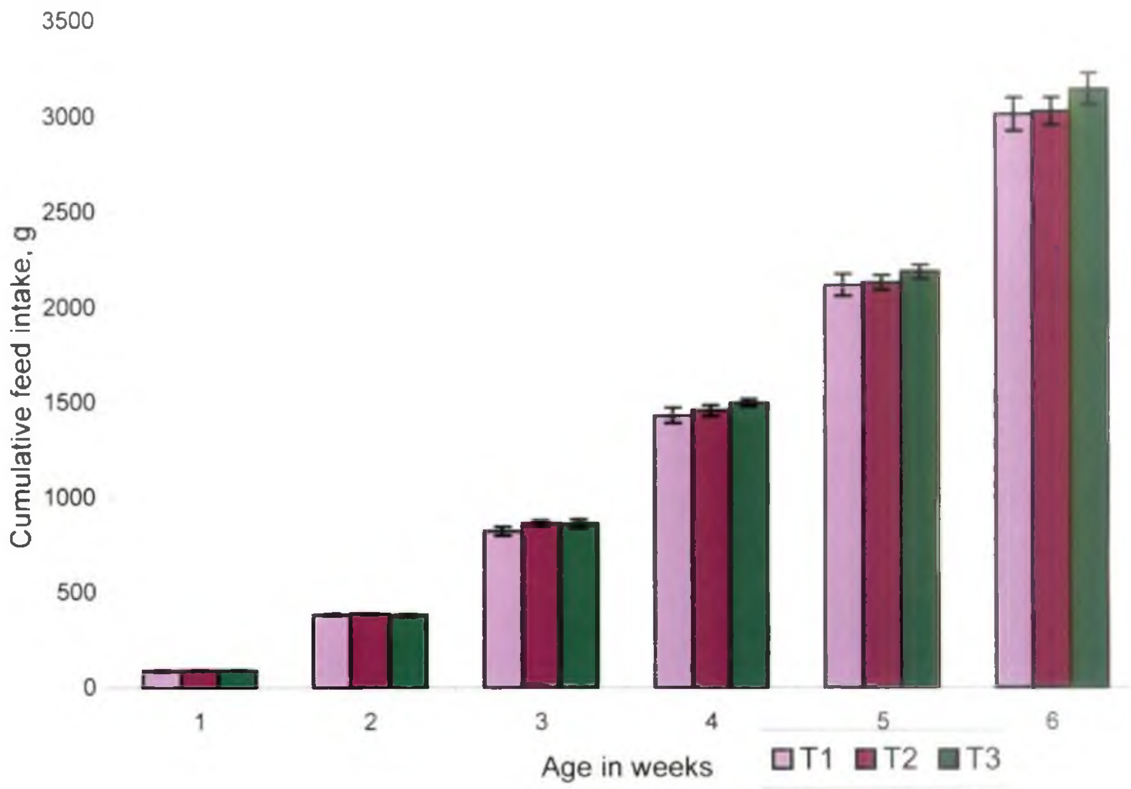


Fig. 3. Cumulative mean feed intake of birds maintained on different dietary treatments

Table 7. Cumulative mean feed conversion ratio of birds maintained on different dietary treatments

Age in weeks	Treatments			CD
	T1	T2	T3	
1	1.29±0.12	1.17±0.02	1.18±0.03	NS
2	1.48±0.03	1.48±0.004	1.47±0.03	NS
3	1.68±0.06	1.81±0.04	1.75±0.06	NS
4	1.89±0.06	1.98±0.05	1.92±0.08	NS
5	1.93±0.05	1.92±0.06	1.92±0.07	NS
6	2.12±0.04	2.08±0.03	2.09±0.04	NS

NS - Non significant

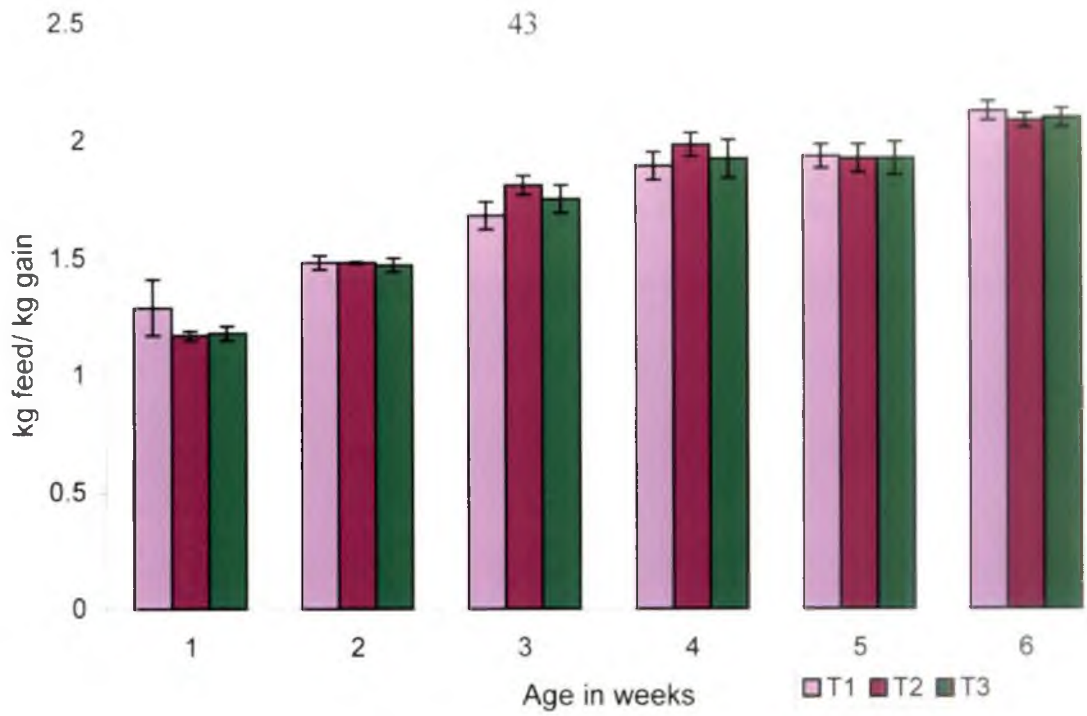


Fig. 4. Cumulative mean feed conversion efficiency of birds maintained on different dietary treatments

Table 8. Balance and retention of nitrogen, calcium and phosphorus in birds maintained on different dietary treatments

Parameters	Treatments			CD
	T1	T2	T3	
Nitrogen balance (g/day)	1.99±0.19	2.50±1.12	2.16±0.97	NS
Nitrogen retention (%)	41.48±2.74	43.36±5.16	40.92±2.69	NS
Calcium balance (g/day)	0.37±0.08	0.31±0.07	0.31±0.03	NS
Calcium retention (%)	28.73±5.87	23.66±5.21	22.93±2.02	NS
Phosphorus balance (g/day)	0.29±0.03	0.36±0.02	0.30±0.03	NS
Phosphorus retention (%)	31.72±3.23	33.37±2.29	30.27±1.72	NS

NS - Non significant

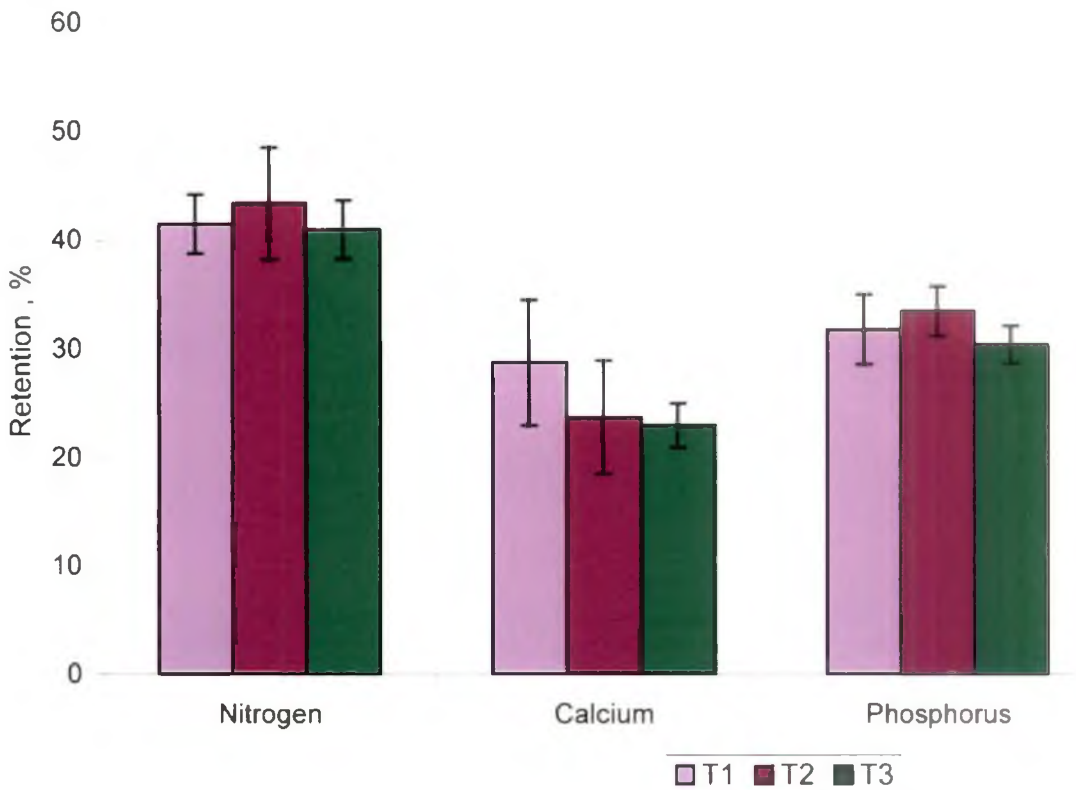


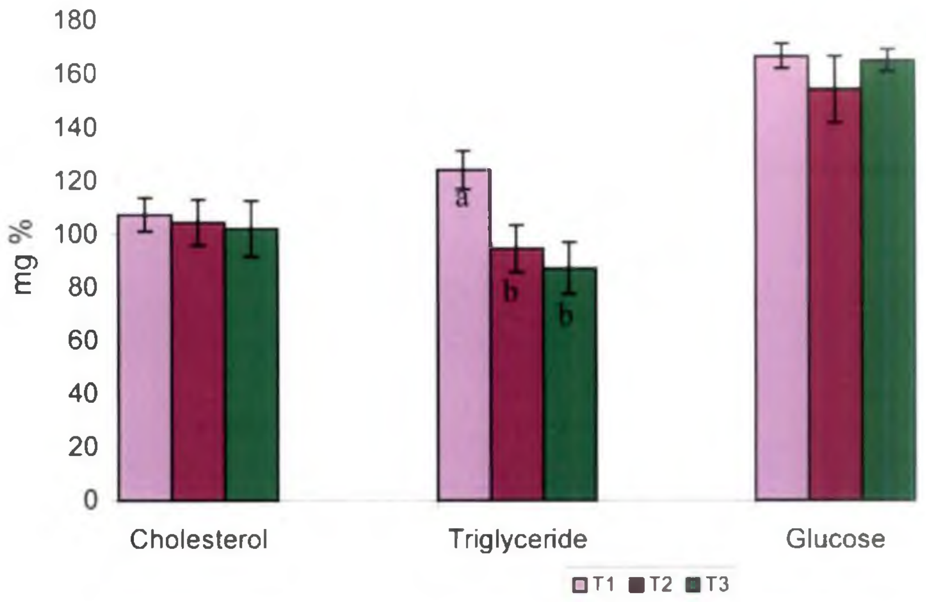
Fig. 5. Nitrogen, calcium and phosphorus retention in birds maintained on different dietary treatments

Table 9. Serum biochemical parameters of birds maintained on different dietary treatments at six weeks of age, mg %

Parameters	Treatments			CD
	T1	T2	T3	
Cholesterol	107.36±6.37	104.48±8.60	101.98±10.48	NS
Triglyceride	123.94^{a}±7.10	94.37^{b}±8.83	87.04^{b}±9.67	26.50
Glucose	166.20±4.63	153.80±12.39	164.60±4.17	NS
Creatinine	0.36±0.02	0.35±0.004	0.36±0.004	NS
Uric acid	3.35±0.67	2.98±0.30	2.85±0.40	NS
Calcium	9.70±0.88	10.40±0.58	9.40±1.01	NS
Phosphorus	5.43±1.31	5.33±1.39	5.95±1.10	NS

a, b- Means bearing the different superscript within the same row differed significantly (P<0.05)

NS - Non significant



a, b Means with different superscripts differ (P<0.05)

Fig. 6. Serum cholesterol, triglyceride and glucose content of birds maintained on different dietary treatments at six weeks of age

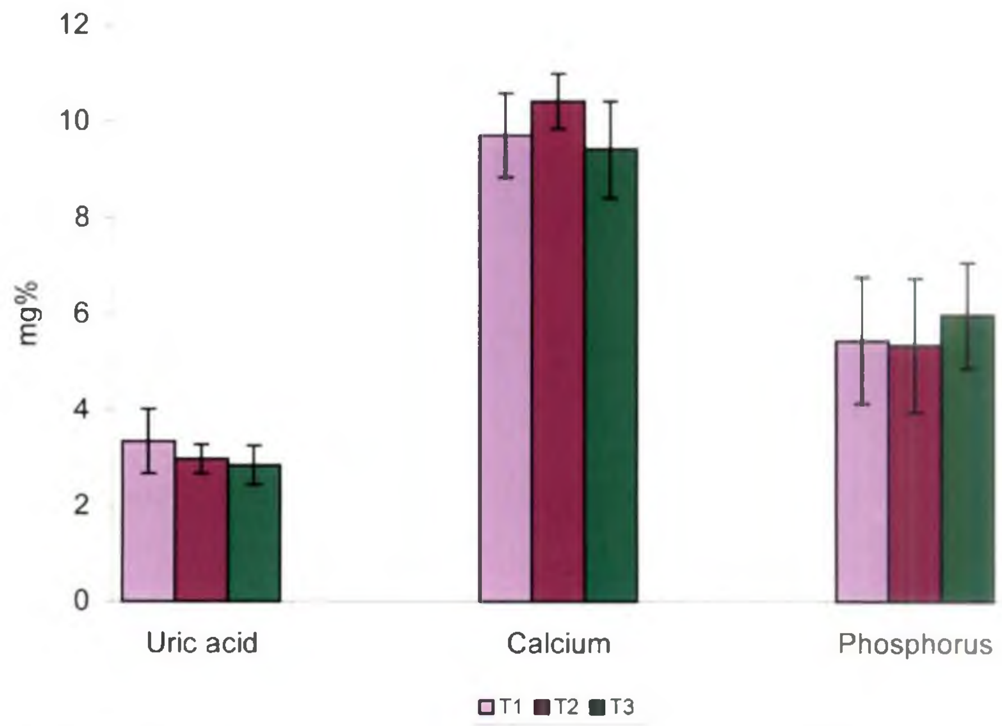


Fig. 7. Serum uric acid, calcium and phosphorus content of birds maintained on different dietary treatments at six weeks of age

Table 10. Processing yields of birds maintained on different dietary treatments at six weeks of age, %

Parameters	Treatments			CD
	T1	T2	T3	
Ready-to-cook yield	$69.07^{a}\pm0.92$	$67.04^{ab}\pm0.70$	$65.39^{b}\pm1.14$	2.89
Giblet yield	4.15±0.10	4.11±0.13	3.98±0.19	NS
Abdominal fat yield	0.96±0.08	0.91±0.12	0.72±0.06	NS

a, b- Means bearing the different superscript within the same row differed significantly (P<0.05)

NS - Non significant

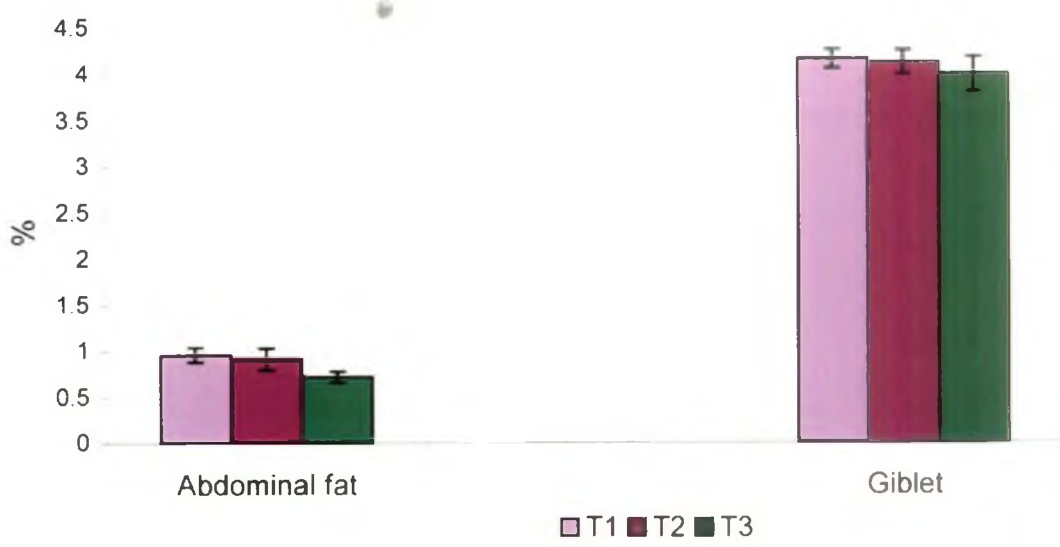
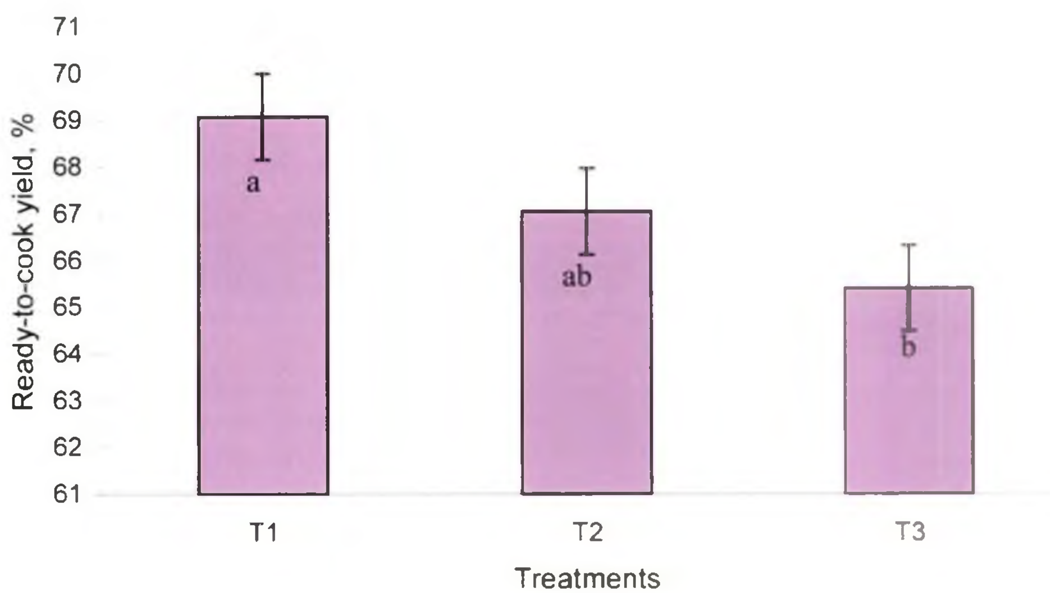


Fig. 8. Abdominal fat and giblet yields of birds maintained on different dietary treatments at six weeks of age



a, b Means with different superscripts differ ($P<0.05$)

Fig. 9. Ready-to-cook yield of birds maintained on different dietary treatments at six weeks of age

Table 11. Cost of feeding of birds maintained on different dietary treatments

Parameters	Treatments		
	T1	T2	T3
Cost of feed/kg* (Rs)			
Starter	9.80	9.74	9.68
Finisher	9.31	9.25	9.19
Total feed intake (kg)			
Starter	1.43 ± 0.04	1.45 ± 0.03	1.49 ± 0.02
Finisher	1.58 ± 0.06	1.56 ± 0.05	1.63 ± 0.07
Live weight gain of birds (kg)			
0 to 4th week	0.74 ± 0.02	0.74 ± 0.02	0.78 ± 0.03
5th to 6th week	0.66 ± 0.03	0.70 ± 0.02	0.71 ± 0.03
0 to 6th week	1.40 ± 0.06	1.44 ± 0.03	1.49 ± 0.06
Cost of feed/kg live weight gain (Rs.)			
0 to 4th week	18.94	19.09	18.49
5th to 6th week	22.28	20.61	21.10
0 to 6th week	20.51	19.83	19.73

* Cost calculated using the rate contract values fixed for feed Ingredients by College of Veterinary and Animal Sciences, Mannuthy.

Fig. 10. Cost of production of birds maintained on different dietary treatments

Discussion

5. DISCUSSION

5.1 CHEMICAL COMPOSITION OF FERMENTED FISH WASTE SILAGE

5.1.1 Dry Matter

The dry matter content of fish silage varied depending on the type of product (dried or wet), drying method (sun dried or oven dried) and the nature of filler material used. The dry matter content of fermented fish waste silage used in the present study was 91.91 per cent. Krishnaswamy *et al.* (1965) also reported a dry matter content of 93.2 when silage was prepared from fresh water fish and dried in a double drum drier and flaker at 50 p.s.i. steam pressure. Similarly, Johnson *et al.* (1985) obtained a dry matter content of 93.6 and 92.5 percent for acid fish silage meal and fermented fish silage meal, respectively, when it was dried with wheat bran. Lower dry matter content of 19 to 30 per cent was reported by Myer *et al.* (1990), Espe *et al.* (1992a) and Alwan *et al.* (1993) in different fish silages.

5.1.2 Crude Protein

The crude protein content of fish silage varied depending on the type of fish and filler material used. Crude protein of fermented fish waste silage used in the present study was 46.56 per cent. Similar values for crude protein (45.9 and 45.7 per cent) were reported by Espe *et al.* (1992a) and White *et al.* (1998), respectively for different fish silages.

Myer *et al.* (1990) obtained a higher crude protein content of 85.4 per cent when no filler material was used. A lower protein content of 11.34 and 13 per cent were reported by Hammoumi *et al.* (1998) and Lourhzal *et al.* (2002) in different fish silages.

5.1.3 Ether Extract

Ether extract content of the fermented fish silage used in the present study was 3.23 percent. Tibbetts *et al.* (1981) reported the ether extract content of 3.1 per cent for fish silage dried with corn and molasses, which is in accordance with the values obtained in the present study. Similar values were also reported by Myer *et al.* (1990) in scallop viscera silage. Ngoan *et al.* (2000) reported the ether extract content of shrimp by product ensiled with molasses as 2.9 per cent.

However, Whittemore and Taylor (1976a) found that the oil content of fish silage fluctuated from 1.5 to 50 per cent of dry matter according to the season of the year. Johnsen and Skrede (1981), Espe *et al.* (1992a), Alwan *et al.* (1993) and Green *et al.* (1988) also reported values in the above range in different fish silages.

5.1.4 Crude Fibre

The crude fibre content of fish silage varied based on the filler material used. The crude fibre content of fermented fish waste silage used in the present study was 3.14 per cent. Machin *et al.* (1990) reported the crude fibre content of high and low oil fish silages as 2.4 and 2.8 per cent, respectively, when silage was dried with cassava meal in 2:1 proportion. A lower crude fibre content of 0.08 and one per cent was reported by Hammoumi *et al.* (1998) and Magana *et al.* (1999) when no filler material was added. However, a higher crude fibre content of 15.04 per cent was observed by Sakthivel (2003), when rice bran was used as the filler material in cuttle fish waste silage.

5.1.5 Total Ash

The total ash content of fermented fish waste silage used in the present study was 24.41 per cent. Ngoan *et al.* (2000) reported a total ash content of 21 per cent for shrimp by-product ensiled with molasses.

Ward *et al.* (1985) reported a very low ash content of 1.55 per cent in acid fish waste silage, while, a higher total ash content of 51 per cent was reported by Alwan *et al.* (1993). Total ash content ranging from 8 to 15 per cent was obtained by Fagbenro and Jauncey (1995b) and Hammoumi *et al.* (1998) in fermented fish waste silage and Magana *et al.* (1999) and Kjos *et al.* (1999) in acid fish silage.

5.1.6 Nitrogen Free Extract

The nitrogen free extract of fermented fish waste silage was 22.66 per cent which is in agreement with Ali *et al.* (1995) who reported that the nitrogen free extract of fish silage ranged between 16.91 and 28.43.

Kumar and Sampath (1979) found the nitrogen free content as 28.66 and 57.64 percent in solid fish silage and liquid fish silage, respectively. Magana *et al.* (1999) also observed higher nitrogen free extract of 45.4 per cent in acid fish silage.

5.1.7 Calcium and Phosphorus

The calcium and phosphorus content of fermented fish waste silage in the present study was 7.26 and 2.52 per cent, respectively. Similar value for calcium (7.2 percent) was reported by Samuels *et al.* (1991) in finfish waste silage, while, the phosphorus content was 0.71 per cent.

The calcium and phosphorus content ranging from 1.3 to 3.2 and 0.5 to 1.97 per cent, respectively, was reported by Kumar and Sampath (1979), Tibbetts *et al.* (1981) and Johnson *et al.* (1985) in different fish silages. A higher calcium value of 12.7 per cent was reported by Samuels *et al.* (1991) in crab waste silage, while the phosphorus content was 0.35 per cent.

5.2 BODY WEIGHT

From the Table 3 it can be seen that the average weekly body weight of birds maintained on the three different dietary treatments were almost similar and the difference between groups was non-significant ($P>0.05$) for all week periods. However the body weight of birds maintained on T2 and T3 were seen to increase numerically than those of T1 after the third week. At six weeks of age the body weight of birds maintained on T2 and T3 were 40.50 and 96.71 g higher than those of T1, respectively.

This finding is in agreement with Johnson *et al.* (1985) who observed no significant effect on growth performance of broilers when acid silage meal or fermented silage meal was added upto 10 per cent level in the diet of broilers. Similarly, Ochetim (1992) effectively replaced meat and bone meal with local fish waste meal at 15 and 12 per cent levels in the starter and finisher broiler rations, respectively, without adversely affecting the broiler performance. Ahmed and Mahendrakar (1996b) also found no significant difference in the growth rate of chicks fed diets containing fermented fish viscera silage replacing fish meal at 25 and 50 per cent levels.

Raj *et al.* (1996) on the other hand reported that replacement of 50 per cent fish meal with fermented fish viscera silage improved the growth rate. Hammoumi *et al.* (1998) also observed a net increase in the live weight of broilers when fish silage was supplemented with barley flour and bran.

5.3 BODY WEIGHT GAIN

From the data presented in Table 4 it could be seen that the weekly cumulative mean weight gain of birds maintained on the three dietary treatments T1, T2 and T3 were statistically similar ($P>0.05$). However, after third week the cumulative mean weight gain of birds maintained on the dietary treatment T3 was numerically higher than those under T1 and T2. At six weeks of age birds of T2 and T3 had 2.35 and 6.41 per cent more weight gain than those of T1. Though the cumulative mean body weight gain of birds fed fermented fish waste silage was numerically higher than that of control diet containing unsalted dried fish, the difference between the groups was non-significant.

The results of the present study are in close agreement with Krogdahl (1985b) who reported that there was no significant difference ($P>0.05$) in weight gain in birds when fed different levels of fish viscera silage. Similarly, Espe *et al.* (1992a) found no significant difference in weight gain when fish silage was included to supply upto 30 per cent of diet protein. Magana *et al.* (1999) also found no effect on weight gain upto 15 per cent inclusion of fish silage in the diet of broilers.

On the other hand, Rodriguez *et al.* (1990) concluded that the diet with 5 per cent fish silage gave best results for weight gain. Machin *et al.* (1990) also found that the live weight gains were significantly higher for chicks fed on low oil fish silage than those fed on high oil fish silage. Similarly, Bello and Fernandez (1995) found an increase in weight gain in chicken fed 5 to 20 per cent fish silage in their diets.

5.4 FEED CONSUMPTION

The data on weekly average of daily feed intake of birds maintained on different dietary treatments presented in Table 5 indicate that the difference between the groups was non-significant (P>0.05) for all week periods. However, the feed intake of birds maintained on T2 and T3 were numerically higher than those on Tl diet at three weeks of age but at fifth week the birds in all three treatments were found to be similar. At six weeks of age the average daily feed intake of birds maintained on the dietary treatment T3 (135.55 g) was numerically higher than that of T1 (126.79 g) and T2 (127.23 g).

The mean cumulative feed intake (Table 6) of birds was 2997.60, 3012.8 and 3127.36 g from zero to sixth week for Tl, T2 and T3, respectively, which shows an increasing trend in the feed intake when the level of fermented fish waste silage was increased. However, the mean cumulative feed intake of birds in the three different dietary treatments did not differ significantly (P>0.05).

The findings of the present study are in agreement with that of Espe *et al.* (1992a) who found no significant difference in feed intake between different treatments when herring offal silage was added to supply upto 30 per cent of diet protein. Similarly, Ahmed and Mahendraker (1996b) found no significant difference in feed consumption when 25 and 50 per cent of fish meal was replaced by fermented fish viscera silage in the ration of broilers, while, Magana *et al.* (1999) observed no effect on feed intake upto 15 per cent level of inclusion of fish silage in the diet of broilers.

Rodriquez *et al.* (1990) reported higher feed consumption in birds fed fish silage at 5 per cent level. Similar results were obtained by Mahendrakar *et al.* (1991) in birds fed fish viscera silage and Bello and Fernardez (1995) in broilers when fish silage was included at 5 to 20 per cent level.

5.5 FEED CONVERSION EFFICIENCY

From the results given in Table 7, it can be seen that the mean cumulative feed conversion efficiency values of birds maintained on the dietary treatments T1, T2 and T3 were statistically similar (P>0.05). The birds maintained on the three dietary treatments T1, T2 and T3 showed a cumulative feed conversion efficiency of 2.12, 2.08 and 2.09, respectively.

The efficiency of feed conversion by the birds fed fish silage was related to the balance of essential amino acids in the silage that was depended on the type and quality of fish used. Krogdahl (1985b) reported the feed conversion efficiency of broilers as 2.46, 2.37 and 2.36 when fed 25, 50 and 100 g per kg fermented silage meal. Similarly, Espe *et al.* (1992a) and Magana *et al.* (1999) reported that the feed conversion efficiency of birds did not differ significantly when fish silage was incorporated in their diets at 30 and 15 per cent levels, respectively.

Hassan and Heath (1987) found that broiler chicks fed a ration containing 5 and 10 per cent fish silage had better feed efficiency than birds fed a ration without silage. Similar results were obtained by Nwokola and Sim (1990) and Rodriguez *et al.* (1990) when 5 per cent fish silage was added in the diet of broilers and Raj *et al.* (1996) when 50 per cent fermented fish viscera silage was added in the diet. Kjos *et al.* (2000) also found that the broiler chicks had a lower feed to gain ratio when diets containing 50 and 100 g per kg fish silage were fed.

5.6 NITROGEN BALANCE AND RETENTION

The effect of different dietary treatments of nitrogen balance and per cent retention were determined and the values are given in Table 8. The values for nitrogen balance and retention for the three dietary treatments were 1.99, 2.5 and 2.16 g per day and 41.48, 43.36 and 40.92 per cent, respectively. Even though there was no significant difference (P>0.05) between treatments for these parameters, T2 and T3 birds registered 25.63 and 8.54 per cent higher nitrogen balance, respectively, than those of T1. The nitrogen retention of birds fed T2 diet was 4.53 per cent higher than that of T1.

Bonnet *et al.* (1997) observed the values for nitrogen balance and retention as 4.5 g and 43.2 per cent in male chicken fed corn-soybean diet for four days at 32°C. Hariharan (2003) reported similar values for nitrogen balance and retention (1.62 g/day and 42.08 per cent, respectively) in birds given diets containing maize, soyabean and dried fish. Keshavarz and Austic (2004) reported the nitrogen retention as 48.8 per cent in laying hens fed corn-soybean diet containing 16.5 per cent crude protein and 0.06 per cent methionine.

5.7 BALANCE OF CALCIUM AND PHOSPHORUS

The balance and per cent retention of calcium and phosphorus as influenced by different dietary treatments are presented in Table 8. It indicated the calcium balance for T1 as 0.37 and that of T2 and T3 as 0.31 g each per day and calcium retention for T1, T2 and T3 as 28.73, 23.66 and 22.93 per cent, respectively. Eventhough the values for calcium balance and retention were higher for T1 than that of T2 and T3, there was no significant difference (P>0.05) between the treatments. The values for phosphorus balance and retention of the dietary treatments T1, T2 and T3 (0.29, 0.36 and 0.30 g per day and 31.72, 33.37 and 30.27 per cent, respectively) were statistically similar.

Belay *et al.* (1992) found the calcium and phosphorus balance in broilers as 268 and 271 mg per kg body weight per day. Hariharan (2003) reported almost similar values for calcium and phosphorus balances as 0.49 and 0.27 g per day and retention as 38.05 and 26.56 per cent, respectively in birds fed diets containing maize, soyabean and dried fish. Keshavarz and Austic (2004) reported the phosphorus retention in laying hens as 24 per cent when fed corn-soybean diet containing 16.5 per cent protein and 0.06 per cent methionine.

5.8 SERUM BIOCHEMICAL PARAMETERS

5.8.1 Serum Cholesterol, Triglyceride and Glucose

From the results presented in Table 9, it can be seen that there was no significant difference ($P>0.05$) between treatments for serum cholesterol. The serum cholesterol values of T1, T2 and T3 birds were 107.36, 104.48 and 101.98 mg per cent, respectively. There was a decreasing trend in serum cholesterol content when the level of fermented fish waste silage was increased.

From the results presented in Table 9, it can be seen that the serum triglyceride of birds maintained on different treatments was significantly different ($P<0.05$). The serum triglyceride of birds under T1 (123.94 mg per cent) was significantly higher than those in T2 and T3 (94.37 and 87.04 mg per cent, respectively).

Serum glucose content of birds maintained on the three experimental diets T1, T2 and T3 were 166.20, 153.80 and 164.60 mg per cent. When the means were compared statistically no significant difference ($P>0.05$) could be noted among the different dietary treatments. Kaneko *et al.* (1997) reported similar value (167.8 mg per cent) for blood glucose in chicken.

Tanaka *et al.* (1990) found that 1 or 2 per cent of fermented products of chub mackerel in diets of 4 week old chicken decreased the plasma triglyceride and free cholesterol concentrations. This is in accordance with the findings of the present study. Daly and Peterson (1990) reported almost similar values for serum glucose (188 to 193 mg per cent) and higher value for serum triglyceride (245 to 256 mg per cent) in young chicken, when compared to that of the present study.

Meluzzi *et al.* (1992) found the values for plasma total cholesterol and triglyceride in the range of 134 to 146 and 82.6 to 97.7 mg per cent, respectively. Peebles *et al.* (1997) observed almost similar values for mean serum cholesterol and triglyceride levels (118.3 and 93.5 mg per cent, respectively) to that of the present study. However, they reported higher serum glucose levels (240 mg per cent) in broilers fed diets containing different levels of lard.

Mohan *et al.* (1996) reported a reduction in serum cholesterol (93.3 mg per cent) in probiotic supplemented diet of broiler birds when compared to that of the control (132.2 mg per cent). Jin *et al.* (1998) and Kalavathy *et al.* (2003) also concluded that addition of 0.1 per cent of lactobacillus culture reduced the serum cholesterol and triglyceride levels in broilers.

The reduction in serum cholesterol and triglyceride may be due to the effect of bacterial culture and yeast added during the process of fermentation of fish waste during silage production.

5.8.2 Serum Creatinine and Uric Acid

The results given in Table 9 indicate that serum creatinine values were similar ($P \geq 0.05$) for the treatments T1 (0.36 mg per cent), T2 (0.35 mg per cent) and T3 (0.36 mg per cent).

The data on serum uric acid levels of birds presented in Table 9 did not show any significant difference ($P>0.05$) between the three treatments. However a decreasing trend was seen when fermented fish waste silage was incorporated to replace dried fish.

Saoud and Daghir (1980) reported the serum uric acid content of broiler chicken as 5.22 mg per cent when fed soybean meal. The findings of the given study were in accordance with that of Mercy (1996) who found that the serum uric acid content in birds decreased as the percentage of crab waste protein supplement was increased in their diets. The per cent serum uric acid content in birds fed crab waste protein supplement at 0, 25 and 50 per cent levels were 4.29, 3.93 and 3.18 mg, respectively. Rao and Sundararaj (1998) also reported the serum uric acid content of broiler chicken as 4.85 mg per cent when fed broiler mash.

The decreasing trend in the serum uric acid concentrations when the level of fermented fish waste silage was increased may be due to the fact that the protein in fermented fish waste silage was of good quality which leads to increased protein utilization leading to reduced nitrogen or uric acid excretion.

5.8.3 Serum Calcium and Phosphorus

The data on serum calcium and phosphorus content presented in Table 9 showed no significant difference (P>0.05) between the different dietary treatments.

Meluzzi *et al.* (1992) reported similar values for serum calcium (10.48 mg per cent) and phosphorus (6.44 mg per cent). Hariharan (2003) also reported values for serum calcium (8.38 mg per cent) and phosphorus (5.12 mg per cent) in broiler birds fed control diet almost similar to that obtained in the present study. Kollanoor (2004) reported that the values of serum calcium varied between 11.16 and 13.11 mg per cent and that of phosphorus varied between 3.49 and 6.59 mg per cent, respectively, when phytase and iron were supplemented in the diet of broilers.

Samanta and Biawas (1994) reported that the serum calcium and phosphorus content remained unchanged when lactobacillus culture was added in the diet of broilers. However, Sukumar (1999) observed the values for serum calcium and phosphorus in the range of 18.14 to 21.11 mg per cent and 3.76 to

4.38 mg per cent, respectively when phytase was supplemented in the diet of layer chicken.

5.9 PROCESSING YIELDS

From the data on processing yields presented in Table 10, it could be seen that the ready-to-cook yield of birds maintained on treatments T1 and T2 (69.07 and 67.04 per cent, respectively) and T2 and T3 (67.04 and 65.39 per cent, respectively) were similar ($P>0.05$). However the ready-to-cook yield of birds maintained on T3 were significantly lower ($P<0.05$) than that of birds in T1. Mahendrakar *et al.* (1991) reported that the percentage of carcass yield was lowest for diets containing 15 per cent fish viscera autolysate followed by 30 per cent fish viscera autolysate.

Narahari *et al.* (1988) reported the per cent ready-to-cook yield in broilers as 70 per cent, while, Kumar and Narayanankutty (1992) concluded that the ready-to-cook yield in 8 week old broilers was 72 per cent.

The Giblet yield (4.15, 4.11 and 3.98 per cent, respectively) of the birds maintained on the three dietary treatments T1, T2 and T3 were similar ($P>0.05$). The abdominal fat yield (0.96, 0.91 and 0.72 per cent, respectively) of the birds maintained on the three dietary treatments T1, T2 and T3 were also found to be similar ($P>0.05$). However, a decreasing trend was seen in all the three parameters when the level of fermented fish waste silage was increased in the diet of broilers.

Ahamed and Mahendrakar (1996b) and Raj *et al.* (1996) observed no difference in carcass yield and organ weights when fermented fish silage was included in the diet of broilers. Kjos *et al.* (2000) also found that the carcass weights and abdominal fat pad did not differ significantly when fish silage was incorporated in the diet of broilers. However, they found a numerically lower carcass weight and abdominal fat yield when the level of fish silage was increased, which agrees with the results obtained in the present study.

5.10 ECONOMICS OF GAIN

The production cost of fermented fish waste silage was Rs. 11 per kg and the cost of unsalted dried fish was Rs. 12 per kg. The growth performance of birds fed diets containing fermented fish waste silage was almost similar to those fed diets containing unsalted dried fish.

Data presented in Table 11, indicate that the diets containing fermented fish waste silage were economically efficient. There was a saving of Rs. 0.68 and 0.78 per kg, respectively, when dried fish was replaced by fermented fish waste silage at 50 and 100 per cent levels on protein basis. Cost of production of ready-to-cook meat of birds of the three treatments was Rs. 29.69, 29.58 and 30.17 per kg, respectively. This shows that replacement of dried fish completely with fermented fish waste silage on protein basis did not show any economic benefits, while, replacement at 50 per cent level showed a benefit of Rs. 0.11 per kg. This might be due to the almost similar cost of fermented fish waste silage and dried fish and significantly lower ready-to-cook yield obtained when dried fish was replaced completely with fermented fish waste silage on protein basis.

Vedhanayakam *et al.* (1976) and Ologhobo *et al.* (1988) reported that the cost of feed per kilogram gain was lower in birds fed diets containing fish silage. Sakthivel (2003) also reported a lower cost of feed per kilogram gain when cuttle fish waste silage rations were fed to growing pigs.

A critical evaluation of the results obtained in the present study indicates that fermented fish waste silage can be used as a substitute for unsalted dried fish on protein basis without any adverse effects on average daily gain, feed intake, feed efficiency and nitrogen, calcium and phosphorus balances. However, when the cost of production per kg of ready-to-cook meat is considered, replacement of dried fish with fermented fish waste silage at 50 per cent level on protein basis was found to be economical.

Summary

6. SUMMARY

An investigation was carried out in the Department of Animal Nutrition, College of Veterinary and Animal Sciences, Mannuthy using 180 day-old commercial broiler chicks (Vencob) to study the growth performance and nutrient utilization of broiler chicken fed on fermented fish waste silage ration. The chicks were randomly divided into 15 groups of 12 chicks each. The groups were allotted randomly to three dietary treatments viz., T1, T2 and T3 with five replicates in each treatment. The dietary treatments consisted of a standard broiler ration T1 (Control) with 0 per cent fermented fish waste silage, T2 in which 50 per cent protein of unsalted dried fish of the control ration was replaced by fermented fish waste silage and T3 in which 100 per cent protein of unsalted dried fish of the control ration was replaced by fermented fish waste silage.

Chicks in each replicate were housed randomly in individual but identical pens and reared under deep litter system of management. Standard managemental procedures were adopted throughout the experimental period of six weeks. Feed and water were provided *ad libitum*. Birds were fed with broiler starter ration up to four weeks of age and then switched to broiler finisher ration till the end of the experiment. The body weight of individual birds was recorded at weekly intervals. Feed consumption of the birds was recorded replicate wise at weekly intervals.

At the end of sixth week, two birds from each replicate were randomly selected and used to study the processing yields viz., ready-to-cook, giblet and abdominal fat yields and serum biochemical parameters such as serum calcium, inorganic phosphorus, cholesterol, triglyceride, glucose, creatinine and uric acid levels.

A three-day metabolism trial was conducted after the end of the feeding experiment using two birds from each replicate selected randomly and housed in

individual metabolism cages with facilities for feeding, watering and excreta collection. Total collection method was employed for excreta collection. The economics of gain was calculated from the data on feed intake and body weight gain of birds.

The birds maintained on the experimental rations T1, T2 and T3 recorded similar body weight and body weight gain, indicating that inclusion of fermented fish waste silage did not adversely affect the body weight and weight gain. The mean weekly and cumulative feed intake and cumulative feed efficiency did not differ significantly ($P>0.05$) between treatments. The birds maintained on the experimental rations T1, T2 and T3 had a cumulative feed conversion efficiency of 2.12, 2.08 and 2.09, respectively. The mean nitrogen balance (g/day) recorded by birds were 1.99, 2.50 and 2.16 in T1, T2 and T3, respectively, with a corresponding per cent retention of 41.48, 43.36 and 40.92, respectively. It can be noticed that even though, there was no significant difference between treatments, nitrogen balance and per cent retention was higher in rations containing 50 per cent fermented fish waste silage when compared to the control (T1) group. Percentage of calcium retention recorded by birds of T1, T2 and T3 were 28.73, 23.66 and 22.93, respectively, without any significant difference between treatments. The results revealed that group (T1) which was fed rations containing no fermented fish waste silage had the highest calcium retention. Phosphorus retention recorded by experimental birds was similar in all the three groups, the values being 31.72, 33.37 and 30.27 per cent for T1, T2 and T3, respectively.

A decreasing trend in serum cholesterol was noticed for T2 and T3 when compared to that of control group (T1) with a significant decrease ($P<0.05$) in serum triglyceride for T2 and T3 compared to the control, tending to suggest that rations containing fermented fish waste silage decrease the serum triglyceride content. No significant difference could be observed in the serum calcium and phosphorus contents of birds among the three dietary groups. There was no significant difference in serum creatinine and uric acid. Birds of experimental group T3 recorded a significantly lower ($P<0.05$) percentage of ready-to-cook yield when compared to birds of experimental group T1. Birds maintained on different dietary treatments registered no significant difference in per cent giblet and abdominal fat yields when compared to that of the control group. The cost of feed per kg gain of birds maintained in the three dietary treatments was Rs. 20.51, 19.83 and 19.73, respectively. There was a saving of Rs. 0.68 and 0.78 per kg, respectively, when dried fish was replaced by fermented fish waste silage at 50 and 100 per cent levels on protein basis. However, cost of production of 1 kg ready-to-cook yield of birds of the three treatments was Rs. 29.69, 29.58 and 30.17, respectively

Overall evaluation of the results of the present study revealed that fermented fish waste silage could be used as a substitute for unsalted dried fish in the ration of broilers on protein basis, without any adverse effect on growth rate and feed conversion efficiency. However, when the cost of feed per kg of ready-to-cook meat is considered, replacement of dried fish with fermented fish waste silage at 50 per cent level on protein basis was found to be economical.

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GROWTH PERFORMANCE OF BROILER CHICKEN FED ON FERMENTED FISH WASTE SILAGE RATION

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Abstract of the thesis submitted in partial fulfilment of the requirement for the degree of

Master of Veterinary Science

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2005

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ABSTRACT

An investigation spread over a period of six weeks was carried out to study the effect of replacing unsalted dried fish with fermented fish waste silage on nutrient utilization and growth performance in broiler chicken. One hundred and eighty day-old broiler chicks (Vencob) were divided into three identical groups having five replicates in each group with 12 birds in each replicate and allotted randomly into three dietary treatments viz., T1, T2 and T3. The three groups of birds were maintained on isonitrogenous and isocaloric rations in which protein of unsalted dried fish was replaced by protein from fermented fish waste silage at 0, 50 and 100 per cent levels. Birds were fed broiler starter rations up to four weeks of age and then they were switched to broiler finisher rations till the end of the experiment.

The birds maintained on the three dietary treatments T1, T2 and T3 had almost similar growth rate ($P>0.05$) with a cumulative mean body weight gain of 1401.45, 1434.48 and 1491.31 g, respectively. The cumulative feed intake and cumulative feed conversion efficiency did not differ significantly ($P>0.05$) between treatments, the cumulative feed conversion efficiency being 2.12, 2.08 and 2.09, respectively for the birds of T1, T2 and T3. Nitrogen retention and balance were similar for the diets T1, T2 and T3. The retention and balance of calcium and phosphorus were also similar. Serum calcium, phosphorus, cholesterol, glucose, creatinine and uric acid contents were not significantly influenced by the inclusion of fermented fish waste silage. Serum triglyceride was significantly reduced ($P<0.05$) in T2 and T3 when compared to that of T1. Birds maintained on T3 registered significantly lower ($P<0.05$) ready-to-cook yield when compared to T1 fed on control diet. The cost of feed per kg gain of birds in the three dietary treatments was Rs. 20.15, 19.83 and 19.73, respectively.

Overall evaluation of the results of the present study revealed that fermented fish waste silage could be used economically as a substitute for unsalted dried fish in the ration of broilers on protein basis, without any adverse effect on growth rate and feed conversion efficiency, while, the ready-to-cook yield tended to be lower in birds receiving diets with 100 per cent fermented fish silage.