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NUTRIENT ANALYSIS AND VALUE ADDITION OF UNDERUTILIZED FISH

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled **"Nutrient analysis and value addition of underutilized fish"** is a bonafide record of research work done by me during the course of research and that this 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 **"Nutrient analysis and value addition of underutilized fish"** is a record of research work done independently by **Ms. Jishy, K.K.,** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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DEDICATED TO MY LOVING PARENTS

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ABBREVIATIONS

A.O.A.C.	–	Association of Official Analytical Chemists
B A	_	Butylated Acrylonitrile
cfu	_	Colony forming units
$CuSO_4$	_	Copper sulphate
CD	_	Critical Difference
EDTA	_	Ethelene Diamine Tetra Acetic acid
g	_	Gram
HCl	_	Hydrochloric acid
kg	_	Kilo gram
meq	_	Milli equivalent
mg	_	Milli gram
HNO_3	_	Nitric acid
N	_	Normality
$HClO_4$	_	Perchloric acid
$K_2 SO_4$	_	Potassium sulphate
%	_	Per cent
NaOH	_	Sodium hydroxide
H_2SO_4	_	Sulphuric acid
WHO	_	World Health Organisation

Introduction

1. INTRODUCTION

Fish contains the best and top most proteins and other superior nutritional substances that place them in a specially important category of food. Fish is thus recognized as an excellent source of protein, containing all the ten essential amino acids in desirable concentrations for human beings and available at cheaper rate (Chitranshi, 2001). More over, fisheries is a renewable and dynamic resource which when judiciously exploited replenishes the loss and hence a maximum sustainable yield from this resource is possible (Vardia, 2001).

India has a vast coastline and is a major maritime state with established traditions of fisheries, influencing lives of millions of people. The present annual fish production from the sea is about 2.9 million tonnes, being about 50 per cent of the total fish production. India occupies an important place in the global fisheries, being the sixth largest producer of fish in the world and second largest producer of inland fish (Rai, 2003).

Kerala is a small state, tucked away in the southwest corner of India. It represents only 1.18 per cent of the total area of India but 3.43 per cent of the total population of the country is in Kerala. The estimated marine fishery potential of the state is 5.17 lakh tonnes. Fisheries contribute about three per cent to the economy of the state. The current level of annual marine fish production is to the tune of about six lakh tonnes per year. The state is endowed with a significant wealth of inland fishery resources also. The current level of inland fish production is about 75036 tonnes per year (CMFRI, 2001). Kerala is also the second largest consumer of fish with 21.16 per cent (Devadasan, 2003).

Fish is perhaps the best quality protein available at affordable cost to the rural poor. The balanced amino acid composition of fish proteins and their easy digestibility and biological value makes fish proteins the choice proteins. Fish lipids also are special due to the high content of polyunsaturated fatty acids (PUFA), especially the omega-3 fatty acids that confer favourable pharmacological properties to dietary fish. Many components isolated from fish are reported to have anti cancer and anti arthritic properties also. Thus, dietary fish reduces risk of heart problems caused by elevated serum cholesterol, thrombotic tendencies etc. and prevents cancer, arthritis and other diseases associated with nutritional deficiencies (Devadasan, 2003).

In spite of the phenomenal increase in fish production during the last few decades, the percapita availability of fish in India continues to be very low at 8 kg per year against the world average of 12 kg. In order to fulfill the minimum nutritional requirement as stipulated by WHO standard, a person needs 11 kg of fish every year (Sugunan, 2003). According to Krishnaswamy *et al.* (2000), the consumption of fish in Kerala is only 11 g per consumption unit per day against the daily requirement of 30 g. Reasons for these disparities are easy perishable nature of fish, high price and under exploitation of low cost varieties which are available in plenty. This gap can be reduced by proper preservation of fish and by producing value added fish products. Hence, the present study entitled 'Nutrient analysis and value addition of under utilized fish' was under taken with the following objectives.

1. To determine the nutritive value of fresh and dried underutilized fish varieties.
2. To prepare pickles and to assess the shelf life and acceptability of the developed products.

Review of Literature

2. REVIEW OF LITERATURE

The literature connected to the study entitled "Nutrient analysis and value addition of underutilized fish" is presented under the following heads.

2.1 Health benefits of fish

2.2 Need for processing fish

2.3 Value added products from fish

2.4 Chemical constituents of fish and fish products

2.5 Effect of packaging and storage on fish products

2.1 HEALTH BENEFITS OF FISH

Fish is a valuable source of food and has been used by man from antiquity. Man has realized its importance from the very inception of the evolution of the human race. It has been the sole diet for many island nations before the evolution of farming techniques (Gopakumar, 2001). Fish should form a part of healthy diet because it is a highly nutritious food. Fish provide a sea of essential and heart healthy nutrients, an array of minerals, essential amino acids and a lot more potential benefits (Robert, 2001). Early Indian medical treatises mentioned about non-vegetarian dietary practices. Charaka, Susrutha and Vagbhata provided an impressive list of the variety of fish used for medical treatments (Devadasan, 2003).

Pioneering studies by Bang *et al.* (1980) showed that Eskimos living in Greenland, who consume large amounts of fish do not suffer from heart attack, despite a high intake of fat and cholesterol. Fish and fish oil contains long chain omega-3 fatty acids namely eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) (Ackman, 1982). Prostaglandins of three series which is a vasodilator is produced from these fatty acids in the body (Ghafoorunissa, 1983). According to Gibson (1988), the health benefits of fish over other animal foods are attributed to the omega-3 polyunsaturated fatty acids in fish and fish oils. The EPA and DHA reduce mortality from coronary heart disease by lowering serum triglyceride levels in patients with hyper triglyceridemia and prolonging platelet aggregation time (Wahlquist *et al.*, 1989). Several epidemiological studies showed an inverse relationship between fish consumption and heart disease (Seidelin, 1992). Fish consumption decreases the ratio of total cholesterol to high density lipoprotein (HDL) and low density lipoprotein (LDL) to HDL cholesterol and reduce blood clotting tendency and lower blood pressure (Adam and Bruce, 1997). Studies by Paul (2000) showed an average reduction of 38 per cent in triglyceride levels and an increase of 24 per cent HDL level in both men and women consuming fish on a daily basis. Fish consumption reduces the risk of sudden cardiac death and this protective effect is attributed to the increased heart rate variability (Thomas and Tarek, 2001).

Fish oil enriched with nutritional supplement was found to be safe and effective in preventing weight loss in cancer patients and reported that this may even increase survival time in patients with cancer of the pancreas (Barber, 1999). Omega-3 fatty acids in fish decrease the risk of cancer and increase the rate of apoptosis, which is a normal physiological cell death, which occurs in all living organisms during embryonic and adult development and eliminates unwanted, functionally abnormal or harmful cell (Sesikeran *et al.*, 2002). The polyunsaturated fatty acids can lower the carcinogenic load of high fat diets and inhibits malignant tumor of the prostate, breast, colon, rectum and lungs (Wetherilt, 2002).

High fish intake can delay the development of diabetes in glucose-intolerant individuals. Long term supplementation with fish oil improves insulin sensitivity in patients with non-insulin dependent diabetes (William, 1995).

Fish has a very high beneficial role in preventing mental disorders. Fish consumption also helps to avoid attention deficit disorders (Barbara, 1997). Low levels of long chain polyunsaturated fatty acids notably docosahexaenoic acid is found in people suffering from Alzheimer's disease and dementia. Therefore, the conditions of these patients can be improved by including fish in their diet (Joseph, 1998). Schizoprenia, a serious mental illness can also be cured by the intake of fish (Silver and Scott, 2002).

Supplementation with eicosapentaenoic acid and docosahexaenoic acid, which are important components of fish, can reduce interleukin-1 beta production and result in a significant reduction in morning stiffness and the number of painful joints in rheumatoid arthritis patients. Thus, fish consumption alleviates the symptoms of rheumatoid arthritis (Joel, 1989).

The symptoms of cystic fibrosis, which is a serious inherited disease, which involve malfunctioning of the body's mucus glands, can be alleviated by the consumption of fish and smokers who eat fish regularly are much less likely to develop chronic obstructive pulmonary diseases such as chronic bronchitis (Lawrence and Sorell, 1993). Linda (1996) suggests that long term fish consumption may reduce asthma severity.

According to Kurt (2000), intake of fish improves the healing of ligament injuries by enhancing the entry of new cells into the wound area and by speeding up collagen synthesis. People who ate fish more than four times per week was found to have a 35 per cent lower risk of age related macular degeneration than people who ate fish three times per month or less (Eunyoung, 2001).

The eicosapentaenoic acid in fish is helpful in alleviating the symptoms of Raynaud's disease, which is characterized by periods of disrupted blood flow to the fingers caused by exposure to cold or stress (Ralph, 1989). Fish is also considered as a preventive measure against kidney diseases (James, 1994).

Fish is found to be preventive against Crohn's disease, an inflammatory disease involving intestinal pain, diarrhoea and malabsorption of nutrients. The protective effect is due to the presence of EPA and DHA in fish (Edward and Robert, 1996). Atopic disease, a form of allergy when the hypersensitivity reaction occurs at a location different from the initial contact point between the body and the offending agent can be alleviated by the intake of fish (Pasi, 1999).

Eating fish twice or three times a week can be encouraged as a part of healthy balanced diet, during pregnancy and for all the family and it should be consumed in steamed or boiled form rather than fried form (Ismail, 2002). Fish, which is rich in omega-3 fatty acids, can increase the child's birth weight by prolonging the pregnancy and preventing premature birth (Marine Products Export Development Authority, 2002). Absence of omega-3 fatty acid early in life may forever alter the way in which the brain develops and operates (Ramachandran, 2003).

The amount of long chain omega-3 polyunsaturated fatty acids required for beneficial effects can be obtained by including 100-200 g of fish in the diet 2-3 times a week (Ghafoorunissa, 1992).

2.2 NEED FOR PROCESSING FISH

Aquatic resources are finite unless man intervenes in some way to increase production from aquaculture, habitat improvement or by restocking. Therefore, it is very essential to make best use of the harvested resources to give food security to the increasing population. Current fish utilization trends in India indicate that the major quantity of fish is marketed in fresh form that is about 65 per cent of the total fish production. In the processing sector, 20 per cent of the catch is processed by the traditional methods like sun drying and are largely utilized for domestic consumption (FAO, 1998).

Fish is more susceptible for spoilage compared to land animals hence it should be preserved and processed properly to reduce post harvest loses and to increase its demand. Presently 20 per cent of world fish catch is consumed fresh, 11.6 per cent is used for canning, 8.2 per cent for curing, 23.6 per cent for freezing and 27.6 per cent is converted to animal feed (FAO, 1993).

It has been estimated by FAO (1994) that post-harvest losses remain at a staggering 25 per cent of the total catch. FAO (1998) estimated that 10 to 12 million tones of fish loss occur due to spoilage, which accounts for 10 per cent of the total fish production from capture and aquaculture. Estimates are that 20 million tones of fish are lost as by catch. Though, accurate loss estimates are lacking for India, it is believed to be close to 10 to 15 per cent (Devadasan, 2003). According to Lim and Low (2003), every year 22 million tons of edible marine fish are thrown away at sea by shrimp trawlers worldwide. In view of the ever increasing demand for fish the processors can no longer afford the luxury of wasting the oceans resources. So processing of fish is essential.

Better utilization of the aquatic resources should therefore aim primarily at reducing these enormous losses by improving the quality and preservation of fish and fish products and by upgrading discarded low value fish to food products. The world demand for fish is expected to exceed all available supplies owing to the rapid changes taking place in the dietary habits of people. On the other hand, availability of fish from seas and other aquatic resources is not increasing in proportion to its demand (Marine Products Export Development Authority, 1996). The increasing demand for fish will have to be met by proper utilization of trash fish and by processing of fish (Sahu *et al.*, 1996).

In spite of the phenomenal increase in fish production during the last 5 decades, the per capita consumption of the fish in the country is about nine kg per year for the fish eating population against the world average of 12 kg (Juneja and Nair, 2000). Based on the projected human population and considering that 56 per cent population would be including fish in their daily diet and further considering the WHO recommendation of providing 11 kg of fish per capita annually in human diet, the demand for fish in India is about 12.5 million tonnes by the end of this century (Juneja, 2001). This demand can be met by reducing post harvest losses and by popularizing scientific fish processing techniques (Sugunan, 2003). According to

Singh and Kumar (2003), improvement in the post harvest utilization of fish catches can ensure further nutritional security among a wide range of people in our country.

According to Krishnaswamy *et al.* (2000), the consumption of fish in Kerala is only 11 g per consumption unit per day against the daily requirement of 30 g. Although Kerala is the second largest consumer of fish, the requirement can be met only by processing low cost fish varieties, which are available in plenty (Devadasan, 2003).

2.3 VALUE ADDED PRODUCTS FROM FISH

The term value added refers to value that is added to a product from the time it enters the processing plant to the time it leaves (Sahu *et al.*, 1996). Value addition is one of the possible approaches to raise the profitability of fish processing industry, which now lays greater emphasis on quality assurance (Hassan and Mathew, 1999).

Production of value added products will lead to complete utilization of by catch and less important fish which will help in filling the gap of supply and demand of fish in addition to employment and revenue generation (Nair, 2002).

The world fish processing scenario is under going rapid change. Conventional fish products are slowly disappearing from the market followed by their emergence in new style and form (Davies, 1995). The value addition involves use of machineries, attractive packaging materials, use of prime quality raw material and sub material and a complete knowledge of consumers' preferences (Sudhakara, 2002).

A large number of value added products both for export and internal markets based on different varieties of fish and low priced fish have been identified (Abraham, 1991). Drying is the most widely used traditional methods of fish preservation (Subasinghe, 1993). It is a low cost processing technique (Moorjani, 1998). Dried fish does not require sophisticated storage systems for preservation.

Therefore, it attracts the low-income consumers (Gopakumar, 2002). The effectiveness of drying as a means of increasing the shelf life of fish is due to reducing growth of microorganisms by reducing the availability of water (Doe, 2002). According to Nair (2002), a profitable method of value addition of low value by catch fishes is by traditional methods of preservation like drying. The consumer preferences regarding the quality of dried seafood are much diversified. In some countries dried products are unknown while in other areas like tropical countries, they are staple food. Some dried seafoods are even regarded as a delicacy (Tarr, 2002). Value added dried fish in the form of ready to eat products have been developed by Sachindra *et al.* (2003).

Pickling, using acids is one of the safest means of preservation of fish (Abraham *et al.*, 1993). Pickling of fish is one of the earliest methods of value addition of fish (Abraham, 1998). According to Gopalakrishnan (1998), pickling is a natural preservation process by which naturalness can be preserved. Although pickled products are of a semi perishable nature, since the concentrations of salt and vinegar employed are limited by considerations of palatability, they possess a greater appeal to consumers than salted and dried fish (Moorjani, 1998).

According to Thankamma *et al.* (1998) one of the best and popular methods of using the by catches is pickled products. Low value fishes are ideal raw materials for the preparation of fish pickles (Vijayan *et al.*, 1998). Non fatty fishes with good meat content are also preferable for pickle production (Nair, 2002). Fish pickles are very popular in India and varieties of methods are available from traditional process to industrial methods (Gopakumar, 2002).

Clam pickle with lactic acid and acetic acid were found to be equally acceptable among consumers (Yellappa *et al.*, 1991). Fish pickles generally have high content of liquid gravy (Prabhu and Gopal, 1993). The fish pickle has an emulsion consistency and contains fried fish in an aqueous medium of acid, salt, spices, condiments and sugar. The taste of pickles can be adjusted to preference of the consumers by selecting the ingredients and spices (Kumar, 1999). Studies by Lakshmi *et al.* (2003) clearly indicated that the stingray fish could be pickled well in the pickling media, vinegar and lime juice.

Fermented fish products are very popular in Southeast Asian countries. Among them fish sauce is most popular (Cho *et al.*, 2000). The fermented fish sauce is easy to handle, transport and store, and can be easily be incorporated with the cereal based diet (Mansur *et al.*, 2000). Fish sauce is much used in South East Asia to give rice dishes taste and essential amino acids (Skerdal and Pedersen, 2001). Making fish sauce is one of the best ways of using low value by catches (Gopakumar, 2002).

Fermented fish products contribute to the protein intake of the people especially those in the rural areas where fresh fish is not readily available (Essuman, 1992). Curing by fermentation was found to be an important method of preservation because poor quality fish or unpopular species of fish are usually processed in this way (Sarojnalini and Vishwanath, 1994a).

Mincing or surimi processing, followed by fermentation, extrusion and intermediate moisture food (IMF) processing were combined to investigate new ways to create fish protein based snack foods (Karmas and Lauber, 1987). Minced fish is an important ingredient in the production of a variety of sea food products in many countries, for its several advantageous such as better yield, ease in incorporation with stabilizers, flexibility in product preparation, suitability in blending etc. (Abraham, 1991). Several products including fermented pastes, sauces, sausages, patties, sticks, balls and dried products can be manufactured from the mince (Thankamma *et al.*, 1998). Significant value addition will occur to low value fish by application of mincing technology because of the use of mincer in the processing of variety of value added products (Nair, 2002).

Strained baby foods based on fish have been prepared and offer an excellent way of introducing fish in the diet of babies (Swaminathan, 1987). The most important class of value added fish products are the battered and breaded products, which are produced by the process of coating with batter and bread crumbs to increase the bulk of the product, thereby reducing the cost (Sahu *et al.*, 1996). Fish fillets, fish fingers, fish cutlet, fish patties, squid rings etc. are some of the battered and breaded products (Gopakumar, 1997a).

Surimi is a Japanese term for mechanically deboned fish mince from white fleshed fish that has been washed, refined and mixed with cryoprotectants for good frozen shelf life (Rathnakumar and Shamasundar, 1998). Because of its gel strength surimi is used as an intermediate in the processing of several products with simulated textures, flavours and appearance like shrimp (Nair, 2002).

With the increased demand for more ready to prepare/serve products, use of separated meat from inexpensive varieties of fish has assumed considerable importance. Fish sausage, a semi processed food, is one such delicious product (Hedge *et al.*, 1990). Sausages are made by mixing surimi with salt, sugar, monosodium glutamate, starch, soy protein, shortening agent, polyphosphates and smoky flavourings (Sahu *et al.*, 1996).

Excellent canned products from marine fish species make an important contribution to human nutrition (Govindan, 1991). The process of canning is aimed at retaining most of the nutrients contained in the raw fish (Aubourg, 1997). In the developing countries, fish curing has retained its importance catering to the needs of the poorer sections of the population even after the advent of modern techniques (Yasodha and Rao, 1998).

Value added fish products for the domestic market include battered and breaded products like fish fingers and cakes, fish mince and mince based products like sausages, cutlets, patties, balls, pastes, surimi and surimi based products and ready-to-serve fish curries suiting the tastes of different regions (Devadasan, 2003).

2.4 CHEMICAL CONSTITUENTS OF FISH AND FISH PRODUCTS

The four major constituents in the edible portion of fish are water, protein, fat and minerals (Gopakumar, 1998).

According to Swaminathan (1987) the moisture content of common fishes varies between 63 per cent and 89 per cent. Catsberg and Dommelen (1990) reported average moisture content of 70 percent to 80 per cent in fishes. According to Gopalan *et al.* (1994) the moisture content of fishes varies between 60 per cent and 80 per cent. Poulter and Nicolaides (1995) reported a moisture content of 60 per cent to 85 per cent in fish. Basavakumar *et al.* (1998) reported a moisture content of 77.6 per cent in prawns and Sarma *et al.* (1998) reported a moisture content of 80 per cent in pink perch and 75 per cent in oil sardine.

The water content of fish may vary between 28 per cent and 90 per cent. The higher the water content higher is the chance of spoilage and vice versa (Mukundan, 2000a). Nair and Susheela (2000) reported a moisture content of 65 per cent to 90 per cent in majority of Indian fishes. Gopakumar (2002) reported an average moisture content of 65 per cent to 80 per cent in fishes.

Fish is an excellent source of protein. The protein content of small fish like white bait on an average varies from 14 per cent to 20 per cent depending on the water content of fish (Bykov, 1985). According to Swaminathan (1987) the protein content of fishes normally lies in between 9 per cent and 20 per cent. Catsberg and Dommelen (1990) reported a protein content of 15 per cent to 20 per cent in marine fishes. Gopalan *et al.* (1994) reported a protein content of 19.3 per cent, 19.5 per cent and 14.5 per cent for anchovy, sole and white bait respectively. Basavakumar *et al.* (1998) reported a protein content of 19.9 per cent in prawns and Sarma *et al.* reported 17.08 per cent protein in pink perch and 19.29 per cent in oil sardine.

According to Manay and Shadaksharaswamy (1998) the protein content of fish on an average is about 20 per cent. Nutritionally protein is the most important constituent of fish. The content of protein of fish on an average is about 19 per cent with a variation of 15 per cent to 22 per cent (Mukundan, 2000a). Fish protein contains all essential amino acids and has an overall balance in total amino acid levels and fish protein is easily digestible (Gopakumar, 2001).

Quantitatively, protein is the second major component in muscle tissues of fish and is generally present in the range of 16 per cent to 18 per cent (Nair, 2002). The most important dietary function of fish is that of supplying readily digestible animal protein of high nutritive value and it ranges from 14 per cent to 20 per cent (Tarr, 2002). The protein content of most fishes lies between 18 per cent and 22 per cent and nutritional quality of protein from low cost, underutilized and by catch fish is comparable to that from commercially important species (Venugopal, 2003).

The fat content of the fish varies widely from 0.2 to 20 per cent depending on the species and season of the year (Swaminathan, 1987). Fish gives fat, which is easy to digest because it has a low melting point. The fish fat is found in muscle tissues, in the liver and just under the skin. Fish contains unsaturated fatty acids namely omega-3 fatty acids (Ramadas and Easwaran, 2000).

According to Catsberg and Dommelen (1990), fat content in fishes varies from 1 per cent to 20 per cent. Gopalan *et al.* (1994) reported 9.6 per cent, 4.7 per cent and 1.4 per cent fat content in anchovy, sole and white bait respectively. Poulter and Nicolaides (1995) reported a fat content of 2.65 per cent in white bait and Basavakumar *et al.* (1998) reported 0.96 per cent fat in prawn.

Sarma *et al.* (1998) reported an oil content of 2.14 per cent and 3.99 per cent in pink perch and sardine respectively. According to Manay and Shadaksharaswamy (1998) the fat content of fish varies from 0.1 per cent to 25 per cent. According to Mukundan (2000a) and Tarr (2002) the lipid content of fish varies from 0.2 per cent to 30 per cent.

Fish with fat content as low as 0.5 per cent and as high as 16 per cent to 18 per cent are of common occurrence. Fat content varies between species and within species (Nair, 2002). According to Lim and Low (2003), the fat content of fish varies from species to species, ranging from 1 per cent to15 percent, but averages at 4 per cent. These fats are mainly unsaturated fats and some are highly polyunsaturated.

Fish is a good source of minerals. The calcium, phosphorus and iron content of sole reported by Govindan (1970) are 100 mg, 520 mg and 10.1 mg per 100 g of sample. Salt water fish is rich in iodine, phosphorus and calcium. Fish also contain copper (Olsen, 1992). Gopalan *et al.* (1994) reported that anchovy, sole and white bait had a calcium content of 143 mg, 1072 mg and 643 mg respectively per 100 g of the sample. The phosphorus content reported for these fishes were 174 mg, 524 mg and 437 mg and iron content were 1.5 mg, 0.5 mg and 3.8 mg respectively per 100 g of sample.

Fish is a good source of copper, sulphur and phosphorus. Marine fish is a dependable source of iodine and its content varies from 0.01 to 0.5 mg per 100 g of fish meat (Manay and Shadaksharaswamy, 1998). Naik and Reddy (1999) reported that the most abundant minerals in fish are calcium and phosphorus. Mukundan (2000a) reported that mineral content of fish varies from 0.4 per cent to 2 per cent. According to the author besides minerals such as calcium, sodium and potassium, which form the major constituents of fish, it also contains copper, iron, magnesium etc. as minor constituents. Nair (2002) reported that calcium content would be low in edible portions compared to whole fish where bone is also included. Fish is one of the natural sources of fluorine and contains some cobalt (Tarr, 2002). The mineral salts in fish consist chiefly of calcium and phosphorus. These are provided in largest amounts when we eat the bones of such fish as sardines, sprats and white bait (Vijay, 2002).

According to Lim and Low (2003), fishes are rich in phosphorus, fluorine, magnesium, iodine, calcium and potassium and it contains trace amounts of iron, zinc and selenium. Venugopal (2003) reported that the total content of minerals, both macro and microelements in the raw flesh of marine fish and invertebrates are in the range of 0.6 per cent to 1.5 per cent.

Fish contains water soluble and fat soluble vitamins. Vitamin A content of fish fillets varies in between 50 IU g^{-1} and 400 IU $g^{-1.}$ This is found mostly in fillets made of fatty fishes (Maage *et al.*, 1991). Fish flesh contains higher concentration of fat soluble vitamins and water soluble vitamins than meat. Shark liver oil is an excellent source of vitamin A and cod liver oil is rich in vitamin D (Nair, 2002). Tarr (2002) reported that vitamin A in fishes varies in between 200 IU 100 g^{-1} and 800 IU 100 g^{-1} and it is more in fatty fishes. Fish fat contains more vitamins than white (Vijay, 2002). Fatty fish species such as sardine contain up to 4500 IU and 5400 IU of vitamin A and D respectively per 100 g weight (Venugopal, 2003).

Peroxide value of fresh mackerel was found to be 0.91 millimoles of O_2 kg^{-1} fat (George and Saralaya, 1993). Mathews *et al.* (1998) reported that peroxide value was always well below the limit of 10 meq kg^{-1} of oil. The peroxide value reported by Sarma *et al.* (1998) for pink perch and oil sardine are 6.16 meq kg^{-1} and 6.55 meq kg^{-1} respectively. Peroxide value is a good guide to evaluate the quality of fat (Mukundan, 2000a). Ismail (2002) reported a peroxide value of 4.0 meq kg^{-1} for white herring and Spanish mackerel.

Studies by Ramachandran *et al.* (1988) showed a moisture content of 16.15 per cent for dried squid. Studies by Solanki and Sankar (1988) revealed a moisture and fat content of 19 per cent and 9.18 per cent in dried *Cynoglossus species*. Basu *et al.* (1989) observed a moisture content of 27.3 per cent and 13.5 per cent in dried sole and anchovy respectively. Dried fish have higher protein, fat and other nutrient content because of its lower moisture content (Ollilainen *et al.*, 1989). Pivarnik *et al.* (1989) reported that smoked fish had a protein content of 23.4 per cent and fat content of 1.2 per cent. Protein content of canned mackerel was found to be 25.31 per cent by George and Saralaya (1993).

Moisture, protein and fat content of sun dried Puntius sophore, a low cost fish was found to be 18.1 per cent, 45 per cent and 18.5 per cent respectively (Sarojnalini and Vishwanath, 1994b). According to Doe (2002), the moisture content of dried fish varied from 15 per cent to 40 per cent. Gopakumar (2002) had reported a moisture content of 18 per cent in dried Bombay duck. Studies by Majumdar *et al.* (2003) revealed that acidity in fish products ranged from 0.6 per cent to 2.5 per cent. Sachindra *et al.* (2003) showed that moisture and protein content of ready to eat spiced product prepared from dried anchovies ranged from 6 per cent to 8 per cent and 65 per cent to 68 per cent respectively.

Peroxide value of seer fish fillet and pomfret fillets were found to be 0.62 millimoles of O_2 100 g^{-1} fat and 0.58 millimoles of O_2 100 g^{-1} fat respectively (Hiremath and Sen, 1988). Khuntia *et al.* (1993) reported a peroxide value of 4.16 millimoles of O_2 kg^{-1} lipid in dry salted mackerel. Reddy *et al.* (1993) reported a peroxide value of 12.29 millimoles kg^{-1} fat in fresh fish mince.

2.5 EFFECT OF PACKAGING AND STORAGE ON FISH PRODUCTS

2.5.1 Effect of packaging on fish products

Packaging is known to have brought out a revolution in the marketing and distribution of commodities in the world. Improved methods of packing have helped not only in keeping food safe with longer shelf life but also in enhancing its consumer acceptance. Aquatic food products have special packaging requirements as distinct from fruits and vegetables, meat and meat products, dairy products etc. (Gopal, 1998). With spending shifts from staple foods to value added processed foods taking place, the demand for consumer packs of processed foods will gather momentum as is being witnessed now (Narasimhan, 2003).

The special function required for suitable dried fish product package is inertness, leak proofness, impermeability to oxygen and moisture and low transparency (Antony, 1993). The commonly used packaging materials for consumer pack of dry fish are low density polythene or polypropylene. These materials are cheap, readily available and have good tearing and bursting strength. Shelf life is limited (Gopal, 1998). A recent development in cured fish packaging is the use of polyester polythene laminate pouches for consumer packaging (Gopal *et al.*, 1998).

The dried fish being highly sensitive to changes in relative humidity, the packaging have to be sufficiently water proof (Gopakumar, 1993). Thick gauge (300 gauge) low density polyethylene (LDPE) or 12 micron plain polyester laminated with LDPE had been found to be highly suitable for hygienic retail packaging of cured fish products (Gopal, 1996).

Flexible packaging materials are developed for fish pickle based on plain polyester laminated with LDPE-HDPE (High density polyethylene) co-extruded film or nylon/surlyn or LD/BA/nylon/BA/primacore (Gopal *et al.*, 1986). Prabhu and Gopal (1993) reported that dry fish pickle from *Kowala coval* could be safely stored up to 14 months at ambient temperature in nylon/surlyn or LD/BA/nylon/BA/primacore. These are inert to the produce, can be attractively fabricated as stand up packs and can be printed on the reverse side of the polyester film. Flexible packaging materials are also found to be cheaper than glass (Gopal, 1996). Conventionally, glass bottles are used as containers, which offer properties like inertness, non-toxicity, durability, non permeability to gases, moisture etc. However, they are heavily prone to break, voluminous and expensive (Gopal, 1998).

Studies by Gopal *et al.* (1988) showed that flexible packaging materials can be safely used for packing frozen fish curry. Fish curry can also be packed in retortable pouches and they remained sterile through out the storage period (Devadasan, 2001). Tin free steel cans are also used for processing ready to serve fish products, which can be stored at ambient temperature for long periods (Mallick *et al.*, 2003).

Most important class of value added marine products is battered and breaded products. The thermoformed trays produced from food grade materials like

PVC (polyvinyl chloride) and high impact polystyrene are suitable for packing these products without affecting their shelf life (Gopal, 1996). Indigenously developed aluminium can has been found quite good for heat processing fish and fish based products especially canned fish (Balachandran *et al.*, 1998).

Thus, better packaging ensures improved quality and presentation of the product, higher returns to the producer and better shelf life (Gopal, 1998).

2.5.2 Effect of storage on sensory qualities and chemical constituents of fish products

Sensory quality of food is the consumer's reaction to the physical and chemical constituents of the food in its prepared and formulated form. Sensory evaluation is the main technique for evaluating consumer acceptance and preference, relative importance of sensory attributes in relation to food type for the consumer, consumer response to non sensory characteristics in relation to quality of food and changes in consumer food preferences (Govindarajan, 1979). Measuring the sensory properties and determining the importance of these properties as a basis for predicting acceptance by the customer represents major accomplishments for sensory evaluation (Bodyfelt *et al.*, 1988). For consumers the perceivable sensory attributes like colour, appearance, feel, aroma, taste and texture are the deciding factors in food acceptance (Pal *et al.*, 1995). According to Yenigi (1997), sensory methods are used to evaluate the quality of food as well as to determine consumer preferences among food items. Sensory analysis of seafood has become popular in marketing research, product development, quality assurance and research and development (Joseph, 2002).

Studies by Hiremath and Sen (1988) showed that fish fillets made from medium fatty fishes were stable at -20°C for more than 12 months but fillets made from fishes with high fat content had unacceptable texture after 7 months of storage. According to Ramachandran *et al.* (1988), the dried squid stored in refrigerated condition had better colour than stored in ambient storage condition. According to Ramachandran and Solanki (1988) the semi dried fish products maintained its acceptability till eighth week of storage, but higher overall acceptability was observed initially.

Studies by Solanki and Sankar (1988) showed that dried *Cynoglossus spp.* had better acceptability qualities like odour, appearance and texture than other varieties during the three months of storage. Studies by Khuntia *et al.* (1993) showed that overall acceptability scores of dried mackerel decreased from 4.13 to 3.14 during 35 days of storage.

Studies by Rahman *et al.* (1998) revealed that commercial sun dried fishes can be stored for more than six months without deleterious effects. Studies by Yasodha and Rao (1998) showed a progressive decrease in the overall acceptability of dried fish during the storage period. According to Tarr (2002), dried fish have a shelf life of several months at room temperature. A ready to eat spiced product prepared from dried anchovies was found to be well accepted with respect to sensory attributes like appearance, colour, texture, flavour and taste for a period of six months (Sachindra *et al.*, 2003).

Studies by Yellappa *et al.* (1991) showed that clam pickle was acceptable for a period of six months. Abraham *et al.* (1993) observed that fermented prawn pickles kept well for 60 days at room temperature. Studies by Prabhu and Gopal (1993) revealed that dry fish pickle from white sardine (*Kowala coual*) could be stored for 13 months without much change in acceptability. Studies by Lakshmi *et al.* (2003) showed that stingray pickle maintained sensory scores between good to excellent range even up to the 90th day of storage.

During storage a number of chemical changes occur which makes the product either unfit for consumption or sometimes rejection on aesthetic grounds. Studies by Hiremath and Sen (1988) showed that the peroxide value of fishes increased during the frozen storage period. Thompkinson and Mathur (1989) showed that peroxide value of dried foods increased up to nine months of storage and then decreased. Khuntia *et al.* (1993) also reported an increase in peroxide value during the storage of dry salted mackerel.

The increase in extent of lipid oxidation is a general phenomenon of aerobically stored, dehydrated fish products (Horner, 1992, Jeevanandam *et al.*, 2001, Smruthi *et al.*, 2003).

Studies by Abraham and Setty (1992) showed that titratable acidity of fermented prawn pickle increased to 0.47% and pH decreased to 5.4 in 60 days of storage. The peroxide value of dry fish pickle made from white sardine was found to be increasing during the storage period (Prabhu and Gopal, 1993). Lakshmi *et al.* (2003) reported that stingray pickles maintained pH values below 4.56 even after 90 days of storage.

2.5.3 Effect of storage on microbial quality of fish products

In recent years, the increasing consumer awareness has emphasized the need for microbiologically safe food. Serious health hazards due to the presence of organic microbes in food can lead to food poisoning out breaks (Frazier and Westhoff, 1997). Microbial quality is one of the most critic quality parameters in a dynamic system such as food. There are different threats in food quality originating from microbial sources. Spoilage causing organisms cause off odour and off taste and lead to economic loss (Rao, 1998). The concept of spoilage by micro organisms are the primary cause of the end of shelf life and hence reducing initial microbial populations is a strategy to extend shelf life (Zagory, 1999).

Bacterial counts have been used as an index of sanitary quality. High bacterial counts are unacceptable but do not always indicate extent of quality loss or spoilage. This is caused by difference in biochemical activities of individual bacterial species (Shamsad *et al.*, 1990).

Lu *et al.* (1988) reported a microbial count of 42 x 10^6 organisms g^{-1} sample in dried fish in Ghana. The total plate count of semi dried shark varied between 2.0 x 10^3 colonies g^{-1} to 6.2 x 10^6 colonies g^{-1} during three months of storage (Ramachandran and Solanki, 1988). The total bacterial count of different dried fishes varied from 1.7 x 10^3 colonies g^{-1} to 2.1 x 10^5 colonies g^{-1} during the three months of storage period (Basu *et al.*, 1989).

The presence of fungi in dried fish along the west coast of India has been reported by Gupta and Samuel (1985). Chakrabarti and Varma (1997) reported the occurrence of fungi in salted and sun dried fishes at Kakinada and lower at Vishakapatnam coast. Chakrabarti and Varma (2002) reported that though there was no visible fungal growth in some dried fishes, the presence of different types of fungi was noticed after plating on potato dextrose agar media. Similar results were also reported by Shanthini and Patterson (2002). Sachindra *et al.* (2003) reported that there was no significant increase in the microbial load of the ready to eat spiced product prepared from dried anchovies during the six months of storage.

Abraham and Setty (1992) reported that the total plate count in fermented prawn pickle increased from log 7.08 to log 10.75 during 30 days of storage. Prabhu and Gopal (1993) reported that the total plate count of dry fish pickle from white sardines was in the range of 2 x 10^5 g^{-1} to 6 x 10^5 g^{-1} during thirteen months of storage. Studies by Lakshmi *et al.* (2003) showed that pickles from stingray maintained low bacterial counts well within the acceptable range during the 90 days of storage.

Materials and Methods

3. MATERIALS AND METHODS

The present study entitled "Nutrient analysis and value addition of under utilized fish" was attempted to evaluate the nutritive value of three under utilized fresh and dehydrated fish varieties, to prepare pickles from fresh and dehydrated fish and to evaluate the quality of pickles. The materials and methods used for this are given under the following heads.

3.1 Selection of fish varieties
3.2 Preparation and storage of fish products
3.3 Chemical analysis of fish and fish products
3.4 Organoleptic evaluation of fish products
3.5 Microbial enumeration of fish products
3.6 Benefit cost analysis of fish products
3.7 Statistical analysis

3.1 SELECTION OF FISH VARIETIES

Three small varieties of fish which were locally available and which could be utilized fully including bones were selected for the study. The varieties selected are

1) Netholi (*Stoliphorus heterolobus*)
2) Flat fish (*Cynoglossus macrostorus*)
3) Veluri (*Kovala koval*)

All the selected varieties were procured from the fish market, Trichur, in a lot.

3.2 PREPARATION AND STORAGE OF FISH PRODUCTS

Two products namely dried fish and pickle were prepared from the selected samples. Dried fish was prepared from three selected fish varieties. Pickle was prepared from both fresh and dried samples of all the three fish varieties.

3.2.1 Preparation and storage of dried fish

Fish was dried by drying under the sun using standard procedure suggested by Basu *et al.* (1987). The flow chart for the preparation of dried fish is given in Fig.1.

Fresh fish was cleaned and washed thoroughly. Salt was added at the rate of 200 g kg^{-1} of fish. It was mixed well and kept for 20 minutes. The fish was then spread on trays and dried in sun. Dried fish (50 g) was packed in polythene covers and stored in ambient storage conditions for a period of three months.

3.2.2 Preparation of fresh fish pickle

Pickle with fresh fish was prepared by the standard procedure recommended by Vijayan *et al.* (1989). The flow chart for the preparation of fish pickle is given in Fig.2 and the recipe in Appendix I.

Fresh fish was washed and cleaned thoroughly. Salt was added at the rate of 100 g kg^{-1} of fish. It was mixed well and kept for two hours. Fish was fried in coconut oil and other ingredients like mustard seeds, green chilli, garlic and ginger were fried in gingelly oil. Turmeric and chilli powder were added towards the end. Fried fish was mixed thoroughly with other ingredients and vinegar was added. The pickle was cooled and packed in air tight glass bottles and in polyester laminated High Density Polyethylene (HDPE) film (200 g in each) and stored under ambient storage conditions for a period of six months.

3.2.3 Preparation of dried fish pickle

Pickle was prepared with dried fish using the procedure detailed in 3.2.2 and illustration is given in Fig. 2. The pickle was cooled and packed in air tight glass bottles and in polyester laminated HDPE film (200 g in each) and stored under ambient storage conditions for a period of six months.

The fresh fish and the products developed are given in plates 1 to 18.

Fresh fish

↓

Cleaning/Washing

↓

Draining

↓

Salting (200 g kg^{-1})

↓

Drying

↓

Packing in polythene covers

Fig.1. Flow chart for the preparation of dried fish

Fresh fish

↓

Cleaning/Washing

↓

Draining

↓

Salting (100 g kg^{-1} of fish)

↓ (Use dried fish directly)

Frying

↓

Mixing with fried ingredients

↓

Mixing with salt and vinegar

↓

Cooling

↓

Packing

Fig.2. Flow chart for the preparation of fish pickle

Plate 1. Fresh netholi

Plate 2. Fresh netholi pickle stored in glass bottle

Plate 3. Fresh netholi pickle stored in polyester laminated HDPE film

Plate 4. Dried netholi

Plate 5. Dried netholi pickle stored in glass bottle

Plate 6. Dried netholi pickle stored in polyester laminated HDPE film

Plate 7. Fresh flat fish

Plate 8. Fresh flat fish pickle stored in glass bottle

Plate 9. Fresh flat fish pickle stored in polyester laminated HDPE film

Plate 10. Dried flat fish

Plate 11. Dried flat fish pickle stored in glass bottle

Plate 12. Dried flat fish pickle stored in polyester laminated HDPE film

Plate 13. Fresh veluri

Plate 14. Fresh veluri pickle stored in glass bottle

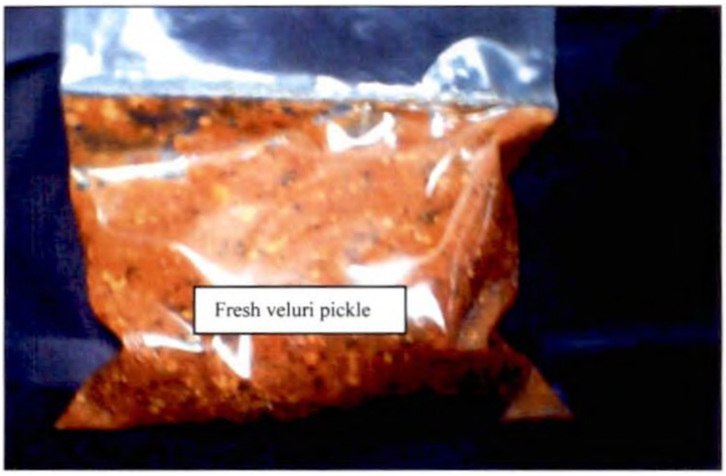

Plate 15. Fresh veluri pickle stored in polyester laminated HDPE film

Plate 16. Dried veluri

Plate 17. Dried veluri pickle stored in glass bottle

Plate 18. Dried veluri pickle stored in polyester laminated HDPE film

3.3 CHEMICAL ANALYSIS OF FISH AND FISH PRODUCTS

3.3.1 Analysis of chemical constituents of fresh and dried fish

Fresh and dried fish were analysed for the following chemical constituents.

1. Moisture
2. Fat
3. Protein
4. Calcium
5. Phosphorus
6. Iron
7. Vitamin A
8. Peroxide value

3.3.1.1 *Moisture*

The moisture content was estimated using the method of AOAC (1980) and expressed in g 100 g^{-1}.

To determine the moisture content 10 g of the sample was taken in a petri dish and dried at 60°C to 70°C in hot air oven. Cooled it in a dessicator and weighed. The process of heating and cooling was repeated until constant weight was achieved. The moisture content of the sample was calculated from the loss in weight during drying. The period of drying varied from two to three hours.

3.3.1.2 *Fat*

The fat content was estimated using the method of A.O.A.C. (1955).

Ten grams of sample was weighed accurately into a thimble and plugged with cotton. The fat content was extracted with anhydrous ether for about four hours in a soxhlet apparatus. The washings were transferred from the flask and ether was removed by evaporation. Fat content was calculated from the residue remaining in the flask and expressed as g 100 g^{-1} of the sample.

3.3.1.3 *Protein*

The protein content was estimated using the method of A.O.A.C. (1980).

Digestion was done by adding 0.4 g of $CuSO_4$, 3.5 g K_2SO_4 and 6 ml Con.H_2SO_4 to 0.3 g of sample taken in a digestion flask until the colour of the sample changed to green. After digestion, it was diluted with water and 25 ml of 40 per cent NaOH was pumped. The distillate was collected in 2 per cent boric acid containing mixed indicators and then titrated with 0.2 *N* HCl. The nitrogen content obtained was multiplied with a factor of 6.25 to get the protein content. It was expressed as g 100 g^{-1} of the sample.

3.3.1.4 *Calcium*

The calcium content was estimated using titration method with EDTA as suggested by Page (1982).

One gram of dry powdered sample was predigested with 12 ml of 9:4 mixture of HNO_3: $HClO_4$ and volume made up to 100 ml. Five millilitres of diacid extract was taken and added 100 ml water, 10 drops of hydroxylamine, 10 drops of triethanolamine and 2.5 ml of NaOH and 10 drops of calcone. Then it was titrated with EDTA until the appearance of permanent blue colour. It was expressed in mg 100 g^{-1} of the sample.

3.3.1.5 *Phosphorus*

Phosphorus content was estimated colourimetrically after preparing a diacid extract by Vandomolybdophosphoric yellow colour method in nitric acid medium as suggested by Jackson (1973).

Five millilitres of diacid extract made up to 100 ml was taken in a 50 ml volumetric flask and five millilitre of nitric acid vandate molybdate reagent was added and made up to 50 ml. After 10 minutes, the optical density was read at 470 nm in a spectronic photometer. A standard graph was prepared using serial dilution of the standard phosphorus solution. From the standard graph, the phosphorus content of the sample was estimated and expressed as mg 100 g^{-1} of the sample.

3.3.1.6 ***Iron***

The iron content was estimated colourimetrically by Wong's method as suggested by Raghuramulu *et al.* (1983).

An aliquot of the mineral solution was taken and enough water was added to make up to a volume of 6.5 ml followed by one millilitre of 30 per cent H_2SO_4, one millilitre potassium persulphate solution and 1.5 ml 40 per cent potassium thiocyanate solution. The red colour developed was read at 540 nm. The content of iron was expressed in mg 100 g^{-1} of sample from the standard graph prepared using serial dilution of standard iron solution.

3.3.1.7 ***Vitamin A***

The vitamin A content was estimated by Carr-Price method as suggested by Raghuramulu *et al.* (1983).

An aliquot of the vitamin A solution in chloroform was taken in spectrometer cuvette and the volume made up to one millilitre. Two millilitres of antimony trichloride solution was added and the intensity of the blue colour was read at 630 nm within 15 seconds. From the standard graph prepared using serial dilution of standard vitamin A solution, the vitamin A content of the sample was estimated and expressed as μg 100 g^{-1} of the sample.

3.3.1.8 *Peroxide value*

Peroxide value was assessed to find the rate of rancidity during storage. It was estimated by the method suggested by Sadasivam and Manickam (1992).

The peroxide content was determined by titration against thiosulphate in presence of potassium iodide using starch as the indicator. The peroxide value of dried fish was estimated at monthly intervals for a period of three months.

All the analyses were carried out in triplicate samples and the values were expressed in fresh weight basis.

3.3.2 Analysis of chemical constituents of pickle

3.3.2.1 *Peroxide value*

Peroxide value of pickle was estimated at monthly intervals for a period of six months by the procedure described in 3.3.1.8.

3.3.2.2 *Acidity*

Acidity of the pickle was estimated at monthly intervals for a period of six months by the method suggested by Ranganna (1986).

Ten grams of the sample was digested with boiling water. An aliquot of the digested sample was titrated with standard alkali using phenolphthalein as an indicator. Acidity was expressed in terms of acetic acid as percentage.

3.4 ORGANOLEPTIC EVALUATION OF FISH PRODUCTS

3.4.1 **Selection of judges**

A series of organoleptic trials were carried out using simple triangle tests at the laboratory level to select a panel of ten judges between the age group of 18-35 years as suggested by Jellanick (1985).

3.4.2 Organoleptic evaluation

Organoleptic evaluation of fish products was carried out using scorecard method (Swaminathan, 1974) by the panel of ten selected judges. The dried fish was evaluated at monthly intervals for a period of three months and pickle was evaluated at monthly intervals for a period of six months.

For dried fish, three quality attributes like appearance, colour and flavour were included as the quality attributes and for pickle appearance, colour, flavour, texture and taste were evaluated. Each of the above mentioned quality attributes was assessed by a five point hedonic scale. Overall acceptability of pickle and dried fish was calculated separately using the average of above mentioned quality attributes. The scorecards used for evaluation of dried fish and pickles are given in Appendix II and III respectively.

3.5 MICROBIAL ENUMERATION OF FISH PRODUCTS

The microbial evaluation of the stored dried fish was conducted at monthly intervals for a period of three months and that of pickle was conducted at monthly intervals for a period of six months. The method used for the evaluation was serial dilution and plate count method as described by Agarwal and Hasija (1986). Ten grams of sample was added to 90 ml sterile water and shaken for ten minutes. One millilitre of this solution was transferred to a test tube containing 9 ml sterile water to get 10^{-2} dilution and similarly 10^{-3}, 10^{-4}, 10^{-5} and 10^{-6} dilutions were prepared.

Enumeration of total micro flora was carried out using nutrient agar media for bacteria, potato dextrose agar media for fungi and sabouraud's dextrose agar media for yeast (Appendix IV) as suggested by Agarwal and Hasija (1986). The dilution used for bacteria was 10^{-6} and for fungi and yeast, 10^{-4} dilution was used.

3.6 BENEFIT COST ANALYSIS OF FISH PRODUCTS

The benefit cost analysis of the products was worked out to assess the extent of expense aroused to prepare different products and to calculate benefit cost (BC) ratio.

Price of fish exhibits regular seasonal variations, although at times the seasonal patterns may be observed by other factors. Hence, cost analysis is of utmost importance in product development.

The cost was worked out based on the prices of various commodities needed for the preparation of product. The final product yield was computed by taking into consideration the quantity of fish and other ingredients required to prepare a definite quantity of the product. The market price of the product was also taken into consideration and benefit cost ratio was calculated thereafter.

3.7 STATISTICAL ANALYSIS

The data was analysed as a Completely Randomized Design (CRD) using MSTAT C package, and wherever necessary the data was analysed as a factorial CRD to bring out the differences between the levels of different factors under consideration like fresh/dried fish, glass/polyester laminated HDPE film types of packing.

Different periods of storage were taken into consideration as the different phases of storage in the storage study to evaluate the impact of storage. Logarithmic transformation was effected to microbial count to satisfy the assumption of analysis of variance.

Results

4. RESULTS

The results pertaining to the study entitled 'Nutrient analysis and value addition of under utilized fish' are presented under the following heads.

1. Chemical constituents of fresh and dried fish
2. Chemical constituents of products during storage
3. Organoleptic evaluation of products during storage
4. Total microbial enumeration of products during storage
5. Benefit cost analysis of products

4.1 CHEMICAL CONSTITUENTS OF FRESH AND DRIED FISH

The chemical constituents of fresh and dried fish are given in Table 1.

Moisture

In fresh fish, the highest moisture content was observed in flat fish (78.6 g 100 g^{-1}) and lowest moisture content in veluri (76.85 100 g^{-1}). Statistically, there was significant variation in the moisture content of flat fish and veluri and in netholi and veluri. There was no significant variation in the moisture content of flat fish and netholi.

The moisture content of dried fish varied from 10.2 g 100 g^{-1} (flat fish) to 13.13 g 100 g^{-1} (veluri) with a mean moisture content of 12.03 g 100 g^{-1}. Statistically, significant variation was found in the moisture content of veluri and flat fish and in netholi and flat fish. There was no significant variation in the moisture content of veluri and netholi.

Table 1. Chemical constituents of fresh and dried fish

Sl. No.	Variety	Moisture (g 100 g^{-1})		Fat (g 100 g^{-1})		Protein (g 100 g^{-1})		Calcium (mg 100 g^{-1})		Phosphorus (mg 100 g^{-1})		Iron (mg 100 g^{-1})		Vitamin A (µg 100 g^{-1})		Peroxide value (meq kg^{-1})	
		Fresh	Dried	Fresh	Dried	Fresh	Dried	Fresh	Dried	Fresh	Dried	Fresh	Dried	Fresh	Dried	Fresh	Dried
1	Netholi	78.44	12.76	4.05	9.49	17.57	43.75	309.03	767.34	283.07	536.50	1.61	2.01	60.87	113.10	2.52	4.67
2	Flat fish	78.60	10.20	2.98	7.68	14.84	40.11	706.58	2234.40	414.40	1030.50	0.76	1.43	74.90	129.00	1.67	3.42
3	Veluri	76.85	13.13	1.15	3.02	18.00	46.17	638.63	1790.46	404.80	899.00	3.27	8.48	88.93	162.40	1.56	2.78
	Mean	77.96	12.03	2.73	6.73	16.80	43.34	551.41	1597.40	367.42	822.00	3.27	3.97	74.9	134.83	1.92	3.62
	CD ($p<0.05$)	0.89	0.89	0.87	0.87	2.00	2.00	103.73	103.73	26.32	26.32	0.52	0.52	11.49	11.49	0.40	0.40

Fat

Netholi had the highest fat content of 4.05 g 100 g^{-1} and the lowest fat content was observed in veluri (1.15 g 100 g^{-1}) among fresh fish. Significant variation in the fat content was observed in three varieties.

The fat content of dried fish ranged from 3.02 g 100 g^{-1} to 9.49 g 100 g^{-1}. The highest and the lowest fat content were seen in netholi and veluri respectively. Statistically, significant variation was found in the fat content of all the three fish varieties.

Protein

The protein content of fresh fish varied from 14.84 g 100 g^{-1} (flat fish) to 18.00 g 100 g^{-1} (veluri) with a mean protein content of 16.80 g 100 g^{-1}. Significant variation in the protein content of veluri and flat fish and netholi and flat fish was observed. However, there was no significant variation in the protein content of veluri and netholi.

Among the three varieties of dried fish, veluri had the highest protein content of 46.17 g 100 g^{-1} and the lowest protein content was in flat fish (40.11 g 100 g^{-1}). The protein content of the dried fish varied significantly between the three varieties.

The illustrations of moisture, fat and protein contents of fresh and dried fish are given in Fig.3.

Calcium

The calcium content of fresh fish varied from 309.03 mg 100 g^{-1} to 706.58 mg 100 g^{-1}. The highest value was observed in flat fish and the lowest in netholi. Statistically significant variation was observed in the calcium content of flat fish and netholi and veluri and netholi.

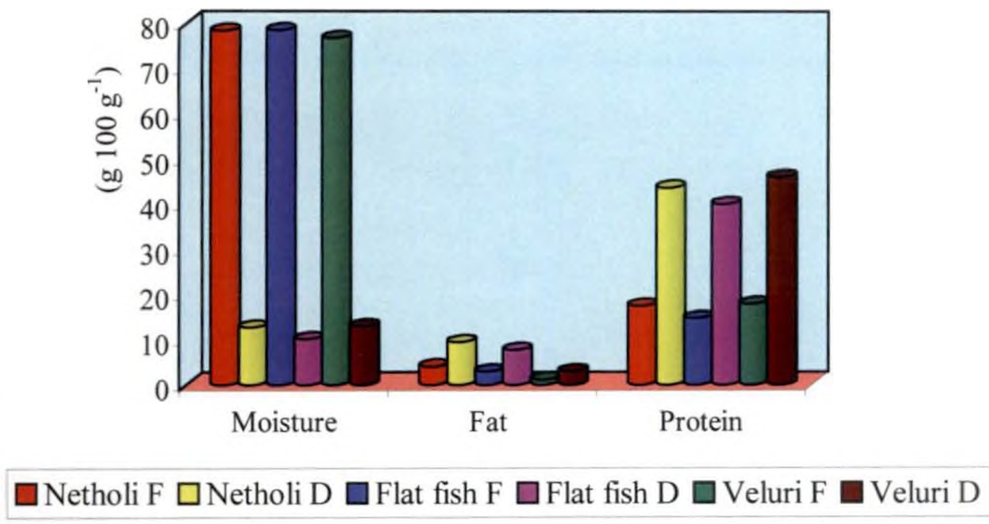

Fig. 3. Moisture, fat and protein content of fresh and dried fish, g 100 g^{-1}

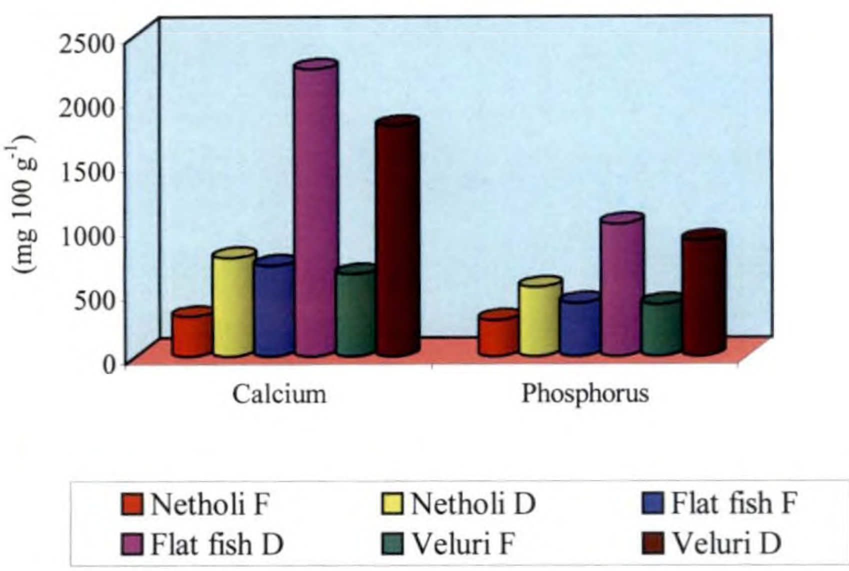

Fig. 4. Calcium and phosphorus content of fresh and dried fish,mg 100 g^{-1}

F-Fresh D-Dried

The calcium content of dried fish varied from 767.34 mg 100 g^{-1} to 2234.4 mg 100 g^{-1} with the highest and lowest calcium content in flat fish and netholi respectively. Significant variation was observed in the calcium content of all the three varieties of dried fish.

Phosphorus

As revealed in Table 1, the phosphorus content of fresh fish ranged from 283.07 mg 100 g^{-1} in netholi to 414.40 mg 100 g^{-1} in flat fish. Significant variation was observed in the phosphorus content of flat fish and netholi and in veluri and netholi. However, the phosphorus content between flat fish and veluri was found to be insignificant.

Among the dried fish also the highest phosphorus content was observed in flat fish (1030.50 mg 100 g^{-1}) and lowest in netholi (536.50 mg 100 g^{-1}). Statistically significant variation was observed in phosphorus content of all the three varieties.

The calcium and phosphorus content of fresh and dried fish are illustrated in Fig.4.

Iron

In fresh fish, the highest and the lowest iron contents were observed in veluri (3.27 mg 100 g^{-1}) and flat fish (0.76 mg 100 g^{-1}) respectively. Variation in the iron content of three fish varieties was significant.

In the case of dried fish also the highest and lowest iron contents were observed in veluri (8.48 mg 100 g^{-1}) and flat fish (1.43 mg 100 g^{-1}) respectively. Statistically, significant variation was observed between the iron content of three fish varieties.

The iron content of fresh and dried fish is illustrated in Fig.5.

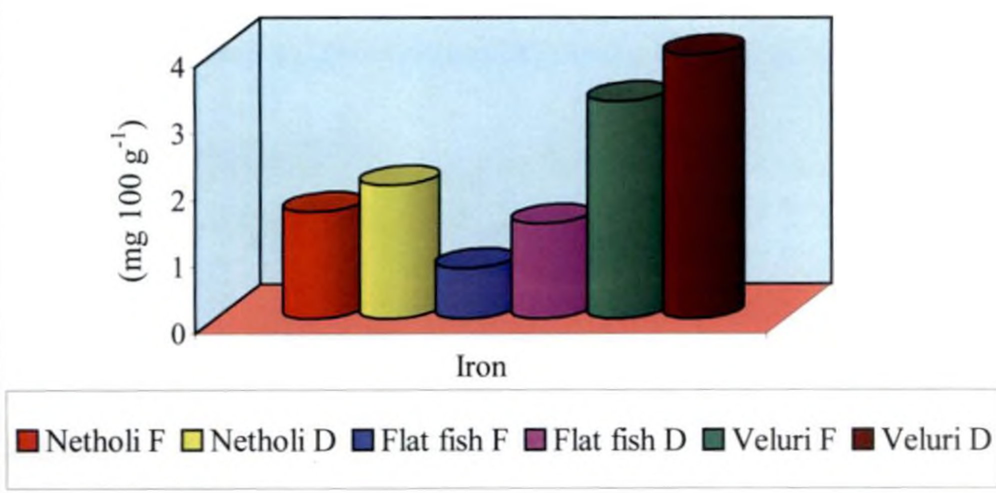

Fig. 5. Iron content of fresh and dried fish, mg 100 g^{-1}

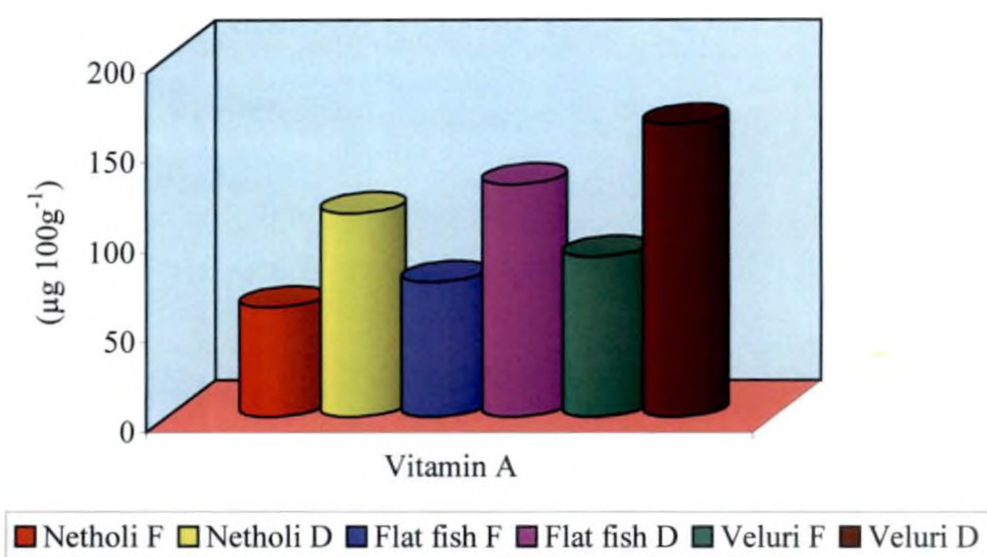

Fig. 6. Vitamin A content of fresh and dried fish, µg 100 g^{-1}

F-Fresh D-Dried

Vitamin A

As given in Table 1 the highest and lowest vitamin A content in fresh fish was observed in veluri (88.93 μg 100 g^{-1}) and netholi (60.87 μg 100 g^{-1}) respectively and the vitamin A content of the three fish varieties varied significantly.

The vitamin A content of dried fish ranged from 113.10 μg 100 g^{-1} to 162.40 μg 100 g^{-1}. The lowest and highest vitamin A content was seen in netholi and veluri respectively. Statistically significant variation was observed in the vitamin A content of all the three varieties.

The vitamin A content of fresh and dried fish is illustrated in Fig.6.

Peroxide value

Among the fresh fish, the highest peroxide value was observed in netholi (2.52 meq kg^{-1}) and lowest in veluri (1.56 meq kg^{-1}). Statistically significant variation was observed in the peroxide value of netholi and flat fish and in netholi and veluri. However, the variation observed in the peroxide value of flat fish and veluri was found to be insignificant.

In the dried fish also the highest and lowest peroxide value was observed in netholi (4.67 meq kg^{-1}) and veluri (2.78 meq kg^{-1}) respectively. Statistically significant variation was observed in the peroxide value of all the three fish varieties.

Illustration of the peroxide value of fresh and dried fish is given in Fig.7.

4.2 CHEMICAL CONSTITUENTS OF PRODUCTS DURING STORAGE

4.2.1 Peroxide value of dried fish during storage

The peroxide value of dried fish was evaluated at monthly intervals for a period of three months, the results are given in Table 2, and it is illustrated in Fig.8.

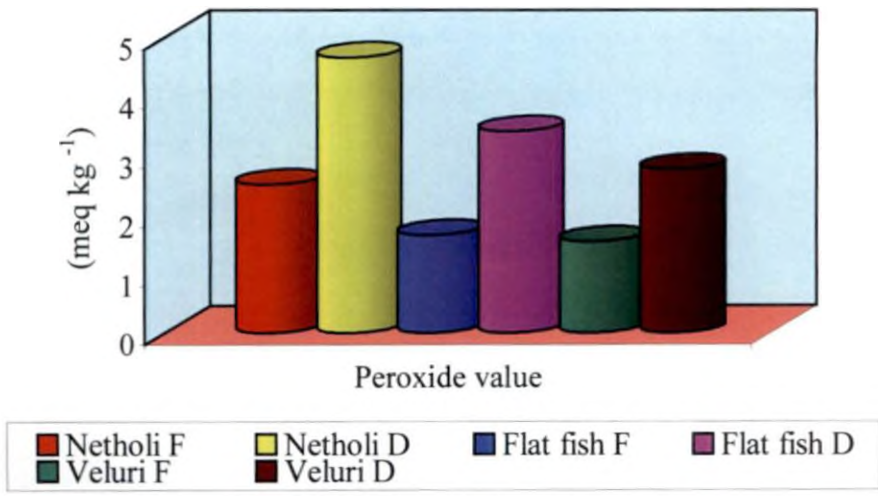

Fig. 7. Peroxide value of fresh and dried fish, meq kg^{-1}

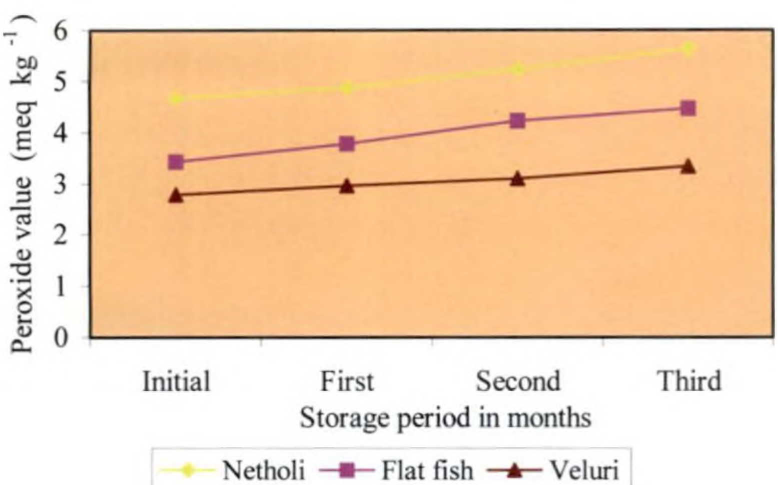

Fig. 8. Peroxide valueof dried fish during storage, meq kg^{-1}

F-Fresh D-Dried

Table 2. Peroxide value of dried fish during storage, meq kg^{-1}

Sl.No.	Variety	Storage period (months)				Mean
		Initial	First	Second	Third	
1	Netholi	4.67	4.87	5.22	5.63	5.10
2	Flat fish	3.42	3.78	4.23	4.47	3.98
3	Veluri	2.78	2.96	3.10	3.34	3.05
	CD($p<0.05$)	0.28			0.55	

An increase in the peroxide value was noticed during the storage of dried fish. Highest and lowest peroxide value was observed in netholi and veluri respectively. However, the increase in peroxide value was found to be statistically insignificant in all the three varieties of dried fish during storage. In netholi, peroxide value increased from 4.67 meq kg^{-1} during the initial period to 5.63 meq kg^{-1} during the third month of storage. In flat fish the values varied from 3.42 meq kg^{-1} (initial) to 4.47 meq kg^{-1} (third month of storage). In veluri the peroxide value increased from 2.78 meq kg^{-1} (initial) to 3.34 meq kg^{-1} (third month of storage). Significant variation was observed in the peroxide value of the dried fish between the three varieties.

4.2.2 Peroxide value of pickle during storage

Peroxide value of pickle prepared using both fresh and dried fish, which were packed in glass bottle and in polyester laminated HDPE film is given in Table 3. Illustrations are given in Fig.9 and 10.

An increase in the peroxide value of fresh and dried pickle stored in glass bottle was observed during the six months of storage. The dried fish pickle had higher peroxide value than fresh fish pickle through out the storage period.

Initially, among the three varieties of fresh fish pickle netholi pickle had the highest peroxide value of 2.94 meq kg^{-1} and the lowest value was observed in veluri pickle (2.83 meq kg^{-1}) and the variation was found to be insignificant.

Table 3. Peroxide value of pickle during storage, meq kg^{-1}

Sl. No.	Variety	Storage period (months)													Mean	
		Initial	First		Second		Third		Fourth		Fifth		Sixth			
			G	P	G	P	G	P	G	P	G	P	G	P	G	P
1	Netholi F	2.94	3.37	3.37	3.73	3.87	4.17	4.50	4.50	4.80	4.63	5.17	4.67	5.37	4.00	4.29
2	Netholi D	3.10	3.50	3.50	3.97	4.00	4.43	4.60	4.90	5.10	5.30	5.50	5.43	5.57	4.38	4.48
3	Flat fish F	2.90	3.20	3.20	3.43	3.50	3.80	4.00	4.33	4.50	4.57	5.00	4.60	5.13	3.83	4.03
4	Flat fish D	3.00	3.40	3.47	3.90	3.97	4.40	4.50	4.80	4.97	5.30	5.33	5.40	5.43	4.31	4.38
5	Veluri F	2.83	3.10	3.10	3.40	3.50	3.80	3.77	4.30	4.20	4.50	4.63	4.57	4.80	3.79	3.83
6	Veluri D	2.93	3.10	3.40	3.57	3.70	3.77	4.20	4.23	4.70	4.60	5.20	4.73	5.27	3.85	4.20
	CD ($p<0.05$)	0.17	0.22	0.22									0.35	0.35		

F - Fresh
D - Dried
G - Glass bottle
P - Polyester laminated HDPE film

CD($P<0.05$) between glass and polyester laminated HDPE film - 0.14

In dried fish pickle, peroxide value varied from 2.93 meq kg^{-1} to 3.1 meq kg^{-1} and the lowest and the highest values were found in dried fish pickle from veluri and netholi respectively. The variation was found to be statistically significant. Within a variety, no significant variation was observed in all the three varieties between fresh and dried fish.

In the first month also, highest and lowest values in fresh fish pickle stored in glass bottle were observed in netholi (3.37 meq kg^{-1}) and veluri (3.1 meq kg^{-1}) respectively. The variation was found to be significant.

Dried fish pickle from netholi had highest peroxide value (3.5 meq kg^{-1}) and that from veluri pickle had the lowest value (3.1 meq kg^{-1}). Statistically significant variation was observed in dried fish pickles of veluri and flat fish and in veluri and netholi and the variation between flat fish and netholi pickle was insignificant. No significant variation was observed between fresh and dried fish pickle of all the three fish varieties.

During the different months of storage also in the fresh and dried fish pickle highest and lowest peroxide value was observed in netholi and veluri pickle respectively.

During the sixth month of storage among the fresh fish pickle stored in glass bottle netholi pickle (4.67 meq kg^{-1}) had the highest peroxide value and pickle from veluri (4.57 meq kg^{-1}) had the lowest. Statistically there was no significant variation between them.

Dried fish pickle from netholi (5.43 meq kg^{-1}) and veluri (4.73 meq kg^{-1}) had the highest and lowest peroxide values respectively. Significant variation was observed in the peroxide value of veluri pickle from netholi and flat fish pickle during the sixth month of storage. Within a variety, statistically significant variation was

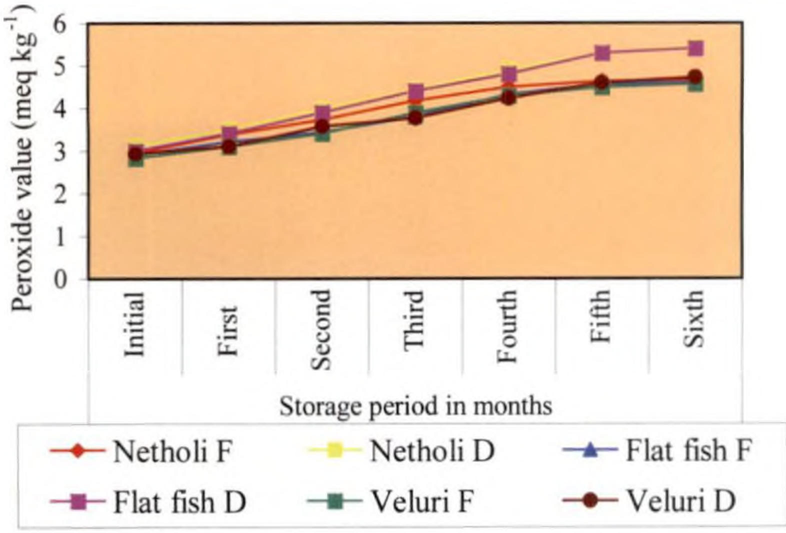

Fig. 9. Effect of storage period on peroxide value of pickle stored in glass bottle

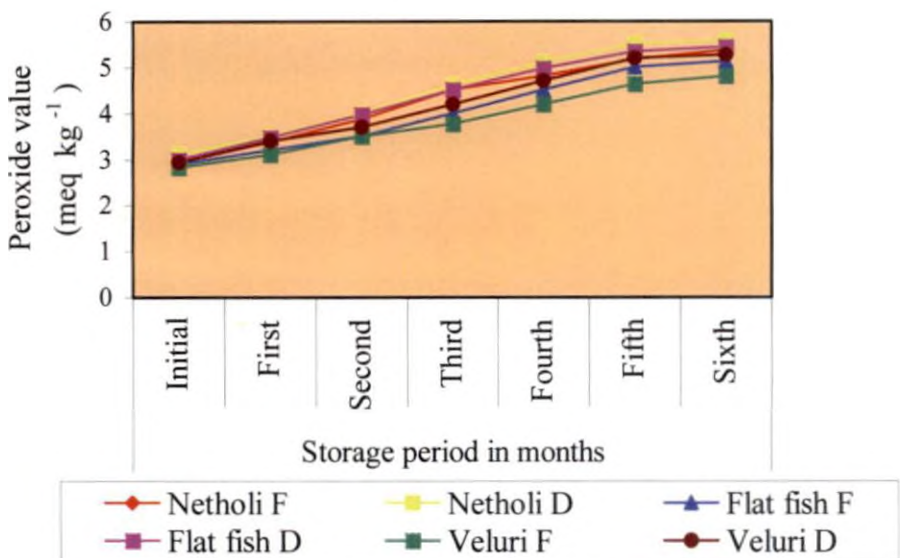

Fig. 10. Effect of storage on peroxide value of pickle stored in polyester laminated HDPE film

F-Fresh D-Dried

observed in the peroxide value between the fresh and dried pickles of netholi and flat fish. In veluri pickle, the variation was found to be insignificant.

As revealed in Table 3, during the first month in the fresh fish pickle stored in polyester laminated HDPE film, highest and lowest peroxide values were observed in netholi pickle (3.37 meq kg^{-1}) and in veluri pickle (3.10 meq kg^{-1}) respectively and the variation was found to be statistically significant.

The peroxide value of pickle prepared from dried fish varied from 3.40 meq kg^{-1} (veluri) to 3.50 meq kg^{-1} (netholi). The variation was insignificant. Within a variety, significant variation was observed in the fresh and dried pickles of flat fish and veluri but not in netholi.

Through out the storage period in both fresh and dried fish pickle stored in polyester laminated HDPE film netholi pickle and veluri pickle had the highest and lowest peroxide values respectively.

In the sixth month, among the fresh fish pickles, netholi pickle (5.37 meq kg^{-1}) had the highest peroxide value and veluri pickle (4.80 meq kg^{-1}) had the lowest. The variation was found to be significant.

In dried fish pickle the highest and lowest peroxide values were observed in netholi pickle (5.57 meq kg^{-1}) and in veluri pickle (5.27 meq kg^{-1}) respectively and the variation was found to be statistically insignificant. Statistically significant variation existed between the fresh and dried pickles of veluri.

4.2.3 Acidity of pickle during storage

The acidity of pickle stored in glass bottle and in polyester laminated HDPE film is given in Table 4.

Table 4. Acidity of pickle during storage, g 100 g^{-1}

Sl. No.	Variety	Storage period (months)													Mean	
		Initial	First		Second		Third		Fourth		Fifth		Sixth			
			G	P	G	P	G	P	G	P	G	P	G	P	G	P
1	Netholi F	1.30	1.60	1.70	1.75	1.85	1.90	2.00	2.15	2.25	2.28	2.40	2.35	2.50	1.90	2.00
2	Netholi D	1.40	1.75	1.75	1.95	1.95	2.15	2.15	2.30	2.30	2.45	2.45	2.52	2.53	2.06	2.08
3	Flat fish F	1.23	1.50	1.60	1.70	1.70	1.80	1.80	2.00	2.00	2.15	2.30	2.25	2.35	1.80	1.85
4	Flat fish D	1.25	1.65	1.70	1.90	1.90	2.00	2.10	2.25	2.25	2.40	2.40	2.50	2.45	1.99	2.01
5	Veluri F	1.25	1.55	1.65	1.75	1.80	1.85	1.95	2.15	2.25	2.25	2.35	2.30	2.45	1.87	1.96
6	Veluri D	1.45	1.85	1.85	2.05	2.05	2.15	2.20	2.30	2.40	2.45	2.55	2.55	2.58	2.11	2.15
	CD ($P<0.05$)	0.18	0.22	0.22									0.17	0.17		

F - Fresh
D - Dried
G - Glass bottle
P - Polyester laminated HDPE film

The acidity of pickle increased during the storage period and dried fish pickle exhibited higher acidity than fresh fish pickle.

Initially in fresh fish pickle, highest and lowest acidity was observed in netholi pickle (1.3%) and in flat fish pickle (1.23%) respectively. The variation was found to be statistically insignificant.

In the case of dried fish pickle, veluri pickle (1.45%) had the highest acidity and flat fish pickle (1.25%) had the lowest acidity and the variation was found to be significant. Within a variety, significant variation was observed between the fresh and dried veluri pickles.

In the case of fresh fish pickle stored in glass bottle during the first month of storage, the acidity varied from 1.50 per cent to 1.60 per cent and the lowest and highest acidity were observed in flat fish and netholi pickle respectively. The variation was statistically insignificant.

Dried fish pickle from veluri (1.85%) and flat fish (1.65%) had the highest and lowest acidity respectively. Statistically no significant variation existed between them. Significant variation existed only between the fresh and dried fish pickles of veluri.

Through out the storage period in glass bottle, among fresh fish pickle, netholi and flat fish pickle had the highest and lowest acidity respectively. In dried fish pickle, veluri had the highest acidity and flat fish pickle had the lowest acidity.

In the sixth month of storage, among the fresh fish pickle stored in glass bottle, netholi pickle (2.35%) had the highest acidity and the flat fish pickle (2.25%) had the lowest acidity and the variation was found to be insignificant.

In dried fish pickle highest and lowest acidity were observed in veluri pickle (2.55%) and flat fish pickle (2.5%) respectively. No significant variation existed between them. Within a variety, significant variation was observed between the fresh and dried pickles of all the three fish varieties.

As shown in Table 4, in the case of fresh fish pickle stored in polyester laminated HDPE film during the first month the acidity varied from 1.60 per cent to 1.70 per cent and the lowest and highest acidity were observed in flat fish and netholi pickle respectively and the variation was found to be insignificant.

Among the dried fish pickle, highest acidity was observed in veluri pickle (1.85%) and the lowest in flat fish pickle (1.70%). No significant variation was observed between them. Within a variety, no significant variation existed between the fresh and dried pickles of all the three varieties.

In the entire storage period, among fresh fish pickle netholi and flat fish pickle had the highest and lowest acidity respectively. In dried fish pickle flat fish pickle had the lowest and veluri pickle had the highest acidity through out the storage.

In the sixth month of storage in polyester laminated HDPE film among fresh fish pickle, highest and lowest acidity were observed in netholi pickle (2.50%) and flat fish pickle (2.35%) respectively and the variation was insignificant.

Veluri pickle (2.58%) and flat fish pickle (2.45%) had the highest and lowest acidity in dried fish pickle. No significant variation existed between them. Within a variety, no significant variation in the acidity existed between the fresh and dried pickles of all the three varieties.

Effect of storage conditions on the acidity of pickle stored in both packaging materials is illustrated in Fig.11 and Fig.12.

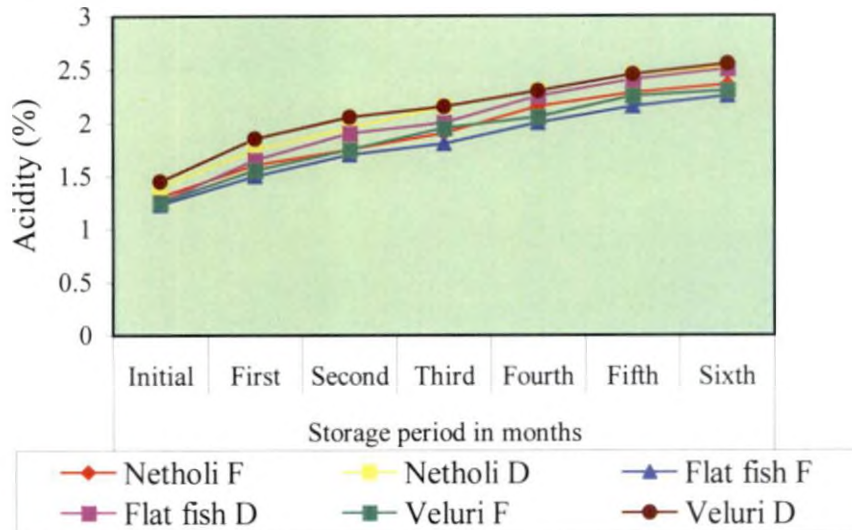

Fig.11. Effect of storage on acidity of pickle stored in glass bottle

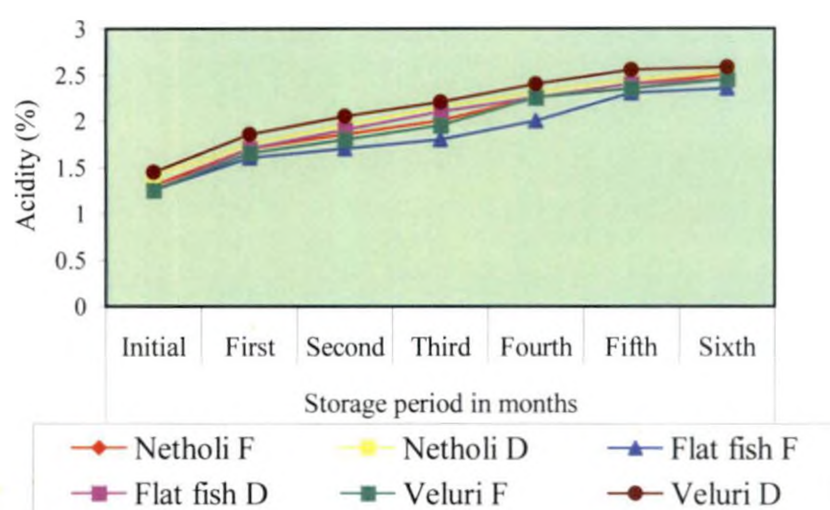

Fig.12. Effect of storage on acidity of pickle stored in polyester laminated HDPE film

F-Fresh D-Dried

4.3 ORGANOLEPTIC EVALUATION OF PRODUCTS DURING STORAGE

4.3.1 Organoleptic evaluation of dried fish

Mean scores of organoleptic evaluation of dried fish stored in polythene cover for three months are given in Table 5.

The colour of dried fish decreased during the storage period. Initially, dried veluri had the maximum score (4.91) for colour and dried flat fish had the minimum score (4.57). Statistically significant variation was observed in the colour between dried veluri and flat fish and in veluri and netholi but not in netholi and flat fish. Throughout the storage period veluri had the maximum score for colour and flat fish had the minimum score. In the third month also maximum score for colour was observed in veluri (4.21) and minimum score in flat fish (3.44). Statistically significant variation existed in the colour between veluri and flat fish and between flat fish and netholi but not between of veluri and netholi.

In the case of flavour maximum score was observed in veluri (4.88) and minimum score in flat fish (4.6) initially and the variation was found to be statistically significant. Through out the storage period maximum and minimum scores for flavour were observed in veluri and flat fish respectively. In the third month, the score for flavour varied from 3.6 to 4.06 and the minimum and maximum scores were observed in flat fish and veluri respectively. Statistically significant variation existed in the scores for flavour between veluri and flat fish and between veluri and netholi, but the variation between netholi and flat fish was insignificant.

As revealed in Table 5 initially, maximum score for appearance was observed in veluri (4.91) and minimum score in flat fish (4.63) and the variation was found to be statistically significant. In the entire period of storage, veluri and flat fish had the highest and lowest scores for appearance respectively. In the third month also maximum score for appearance was observed in veluri (4.18) and minimum score in flat fish (3.63). Significant variation existed in the scores for appearance between

Table 5. Mean scores of organoleptic evaluation of dried fish during storage

Sl. No.	Variety	Colour					Flavour					Appearance					Overall acceptability				
		Storage period (months)					Storage period (months)					Storage period (months)					Storage period (months)				
		Initial	First	Second	Third	Mean	Initial	First	Second	Third	Mean	Initial	First	Second	Third	Mean	Initial	First	Second	Third	Mean
1	Netholi	4.59	4.20	4.07	3.90	4.21	4.78	4.41	4.04	3.67	4.23	4.85	4.48	4.11	3.78	4.31	4.74	4.47	4.07	3.78	4.27
2	Flat fish	4.57	4.11	3.78	3.44	3.98	4.60	4.27	3.93	3.60	4.10	4.63	4.30	4.00	3.63	4.14	4.60	4.23	3.90	3.56	4.07
3	Veluri	4.91	4.73	4.49	4.21	4.59	4.88	4.64	4.36	4.06	4.49	4.91	4.73	4.49	4.18	4.58	4.90	4.71	4.45	4.15	4.55
	CD (P<0.05)	0.32			0.38		0.26			0.29		0.23			0.32		0.20			0.26	

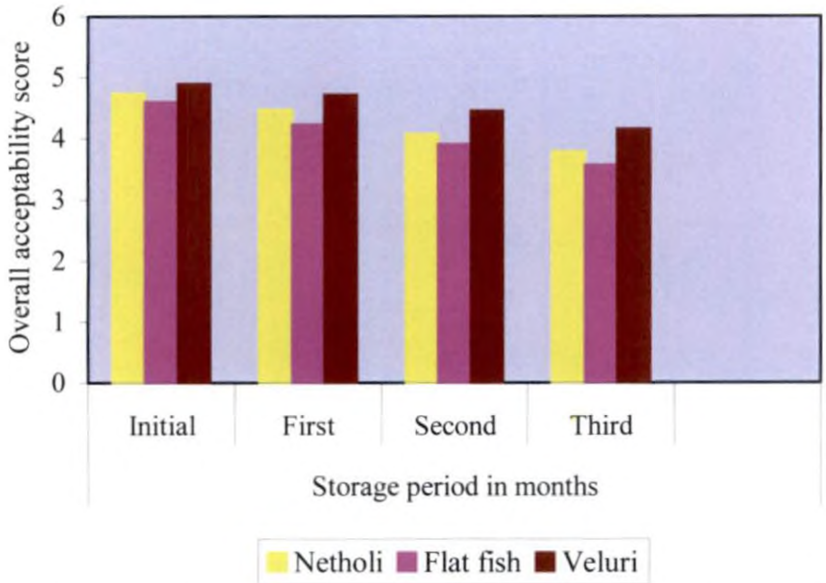

Fig.13. Effect of storage on overall acceptability of dried fish

veluri and netholi and between veluri and flat fish and not between netholi and flat fish.

The overall acceptability of dried fish decreased during the period of storage. Initially, maximum and minimum scores for overall acceptability were observed in veluri (4.90) and flat fish (4.6) respectively. Significant variation existed in the overall acceptability between veluri and flat fish and between veluri and netholi and not between netholi and flat fish. In the entire storage period including the third month, maximum and minimum scores for overall acceptability were observed in veluri and flat fish respectively. In the third month, score for overall acceptability ranged from 3.56 to 4.15. Statistically significant variation existed in the scores for overall acceptability between veluri and flat fish, veluri and netholi and not between flat fish and netholi.

The effect of storage on overall acceptability of dried fish is illustrated in Fig.13.

4.3.2 Organoleptic evaluation of pickle during storage

The organoleptic evaluation of pickle stored in glass bottle and polyester laminated HDPE film with respect to quality attributes like appearance, colour, flavour, texture, taste and overall acceptability is given from Tables 6 to 11.

Mean scores of appearance (Table 6) of fresh fish pickle varied from 4.4 to 4.8 initially. The lowest and highest mean scores were found in flat fish and veluri pickle respectively. The variation between them was statistically significant.

Among the dried fish pickle, maximum score for appearance was observed in veluri pickle (4.73) and minimum in netholi pickle (3.83). Statistically significant variation existed between the three varieties. Although fresh fish pickle had better appearance than dried fish pickle through out the storage period, statistically significant variation in the scores for appearance existed only between the fresh and dried netholi pickle.

Table 6. Mean scores of appearance of pickle during storage

Sl. No.	Variety	Storage period (months)													Mean	
		Initial	First		Second		Third		Fourth		Fifth		Sixth			
			G	P	G	P	G	P	G	P	G	P	G	P	G	P
1	Netholi F	4.47	4.44	4.50	4.40	4.40	4.37	4.34	4.37	4.33	4.33	4.33	4.33	4.30	4.39	4.38
2	Netholi D	3.83	3.90	3.87	3.93	3.90	3.87	3.83	3.83	3.80	3.73	3.73	3.73	3.67	3.83	3.80
3	Flat fish F	4.40	4.43	4.43	4.47	4.47	4.37	4.33	4.33	4.30	4.30	4.23	4.27	4.20	4.37	4.34
4	Flat fish D	4.30	4.37	4.33	4.40	4.37	4.33	4.27	4.27	4.23	4.23	4.20	4.20	4.17	4.30	4.27
5	Veluri F	4.80	4.84	4.84	4.87	4.87	4.77	4.77	4.74	4.70	4.70	4.67	4.67	4.63	4.77	4.75
6	Veluri D	4.73	4.77	4.77	4.80	4.80	4.70	4.70	4.63	4.60	4.60	4.53	4.57	4.47	4.69	4.66
	CD ($P<0.05$)	0.35	0.33	0.33									0.47	0.47		

F - Fresh
D - Dried
G - Glass bottle
P - Polyester laminated HDPE film

In the case of pickle stored in glass bottle, among fresh fish pickle the maximum score for appearance was observed in veluri pickle (4.84) and minimum score in flat fish pickle (4.43) during the first month of storage. Statistically significant variation existed in the appearance between veluri and flat fish pickle and between veluri and netholi pickle but not between netholi and flat fish pickle. Veluri pickle and netholi pickle had the maximum (4.77) and minimum score (3.9) for appearance in the dried fish pickle respectively. Significant variation in the appearance existed between the dried fish pickles of all the three varieties. Statistically significant variation existed in the scores of appearance only between fresh and dried netholi pickle.

Through out the storage period in fresh fish pickle stored in glass bottle, maximum and minimum scores for appearance were observed in veluri and flat fish respectively except in the second month of storage. Veluri and netholi pickle had the maximum and minimum scores for appearance in dried fish pickle stored in glass bottle in the entire storage period.

In the sixth month of storage, in fresh fish pickle stored in glass bottle, the score for appearance varied from 4.27 (flat fish pickle) to 4.67 (veluri pickle). Variation between the three varieties was statistically significant. In dried fish pickle scores varied from 3.73 (netholi pickle) to 4.57 (veluri pickle). Statistically significant variation existed in the scores for appearance of veluri and netholi and in flat fish and netholi pickles. Significant variation existed between the fresh and dried pickles of netholi.

As revealed in Table 6 in the pickle stored in polyester laminated HDPE film during the first month, among the fresh fish pickle maximum and minimum scores for appearance were observed in veluri pickle (4.84) and in flat fish pickle (4.43) respectively. Statistically significant variation existed in the scores for appearance between veluri and netholi pickle and between veluri and flat fish pickle, but the variation between netholi and flat fish pickle was insignificant. In the dried fish pickle veluri pickle (4.77) had the maximum score for appearance and netholi (3.87) had the minimum score. Statistically significant variation existed between the appearance of all the three varieties of dried fish pickle. The fresh fish pickle had highest score for appearance then dried fish pickle but only significant variation existed between fresh and dried pickles of netholi.

Veluri and flat fish pickle had the maximum and minimum scores for appearance among fresh fish pickle stored in polyester laminated HDPE film during the entire storage period except in the second month of storage. In dried fish pickle veluri and netholi pickle had the highest and lowest scores for appearance respectively in the storage period.

Among the fresh fish pickle stored in polyester laminated HDPE film during the sixth month score for appearance varied from 4.2 (flat fish pickle) to 4.63 (veluri pickle) and the variation was statistically insignificant. The score for appearance varied from 3.67 (netholi pickle) to 4.47 (veluri pickle) in dried fish pickle. Statistically significant variation existed between veluri and netholi pickle and between flat fish pickle and netholi pickle. Within a variety significant variation existed between the fresh and dried pickles of netholi.

As revealed in Table 7 initially for fresh fish pickle maximum score for colour was observed in veluri pickle (4.63) and minimum score in flat fish pickle (4.43). Statistically no significant variation existed in the scores for colour between the three varieties of fresh fish pickle. Among the dried fish pickle highest and lowest scores for colour was observed in veluri pickle (4.57) and in netholi pickle (3.93) respectively and the variation was found to be statistically significant. The colour of fresh fish pickle was found to be better than dried fish pickle but significant variation existed only between fresh and dried pickles of netholi.

In the first month, among the fresh fish pickles stored in glass bottles the maximum score for colour was observed in veluri pickle (4.67) and minimum score was observed in flat fish pickle (4.4). Statistically no significant variation existed in

Table 7. Mean scores of colour of pickle during storage

Sl. No.	Variety	Storage period (months)													Mean	
		Initial	First		Second		Third		Fourth		Fifth		Sixth			
			G	P	G	P	G	P	G	P	G	P	G	P	G	P
1	Netholi F	4.53	4.43	4.40	4.43	4.33	4.40	4.30	4.30	4.27	4.30	4.27	4.27	4.27	4.38	4.34
2	Netholi D	3.93	3.90	3.90	3.87	3.87	3.83	3.83	3.73	3.70	3.63	3.60	3.43	3.40	3.76	3.74
3	Flat fish F	4.43	4.40	4.40	4.37	4.30	4.33	4.27	4.30	4.23	4.23	4.13	4.20	4.10	4.32	4.27
4	Flat fish D	4.33	4.30	4.27	4.27	4.23	4.23	4.20	4.20	4.17	4.17	4.13	4.13	4.03	4.23	4.19
5	Veluri F	4.63	4.67	4.67	4.57	4.57	4.50	4.50	4.47	4.43	4.40	4.40	4.37	4.37	4.52	4.51
6	Veluri D	4.57	4.60	4.60	4.63	4.63	4.53	4.50	4.43	4.40	4.40	4.37	4.33	4.30	4.50	4.48
	CD ($P<0.05$)	0.48	0.48	0.48									0.61	0.61		

F - Fresh
D - Dried
G - Glass bottle
P - Polyester laminated HDPE film

the scores for colour between the three varieties of fresh fish pickle. In the dried fish pickle, veluri and netholi pickles had the maximum (4.6) and minimum (3.9) scores for colour respectively and the variation was statistically significant. Within a variety variation existed only between the fresh and dried pickles of netholi.

During the different months of storage also highest and lowest scores for colour of fresh fish pickle were observed in veluri and flat fish pickle respectively. In the case of dried fish pickle also highest and lowest scores for colour were observed in veluri and netholi pickles respectively.

In the sixth month of storage also the variation existed in the colour between the varieties of fresh fish pickle stored in glass bottle was found to be insignificant. In the case of dried fish pickle significant variation existed in the colour between veluri and netholi and between flat fish and netholi pickles stored in glass bottle. Among the fresh and dried pickles, fresh pickle was found to be better but with respect to colour significant variation existed only between fresh and dried pickles of netholi.

In the case of pickle stored in polyester laminated HDPE film during the first month among fresh fish pickle maximum score for colour was observed in veluri (4.67) and minimum score in netholi and flat fish (4.4). The difference in the colour between the three varieties of pickle was found to be statistically insignificant. Among the dried fish pickle highest and lowest scores for colour were observed in veluri (4.6) and netholi (3.90) pickle respectively and the variation was found to be statistically significant. Fresh fish pickle had better colour than dried fish pickle but significant variation existed only between the fresh and dried pickles of netholi.

Through out the storage period in the case of pickle stored in polyester laminated HDPE film in fresh fish pickle highest and lowest score for colour were observed in veluri and flat fish respectively. Veluri and netholi had the maximum and minimum scores for colour in dried fish pickle.

During the sixth month in fresh fish pickle the score for colour varied from 4.1 (flat fish) to 4.37 (veluri) and the variation was statistically insignificant. In dried fish pickle the score for colour varied from 3.40 (netholi) to 4.30 (veluri). Significant variation existed between veluri and netholi and between flat fish and netholi. Within a variety, the variation between the fresh and dried pickles of netholi was significant.

As analysed in Table 8, the mean scores of flavour of fresh fish pickle varied from 4.3 to 4.4 initially. The highest and lowest mean scores were found in veluri and flat fish respectively and the variation was statistically insignificant. Among the dried fish pickle maximum score for flavour was observed in veluri pickle (4.37) and minimum score was observed in netholi pickle (3.69). Statistically significant difference existed between veluri and netholi pickle and between flat fish and netholi pickle. The fresh fish pickle had better score for flavour in both packaging materials throughout the storage period.

In the case of pickle stored in glass bottle during the first month among fresh fish pickle the highest score for flavour was found in veluri and netholi pickle (4.43) and lowest score was found in flat fish pickle (4.33) and the variation was insignificant. In dried fish pickle highest and lowest score for flavour were observed in veluri pickle (4.40) and netholi pickle (3.80) respectively. Statistically significant variation existed in the scores for flavour between flat fish and netholi and between veluri and netholi pickle. Within a variety significant variation existed only between the fresh and dried pickles of netholi.

During the entire storage period in fresh fish pickle stored in glass bottle veluri and flat fish pickle had the highest and lowest score for flavour. Veluri and netholi had the highest and lowest scores for flavour in dried fish pickle stored in glass bottle during storage.

In the sixth month among the fresh fish pickle stored in glass bottle the score for flavor varied from 4.60(flat fish pickle) to 4.83 (veluri pickle) and the

Table 8. Mean scores of flavour of pickle during storage

Sl. No.	Variety	Storage period (months)													Mean	
		Initial	First		Second		Third		Fourth		Fifth		Sixth			
			G	P	G	P	G	P	G	P	G	P	G	P	G	P
1	Netholi F	4.37	4.43	4.43	4.47	4.47	4.53	4.50	4.57	4.53	4.67	4.60	4.77	4.70	4.54	4.51
2	Netholi D	3.69	3.80	3.73	3.87	3.83	4.00	3.87	4.07	3.90	4.10	3.93	4.07	3.97	3.94	3.85
3	Flat fish F	4.30	4.33	4.33	4.40	4.37	4.43	4.43	4.50	4.47	4.57	4.50	4.60	4.53	4.45	4.42
4	Flat fish D	4.20	4.23	4.23	4.27	4.27	4.37	4.33	4.40	4.43	4.43	4.40	4.47	4.37	4.34	4.32
5	Veluri F	4.40	4.43	4.43	4.50	4.50	4.57	4.57	4.60	4.60	4.73	4.67	4.83	4.73	4.58	4.56
6	Veluri D	4.37	4.40	4.40	4.47	4.43	4.57	4.47	4.60	4.57	4.67	4.60	4.73	4.63	4.54	4.50
	CD ($P<0.05$)	0.42	0.43	0.43									0.37	0.37		

F - Fresh
D - Dried
G - Glass bottle
P - Polyester laminated HDPE film

variation was insignificant. In dried fish pickle the flavour varied from 4.07 (netholi pickle) to 4.73 (veluri pickle). Significant variation existed in the scores for flavour between veluri and netholi and between flat fish and netholi pickles. Within a variety significant variation existed only between the fresh and dried pickles of netholi.

As given in Table 8 in the case of pickle stored in polyester laminated HDPE film during the first month, among fresh fish pickle maximum score for flavour was found in veluri and netholi pickle (4.43) and minimum score was found in flat fish pickle (4.33) and the variation was insignificant. Among the dried fish pickle the scores for flavour varied from 3.73 to 4.4 and the lowest and highest scores for flavour were found in netholi and veluri pickle respectively. Significant variation in score for flavour existed between veluri and netholi pickle and between flat fish and netholi pickle. Within a variety variation existed only between the fresh and dried pickles of netholi.

From first month to sixth month among fresh fish pickle stored in polyester laminated HDPE film, veluri and flat fish pickle had the highest and lowest score for flavor respectively. In dried fish pickle maximum and minimum scores were observed in veluri and netholi respectively.

Among the fresh fish pickle stored in polyester laminated HDPE during the sixth month the score for flavour varied from 4.53 (flat fish pickle) to 4.73 (veluri pickle) and the variation was insignificant. In dried fish pickles the score varied from 3.97 (netholi pickle) to 4.63 (veluri pickle) and the variation was significant. Variation also existed between flat fish and netholi. Significant variation existed between the fresh and dried pickles of netholi in the sixth month.

As revealed in Table 9, initially for fresh fish pickle maximum score for texture was found in veluri pickle (4.37) and minimum score in flat fish pickle (4.27) and the variation was insignificant. Among the dried fish pickle highest and lowest scores for texture was found in veluri pickle (4.33) and in netholi pickle (3.6)

Table 9. Mean scores of texture of pickle during storage

Sl. No.	Variety	Storage period (months)													Mean	
		Initial	First		Second		Third		Fourth		Fifth		Sixth			
			G	P	G	P	G	P	G	P	G	P	G	P	G	P
1	Netholi F	4.30	4.37	4.37	4.43	4.40	4.53	4.47	4.60	4.57	4.63	4.60	4.70	4.70	4.51	4.49
2	Netholi D	3.60	3.67	3.63	3.73	3.67	3.77	3.73	3.80	3.77	3.87	3.83	3.97	3.87	3.77	3.73
3	Flat fish F	4.27	4.30	4.30	4.33	4.33	4.43	4.37	4.47	4.40	4.53	4.43	4.57	4.47	4.41	4.37
4	Flat fish D	4.20	4.27	4.23	4.30	4.27	4.33	4.30	4.37	4.37	4.40	4.40	4.43	4.33	4.33	4.30
5	Veluri F	4.37	4.40	4.40	4.50	4.47	4.53	4.50	4.63	4.60	4.73	4.67	4.83	4.73	4.57	4.53
6	Veluri D	4.33	4.37	4.37	4.43	4.40	4.53	4.50	4.63	4.53	4.67	4.60	4.73	4.63	4.53	4.48
	CD (P<0.05)	0.56	0.53	0.53									0.46	0.46		

F - Fresh
D - Dried
G - Glass bottle
P - Polyester laminated HDPE film

respectively and the variation was significant. Variation in score for texture between flat fish and netholi was also significant. The fresh fish pickle had better texture than dried fish pickle in both packaging materials throughout the storage period but initially significant variation existed only between fresh and dried pickles of netholi.

In the first month among the fresh fish pickle stored in glass bottle the score for texture varied from 4.30 to 4.40 and the lowest and highest scores were found in flat fish and veluri respectively and the variation was insignificant. In the dried fish pickle veluri and netholi pickle had the highest (4.37) and lowest (3.67) score for texture respectively and the variation was significant. Significant variation in score for texture also existed between flat fish and netholi. Within a variety significant variation existed only between fresh and dried pickles of netholi.

During the different months of storage also highest and lowest scores for texture of fresh fish pickle stored in glass bottle were found in veluri and flat fish pickle respectively. In the case of dried fish pickle also highest and lowest scores for texture were observed in veluri and netholi pickle respectively.

Similarly in the sixth month of storage, no significant variation existed in the three varieties of fresh fish pickle stored in glass bottle. In the case of dried fish pickle significant variation existed in the texture between veluri and netholi and between flat fish and netholi pickle. Within a variety significant variation in texture existed only between fresh and dried pickles of netholi.

In the case of pickle stored in polyester laminated HDPE film during the first month among the fresh fish pickle maximum score for texture was found in veluri pickle (4.40) and in flat fish pickle (4.30) respectively and the variation was in significant. In dried fish pickle maximum and minimum scores were observed in veluri pickle (4.37) and netholi pickle (3.63) respectively and the variation was significant. Significant variation also existed in the score for texture between flat fish and netholi pickles.

In the entire storage period in fresh fish pickle stored in polyester laminated HDPE film, highest and lowest score for texture were found in veluri and flat fish respectively. Veluri and netholi had the highest and lowest score for texture in dried fish pickle.

During the sixth month in fresh fish pickle stored in polyester laminated HDPE film, the score for texture varied from 4.47 (flat fish) to 4.73 (veluri) and the variation was insignificant. In dried fish pickle score for texture varied from 3.87 (netholi pickle) to 4.63 (veluri pickle) and the variation was significant. Significant variation also existed in the texture of flatfish and netholi. Fresh and dried pickles of netholi varied significantly in texture.

As revealed in Table 10, the mean scores of taste for fresh fish pickle varied from 4.20 to 4.50 initially. The highest and lowest mean scores for taste were found in veluri and flatfish pickles respectively, and the variation was insignificant. Among the dried fish pickle maximum score for taste was found in veluri pickle (4.43) and minimum score was found in netholi pickle (3.57) and variation was significant. The fresh fish pickle had better taste than dried fish pickle in both packaging materials through out the storage period. Initially significant variation existed only between the fresh and dried pickles of netholi.

In the case of pickle stored in glass bottle during the first month among the fresh fish pickle the highest score for taste was found in veluri pickle (4.57) and lowest score was found in flat fish pickle (4.23) and the variation was insignificant. In dried fish pickle veluri and netholi pickle had the highest (4.47) and lowest (3.63) scores respectively and the variation was significant. Significant variation existed between the taste of flat fish and netholi pickle. Taste of fresh and dried pickles of netholi varied significantly.

During the entire storage period among fresh fish pickle veluri and flat fish pickle had the highest and lowest scores for taste. Veluri and netholi had the highest

Table 10. Mean scores of taste of pickle during storage

Sl. No.	Variety	Storage period (months)													Mean	
		Initial	First		Second		Third		Fourth		Fifth		Sixth			
			G	P	G	P	G	P	G	P	G	P	G	P	G	P
1	Netholi F	4.40	4.50	4.47	4.57	4.53	4.63	4.60	4.73	4.70	4.83	4.73	4.93	4.83	4.66	4.61
2	Netholi D	3.57	3.63	3.60	3.67	3.63	3.70	3.67	3.77	3.73	3.87	3.83	3.83	3.77	3.72	3.69
3	Flat fish F	4.20	4.23	4.23	4.27	4.27	4.37	4.30	4.43	4.37	4.40	4.40	4.30	4.30	4.31	4.30
4	Flat fish D	4.10	4.20	4.13	4.23	4.17	4.30	4.23	4.37	4.27	4.33	4.30	4.27	4.20	4.26	4.20
5	Veluri F	4.50	4.57	4.57	4.63	4.63	4.73	4.70	4.83	4.77	4.93	4.80	4.97	4.85	4.74	4.69
6	Veluri D	4.43	4.47	4.47	4.57	4.57	4.63	4.60	4.73	4.63	4.77	4.67	4.83	4.73	4.63	4.59
	CD ($P<0.05$)	0.62	0.55	0.55									0.46	0.46		

F - Fresh
D - Dried
G - Glass bottle
P - Polyester laminated HDPE film

and lowest scores for taste in dried fish pickle stored in glass bottle during storage.

In the case of fresh fish pickle stored in glass bottle during the sixth month, the score for taste varied from 4.3 (flat fish) to 4.97 (veluri pickle). Statistically significant variation existed in the score for taste between veluri and flat fish pickle and between netholi and flat fish pickle. In the dried fish pickle score varied from 3.83 (netholi pickle) to 4.83 (veluri pickle). Variation between the three varieties was significant. Taste of fresh and dried pickles of netholi varied significantly.

As given in Table 10, in the case of pickle stored in polyester laminated HDPE film during the first month among fresh fish pickle veluri pickle (4.57) had the highest score for taste and lowest score for taste was found in flat fish pickle (4.23) and the variation was insignificant. In dried fish pickle, the score for taste varied from 3.6 to 4.47 and the highest and lowest score for taste were observed in veluri and netholi respectively and significant variation existed between them. Within a variety significant variation existed only between the fresh and dried pickle of netholi.

In the entire period of storage in fresh fish pickle stored in polyester laminated HDPE film, veluri and flat fish pickle had the highest and lowest scores for taste. In dried fish pickle, maximum and minimum score were observed in veluri and netholi pickles through out the storage.

In fresh fish pickle stored in polyester laminated HDPE film during the sixth month, the score for taste varied from 4.3 (flat fish pickle) to 4.85 (veluri pickle). Significant variation existed in the score for taste between veluri and flat fish and netholi and flat fish. In dried fish pickle, taste varied from 3.77 (netholi pickle) to veluri pickle (4.73). The taste of veluri differed significantly from flat fish and netholi pickle. Within a variety fresh and dried pickles of netholi differed significantly in taste.

As revealed in Table 11, initially for fresh fish pickle, maximum score for overall acceptability was observed in veluri pickle (4.52) and minimum score in flat fish pickle (4.32) and the variation was insignificant. Among the dried fish pickle highest and lowest scores for overall acceptability were observed in veluri pickle (4.49) and netholi pickle (3.73) respectively and the variation was significant. Significant variation also existed in the scores for overall acceptability between flat fish and netholi. The overall acceptability of the fresh fish pickle was found to be better than dried fish pickle through out the storage period in both packaging materials but significant variation existed only between fresh and dried pickles of netholi.

In the first month among the fresh fish pickle stored in glass bottles the maximum score for overall acceptability was found in veluri pickle (4.58) and minimum score was found in flat fish pickle (4.34) and the variation was insignificant. In dried fish pickle highest and lowest scores were found in veluri pickle (4.52) and netholi pickle (3.78) respectively and the variation was found to be statistically significant. Overall acceptability of dried flat fish and netholi pickle differed significantly in the first month of storage. Within a variety, overall acceptability of fresh and dried pickles of netholi differed significantly.

During the different months of storage also highest and lowest scores for overall acceptability of fresh fish pickle were observed in veluri and flat fish respectively. In the case of dried fish pickle also highest and lowest scores for overall acceptability were observed in veluri and netholi pickles respectively.

In the sixth month of storage also the variation in the overall acceptability of fresh fish pickle stored in glass bottle was significant between veluri (4.73) and flat fish pickle (4.39). In the case of dried fish pickle significant variation existed in the overall acceptability of veluri (4.61), flatfish (4.34) and netholi pickle (3.79). Within a variety significant variation in overall acceptability existed between the fresh and dried pickles of netholi.

Table 11. Mean scores of overall acceptability of pickle during storage

Sl. No.	Variety	Storage period (months)													Mean	
		Initial	First		Second		Third		Fourth		Fifth		Sixth			
			G	P	G	P	G	P	G	P	G	P	G	P	G	P
1	Netholi F	4.40	4.43	4.41	4.45	4.41	4.47	4.43	4.53	4.49	4.59	4.54	4.61	4.54	4.50	4.46
2	Netholi D	3.73	3.78	3.77	3.81	3.78	3.82	3.78	3.83	3.80	3.80	3.80	3.79	3.78	3.79	3.78
3	Flat fish F	4.32	4.34	4.34	4.37	4.35	4.39	4.35	4.41	4.35	4.41	4.35	4.39	4.34	4.38	4.34
4	Flat fish D	4.27	4.29	4.28	4.33	4.30	4.35	4.31	4.36	4.33	4.35	4.33	4.34	4.26	4.33	4.30
5	Veluri F	4.52	4.58	4.58	4.61	4.59	4.61	4.61	4.63	4.60	4.67	4.62	4.73	4.63	4.62	4.59
6	Veluri D	4.49	4.52	4.52	4.58	4.57	4.59	4.55	4.60	4.55	4.61	4.55	4.61	4.56	4.57	4.54
	CD ($P<0.05$)	0.25	0.25	0.25									0.23	0.23		

F - Fresh
D - Dried
G - Glass bottle
P - Polyester laminated HDPE film

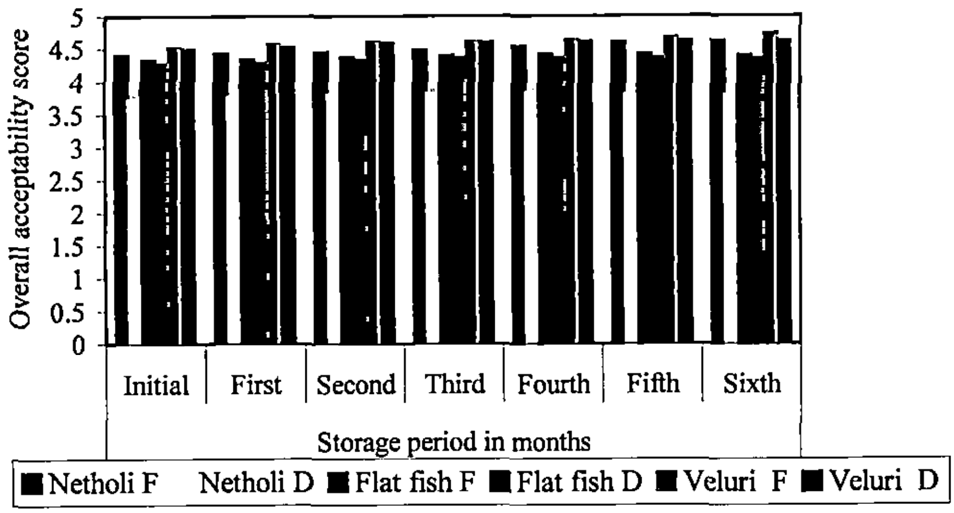

Fig.14. Effect of storage on overall acceptability of pickle *stored in glass bottle*

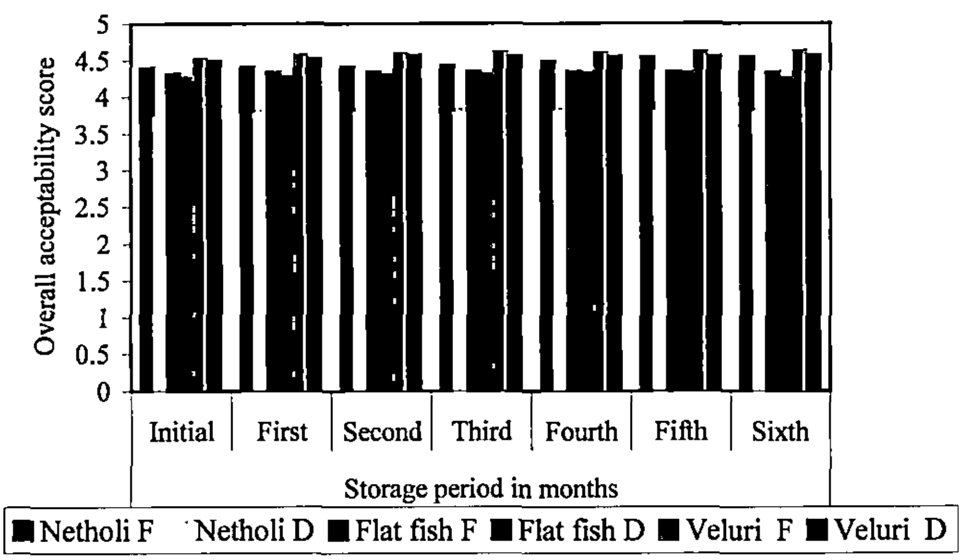

Fig.15. Effect of storage on overall acceptability of pickle stored in polyester laminated HDPE film

F-Fresh D-Dried

In the case of fresh fish pickle stored in polyester laminated HDPE film (Table 11) during the first month maximum and minimum scores for overall acceptability was observed in veluri (4.58) and flat fish pickle (4.34) respectively and the variation was insignificant. In dried fish pickle veluri (4.52) and netholi pickle (3.77) had highest and lowest scores for overall acceptability respectively. Overall acceptability of dried netholi pickle was statistically significant from veluri and flat fish pickles. Overall acceptability of fresh and dried pickles of netholi varied significantly.

In the entire storage period among fresh fish pickle stored in polyester laminated HDPE film veluri pickle had the highest score for overall acceptability and lowest score was found in flat fish pickle. In dried fish pickle, highest and lowest scores were found in veluri and netholi pickles respectively.

In the sixth month score for overall acceptability varied from 4.34 (flat fish) to 4.63 (veluri) and the variation was significant. In dried fish pickle the overall acceptability varied from 3.78 (netholi) to 4.56 (veluri pickle) and the variation in three varieties was significant. Within a variety overall acceptability of fresh and dried pickles of netholi varied significantly.

The effect of storage on the overall acceptability of pickle stored in different packaging materials is given in Fig.14 and 15.

4.4 TOTAL MICROBIAL ENUMERATION OF PRODUCTS DURING STORAGE

4.4.1 Total microbial population of dried fish during storage

The bacterial and fungal population of dried fish stored for three months are given in Table 12 and Table 13. and illustrations are given in Fig.16 and 17.

In dried netholi, the bacterial population increased from 1.00 x 10^5 cfu g^{-1} (initially) to 3.33 x 10^5 cfu g^{-1} during the third month of storage. In dried flat fish, the bacterial population varied from 1.33 x 10^5 cfu g^{-1} (initially) to 2.33 x 10^5 cfu g^{-1} (third month). Bacterial population of veluri varied from 1.00 x 10^5 cfu g^{-1} to 2.67 x 10^5 cfu g^{-1} in the third month. Taking into account the mean bacterial population, highest and lowest populations were found in veluri (2 x 10^5 cfu g^{-1}) and flat fish (1.83 x 10^5 cfu g^{-1}) respectively. Statistically no significant variation was observed in bacterial population of dried fish during the three months of storage and between the varieties. The difference in bacterial population during the three months of storage was also statistically insignificant.

Table 12. Total bacterial population of dried fish during storage

Sl.No.	Variety	Bacteria (x10^5cfu g^{-1})				Mean
		Storage period (months)				
		Initial	First	Second	Third	
1	Netholi	1.00 (5.26)	0.67 (5.20)	2.67 (5.56)	3.33 (5.63)	1.92 (5.41)
2	Flat fish	1.33 (5.36)	1.67 (5.42)	2.00 (5.46)	2.33 (5.50)	1.83 (5.44)
3	Veluri	1.00 (5.26)	2.00 (5.48)	2.33 (5.52)	2.67 (5.55)	2.00 (5.45)

Values in parenthesis shows logarithmically transformed values

Table 13. Total fungal population of dried fish during storage

Sl.No.	Variety	Fungus (x10^3 cfu g^{-1})				Mean
		Storage period (months)				
		Initial	First	Second	Third	
1	Netholi	ND	ND	0.33	0.33	0.17
2	Flat fish	ND	ND	0.33	0.33	0.17
3	Veluri	ND	ND	0.33	0.67	0.25

ND-Not detected

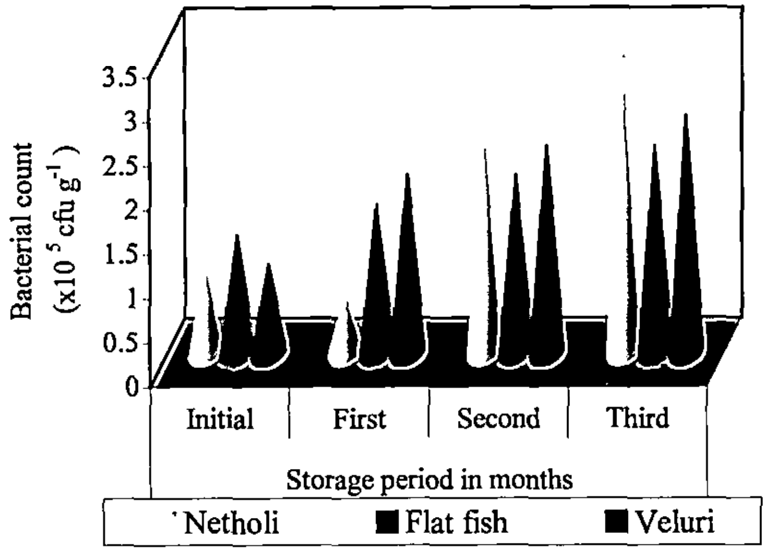

Fig.16. Bacterial count of dried fish during storage

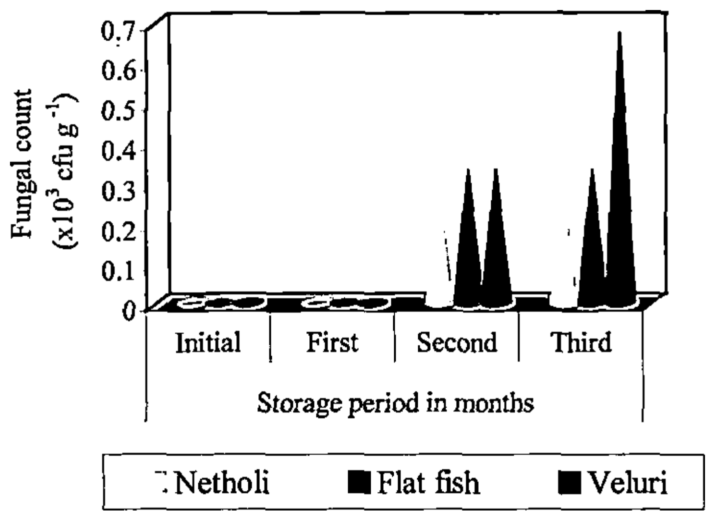

Fig.17. Fungal count of dried fish during storage

Fungal growth was found only from the second month of storage. Dried netholi and flat fish had fungal population of 0.33 x 10^3 cfu g^{-1} in second month and third month of storage. In dried veluri, fungal population increased from 0.33 x 10^3 cfu g^{-1} during second month to 0.67 x 10^3 cfu g^{-1} in third month. Taking into account the mean fungal population veluri had the highest population (0.25 x 10^3 cfu g^{-1}) and the lowest was in netholi and flat fish (0.17 x 10^3 cfu g^{-1}). Since the fungal population was very low, statistical analysis could not be done.

Yeast was not present in dried fish through out the storage period.

4.4.2 Total microbial population of pickle during storage

The bacterial and fungal populations of pickle stored in different packaging material for a period of six month are given in Table 14 and 15 respectively.

In netholi fresh pickle the bacterial population varied from 1.00 x 10^5 cfu g^{-1} (initially) to 2.67 x 10^5 cfu g^{-1} in glass bottle and to 3.00 x 10^5 cfu g^{-1} in polyester laminated HDPE film during the sixth month. Flat fish fresh pickle had a bacterial population of 0.33 x 10^5 cfu g^{-1} initially and it increased to 3.0 x 10^5 cfu g^{-1} during the sixth month in both packaging materials. In veluri fresh pickle the bacterial population varied from 1.33 x 10^5 cfu g^{-1} (initially) to 3.6 x 10^5 cfu g^{-1} in glass bottle and to 3.67 x 10^5 cfu g^{-1} in polyester laminated HDPE film during the sixth month.

In dried netholi pickle the bacterial population increased from 1.00 x 10^5 cfu g^{-1} to 3.67 x 10^5 cfu g^{-1} in glass bottle and to 3.33 x 10^5 cfu g^{-1} in polyester laminated HDPE film. Flat fish dried pickle had a bacterial population of 0.33 x 10^5 cfu g^{-1} initially and 3.33 x 10^5 cfu g^{-1} in sixth month in glass bottle. In polyester laminated HDPE film the bacterial population of pickle during sixth month was 3.67 x 10^5 cfu g^{-1}. In dried veluri pickle the bacterial population varied from 1.33 x 10^5 cfu g^{-1} (initially) to 3.67 x 10^5 cfu g^{-1} (sixth month) in both packaging.

Table 14. *Bacterial population of pickle during storage*

Sl. No.	Variety	Bacteria (x10^5 cfu g^{-1})														
		Storage period (months)													Mean	
		Initial	First		Second		Third		Fourth		Fifth		Sixth			
			G	P	G	P	G	P	G	P	G	P	G	P	G	P
1	Netholi F	1.00	1.67	1.33	2.00	1.33	2.33	2.33	2.33	2.67	2.67	3.00	2.67	3.00	2.14	2.09
		(5.32)	(5.36)	(5.36)	(5.46)	(5.30)	(5.50)	(5.52)	(5.49)	(5.55)	(5.53)	(5.59)	(5.56)	(5.63)	(5.46)	(5.46)
2	Netholi D	1.00	1.33	2.00	1.67	1.67	2.33	2.33	2.67	2.33	3.67	3.00	3.67	3.33	2.33	2.28
		(5.26)	(5.32)	(5.40)	(5.33)	(5.33)	(5.50)	(5.56)	(5.53)	(5.49)	(5.67)	(5.59)	(5.67)	(5.63)	(5.49)	(5.47)
3	Flat fish F	0.33	0.33	0.67	1.67	1.00	1.67	2.00	3.00	2.67	3.00	3.00	3.00	3.00	1.86	1.81
		(5.10)	(5.10)	(5.16)	(5.42)	(5.20)	(5.40)	(5.46)	(5.59)	(5.53)	(5.57)	(5.57)	(5.59)	(5.59)	(5.40)	(5.37)
4	Flat fish D	0.33	0.33	0.33	1.33	1.00	2.67	1.67	3.00	2.67	3.33	3.33	3.33	3.67	2.05	1.86
		(5.10)	(5.10)	(5.10)	(5.32)	(5.26)	(5.56)	(5.42)	(5.59)	(5.53)	(5.63)	(5.63)	(5.63)	(5.67)	(5.40)	(5.39)
5	Veluri F	1.33	1.67	1.33	1.67	1.67	2.33	2.33	3.00	3.00	3.60	3.33	3.60	3.67	2.48	2.38
		(5.36)	(5.42)	(5.32)	(5.40)	(5.42)	(5.52)	(5.52)	(5.59)	(5.59)	(5.67)	(5.63)	(5.67)	(5.67)	(5.52)	(5.50)
6	Veluri D	1.33	1.67	1.33	2.00	1.67	2.50	3.00	3.00	3.00	3.33	3.33	3.67	3.67	2.50	2.48
		(5.36)	(5.33)	(5.30)	(5.39)	(5.36)	(5.53)	(5.60)	5.59)	(5.59)	(5.63)	(5.63)	(5.67)	(5.67)	(5.50)	(5.50)

Values in parenthesis shows logarithmically transformed values
F - Fresh
D - Dried
G - Glass bottle
P - Polyester laminated HDPE film

Table 15. Fungal population of pickle during storage

Sl. No.	Variety	Fungi (x10^3 cfu g^{-1})													Mean	
		Storage period (months)														
		Initial	First		Second		Third		Fourth		Fifth		Sixth			
			G	P	G	P	G	P	G	P	G	P	G	P	G	P
1	Netholi F	ND	ND	ND	ND	ND	ND	ND	0.33	ND	0.33	0.33	0.33	0.33	0.14	0.09
2	Netholi D	ND	ND	ND	ND	ND	0.67	0.33	0.67	0.67	0.67	0.67	0.67	0.33	0.38	0.29
3	Flat fish F	ND	ND	ND	ND	ND	ND	ND	0.33	ND	0.33	ND	0.33	0.33	0.14	0.05
4	Flat fish D	ND	ND	ND	ND	ND	0.33	ND	0.33	0.33	0.33	0.33	0.33	0.33	0.19	0.14
5	Veluri F	ND	ND	ND	ND	ND	ND	ND	0.33	ND	0.33	0.33	0.33	0.33	0.14	0.09
6	Veluri D	ND	ND	ND	ND	ND	0.67	ND	0.33	0.33	0.33	0.33	0.67	0.33	0.29	0.14

F - Fresh
D - Dried
G - Glass bottle
P - Polyester laminated HDPE film
ND-Not detected

Taking into account the mean bacterial population, the highest and lowest bacterial population in both fresh and dried fish pickles stored in both packaging materials were observed in veluri and flat fish respectively.

Throughout the storage period, no significant variation was observed in bacterial population. Variation between the different types of pickle and between different packaging materials was insignificant, but mean values showed that dried fish pickles had higher bacterial population than fresh fish pickle. The difference in bacterial population during six months of storage was also statistically insignificant.

There was no fungal growth in all kinds of pickle till second month of storage. In all varieties of fish, fresh pickle stored in glass bottle the fungal population was 0.33×10^3 cfu g^{-1} in the fourth, fifth and sixth months of storage. The netholi and veluri fresh pickle stored in polyester laminated HDPE film had the same fungal population in the fifth and sixth month of storage. The fresh flat fish pickle stored in polyester laminated HDPE film had a fungal population of 0.33×10^3 cfu g^{-1} only in the sixth month of storage.

Dried netholi pickle stored in glass bottle had a fungal population of 0.67×10^3 cfu g^{-1} from third to sixth month of storage. Netholi dried pickle stored in polyester laminated HDPE film had a fungal population of 0.33×10^3 cfu g^{-1} in the third and sixth month and a fungal population of 0.67×10^3 cfu g^{-1} in fourth and fifth month. Flat fish dried pickle stored in glass bottle had a fungal population of 0.33×10^3 cfu g^{-1} from third month to sixth month. The pickle stored in polyester laminated HDPE film also had a fungal population of 0.33×10^3 cfu g^{-1} in the fourth, fifth and sixth months of storage. In the case of dried veluri pickle, which was stored in glass bottle had a fungal population of 0.67×10^3 cfu g^{-1} in third and sixth month of storage and 0.33×10^3 cfu g^{-1} in fourth and fifth months of storage. In the case of flat fish and veluri dried pickle, stored in polyester laminated HDPE film had a fungal population of 0.33×10^3 cfu g^{-1} in fourth, fifth and sixth months of storage.

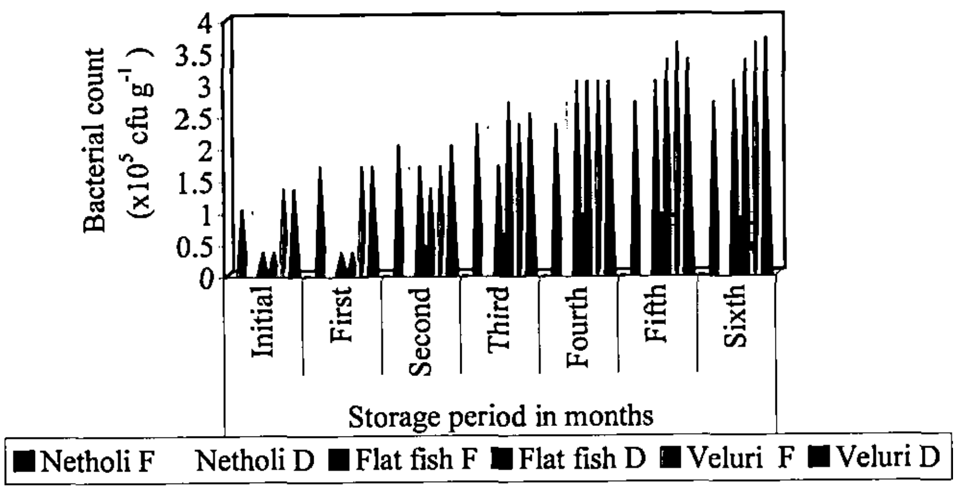

Fig.18.Bacterial count of pickle stored in glass bottle

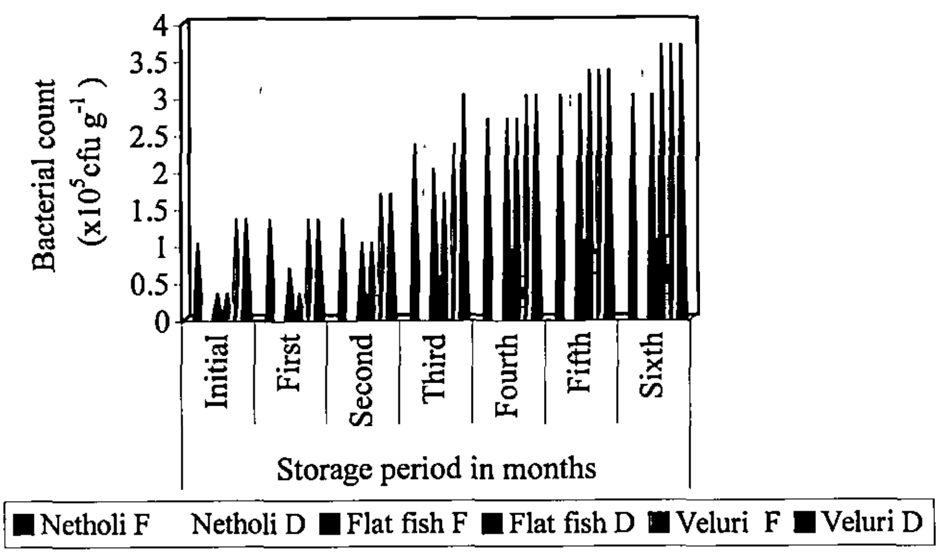

Fig.19. Bacterial countof pickle stored in polyester laminated HDPE film

F-Fresh D-Dried

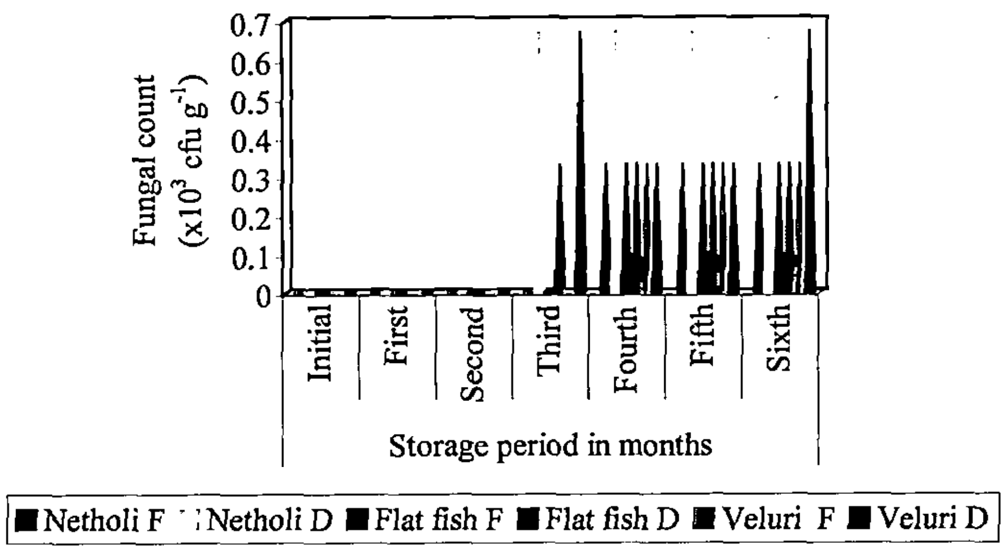

Fig.20. Fungal count of pickle stored in glass bottle

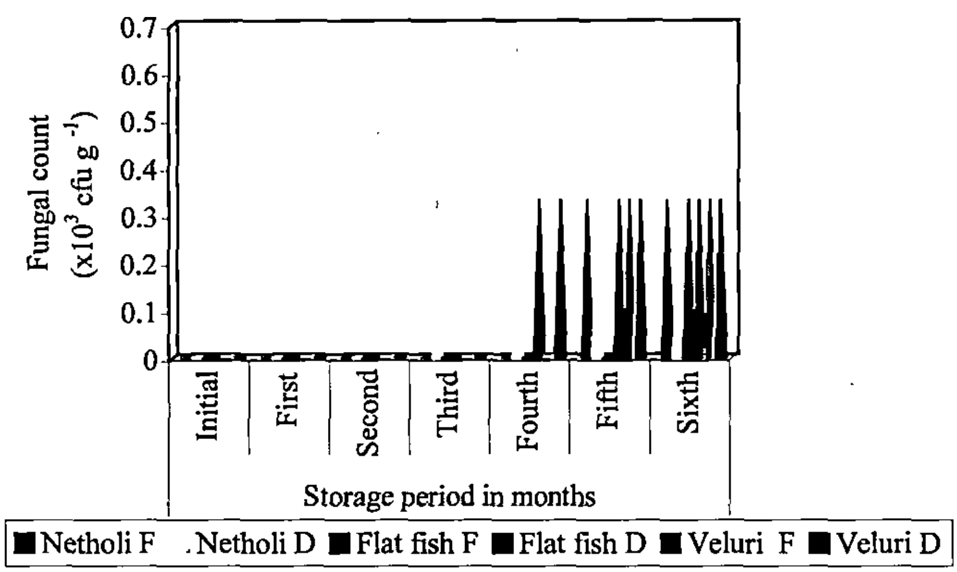

Fig.21. Fungal count of pickle stored in polyester laminated HDPE film

F-Fresh D-Dried

Taking into account the mean fungal population, the dried fish pickle had higher fungal population than fresh fish pickle. In the case of fresh fish pickle stored in glass bottle all had the same mean fungal population (0.14×10^3 cfu g^{-1}). In the case of fresh fish pickle stored in polyester laminated HDPE film highest mean fungal population was found in netholi and veluri pickle (0.09×10^3 cfu g^{-1}) and lowest was found in flat fish pickle (0.05×10^3 cfu g^{-1}). In dried fish pickle stored in both packaging materials highest mean fungal population was found in netholi pickle. Lowest mean fungal population in dried fish pickle stored in glass bottle was observed in flat fish pickle (0.19×10^3 cfu g^{-1}) and in polyester laminated HDPE film lowest was found in flat fish and veluri pickle (0.14×10^3 cfu g^{-1}). Statistical analysis for fungi was not done due to its very low population.

Yeast was not observed in any pickle through out the storage period.

The illustrations of bacterial and fungal counts of pickle stored in different packaging materials are given in Fig.18 to 21.

4.5 BENEFIT COST ANALYSIS OF PRODUCTS

Yield and Benefit Cost (BC) ratio of products is given in Table 16.

Among the dried fish, highest yield was observed in veluri (0.25 kg kg^{-1} of fresh fish) and lowest in flatfish (0.20 kg kg^{-1} of fresh fish). Among the pickles, highest and lowest yields were observed in veluri fresh pickle (1.28 kg kg^{-1} of fresh fish) and in flat fish dried pickle (0.93 kg kg^{-1} of fresh fish) respectively.

Among the dried fish, the cost was highest for veluri (Rs 284.55) and lowest for netholi (Rs 170.58). Among pickles, highest cost was observed in veluri dried pickle (Rs 99.27) and lowest in netholi dried pickle (Rs 73.07).

Table 16. Yield and BC ratio of products

Sl.No.	Product	Yield/kg of fresh fish (kg)	Cost/kg of product (Rs)	BC ratio
1	Netholi dried	0.24	170.58	1.76
2	Flat fish dried	0.20	197.50	1.09
3	Veluri dried	0.25	284.55	1.05
4	Netholi fresh pickle	1.14	75.92	2.54
5	Netholi dried pickle	1.07	73.07	2.84
6	Flat fish fresh pickle	1.15	75.45	2.55
7	Flat fish dried pickle	0.93	84.75	2.45
8	Veluri fresh pickle	1.28	93.06	2.07
9	Veluri dried pickle	1.12	99.27	2.09

All the products had BC ratio greater than one. The highest BC ratio among the dried fish was observed in netholi (1.76) and lowest in veluri (1.05). Among pickles, highest BC ratio was observed in netholi dried pickle (2.84) and lowest in veluri fresh pickle (2.07).

Discussion

5. DISCUSSION

The discussion pertaining to the study is presented under the following headings.

5.1 CHEMICAL CONSTITUENTS OF FRESH AND DRIED FISH

In the present study, highest moisture content in fresh fish was observed in flat fish (78.6 %). The values obtained are close to the values reported by Gopalan *et al.* (1994). Netholi had a moisture content of 78.44 g 100 g^{-1}. The result obtained is in line with the findings of Nair and Susheela (2000). The value obtained is slightly higher than those obtained by Gopalan *et al.* (1994) who reported a moisture content of 69.3 g 100 g^{-1} in *Stolephorus spp.* Veluri had the lowest moisture content of 76.85 g 100 g^{-1} which was slightly lower than the value reported by Swaminathan (1987). All the values were in the range reported by Gopakumar (2002). The moisture content of fish varied with species. Similar findings were also reported by Nair (2002).

Dried veluri had the highest moisture content of 13.13 g 100 g^{-1} and netholi had a moisture content of 12.76 g 100 g^{-1}. These values were similar to the findings of Basu *et al.* (1989) and Gopakumar (2002). Flat fish had a moisture content of 10.2 g 100 g^{-1}, which was lower than the values reported by Solanki and Sankar (1988) and Basu *et al.* (1989). This may be because of the difference in drying method employed. According to Doe (2002) the moisture content of dried fish varied with the drying method.

As per the results, in fresh fish the highest fat content was observed in netholi (4.05 %), which is slightly lower than the findings of Gopalan *et al.* (1994). The value was within the range reported by Manay and Shadaksharaswamy (1998) and Lim and Low (2003). The flat fish and veluri had a fat content of 2.98 g 100 g^{-1} and 1.15 g 100 g^{-1} respectively. The values obtained are close to the value reported by Gopalan *et al.* (1994) and Poulter and Nicolaides (1995).

The dried netholi and veluri had the highest (9.49 %) and lowest (3.02 %) fat content respectively. The dried flat fish was found to have a fat content of 7.68 g 100 g^{-1}. This was close to the value reported by Solanki and Sankar (1988).

Different species of fish showed variation in fat content. This was supported by Gopakumar (2002), who observed that fat content in fish varied between species and within species and showed wide variations with season and sexual maturity.

In fresh fish, highest protein content (18 %) was observed in veluri followed by netholi (17.57 %). This was similar to the findings of Gopalan *et al.* (1994) and Cuisa and Giaccio (1999). Flat fish had a protein content of 14.84 g 100 g^{-1}. The result obtained was slightly lesser than that obtained by Gopalan *et al.* (1994) who reported a protein content of 19.50 g 100 g^{-1} in flat fish. The values were within the range reported by Tarr (2002).

As per the analysis the dried veluri, netholi and flat fish had a protein content of 46.17 g 100 g^{-1}, 43.75 g 100 g^{-1} and 40.11 g 100 g^{-1} respectively. This is in line with the findings of Sarojnalini and Vishwanath (1994b).

As observed in this study, the underutilized fish varieties can be a good and inexpensive source of quality protein in our daily diet .It can be used as a source to prevent protein calorie malnutrition.

Flat fish had the highest calcium content (706.58 mg 100 g^{-1}) in fresh fishes. This value was lower than the value reported by Gopalan *et al.* (1994), but higher than the value reported by Govindan (1970). Veluri had a calcium content of 638.63 mg 100 g^{-1} and it is close to the findings of Gopalan *et al.* (1994). Flat fish had a calcium content of 706.58 mg 100 g^{-1} and it was found to be higher than the value reported by Gopalan *et al.* (1994). The values were within the range as reported by Murray and Burt (1989).

As revealed in the result flat fish had the highest calcium content of 2234.4 mg 100 g^{-1} in dried fish. Dried veluri and netholi had 1790.46 mg 100 g^{-1} and 767.34 mg 100 g^{-1} calcium respectively. The values obtained were close to the values reported by Gopalan *et al.* (1994) who reported a calcium content of 2231 mg 100 g^{-1} and 1389 mg 100 g^{-1} in dried parsey and bombay duck respectively.

Fresh flat fish had the highest phosphorus content of 414.40 mg 100 g^{-1} and this was found to be slightly lower than the value (524 mg 100 g^{-1}) reported by Gopalan *et al.* (1994). Fresh netholi and veluri had a phosphorus content of 283.07 mg 100 g^{-1} and 404.80 mg 100 g^{-1} respectively. Similar values were reported by Chitranshi (2001) in pomphret and sardine.

Results revealed that dried flat fish had highest phosphorus content of 1030.50 mg 100 g^{-1} and lowest was in dried netholi (536.50 mg 100 g^{-1}). Veluri was found to have a phosphorus content of 899 mg 100 g^{-1}. Small fishes were found to be rich in phosphorus. This is in line with the findings of Tarr (2002) who reported that small fish eaten with bone are rich source of phosphorus.

Thus, small varieties of fish eaten with bone are rich source of calcium and phosphorus. Therefore, consumption of these fishes helps to prevent osteoporosis, which is caused by deficiency of calcium.

The iron content of fresh fish varied from 0.76 mg 100 g^{-1} to 3.27 mg 100 g^{-1} with the highest and lowest values in veluri and flat fish respectively. Gopalan *et al.* (1994) reported similar values in white bait and sole. Swaminathan (1999) also reported similar iron content in white bait. Netholi had an iron content of 1.61 mg 100 g^{-1}. This is in line with the findings of Gopalan *et al.* (1994).

Dried veluri had highest iron content (8.48 mg 100 g^{-1}). This is slightly lower than the value reported by Swaminathan (1999) in dried chela. Netholi and flat fish had an iron content of 2.01 mg 100 g^{-1} and 1.43 mg 100 g^{-1} respectively. The variation may be because of varietal difference.

Highest and lowest vitamin A content in fresh fish was observed in veluri (88.93 μg 100 g^{-1}) and netholi (60.87 μg 100 g^{-1}) respectively. Flat fish had a vitamin A content of 74.90 μg 100 g^{-1}. Tarr (2002) reported that vitamin A in fish varied between 60 μg 100 g^{-1} to 800 μg 100 g^{-1}. The values obtained in the present study were found to be in accordance with these findings. Maage *et al.* (1991) also reported that vitamin A content in fish varied between 15 μg 100 g^{-1} to 3000 μg 100 g^{-1}.

The vitamin A content of dried veluri, flat fish and netholi were 162.40 μg 100 g^{-1}, 129.00 μg 100 g^{-1} and 113.10 μg 100 g^{-1} respectively. Loesecke (1999) reported that drying of foods brings about concentrations of nutrients and high vitamin A content of dried fish may be because of this reason.

In fresh fish, highest peroxide value was observed in netholi (2.52 meq kg^{-1}). This may be because of higher fat content of netholi. Lowest peroxide value (1.56 meq^{-1} kg) was observed in veluri. Flat fish had a peroxide value of 1.67 meq kg^{-1}. The values were within the acceptable range reported by Mathews *et al.* (1998). Ismail (2002) reported a peroxide value of 4.0 meq kg^{-1} in white herring. The values obtained in the present study were found to be lower than this. This variation may be due to varietal difference and due to difference in the fat content.

Dried netholi and veluri had the highest (4.67 meq kg^{-1}) and lowest (2.78 meq kg^{-1}) peroxide value respectively. Flat fish had a peroxide value of 3.42 meq kg^{-1}. These values were in line with the findings of Khuntia *et al.* (1993) who reported a peroxide value of 4.16 millimoles of O_2 kg^{-1} in dry salted mackerel.

5.2 CHEMICAL CONSTITUENTS OF PRODUCTS DURING STORAGE

In the present study, an increase in the peroxide value of the dried fish was noticed during the storage period. Increase in peroxide value may be attributed to the oxidation of highly unsaturated fatty acids in fish lipids by the catalytic activity of common salt, iron impurities that are probably present in the crude salt, proxidant action of moisture and also auto oxidation by atmospheric oxygen (Amano, 1962 and Wheaton and Lawson, 1985). Increase in peroxide value of dried fish during storage was also reported by Thompkinson and Mathur (1989) and Khuntia *et al.* (1993).

Significant variation was observed in the peroxide value of the dried fish between the three varieties. Netholi had the highest peroxide value. This may be because of higher fat content of netholi. Lowest was found in veluri because veluri had the lowest fat content. The increase in peroxide value over the three months was not statistically significant. Although the peroxide value increased during storage period, it was within the limit as described by Mathews *et al.* (1998) who reported that oils having peroxide value less than 10meq kg^{-1} are free from rancidity and suitable for consumption. So all the three fish varieties can be recommended for drying and storing for three months without becoming rancid.

Changes in the peroxide value of pickle stored in glass bottle and polyester laminated HDPE film was studied for a period of six months.

Results revealed that the peroxide value of the pickle increased during the storage. It may be because of the reasons as described by Amano (1962) and Wheaton and Lawson (1985). The dried fish pickle had highest peroxide value than fresh fish pickle. It may be because of higher percentage of fat in dried fish. The pickle stored in polyester laminated HDPE film had higher peroxide value than pickle stored in glass bottle. This could be related to higher oxygen transmission rate for the package film as reported by Prabhu and Gopal (1993). Gopal (2002) had reported that glass is an excellent barrier to solids, liquids and gases. This might be the reason for lower peroxide value of pickles stored in glass bottles.

Statistically no significant variation was observed between the peroxide values of the pickle stored in different packaging materials in the first month. However, in the sixth month significant variation existed between the peroxide values of the pickle stored in different packaging materials except in dried flat fish pickle. Taking into consideration the differences in the peroxide values of the pickles stored in different packaging materials, it was found that the difference was statistically significant and significant variation existed in the difference in peroxide value between fresh and dried pickles and between different packaging materials over the six months of storage.

In both fresh and dried pickles, the netholi pickle had the highest peroxide value because of its high fat content. Veluri had lower fat content so the peroxide value was also lower.

The increase in peroxide value of the pickle with the advancement of storage period as observed in the present study was in agreement with the result obtained by Prabhu and Gopal (1993). Similarly, an increase in peroxide value was reported by Puttarajappa *et al.* (1996) in chicken pickle.

According to Lakshmanan (2000), good quality oils have peroxide value between 1meq kg^{-1} and 10meq kg^{-1}. In the present study, all pickles had peroxide value less than 10meq kg^{-1}. So all pickles can be considered to be free from rancid flavour through out the storage period.

The acidity of the pickle stored in glass bottle and in polyester laminated HDPE film increased during the storage and the increase was statistically significant. The increase in acidity may be attributed to the liberation of acids during the storage as reported by Gopal *et al.* (1988). Significant variation was not observed in the acidity of the pickle during storage in different packaging materials.

The pickle stored in polyester laminated HDFE film had slightly higher acidity than pickle stored in glass bottle. The dried fish pickle also had slightly higher acidity than fresh fish pickle. This might be because of variation in fermentation taking place in pickle as described by Gopakumar (1997b). The result obtained in the present study was in line with the findings of Abraham and Setty (1992), Singh *et al.* (2000) and Lakshmi *et al.* (2003).

Taking into account the mean values the highest and lowest acidity in fresh fish pickle stored in both packaging media was found in netholi and flat fish respectively. In dried fish pickle highest and lowest acidity was found in veluri and flat fish pickle respectively.

5.3 ORGANOLEPTIC EVALUATION OF PRODUCTS DURING STORAGE

The dried sample of veluri had the highest mean score for overall acceptability (4.55) and the lowest (4.07) for dried flat fish. The dried flat fish had the lowest score for all the quality characters namely colour, flavour and appearance at the starting of the experiment and also during the end of the storage period. Dried veluri had the highest score for all quality characters throughout the storage period. Dried fish prepared from veluri was found to be the best, since the overall acceptability of the sample was found to have a high score during different storage periods. The greater flesh content and lower fat content of veluri might be the reason for this.

The organoleptic qualities of dried fish namely colour, flavour and appearance decreased during the storage period thereby causing a decrease in overall acceptability. The difference in scores of quality characters was not statistically significant, but significant variation existed between the varieties through out the storage period.

In effect, the acceptability of dried fish decreased gradually towards the end of the storage period. This is in line with the findings of Ramachandran and

Solanki (1988), Khuntia *et al.* (1993) and Yasodha and Rao (1998) who described similar changes for dried fish. The fish did not develop any rancid flavour till the end of storage. This is in line with the findings of Rahman *et al.* (1998) and Tarr (2002) who reported that dried fish could be stored for several months in room temperature without deleterious effects. Thus, veluri, flat fish and netholi can be recommended for drying.

The appearance and colour of some pickle increased slightly for first few months and it later decreased gradually by the sixth month. The difference in score for appearance during six months of storage was statistically significant but that of colour was insignificant. The highest score for flavour and texture of pickle was exhibited during the sixth month of storage. The taste and overall acceptability of all pickles except pickles made out of fresh flat fish, dried flat fish and dried netholi increased till the sixth month of storage. The taste and overall acceptability of these pickles increased till fifth month and then decreased. The difference in score for flavour, texture, taste and overall acceptability of all pickles during six months of storage was insignificant.

The quality attributes namely appearance, colour, flavour, texture, taste and overall acceptability did not show any variation between two packaging materials. This is in line with the findings of Gopal *et al.* (1986) who reported that flexible packaging material can also be used for packing pickles. However, the pickle stored in glass bottle had better quality attributes than pickle stored in polyester laminated HDPE film. This might be because of inertness and non permeability of glass as reported by Gopal (1998). Fresh fish pickle had better acceptability throughout the storage period in both the packaging media. This can be attributed to the texture of the fresh fish compared to dried fish. The colour of fresh fish pickle was also better than dried fish.

In fresh fish pickle stored in both packing materials, veluri pickle had the highest score for all quality attributes and lowest score was found in flat fish pickle. In the case of dried fish pickle, pickle made out of veluri had highest score for all quality attributes and lowest was found in netholi dried pickle. Thus, fresh veluri pickle had the highest score for overall acceptability and dried netholi pickles had the lowest score. Veluri had more flesh than other two fish varieties. This might be the reason for its better acceptability.

The improved acceptability of the pickles with the advancement of storage period may be attributed to the increased penetration of spices into fish tissues and the improvement of texture. Similar result was reported by Prabhu and Gopal (1993) who revealed that dry fish pickle from white sardine (*Kowala coval*) can be stored for 13 months without much change in acceptability.

The result obtained in the present study was supported by Yellappa *et al.* (1991), who showed that clam pickle was acceptable for a period of six months. Similar results were also reported by Abraham *et al.* (1993) and Lakshmi *et al.* (2003). Thus, as revealed in the present study fresh veluri, flat fish and netholi can be recommended for pickling than dried fish because of its better acceptability.

5.4 TOTAL MICROBIAL ENUMERATION OF PRODUCTS DURING STORAGE

The quality of dried fish depends on the total micro flora present in them. Many organisms causing food borne illnesses may grow in foods under favourable conditions.

In the present study, a gradual increase in the bacterial population was observed in dried fish, but the increase was not significant. The fungal population was detected only during the second and third month of storage. According to Bera *et al.* (2001), the growth of fungi and bacteria in the food samples are influenced by moisture content, high or low relative humidity, temperature of storage and type of samples. The low bacterial and fungal population of the dried fish might be because of high salt content and reduced moisture content of dried fish. According to Sen and

Lahiry (1962) the microbial activity in dried fish is retarded by inhibiting various enzymes in microbial cells. Yeast was not detected throughout the storage. It might be because of the absence of sugar.

Taking into account the mean values, the highest bacterial and fungal population was observed in dried veluri. It might be because of high moisture content of veluri when compared with others. The lowest bacterial population was found in flat fish. The lowest fungal population was found in netholi and flat fish. The microbial population of dried fish reported in the present study was in line with the findings of Lu *et al.* (1988), who reported a microbial count of 42 x 10^6 organisms g^{-1} sample in dried fish in Ghana. Ramachandran and Solanki (1988) reported that the total plate count of semi dried shark varied from 2.0 x 10^3 colonies g^{-1} to 6.2 x 10^6 colonies g^{-1} during three months of storage. Basu *et al.* (1989) also reported similar results. The presence of fungi in dried fish was also reported by Gupta and Samuel (1985), Chakrabarti and Varma (1997), Shanthini and Patterson (2002) and Sachindra *et al.* (2003). In the present study, although fungus was reported in dried fish it could not be detected visibly. Similar results were reported by Chakrabarti and Varma (2002).

According to Mukundan (2000b) the acceptable total plate count of raw fish products for human consumption is $5x10^5$ g^{-1}. In the present study, all dried fish had total bacterial count less than this and hence varieties are considered as acceptable for human consumption.

The shelf life of pickle also can be assessed by measuring the microbial population.

The bacterial population of pickle increased gradually during the storage period, but the increase was insignificant. The fungal population was observed only from third month of storage and there was not much increase till the end. The pickle stored in glass bottle had slightly higher microbial population than pickle stored in polyester laminated HDPE film. It might be because of reasons as described by Bera *et al.* (2001). The dried fish pickle showed slightly higher microbial population than fresh fish pickle, which may be attributed to the drying of fish in open air.

Comparitively low microbial population was observed in pickle. It can be due to low acidity of pickle, high salt content, presence of garlic and mustard and use of gingelly oil. Srilakshmi (1997) reported that garlic has antibacterial properties against gram positive and gram negative bacteria and the extract of garlic are known to inhibit the growth of many pathogenic fungi belonging mainly to *Aspergillus species* and *Candida species*. The protective action of gingelly oil was also reported by Davidar (2003). The absence of yeast can be due to low sugar content present in pickle.

Taking into account the mean bacterial population, the highest and lowest bacterial counts in fresh and dried pickle stored under both packaging conditions was observed in veluri and flat fish pickle respectively. The variation might be because of the growing conditions of fish. There was not much difference in fungal population and all pickles maintained fungal count less than 1×10^3 cfu g^{-1}. The results obtained in the present study were in line with the findings of Prabhu and Gopal (1993), who reported that the total plate count of dry fish pickle from white sardine ranged from 2×10^5 g^{-1} to 6×10^5 g^{-1} during 13 months of storage. Studies by Lakshmi *et al.* (2003) also showed that pickles from stingray maintained low bacterial count well with in the acceptable range during the 90 days of storage.

According to Mukundan (2000b) the acceptable total plate count of cooked fish products for human consumption is in the range of 10^5 g^{-1}. In the present study, all pickles had total bacterial count with in this range, hence all the varieties can be recommended for pickling.

5.5 BENEFIT COST ANALYSIS OF PRODUCTS

In dried fish, veluri had the highest yield and lowest yield was found in flat fish. The difference in yield might be because of structural difference of fish. Among pickles, fresh fish pickle had higher yield than dried fish pickle. It is caused by difference in moisture content.

Cost analysis showed that dried netholi is the cheapest (Rs170.58kg^{-1}) among dried fishes. Among pickles, dried netholi pickle had the lowest cost. Veluri had the highest cost in both dried fish and in pickles.

All the products had benefit cost ratio above one and could be recommended for commercial popularization. Dried netholi had the highest BC (1.76) ratio among dried fish. It can be attributed to the lower cost of netholi when compared with other fishes. In pickle also, highest BC ratio was found in dried netholi pickle (2.84) and lowest in veluri fresh pickle (2.07). The lower BC ratio of veluri pickle was because of higher cost of veluri.

Summary

6. SUMMARY

The present study entitled "Nutrient analysis and value addition of under utilized fish" was attempted to evaluate the nutritive value of three underutilized fresh and dehydrated fish varieties namely netholi (*Stoliphorus heterolobus*), flat fish (*Cynoglossus macrostorus*), and veluri (*Kovala koval*). The study also aimed to evaluate the quality of dehydrated fish and pickles prepared from fresh and dehydrated fish.

The nutrient evaluation revealed that the moisture content of fresh fish varied from 76.85 g 100 g^{-1} (Veluri) to 78.6 g 100 g^{-1} (flat fish). In dried fish the highest and lowest moisture content was observed in veluri (13.13 %) and flat fish (10.2 %) respectively.

Netholi and veluri had the highest (4.05 %) and lowest (1.15 %) fat content in fresh fish. In dried fish highest fat content of 9.49 g 100 g^{-1} was observed in netholi and lowest (3.02 %) was in veluri. The protein content of fresh fish varied from 14.84 g 100 g^{-1} to 18.00 g 100 g^{-1} and that of dried fish varied from 40.11 g 100 g^{-1} to 46.17 g 100 g^{-1}. In both cases highest and lowest protein content were found in veluri and flat fish respectively.

The highest calcium content (706.58 mg 100 g^{-1}) in fresh fish was found in flat fish and netholi had the lowest (309.03 mg 100 g^{-1}). In dried fish also flat fish and netholi had the highest (2234.4 mg 100 g^{-1}) and lowest (767.34 mg 100 g^{-1}) calcium content.

In fresh fish the phosphorus content varied from 283.07 mg 100 g^{-1} to 414.40 mg 100 g^{-1} and in dried fish phosphorus content varied from 536.50 mg 100 g^{-1} to 1030.50 mg 100 g^{-1}. In both cases the highest and lowest values were observed in flat fish and netholi respectively. Veluri and flat fish had the highest (3.27 mg 100 g^{-1}) and lowest (0.76 mg 100 g^{-1}) iron content in fresh fish respectively. In dried fish also the highest iron content was found in veluri (8.48 mg 100 g^{-1}) and the lowest (1.43 mg 100 g^{-1}) was found in flat fish.

The vitamin A content in fresh fish varied from 60.87 µg 100 g^{-1} in netholi to 88.93 µg 100 g^{-1} in veluri. The highest (162.40 µg 100 g^{-1}) and lowest (113.10 µg 100 g^{-1}) vitamin A content in dried fish was also found in veluri and netholi respectively. In both fresh and dried fish the highest and lowest peroxide value was reported in netholi and veluri respectively. In fresh fish the peroxide value varied from 1.56 meq kg^{-1} to 2.52 meq kg^{-1}. In dried fish the peroxide value varied from 2.78 meq kg^{-1} to 4.67 meq kg^{-1}.

Dried fish was stored for a period of three months in polythene bags and the peroxide value, organoleptic qualities and the microbial population were analysed at monthly intervals. The peroxide value increased during the storage period but the variation was not significant. Highest (5.1 meq kg^{-1}) and lowest (3.05 meq kg^{-1}) mean peroxide values were reported in netholi and veluri respectively.

With regard to the organoleptic qualities of dried fish there was a gradual reduction for each quality criteria namely colour, flavour, appearance and overall acceptability during the storage. Statistical analysis revealed that there was no significant variation in these qualities on storage. Veluri had the highest acceptability throughout the storage period. Lowest acceptability was found in flat fish.

Regarding the microbial population, the bacterial population was found to be gradually increasing with storage. The fungus was found only in third and fourth month of storage. The mean values showed that highest bacterial population (2 x 10^5 cfu g^{-1}) was found in veluri and lowest (1.83 x 10^5 cfu g^{-1}) in flat fish. The highest fungal population was found in veluri (0.25 x 10^3 cfu g^{-1}) and lowest (0.17 x 10^3 cfu g^{-1}) in netholi and flat fish. There were no traces of yeast in the dried fish throughout the storage period.

The pickle prepared from fresh and dried fishes were stored in glass bottles and in polyester laminated HDPE film for a period of six months. Peroxide value, acidity, organoleptic qualities and microbial load were analysed at monthly intervals.

The peroxide value and acidity of the pickle in both packaging materials increased during the storage. The increase in peroxide value was insignificant but that of acidity was significant. The pickle stored in polyester laminated HDPE film had higher peroxide value and acidity than pickle stored in glass bottle. Within a package, dried fish pickle had higher peroxide value and acidity than fresh fish pickle. In fresh and dried pickle stored in both packaging materials, the highest and lowest mean peroxide value was found in netholi and veluri respectively. In fresh fish stored in glass bottle and polyester laminated HDPE film highest and lowest acidity were observed in netholi and flat fish pickle respectively. In dried fish veluri and flat fish pickle had the highest and lowest acidity in both packaging media.

The organoleptic evaluation of pickle stored in glass bottle and polyester laminated HDPE film showed that appearance and colour of pickle decreased during the storage period. Some pickles like fresh and dried pickles of veluri showed a slight increase in appearance and colour in first few months and then decreased. The flavour, texture, taste and overall acceptability of pickles increased during storage. For some pickles like dried netholi pickle and fresh and dried flat fish pickle flavour, taste and overall acceptability increased till fifth month and then showed a slight decrease. The pickle stored in glass bottle had better organoleptic qualities than pickle stored in polyester laminated HDPE film. Within a variety, fresh fish pickle had better organoleptic qualities than dried fish pickle in both packages. The organoleptic scores showed that in fresh fish pickle stored in glass bottle and in polyester laminated HDPE film the highest and lowest scores were found in veluri and flat fish respectively. In dried fish pickle the highest score for all organoleptic qualities were found in veluri and lowest was found in netholi pickle.

Statistical analysis revealed that there was no significant variation in organoleptic qualities between the two packaging materials and no significant variation in sensory qualities such as colour, flavour, texture, taste and overall acceptability on storage but there was a significant change in appearance due to storage.

The microbial enumeration of pickle revealed that the bacterial population increased slightly during the storage period in pickles stored in glass bottle and in polyester laminated HDPE film but the increase was not significant. The fungal population was found only from third month onwards and it remained almost the same throughout the storage period in both packaging materials. The pickle stored in glass bottle had higher microbial population than pickle stored in polyester laminated HDPE film. In both packaging conditions dried fish pickle had higher microbial population than fresh fish pickle. In the case of pickle stored in both glass bottle and in polyester laminated HDPE film the highest and lowest bacterial population in fresh and dried fish were found in veluri and flat fish pickle respectively.

All the fresh fish pickle stored in glass bottle had the same mean fungal population (0.14×10^3 cfu g^{-1}). In fresh fish pickle stored in polyester laminated HDPE film highest fungal (0.09×10^3 cfu g^{-1}) population was found in veluri and netholi pickle and lowest fungal population (0.05×10^3 cfu g^{-1}) was found in flat fish pickle. Netholi pickle had the highest fungal population in dried fish stored in glass bottle and in polyester laminated HDPE film. Lowest fungal population in dried fish pickle stored in glass bottle was found in flat fish pickle (0.19×10^3 cfu g^{-1}) and in polyester laminated HDPE film lowest fungal population was found in flat fish and veluri pickle (0.14×10^3 cfu g^{-1}). Yeast was not observed in the pickle throughout the storage period.

In dried fish the highest (0.25 kg) and lowest yield (0.20 kg) was found in veluri and flat fish respectively. The fresh fish pickle had higher yield than dried fish pickle.Dried netholi pickle was found to have the lowest cost when compared with other fish. All the products had BC ratio greater than one. Hence, the development of products from underutilized fish was found to be economically beneficial.

Underutilized fish varieties are good sources of nutrients and products developed from them were highly acceptable. Dried fish could be stored for three months and pickles could be stored for six months without affecting its qualities. Pickle stored in glass bottle had better acceptability but pickle could be safely stored in both glass and polyester laminated HDPE film. The fresh fish pickle had higher acceptability than dried fish pickle. Veluri was found to be the most suitable fish for preparing products. All products had BC ratio greater than one. Thus, the utilization of these underutilized fish for developing value added products could be encouraged by the fisherwomen to take up as an income generating activity and this approach will reduce the wastage of these fish varieties during the season.

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* Originals not seen

Appendices

APPENDIX-I

RECIPE FOR THE PREPARATION OF FISH PICKLE

PICKLE

Ingredients

Fish (dressed and cut into small pieces)	:	1 kg
Mustard seed	:	10 g
Green chilli (cut into pieces)	:	50 g
Garlic (peeled)	:	80 g
Ginger (peeled and chipped)	:	80 g
Chilli powder	:	35 g
Turmeric powder	:	2 g
Gingelly oil	:	200 g
Vinegar	:	400 g
Salt	:	100 g
Sugar	:	10 g

Procedure

1) Mix the fish with salt and keep for two hours (previously salted and dried fish can also be used)
2) Fry the fish in minimum quantity of coconut oil
3) Fry all other ingredients in gingelly oil
4) Add turmeric and chilli powder towards the end
5) Mix the ingredients with fried fish.
6) Remove from fire and add vinegar to the hot pickle
7) Cool and pack the pickles. Store in a place away from heat and light

APPENDIX-II

SCORE CARD FOR ORGANOLPETIC EVALUATION OF DRIED FISH

Name of fish

No.	Character	Description	Score	1	2	3	4	5
I	Appearance	Excellent	5					
		Good	4					
		Fair	3					
		Poor	2					
		Very poor	1					
II	Colour	Excellent	5					
		Good	4					
		Fair	3					
		Poor	2					
		Very poor	1					
III	Flavour	Excellent	5					
		Good	4					
		Fair	3					
		Poor	2					
		Very poor	1					

Name

Date

Signature

APPENDIX-III

SCORE CARD FOR ORGANOLEPTIC EVALUATION OF FISH PICKLE

Name of pickle

No.	Character	Description	Score	1	2	3	4	5
I	Appearance	Excellent	5					
		Good	4					
		Fair	3					
		Poor	2					
		Very poor	1					
II	Colour	Excellent	5					
		Good	4					
		Fair	3					
		Poor	2					
		Very poor	1					
III	Flavour	Excellent	5					
		Good	4					
		Fair	3					
		Poor	2					
		Very poor	1					
IV	Texture	Excellent	5					
		Good	4					
		Fair	3					
		Poor	2					
		Very poor	1					
V	Taste	Excellent	5					
		Good	4					
		Fair	3					
		Poor	2					
		Very poor	1					

Name

Date

Signature

APPENDIX-IV

COMPOSITION OF MEDIA

I. NUTRIENT AGAR MEDIA

Peptone	-	10 g
Beef extract	-	5 g
Agar	-	20 g
Sodium chloride	-	5 g
Distilled water	-	1 litre
pH	-	6.5 to 7.5

II. POTATO DEXTROSE AGAR MEDIA

Potato	-	200 g
Dextrose	-	20 g
Agar	-	20 g
Distilled water	-	1 litre
pH	-	7.0

III. SABOURAUD'S MEDIA

Dextrose	-	20 g
Peptone	-	10 g
Agar	-	20 g
Distilled water	-	1 litre
pH	-	6.8 - 7.0

NUTRIENT ANALYSIS AND VALUE ADDITION OF UNDERUTILIZED FISH

By

JISHY, K. K.

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirement for the degree of

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ABSTRACT

Fish contains the best proteins and other superior nutritional constituents that place them in a specially important category of food. It has very poor shelf life. Hence, the present study on nutrient analysis and value addition of under utilized fish was aimed at evaluating the nutrients and developing products from three under utilized fish varieties namely netholi (*Stoliphorus heterolobus*), flat fish (*Cynoglossus macrostorus*) and veluri (*Kovala koval*). This will help in meeting the increasing demand for fish, to avoid wastage of small fish and to provide income to the fisher women.

The fresh and dried fish varieties were analysed for chemical constituents like moisture, fat, protein, calcium, phosphorus, iron, vitamin A and peroxide value. Fish was found to be rich sources of protein, calcium and phosphorus. Chemical constituents varied significantly between the varieties.

The dried fish was packed in polythene covers and was stored for a period of three months. The peroxide value increased during the storage but the increase was not significant. Dried netholi had the highest peroxide value throughout the storage period. The organoleptic qualities decreased during storage. The change of organoleptic scores was not significant; veluri had the highest acceptability throughout the storage period. Microbial enumeration revealed that bacterial population increased slightly during storage and fungus was found only in second and third month of storage. No traces of yeast were found throughout the storage period.

The pickle prepared from fresh and dried fish was stored in glass bottle and polyester laminated HDPE film for a period of six months. The peroxide value of the pickle increased during the storage but the increase was insignificant. The acidity of the pickle increased significantly. The pickle stored in flexible packaging material had higher peroxide value and acidity than pickle stored in glass bottle. Dried fish pickle had higher peroxide value and acidity than fresh fish pickle.

The organoleptic evaluation of pickle revealed that appearance and colour decreased during storage. The flavour texture, taste and overall acceptability of pickle increased during storage. Changes in organoleptic scores except appearance were insignificant. Appearance decreased significantly. The pickle stored in glass bottle had better acceptability than pickle stored in polyester laminated HDPE film, but the variation was insignificant. The fresh fish pickle had better acceptability and among them veluri pickle was found to be the best. A gradual increase in the bacterial and fungal load with storage of pickle was observed but yeast was not found during the storage.

The benefit cost analysis showed that all products had BC ratio above one hence, all are economically beneficial.