QUALITY EVALUATION OF VALUE ADDED PRODUCTS WITH MARINE AND FRESH WATER FISH

By

SOUMYA. P.S

THESIS

Submitted in partial fulfilment of the requirement for the degree of

MASTER OF SCIENCE IN HOME SCIENCE

(FOOD SCIENCE AND NUTRITION)

Faculty of Agriculture

Kerala Agricultural University

Department of Home Science

COLLEGE OF HORTICULTURE

VELLANIKKARA, THRISSUR - 680 656

KERALA, INDIA

2009

DECLARATION

I, hereby declare that this thesis entitled **"Quality evaluation of value added products with marine and fresh water fish"** is a bonafide record of research work done by me during the course of research and that it has not been previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

Vellanikkara **Soumya, P.S**

CERTIFICATE

Certified that this thesis entitled **"Quality evaluation of value added products with marine and fresh water fish"** is a bonafide record of research work done independently by **Ms. Soumya, P. S** under my guidance and supervision and that it has not formed the basis for the award of any degree, diploma, fellowship or associateship to her.

Vellanikkara

Dr. V. Usha
(Major Advisor)
Professor and Head
Department of Home Science
College of Horticulture
Vellanikkara
Thrissur

CERTIFICATE

We, the undersigned members of the Advisory Committee of **Miss. Soumya.P.S**, a candidate for the degree of **Master of Science in Home Science** with major in **Food Science and Nutrition**, agree that this thesis entitled "**Value added products with marine and fresh water fish**" may be submitted by **Miss. Soumya.P. S.**, in partial fulfillment of the requirement for the degree.

Dr. Usha V.
Professor and Head
Department of Home Science
College of Horticulture
Vellanikkara
Chairperson, Advisory committee

Dr. Indira V.
Professor
technology
Department of Home Science
College of Horticulture,
Vellanikkara
,

(Member, Advisory committee)

Dr. Sheela K.B.
Department of processing

College of Horticulture
Vellanikkara

(Member, Advisory committee)

Dr. M.C. George
Associate professor
Department of Processing Technology
College of Fisheries, Panangad, Cochin

(Member, Advisory committee)

EXTERNAL EXAMINAR

ACKNOWLEDGEMENT

And so comes the time to look back on the path traversed during the endeavour and to remember the faces behind the action with a sense of gratitude. Nothing of significance can be accomplished without the acts of assistance, words of encouragement and gestures of helpfulness from others.

First and foremost I bow my head the ***Almighty God*** *who enabled me to successfully complete the thesis work in time.*

I avail this opportunity to express my deep sense of reverence, gratitude and indebtedness to my major advisor ***Dr. V. Usha****, Professor & Head, Department of Home Science, College of Horticulture and Chairperson of my Advisory Committee for her sustained and valuable guidance, constructive suggestions, unfailing patience, friendly approach, constant support and encouragement during the course of this research work and preparation of the thesis.*

I express my sincere gratitude to ***Smt. Omana Pavunny,*** *Assistant Professor, Department of Processing Technology, Panangad and former chairperson of my advisory committee for suggesting me the problem and her valuable guidance, unfailing support and being a constant source of encouragement.*

I place a deep sense of obligation to ***Dr. V. Indira,*** *Professor, Department of Home Science, College of Horticulture and member of my Advisory Committee for her unwavering encouragement, unflagging perseverance, well timed support and help rendered which made the successful completion of this thesis.*

I am deeply indebted to ***Dr. K. B. Sheela,*** *Professor, Department of Processing Technology, College of Horticulture, Vellanikkara and member of my advisory committee for her unbounded support, critical assessment, timely help at various stages of my work and critical scrutiny of the manuscript which has helped a lot for the improvement and preparation of the thesis.*

My heartfelt thanks are expressed to ***Sri. M. C. George****, Associate Professor, Department of Processing Technology, College of Fisheries, Panangad and member of my advisory committee for his whole hearted cooperation and immense help extended for the statistical analysis of the data.*

I take this opportunity to thank my seniors ***Ms. Sharon, Ms. Aneena, Ms. Lakshmi, for*** *their support and encouragement.*

I have no words to express my deep sense of gratitude to my dear friends ***Deepthi chechi, Dr. Mini and Dr. Smitha*** *for their eternal support, honest guidance and encouragement.*

Words cannot really express the true friendship that I relished from ***Jyothi, Remya, Archana, Divya and Sophia*** *for the heartfelt help, timely suggestions and for their moral support, encouragement and help throughout the course of my research work.*

Ineffable thanks to my dearest class mates ***Nidhi, Ambili****, and all my M.Sc. Classmates, for their moral support and encouragement.*

I am happy to place on record my sincere thanks to my dear juniors ***Deepa, Vimi, Shiji, Nisha, Mittu, Saritha, Kavitha, Bindhya and Hemalatha,*** *for their immeasurable help and support during the course of this study. I am also thankful to* ***Ms. Umaiba*** *for her timely help and co-operation while working in the laboratory.*

I deeply indebted to my ***Parents****,* ***my brother, kochichan, ammu, anju, sruthi and appu*** *without whose moral support, blessings and affection this would not have been a success. It would be impossible to list out all those who have helped me in one way or another in the successful completion of this work. I once again express my heartful thanks to all those who helped me in completing this venture in time.*

Soumya

Dedicated to

Ammamma &

Kunjamma

Achan & Amma

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

Abbreviation

AOA	Association of Official Analytical Chemists
B A	Butylated Acrylonitrile
^0C	Degree centigrade
cfu	Colony forming unit
CHD	Coronary Heart Diseases
cm	Centimeter
CRD	Complete Randomized Design
EDTA	Ethelene Diamine Tetra Acetic acid
FAO	Food and Agricultural Organization
g	Gram
HCL	Hydrochloric acid
KAU	Kerala Agricultural University
Kg	Kilogram
Meq	Milli equivalent
mg	Milligram
ml	Milliliter
HNO_3	Nitric acid
N	Normality
NIN	National Institute of Nutrition
$HCLO_4$	Per chloric acid
%	Percentage
K_2SO_4	Pottasium sulphate
NaOH	Sodium hydroxide
H_2SO_4	Sulphuric acid
WHO	World Health Organization

Introduction

1. INTRODUCTION

In the early 1970's fish was considered as a resource against hunger in the world. Presently, fish has gained importance as a health food, because several species have been identified as rich in easily digestable protein containing all the essential amino acids, therapeutically important polyunsaturated fatty acids, in addition to calcium, iodine, vitamins, and many other nutrients (Venugopal, 2006).

Fish is a natural renewable resource, not only in terms of bio diversity but a source of high quality animal protein food for the people (Ravindra and Pahwar, 2001). Fisheries sector is one of the fastest growing production sectors in the world. In India, fisheries have always been playing a pivotal role in the food and nutritional security of the rural people especially in the maritime and north eastern state of India. In recent years, fish and fish products recorded a substantial quantitative rise in the domestic and export markets (Nair, 2006).

India has a vast coastline and is a major maritime state with established traditions of fisheries, influencing lives of millions of people. The annual production from the sea is about 2.9 million tones, being about 50 percent of the total fish production (Rai, 2003). Fisheries form an important sector of the country's economy in terms of food supply, employment, income and foreign earnings (Rao, 2005). World fish center's studies on global fish demand predict that the total demand for fish products will increase to 127.8 million tones by 2020. FAO estimates that global fish consumption will increase from 19 Kg to 21 Kg per capita by 2020 (Feruzkhan and Preetha, 2006). India is presently the world's fourth highest fish producer and the second highest inland fish producer (Asha and Muthiah, 2006).

Kerala, the southwestern state of India is gifted with large number of backwaters, ponds, and streams. The total costline of the state is 590 Kms.

Fishing is a major occupation in the state. Kerala has a big export market as well as a huge domestic consumer base with regard to the export of marine products; the share of Kerala has been 15.97 percent in values. The net production of fish is 6.78 tones and is the second largest consumer state of fish with 21.16 per cent (Devadasan, 2003).

Fish is one of the most valuable sources of protein food. Worldwide, people obtain about 25 percent of this animal protein from fish and shellfish. Fish oils are special due to the high content of poly unsaturated fatty acids especially omega 3 fatty acids. Fish oil can also help the cardiovascular system and it reduces the chance of breast, colon, and prostate cancer. In the case of athletes, the main benefit of fish oil is to reduce the inflammation and pain in the muscle and joints (Goldberg, 2007). Fish oil may protect the brain from cognitive problems associated with Alzheimer's disease, those with rheumatoid arthritis, psoriasis or other auto- immune disorders. Fish oil prevents age related blindness (Leanarda, 2007).

In spite of phenomenal increase in fish production during the last few decades, the per capita 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). Per capita consumption of fish in developed countries is 2 to 9 Kg. In India per capita consumption of fish is 9 Kg (Venugopal, 2004). The consumption of fish in Kerala is only 11g per consumption unit per day against the daily requirement of 30 g (Krishnaswamy *et al.,* 2000).

Value addition is one of the possible approaches to raise the profitability of fish processing industry, which now lays greater emphasis on quality assurance. The minced fish flesh was widely used as an intermediate product for fabricated foods including kamabuko, fish sausage, fish ball, fish burger, fish stick and similar products (Hassan and Mathew, 1999). The processing and supply of fish products is a huge global business. Like other sectors of the food industry it depends on providing products, which are both safe and which meet consumer's increasing demand for quality (Bremner, 2002). Hence, the present study entitled 'Quality evaluation of value added products with marine and fresh water fish' was undertaken with the following objectives.

1. To determine the nutritive characteristics of the selected marine and fresh water fish varieties.
2. To develop value added products and to assess the acceptability and shelf life of the developed products.

Review of Literature

2. REVIEW OF LITERATURE

The literature pertaining to the study "Quality evaluation of value added products with marine and fresh water fish" is presented under the following heads.

2.1 Health benefits of fish

2.2 Chemical constituents of fish

2.3 Need for processing fish

2.4 Value added products from fish

2.5 Effect of packing and storage on the quality of fish products

2.1 HEALTH BENEFITS OF FISH

Fish is reported as a valuable source and important food item for mankind in view of its high protein content, vitamins and polyunsaturated fatty acids Gopakumar (2002). Devadasan (2003) reported that, early Indian medical treatises mentioned about non-vegetarian dietary practices. Charaka, Susrutha and Vagbhata provided an impressive list of a variety of fish used for medical treatments. Easily digestable protein and calcium, iron, omega 3 fatty acids and vitamin A, especially retinol are provided by fish and hence it is considered essential for the prevention of blindness and for the proper development of children (Tripathi, 2007).

Eskimos living in Greenland, who consume large amounts of fish had a very low incidence of heart attack, asthma, diabetes, psoriasis and allergies (Bang *et al*., 1980). Fish oils are rich source of docosahexanoic acid (DHA) and it can also be biosynthesized in the body from linolenic acid (Joseph and Norman, 1995). Agostonic and Carlo (1995) reported the essentiality of long chain polyunsaturated fatty acids (PUFA) especially DHA for better brain development in children. The importance of eicosapentanoic acid (EPA) and docosahexanoic acid (DHA) in overall health was reported by Alfonso (1996). DHA was reported to be the building blocks of human brain tissue. The abundance of DHA in the grey matter of the brain and retina was also observed by Levine and Barbars (1997). A low level of DHA was found to cause depression, memory loss, dementia and visual problems. The most common PUFA like linolenic acid, linoleic acid, EPA and DHA were reported to be present in fish oils. Due to the inability of humans to synthesise PUFA of the n-6 and n-3 configurations, it should be obtained from the diet (Eritsland, 2000). The deficiency of DHA, during gestation resulted in visual impairment and lower intelligence quotients (Connor and William 2000).

According to Siscovick and David (1995), the risk of cardiac arrest was lowered by an increased intake of seafood rich in EPA and DHA. The coronary heart disease could be reduced by the consumption of fish oil (Simon and Joel, 1995). As reported by Albert and Christine (1999), consumption of fish prevented sudden cardiac death in men thereby reducing the total mortality. The concentration of n-3 PUFA in cell membranes increased due to high rate of fish consumption and this increase could be associated with a significant beneficial increase in heart rate variability (HRV) (Christensen and Hagstrap, 1999). Conjugated linolenic acid (CLA) was reported to have the capacity of reducing or eliminating cancer, preventing heart disease, improving immune function and altering body composition to treat obesity or build lean body mass (Richard *et al.,* 2000). Regular fish consumption was observed to be the most effective and least costly way for the prevention of heart disease (Shahib and Asha, 2005).

Fish oils were found to be effective in the prevention of cancer (Nair, 1993). Fish oil enriched with nutritional supplements was found to be safe and effective in preventing weight loss in cancer patients. This might be one of the reasons in the survival time in patients suffering from pancreatic cancer (Barber, 1999). According to Wetherilt (2002) the polyunsaturated fatty acids can lower the carcinogenic load of high fat diets and inhibited malignant tumor of the prostate, breast, colon, rectum and lungs. Fraser (2006) reported that frequent consumption of fatty fish appears to reduce the risk of prostate cancer. Omega-3 fatty acids not only reduced the risk of prostate cancer, but also dramatically lowered the risk of breast cancer, heart disease, depression and mental disorders, along with other common health problems.

Hibbeln and Joseph (1998) observed that low fish consumption led to a high incidence of depression in people. Fish consumption was found to prevent mental disorders and it was used in the treatment of bipolar disorders (Calabrese and Joseph, 1999). Omega-3 intake in infancy was reported to reduce the risk of anxiety, aggression and depression in adulthood (Maccnamara and Carison, 2006). Dairma (2006) found that fish and omega-3 fatty acid consumption was effective in preventing or slowing the progression of Alzheimer's disease. Fish fat can prevent or alleviate depression and bipolar disorders (Weather, 2007). Connor and Connor (2007) reported that fatty acids like DHA and EPA in fish and fish oil might delay Alzheimer's disease.

Fish consumption alleviated the symptoms of rheumatoid arthritis (Joel, 1989). Cleland and Leslie (1992) suggested that fish oil supplements containing EPA had anti-inflammatory effect, which is beneficial for people suffering from rheumatoid arthritis and psoriasis. Sanders and Allison (1992) found that fish oil supplementation increased the need for antioxidant supplementation.

Toft and Ingrid (1995) found that fish or fish oil was useful in the prevention of vascular disease in diabetes. High fish intake could delay the development of diabetes in glucose intolerant individuals. Long-term supplementation of fish oil improved insulin sensitivity in patients with non-insulin dependent diabetes (William, 1995). Fish oil supplementation lowered the levels of very low-density lipoprotein and triglycerides (Sheehan and John, 1997).

According to Lawrence and Sorrell (1993) many of the symptoms of cystic fibrosis could be alleviated with the daily supplementation of fish oil capsules. The intake of fish was reported to prevent Crohn's disease (Billuzzi and Andrea 1996; Shahib and Asha, 2005).

Daily fish consumption was highly effective in reducing blood pressure, lowering triglyceride levels which promoted the good cholesterol levels and improved glucose tolerance (Mori and Trevor, 1999). Hankenson and Jourt (2000) observed that intake of fish improved the healing of ligament injuries by enhancing the entry of new cell 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 muscular degeneration than people who ate fish three times per month or less (Eunyoung, 2001).

High dietary intake of fish oils (n-3 fatty acids) was reported to protect smokers against chronic obstructive pulmonary diseases (Shahar and Egul, 1994). A study conducted by Hodge and Lenda (1996) revealed that regular consumption of oily fish reduced risk of developing asthma in childhood. Linda (1996) observed that long-term fish consumption might reduce the severity of asthma. Broughton (1997) suggested that dietary supplementation with fish oil or other enriched sources of n-3 PUFA could be used as a therapy for asthma. The consumption of fish during pregnancy was found to protect children from asthma and allergies Ruth (2007).

A study conducted by Ralph (1989) revealed that EPA in fish was found to reduce the symptoms of Raynaud's disease. Daily consumption of fish, lowered blood pressure in people suffering from hypertension. The benefit of fish oil was comparable to that obtained by sodium restriction and weight loss (Lawrence and Sorrell, 1993). Harris and William (1998) suggested that long term but not acute fish oil consumption improved fat tolerance. Clemans (1999) observed that fish oil supplementation was found to be beneficial for atherosclerotic patients. A study conducted by Eritsland (2000) revealed that fish intake could reduce the tendency of blood to aggregate. Davidow (2006) observed the ability of omega-3 fatty acids in reducing the risk of dementia, arthritis, asthma, and kidney disease.

Eating fish twice or thrice a week could be encouraged as a part of healthy balanced diet, during pregnancy and for all the family members and it should be consumed in steamed or boiled form rather than fried form (Ismail, 2002). Consumption of 100-200 g of fish two or three times a week helped to prevent heart disease (NIN, 2002).

2.2 CHEMICAL CONSTITUENTS OF FISH

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 varied between 63 to 89 per cent. Poulter and Nicolaides (1995) found 60-85 per cent moisture in fish. According to Nair and Susheela (2000) moisture content in majority of Indian fishes varied between 65 to 85 per cent. Mukundan (2000) reported that water content of fish varied between 28 per cent and 90 per cent. Average moisture content of fish varied between 65-80 per cent (Gopakumar, 2002). In an experiment conducted by Ozden and Erkan (2007) the moisture content of fish was found to range from 69.68 to 76.42 per cent.

Experiments conducted by Govindan (1974), found that the moisture content of prawn was 80.76 per cent. Giri *et al*. (1983) found that the moisture content of tilapia was 81.76 per cent. The moisture content of shellfish and finfish varied from 79.80 to 82.20 per cent (Anthony *et al*., 1983). Quasim (1983) found the moisture content of katla to be 78.4 per cent. Keshava and Sen (1983) observed that the moisture content of flat fish flesh was 78.3 per cent. Mustafa and Mediros (1985) reported a moisture content of 76.7 per cent in catfish. Reddy *et al*. (1990) observed that moisture content in pink perch was 82.34 per cent. Basavakumar *et al*. (1998) revealed that the moisture content of prawn was 77.6 per cent. A study conducted by Sarma *et al*. (1998), observed that the moisture content was 80 per cent in pink perch and 75 per cent in oil sardine. According to Nair and Suseela (2000) the moisture content in katla was 76.30 per cent, 74.70 per cent in silver belly and 77.30 per cent in tilapia. A study conducted by Jayakumari *et al*. (2006) showed that the moisture content of pink perch was 81.47 per cent.

Swaminathan (1987) reported that fat content of the fish varied widely which ranged from 0.2-20 per cent. Catsberg and Dommelen (1990) found that fat content in fish varied from 1.2 to 20 per cent. Fresh water fish was reported to contain n-3 polyunsaturated fatty acids. According to Manay and Shadaksharaswamy (1998) fat content of fish varied from 0.1 to about 25 per cent depending on the factors like the season, sex and stage of maturity. According to Ramadas and Easwaran (2000) fish contain unsaturated fatty acids namely omega-3 fatty acids. Fat content varied between species and within species (Nair, 2002). An experiment conducted by Lim and Low (2003) also showed that fat content of fish varied with species, ranging from 1 to 15 per cent, but average at 4 per cent. Begum (2005) reported that the fat content of fish varied from 1-25 per cent or more. The level of fatty acids varied widely from 0.07 to 0.28-g/100 g (Srilakshmi, 2007). In another experiment conducted by Ozden and Erkan (2007) the fat content of fish varied from 2.29-8.10 per cent.

Gopakumar (1975) found that lipid content of tilapia wet muscle was 3.7 per cent. A study conducted by Giri *et al*. (1983) revealed that the fat content of tilapia was 2.01 per cent. Anthony *et al*. (1983) observed that the fat content of fish was 3.41 per cent and in shellfish it was 2.36 per cent. Keshava and Sen (1983) reported the fat content of flat fish flesh to be 1.3 per cent. Quasim (1983) reported that fat content in katla was 0.75 per cent. Jhaveri *et al.* (1984) found that the fat content to be 0.42, 1.67, 3.97, 1.67 and 0.53 per cent for cod, whiting, scup, squid and monkfish respectively. The study conducted by Mustafa and Mediros (1985) revealed that fat content was 3.5 per cent in catfish. Gopalan *et al*. (1989) observed 2.4 per cent fat in katla fish, whereas Reddy *et al*. (1990) reported a fat content of 3.73 per cent in pink perch. Gopalan *et al*. (1989) recorded 9.6 per cent, 4.7 per cent and 1.4 per cent fat content in anchovy, sole and white bait respectively. As per Poulter and Nicolaides (1995) fat content of white bait was 2.65 per cent.

Basavakumar *et al*. (1998) reported that the fat content in prawn was 0.96 per cent. A study conducted by Sarma *et al*. (1998) revealed that the fat content in pink perch and oil sardine was 2.14 per cent and 3.99 per cent respectively. Rahman *et al.* (2000) observed that the lipid content of tilapia was 1.26 per cent. Dobrzanski *et al.* (2000) revealed that in modified fishmeal the crude fat was 24.5 per cent. Fat content of Indian fishes ranged from 1-20 per cent and 1.30 per cent fat was observed in katla and 0.58 per cent in tilapia (Nair and Suseela, 2000). According to Mukundan (2000) and Tarr (2002) the lipid content of fish varied from 0.2 per cent to 30 per cent. Gopakumar (2002) reported that fat content of fish ranged from 0.5-16 per cent. Jayakumari (2006) found that fat content in pink perch was 3.3 per cent.

According to Swaminathan (1987) protein content of fish normally varied between 9-20 per cent. Catsberg and Dummelen (1990) found that the protein content of marine fish was 15 to 20 per cent. According to Manay and Shadaksharaswamy (1998) protein content of fish on an average was about 20 per cent. Gopakumar (2002) observed a protein content of fish ranging from 12-22 per cent. Venugopal (2003) found that the protein content of most fishes ranged from 18 per cent to 22 per cent. Begum (2005) observed that protein content of fish ranged from 15-20 per cent by weight of flesh. According to Srilakshmi (2007) the protein content of all kinds of fish was found to range from 10 to 20 per cent.

According to Giri *et al*. (1983) the protein content of tilapia was 21.80 per cent. In an experiment conducted by Quasim (1983), protein content of katla was found to be 14.06 per cent. Anthony *et al*. (1983) observed that the protein content of fin fish to be 19.70 per cent and in shellfish it was 16.42 per cent. Keshava and Sen (1983) reported that protein content of flat fish flesh was 18.6 per cent. Jhaveri *et al*. (1984) found a protein content of 18.42, 17.51, 15.85 and 16.33 per cent for cod, whiting sap, squid and monkfish respectively. The protein content of small fish like white bait on an average varies from 15 to 20 per cent depending on the water content of fish (Bykov, 1985). Mustafa and Medeiros (1985) found that the protein content of catfish to be 16.9 per cent. In an experiment conducted by Basevakumar *et al*. (1998) it was reported that the protein content of prawn was 19.9 per cent. Sarma *et al*. (1998) observed 17.08 per cent protein in pink perch and 19.29 per cent in oil sardine.

Gopalan *et al*. (1989) reported a protein content of 19.3, 19.5 and 14.5 per cent for anchovy, katla and white bait respectively. In an experiment conducted by Reddy *et al*. (1990) the protein content of pink perch was found to be 16.18 per cent. Nair and Suseela (2000) reported a protein content of 19.60 per cent in katla, 18.70 per cent in silver belly and 20.47 per cent in tilapia. Mukundan (2000) reported that the protein content of fish on an average was about 19 per cent with a variation of 15 to 22 per cent. Dobrzanski *et al*. (2000) revealed that modified fishmeal contained 25 per cent total protein. Nair (2002) observed that quantitatively, protein was the second major component in muscle tissue of fish and was generally present in the range of 16 to 18 per cent. Ali *et al*. (2005) revealed that protein content of fillet species varied from 13.8 to 15.9 per cent. Jayakumari *et al*. (2006) found that the protein content of pink perch to be 16.22 per cent. Ozden and Erkan (2007) observed that the protein content of fish was 8.21 to 21.70 per cent.

Fish was reported to be a good source of minerals. The calcium, phosphorus and iron content of solefish reported by Govindan (1970) were 100 mg, 520 mg and 10.1 mg respectively per 100 g of sample. According to Giri (1983) the calcium, phosphorus and iron content of tilapia were 145.60, 479.05 and 3.14 mg respectively per 100 gm of sample. Mustafa and Mederus (1985) reported that catfish had a phosphorus content of 220 mg and iron content 1.8 mg per 100 g of sample. Gopalan *et al*. (1989) reported that calcium, phosphorus and iron content of katla were 530 mg, 235 mg and 0.9 mg respectively per 100 g of sample. As per Gopalan *et al*. (1989) anchovy, sole and white bait had a calcium content of 143 mg, 1072 mg and 643 mg respectively per 100 g of sample. A study conducted by Gopakumar (1997) found that calcium, iron and phosphorus content of katla was 495.2, 1.0 and 245 mg respectively and in tilapia it was 585.2, 1.5 and 235 mg respectively per 100g. Manay and Shadaksharaswamy (1998) found that fish was a good source of copper, sulphur and phosphorus. The iodine content of marine fish varied from 0.01 to 0.5-mg/100 g of fish meat. Naik and Reddy (1999) reported that the most abundant minerals in fishes were calcium and phosphorus. The concentration of minerals in fish and fish products was influenced by a number of factors such as seasonal and biological differences. Mukundan (2000) found that mineral content of fish varied from 0.4 to 2 per cent. Balachandran (2001) observed that calcium and iron content in fish ranged from 19 to 88 mg and 1.0 to 5.60 mg per 100 g of sample. Nair (2002) found that calcium content would be low in edible portions compared to whole fish where bone was also included. Gopakumar (2002) found that the mineral content of fish was 0.1-3 per cent. Salt-water fish was reported to be rich in iodine, phosphorous and calcium. Begum (2005) revealed that the mineral content of fish varied from 1 to 1.5 per cent. Experiments conducted by Ozden and Erkan (2007), revealed that the highest potassium, magnesium, phosphorus, iodine and selenium content were in turkey fish.

The fishes were reported to contain both water soluble and fat-soluble vitamins. Maage *et al*. (1991) reported that vitamin A content of fish fillets varied from 50 IU100 g^{-1} and 400 IU100 g^{-1}. Vitamin A in fish varied between 200 IU 100 g^{1} and 800 IU 100 g^{-1} and it was more in fatty fish (Tarr, 2002). According to Nair (2002) fish flesh in general was richer than animal meat in the concentration of fat-soluble vitamins (A, D and E). Cod liver oil was reported to be an excellent source of vitamin A and D. As reported by Venugopal

(2004) fatty fish species such as sardine contained up to 4500 IU and 5400 IU of vitamin A and vitamin D respectively per 100 g meat weight. According to Shukla and Singh (2004) fish is rich in vitamins particularly vitamin A and vitamin D. Shahib and Asha (2005) reported that tuna fats are also an excellent source of vitamin A and D. The vitamin A content in small fish was 2680 IU retinol equivalents (RE)/100 g (Roos *et al*., 2007).

Reddy *et al.* (1990) reported that peroxide value of pink perch was found to be 1.33 milli equivalent / kg fat. Peroxide value of fresh mackerel was found to be 0.91 millimoles of O_2 kg^{-1} fat (George and Saralaya, 1993). In Silver pomfret muscle stored at 10°C the maximum peroxide value observed was 80 meq/kg lipid (Nair, 1993). Sarma *et al*. (1998) reported that peroxide value of pink perch and oil sardine to be 6.16 meq kg^{-1} and 6.55 meq kg^{-1} respectively. Mukundan (2000) found that peroxide value was a good guide to evaluate the quality of fat. Ismail (2002) observed a peroxide value of 4.0 meq kg^{-1} for white herring and Spanish mackerel. Peroxide value of fresh pink perch was found to be 1.14-milli equivalent/kg of fat (Jayakumari *et al.* 2006). Peroxide value of silver Jew fish was found to be 1.27 to 2.81-meq kg^{-1} fat (Raza *et al*., 2006).

2.3 NEED FOR PROCESSING FISH

The marine fisheries sector in India had registered a phenomenal growth during the last five decades both quantitatively and qualitatively (Srinath and Pillai, 2000). The per capita consumption of fish in the country was about 9 Kg per year for the fish eating population against the world average of 12 Kg (Juneja and Nair, 2000). Global production of aqua cultured fishery product increased annually at an average rate of about 11 per cent (Venugopal, 2003). According to Devadasan (2003) 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.

A survey of human consumption pattern showed that out of the total production, 65 per cent was consumed as fresh, 7 per cent as frozen, 20 per cent as cured and 0.2 per cent as canned. In the total export in frozen form, 34 per cent is shrimps, 22 per cent cephalopods and 36 per cent were other fishes (Mishra, 2003).

Fish is considered to be the most important health food today. The well-synthesized combination of protein, calcium, vitamin A, essential fatty acids, amino acids and other vital elements made it a very nutritious health food. Due to the highly perishable nature of fish, various processes were developed for extension of shelf life of the products (Kakat *et al.,* 2004).

Current fish utilization trends in India indicated the marketing of major quantity of fishes in fresh form and it was about 65 per cent of the total fish production. In the processing sector, 20 per cent of catch was processed by the method like sun drying and were largely utilized for domestic consumption (FAO 1998). India is a major exporter of fishery products, worth above one billion per year. The share of seafood export in India was about 16 per cent of the total exports of agriculture products (Rao and Prakash, 1999). The per capita availability of fish and fishery products was nearly doubled in the last 40 years. The world average per capita fish consumption was expected to rise between 19 and 21 Kg by the year 2030 (Ye, 1999).

FAO (1998) reported a loss of 10 to 20 million tones of fish due to spoilage and it accounted 10 per cent of the total production from capture and aquaculture. According to Devadasan (2003), for India even though the accurate loss estimates were lacking, it was believed to be close to 10 to 15 per cent.

There is an urgent need to develop preservation and processing facilities as about ¼th of the sea food products in India is being wasted. During the glut season, the fish and other marine products have to be processed and stored.

According to Shukla and Singh (2004).Chilling in ice was commonly employed for short term preservation and processing methods such as freezing, salting, drying, smoking, canning and fermentation are required to be adopted on large scale

The proper utilization of trash fish and processing of fishes were reported to be done to meet the increasing demand for fish (Sahu *et al.,* 1996). Processed foods that are more convenient to handle, store and prepare were preferred by modern consumer. The consumers also insist food items produced by more ethical methods, including environmentally friendly process and economically acceptable behavior (Dey, 2000).

2.4 VALUE ADDED PRODUCTS FROM FISH

In general value addition means “any additional activity that in one way or another changes the nature of a product, adding to its value at the time of sale (Joseph, 1987). According to Nair (2006) value addition is the most valued about phrase in the food-processing sector. Value addition is defined as the addition of value through processing and addition of ingredients so as to render the product more attractive to the buyer. Value addition makes the fish more convenient and ready to use with enhanced appeal and attraction.

A large number of value added products both for export and internal markets based on different varieties of fish and low priced fish were identified Abraham (1991). The rapid change of conventional fish into a new style and form was observed in the world fish processing sector (Davies, 1995). According to Nair (2002) the production of value added products would lead to complete utilization of catch and less important fish, which would help in filling the gap of supply and demand of fish in addition to employment and revenue generation. Venugopal (2003) observed that several techniques, which are available for value addition of marine fish and shellfish, could be applied with suitable modification for development of products from aqua cultured fish and shellfish.

Drying and salt curing were the low cost processing techniques (Moorjani, 1998). The effectiveness of drying as a means of increasing the shelf life of fish was due to reduction in the growth of microorganism with the reduction in the availability of water (Peter, 2002). According to Tarr (2002) consumer preferences regarding the quality of dried sea food were much diversified. Value added dried fish in the form of ready to eat products had been developed (Sachindra *et al*., 2003). Dehydration involved drying with or without other preservatives to form dried salted and smoked fish (Bhatt and Tomar, 2006). According to Srilakshmi (2007) the most important method of fish preservation was salting and drying.

One of the earliest methods of value addition of fish was pickling (Abraham, 1998). Pickling was regarded as a natural preservation process (Gopalakrishnan, 1998). Gopakumar (2002) reported that fish pickles were found to be very popular in India, availing varieties of methods from traditional process to industrial methods.

Fermented fish products were reported to contribute to the protein intake of people especially those in the rural areas where fresh fish were not readily available (Essuman, 1992). Moorjani (1998) reported, fish sausage, a semi-processed food as a delicious product. Sarojnalini and Vishwanathan (1994) reported that curing by fermentation was found to be an important method of preservation as poor quality fish or unpopular species of fish were usually processed in this way. Cho *et al*. (2000) indicated the popularity of fermented fish products in South East Asian countries. The fermented fish sauce was found easy to handle, transport and store and it could easily be incorporated with the cereal-based diet (Mansur *et al*., 2000). Making fish sauce was observed to be one of the best ways of using low values by catches (Gopakumar, 2002).

The Japanese term surimi was given for mechanically deboned fish mince for white-fleshed fish that had been washed, refined and minced with cryo protectants for good frozen shelf life (Rathnakumar and Shamasundar, 1998). Surimi is a wet, frozen concentrate of the myofibrilar proteins of fish muscle (Medina and Garrole, 2001). Peinoto *et al.* (2002) reported that surimi could be used in processed foods for human consumption and indicated as an alternative use for the low value fish. Because of its gel strength surimi is used as an intermediate in the processing of several products with simulated, texture, flavour and appearance like shrimp (Venugopal, 2004). According to Nair (2006) surimi is minced appropriately with salt, sugar, MSG, starch, oil, poly phosphates and other flavorings.

The preparation of strained baby foods based on fish offered an excellent way of introducing fish in the diet of babies (Swaminathan, 1987).

Freeze dried ready to serve foods were prepared from fish products like fish salad, fish soup minces and prawn cake (Govindan 1970). Manay and Shadaksharaswamy (1998) reported the preparation of a number of fish products. These included fish meal used as animal feed, fish flour used for protein enrichment of human food, used in infant foods, fish glew, for industrial purpose and fish collagen used for the clarification of wine, beer, vinegar etc. Several different binding materials had been used for fish products, like in fish sticks, fish fingers and breaded fillets (Giannini *et al*. 2003). He reported that in all the cases binding agent was starch and in most cases a modified starch.

According to Lambert (1990), value added seafood included battered and breaded sea food, smoked seafood, dried fish and pre cooked seafood. Battered and breaded sea food included fish stick, fish fingers, fish nuggets, fish burgers, shrimp scallops and specialty products such as fish chips, steaks, stuffed fillets and crab sticks. The most important class of value added fish products were the battered and breaded products, which were 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 finger, fish cutlet, fish patties, squid rings etc. were reported to be some of the battered and breaded products (Gopakumar, 1997). Devadasan (2003) reported that the most prominent among the group of value added products was the battered and breaded products processed out of a variety of fish and shellfish. Battered and breaded seafood as a convenient food, are valued widely by the consumer. Value added fish products for the domestic market included battered and breaded products like fish fingers and cakes, fish mince and mince based products like sausages, cutlet, patties, balls, pastes, surimi and surimi based products and ready to serve fish curries suiting to the taste of different regions (Devadasan, 2003).

Komarik *et al.* (1974) and Raju *et al.* (1997) reported that preparation of cutlets and sticks from fish meat and crab meat was highly acceptable. Pavunny *et al.* (2007) utilized under sized prawn by preparing value added products such as pickle, cutlet, and stick, and these products were found to be highly acceptable.

Joseph *et al*. (1984) reported that cutlets prepared from the minced lizardfish showed highest acceptability. According to Raju *et al.* (1999) the cutlet prepared from minced pink perch showed good biochemical, microbiological, and organoleptic qualities. Sehgal and Sehgal (2002) prepared three value added fish products namely fish patty, fish finger and fish salad from carp flesh and were compared with a reference product (fish pakoara). Sensory evaluation of these products gave highly encouraging results. Cakli *et al.* (2005) observed that microbiological and chemical constituents of fish fingers prepared from fish species such as sardine, whiting, and pink perch, were found to be within acceptable limits.

Venugopal and Shahidi (1995) indicated that product development using mince from low cost fishing resources, which included surimi and surimi-based products, sausages, fermented products, protein concentrates and hydrolysates and extracted products were found to have good biotechnological possibilities. Crab processing generates by products that could be used in new value added products to decrease processing waste and to increase profits (Obatolu *et al*., 2001).

Excellent canned products from minced fish contributed to human nutrition (Govindan, 1991). In the developing countries, fish curing had 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). According to Gildberg (2000) Arctic Capelin and Atlantic cod intestines could be utilized as raw materials for the production of high value fish sauce for human consumption. Aldos *et al*. (2002) reported that converting herring by products into fish oil is an opportunity of adding value to by products.

Consumer preference for value added seafood products revealed that, grilled seafood was more popular, particularly, preseason ready to grill items, while boil- in bag products were preferred less. Fried products attracted poor support (NFI, 2002). Aqua cultured fishery products, if processed suitably stand a chance to capture markets throughout the world. Currently the demands for those products are mostly with localized segments of the society. It is therefore important that sufficient technological tools are used in processing these items in order to make them appealing universally and to diverse consumer segments (Venugopal, 2003).

Appearance, packaging and display were all important factors leading to successful marketing of any new value added product (Joseph, 1987). The traditional seafood trade was observed to be different from marketing of value added products. Value addition was reported to involve the use of machineries, attractive packaging materials, use of prime quality raw materials as sub material and a complete knowledge of consumer preference (Sudhakara, 2002). It was considered to be dynamic, sensitive, complex and very expensive.

2.5 EFFECT OF PACKAGING AND STORAGE ON THE QUALITY OF FISH PRODUCTS

The better packaging ensured improved quality and presentation of the product, higher returns to the producer and better shelf life (Gopalakrishnan, 1998).

Improved methods of packaging have helped not only in keeping food safe with longer shelf life but also in enhancing its consumer acceptance (Gopal *et al.* 1998). According to Arvanitoyannis and Gorris (1999) packaging was an important element in many preservation concepts. The packaging materials provided physical protection and created the physicochemical conditions around a food product that were essential for obtaining a satisfactory shelf life. Packaging brought out a revolution in the marketing and distribution of commodities in the world. According to Ayyappan and Devadasan (2004) packaging technologies minimized flavor loss and ensured great shelf life and was energy saving. They were economical and eco-friendly also, as fabricated food became more popular. Use of edible films and coating became common edible packaging films.

With spending, shifts from staple foods to value added processed foods, the demand of consumer packs for processed foods will gather momentum as is being witnessed now (Narasimhan, 2003). Venugopal (2003) reported that the processed products were packed in consumer friendly packages for retail marketing. Packaging was found to be a major factor in storage and transport of frozen fish. Bhatt and Tomar (2006) reported that desiccation in frozen fish can be prevented by proper packaging.

According to Joseph (1987) thermoformed packaging containers were most commonly used for coated fish products. The thermoformed trays produced from food grade materials were suitable for the packaging of value added fishery products both for internal and export markets. Trays made of materials like PVC, HIPE and HDPE were unaffected by low temperature of frozen storage and provide protection to the contents against desiccation, oxidation etc., during prolonged storage (Srinivasagopal, 1998). HDPE trays as a container having 175 guage, was used for some selected frozen fish products; it was formed from granules which were imported and indigenously made (Moorjani, 1998).

According to Joseph *et al.,* (1984) fish cutlets were kept in duplex cartons lined inside with polyethylene sheet, which can be stored at ambient temperature for long period. The frozen blocks were packed in mater cartons usually made of corrugated waxed paper boards. The frozen materials were stored in cold stores at -18°C (Shukla and Singh, 2004). Bindhu *et al*. (2005) reported that a ready to eat black clam product was packed in retortable pouch and it rated excellent taste and good shelf life. Eboh *et al.* (2006) reported that smoke dried fish cakes packed in low density polyethylene bags had better storage life.

In a study conducted by Paroda (1996), fish curry was packed in retortable pouches and they remained sterile throughout the storage period. Gopal *et al*. (1998) showed that flexible packaging materials could be safely used as packaging for frozen fish curry.

Most important class of value added marine products are battered and breaded products. The thermoformed trays produced from food grade materials like PVC and HIPE were suitable for packaging these products without affecting their shelf life (Gopal, 1996). Aluminium can was found quite well for heat processing fish and fish based products especially canned fish (Balachandran *et al*., 1998). Mallik *et al*. (2003) reported that tin free steel cans were also used for processing and packing ready to serve fish products, which could be stored at ambient temperature for long periods.

The peroxide value of the fish ball decreased considerably during initial period of storage upto two months and then increased gradually during the latter half of the storage period (Nair *et al*., 1982). Joseph *et al.* (1984) reported that peroxide value of deep fried cutlet stored for 22 days at -20°C was found to be 4.50-milli eq/kg and raw cutlet was found to contain 6.22-milli eq/kg. Reddy *et al*. (1990) observed a peroxide value of 12.29 millimoles kg^{-1} fat in fresh fish minces. (Khontia *et al*. (1993) reported a peroxide value of 4.16 millimoles of O_2 kg^{-1} lipid in dry salted mackerel. The peroxide value of fish burger produced from tilapia was 0.18 meq/kg at the beginning of the storage but increased to 5.03 meq/kg at 6 months of storage and then decreased to 0.82 meq/kg at the 8^{th} month (Tokur *et al*., 2004). Singh and Balange (2005) reported that in pink perch, surimi during 36 weeks of frozen storage at -20°C, peroxide value was found to be 0.8 meq/kg.

Joseph *et al*. (1984) reported that raw fish cutlet had a storage life of 6 days, 11 weeks and 19 weeks at 4°C, -8°C and -20°C respectively and deep fried cutlets had a shelf life of 22 weeks at -20°C. Studies by Joseph *et al*. (1993) showed that ready to serve dried and fried prawns stored at ambient temperature of 22-28°C had a storage life for 42 days. Ready to fry fish cutlet from pink perch was acceptable even after a storage period of 27 weeks at -20°C (Raju *et al*., 1999). According to Dutta *et al*. (2004) fish balls prepared from minced rohu meat stored under refrigerated condition at a temperature of 10 ± 2°C for 7 days were found to be acceptable.

Sensory evaluation is a scientific discipline that applies principles of experimental design and statistical analysis to use human senses such as sight, smell, taste, touch and hearing for evaluation on consumer products (Meilguard *et al*., 1991). Sensory evaluation plays a vital role in food product development because as a scientific discipline, it represents a unique technique that harnesses human behavioral instincts of perception, learning, cognition, psychophysics and psychometrics for the evaluation of quality of foods (Khatkar, 1997). According to Joseph (2002) sensory analysis of seafood is becoming popular in marketing research, product development, quality assurance and research and development.

Reddy *et al.* (1990) reported that sensory attributes of the cooked mince of pink perch during frozen storage deteriorated after 90 days. In commercially prepared fish cutlets, maximum shelf life extension observed was 14 days for samples treated with 5 kGY of irradiation and stored at ambient temperature (Bari *et al*., 2000). Tokur *et al*. (2004) reported that fish burger produced from tilapia could be stored in frozen condition at -18°C over a period of 8 months. Pink perch surimi was acceptable at the end of the 36-week storage period at frozen condition of -20°C (Singh and Balange, 2005). Sensory analysis of fish finger prepared from sardine during frozen storage for 8 months at -18°C, indicated that at the end of the frozen storage it could not be consumed because of rancidity (Cakli *et al*., 2005).

Seafood was reported to be a vehicle for many pathogens (Senthilatiban *et al.,* 1999). Spoilage of fish is a complex process and takes place due to a combination of several processes. Microbial contamination and consequent spoilage is a serious problem faced by the seafood processing industry (Ayyappan and Devadasan 2004).

Joseph *et al.* (1984) reported that, fish cutlet prepared from the minced lizard fish showed a total plate count which varied from $1.33x10^5 cfug^{-1}$ to $9.66x10^5 cfug^{-1}$ during the 11 weeks of storage. Iyer *et al.* (1986) found that, bacterial count in fish curry increased from $1.9x10^3$ to $8.5x10^6$ colonies g^{-1} during 30 days 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. Raju *et al.,* 1999 observed that cutlet from pink perch had low bacterial count, the product was within the acceptable range during the storage period of 27 weeks. 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 6^{th} month of storage. According to Cakli *et al.* (2005) total plate count of fish fingers from pink perch were found to be within acceptable limits during frozen storage for 8 months. Singh and Balange (2005) reported that the microbial count in pink perch surimi increased from 5.25×10^3 to $9.58 \times 10^3 cfg^{-1}$ during 36 weeks of storage at frozen storage.

Materials and Methods

3. MATERIALS AND METHODS

The present study entitled "Quality evaluation of value added products with marine and fresh water fish" was attempted to evaluate the nutritive value of four under utilized fish varieties, to prepare the products viz., cutlet and stick, from two fresh water and two marine fishes and to evaluate the quality of the products. The materials and methods used for the study are given under the following headings.

3.1 Selection of fish varieties
3.2 Extraction of fish muscle
3.2.1 Analysis of chemical constituents of fresh fish muscle
3.3 Preparation and storage of fish products
3.4 Quality evaluation of the products
3.4.1 Peroxide value
3.4.2 Organoleptic evaluation of fish products
3.4.3 Microbial enumeration of fish products
3.5 Computation of nutritive value of the products per packet
3.6 Statistical analysis

3.1 SELECTION OF FISH VARIETIES

Two marine and two fresh water fish varieties, which are popular and comparatively cheap, were selected for the study. They were pink perch (*Nemipterus raponicus*) and silver belly (*Gerres filamentoses*) belonging to marine species and tilapia (*Tilapia mossambica*) and katla (*Catla catla*) of fresh water species. All the selected varieties were bought from Thrissur local market.

3.2 EXTRACTION OF FISH MUSCLE

Fish muscle was extracted as detailed by Moorjani (1998).

Plate 1 Products prepared from tilapia fish

Cutlets before frying

Cutlets after frying

Sticks before frying

Sticks after frying

Plate 2 Products prepared from katla fish

Katla

Cutlets before frying

Cutlets after frying

Sticks before frying

Sticks after frying

Plate 3 Products prepared from pink perch fish

Pink perch

Cutlets before frying

Cutlets after frying

Sticks before frying

Sticks after frying

Plate 4 Products prepared from silver belly fish

Silver belly

Cutlets before frying

Cutlets after frying

Sticks before frying

Sticks after frying

Whole fish (weighed quantity) was washed with water and drained well. The edible portion was separated from skin and bones with a sharp knife. The extracted fish muscle was washed in 1 per cent sodium chloride solution and drained.

3.2.1 Analysis of chemical constituents of fresh fish muscle

The fresh fish muscle was analyzed for the following chemical constituents

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

3.2.1.1 Moisture

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

To determine the moisture content, 10g of fish muscle was taken in a Petri dish and dried at 60^0C to 70 ^0C, in hot air oven. It was cooled in a desiccator and weighed. The process of heating and cooling was repeated until a constant weight was achieved. The moisture content was calculated from the loss in weight during drying and expressed in percentage

3.2.1.2 Fat

The fat content of fish muscle was estimated by the method of AOAC (1955).

Five gram of fish muscle was taken in a thimble and plugged with cotton. The material was extracted with petroleum ether for 6 hours without interruption by gentle heating in a soxhlet apparatus. Extraction flask was then cooled and repeated heating was done to remove ether and weight was taken. The fat content was expressed in g $100g^{-1}$ of the sample.

3.2.1.3 Protein

The protein content was estimated by the method of AOAC (1980).

Fish muscle (0.3g) was digested with 6ml con: H_2SO_4 after adding 0.4g of $CUSO_4$ and 3.5g K_2SO_4 in a digestion flask until the colour of the sample was converted to green. After digestion, it was diluted with water and 25ml of 40 percent NaOH was pumped. This distillate was collected in 20 per cent boric acid containg mixed indicator and then titrated with 0.2N HCl. The nitrogen content obtained was multiplied with a factor of 6.25 to get the protein content and expressed in percentage.

3.2.1.4 Calcium

Calcium content was estimated by titration method with EDTA as suggested by Page (1982).

Two gram of dried and powdered sample was predigested with 20ml of 9:4 mixture of nitric acid and perchloric acid and the volume was made up to 100ml with water. To 5ml of the diacid extract, 10ml water, 10 drops of hydroxylamine hydrochloride, 10 ml tri ethanolamine, 2.5ml sodium hydroxide and 10 drops of calcone were added. Then, it was titrated with 0.02N EDTA till the appearance of permanent blue color. Calcium content was expressed in mg $100g^{-1}$ of the sample.

3.2.1.5 Phosphorus

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

Five milli liters of diacid extract made up to 100ml was taken in a 50 ml volumetric flask and 5 ml 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. From the standard graph, the phosphorus content of the sample was estimated and expressed as mg $100g^{-1}$ of the sample.

3.2.1.6 Iron

Iron was analyzed colorimetrically using ferric iron, which gives a blood red colour with potassium thiocyanate (Raghuramulu *et al.,* 2003)

To an aliquot of 6.5ml diacid solution, 1 ml of 30 per cent sulphuric acid, 1 ml of 7 per cent potassium persulphate solution and 1.5 ml of 40 per cent potassium thiocynate solution were added. The intensity of the red colour developed was measured within twenty minutes at 540 nm. A standard graph was prepared using serial dilution of standard iron solution. The iron content of the sample was estimated from the standard graph and expressed in mg $100g^{-1}$.

3.2.1.7 Vitamin A

Vitamin A was estimated by the method suggested by Srivastava and Kumar (2006).

Five gram of fresh sample was taken and crushed in Ten to fifteen mililiter acetone, few crystals of anhydrous sodium sulphate was added and ground with the help of pestle and mortar. Supernatant was decanted into a beaker and transferred to a separating funnel. Ten to fifteen mililiter petroleum ether was added and mixed thoroughly. The lower layer was discarded and collected the upper layer and the volume was made up to 100 ml with petroleum ether and optical density was read at 452 nm.

$$\textbf{Vitamin A (I.U)} = \frac{\textbf{Beta-carotene } \mu g/100g}{\textbf{0.6}}$$

3.2.1.8 Peroxide value

Peroxide value was determined to assess to the rate of rancidity during storage. It was estimated by the method suggested by Sadasivam and Manickam (1992). The peroxide content of fresh fish muscle was determined by titration against thiosulphate in presence of potassium iodide using starch as the indicator.

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

3.3 PREPARATION AND STORAGE OF THE PRODUCTS

Products like cutlet and stick were prepared with fresh fish muscle following standard procedure (Vijayan *et al.,* 1989). The flow chart for the preparation of fish products is given in Fig .1 and 2.

3.3.1 Preparation of the products

One kilogram fish muscle from each of the fresh water and marine fish varieties were used. Washed, cleaned and drained fish muscle were blanched in water (100^0C) for 10-15 minutes. The blanched fish muscle was then minced and was used for product preparation.

Preparation of fish cutlet

Detailed procedure for the preparation of fish cutlet is given in Appendix I.

Chopped onion, ginger and green chillies were sauted in 150 ml refined vegetable oil for 10 minutes and then added chilli powder, turmeric powder and masala powder and again sauted for 5 minutes. Fish mince and salt were added and mixed well. Cooked for some time until the mixture was dry. It was then mixed well with boiled and mashed potato. This mixture (20g) was moulded into round shape of around 2 cm thicknes. They were then dipped in egg white and rolled over bread-crumbs. Before use, the battered and breaded fish cutlets were deep fried in vegetable oil maintained at 160-170^{0}C for five minutes turning on both sides and drained.

Preparation of fish stick

Detailed procedure for the preparation of fish stick is given in Appendix II.

The binder paste made as per recipe (Appendix II), was mixed and blended with the blanched fish mince along with corn flour in the proportion of 100 binder paste: 135 corn flour: 765 blanched fish mince. Since mixing and grinding of the ingredients has to be done by a slow process, blending was done in a food processor. This mixture (25g) was moulded into rectangular sticks, dipped in egg white, drained and rolled in bread crumbs. Before use the product was deep fried in vegetable oil at 160^{0}C for 3 minutes.

3.3.2. STORAGE OF THE PRODUCTS

The cutlets and sticks (before frying in oil) were packed in polythene covers (200 guage). In each packet 4 number of cutlets (80g) and sticks (100g) were packed and stored under frozen condition (-4^{0}c) for a period of two months. The products were thawed for 1 hour before frying.

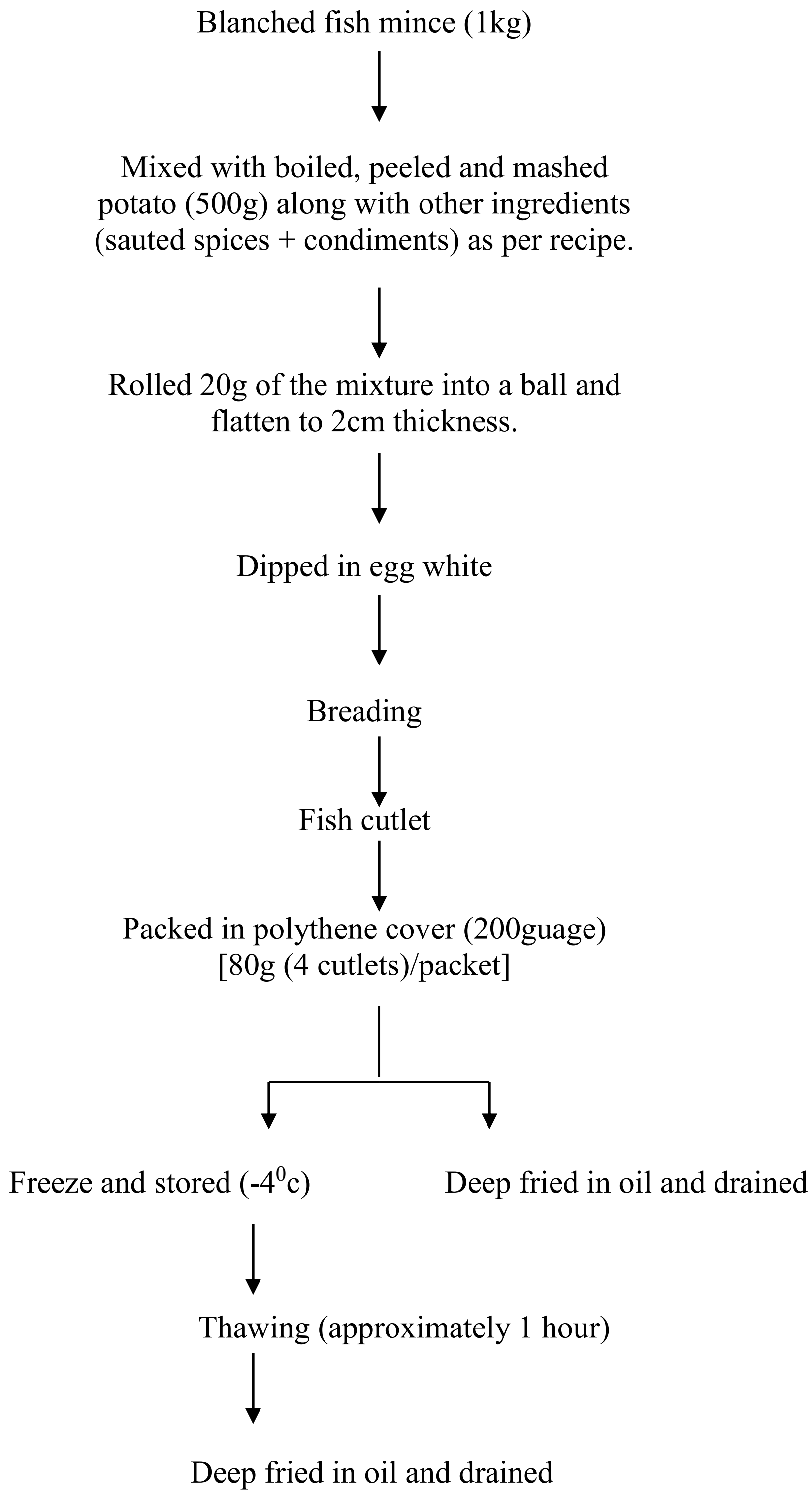

Fig.1. Flow chart for the preparation of fish cutlet

Blanched fish mince (1kg)

↓

Mixed with binder paste and corn flour

↓

Grinding

↓

Moulded into rectangular sticks (25g)

↓

Dipped in beaten egg white

↓

Breading

↓

Fish stick

↓

Packed in polythene cover (200guage)
[100g (4 sticks)/pack]

↓ ↓

Freeze and stored (-4^0c) | Deep fried in oil and drained

↓

Thawing (approximately 1 hour)

↓

Deep fried in oil and draine

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

3.4 QUALITY EVALUATION OF THE PRODUCTS

3.4.1 Peroxide value

Peroxide value of cutlet and stick were estimated initially and at fortnightly intervals for a period of two months as described in procedure 3.2.1.8.

3.4.2 Organoleptic evaluation of fish products

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).

Organoleptic evaluation

Organoleptic evaluation of the fish products was carried out using score card method (Swaminathan, 1974) by the panel of ten selected judges. The fish products were evaluated after frying initially and at fortnightly intervals for a period of two months.

The quality attributes of the fish products, like appearance, colour, flavour, texture and taste were evaluated. Each of the above mentioned quality attributes were assessed by a nine point hedonic scale. Overall acceptability of the fish products were calculated separately using the average of the above mentioned quality attributes. The score cards used for evaluation are given in appendix III and IV respectively.

3.4.3 MICROBIAL ENUMERATION OF FISH PRODUCTS

The microbial evaluation of the fish products like cutlet and stick were conducted initially and at fortnightly intervals for a period of two months. The method used for the evaluation was serial dilution and plate count method as described by Agarwal and Hasija (1986). Ten grams of the sample was added to

90 ml sterile water and shaken for 10 minutes. One milliliter 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 microbial count was carried out using nutrient agar media for bacteria, potato dextrose agar media for fungi and sabouraud's dextrose agar media for yeast (Appendix v). The dilution used for bacteria was 10^{-5} and for fungi and yeast 10^{-3} dilutions were used.

3.5 COMPUTATION OF NUTRITIVE VALUE OF THE PRODUCTS PER PACKET

Based on the nutritive value estimated (fresh weight basis) for fresh fish muscle and other ingredients used, the nutritive value of the products per packet was calculated using food composition table.

3.6 STATISTICAL ANALYSIS

The data was analysed using Duncan's Multiple Rank test and Kendal's coefficient level of significance.

Results

4. Results

The results pertaining to the study entitled "Quality evaluation of value added products with marine and fresh water fish" are presented under the following headings

4.1 Yield of fish muscle
4.2 Chemical constituents of fresh fish muscle
4.3 Preparation and storage of the products
4.4 Quality aspects of the products
4.4.1 Peroxide value of the products during storage
4.4.2 Organoleptic qualities of the products
4.4.3 Total microbial count of the products during storage
4.5 Calculated nutritive value of the products per packet

4.1 YIELD OF FISH MUSCLE

Fish muscle was extracted from the selected fish varieties. 1 kg fish from each of the fresh water and marine fish varieties were used. The per cent weight of fish muscle separated from the two fresh water fish varieties *viz*., tilapia and katla were 76 and 78 per cent respectively. About 68 and 60 per cent of fish muscle were obtained from marine fish *viz*., pink perch and silver belly respectively.

4.2 CHEMICAL CONSTITUENTS OF FRESH FISH MUSCLE

Data pertaining to the chemical constituents of fresh fish muscle is given in Table 1

4.2.1 Moisture

Among the four fish varieties maximum moisture content was observed in pink perch (81.39 g $100g^{-1}$) and minimum in silver belly (75.50 g $100g^{-1}$). A significant variation was observed in the moisture content of fish varieties.

Fish varieties	Moisture (%)	Fat (g)	Protein (g)	Calcium (mg)	Phosphorus (mg)	Iron (mg)	Vitamin A (µg)	Peroxide value (meq)
Tilapia	78.83^{b}	2.63^{b}	20.75^{a}	575.93^{c}	457.42^{b}	1.84^{c}	90.77^{b}	0.16^{b}
Katla	77.50^{c}	2.5^{c}	19.60^{b}	542.26^{d}	249.38^{c}	1.27^{d}	96.28^{a}	0.15^{c}
Pink perch	81.39^{a}	3.74^{a}	16.25^{d}	943.25^{a}	248.89^{d}	2.14^{b}	86.06^{c}	0.17^{a}
Silver belly	75.50^{d}	1.78^{d}	18.66^{c}	728.40^{b}	674.81^{a}	2.30^{a}	80.43^{d}	0.13^{d}

Table.1. Chemical constituents of fresh fish muscle (per 100 g)

Values having different super script differ significantly at 5% level
DMRT column wise comparison

4.2.2 Fat

Fat content ranged from 1.78 to 3.74 g $100g^{-1}$, the maximum being for pink perch and the minimum for silver belly. There was significant variation in the fat content of the four fish varieties.

4.2.3 Protein

Tilapia (20.75 g $100g^{-1}$) had the maximum protein content and it was minimum in pink perch (16.25 g $100g^{-1}$). Significant variation in the protein content of tilapia and katla and in pink perch and silver belly was observed. Variation between the fresh water and marine water fish species was also significant. Moisture, protein and fat content of fish varieties are depicted in Fig 3.

4.2.4 Calcium

Calcium content varied from 542.26 mg $100g^{-1}$ in katla to 943.25 mg $100g^{-1}$ in pink perch .Statistically, a significant variation was observed in the calcium content of fresh water and marine water species and also, between the selected four varieties.

4.2.5 Phosphorus

A significant variation was observed in the phosphorus content of fresh water and marine water fish varieties. Phosphorus content was highest in silver belly (674.81 mg $100g^{-1}$) and lowest in pink perch 248.89 mg $100g^{-1}$. Variation between the four fish varieties was also significant. Calcium and phosphorus content of fish varieties are given in Fig. 4.

4.2.6 Iron

Silver belly had the maximum iron content (2.30 mg $100g^{-1}$) and katla the minimum (1.27 mg $100g^{-1}$) (Fig 5). Significant variation was observed in the iron content in all the fish varieties. The variation observed between fresh water and marine water fish varieties was also significant.

4.2.7 Vitamin A

Significant variation was observed in the vitamin A content of fresh water and marine water fish species. Katla recorded maximum vitamin A (96.28µg/ $100g^{-1}$) followed by tilapia (90.77 µg/ $100g^{-1}$) whereas vitamin A was minimum in silver belly (80.43 µg/ $100g^{-1}$) (Fig 6). Variation in the vitamin A content of the four fish varieties was significant.

4.2.8 Peroxide value

Highest peroxide value was observed in pink perch (0.17meq $100g^{-1}$) and lowest in silver belly (0.13meq$100g^{-1}$) (Fig 7). Statistically significant

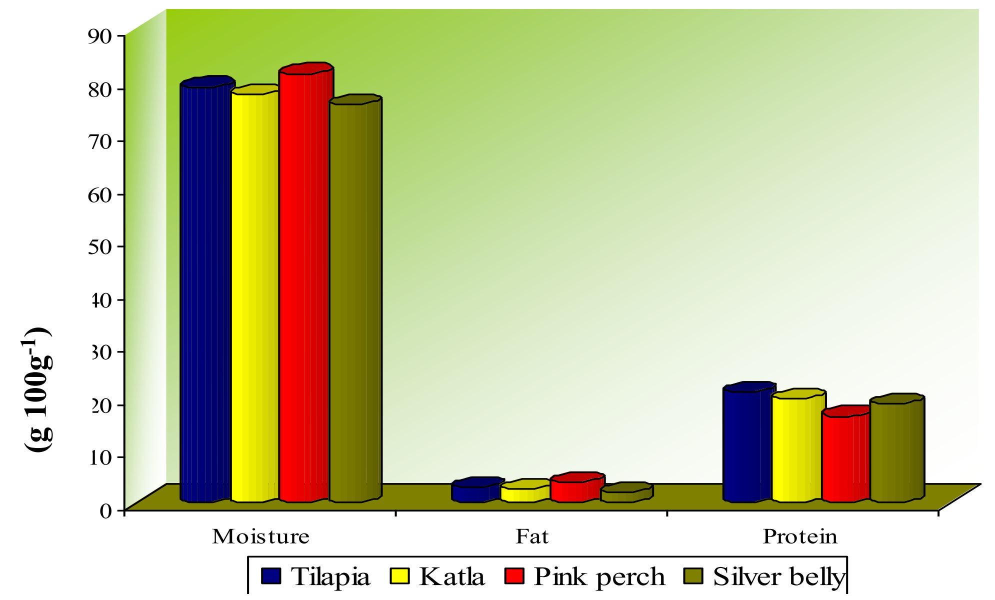

Fig.3. Moisture, fat and protein content of fresh fish muscle

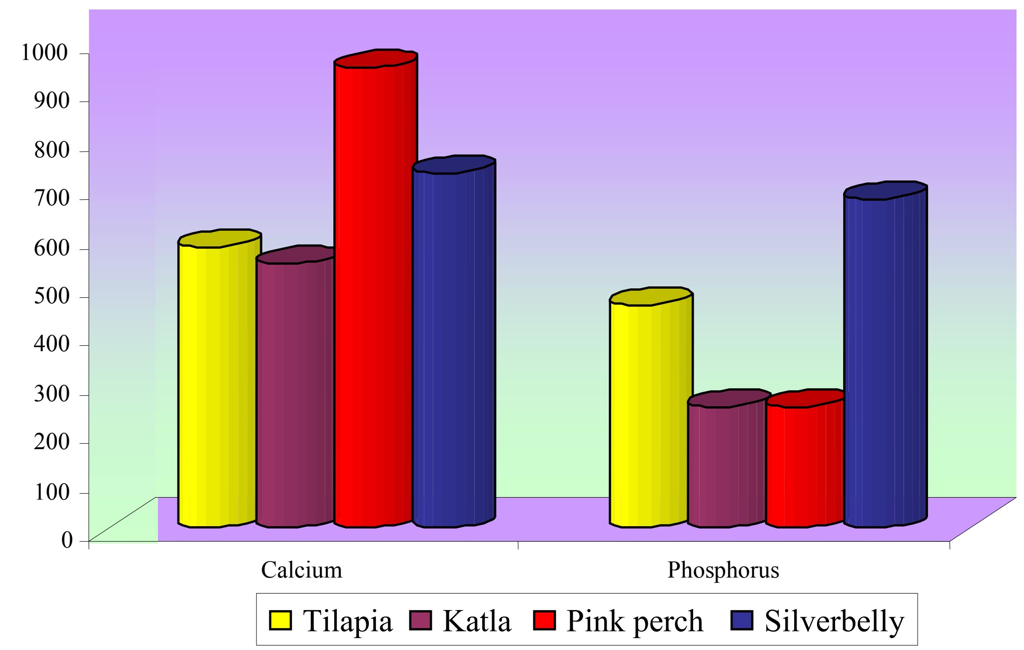

Fig. 4. Calcium and phosphorus content of fresh fish muscle

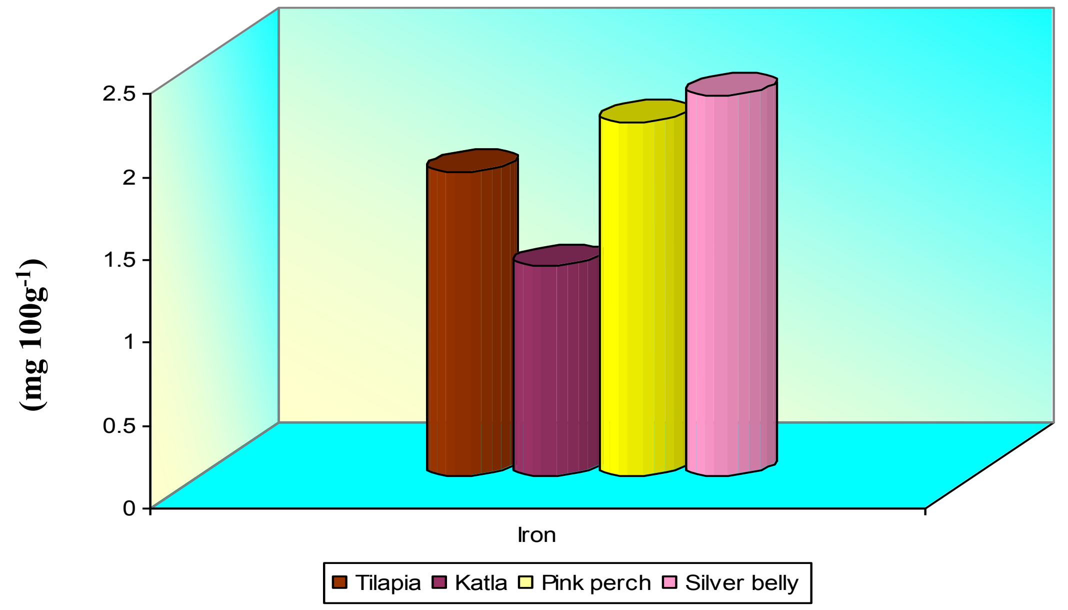

Fig.5 Iron content of fresh fish muscle

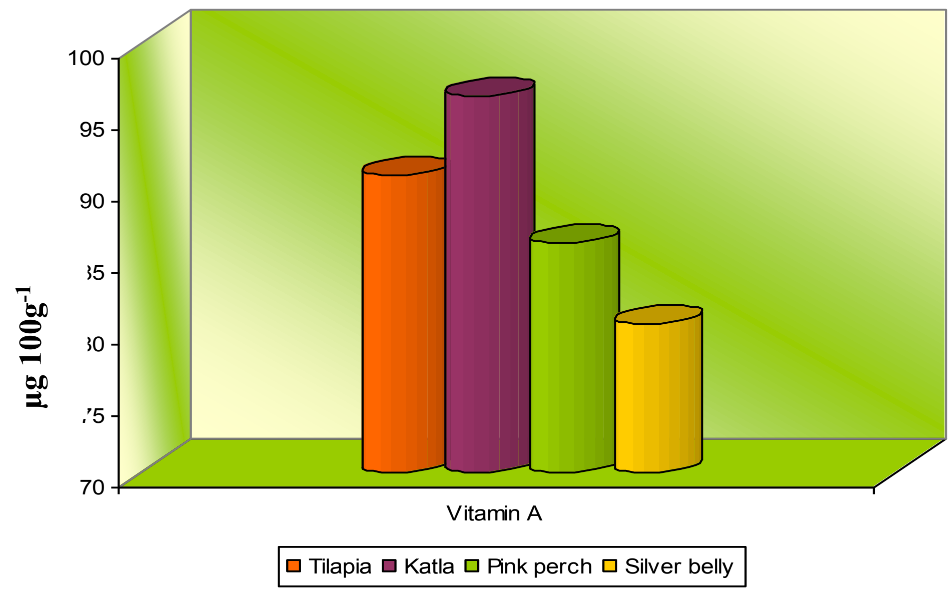

Fig.6. Vitamin A content of fresh fish muscle

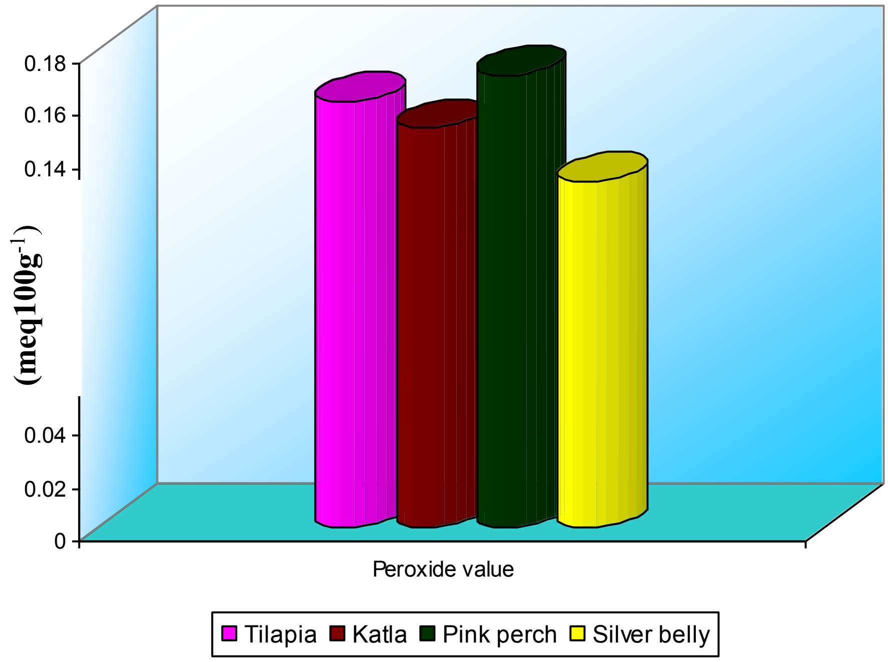

Fig.7. Peroxide value of fresh fish muscle

variation was observed in the peroxide value of fresh water and marine water fish species and also between the four varieties.

4.3 PREPARATION AND STORAGE OF THE PRODUCTS

4.3.1 Preparation of fish cutlet

About 78 cutlets were prepared from 1 kg fish mince from each variety of fish, each cutlet weighing 20g.

4.3.2 Preparation of fish stick

Sticks were prepared from fresh water and marine water fish mince. One kg of each fish variety (mince) gave 56 sticks each weighing 25g.

4.3.3 Duration of storage

Even though the duration of storage of fish products was expected to be for three months, the storage studies of the products were done only for two months, after which all the qualities of the products became unacceptable due to deterioration. The main reason for deterioration was frequent and prolonged power failure in the laboratory which affected the efficiency of the deep freezer.

4.4 QUALITY ASPECTS OF THE PRODUCTS

4.4.1 Peroxide value of the products during storage

4.4.1.1 Peroxide value of fish cutlets during storage

The data obtained for peroxide value of fish cutlets during storage is presented in Table 2

Initially the peroxide value of the fish cutlet ranged from 0.83meq kg^{-1} to 1.09meq kg^{-1}, the maximum being in pink perch and minimum in silver belly. This increased to a range of 1.13meq kg^{-1} to 1.57meq kg^{-1}, after 15 days of storage period. During this period also, the minimum peroxide value was in silver belly and maximum in pink perch. During the initial stage and after 15 days of storage, the peroxide value showed significant variation between tilapia and katla and also between pink perch and silver belly but the variation observed between pink perch and tilapia was not significant. After 30 days of storage, peroxide value of cutlet made of pink perch (2.00meq kg^{-1}) was significantly high compared to other fish cutlets. No significant variation was observed between tilapia (1.68meq kg^{-1}) and katla (1.72meq kg^{-1}) after 30 days of storage. After 45 days of storage, the maximum peroxide value was observed in pink perch (3.20meq kg^{-1}) which was significantly high when compared to other three fish varieties. Maximum storage period of 60 days resulted in a peroxide value ranging from 3.32meq kg^{-1} to 4.14meq kg^{-1} in silver belly and pink perch respectively. No significant variation was observed in the peroxide value of fish cutlets except for pink perch which showed the maximum peroxide value. Peroxide value was found to increase with the storage period of fish cutlets (Fig 8).

4.4.1.2 Peroxide value of fish stick during storage

The peroxide value of fish stick ranged from 0.92meq to 1.21meq kg^{-1} during the initial period of storage, the maximum being in pink perch and minimum in silver belly (Table 3). There was significant variation in the peroxide value of tilapia and katla and also between pink perch and silver belly during the initial period but the variation observed in silver belly and katla was not significant. The peroxide value increased to a range of 1.34 to 1.69meq kg^{-1} after 15 days with a maximum in pink perch and minimum in silver belly. After 30 days of storage a further increase in the peroxide value was observed in all fish sticks, maximum being in pink perch (1.92meq kg^{-1}) and the least in silver belly (1.71meq kg^{1}). No significant variation in the peroxide value of tilapia, katla and silver belly was observed but pink perch was found to have significantly high peroxide value. After 45 days of storage, the peroxide value of fish stick varied from 2.23meq kg^{-1} in silver belly and 3.02meq kg^{-1} in pink perch. The increase in peroxide value was comparable in tilapia and pink perch after 45 days of storage. By the end of the storage period, (60 days) the peroxide value ranged from

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

Sl No	Fish varieties	Storage period				
		Initial	15 days	30 days	45 days	60 days
1	Tilapia	1.03^{a}	1.52^{a}	1.68^{b}	2.71^{b}	3.75^{b}
2	Katla	0.96^{b}	1.49^{c}	1.72^{b}	2.68^{b}	3.45^{b}
3	Pink perch	1.09^{a}	1.57^{a}	2.00^{a}	3.20^{a}	4.14^{a}
4	Silver belly	0.83^{c}	1.13^{d}	1.29^{d}	2.13^{b}	3.32^{b}

Values having different super script differ significantly at 5% level

DMRT column wise comparison

Table.3. Peroxide value of fish stick during storage, meq Kg^{-1}

Sl No	Fish varieties	Storage period				
		Initial	15 days	30 days	45 days	60 days
1	Tilapia	1.14^{b}	1.58^{b}	1.74^{b}	2.87^{a}	3.47^{b}
2	Katla	1.07^{c}	1.59^{bc}	1.78^{b}	2.53^{b}	3.20^{c}
3	Pink perch	1.21^{a}	1.67^{a}	1.92^{a}	3.02^{a}	4.05^{a}
4	Silver belly	0.92^{c}	1.34^{c}	1.71^{b}	2.23^{c}	3.26^{c}

Values having different super script differ significantly at 5% level

DMRT column wise comparison

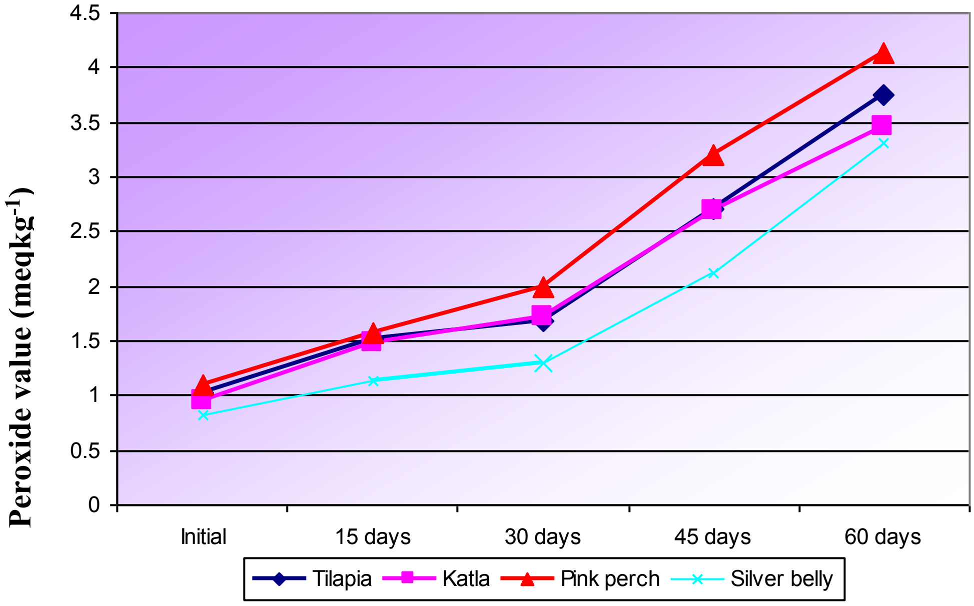

Fig.8. Peroxide value of fish cutlet during storage

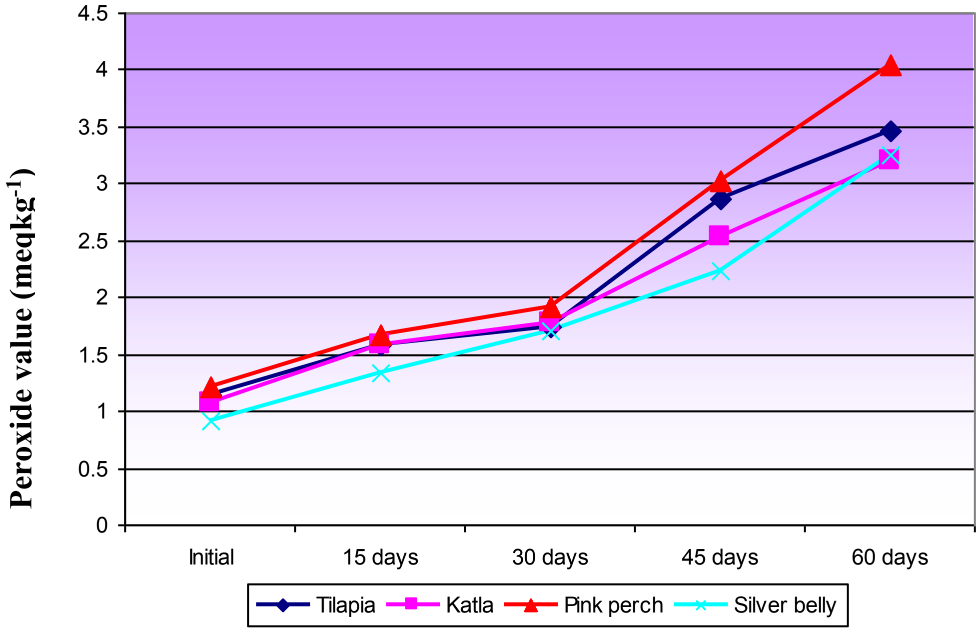

Fig.9. Peroxide value of fish stick during storage

3.20meq kg^{-1} to 4.05meq kg^{-1} in katla and pink perch respectively. There was no significant variation in the peroxide value of katla and silver belly fish stick. On storage, the peroxide value had increased significantly for all the fish stick (Fig 9).

4.4.2 Organoleptic qualities of the products during storage

Ten judges selected as in 3.4.2 assessed the organoleptic qualities of the products like appearance, colour, flavour, texture and taste using 9-point hedonic scale. Judges evaluated the quality of the products for a period of 2 months at fortnightly intervals. Statistical analysis used for organoleptic studies were Kendall's coefficient level of concordance. Kendall's coefficient of concordance (W) was worked out to measure the degree of agreement among the judges for the various parameters. Lower the percentage of level of significance, higher the degree of agreement among the judges. All 'W' values with less than 20% probability level of significance were judged as indicating high degree of agreement.

4.4.2.1 Changes in the organoleptic qualities of fish cutlet during storage

The mean score and rank score obtained for fish cutlets initially, and at fortnightly intervals, for a period of 2 months of storage are presented in Tables 4 to 9.

Initially (Table 4) cutlet made of katla fish had the maximum score (8.66) for appearance and cutlet made of silver belly fish had the minimum score (8.55). After 15 days of storage there was an increase in the mean score for katla (8.68) and silver belly (8.57), but a decrease in tilapia (8.58).There was no change in the mean score for pink perch (8.58). After 30 days of storage tilapia and pink perch had the same score (8.58). Katla showed an increase in mean score (8.70) whereas silver belly showed a decrease (8.56). After 30 days also, the maximum score for appearance was for katla and the minimum for silver belly. In all the samples after 45 days of storage, there was a decreasing trend in the mean score for appearance. Minimum score was for silver belly (6.46) and maximum for katla

(6.91). After 60 days the mean score for appearance further showed a decline in the value which varied from 3.95 to 4.15 in silver belly and katla respectively.

The highest ‘W’ value was found to be for initial storage period (0.300), followed by 15 days (0.246), 30 days (0.198), 45 days (0.137) and 60 days (0.021). Probable level of significance indicated that the appearance of the cutlets were acceptable to the judges only up to 30 days of storage.

In the case of colour of fish cutlet (Table 5) initially maximum score was for tilapia (8.73) and minimum score for pink perch (8.60). Katla and silver belly had an initial mean score of 8.69 and 8.65 respectively. After 15 days of storage there was no change in the score for tilapia (8.73) but an increase in the mean score for katla (8.71), pink perch (8.65) and silver belly (8.68) was observed. Here also the maximum was for tilapia and minimum for pink perch. After 30 days of storage, the score decreased to a range of 8.25 to 8.43, and the maximum and minimum score was for pink perch and tilapia respectively. The declining trend continued with storage period. After 45 days, the highest score was for tilapia (6.41) and lowest for pink perch (6.17). The score finally reached to a range of 3.42 to 3.80 at the end of the storage period. During this period also the minimum score was for pink perch and maximum for tilapia.

Maximum ‘W’ value for colour was obtained in the initial storage period (0.395) which decreased to 0.257, 0.242, 0.122 and 0.029 after 15, 30, 45 and 60 days of storage respectively. Probable level of significance showed that the colour of fish cutlet was not acceptable among judges after 60 days of storage.

Initially maximum score for flavour (Table.6) was for katla fish cutlet (8.70) and minimum score for pink perch cutlet (8.50). Acceptability score for flavour showed a decrease after 15 days of storage and ranged from 7.75 to 8.03 wherein the minimum score was for pink perch and maximum score for katla. After 30 days of storage, the score for flavour had again decreased to a range of 7.06 to 7.70 for pink perch and katla respectively. After 45 days of storage, the mean score varied from 5.01 to 5.80, the maximum and minimum score was in pink perch and katla respectively. After 60 days there was a further reduction in the flavour of cutlets as observed in the mean score. Maximum score after 60 days was found in katla (3.55) and minimum in pink perch (2.67).

The highest 'W' value of 0.381 was for the initial period, followed by 0.320 for 15 days and 0.274 for 30 days of storage. Considering the probable level of significance, the flavour of fish cutlet was acceptable to judges only up to 30 days of storage.

Table 4. Mean scores for appearance of fish cutlets in different storage periods

Fish varieties	Initial	15 days	30 days	45 days	60 days
Tilapia	8.60 (2.80)	8.58 (2.25)	8.58 (2.25)	6.61 (2.23)	4.11 (2.20)
Katla	8.66 (3.15)	8.68 (3.40)	8.7 (3.41)	6.91 (3.38)	4.15 (3.33)
Pink perch	8.58 (2.25)	8.58 (2.25)	8.58 (2.24)	6.54 (2.23)	4.01 (2.18)
Silver belly	8.55 (1.80)	8.57 (2.10)	8.56 (2.09)	6.46 (2.00)	3.95 (1.80)
Kendall W value	0.300	0.246	0.198	0.137	0.021
Prob level of sig(%)	2.9%	6.1%	11.5%	24.9%	63.2%

(Figures in parenthesis are mean rank scores)

Table 5. Mean scores for colour of fish cutlets in different storage periods

Fish varieties	Initial	15 days	30 days	45 days	60 days
Tilapia	8.73 (3.00)	8.73 (3.00)	8.43 (2.97)	6.41 (2.95)	3.80 (2.93)
Katla	8.69 (2.76)	8.71 (2.78)	8.40 (2.74)	6.29 (2.72)	3.74 (2.7)
Pink perch	8.60 (2.05)	8.65 (2.11)	8.25 (2.00)	6.17 (1.9)	3.42 (1.85)
Silver belly	8.65 (2.25)	8.68 (2.28)	8.35 (2.23)	6.23 (2.05)	3.50 (2.00)
Kendall W value	0.395	0.257	0.242	0.122	0.029
Prob level of sig(%)	0.01%	0.01%	2.5%	8.6%	83.6%

(Figures in parenthesis are mean rank scores)

Table 6. Mean scores for flavour of fish cutlets in different storage periods

Fish varieties	Initial	15 days	30 days	45 days	60 days
Tilapia	8.53 (2.70)	7.9 (2.67)	7.1 (2.58)	5.68 (2.57)	2.8 (2.55)
Katla	8.70 (3.40)	8.03 (3.40)	7.7 (3.35)	5.8 (3.32)	3.55 (3.30)
Pink perch	8.50 (1.80)	7.75 (1.77)	7.06 (1.70)	5.01 (1.68)	2.67 (1.66)
Silver belly	8.55 (2.10)	7.88 (2.07)	7.09 (2.00)	5.33 (1.97)	2.73 (1.95)
Kendall W value	0.381	0.320	0.274	0.117	0.049
Prob level of sig(%)	1%	2.9%	6.3%	31.8%	68.7%

(Figures in parenthesis are mean rank scores)

Table 7. Mean scores for texture of fish cutlets in different storage periods

Fish varieties	Initial	15 days	30 days	45 days	60 days
Tilapia	8.46 (2.75)	8.37 (2.72)	7.93 (2.70)	4.71 (2.68)	2.87 (2.66)
Katla	8.63 (2.85)	8.59 (2.83)	8.97 (2.81)	5.02 (2.77)	2.90 (2.75)
Pink perch	8.37 (2.4)	8.27 (2.38)	7.87 (2.35)	4.64 (2.30)	2.55 (2.27)
Silver belly	8.24 (2.00)	8.16 (1.98)	7.78 (1.95)	4.54 (1.92)	2.43 (1.9)
Kendall W value	0.39	0.294	0.285	0.117	0.021
Prob level of sig(%)	1.4%	5.2%	7.5%	40.3%	89%

(Figures in parenthesis are mean rank scores)

Table 8. Mean scores for taste of fish cutlets in different storage periods

Fish varieties	Initial	15 days	30 days	45 days	60 days
Tilapia	8.45 (2.6)	8.66 (2.65)	7.90 (2.51)	4.75 (2.47)	2.91 (2.45)
Katla	8.53 (2.7)	8.76 (2.78)	7.95 (2.75)	5.08 (2.70)	3.05 (2.67)
Pink perch	8.40 (2.50)	8.61 (2.58)	7.87 (2.54)	4.64 (2.5)	2.67 (2.48)
Silver belly	8.30 (2.20)	8.36 (2.25)	7.74 (2.20)	4.60 (2.15)	2.62 (2.10)
Kendall W value	0.379	0.395	0.260	0.093	0.027
Prob level of sig(%)	1%	8%	5%	42.3%	84.9%

(Figures in parenthesis are mean rank scores)

Table 9. Mean scores for overall acceptability of fish cutlets in different storage periods

Fish varieties	Initial	15 days	30 days	45 days	60 days
Tilapia	8.66 (2.50)	8.40 (2.45)	7.97 (2.43)	5.60 (2.40)	3.24 (2.38)
Katla	8.73 (3.05)	8.52 (3.00)	8.60 (2.97)	5.72 (2.95)	3.31 (2.92)
Pink perch	8.47 (2.40)	8.10 (2.37)	7.93 (2.34)	5.47 (2.30)	3.07 (2.25)
Silver belly	8.40 (2.05)	7.97 (2.00)	7.73 (1.95)	5.39 (1.90)	3.07 (1.87)
Kendall W value	0.437	0.285	0.197	0.174	0.096
Prob level of sig(%)	0.01%	3.6%	11.7%	13.2%	40.9%

(Figures in parenthesis are mean rank scores)

Considering the texture of fish cutlets (Table. 7) initially the highest score was for katla (8.63) and lowest score for silver belly (8.24) cutlet. The texture of the fish cutlet also showed a decreasing trend during the storage period. After 15 days of storage the score decreased to a range of 8.16 to 8.59 in silver belly and katla cutlet respectively. But after 30 days of storage, the acceptability for texture increased to a mean score of 8.97 in katla, even higher than the initial score. After 45 days of storage, the mean score for katla cutlet declined to 5.02 Maximum reduction was observed in silver belly (4.54) followed by pink perch (4.64). After 60 days, the cutlets showed the least acceptability with regards to texture with a score of 2.90 in katla and 2.43 in silver belly. During the entire period of storage, katla and silver belly cutlet had the highest and lowest score respectively for texture.

The highest 'W' value of 0.39 was in the initial period. After that the 'W' value showed a declining trend with values 0.294, 0.285, 0.117, 0.021 for 15 days, 30 days, 45 days and 60 days of storage respectively. After 45 and 60 days of storage, the probable level of significance indicated that the texture of the products were not acceptable for the judges.

The taste of fish cutlet (Table 8) showed a maximum score of 8.53 in katla followed by tilapia (8.45). The minimum score for taste was observed in silver belly (8.30) cutlet. After 15 days of storage the score for taste increased to 8.76 in katla cutlet, which was again the maximum score followed by tilapia (8.66) which also showed an increase in the score. After 15 days of storage pink perch (8.61) and silver belly (8.36) also showed an increase in the score for taste and silver belly scored the least score. After 30 days of storage the score for taste showed a decline, ranging from the highest score of 7.95 for katla to the lowest score of 7.74 in silver belly. After 45 days, the scores again declined to 5.08 in katla and 4.60 in silver belly. The scores for taste 60 days after storage further declined to 3.05 and 2.62.

The highest ‘W’ value for the taste of the cutlet was 0.395 was recorded after 15 days of storage. ‘W’ value initially was found to be 0.379. After 30 days it decreased to 0.260, after 45 days to 0.093 and after 60 days to 0.027. Probable level of significance indicated that after 45 days of storage the taste of the products was not acceptable to the judges.

The maximum score for overall acceptability of fish culet (Table 9) was for katla (8.73) followed by tilapia (8.66). Minimum score was for silver belly (8.40). After 15 days of storage, the mean score for overall acceptability of all fish cutlets showed a decreasing trend. Maximum score was again for katla (8.73) followed by tilapia (8.40) and minimum was in silver belly (7.97). After 30 days of storage the score for overall acceptability of katla cutlets increased to 8.60 whereas in all other cutlets the scores were found to be decreasing, with a minimum score of 7.73 in silver belly. But after 45 days of storage, all the cutlets showed low acceptability as revealed by a score of 5.72 in katla and a minimum score of 5.39 in silver belly. The same trend was observed after 60 days storage also, with a maximum score of 3.31 in katla and minimum score of 3.07 in pink perch and silver belly (Fig 10).

The overall acceptability was good initially, the ‘W’ value was found to be 0.437. The ‘W’ values were found to be in a declining trend of 0.285, 0.197, 0.174, and 0.096 for 15, 30, 45 and 60 days of storage respectively. Probable level of significance showed that the products were acceptable to the judges up to 45 days of storage beyond which they were not acceptable considering various quality criteria.

4.4.2.2. Changes in the organoleptic qualities of fish stick during storage

The results are presented in tables 10 to 15. Table 10 revealed that maximum score for appearance of fish stick was for tilapia (8.76) followed by katla (8.66) and minimum score was for silver belly (8.36) during the initial period. A decreasing trend in the scores was noticed during the storage of fish stick. After 15 days maximum mean score for appearance was 8.61 in tilapia followed by katla (8.57) and the minimum score was for silver belly (8.25). After 30, 45 and 60 days of storage also, with a declining trend the same pattern was observed with tilapia having the highest score among the sticks (8.1, 6.9 and 4.14 respectively) followed by katla (7.98, 6.61 and 4.08 respectively). Silver belly showed the least score (7.88, 6.46 and 3.89 respectively).

The 'W' value 0.445 observed in the initial storage period was maximum, and after 15 days the 'W' value decreased to 0.283, after 30 days to 0.228, after 45 days to 0.114 and finally to 0.059. Considering the probable level of significance with regards to appearance, fish sticks were acceptable only upto 30 days of storage.

The colour of fish stick scored maximum initially (Table 11). The highest score for colour was observed initially in fish stick made of tilapia (8.75) followed by katla (8.73). Minimum score was in pink perch (8.69). A declining trend in the scores was observed during storage. A score of 8.55 in tilapia at 15 days of storage declined to 8.1, 6.53 and 3.80 during 30, 45 and 60 days of storage respectively. Maximum decline in the score was observed for silver belly from a score of 8.43 on 15 days storage to 7.83, 6.35 and 3.42 during 30, 45 and 60 days of storage.

The highest 'W' value was found to be in the initial period (0.392) followed by 0.374 for 15 days, 0.195 for 30 days, 0.165 for 45 days and 0.046 for 60 days. Probable level of significance showed that there was agreement between judges regarding the colour of fish stick up to 45 days of storage.

Regarding the flavour of fish stick, (Table 12) during the initial period maximum score (8.72) was for katla followed by silver belly (8.60) and minimum score was noticed in pink perch fish stick (8.58). Here also a declining trend was noticed in the mean scores during storage. After 15 days, the maximum mean score for flavour was found in katla stick (8.27) followed by tilapia (8.10). Pink perch stick had a least score of 8.00. After 30, 45 and 60 days of storage the mean score of katla varied from 7.33, 5.78 and 3.90 which was found to be the highest score when compared to other samples. The mean score for silver belly was the least during these storage periods.

The highest ‘W’ value was 0.482 for initial storage period, 0.471 for 15 days, 0.280 for 30 days, 0.167 for 45 days and 0.034 for 60 days of storage. Probable level of significance showed that the flavour of fish stick was acceptable to judges only up to 45 days of storage. After that the flavour of the products were not acceptable.

Initially (Table 13) stick made of katla had the maximum score (8.37) for texture, followed by pink perch (8.26). The least score was for silver belly (8.13). After 15 days of storage mean score of tilapia, pink perch and silver belly increased to 8.43, 8.40 and 8.27 respectively whereas in katla the score declined to 8.30. Hence the maximum score was for tilapia and least score for silver belly. After 30 days of storage a declining trend was noted in the scores in all fish varieties. In all the storage periods stick made with tilapia scored the maximum, followed by katla and the least score was for silver belly.

The maximum ‘W’ value of 0.247 was during the initial storage period followed by 0.212 for 15 days, 0.211 for 30 days, 0.124 for 45 days and 0.062 for 60 days of storage. Probable level of significance indicated that the texture of fish stick was acceptable to judges only upto 30 days of storage.

Considering the taste of fish stick, it could be seen that (Table 14) initially stick made of katla had the maximum score for taste (8.60) followed by tilapia (8.52) and minimum in silver belly (8.43). The mean score for taste was found to increase after 15 days of storage in all fish sticks. The scores increased to 8.63 in katla and to 8.47 in silver belly. After 30 days of storage, the score for taste had gradually reduced. Stick made of katla had comparatively high mean score during the entire period of storage, (8.01, 5.45 and 2.65 respectively) and the least score was in silver belly (7.75, 4.47 and 2.44 respectively).

'W' value was maximum (0.370) at 15 days of storage since maximum scores were also during this period. Probable level of significance indicated that the taste of the products were acceptable to the judges only upto 30 days of storage.

With regard to overall acceptability, initially katla showed the maximum score (8.63) followed by tilapia (8.55) and silver belly showed the least score (8.43). The overall acceptability declined with the storage period but maximum score was always for katla (8.42, 8.03, 5.62 and 3.28) in all the storage periods (Fig 11). This was followed by tilapia (8.33, 7.88, 5.58 and 3.20). The least scores in all storage periods were for silver belly (7.94, 7.00, 5.32 and 2.74).

The highest 'W' value (0.611) was for the initial period which decreased with storage period. This was 0.298 for 15 days, 0.199 for 30 days, 0.166 for 45 days and 0.141 for 60 days respectively. The judges were in agreement with regard to overall acceptability upto 45 days of storage.

Table10. Mean scores for appearance of fish sticks in different storage period

Fish varieties	Initial	15 days	30 days	45 days	60 days
Tilapia	8.76 (2.95)	8.61 (2.90)	8.1 (2.85)	6.91 (2.81)	4.14 (2.76)
Katla	8.66 (2.80)	8.57 (2.76)	7.98 (2.74)	6.61 (2.70)	4.08 (2.68)
Pink perch	8.6 (2.25)	8.50 (2.23)	7.90 (2.20)	6.54 (2.15)	4.01 (2.10)
Silver belly	8.36 (2.00)	8.25 (1.97)	7.88 (1.94)	6.46 (1.90)	3.89 (1.88)
Kendall W value	0.445	0.283	0.228	0.114	0.059
Prob level of sig(%)	0.4%	6.1%	7.8%	27.1%	62.5%

Figures in parenthesis are mean rank scores

Table 11. Mean scores for colour of fish sticks in different storage periods

Fish varieties	Initial	15 days	30 days	45 days	60 days
Tilapia	8.75 (2.90)	8.55 (2.87)	8.1 (2.85)	6.53 (2.83)	3.80 (2.80)
Katla	8.73 (2.65)	8.46 (2.62)	7.90 (2.58)	6.40 (2.55)	3.72 (2.48)
Pink perch	8.69 (2.10)	8.37 (2.10)	7.79 (2.00)	6.20 (1.95)	3.3 (1.90)
Silver belly	8.70 (2.35)	8.43 (2.32)	7.83 (2.27)	6.35 (2.25)	3.42 (2.20)
Kendall W value	0.392	0.374	0.195	0.165	0.046
Prob level of sig(%)	0.01%	1.2%	12%	17.5%	71.2%

(Figures in parenthesis are mean rank scores)

Table 12.Mean scores for flavour of fish sticks in different storage periods

Fish varieties	Initial	15 days	30 days	45 days	60 days
Tilapia	8.16 (2.80)	8.10 (2.78)	7.27 (2.75)	5.70 (2.70)	3.87 (2.65)
Katla	8.72 (2.85)	8.27 (2.83)	7.33 (2.78)	5.78 (2.75)	3.90 (2.69)
Pink perch	8.58 (2.15)	8.00 (2.11)	7.10 (2.08)	5.55 (2.01)	3.52 (1.90)
Silver belly	8.60 (2.20)	8.07 (2.17)	7.16 (2.14)	5.60 (2.10)	3.65 (2.00)
Kendall W value	0.482	0.471	0.280	0.167	0.034
Prob level of sig(%)	0.01%	0.3%	3.7%	17.2%	79.4%

(Figures in parenthesis are mean rank scores)

Table 13. Mean scores for texture of fish sticks in different storage periods

Fish varieties	Initial	15 days	30 days	45 days	60 days
Tilapia	8.22 (2.55)	8.43 (2.95)	6.76 (2.92)	4.65 (2.85)	2.62 (2.80)
Katla	8.37 (3.25)	8.30 (2.95)	6.67 (2.93)	4.98 (2.87)	2.75 (2.84)
Pink perch	8.26 (2.15)	8.40 (2.25)	6.61 (2.22)	4.60 (2.20)	2.53 (2.00)
Silver belly	8.13 (2.05)	8.27 (1.85)	6.55 (1.82)	4.52 (1.78)	2.47 (1.75)
Kendall W value	0.247	0.212	0.211	0.124	0.062
Prob level of sig(%)	0.6%	9.5%	9.7%	29.4%	60.3%

(Figures in parenthesis are mean rank scores)

Table 14. Mean scores for taste of fish sticks in different storage periods

Fish varieties	Initial	15 days	30 days	45 days	60 days
Tilapia	8.52 (2.40)	8.57 (2.45)	7.94 (2.43)	4.65 (2.40)	2.60 (2.38)
Katla	8.60 (2.85)	8.63 (2.87)	8.01 (2.85)	5.45 (2.83)	2.65 (2.80)
Pink perch	8.48 (2.65)	8.50 (2.66)	7.91 (2.60)	4.52 (2.57)	2.54 (2.52)
Silver belly	8.43 (2.10)	8.47 (2.10)	7.75 (2.09)	4.47 (2.00)	2.44 (1.95)
Kendall W value	0.292	0.370	0.174	0.115	0.082
Prob level of sig(%)	3.2%	1.4%	15.6%	32.6%	48.3%

(Figures in parenthesis are mean rank scores)

Table 15. Mean scores for overall acceptability of fish sticks in different storage periods

Fish varieties	Initial	15 days	30 days	45 days	60 days
Tilapia	8.55 (3.10)	8.33 (3.00)	7.88 (2.95)	5.58 (2.92)	3.20 (2.90)
Katla	8.63 (3.45)	8.42 (3.40)	8.03 (3.38)	5.62 (3.33)	3.28 (3.00)
Pink perch	8.50 (1.80)	8.05 (1.79)	7.74 (1.76)	5.45 (1.72)	3.01 (1.7)
Silver belly	8.43 (1.65)	7.94 (1.63)	7.00 (1.60)	5.32 (1.54)	2.74 (1.68)
Kendall W value	0.611	0.298	0.199	0.166	0.141
Prob level of sig(%)	0.0%	3%	11.3%	17.3%	23.6%

(Figures in parenthesis are mean rank scores)

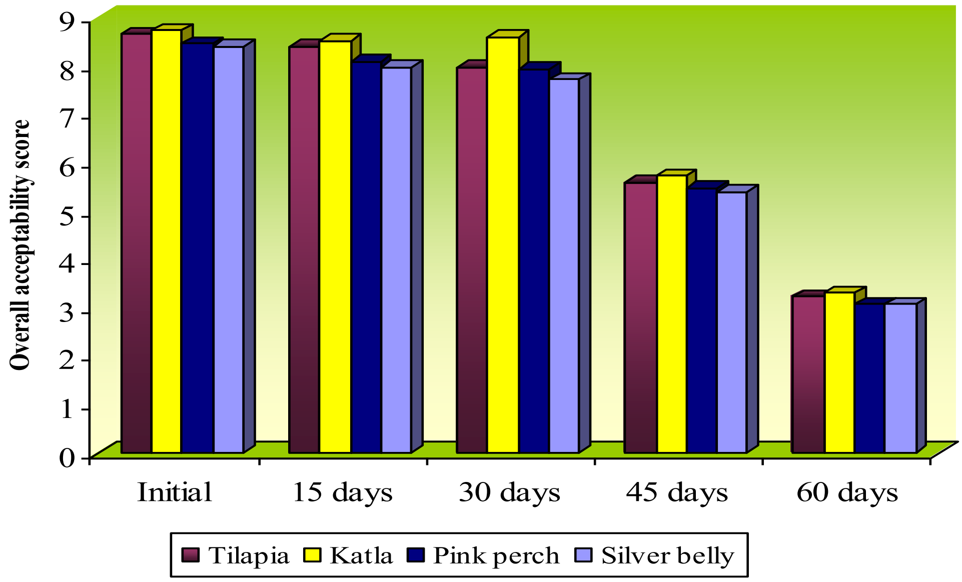

Fig.10. Effect of storage on overall acceptability of cutlet

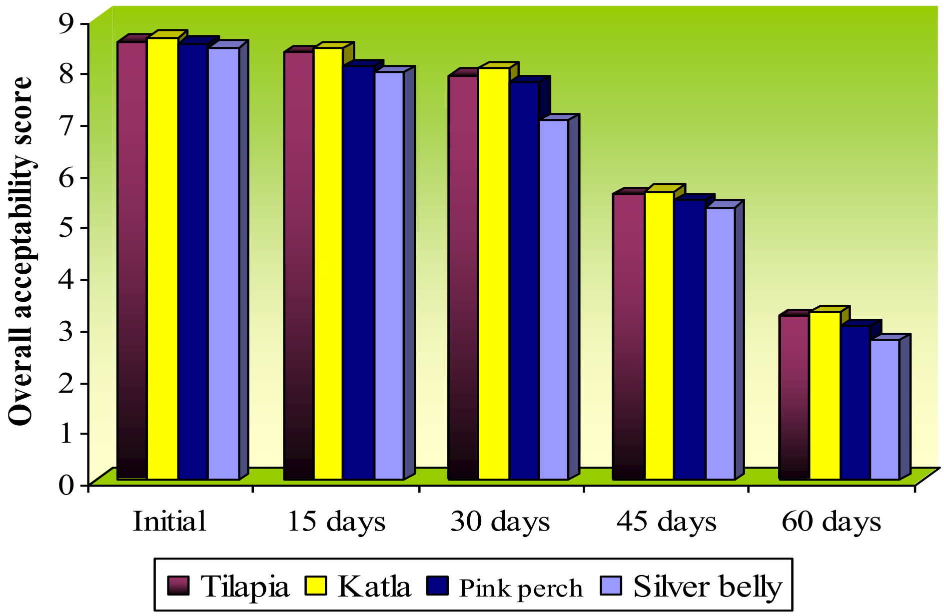

Fig.11. Effect of storage on overall acceptability of fish stick

4.4.3. Total microbial count of the products during storage

4.4.3.1. Total microbial population of fish cutlet during storage

The bacterial, fungal, and yeast population of fish cutlet stored for 2 months are given in Table 16, 17 and 18.

Initially bacterial count (Table 16) was minimum in silver belly and katla cutlet ($0.33x10^5cfug^{-1}$). Maximum initial bacterial count was in pink perch ($1.33\ x10^5\ cfug^{-1}$), which was significantly high. Tilapia had an initial bacterial count of $1.00x10^5cfug^{-1}$. There was no significant variation in the initial bacterial count of pink perch and tilapia. After 15 days of storage the bacterial count increased to $1.00x10^5cfug^{-1}$ in silver belly cutlet and to $1.33\ x10^5cfug^{-1}$ in katla cutlet. Bacterial count had increased to $2.33x10^5cfug^{-1}$ in pink perch and to $1.66\ x10^5cfug^{-1}$ in tilapia. Bacterial count was significantly high in pink perch after 15 days of storage when compared to katla and silver belly cutlet. Bacterial count of tilapia cutlet showed no significant variation with the pink perch cutlet. There was no significant variation in the bacterial count of fresh water fish cutlets after 15 days but variation between marine fish cutlet was significant.

After 30 days of storage, a further increase in the bacterial count was observed in all fish cutlets, maximum being in pink perch ($4.66x10^5cfug^{-1}$) and the least in silver belly ($2.66\ x10^5cfug^{-1}$). The increase in bacterial count was comparable in pink perch and tilapia. The bacterial count after 30 days in marine fish cutlets showed significant variation but variation observed in fresh water fish cutlets was not significant.

After 45 days of storage, pink perch showed a significantly high bacterial count ($7.66x10^5cfug^{-1}$). In other fish cutlets, there was an increase in bacterial count but the variation observed was not significant. Again here also the cutlet with marine fish varieties showed significant variation while no significant variation was observed between fresh water fish cutlets. Maximum storage period of 60 days showed maximum bacterial count in all fish cutlets. Pink perch showed the highest bacterial count of $10.66x10^5cfug^{-1}$ followed by tilapia ($9.33x10^5cfug^{-1}$). Least bacterial count after 60 days of storage was in silver belly ($8.33x10^5cfug^{-1}$). Bacterial count in pink perch was significantly high. The variation observed in the bacterial count of fresh water fish cutlets was not significant but the variation in marine fish cutlet was significant (Fig 12).

The fungal count of fish cutlets during storage is given in Table 17. No fungal population was observed initially for all the treatments. Observations during the 15^{th} day of storage showed a minimum fungal count for silver belly ($0.66x10^3cfug^{-1}$) and maximum for pink perch ($1.66x10^3cfug^{-1}$). Fungal count observed in the case of tilapia and katla was 1.33 $x10^3cfug^{-1}$and $1.00x10^3cfug^{-1}$ respectively. No significant variation was observed in the fungal counts of fresh water and marine fish cutlets even after 15 days of storage.

The fungal count was found to increase after 30 days of storage. The fungal count of tilapia cutlets increased to 2.33 $x10^3cfug^{-1}$ and that of katla to 2.33 $x10^3cfug^{-1}$. Pink perch recorded the maximum fungal count (3.33 $x10^3cfug^{-1}$) and silver belly the least (2.00 $x10^3cfug^{-1}$). After 30 days of storage, the fungal population was significantly high for pink perch when compared to katla and silver belly. The marine fish cutlets showed significant variation in fungal population while the variations observed in fresh water fish cutlets were not significant.

The fungal population was observed to increase again after 45 days of storage in all the fish cutlets. It was significantly high in cutlets prepared from pink perch ($5.00x10^3cfug^{-1}$) and low in silver belly ($3.33x10^3cfug^{-1}$). The increase observed in fungal population was comparable in the cutlets made with tilapia, katla and pink perch. No significant variation was found in the fungal counts of cutlets prepared from fresh water fish varieties. But significant variation was observed in the case of cutlets prepared from marine fish varieties.

Maximum fungal count was observed after the 60 days of storage in cutlets made from all fish varieties. The highest fungal count was observed in cutlets made from pink perch ($7.66x10^3cfug^{-1}$) followed by tilapia ($7.33x10^3cfug^{-1}$). In katla fish cutlets, the fungal population was observed to be $6.66x10^3cfug^{-1}$. Fungal count was low in silver belly fish cutlets ($6.00x10^3cfug^{-1}$). Significant variation was observed in the fungal population of marine fish pink perch and fresh water fish katla and also between marine varieties; pink perch showing significantly high fungal count when compared to silver belly (Fig 13).

The yeast count of the stored fish cutlets are presented in Table. 18. There was no yeast population upto 30 days of storage in the cutlets made out of all the four fish varieties.

After 45 days, the yeast count was observed to be $0.33x10^3cfug^{-1}$in silver belly. The yeast population for katla, tilapia and pink perch was found to be 0.66 $x10^3cfug^{-1}$, $1.0x10^3cfug^{-1}$ and $1.33x10^3cfug^{-1}$ respectively, but the variation observed in yeast population was not significant.

The yeast population increased after 60 days of storage in the case of all the four fish varieties. Maximum yeast count was in pink perch (2.66 $x10^3cfug^{-1}$) which was significantly high when compared to silver belly (1.33 $x10^3cfug^{-1}$). But the yeast population in tilapia (2.33 $x10^3cfug^{-1}$), katla (1.66 $x10^3cfug^{-1}$) and pink perch were comparable without significant variation. The yeast count after 60 days in marine fish cutlets showed significant variation with silver belly having significantly low yeast count but variation observed in fresh water fish cutlet was not significant (Fig 14).

Table 16. Total bacterial population of fish cutlet during storage.

Sl No	Fish varieties	Bacteria ($x10^5 cfug^{-1}$)				
		Storage period				
		Initial	15 days	30days	45 days	60 days
1	Tilapia	1.00^{ab}	1.66^{ab}	3.66^{ab}	6.33^{b}	9.33^{b}
2	Katla	0.33^{b}	1.33^{b}	3.33^{b}	5.66^{b}	9.00^{bc}
3	Pink perch	1.33^{a}	2.33^{a}	4.66^{a}	7.66^{a}	10.66^{a}
4	Silver belly	0.33^{b}	1.00^{b}	2.66^{b}	5.33^{b}	8.33^{c}

Values having different super script differ significantly at 5% level

DMRT column wise comparison

Table 17. Total fungal population of fish cutlet during storage

Sl No	Fish Varieties	Fungus ($x10^3 cfug^{-1}$)				
		Storage period				
		Initial	15 days	30days	45 days	60 days
1	Tilapia	Nil	1.33^{a}	2.66^{ab}	4.66^{ab}	7.33^{ab}
2	Katla	Nil	1.00^{a}	2.33^{b}	4.33^{ab}	6.66^{bc}
3	Pink perch	Nil	1.66^{a}	3.33^{a}	5.00^{a}	7.66^{a}
4	Silver belly	Nil	0.66^{a}	2.00^{b}	3.33^{b}	6.00^{c}

Values having different super script differ significantly at 5% level

DMRT column wise comparison

Table 18. Total yeast population of fish cutlet during storage

Sl No	Fish varieties	Yeast ($x10^3 cfug^{-1}$)				
		Storage period				
		Initial	15 days	30days	45 days	60 days
1	Tilapia	Nil	Nil	Nil	1.00^{a}	2.33^{ab}
2	Katla	Nil	Nil	Nil	0.66^{a}	1.66^{ab}
3	Pink perch	Nil	Nil	Nil	1.33^{a}	2.66^{a}
4	Silver belly	Nil	Nil	Nil	0.33^{a}	1.33^{b}

Values having different super script differ significantly at 5% level

DMRT column wise comparison

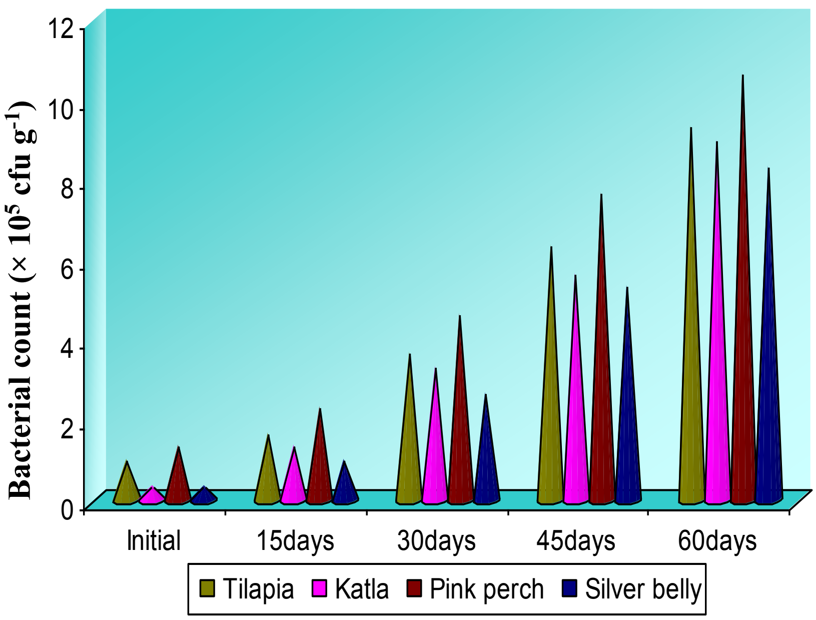

Fig.12. Bacterial population of cutlet during storage

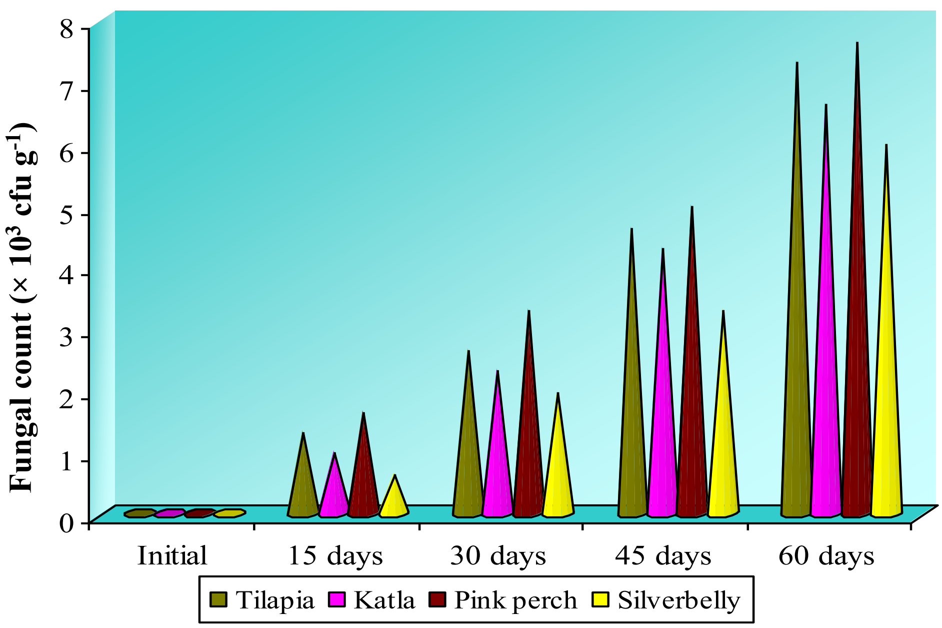

Fig.13. Fungal population of cutlet during storage

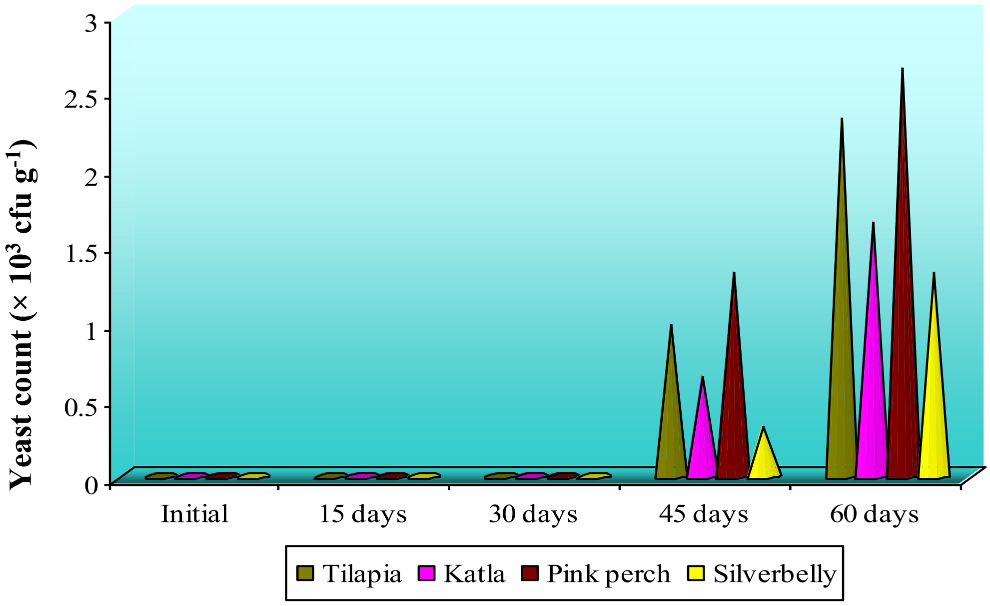

Fig.14. Yeast population of cutlet during storage

4.4.3.2 Total microbial population of fish stick during storage

Total microbial population of fish stick during storage is given in Tables 19, 20 and 21.

Initially the bacterial count was minimum in stick made of silver belly (0.33×10^5cfu g^{-1}) followed by tilapia and katla (1.00×10^5cfu g^{-1}) stick and a maximum initial bacterial count was found in pink perch (1.33×10^5cfu g^{-1}). After 15 days of storage the bacterial count increased to 0.66×10^5cfu g^{-1} in silver belly and to 1.33×10^5cfu g^{-1} in katla stick but the variation was not significant. In the case pink perch, the bacterial count had increased to 2×10^5cfu g^{-1} and was significantly high when compared to silver belly. Bacterial count was not significantly high in pink perch after 15 days of storage when compared to tilapia and katla. There was no significant variation in the bacterial count of fresh water fish varieties but significant variation was observed in marine fish varieties; pink perch showing highest bacterial count after 15 days of storage.

After 30 days of storage, a gradual increase in the bacterial count was observed in fish stick. Maximum bacterial count was observed in pink perch (3.66 $x10^5$cfug^{-1}) but the increase observed in tilapia (3.33 $x10^5$cfug^{-1}) and katla (3.00$x10^3$cfug^{-1}) showed no significant variation with pink perch. Bacterial count was least in silver belly (2.33×10^5cfu g^{-1}). There was no significant variation in the bacterial count of fresh water fish sticks after 30 days of storage, but variation between marine fish stick was significant, with silver belly showing significantly low bacterial count.

After 45 days of storage, silver belly (4.00×10^5cfug^{-1}) showed significantly low bacterial count and the increase in katla (4.33 $x10^5$cfug^{-1}) showed no significant variation with silver belly. Significantly high bacterial count was observed in stick made of pink perch (6.66×10^5cfu g^{-1}) followed by tilapia (5.66 $x10^5$cfug^{-1}) and the variation observed between these two fish sticks was also significant. A significant variation was observed in the bacterial population of fish stick made from marine and fresh water fish after 45 days of storage.

After 60 days of storage, maximum bacterial count was found in all fish sticks. Pink perch showed highest bacterial count (9.00 x10^5cfug^{-1}) which showed no significant variation with the increase in bacterial count of tilapia (8.33x10^3cfug^{-1}) sticks. Bacterial count in pink perch was significantly high, when compared to katla (7.66 x10^5cfug^{-1}) and silver belly (7.33x10^5cfug^{-1}). Least bacterial count was observed in silver belly. There was a significant variation in the bacterial count of marine fish sticks but not with fresh water fish sticks (Fig 15).

The fungal count of the stored sticks are presented in Table 20. Initially there was no fungal growth in the sticks. Fungal growth observed in tilapia and katla was 0.66×10^3cfu g^{-1} after 15 days of storage. The maximum fungal growth was observed in pink perch (1×10^3cfu g^{-1}) and minimum in silver belly (0.33×10^3cfu g^{-1}). After 15 days of storage there was no significant variation in the fungal count of the sticks. After 30 days of storage, there was an increasing trend in the fungal growth in all the sticks, minimum count being in silver belly (1.00×10^3cfu g^{-1}) and maximum in pink perch and tilapia (1.66×10^3cfu g^1) but the variation observed was not significant.

After 45 days of storage the fungal growth increased to 2.66×10^3cfu g^{-1} in silver belly which showed no significant variation with the increased fungal count in tilapia (3.16 x10^3cfug^{-1}) and katla (3.33 x10^3cfug^{-1}). Fungal count was significantly high in pink perch (4.66x10^3cfug^{-1}) and tilapia showed no significant variation with that of pink perch. No significant variation was observed in the fungal growth of fresh water fish stick after 45 days of storage but variation between marine fish stick was significant, with silver belly showing significantly low fungal count.

Maximum storage period of 60 days showed maximum fungal count in all fish sticks. Pink perch showed the highest fungal count of 7.33×10^3cfu

g^{-1} followed by 6.66×10^{3}cfu g^{-1} in tilapia and the variation was not significant. Least fungal count after 60 days of storage was in silver belly (5.33×10^{3}cfu g^{-1}). The variation observed in the fungal growth of fresh water stick was not significant but marine water fish stick showed significant variation (Fig 16).

The yeast count of the stored fish sticks are presented in Table 21. Upto 30 days of storage, no yeast population was observed. After 45 days of storage maximum yeast population was observed in stick made of pink perch (1.00×10^{3}cfug^{-1}) and minimum in silver belly and katla (0.33×10^{3}cfu g^{-1}). Stick made of tilapia had 0.66×10^{3}cfu g^{-1} of yeast population. There was no significant variation in the yeast count after 45 days of storage. After 60 days of storage the yeast population increased to 2.00×10^{3}cfu g^{-1} in pink perch stick and to 1.00×10^{3}cfu g^{-1} in silver belly. The yeast population after 60 days in marine stick showed significant variation but variation observed in fresh water fish stick was not significant (Fig 17).

Table 19. Total bacterial population of fish stick during storage

Sl No	Fish varieties	Bacteria (x10^5cfug^{-1}) Storage period				
		Initial	15 days	30days	45 days	60 days
1	Tilapia	1.00^{ab}	1.66^{a}	3.33^{a}	5.66^{b}	8.33^{ab}
2	Katla	1.00^{ab}	1.33^{ab}	3.00^{ab}	4.33^{c}	7.66^{bc}
3	Pink perch	1.33^{a}	2.00^{a}	3.66^{a}	6.66^{a}	9.00^{a}
4	Silver belly	0.33^{b}	0.66^{b}	2.33^{b}	4.00^{c}	7.33^{c}

Values having different super script differ significantly at 5% level

DMRT column wise comparison

Table 20. Total fungal population of fish stick during storage

Sl No	Fish varieties	Fungus (x10^3cfug^{-1}) Storage period				
		Initial	15 days	30days	45 days	60 days
1	Tilapia	Nil	0.66^{a}	1.66^{a}	3.66^{ab}	6.66^{ab}
2	Katla	Nil	0.66^{a}	1.33^{a}	3.33^{b}	5.66^{bc}
3	Pink perch	Nil	1.00^{a}	1.66^{a}	4.66^{a}	7.33^{a}
4	Silver belly	Nil	0.33^{a}	1.00^{a}	2.66^{b}	5.33^{c}

Values having different super script differ significantly at 5% level

DMRT column wise comparison.

Table 21. Total yeast population of fish stick during storage

Sl No	Fish varieties	Yeast ($x10^3 cfug^{-1}$)				
		Storage period				
		Initial	15 days	30days	45 days	60 days
1	Tilapia	Nil	Nil	Nil	0.66^{a}	1.66^{ab}
2	Katla	Nil	Nil	Nil	0.33^{a}	1.33^{ab}
3	Pink perch	Nil	Nil	Nil	1.00^{a}	2.00^{a}
4	Silver belly	Nil	Nil	Nil	0.33^{a}	1.00^{b}

Values having different super script differ significantly at 5% level

DMRT column wise comparison

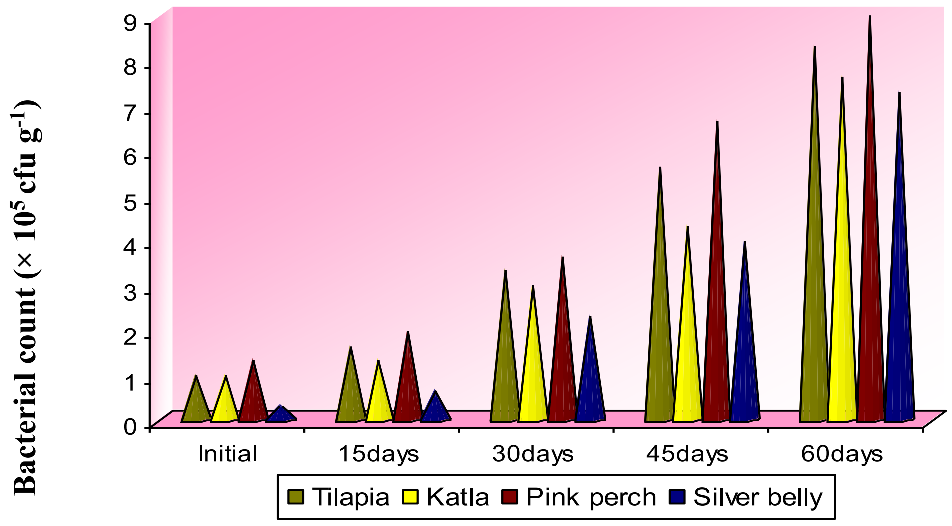

Fig.15. Bacterial population of stick during storage

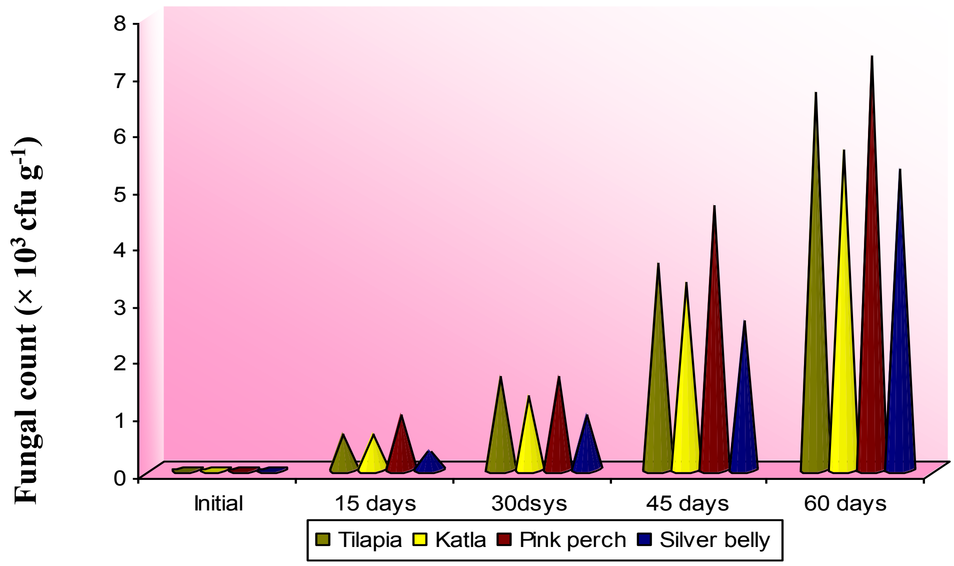

Fig.16. Fungal population of stick during storage

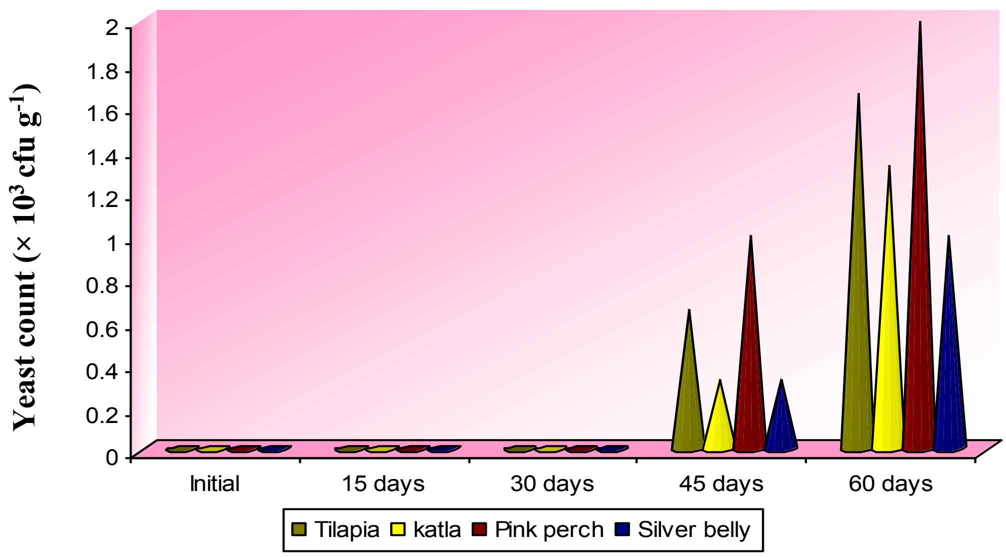

Fig.17. Yeast population of stick during storage

4.5. CALCULATED NUTRITIVE VALUE OF THE PRODUCTS PER PACKET

Nutrients like protein, calcium, phosphorus; iron and vitamin A content of fish products like cutlets (20g) and sticks (25g) were computed using the analysed nutritive value of the fish muscle extracted from the four varieties and the values from the food composition table (Gopalan *et al.,* 1989) for the other ingredients used. In each packet 4 numbers of cutlets (80g) and sticks (100g) were packed. The results are presented in Tables 22 and 23.

4.5.1. Cutlets

4.5.1.1. Protein

Protein content of fish cutlet was found to be 2.98g (11.92g/packet) in tilapia which had the highest protein content and lowest in pink perch fish cutlet (2.48g.9.92g/packet). Statistically there was no significant variation in the protein content of fish cutlet made from tilapia and katla but significant variation was observed between pink perch and silver belly.

4.5.1.2. Calcium

Calcium content of fish cutlet, varied from 72.84mg (291.36mg/packet) in katla to 124.56mg (498.24mg/packet) in pink perch. Statistically significant variation was observed in the calcium content of all fish cutlets.

4.5.1.3.Phosphorus

Maximum phosphorus was observed in silver belly fish cutlet (95.50mg.382mg/packet) followed by tilapia (67.54mg.270.16mg/packet). Katla and pink perch fish cutlets were found to have 40.62mg (162.48mg/packet) and 40.55mg (162.22mg/packet) phosphorus respectively. Statistically no significant variation was observed in cutlets made of katla and pink perch.

Table.23. Computed nutritive value of fish stick

Fish varieties	Nutrients									
	Protein (g)		Calcium (mg)		Phosphorus (mg)		Iron (mg)		Vitamin A (µg)	
	PS (25g)	PP (100g)	PS (25g)	PP (100g)	PS (25g)	PP (100g)	PS (25g)	PP (100g)	PS (25g)	PP (100g)
Tilapia	4.09[a]	16.36[a]	108.96[c]	435.84[c]	91.11[b]	364.44[b]	0.64[b]	2.56[b]	17.25[b]	66.00[b]
Katla	3.89[b]	15.56[b]	102.95[d]	411.8[d]	53.98[c]	215.92[c]	0.53[c]	2.12[c]	18.24[a]	72.96[a]
Pink perch	3.29[d]	13.16[d]	174.53[a]	698.12[a]	53.90[c]	215.60[c]	0.68[a]	2.72[a]	15.34[c]	61.36[c]
Silver belly	3.72[c]	14.88[c]	136.16[b]	544.64[b]	129.92[a]	519.68[a]	0.71[a]	2.84[a]	15.41[c]	61.64[c]

PS- Per Stick

PP- Per Packet

Values having different super script differ significantly at 5% level

DMRT column wise comparison

Table.22.Computed nutritive value of fish cutlet

Fish varieties	Nutrients									
	Protein (g)		Calcium (mg)		Phosphorus (mg)		Iron (mg)		Vitamin A (µg)	
	PC (20g)	PP (80g)	PC (20g)	PP (80g)	PC (20g)	PP (80g)	PC (20g)	PP (80g)	PC (20g)	PP (80g)
Tilapia	2.98[a]	11.92[a]	77.18[c]	308.72[c]	67.54[b]	270.16[b]	0.69[b]	2.76[b]	22.56[b]	90.24[b]
Katla	2.91[a]	11.64[b]	72.84[d]	291.36[d]	40.62[c]	162.48[c]	0.62[c]	2.48[c]	23.28[a]	93.12[a]
Pink perch	2.48[c]	9.92[d]	124.56[a]	498.24[a]	40.55[c]	162.22[c]	0.72[a]	2.88[a]	21.96[c]	87.84[c]
Silver belly	2.79[b]	11.16[c]	93.96[b]	375.84[b]	95.50[a]	382[a]	0.74[a]	2.96[a]	21.23[c]	84.92[c]

PC- Per Cutlet

PP- Per Packet

Values having different super script differ significantly at 5% level

DMRT column wise comparison

4.5.1.4. Iron

Iron content of fish cutlet ranged between 0.62mg (2.48mg/packet) and 0.74mg (2.96mg/packet) with the highest iron content in silver belly and lowest in katla. Statistically no significant difference was observed in the iron content of pink perch and silver belly fish varieties but a significant variation was observed in tilapia and katla.

4.51.5. Vitamin A

Vitamin A of fish cutlet varied from 21.23µg (87.84 µg/packet) in silver belly to 23.28µg (93.12 µg/packet) in katla. Significant variation was observed in the vitamin A content of tilapia and katla and but pink perch and silver belly had no significant variation.

4.5.2. Fish sticks

Nutritive value of fish stick is presented in Table 23.

4.5.2.1.Protein

Protein content of fish stick was found to be highest in tilapia (4.09g.16.36g/packet) and lowest in pink perch (3.29g.13.16g/packet). Statistically protein content of fish stick varied significantly among the four varieties.

4.5.2.2. Calcium

Calcium content was observed to be maximum in pink perch (174.53mg.698.12mg/packet) followed by silver belly (136.16mg.544.64mg/ packet). Fish stick made of tilapia and katla were found to contain 108.96mg (435.84mg/packet) and 102.95mg (411.8mg/packet) calcium respectively. Statistically, significant variation was observed between the four varieties in calcium content.

4.5.2.3.Phosphorus

Phosphorus content of fish stick varied from 53.90mg (215.60mg/packet) in pink perch to 129.92mg (519.68mg/packet) in silver belly. Statistically significant variation was observed in the phosphorus content of tilapia and katla and also between pink perch and silver belly but the variation observed between katla and pink perch was not significant.

4.5.2.4. Iron

Silver belly showed the highest value for iron (0.71mg.2.84mg/packet). Iron content was lowest in stick made of katla (0.53mg.2.12mg/packet). Statistically significant variation was observed in the iron content of fish stick made of tilapia and katla and but no significant variation was observed in pink perch and silver belly fish stick.

4.5.2.5.Vitamin A

Vitamin A of fish stick varied from 15.34µg (61.36µg/packet) in pink perch stick to 18.24µg (72.96µg/packet) in katla. Statistically significant variation was observed in vitamin A content of tilapia and katla fish stick, but no significant variation between pink perch and silver belly.

Discussion

5. Discussion

The discussion pertaining to the study entitled "Quality evaluation of value added products with marine and fresh water fish" is presented under the following headings.

5.1 Yield and chemical constituents of fresh fish muscle.
5.2 Quality aspects of the products
5.2.1 Peroxide value of the products during storage
5.2.2 Organoleptic qualities of the products
5.2.3 Total microbial count of the products during storage
5.3 Calculated nutritive value of the products per packet

5.1. Yield and chemical constituents of fresh fish muscle.

The yield of fish muscle was found to be more in fresh water fish like katla (78 per cent) and tilapia (76 per cent). This is an important factor to be considered in fish processing industry because minced fish flesh is used as an intermediate product for fabricated foods including fish sausage, fish burger and similar products like cutlet and stick.

In the present study, highest moisture content was observed in pink perch (81.39 per cent). This was in confirmation with the findings of Reddy *et al.* (1990), Sarma *et al.* (1998) and Jayakumari *et al.* (2006) who reported almost similar moisture content of 80 to 82.34 per cent in pink perch. The fresh water fish tilapia had a moisture content of 78.83g $100g^{-1}$, which was slightly lower than the moisture content in tilapia fish (81.76 per cent) reported by Giri *et al.* (1983). Katla and silver belly fish had a moisture content of $77.50g100g^{-1}$ and $75.50g100g^{-1}$ respectively. The result obtained by Nair and Suseela (2000) is in line with the present findings (76.30

per cent and 74.70 per cent). The moisture content of fish varied significantly with species. Similar finding was also reported by Nair (2002).

Among the fish varieties highest fat content of $3.74g100g^{-1}$ was found in pink perch. The fat content of this fish variety was within the range reported by Reddy *et al.* (1990) and Jayakumari *et al.* (2006), but this value was slightly higher than the findings of Sarma *et al.* (1998). Silver belly had the lowest fat content of $1.78g100g^{-1}$. This result obtained is close to the value ($1.6g100g^{-1}$) reported by (Gopalan *et al*., 1989). In case of fresh water fish varieties, tilapia showed significantly high fat content ($2.63g\ 100g^{-1}$). This was slightly higher than the fat content of tilapia as reported by Giri *et al.* (1983) and Rahman *et al.* (2000). The above authors indicated a fat content in the range of $0.589g100g^{-1}$ to $2.01g\ 100g^{-1}$in tilapia fish. However, Gopakumar (1975) reported a slightly higher fat content ($3.79g100g^{-1}$) in tilapia. Katla had a fat content of $2.5g100g^{-1}$. This result ($2.4g100g^{-1}$) is in line with the findings of Gopalan *et al.* (1989).

There was significant variation in the fat content of the four fish varieties. The fat content of fish depends upon the factors like season, sex, and maturity as reported by Manay and Shadaksharaswamy (1998). Different species of fish showed variation in fat content. This was also supported by Gopakumar (2002). Lim and Low (2003) also reported that fat content of fish varied from species to species. Generally fish fats are mainly unsaturated and this plays an important role in preventing the development of cardiac diseases.

Among the four fish varieties, highest protein content was observed in the fresh water fish variety tilapia ($20.75g100g^{-1}$). Giri *et al.* (1983) and Nair and Suseela (2000) reported a similar protein content in tilapia ($20.47g\ 100g^{-1}$). The result obtained for the protein content of katla fish ($19.60g\ 100g^{-1}$) was slightly higher than that obtained by Quasim (1983) who reported a protein content of 14.06g $100g^{-1}$ in katla fish. However Gopalan *et al.* (1989) and Nair and Suseela (2000) reported similar protein content in the range of 19.50 to 19.60 g $100g^{-1}$ in katla fish. Silver belly had a protein content of 18.66g $100g^{-1}$, and this is close to the value reported by Nair and Suseela (2000) and Gopalan *et al.* (1989). They reported a protein content of 18.70 g $100g^{-1}$ and 19.2 g $100g^{-1}$ respectively. Pink perch had the lowest protein content of 16.25g $100g^{-1}$. Reddy *et al.* (1990), Jayakumari *et al.* (2006) and Sarma *et al.* (1998) reported almost similar protein content in the range of 16.18 to 17.08g $100g^{-1}$ in pink perch. Variations observed in the protein content between the four fish varieties were also significant. Protein content was found to be significantly high in fresh water fish varieties.

Calcium was found to be significantly high in marine fish. The marine fish pink perch had the highest calcium content of $943.25mg100g^{-1}$. Similar value was reported by Reddy *et al.* (1990). The calcium content of silver belly was 728.40 $mg100g^{-1}$ which was close to ($715mg100g^{-1}$) as reported by (Gopalan *et al.,* 1989). Among the fresh water fish varieties, tilapia had a higher calcium content of $575.93mg100g^{-1}$, which was lower than the calcium content in tilapia fish ($585.2mg100g^{-1}$) reported by Gopakumar (1997). Katla had the lowest calcium content of 542.26mg $100g^{-1}$. Gopalan *et al.* (1989) and Gopakumar (1997) reported a calcium content in the range of 495.2 to 530mg $100g^{-1}$ in katla fish. A significant variation was observed in the calcium content of fish varieties.

Highest phosphorus content was observed in marine fish variety silver belly (674.81 mg $100g^{-1}$). Gopalan *et al.* (1989) reported slightly higher phosphorus content (741mg $100g^{-1}$) in silver belly. Pink perch had the lowest phosphorus content of 248.89 mg $100g^{-1}$, and similar values were reported by Reddy *et al***.** (1990) in pink perch. Phosphorus content of fresh water fish tilapia was found to be 457.42mg100

g^{-1}. Giri *et al*. (1983) reported a similar phosphorus content of 445.60 mg $100g^{-1}$ in tilapia fish, but Gopakumar (1997) reported a lower phosphorus content of 249.38 mg $100g^{-1}$ in tilapia. Katla had a phosphorus content of 249.38mg $100g^{-1}$and Gopalan *et al.* (1989) and Gopakumar (1997) also reported almost similar phosphorus content in katla fish. Generally small fishes were found to be rich in phosphorus. Silver belly is the smallest among the four varieties selected and Tarr (2002) reported that small fish eaten with bone are rich sources of phosphorus. The variations observed between the four fish varieties were also significant. The results revealed that consumption of silver belly fish with small bones is a rich source of calcium and phosphorus.

Marine fish were found to contain significantly high amount of iron when compared to fresh water fish varieties. Here silver belly had the highest iron content of 2.30 mg $100g^{-1}$, which is in line with the findings of Gopalan *et al.,* 1989, who reported an iron content of 2.20 mg $100g^{-1}$ in silver belly fish and 2.14 mg $100g^{-1}$ in pink perch. The lowest iron content was found to be in fresh water fish katla (1.27 mg $100g^{-1}$). Gopakumar (1997) also reported almost similar iron content in the range of 0.9 to 1.0 mg $100g^{-1}$ in katla fish. Tilapia had an iron content of 1.87 mg $100g^{-1}$, which is in line with the findings of Gopakumar (1997) but Giri *et al.* (1983) reported a higher iron content of 3.14 mg $100g^{-1}$ in tilapia fish. There was a significant variation in the iron content of the four fish varieties.

Vitamin A content was found to be high in fresh water fish varieties. Highest and lowest vitamin A content was observed in katla (96.28µg $100g^{1}$) and silver belly (80.43µg $100g^{-1}$) respectively. Tilapia and pink perch had a vitamin A content of 90.77µg $100g^{-1}$, 86.06µg $100g^{-1}$ respectively. Tarr (2002) reported that Vitamin A in fish varied between 60µg $100g^{-1}$ to 800µg $100g^{-1}$. Jishy (2004) reported that marine fish like *veluri, netholi* and *flat fish* had a vitamin A content ranging from 60.87µg $100g^{-1}$ to 88.93 µg$100g^{-1}$. Maage *et al.* (1991) reported that vitamin A content in fish varied between 15µg $100g^{-1}$to 3000µg $100g^{-1}$ depending on the species. Among the four fish varieties there was a significant variation in the vitamin A content.

Highest peroxide value was observed in pink perch (0.17meq $100^{-1}g$) Reddy (1990) and Jayakumari *et al.* (2006) reported almost similar peroxide value in the range of 0.11 to 0.13meq $100g^{-1}$ in pink perch fish. But Sarma *et al.* (1998) noted a higher peroxide value of 0.62meq $100g^{-1}$ in pink perch fish. Highest Peroxide value was observed in katla (0.15meq$100g^{-1}$) and the lowest in silver belly (0.13meq $100g^{-1}$). Significant variation was observed in the peroxide value of the four different fish varieties. The variation may be due to varietal difference and due to difference in the fat content (Jishy, 2004). Here also the peroxide value was significantly high in pink perch which also had the highest fat content.

Minerals like calcium, phosphorus and iron were found to be significantly high in marine fish whereas protein and vitamin A were high in fresh water fish. Fat content was highest in pink perch followed by the fresh water variety tilapia.

5.2. QUALITY ASPECTS OF THE PRODUCTS

5.2.1. Peroxide value of the products during storage

In the present study, an increase in the peroxide value of the fish products *viz.,* cutlet and stick were noticed during the storage period. In fish cutlet, during the initial period maximum peroxide value was in pink perch (1.09meq kg^{-1}) and minimum in silver belly (0.83meq kg^{-1}). During storage, there was a gradual increase in the peroxide value in all fish cutlets. After 60 days the peroxide value varied from 3.32meq kg^{-1} to 4.14meq kg^{-1} in silver belly and pink perch being the minimum and maximum respectively. In the case of sticks also the highest peroxide value of 1.21meq kg^{-1} was observed in pink perch during initial period which increased to 4.05meq kg^{-1} after 60 days of storage. The lowest peroxide value was in silver belly (0.92meq kg^{-1}) stick initially, but after 60 days of storage the lowest peroxide value was in katla (3.20meqkg^{1}) but the variation was not significant with that of silver belly (3.26meq kg^{-1}).

Significant variations were observed in the peroxide value of fish products like cutlet and stick. Pink perch had the highest peroxide value. This may be because of higher initial fat content in pink perch. Lowest peroxide value was in silver belly because it had the lowest initial fat content. Although there was an increase in the peroxide value with 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 the selected fish varieties can be recommended for preparing stick and cutlet and can be stored under frozen condition for two months without becoming rancid. Increase in peroxide value may be attributed to the oxidation of polyunsaturated fatty acids in fish lipids by the catalytic activity of common salt, iron and impurities that are probably present in the crude salt, proxidant action of moisture and also auto oxidation by atmospheric oxygen (Amano, 1962; Wheaton and Lawson, 1985). Increase in peroxide value of fish pickle during storage was also reported by Jishy (2004).

The changes that occur during the manufacture and storage of fish products have received much attention. The fat in fish begins to oxidize the moment the muscle is extracted. Some cooked fish is easily susceptible to rapid oxidation due to high heme content. The oxidation of fat can be delayed or retarded by the addition of antioxidants at the earliest possible stage of processing.

5.2.2. Organoleptic qualities of the products

Organoleptic qualities can be defined as qualities affecting the body organs or senses particularly, of a combination of taste and aroma (Sindhu, 1995). Sensory evaluation of food is assumed to be increasing significantly as this provides information which may be utilized for the development of the product and its improvement (Nair, 1999).

In the present study, fish cutlets with katla had the highest mean score for appearance (8.66) and lowest in silver belly (8.55) initially which increased to 8.7 and 8.56 after 30 days of storage. After 45 days of storage, appearance of the cutlets were not acceptable. Regarding colour, cutlet made of tilapia had the highest mean score initially (8.73) followed by katla (8.69). Among marine fish, silver belly had a higher mean score of 8.65.Colour of the cutlets were acceptable up to 45 days of storage. In the case of flavour the maximum and minimum score was for katla (8.70) and silver belly (8.55) during the initial period. The mean score for flavour was decreased to 3.55 and 2.73 for katla and silver belly respectively after 60 days of storage. Peroxidation of the fat might have contributed to the decreased flavour of cutlets during storage. Considering the texture, cutlet made with katla had high initial score for texture (8.63) followed by tilapia (8.46). During the entire storage period a declining trend was observed in the score for texture except for katla which showed an increase in the score after 30 days of storage (8.97). The mean score for taste ranged from a minimum in silver belly (8.30) to a maximum in katla (8.53) during initial period. After 15 days the score for taste was increased in all cutlets with maximum score in katla (8.76) and minimum in silver belly (8.36). After this a declining trend was observed in the mean score for taste. Taste of the cutlets were also acceptable up to 30 days of storage.

Initially, overall acceptability was also highest in katla cutlet (8.73) which was contributed by the higher scores for quality attributes like appearance, flavour, texture and taste. After 60 days of storage, overall acceptability was highest in katla (3.31) followed by tilapia (3.24). The silver belly fish cutlet had the lowest score for all the quality characters namely appearance, colour, flavour, texture and taste at the starting of the experiment and also during the end of the storage period. The fleshy nature of katla fish might have contributed to their organolepic qualities. Many fish products having firm and meaty texture could be prepared with katla mince. Cutlets were acceptable with good sensory qualities only up to 45 days of storage. This is in line with the finding of Raju *et al.,* (1999) and Joseph *et al.* (1993) who reported that ready to serve fried prawns when stored were found to be acceptable up to 55 days of storage.

In the case of fish stick, the highest mean score for appearance was for tilapia (8.76) followed by katla (8.66). Lowest initial score was in silver belly (8.36). The score has decreased to 4.14 in tilapia after 60 days of storage. The least score was for silver belly (3.89). Appearance of sticks were acceptable when stored up to 30 days. Colour of the sticks were also highest in tilapia initially (8.75) and at the end of the storage period (3.80). This was followed by katla stick (8.73 and 3.72 respectively). Colour of sticks were acceptable up to 45 days of storage. Regarding the flavour, katla stick had significantly higher score (8.72) compared to other fish sticks during initial period and also after the storage period (3.90). Flavour was also acceptable upto 45 days of storage. In the case of texture, maximum score was for stick made of katla at the beginning (8.37) and end (2.75) of storage and least in silver belly (8.13 and 2.47 respectively). Considering taste, katla had the highest mean score initially and finally (8.60 to 2.65 respectively) followed by tilapia. Least score for taste was in silver belly (8.43 to 2.44 respectively). Taste of the stored products were acceptablility upto 30 days of storage. Considering all the quality criteria, overall acceptability was also highest in katla sticks initially (8.63) and finally (3.28) followed by tilapia. Silver belly sticks had the least overall acceptability upto 30 days of storage. The product fish stick had good flavour because of monosodium glutamate, which improved the flavour of fish stick. This is in line with the findings of Nair *et al.* (1982) who reported an improvement of flavour of fish fingers by the addition of monosodium glutamate.

Tokur *et al.* (2004) also reported a decreasing trend in the sensory characters in the case of fish burger from tilapia during storage. In the present study it was found that katla fish was the most suitable fresh water fish ideal for fish cutlet with good organoleptic qualities with a shelf life of 45 days under frozen condition. Raju *et al.* (1999) found that ready to fry fish cutlet from pink perch was acceptable even after a storage period of 27 weeks at -20^{0}c. Sensory analysis of fish fingers prepared from sardine during frozen storage for 8 months at -18^{0}c indicated that at the end of the frozen storage it could not be consumed because of its rancidity (Cakli *et al.,* 2005).

5.2.3. Total microbial count of the products during storage

The quality of fish products during storage depend on the total microbial flora present in them. Many microorganisms causing food borne illness may grow in foods under favourable conditions. According to Bryan (1974) and Nanu *et al.* (1992), several factors such as quality of raw materials, storage temperature, processing temperature, storage containers, processing techniques, the environment in which it is processed, etc will have an effect on microbial quality of processed foods.

In the present study, a gradual increase in the bacterial population was observed in fish cutlets, during storage. Maximum bacterial count was for pink perch initially (1.33 $x10^5cfug^{-1}$) which increased to 3.33 $x10^5cfug^{-1}$ during 30 days and finally to 10.66 $x10^5cfug^{-1}$. Minimum bacterial load was in katla and silver belly both at the beginning and end of storage. There was no significant variation in the bacterial load of fresh water fish cutlet but significant variation was observed in marine fish cutlet with pink perch showing significantly high bacterial load. The fungal population was detected only after the 15th day of storage, which showed no significant variation, but after 30 days pink perch showed (3.33 $x10^3cfug^-1$) significantly high fungal population which increased to a maximum of 7.66 $x10^3cfug^{-1}$ after 60 days of storage. Yeast population was noticed after 45th and 60th day of storage. The maximum yeast population was in pink perch cutlet (1.33 $x10^3cfug^{-1}$ to 2.66$x10^3cfug^{-1}$) and minimum was observed in silver belly (0.33 $x10^3cfug^{-1}$ to 1.33 $x10^3cfug^{-1}$) after 45 and 60 days 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 highest microbial load was observed in cutlet made of pink perch. It might be due to the high moisture content of pink perch when compared with other varieties. The lowest microbial load was observed in cutlet made of silver belly followed by katla. Joseph *et al. (*1984) reported that the total plate count of fish cutlet prepared from the minced fish lizard varied from 1.5$x10^5$ $cfug^{-1}$ to 9.2 $x10^5$ $cfug^{-1}$ during 11 weeks of storage. Raju *et al.* (1999) reported that for the cutlets prepared from pink perch stored for 27 weeks, the microbial load was within the acceptable range. According to Mukundan (2000) the maximum acceptable total plate count of fish products for human consumption is 5$x10^5cfug^{-1}$. According to this in the present study the cutlets are microbiologically safe only up to 30 days of storage

The shelf life of any product depends on the absence of harmful microorganisms. The microbial growth or microbial damage of a product is dependant upon certain factors both chemical and physical which are favorable for the growth. (Fraizer and Westhoff, 1974). In fish sticks, the bacterial count varied from $0.33x10^5$ to $7.33x10^5$cfu g^{-1} for silver belly initially and after 60 days respectively. After 60 days of storage bacterial count was maximum in pink perch stick (9.00 $x10^5$cfug^{-1}). Fungal contamination was observed only after 15 days of storage the highest being in pink perch (1.00 $x10^5$cfug^{-1}) at 15 days and 60 days of storage (7.33 $x10^5$cfug^{-1}). Upto 30 days storage the variation observed in fungal population in fish sticks were not significant but after that pink perch showed significantly high fungal load. Yeast population was observed only after 45 days of storage and that too without any significant variation with different fish sticks. Maximum yeast population was in pink perch (2.00 $x10^3$cfug^{-1}) after 60 days of storage.

In the present study, the shelf life of the fish products with acceptable maximum total plate count was 30 days. After 30days of storage, the products had a total microbial count higher than the acceptable level (5x 10^5cfug^{-1}) reported by (Mukundan, 2000) and also higher peroxide value which is reflected in their lowered sensory qualities. Hence the products after 30 days of storage cannot be used for human consumption.

Handling of fish in good and hygienic condition is of paramount importance. Personal hygiene of the workers is also very important since it play an important role in the production of wholesome products. Rapid chilling and keeping the internal temperature of fish slightly below 0^0c will maintain its prime quality. In the present study the shelf life of the products can be further extended by improving the limited processing conditions in the laboratory including uninterrupted power supply during storage.

5.3 CALCULATED NUTRITIVE VALUE OF THE PRODUCTS PER PACKET

In the present study, nutritive value of fish cutlet (20g/cutlet) was computed and the highest protein content was in tilapia (2.98g.11.98g/packet) and lowest (2.48g.9.92g/packet) in pink perch. Katla had a protein content comparable to that of tilapia (2.91g.11.64g/packet). The maximum calcium content was observed in pink perch (124.56mg.498.24mg/packet) and minimum in katla (72.84mg.291.36mg/ packet). The phosphorus content varied from 40.55mg (162.22mg/packet) to 95.50mg (382mg/packet) for pink perch and silver belly cutlet. In the case of iron, the highest value was for fish cutlet made of silver belly (0.74mg.2.96mg/packet) and lowest for katla (0.62mg.2.48mg/ packet). Maximum vitamin A was found in katla (23.28µg.93.12µg/packet) and minimum in silver belly (21.23µg.84.92µg/packet) fish cutlet. These values were found to be almost similar to the nutritive value of fish cutlet reported by Huda *et al.* (2001). He had reported a level of 17 to 19 per cent of protein for shark fish ball.

In the case of fish stick, (25g/stick) the protein content was significantly high in tilapia (4.09g.16.36g/packet) followed by katla (3.89g.15.56g/packet). Maximum calcium content was found in pink perch (174.53mg.698.12mg/packet) and minimum in katla (102.95mg.411.8mg/packet). The phosphorus content ranged between 53.90mg (215.60mg/packet) to 129.92mg (519.68mg/packet) in stick made of pink perch and silver belly respectively with significant variation. Significantly high values of iron was observed in silver belly (0.71mg.2.84mg/packet), followed by pink perch (0.68mg.2.72mg/packet). Maximum vitamin A was found in stick made of katla (18.24µg.72.96µg/packet) and minimum in silver belly (15.41µg.61.36µg/packet). Shukla and Singh (2004) reported that the components of most sea foods fall in a range of about 14 per cent to 20 per cent protein and 1.0 to 1.8 per cent ashes. Tokur *et al*. (2004) found that the ratio of crude protein to crude ashes in tilapia burger were 17.82 per cent and 2.56 per cent respectively. Sing and Balange (2005) reported almost similar values for the nutritive value in pink perch surimi. In the present study products made with marine fish was found to be high in minerals like calcium, phosphorus and iron whereas fresh water fish were found to be high in protein and vitamin A.

From the study it is clear that the marine fish varieties had higher minerals like calcium, iron and phosphorus compared to fresh water fish varieties. But fresh water fish showed higher protein and vitamin A and also a high yield of fish muscle. Organoleptic evaluation also showed that, maximum score for the products were for fresh water fish products. The marine fish products showed comparatively higher microbial population than fresh water fish products.

Summary

6. SUMMARY

The present study entitled "Quality evaluation of value added products with marine and fresh water fish" was an attempt to evaluate the nutritive value of four fish varities namely pink perch (*Nemipterus raponicus*) and silver belly (*Gerres filamentoses*) belonging to marine species and tilapia (*Tilapia mossambica*) and katla (*Catla catla*) of fresh water species. The study was also aimed to develop value added products like cutlet and stick from selected marine and fresh water fish varieties and to assess the acceptability and shelf life of the developed products.

The weight of fish muscle was found to be more in fresh water fish *viz.,* katla (78 per cent) and tilapia (76 per cent). Moisture content of fish muscle varied from 75.50g100g^{-1} (silver belly) to 81.39g100g^{-1} (pink perch).

Pink perch had the highest fat content of 3.74g100g^{-1} followed by tilapia (2.63g100g^{-1}) and katla (2.5g100g^{-1}). Tilapia had the highest protein content (20.75g100g^{-1}) and pink perch (16.25g100g^{-1}) the lowest.

Calcium content varied from 542.26mg100g^{-1} in katla to 943.25mg100g^{-1} in pink perch. The highest iron content was in silver belly (2.30mg100g^{-1}) and lowest in katla (1.27mg100g^{-1}). Phosphorus content was also highest in silver belly (674.81mg100g^{-1}) whereas the lowest value was observed in pink perch (248.89mg100g^{1}).

The vitamin A content in fish varied from 80.43µg 100g^{-1} (silver belly) to 96.28µg 100g^{-1} (katla). In the case of peroxide value, pink perch (0.17meq100g^{-1}) recorded the maximum followed by tilapia and katla where the peroxide values were 0.16meq100g^{-1} and 0.15meq 100g^{-1} respectively. Peroxide value was minimum in silver belly (0.13meq100g^{-1}). Peroxide value was significantly high in pink perch which also had the highest fat content.

Peroxide value of fish products like cutlet and stick increased during the storage period. Statistically significant variation was observed in the peroxide value of fish products.

In the case of fish cutlets, the lowest and highest peroxide value was observed in silver belly (0.83meq kg^{-1}) and pink perch (1.09meq kg^{-1}) respectively during the initial period. After 60 days of storage the values increased to 3.32meq kg^{-1} in silver belly and 4.14meq kg^{-1} in pink perch fish cutlet. In the case of fish stick, the maximum peroxide value was observed in pink perch (1.21 to 4.05meq kg^{1}) and minimum in silver belly (0.92 to 3.26meq kg^{-1}) before and after storage.

With regard to organoleptic qualities of fish products like cutlet and stick, a gradual reduction was observed in different quality characters like appearance, flavour, colour, texture, taste and overall acceptability during the storage. Statistical analysis revealed that there was significant variation in those qualities on storage.

With regard to the fish cutlet, katla had the highest overall acceptability throughout the storage period which was contributed by the highest scores in qualities like appearance, flavour, texture and taste and lowest was found in silver belly. In the case of fish stick also the overall acceptability was highest in katla.

Microbial population of the products were found to increase during storage period. In fish cutlets the highest bacterial population was found in pink perch ($1.33x10^5$ to $10.66x10^5$cfug^{-1}) and the lowest ($0.33x10^5$ to 8.33x 10^5cfu g^{-1}) in silver belly during after beginning and end of storage. Fungal growth was observed only after 15 days of storage. After 15 to 60 days, the highest fungal population was found in cutlet made of pink perch ($1.66x10^3$ to $7.66x10^3$cfu g^{-1}) and lowest ($0.66x10^3$ to $6.00x10^3$cfu g^{-1}) in silver belly. Yeast population was observed only after 45 days of storage. The maximum yeast population was found in fish cutlet made of pink perch ($1.33x10^3$cfu g^{-1}) and minimum in silver belly ($0.33.x10^3$cfu g^1) after 45 days of storage period.

In the case of fish stick also, the highest bacterial population ($1.33x10^5$ to 9.00 $x10^5$cfu g^{-1}) was found in pink perch and lowest ($0.33x10^5$ to 7.33 $x10^5$cfu g^{-1}) in silver belly during initial to 60 days of storage. Fungal population was observed only after 15 days of storage and upto 30 days of storage the variation observed in fungal population was not significant but pink perch showed significantly high fungal load of $7.33x10^3$cfug^{-1} after 60 days of storage. The highest yeast population was found in pink perch stick ($1x10^3$cfu g^{-1}) followed by tilapia (0.66x 10^3cfung^{-1}) and lowest in silver belly ($0.33x10^3$cfu g^{-1}) after 45 days of storage.

The highest microbial population was observed in the products made from marine fish varieties compared to fresh water fish varieties throughout the storage period.

The storage period of fish products was extended only up to 2 months since higher microbial load was observed at the end of the 2^{nd} month of storage. The texture of the products was found to be slimy with an unpleasant odour, so the storage period of the fish products were limited to two months.

Two products namely fish cutlet and fish stick were prepared with four fish varieties. The nutritive value of the prepared products (per cutlet and stick) were computed. Nutritive value of fish cutlets revealed a high protein content in tilapia (2.98g.11.92g/packet) followed by katla (2.91g.11.64g/packet). The calcium content varied from 72.84mg (291.36mg/packet) and 124.56mg (498.24mg/packet) in katla and pink perch respectively. The highest phosphorus content was observed in cutlet made of silver belly (95.50mg.382mg/packet) and lowest in pink perch (40.55mg.162.22 mg/packet). Maximum iron content was found in cutlet made of silver belly (0.74mg.2.96mg/packet) and minimum in katla (0.62mg.2.48mg/packet). Vitamin A ranged between 21.23µg (84.92µg/ packet) in silver belly to 23.28µg (93.12µg/packet) in katla.

In the case of fish stick, protein was significantly high in tilapia (4.09g.16.36g/packet) followed by katla 3.89g (15.56g/packet) and lowest in pink perch (3.29g.13.16g/packet). The maximum calcium content was observed in fish stick made of pink perch (174.53mg.698.12mg/packet) and minimum in katla (102.95mg.411.8mg/packet). The phosphorus content varied from 53.90mg (215.60mg/packet) to 129.92mg (519.68mg/packet) in pink perch and silver belly fish stick respectively. Fish stick made of silver belly had significantly high iron content (0.71mg.2.84mg/packet) followed by pink perch (0.68mg.2.72mg/packet). The highest and lowest vitamin A content of fish stick ranged between 18.24µg (72.96µg/packet) and 15.34µg (61.64µg/packet) for katla and silver belly.

From the study it was observed that constituents like moisture, fat, calcium, phosphorus and iron were comparatively high in marine fish products. Peroxide value was also found to be more. Fresh water fish varieties had highest protein and vitamin A content. The yield of fish muscle was also found to be more in fresh water varieties like katla and tilapia. The products made from marine water fish varieties recorded highest peroxide value than fresh water fish varieties probably due to their high fat content. All the organoleptic qualities were superior for the products made from fresh water fish varieties when compared to the marine water fish varieties. The fleshy nature of katla fish and low fat content may be the reason for this high acceptability. Fresh water fish products were found to be highly acceptable compared to marine water fish varieties. The highest microbial population was observed in the products made from marine fish varieties than fresh water fish varieties throughout the storage period. But the shelf life of the products irrespective of fresh water or marine varieties with acceptable maximum total plate count was found to be 30 days. After 30 days the products had a total bacterial load higher than the safe level ($5x10^5 cfug^{-1}$) reported by Mukundan, 2000 and also increased in their peroxide value which was reflected in their lowered sensory qualities. The texture of the products were found to be slimy with an unpleasant odour after two months of storage.

Handling of fish in good and hygienic condition is of paramount importance. Personal hygiene of the workers is also very important since it play an important role in the production of wholesome products. Rapid chilling and keeping the internal temperature of fish slightly below 0^0c will maintain its prime quality. In the present study the shelf life of the products can be further extended by improving the limited processing conditions in the laboratory including uninterrupted power supply.

With the increased demand for ready to prepare/serve products, use of separated meat from inexpensive varieties of fish has assumed considerable importance.

From the study it is obvious that the fresh water fish varieties are also ideal for processing and developing newer products. It will be necessary to expand and strengthen programmes for improving inland fish production also. Fresh water ponds, tanks, irrigation reservoirs and brackish water offer vast potentialities for aquaculture. Considering the low price of these fishes in the domestic market, value addition and its diversification are very much needed for better utilization of such fishes. These value added fish products would accelerate our earning through foreign exchange and also play a major role in the employment generation for weaker section of the society particularly women folk. Thus, in addition to the role of income generation, value addition helps to increase the acceptability of the fishes which are presently under utilized.

References

REFERENCE

Abraham, J. 1998. Traditional methods of process underutilized fish for human consumption. *Fd Res. Int*. 14: 35-42.

Abraham, P. 1991. *Fish Preservation Methods for Advances in Fish Technology*. Fishing News Book Ltd., England, 284p.

Abraham, T.J. and Setty, T.M.R. 1992. Lactic acid bacterial fermentation of prawn pickle. *Indian J. Nutr. Dietet*. 29: 312-316.

Agarwal, G. P. and Hasija, S.K. 1986. *Microorganism in the Laboratory*. Print House India Ltd., Lucknow, 155p.

Agostonic, R. and Carlo, M. 1995. Docosahexanoic acid status and developmental quotient of healthy term infants. *Am. J. Clin. Nutr*. 346: 638p.

Albert and Christine, M. 1999. Fish consumption and risk of sudden cardiac death. *J. Am. Med. Ass*. 279: 23-28.

Aldos, S., Lourence, A., Vanderpart, T., Loten, J.B. and Boom, R.M. 2002. Stability of cured herring oil produced from fresh byproducts: Influence of temperature during storage. *J. Fd Sci.* 67(9): 3311-3318.

Alfonso, S. 1996. Marine oils: The health benefits of n_3 fatty acids. *Nutr. Rev*. 54: 102-108.

Ali, M., Iqbal, F., Salam, A., Iram, S. and Athar, M. 2005. Comparative study of body composition of different fish species from brackish water pond. *Int. J. Enviro. Sci. Technol*. 2(3): 229-232.

Amano, K. 1962. Influence of fermentation on the nutritive value of fish with special reference to fermented fish products of South-East Asia. In: Heen, E. and Kreuzer, R. (eds.), *Fish in Nutrition* (11th ed.). Fishing News Books Ltd., London, pp. 150-154.

Anthony, J.E., Hadgis, P.N., Milan, R.S., Herzfeld, G.A., Taper, J.L. and Ritchey, S.J. 1983. Yields, Proximate composition and mineral content of fin fish and shell fish. *J. Fd Sci. Technol*. 48: 313-314.

AOAC. 1955. *Official Methods of Analysis.* 8th(ed.). Association of Official Analytical Chemists, Washington D.C., 1015 p.

AOAC. 1980. *Official Methods of Analysis. 13th*(ed.). Association of Official Analytical Chemists, Washington D.C., 1018 p.

Arvanitoyannis, L. and Gorris, L.G.M. 1999. Edible and biodegradable polymeric materials for food packaging or coating. In: Fernanda, A.R. and Jorye, C. (eds.), *Processing Food Quality Optimization and Process Assessment*. Concept publishing company, New Delhi, pp. 357-387.

Asha, P.S. and Muthiah, P. 2006. Extention Anxieties. *Fishing chimes* 25(12): 7p.

Ayyappan, A. and Devadasan, K. 2004. Biotechnology of fisheries based food products. *Indian Fd Ind.* 23(2): 26-29.

Balachandan, K.K. 2001. *Post Harvest Technology of Fish and Fish Products.* Indian institute of packaging, Bombay, 58p.

Balachandran, K.K., Gopal, T.K.S. and Vijayan, P.K. 1998. *Aliuminium in Food Packaging*. Indian institute of packaging, Bombay, 670p.

Bang, H.O., Dyerberg, J. and Sinclair, H.M. 1980. The composition of the Eskimo food in North Western Greenland. *Am. J. Clin. Nutr*. 33: 57-61. .

Barber, M.D. 1999. The effect of an oral nutritional supplement enriched with fish oil on weight less inpatients with pancreatic cancer. *Br. J. Cancer* 81: 80-86.

Bari, M.L., Sahib, Y., Kusunoki, H. and Uemura, T. 2000. Preservation of fish cutlet (*Pangasius pangasius*) at ambient temperature. *J. Fd Prot*. 63(1): 56-62.

Basavakumar, K.V., Bhaskar, N., Ramesh, A.M. and Redd, G.V.S. 1998. Quality changes in cultured tiger shrimp (*Penaeus monodon*) during ice storage. *J. Fd Sci. Technol.* 35: 305-309.

Begum, R.M. 2005. *Textbook of Foods, Nutrition and Dietetics*. Sterling publishers Pvt. Ltd., New Delhi, 386p.

Bera, M.B., Singh, C.J., Shrivastava, D.C., Kuaar, K.S. and Sharma, Y.K. 2001. Storage stability of coloured substance in thermally processed dry chilli power. *J. Fd Sci. Technol*. 38:8-11.

Bhatt, D.K. and Tomar, P. 2006. *An Introduction to Food Science Technology and Quality management.* Kalyan publishers, New Delhi, 402p.

Billuzzi, R. and Andrea, N. 1996. Effect of an enteric-coated fish oil preparation on relapses in crohn's disease. *New England J. Med*. 334(24): 1557-1560.

Bindhu, J., Ravishankar, C.N. and Gopal, S.T.K. 2005. Shelf life evaluation of a ready to eat black clam (*Villorita cyprinoids*) product in indigenous retort pouches. *J. Fd Engng*. 78(3): 995-1000.

Bremner. 2002. *Safety and Quality Issues in Fish Processing*. Formerly Danish Institute of Fisheries Research, Denmark, 520p.

Broughton, K. 1997. Reduced asthma symptoms with n-3 fatty acids ingestion are related to 5-series leuktriene production. *Am. J. Clin. Nutr*. 65: 1011-1017.

Bryan, F.T. 1974. Microbiological food hazards of today based on epidemiological information. *Fd Technol*. 28:52-66.

Bykov, V.P. 1985. *Marine Fishes*. Fishing News Books, London, 285p.

Cakli, S., Taskaya, L., Kisla, D., Celik, U., Ataman, C.A., Cadon, A., Kiline, B. and Malik, R.H. 2005. Production and quality of fish fingers from different fish species. *Eur. Fd Res. Technol*. 220(5): 526-530.

Calabrese, N. and Joseph, R. 1999. Fish oil and bipolar disorder. *Archives Gen. psychiatry* 56: 413-414.

Catsberg, C.M.E. and Dommelen, G.J.M.K. 1990. *Food Hand Book*. Ellies Horwood, New York, 382p.

Cho, Y.J., Im, Y.S., Park, H.Y. and Choi, Y.J. 2000. Quality characteristics of Southeast Asian salt fermented fish sauces. *J. Korean Fish. Soc*. 33:98-102.

Christensen, S. and Hagstrap, J. 1999. Heart rate variability and fatty acids content of blood cell membranes: A dose response study with n-3 fatty acids. *Am. J. Clin. Nutr.* 70: 331-337.

Cleland, M. and Leslie, R. 1992. Linoliate inhibits EPA incorporation from dietary fish oil supplements in human subjects. *Am. J. Clin. Nutr*. 55: 395-399.

Clemans, R. 1999. The effect of dietary Omga-3 fatty acid on coronary atherosclerosis. *Ann. Int. Med.* 130: 554-562.

Connor, R. and William, E. 2000. Importance of n_3 fatty acids in health and disease. *Am. J. Clin. Nutr*. 71: 171-175.

Connor, W.E. and Connor, S.L. 2007. The importance of fish and Docosahexanoic acid in Alzheimer diseases. *J. Hum. Nutr. Diet*. 20(3): 275-285.

Dairma, T. 2006. Studies find benefits for fish and omega-3 consumption. *Diabetes Self Manage*. 227p.

Davidow, J. 2006. Benifits of eating fish cut weight risks. *Lancet*. 251: 436-439.

Davies, H.K. 1995. Quality Deterioration. In: Ruiter, A.D. (ed.), *Fish and Fishery Products, Composition, Nutritive Properties and Stability.* CAB International publishers, England, pp.215-242.

Devadasan, K. 2003. *Fish in human nutrition*. In*: Trends and needs in the global and Indian contexts.* Fifth International Food Convention: Innovative Food Technologies and Quality Systems; 5-8, December, 2003, Central Food Technological Research Institute, Mysore. Abstract: 176p.

Devadasan, K. 2003. Value added fish and fishery products. *Fishing chimes* 23(1): 131-136.

Dey, V.K. 2000. Value added cephalopod products in Asia. *Inf. Fish Int*. 5: 43p.

Dobrzanski, Z., Bykowski, P., Iwaniuk, Z., Kolacz, R. and Usydus, Z. 2000. Chemical composition of modified fish meal. Medysina, Weterynaryjna. 58: 63-67.

Dutta, C., Dura, K.C., Sarkar, S. and Chand, B.K. 2004. Storage characteristics of ready to serve fried thelly prawn (*Metapenacus debsoni*) at Ambient Temperature. *Fish. Technol*. 30: 25-28.

Eboh, L., Mepha, H. and Ekpo, M. 2006. Heavy metal contaminants, processing effects on the composition, storage stability and fatty acid profiles of five common commercially available fish species, Local Government Nigeria. *Fd chem*. 97: 490-497.

Eritsland, J. 2000. Safety consideration of polyunsaturated fatty acids. *Am. J. Clin. Nutr.* 71: 197-201.

Essuman, K.M. 1992. Fermented fish in Africa: A study on processing, marketing and consumption. *Fish. Technol*. 29: 80p.

Eunyoung, C. 2001. Prospective study of dietary fat and the risk of age related muscular degeneration. *Am. J. Clin. Nutr*. 73: 209-218.

F.A.O (Food and Agricultural Organisation). 1998. *Fishery Statistics*. Food and Agricultural Organisation, Rome, 321p.

Feruzkhan, F.M. and Preetha, P. 2006. Indian fisheries scenario. A deep into constraints\ needs for its future development. *Fishing chimes* 26(9): 13-15.

Fraser, J. 2006. Fatty fish consumption slashes risk of prostate cancer by 43 percent. *News target 20*(3): 18p.

Fraizer, W.C. and Westhoff, D.C. 1974. Microorganisms in Food. In: Fields, M.L. (ed.), *Food Microbiology.* Tata Mc Graw Hill Publishing Company, New Delhi, 339p.

George, R.M. and Saralaya, K.V. 1993. Effect of thermal process variation on the quality of Indian mackerel, Rastrelliger kanagurta. In: Varghese, T.J., Keshavanath, P., Radhakrishnan, K.V. and Lokeshwar, R.R. (eds.), *The Second Indian Fisheries Forum Proceedings;* 27-31 May, 1990; Asian Fisheries Society, Mangalore, pp. 289-293.

Giannini, D.H., Ciarlo, A.S. and Alaandos, M.E. 2003. Use of solubilized muscle of fish as a binding material in battered and breaded products. *Alimentaria* 40(343): 55-58.

Gildberg, A. 2000. *Utilization of male arctic capelin and Atlantic cod intestine for fish sauce production, evaluation of fermentation conditions.* Norwegian Institute of Fisheries and Aquaculture (NIFA), 9291p.

Giri, T.K.J., Devi, K.S., Bhuvaneswari, D. and Uma, N. 1983. Biochemical evaluation of fish grown in sewage water. *Indian J. Nutr. Dietet*. 20: 186-189.

Goldberg, L. 2007. Health Benefits of Fish Oils. Available: http:// order store, yahoo.com/ cgi-bin/wg-order- cheap boxing. (23^{rd}Aug.2007).

Gopakumar, K. 1975. Fatty acid composition of three species of fresh water fishes. *Fish. Technol*. 12: 21-23.

Gopakumar, K. 1997. *Biochemical Composition of Indian Food Fish.* Central Institute of Fisheries Technology, Cochin, 190p.

Gopakumar, K. 1998. Fish as a source of food for human nutrition and food security. *Indian Fmg.* 50:11-13.

Gopakumar, K. 2002. Fishery products. In*:* Gopakumar, K. (ed.), *Fish Processing Technology.* Indian Council of Agricultural Research, New Delhi, 279p.

Gopal, T.K.S. 1996. Packaging of Fresh and Processed Marine Products. In: *Training Progamme on Quality Control of Sea Foods*, 30 July-14 August, 1996. Central Institutes of Fisheries Technology, Cochin. Abstract: 2

Gopal, T.K.S., Nair, P.G.V., Kandora, M.K., Prabhu, P.V. and Gopakumar, K. 1998. Shelf life of direct anchoviella in flexible packaging material. *Fd Control*. 9: 1-5.

Gopalakrishnan, R. 1998. A consumer view of food safety. In: Growther, J.S. and Marthi, B. (eds.), *Proceedings of the Symposium on the Microbiological Safety of Processed Foods*. 2-3, December, 1996; Oxford and IBH Publishing Company, New Delhi, pp.1-8.

Gopalan, C., Sastri, B.V.R. and Balasubramainian, S.C. 1989. *Nutritive Value of Indian Foods* (Reprint, 2002). National Institute of Nutrition, Hyderabad, 156p.

Govindan, T.K. 1970. Some note worthy miscellaneous marine fishes of India. *Sea Fd Export J*. 2: 19-21.

Govindan, T.K. 1974. Freeze drying of fishery products: Part:V, storage characteristics of ready to serve freeze dried foods. *Fish. Technol*. 11: 146-150.

Govindan, T.K. 1991. *Fish Processing Technology.* Oxford and IBH Publishing Co., New Delhi, 282p.

Hankenson, P. and Jourt, R. 2000. Omega-3 fatty acids enhance ligament fibroblast collagen formation in association with changes in interleukin -6 productions. *Proc. Soc Exp Biol*. *Med.* 223: 89-95.

Harris, S. and William, N. 1998. Reduction of postprandial tri glyceridemia in humans by dietary n-3 fatty acids. *J. lipid Res.* 29(11): 1451-1460.

Hassan, M. and Mathew, S. 1999. Value added products from low cost fishes. *Sea Fd Export J.* 30: 3-4.

Hibbeln, T. and Joseph, R. 1998. Fish consumption and major depression. *Lancet.* 351:1213.

Hodge, H. and Lenda, G. 1996. Consumption of oily fish and childhood asthma. *Med. J. Aust.* 164: 134-140.

Huda, N., Abdullah, A. and Babji, A.S. 2001. Physio chemical properties of Malaysian Fish Balls. *Fish. Technol*. 38: 14-17.

Ismail, M.K. 2002. *Fish How Good are They for Us.* Oxford publishers, London, 185p.

Iyer, T.S.G., Varma, P.R.G. and Rao, C.C.P. 1986. Quality of certain ready to eat fish products of the domestic trade. *Fish. Technol*. 23: 73-77.

Jackson, N.L. 1973. *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd., New Delhi, 299p.

Jayakumari, A., Rathnakumar, K. and Velayuthan, P. 2006. Storage behaviour of washed mince from pink perch (*Nemipterous japanicus*) at 30^0c. *Fish. Technol*. 43: 138-145.

Jellanick, G. 1985. *Sensory Evaluation of Food-Theory and Practice*. Ellis Horwood Ltd., Chichester, England, 204p.

Jhaveri, S.N., Karakoltsidis. P.A., Montecalvo, J.J.R. and Constantinedes, S.M. 1984. Chemical composition and protein quality of some southern New England marine species. *J. Fd Sci*. 49: 110-113.

Jishy, K.K. 2004. Nutrient analysis and value addition of underutilized fish. M.sc. (H.Sc) thesis, Kerala Agricultural University, Thrissur, 84p.

Joel, M.K. 1989. Fish oil fatty acid supplementation in active rheumatoid arthritis: A double blinded, controlled, cross over study. *Ann. Int. Med*. 106: 497-503.

Joseph, A.C., Prabhu, P.V. and Nambiar, U.N. 1993. Storage characteristics of ready to serve fried thelly prawns (*Metapenacus dobsoni*) at ambient temperature *Fish. Technol.* 30: 25-27.

Joseph, A.H. 1987. *Value Added Fishery Products, Product Development and Sea Food Safety*. Central Institute of Fisheries Technology, Cochin, 131p.

Joseph, H.R. and Norman, S. 1995. Dietary polyunsaturated fatty acids and depression: When cholesterol does not satisfy. *Am .J. Clin. Nutr*. 62: 1-9.

Joseph, J. 2002. Sensory evaluation of sea food. In: Surendran, P.K. (ed.), *Proceedings of the Symposium on Sea Food Safety*, 28-30 May, 2002; Society of Fisheries Technology, Cochin, pp.101-106.

Joseph, J.P.A., Green, D. and Thampuran, N. 1984. Preparation and storage of cutlet from low priced fish. *Fish. Technol*. 21: 82-89.

Juneja, C.J. and Nair, M.K.R. 2000. Contribution of fisheries food supply. *Int. Agric*. 38: 7-9.

Kakat, K.A.S., Sherekar, S.V. and Venugopal, V. 2004. Fish protein dispersion as a coating to prevent quality less in processed fishery products. *Fish. Technol.* 41(1): 29-36.

Keshava, N. and Sen, D.P. 1983. Proximate composition of five species of flat fishes. *Fish. Technol*. 20: 24-28.

Khatkar, B.S. 1997. *Food Science and Technology*. Daya publishing, New Delhi, 550p.

Khontia, B.K., Srikar, L.N., Srinivasa, B.R. and Reddy, G.V.S. 1993. Keeping quality of wet salted and dry salted mackerel. In: Varghese, T.J., Keshavanatha, P., Radhakrishnan, K.V. and Lokeshwar, R.B. (eds.), *Rastrelliger Kanagurta. The Second Indian Fisheries Farm Proceedings,* 27-31, May, 1990; Asian Fisheries Society, Mangalore, pp. 277-280.

Komarik, S.L., Tressle, D.K. and Long, L. 1974. *Food Products Formulatory*; Vol. 1. *Meats, Poultry, Fish, Shell fish*. IBH publishers, New Delhi, 295p.

Krishnaswamy, K., Vijayaragavan, K., Sastri, J.S., Rao, D.H., Brahmam, G.N.V., Radhaiah, G., Kashinath, K. and Rao, M.V. 2000. *25 Years of National*

Nutrition Monitoring Bureau. National Institute of Nutrition., Hyderabad, 76p.

Lambert, R. 1990. Value added shrimp products in Europe. *Inf. Fish Int.* 4(90): 11-14.

Lawrence, R and Sorrell, T. 1993. Eicosapentaenoic acid in cystic fibrosis: Evidence of a pathogenetic role for leukotriene B_4. *Lancet*. 324: 465-469.

Leanarda, S. 2007. The Many Health Benefits of Fish Oil. Available: http: // en. Wikipedia. org/ Wiki / Fish _oil. (17 Nov.2006).

Levine, H. and Barbars, S. 1997. Most frequently asked questions about DHA. *Nutr. Today* 32: 248-249.

Lim, K.K.P. and Low, J.K.Y. 2003. *A Guide to Common Marine Fishes of Singapore.* Singapore Science Center, Singapore, 320p.

Linda, H. 1996. Consumption of oily fish and childhood asthma risk. *Aust. J. Med.* 164: 137-140.

Maage, A.K., Jolshamn, A. and Ulgens, Y. 1991. A comparison of tissue levels of four essential trace elements in wild and farmed Atlantic salmon. *Fiskeridir. Skr.* 4: 111-116.

Maccnamara, R.K. and Carison, S.E. 2006. Role of omega-3 fatty acids in brain development and function: Potential implication for the pathogenisis and prevention of psychogenisis and prevention of psychopathology. *Prostaglandin Leukot Essent Fatty Acids* 75(4): 329-349.

Mallik, A.K., Gopal, T.K.S., Sankar, R.C.N. and Vijayan, P.K. 2003. Suitability of polymer coated tin free steel cans for canning rohu (*Labeo rohita*) in curry medium. In: *Innovative Food Technologies and Quality Systems*, 5-8 December, 2003. Central Food Technological Resarch Institute, Mysore. Abstract: 218.

Manay, N.S. and Shadaksharaswamy, M. 1998. *Foods: Facts and Principles.* New Age International Publishers, New Delhi, 524p.

Mansur, M.A., Ismail, M.N., Bhoiyan, A.K.M.A. and Haq, M.E. 2000. Nutritional composition, yield and consumer response to a semi- fermented fish product prepared from underutilized fish species of Bangladesh coastline. *Indian J. Mar. Sci.* 29: 73-76.

Mathews, A.R., Mahadeviah, M., Gowramma, R.V. and Krishnamurthy, M.N. 1998. Packaging of raw groundnut oil in the tin free cans. *J. Fd Sci. Technol*. 35: 435-437.

Medina, R. and Garrole, R.L. 2001. Determining washing condition during the preparation of frozen surimi from surubi (*Pseudoplatystome coruscans*) using response surface methodology. *J. Fd Sci.* 67(3): 1455-1461.

Meilguard, D., Civille, G.V. and Carr, B.T. 1991. *Sensory Evaluation Techniques.* CRC Press, Boca Raton, Florida, 360 p.

Mishra, R.K. 2003. Marine products export slides down. *Agric. today* 38-39p.

Moorjani, M.N. 1998. *Fish Processing in India.* Indian Council of Agricultural Research, New Delhi, 83p.

Mori, J. and Trevor, H. 1999. Dietary fish as a major component of a weight less diet: effect on serum lipids, glucose, insulin metabolism in over weight hypertensive subjects. *Am. J. Clin. Nutr* .70: 817-825.

Mukundan, M.K. 2000. Proximate composition of fish. In: Mukundan, M.K., Srinath, k. and Ravindran, K. (eds.), *Sea Food Quality Assurance.* Central Institute of Fisheries Technology, Cochin, pp1-3.

Mustafa, F.A. and Mediros, D.M. 1985. Proximate composition, mineral content and fatty acids of cat fish for different seasons and cooking methods. *J. Fd Sci. Technol.* 50: 585-587.

Naik, G.M. and Reddy, H.R.V. 1999. Macro and trace element in fish and shell fish. *Fish Wild* 6: 8-10.

Nair, K.G.R. 2002. Products from less utilized fish. In: Surendran, P.K.O. (ed.), *Proceedings of the Symposium on Sea Food Safety*, 28-30 may, 2002; Society of fisheries technologists, Cochin, pp.13-19.

Nair, K.G.R. 2006. Value added products from fish. *Fishing chimes* 26 (4): 42-44.

Nair, P. 1993. Dietary fish oil include changes in the distribution of alpha-tocopherol, retinol and beta-carotene in plasma, red blood cells and platelets: Modulation by vitamin E. *Am. J. Clin. Nutr*. 58: 98-102.

Nair, P.G.V. 1993. Lipid peroxidation in silver pomfret muscle at 0 and 10^0 C. *Fish. Technol*. 30: 29-30.

Nair, P.G.V. and Susheela, M. 2000. *Biochemical Composition of Fish and Shell Fish*. Central Institute of Fisheries Technology, Cochin, 210p.

Nair, R. 1999. Impact of soy based energy food on the nutritional status and performance of adolescent atheletes. M.Sc. (Home Science) thesis, Kerala Agricultural University, Thiruvananthapuram, 164p.

Nair, R.P., Tankamma, R. and Gopakumar, K. 1982. Biochemical changes of fish fingers hold at frozen storage. *Fish. Technol*. 19: 19-23.

Nanu, E., Narayan, K.G. and Yadava, R. 1992. Bacteriological quality of pork kabab stored under marketing conditions. *J. Fd Sci. Technol*. 29: 309-310.

Narasimhan, K.R. 2003. Indian food packaging – Has it come of age? In: *Fifth International Food Convention: Innovative Food Technologies and Quality Systems,* 5-8, December, 2003, Central Food Technological Research Institute, Mysore. Abstract: 157-159.

NFI (National Fisheries Institute). 2002. *US Fish and Shell Fish Consumption*. National Fisheries Institute, Washington, 336p.

NIN (National Institute of Nutrition). 2002. *Effect on n-6 and n-3 PUFA in Insulin Resistance*. *Annual Report*. 2001-2002. National Institute of Nutrition. Hyderabad, 25p.

Obatolu, V.A., Skonberg, D.I., Camire, M.E. and Dougherty, M.P. 2001. Effect of moisture content and screw speed on the physical chemical properties of an extruded crab-based snack. *Bioresource. Technol*. 76(2): 119-123.

Ozden, K. and Erkan, D. 2007. Comparison of biochemical composition of three aqua cultured fishes. *J. Fd Sci. Technol.* 12: 1-13.

Page, A.C. 1982. *Methods of Soil Analysis Part ii*. American Society of Agronomists, Washington D.C., 334p.

Paroda, K. 1996. Ready to eat fish curry in flexible packs. *Sea Fd Export J*. 7p.

Pavunny, O., Kumar, K.S., Sherif, P.M., Nambudiri, D.D. and Joseph, S.M. 2007. Development of value added products from underutilized fresh water prawns. *Adv. Biol. Aquaculture mkt*. 648-657.

Peinoto, M.R.S., Sousa, C.L. and Mota, E. 2002. Utilization of fish of low commercial value Macrodon ancyledons for the production of surimi used in the preparation of shrimp- flavoured sausages. *Higene-Aliminater*. 16(99): 95-105.

Peter, E.D. 2002. Fundamentals of Fish Drying. In: Gopakumar, K. (ed.), *Fish Processing Technology.* Indian Council of Agricultural Research, New Delhi, pp.271-279.

Poulter, N.H. and Nicolaides, S.L. 1995. Studies of the iced storage characteristics and composition of a variety of Bolivian fresh water fish. *J. Fd Sci. Technol*. 68: 1240-1243.

Quasim, S.Z. 1983. *Studies on the Biochemical Composition of Some Fresh Water Fishes*. Central Institute of Fisheries Education, Bombay. 157p.

Raghuramulu, N., Nair, K.M. and Kalyanasundaram, S. 2003. *A Manual of Laboratory Techniques*. National Institute of Nutrition, Hyderabad, 183p.

Rahman, S.A., Huah, T.S., Nassan, O. and Daub, N. 2000. Fatty acid composition of some Malaysian fresh water fish. *Fd chem*. 54(1): 45-49.

Rai, M. 2003. *From the D.G'S desk.* ICAR report, January- March. pp.1-2.

Raju, C.U., Naik, A.R.T. and Ramesh, T.J. 1999. Development of ready to fry fish cutlet from pink perch (*Nemipterous Japonicus*). *Indian J. Nutr. Dietet*. 30(1): 23-28.

Raju, C.V., Baskaran. N. and Dhananjaya. S.1997. Development of diversified products from crabmeat. *Fish. Technol*. 34(2): 26-30.

Ralph, A.D. 1989. Fish oil dietary supplementation in patients with Raynaud's phenomenon: a double blind, controlled, prospective study. *Am. J. Med.* 86:158-164.

Ramadas, S.V. and Easwaran, P.P. 2000. Consumption pattern of fats and oils and serum lipid profile of selected adults. *Indian J. Nutr. Dietet.* 37: 71-75.

Rao, M.R. and Prakash, V. 1999. Indian sea food exports. *Info. Fish. Int*. 1(19): 3-25.

Rao, S.N. 2005. Impact of marine environmental degradation on fishery resources and coastal fishing population of India. *Fishing chimes* 24(1): 17p.

Rathnakumar, K. and Shamasundar, B.A. 1998. *Advances and Priorities in Fisheries Technology.* Society of Fisheries Technologists, India, 251p.

Ravindra, N.S. and Pahwar, R.S. 2001. Changing scenario of reverine fisheries of river Ganga around Allahabad. *Fishing chimes* 21(7): 31-36.

Raza, M.S., Azimudeen, K.M., Islam, M.N. and Kamal, M. 2006. *Influence of ice storage on raw materials for the production of high quality dried fish products*. *J. Fd Sci. Technol*. 6: 130-134.

Reddy, V.S.G., Srikar, L.N. and Senthil, A. 1990. Lipid freshness parameters in relation to shelf life of pink perch stored in ice. *Indian J. Nutr. Dietet*. 27: 53-56.

Richard, L., Whigham, L.D. and Cook, M.E. 2000. Conjugated linolenic acid: Implication for human health. Pharmacological Reserch. *Sci. Direct*. 42(6): 503-510.

Roos, N., Leath, T., Chamnan. C., Jacobsen, J. and Thilsted, S. H. 2007. Fresh water fish as a dietary source of vitamin A in Cambodia. *Fd chem.* 103(4): 1104-1111.

Ruth. 2007. Apples and fish consumption during pregnancy reduce childhood asthma and allergies. Available: http:// www. eatingfabulous. Com/ apples-and- fish-consumption-during-pregnancy-reduce-childhood-asthma-and allergies/(14th April 2007).

Sachindra, N.M., Sakhare, P.Z., Modi, V.K. and Rao, N.D. 2003. Quality characteristics of ready to eat dry fish products. In: *Trends and need in the global and Indian contexts. Fifth International Food Convention: Innovative Food Technologies and Quality Systems,* 5-8 December, 2003, Central Food Technological Research Institute, Mysore. Abstract: 131p.

Sadasivam, S. and Manickam, A. 1992. *Biochemical Methods for Agricultural Science*. New Age International Pvt. Ltd., Publishers, New Delhi, 195p.

Sahu, B., Anthony, J.M. and Nayak, D.K. 1996. Value added sea food products: current prospects. *Sea Fd Export J*. 27: 29-35.

Sanders, T.A.B.and Allison, H. 1992. The influence of fish oil high in docosahexanoic acid on plasma lipoprotein and vitamin E concentration and haemostatic function in healthy male volunteers. *Br. J. Clin. Nutr*. 68: 163-179.

Sarma, J., Srikar, L.N. and Reddy, C.V. 1998. Comparative effects of frozen storage on biochemical changes in pink perch (*Nemipterrus japonicus*) and oil sardine (*Sardinella longiceps*). *J. Fd Sci. Technol.* 35: 255-259.

Sarojnalini, C. and Vishwanathan, W. 1994. Nutritional characteristics of fermented fish products. *J. Indian Fish. Ass*. 25: 75-81.

Sehgal, H.S. and Sehgal, G.K. 2002. Aquacultural and socio economic aspects of processing carps into some value added products. *Bioresource Technol*. 82(3): 291-293.

Senthilatiban, R., Selvaraj, P. and Ramkumar, R.K. 1999. Economic feasibility of trawling operations off tuticorin coast. *Fish. Technol*. 36(2): 129-131.

Shahar, L. and Egul, M.T. 1994. Dietary n-3 polyunsaturated fatty acids and smoking related chronic obstructive pulmonary disease. *England J. Med.* 331(4): 228-233.

Shahib, N. and Asha, P 2005. Remarkable medicinal values of sea foods. *Fishing chimes* 25: 51-55.

Sheehan, T. and John, P. 1997. Effect of high fiber intake in fish oil treated patients with non- insulin dependent diabetes mellitus. *Am. J. Clin. Nutr*. 66: 1183-1187.

Shukla, F.C. and Singh, B. 2004. Current scenario of processing export of sea foods. *Sea Fd Ind.* 29-31.

Simon, S. and Joel, E. 1995. Serum fatty acids and the risk of coronary heart disease. *Am. J. Epidemiology* 142: 469-476.

Sindhu, J.C. 1995. Improvement of the nutritional quality of bread. M.Sc (Home science) thesis, Kerala Agricultural University , Thrissur, 134p.

Singh, R.K. and Balange, A.K. 2005. Characteristics of pink perch (*Nemipterrus japonicus)* surimi at frozen temperature. *J. Fd Proc. Technol*. 218: 420-423.

Siscovick, L. and David, S. 1995. Dietary intake and cell membrane levels of long chain n-3 polyunsaturated fatty acids and the risk of primary cardiac arrest. *J. Am. Med. Ass.* 274: 1363-1367.

Srilakshmi, B. 2007. *Text Book of Food science*. New age publishers Ltd., Bangalore, 522p.

Srinath, M. and Pillai, N.G.K. 2000. Marine fisheries of India: An approach to responsible fisheries management. *Fishing chimes* 26(4): 23-25.

Srinivasagopal, T.K. 1998. Advances and Priorities in Fisheries Technology. In: Balachandran, K.K., Lyer, T.S.G., Madhavan, P., Joseph, J., Perigreen, P.A., Raghunath, M.R. and Varghese, M.D. (eds.), pp. 236-241.

Srivastava, R.P. and Kumar, S. 2006. *Fruits and Vegetable Preservation Principles and Practices*. International Book Distributing Company, Lucknow, 360p.

Sudhakara, N.S. 2002. Sea food processing. *National Symposium on Food Quality and Saftey,* 26 November, 2002, Acharya, N.G. Ranga Agricultural University, Hyderabad. Abstract: 72p.

Sugunan, V.V. 2003. Indian aquatic resources and their relevance to fisheries development. In: Vinci, G.K. and Bhaumik, U. (eds.), *Methods of Assessment of Aquatic Ecosystems for Fish Healthcare.* Central Inland Fisheries Research Institute, Kolkata, pp1-2.

Swaminathan, M. 1974. *Essentials of Food and Nutrition.Vol.II.* Ganesh and Company, Madras, 515p.

Swaminathan, M. 1987. *Food Science, Chemistry and Experimental Foods.* The Bangalore Printing and Publishing Company, Bangalore, 463p.

Tarr, H.L.A. 2002. Sea Food. In: Ruiter, A. (ed.), *Fish and Fishery Products.* CAB International, England, pp. 172-177.

Toft, Y.M. and Ingrid, S. 1995. Effect of n-3 polyunsaturated fatty acids on glucose homeostasis and blood pressure in essential hypertension. *Ann. Int. Med.* 1123(12): 911-918.

Tokur, B., Polat, A., Beklaik, G. and Ozkutuk, S. 2004. Changes in the quality of fish burger produced from Tilapia (*Oreochromus niloticus*) during frozen storage (-18^{0}c). *Fd Res. Technol.* 218: 420-423.

Tripathi, M. 2007. Problems and prospects of fisheries development in India. *Fishing chimes* 27: 3-6.

Venugopal, V. 2003. Neutraceuticals and functional biomolecules from sea foods. In: *Fifth International Food Convention: Innovative Food Technologies* *and Quality Systems*, 5-8 December, 2003, Central Food Technological Research Institute, Mysore. Abstract: 16p.

Venugopal, V. 2003. Value addition to Aqua cultured fishery products. *Fishing chimes* 23 (1): 82-84.

Venugopal, V. 2004. Neutraceuticals and functional biomolecules from seafood. *Indian Fd Ind*. 23(6): 52-53.

Venugopal, V. 2006. Sea food processing. Adding value through quick freezing retortable packaging and quick chilling (Book Review). *J. Fd Sci. Technol.* 153: 485-488.

Venugopal, V. and Shahidi, F. 1995. Value added products from under utilized fish species. *Crit. Rev. Fd Sci. Nutr.* 35(5): 431-453.

Vijayan, M., Kumar, S. and Basu, S. 1989. Preparation of fish products and its storage characteristics. *J. Indian Fish.Ass*.28:105-111.

Weather, C. 2007. Recent evidence reviews support the potential of increased intake of fish in infant and children and adults to reduce psychiatric problems. *Am. J. Clin. Nutr.* 4 (125): 411-414.

Wetherilt, H. 2002. Oil seed edible, industrial and speciality oils. *Nutr. Br*. 10: 9-11.

Wheaton, F.W. and Lawson, T.B. 1985. *Proceeding Aquatic Food Products*. John Wiley and Sons, New York, 518p.

William, C.E. 1995. Diabetes, fish oil vascular disease. *Ann. Int. Med*. 123: 950-952.

Yasodha, K.P. and Rao, S.V.S. 1998. Studies on textural and historical changes in cured fish muscle. *J. Fd Sci. Technol.* 35: 21-24.

Ye,Y. 1999. Historical consumption and future demand for fish and fishery products: exploratory calculations for the years 2015\2030. *Fisheries circular* 946: 31.

Appendices

APPENDIX-1

RECIPE FOR THE PREPARATION OF FISH CUTLET

Ingredients

Fish mince	**:**	**1000g**
Mashed potato	**:**	**500g**
Chilli powder	**:**	**25g**
Turmeric powder	**:**	**5g**
Onion (cut into small piecies)	**:**	**100g**
Ginger (Chopped)	**:**	**25g**
Green chilli (Chopped)	**:**	**10g**
Masala powder	**:**	**a pinch**
Salt	**:**	**to taste**
Egg white	**:**	**110g**
Refined vegetable oil	**:**	**150ml**
Bread crumbs	**:**	**200g**
Refined vegetable oil	**:**	**for frying**

Procedure

1) The fishes are cleaned, drained, blanched and minced to a coarse paste.
2) Sauted chopped onion, ginger, and green chillies in refined vegetable oil.
3) Salt, turmeric powder, chilli powder and other ingredients were added along with fish mince to cook for some time until dry.
4) Added mashed potatoes to fish mixture and mixed well.
5) 20g mixture was moulded into round shape and flattened to 2 cm thickness.
6) The fish cutlet was dipped in egg white and rolled in bread crumbs.
7) Deep fried in vegetable oil maintained at 160-170^{0}c for 5 minutes and drained.

APPENDIX-1 1

RECIPE FOR THE PREPARATION OF FISH STICK

A. BINDER PASTE - 100g

Proportion of ingredients

Salt	:	**10g**
Sugar	:	**10g**
Mono sodium glutamate (MSG)	:	**4.85g**
Sodium tri polyphosphate (STPP)	:	**1.5g**
Baking powder	:	**1.7g**
Egg white	:	**4g**
Non-fat dry milk powder	:	**6.00g**
Hydrogenated vegetable oil	:	**9.00g**

B. CORN FLOUR : 135g

C. BLANCHED FISH MINCE : 765g

D. EGG WHITE : 110g

E. BREAD CRUMBS : 200g

F. REFINED VEGETABLE OIL : for frying

Procedure

1) The binder paste was made as per recipe.

2) Mixed the binder paste, blanched-minced fish and corn flour in the following proportion of 100: 765:135 respectively.

3) The ingredients were mixed slowly in a food processor, so as to grind to a fine paste. .

4) The mixture was moulded into rectangular sticks; dipped in beaten egg white, drained and breaded.

5) Deep fried in vegetable oil at 160^0C for 3 minutes and drained.

APPENDIX-III

Score card for organoleptic evaluation of fish cutlet

Date: **Name of judge:**

No	Character	1	2	3
1	Appearance			
11	Colour			
111	Flavour			
1V	Texture			
V	Taste			
V1	Over all acceptability			

Evaluate the product on the basis of the scores given below

Description	Score
Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Signature

APPENDIX-IV

Score card for organoleptic evaluation of fish stick

Date: **Name of judge:**

No	Character	1	2	3
1	Appearance			
11	Colour			
111	Flavour			
1V	Texture			
V	Taste			
V1	Over all acceptability			

Evaluate the product on the basis of the scores given below

Description	Score
Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Signature

APPENDIX-V

COMPOSITION OF MEDIA

1. NUTRIENT AGAR MEDIA

Peptone	:	10g
Beef extract	:	5g
Agar	:	20g
Sodium chloride	:	5g
Distilled water	:	1 litter
PH	:	6.5 to 7.5

11. POTATO DEXTROSE AGAR

Potato	:	200g
Dextrose	:	20g
Agar	:	20g
Distilled water	:	1 litter
PH	:	7.0

111. SABOURAUD'S MEDIA

Dextrose	:	20g
Peptone	:	10g
Agar	:	20g
Distilled water -	:	1 litter
PH	:	6.8 to 7.0

QUALITY EVALUATION OF VALUE ADDED PRODUCTS WITH MARINE AND FRESH WATER FISH

By

SOUMYA. P.S

ABSTRACT OF THE THESIS

submitted in partial fulfilment of the requirement for the degree of

MASTER OF SCIENCE IN HOME SCIENCE (FOOD SCIENCE AND NUTRITION)

Faculty of Agriculture

Kerala Agricultural University

Department of HOME SCIENCE
COLLEGE OF HORTICULTURE
VELLANIKKARA, THRISSUR - 680 656
KERALA, INDIA

2009

ABSTRACT

Fish is 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. The present study, on "Quality evaluation of value added products with marine and fresh water fish" was aimed at evaluating the nutrients and developing products from four fish varieties namely pink perch (*Nemipterus raponicus*) and silver belly (*Gerres filamentoses*) belonging to marine species and tilapia (*Tilapia mossambica*) and katla (*Catla catla*) of fresh water species. Thus, in addition to the role of income generation, value addition helps to increase the acceptability of the fishes which are presently under utilized.

The fresh fish varieties were analysed for chemical constituents like moisture, fat, protein, calcium, phosphorus, iron, vitamin A and peroxide value. Marine fish were found to be rich sources of calcium, phosphorus iron and fat, whereas fresh water fish were rich in protein and vitamin A. Fat content was comparatively low. Yield of fish muscle was found to be high in fresh water species like katla (78 per cent) and tilapia (75.5 per cent). Higher peroxide value was observed in marine varieties.

The fish products like cutlet and stick were prepared following standard procedures and were packed in polythene covers and stored for a period of two months. The peroxide value of the products were found to increase with the storage period with significant variation. Products made out of pink perch had the highest peroxide value throughout the storage period and the lowest was in silver belly. Organoleptic evaluation of the products were carried out using a 9-point hedonic scale. Qualities such as appearance, colour, flavour, texture and taste of the developed products were evaluated for a period of two months at fortnightly

intervals. The sensory qualities were found to decrease during storage with significant variation. Fish cutlets and sticks made of katla fish had the highest acceptability throughout the storage period.

Microbial enumeration of the products revealed that there was a gradual increase in the microbial population with the storage period. Maximum bacterial count was in cutlets made of pink perch initially ($1.33 \times 10^5 cfug^{-1}$) and finally ($10.66 \times 10^5 cfug^{-1}$). Minimum bacterial load was for katla. There was no significant variation in the bacterial load of fresh water fish cutlets but significant variation was observed in marine fish cutlet with pink perch showing significantly high bacterial load. Fungal population was detected in cutlets after 15th day of storage without any significant variation, but after 30 days, cutlet made of pink perch showed significantly high fungal population. Maximum yeast population was also in pink perch cutlet ($2.66 \times 10^3 cfug^{-1}$)

In fish stick also after 60 days of storage, bacterial count was maximum in pink perch ($9.00 \times 10^5 cfug^{-1}$), fungal count and yeast count $7.33 \times 10^3 cfug^{-1}$ and $2.00 \times 10^3 cfug^{-1}$ respectively.

The shelf life of the products with acceptable maximum total plate count was for 30 days. After 30 days of storage, the products had a total plate count higher than $5 \times 10^5 cfug^{-1}$ and also higher peroxide value which is an indication of developing rancidity of fats. This was reflected in their lowered organoleptic qualities with storage period. Katla fish products showed highest overall acceptability may be due to their comparatively low fat content in fish muscle ($2.5g\ 100g^{-1}$). After two months of storage the products were found to be slimy with unpleasant odour.

Computation of nutritive value of cutlets per packet (4 cutlets, 20g each) revealed a high protein content in tilapia (11.92g), calcium in pink perch (498.24mg), phosphorus in silver belly (382mg), iron in silver belly (2.96mg) and vitamin A in katla (93.12µg).

Nutritive value of fish stick per packet (4 sticks, 25g each) revealed a high protein content in tilapia (16.36g), calcium in pink perch (698.12mg), phosphorus in silver belly (519.68mg), iron in silver belly (2.84mg) and vitamin A in katla (72.96µg) respectively.