DEVELOPMENT OF MALAYSIAN TYPE FISH CRACKERS FROM *NEMIPTERUS JAPONICUS* (BLOCH)

By

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THESIS

Submitted in partial fulfilment of the requirement for the degree

MASTER OF FISHERIES SCIENCE

Faculty of Fisheries

Kerala Agricultural University

DEPARTMENT OF PROCESSING TECHNOLOGY

COLLEGE OF FISHERIES

PANANGAD, COCHIN

2001

To

My Family & Friends

With

Love and Gratitude

DECLARATION

I hereby declare that this thesis entitled "DEVELOPMENT OF MALAYSIAN TYPE FISH CRACKERS FROM *NEMIPTERUS JAPONICUS* (BLOCH)" is a bonafide record of research work done by me during the course of research and that the thesis has not formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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ACKNOWLEDGEMENT

I wish to express my deepest regards and profound sense of gratitude to my major advisor, Dr. Sajan George, Associate Professor, Department of Processing Technology, College of Fisheries, Panangad for his inspiring guidance and constant encouragement and affectionate treatment which were the motive force behind the timely completion of my research work. I remain grateful to him for the helpful advice and constructive suggestions given during the course of the experiment and preparation of the thesis. His keen attention and advice helped me a lot in preparation of the thesis and submitting it in the present form.

I owe a great deal to Dr. D.M Thampy, Dean, College of Fisheries, Panangad, for providing necessary facilities for the successful conduct of the research work.

I am most grateful and indebted to Dr. D. Damodaran Nambudiri, Head, Department of Processing Technology, College of Fisheries, Panangad, for his valuable help and support during the course of my study and the constructive suggestions given in the preparation of the thesis.

I wish to place on record my sincere thanks to Sri. S. Krishna Kumar, Assistant professor, Department of Processing Technology, College of Fisheries, Panangad, for his scholarly and critical comments during the preparation of the thesis.

My sincere thanks are also due to Smt. Alphi Korath Assistant Professor, Department of Management Studies, College of Fisheries, Panangad. for the help in statistical analysis of the experiment results and also for her cordial and timely help in the preparation of the thesis.

I sincerely thank Dr. P.M. Sherief, Associate professor and Dr. Lizy Behanan, Associate Professor, Department of Processing Technology, College of Fisheries, Panangad, for their encouragement and support. I wish to extend my sincere thanks to all the staff of the Department of Processing Technology, who directly or indirectly helped me in completing the research work.

I am very much thankful to Dr. Srinivas Gopal, Principle Scientist, Packaging Division, Central Institute of Fishery Technology, Cochin, for providing me with the packaging materials for the conduct of the research work.

The assistance rendered by the library staff of College of Fisheries. Panangad, Central Institute of Fishery Technology, Cochin, are gratefully acknowledged. I am grateful to Dr. Jean Collins, FAO Librarian, Rome, who sent me valuable reprints and documents.

I wish to place on record my sincere thanks to Mr. Saleem, super soft computers, Panangad for their nice piece of work in printing the thesis.

I would like to acknowledge my earnest thanks to ICAR for awarding me with the fellowship throughout the tenure of my M.F.Sc. course.

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Introduction

1. INTRODUCTION

A significant portion of the total fish caught in the country is constituted by commercially unimportant and hence, underutilised species, most of which are landed as by-catch of fishing operations, mainly trawling for prawns. These include croakers, threadfin bream, ribbonfish, horse mackerel, flat fish, carangids, sciaenids, etc. Such species do not have much demand in the fresh fish market and hence, fetch only a low price. Underutilised species can be defined as those fish caught in large quantities or as by-catch and used for low value industrial products, but could be upgraded for human consumption (Whittle and Hardy, 1992). The annual landing of finfish in India is about 2.02M.tons (Anon, 2000) of which about 15% is constituted by low value varieties.

The dietary habits of the people are changing fast in India and there seems to be a tendency for people to go for value–added convenience products that are 'ready-to- prepare' or 'ready-to-serve'. It is possible to use several of the low cost fishes as excellent raw material for preparing such products. Several products could be manufactured using fish meat mince, e.g. sausages, pastes, patties, balls, loaves, burgers, fish fingers, fish fritters, fish wafers, fish flakes and fish pickles (Grantham.1981).

Many starch-based snack-type products, such as chips and wafers, are available in the market. Incorporation of fish meat or proteins into such products has been attempted in order to enhance their nutritive value. Fish supplies a good balance of proteins, vitamins and minerals and relatively low calories (Sikorski *et* *al.*, 1990). In several developing countries including India, where the population is dependent mainly on cereal-based diets, a small quantity of fish often provides a critical nutritional improvement for them (Whittle, 1984).

Fish crackers are popular snack foods of Malaysia and other ASEAN Countries (Yu, 1997). These are 'ready-to-prepare' products, locally called as *keropok* in Malaysia. This type of product has not yet been introduced in India. However, these are similar to various starch–based products such as wafers that are very popular in the country. An added advantage of such products is that they can be manufactured even on a small scale. To make it viable, suitable technology will have to be evolved.

These are prepared by forming dough from a mixture of comminuted fish, flour, salt, sugar and water. The dough is shaped in the form of cylindrical rods, boiled, cut into thin slices and sun dried. The dried slices are fried in oil, whereupon they puff to give a porous, low-density product. (Siaw *et al.*, 1985).

Basically, production of fish crackers, in Malaysia still follows traditional methods and remains largely a cottage industry. However, production of *keropok* by traditional methods often results in inferior quality products. Siaw and Idrus (1979) and Yu (1986) have reported that the poor quality of traditionally prepared fish crackers are on account of improper mixing, cooking, drying etc.. In order to improve the quality mechanization and standardized methods have been introduced recently.

This project was selected in order to standardise a method for preparing the Malaysian-type fish crackers that is acceptable to the Indian consumers as a means of utilizing low cost varieties of fish. Japanese threadfin bream is used as the raw material as this species is available locally the year round. Further, the price of the fish is low and more or less steady. The total landing of the fish was 73994 tonnes in the year 1999-2000 (Anon, 2000).

Standardisation has been done mostly based on consumer preference. In addition, storage studies were conducted in order to determine the shelf life of products under various conditions of packing. It is expected that the method could be adopted for a small-scale industry.

Review of Literature

2. REVIEW OF LITERATURE

In India several fish species, e.g., Japanese threadfin bream, anchovy, horse mackerel, croakers, ribbon fish, flat fish, carangids, and sciaenids, occurring in the catches are not commercially important and are therefore, not fully exploited for human consumption. They are landed in substantial quantities but fetch only a low price. For instance, the landing of Japanese threadfin bream in the year 1999 –2000 was 73,994 tonnes. Much of this is still consumed fresh. Several value-added products such as sausages, pastes, patties, balls, wafers, loaves, burgers, fish fingers, and fish cutlets, could be manufactured using minced meat of such varieties (Venugopal, 1995).

Fish crackers are popular snack foods of Malaysia where they are called *keropok*, and other ASEAN countries. In the West they would be classified as "half products" or "intermediates" (Lachmann, 1969) or as expanded snack products (Cumminford and Beck, 1972). Gopakumar *et al.*, (1975) reported that minced fish offers an excellent raw material for production of wafers. Fish wafers have become a delicacy among urban population of India.

Keropok production is usually confined to the coastal fishing areas in Malaysia along the east coast states of Trengganu and Kelantan. Here, its production is a seasonal activity. Months of September and October are the peak production periods (Siaw and Yu, 1978). *Keropok* production in Malaysia still follows traditional methods and largely remains a cottage industry (Siaw *et al*, 1985). According to one report at least 211 factories in Malaysia are mechanized (Din, 1988).

Gopakumar and Nair (1980) and Shenoy *et al.*, (1983) reported that similar products are known by different names in many Asian countries. In India they are called wafers, flakes or crackers and in Indonesia they are called as *kerupuk* (Cheow and Yu, 1997). In Malaysia, the fried product is known as *keropok lekur* and sliced *keropok* as *keropok hiris* (Yu, 1986). In Thailand, before frying, fish crackers are given a dip treatment in sweet vegetable sauce (Gopakumar, 1997).

Narkiroj and Buckle (1987) described the preparation of oriental prawn crackers. Prawn heads were boiled and dried to a moisture content of 8-10% and ground into a powder. This powder was blended with tapioca flour, salt and sugar and the dough was rolled, steamed and then cooled, sliced and dried.

Annamalai *et al.*, (1987) described the preparation of another type of fish wafers in which dressed fish was cooked and the meat was mixed with water and ground. To this other ingredients like flour and salt were added and ground until the mixture became a soft paste. This paste was spread on trays, cooked and dried until the moisture content was reduced below 10%.

2.1 Processing methods

Siaw and Idrus (1979) have reported that traditionally prepared fish crackers were often of poor quality on account of improper processing steps such as mixing, cooking and drying. They claimed to have standardised a method involving mechanisation. They also claimed that their process is less time consuming and gives a better quality product compared to the traditional methods.

Siaw *et al.* (1985) also reported to have introduced mechanisation and to have standardised a method for *keropok* making. They claimed that their product had a higher expansion ratio and was more acceptable than traditionally produced *keropok.*

Yu (1986) devised an improved method of making fish crackers that is crispier than conventionally produced ones. His observations were that aluminium or stainless steel moulds could be used for stuffing the dough and that 60-90 min steaming under ordinary pressure is sufficient to cook the granules for proper gelatinisation.

In traditional processes cooked rolls are left at room temperature to harden, consequently resulting in spoilage, especially by fungi. This could be prevented by the use of a refrigerator, which also improves the texture and appearance of the sliced product (Yu, 1986). Further, in the traditional process, slicing done manually had varied thickness that resulted in decreased acceptability. In the improved method, slicing was done with the help of a mechanical slicer and thus thickness could be controlled (Yu, 1986).

Quality, particularly expansion characteristics, will be affected by drying conditions. Traditional sun drying method resulted in increased spoilage and poor expansion due to uneven drying and longer drying period. In the improved method followed by Yu (1986), a drier was used, with the initial drying carried out at a temperature of 40-45°C, followed by drying at a temperature of 65-70°C till the moisture content was reduced to about 10%. She has recommended a lower temperature initially in order to prevent case hardening.

Yu (1986) used a stuffer and casings, adopted from sausage production, in order to improve the traditional method, making it easier for forming rolls of uniform size. The fish was deboned manually and mixed with flour (sago or tapioca generally), salt, sugar, monosodium glutamate and water. The mixture was kneaded manually, and the dough formed was shaped by rolling into cylindrical rods. The rolls were boiled for about an hour and a half until sufficiently cooked. The cooked rolls were then allowed to cool at room temperature. Rolls were then sliced manually and the slices were dried under sun. Drying period can be as long as 2 to 3 days depending on prevailing weather conditions.

According to Yu (1997), traditional methods are heavily dependent on manual labour. Many varieties of fish are used in Malaysia, most popular species being *Clupea leiogaster*. In order to further improve the quality and image of the product, she adopted a modified method, with the base steps same as that of the traditional methods. Such methods involved use of equipments such as bowl cutter or mechanical blade mixer, sausage stuffer, mechanical slicer, drier, etc.

2.2 Additives

A Malaysian fish cracker generally consists of fish meat, starch, table salt, monosodium glutamate and water.

Venugopal and Govindan (1967) found that the fish flakes prepared using corn and tapioca was better organoleptically compared to those prepared using refined wheat flour (*maida*) and black gram. Fish flakes from corn being the best, the product had a protein content of 20% and was found to have a storage life of four months at room temperature. No rancidity was noticed because of low fat content. Odourless fish meat and different sources of starch, like corn, tapioca, refined wheat flour and black gram, were used for preparing fish flakes. Deodorisation of fish meat was carried out by the method of Sen and Rao (1965) that involved cooking meat with an equal amount of water at a pH of 5.5 followed by pressing. Boiling and pressing were repeatedly done until the meat was sufficiently deodourised.

The extent of puffing and texture of finished product are influenced by amylose: amylopectin ratio of flour. At least 50% or more amylopectin (Matz, 1970) and 5-20% amylose (Feldbergi, 1969) are required for a good quality product.

Siaw *et al.*, (1979) made an evaluation on Malaysian fish crackers using six combinations of dough mixtures prepared using two types of fish and three types of flour. They found that *keropok* prepared using the fish, *Clupea leiogaster,* and tapioca flour was preferred over other combinations by the taste panelists.

Siaw *et al.* (1985) analysed chemical composition and expansion characteristics of fish crackers. According to them, chemical composition depends on formulation whereas, extent of expansion depends on physical properties of fish-flour mixture. Traditional products have much lower linear expansion, which is on account of poor mixing, variation in thickness of the slices and uneven drying. They also observed that a well-mixed structure will result in smooth texture and good expansion, whereas ungelatinised or semi-gelatinised starch granules will result in poor expansion characteristics and that, controlled cooking ensures adequate gelatinisation of starch granules.

Ice was used instead of water to reduce the temperature of fish during bowl chopping (Choew *et al.,* 1999). This prevented the formation of the *modori* phenomenon (gel weakening or network softening) that occurs at temperature ranges between 46 and 54°C. Sano *et al.*, (1988, 1989) attributed this phenomenon to the dissociation of myosin from actin and possible fragmentation of actin filament. Gradual addition of starch and ice ensured proper mixing of starch and fish, which otherwise formed aggregates.

Tirabal and Raksakulthai (1990) found that fish crackers prepared from Nile tilapia meat and tapioca, mixed in the proportion 35:65, received the highest preference score for crackers compared to other combinations tried, *viz.*, 40:60, 45:55, 50:50, 60:40, 70:30, and 80:20. They stated that fish meat content does not interfere with the expansion of the starch.

Cooking of starch in excess water leads to their gelatinisation. Wang *et al.*, (1991) reported that regardless of the source of starch, the amount of water needed for complete gelatinisation was14 molecules for every anhydrous glucose unit of starch.

According to Yu (1991a) linear expansion of the *keropok* progressively decreased with increasing level of protein content. Protein interacts with the starch granules in a way that inhibits expansion. Yu (1991b) tried different fish: flour ratios, *viz.*, 1:1, 1.5:1, 2:1,2.5:1 and 3:1, on fish crackers and observed that samples with higher protein (i.e., higher fish meat) contents were not acceptable.

Niwa (1992) reported that fish mince becomes a viscous sol or paste upon grinding or comminution with salt and such a paste could not be obtained in the absence of salt even if the comminution was carried out for many hours. The microstructure of myofibril remained intact for the unsalted paste and disappeared when the minced fish was mixed with salt at the rate of 30 gm/kg fish and ground for 25 min. This is probably on account of dissolution of myosin combined with the actin filaments that yielded a network of macromolecular actomyosin.

Yu and Low (1992) reported that more than 65% of the total production cost of *keropok* is attributed to the steaming process that is required to cook the dough. They suggested the use of pregelatinised starch, which has been precooked and would, therefore, not require steaming.

Yu and Low (1992) investigated the effect of pregelatinised tapioca starch for the manufacture of *keropok* using a steam heated double drum film drier. *Keropok* prepared using starch, pregelatinised at a temperature of 133.5°C, and mixed with water in the proportion, water: starch ratio 70:30, was found to be the most acceptable to the sensory panel. They suggested the use of one percent glycerol monosterate in the dough for handling pregelatinised starch since, otherwise the dough becomes sticky and difficult to handle. They adopted the method of Siaw *et al.*, (1985) but with the steaming process eliminated.

Yu (1992) reported that *keropok* could be prepared using a meat mixture of *Oreochromis mossambicus* and *Rastrelliger kanagurta*. *Keropok* was acceptable upto 60% substitution of *Rastrelliger kanagurta* meat with *Oreochromis mossambicus* meat. Colour, crispness, flavour and overall acceptability were not significantly different. However, above a level of 60% acceptability of *keropok* significantly declined. The protein content of *keropok* containing meat of *Oreochromis mossambicus* was higher, but moisture, fat and ash contents were not significantly different.

Yu *et al.*, (1994) suggested that wash water obtained from surimi processing could be used for making fish crackers, since wash water contains 30-40% protein of the fish meat. Incorporation of upto 10% of wash water protein was acceptable to the taste panelists. Appearance, colour and crispness were not affected crackers with 10% wash water proteins contained more protein and less fat.

Raksakulthai (1996) suggested that hybrid catfish *(Clarius* sp.*)* could be used for making fish crackers, provided the minced meat is washed with cold water or 0.2-0.3% brine. Unwashed minced meat resulted in rancid flavour in the finished product. Catfish meat was mixed with tapioca flour, sugar, salt, garlic, pepper, and hot water to form the dough. Crackers after drying had a moisture content of 10-13%.

Cheow and Yu (1997) found that on addition of salt at the rate of 20 gm per kg fish meat, gelatinisation temperature of fish-starch mixture increased by 4-5°C. Sugar and monosodium glutamate cause little effect on gelatinisation of starch. Increase in the fish content of fish-starch mixture decreased the gelatinisation temperature range. The level of addition of salt is limited by the product taste and that of sugar by the capability of maintaining a stable extrusion condition. Hsieh *et al.* (1990) observed that the addition of salt at the rate of

10-30gm and sugar at the rate of 10-40gm per kg meat enhanced the radial and axial expansions of extruded corn meal. Lowering the salt content from 20 to 0 gm/kg significantly reduced the linear expansion of the *keropok* (Cheow *et al.*, 1999).

A study was undertaken by Shojaei (1998) for the preparation of crackers by incorporating meat of kilka, an under-utilised fishery resource of Caspian Sea. Seventeen combinations, with varying amounts of fish, flour, starch, ice, egg, oil, sugar and salt, were compared. Fish to flour ratio in the selected formula was optimised so that a product of maximum linear expansion, crispness and best sensory properties was obtained. A combination of 50% fish and 50% tapioca flour gave the most acceptable product.

2.3 Linear expansion

Linear expansion can be used as a measure of extent of puffing up of crackers upon frying.

The frying characteristics of fish flakes prepared using different flours, were measured by Venugopalan and Govindan (1967), in terms of intake of oil during frying and percentage increase in volume due to swelling on frying. The increase in volume was measured according to the method of Bienveindo *et al.* (1965). The displacement of kerosene by the same weight of flakes, both before and after frying, was measured and the difference reckoned as increase in volume. They found that the percentage increase in volume was more in the case of flakes prepared from corn flour.

The degree of gelatinisation of starch is one of the factors which influences the degree of expansion of 'half products' such as fish crackers, when immersed in hot oil (Lachmann, 1969). Incomplete gelatinisation of starch during steaming causes reduced expansion of half products.

Blanshard and Mitchell (1979), are of the opinion that linear expansion decreases with increase in fish content and that it could be attributed to differences in the degree of starch gelatinisation. Protein interacts with starch leading to inhibition of expansion. Siaw and Idrus (1979) reported that expansion of fish crackers upon frying was much higher when tapioca flour was used compared to other sources of starch such as sago, and that the type of fish did not contribute to the expansion properties.

According to Siaw *et al* (1980) crispness is the most important parameter governing the quality of *keropok* and linear expansion is directly related to the crispness. Linear expansion was found to decrease with increase in fish content by them.

A method of measuring linear expansion was developed by Yu *et al.*, (1981). Average length of crackers upon deep-frying the dried *keropok* in palm oil at 200°C was expressed as a percentage of length before frying.

There was a slight increase in linear expansion of *keropok* with increase in fish meat content from 200 to 300 gm per kg of crackers. This could be due to the fact that the wet fish provided the available water for starch gelatinisation or sufficient protein which when heat denatured, may be able to resist collapse during starch expansion (Faubion *et al.*, 1982). According to Gomez and Aguilera

(1984) only starch granules that have been gelatinised could participate in the formation of a stable expanded structure.

Colonna *et al.*, (1984) reported that when starch granules were fragmented after 30 min of steaming, water was released to the fish and starch structure, thereby weakening the impact force of water vapour on the starch matrices, and therefore, the linear expansion decreased. The fragmentation of starch granules is thought to be in the form of random chain splitting of the amylose network due to prolonged heating, which could weaken the network and lessen its ability to retain trapped water molecules. They are of the opinion that this is the reason why a decrease in linear expansion was observed after steaming for periods longer than 30 min.

Wu *et al.* (1985) reported that one of the possible factors influencing the degree of gelatinisation is the availability of water necessary for gelatinisation. During thermal gelation of proteins, water is entrapped in the protein gel network such that the availability of water for starch gelatinisation could be limited.

Siaw *et al.*, (1985) stressed on the significance of crispness of *keropok* and its relation to linear expansion. Only samples showing linear expansion of more than 77 percent were found acceptable. In addition, they observed that percentage linear expansion decreased with increase in fish content. In the same study they observed that starch granules that were fully gelatinised resulted in a better rupture of the starch cells during frying and gave a linear expansion of more than 77 percent.

The significance of crispness as the most important sensory attribute of fish crackers and the use of linear expansion as a measure of crispness, has also been pointed out by other workers (Chinnaswamy *et al.*, 1988, and Yu, 1992).

Lai *et al.*, (1989) explained that linear expansion is related to the amount of granular aggregates present in the roller dried material and that with decreasing starch content, the aggregates would be able to swell more and disperse.

Yu (1991b) reported that the percentage of linear expansion for puffed *keropok* made from tapioca flour was more than that prepared from wheat flour. Their findings were in agreement with those of Siaw and Idrus (1979), that the type of fish used did not contribute to the expansion properties as there were no significant differences between the crackers prepared from either jew fish or sardine.

Yu and Tan (1990) incorporated spray dried fish protein hydrolysate into crackers. Incorporation at the rate of 10 percent was found to give maximum linear expansion upon frying. Crackers with hydrolysate gave the highest scores for sensory evaluation in terms of appearance, crispness and colour compared to crackers incorporated with the meat of O. *mossambicus* and *Sciaena* sp. (Mohamed *et al.*, 1989).

Yu and Low (1992) suggested a nine-point scale for organoleptic evaluation of fried cracker samples with linear expansion greater than 80 percent, based on colour, flavour, crispness and overall acceptability.

Somchai (1994) stated that the dough was found to be completely gelatinised after 20 min of steaming in the making *Khao Kriap Waue* (KKW), a Thai rice based snack. Greater linear expansion was shown by KKW that had been prepared by steaming for 20 min or more.

Chandrasekhar and Chattopadhyay (1990) stated that the high pressure of steam formed inside starch granules forces the cooked starch to expand during puffing of rice. The increased linear expansion found in this study was most likely due to the steam released from water molecules in the starch granules during frying. Puffing occurs upon flash evaporation of water due to exposure to high temperatures (Guraya and Toledo, 1994).

Slice thickness is an important factor deciding puffing property and acceptability of fish crackers. Siaw *et al.*, (1985) have found that 3 mm thick slices of fish crackers were most acceptable in terms of packing, drying and linear expansion. Yu (1993) is also of the same opinion. According to him, the panelists commented that 1, 1.5 and 2 mm thick samples were too thin and dissolved too quickly in the mouth, whereas, 4 mm thick samples were considered too thick and hard to chew. In any case, linear expansion was not affected by the thickness of the *keropok* slice.

Jujun *et al.* (1994) studied the effect of egg white powder on the physical properties, *viz.*, linear expansion, bulk density and colour, of extruded fish crackers after microwave heating. Microwave heating was used instead of frying in this study in order to obtain low fat fish crackers. Adding egg white powder at the rate of 4.5% to the fish–tapioca mixture significantly reduced linear expansion. However, linear expansion increased with egg white powder content at concentrations between 0.5% and 3%.

An extrusion method has been developed by Yu (1997) for fish cracker preparation. The effect of extrusion temperature on percentage of linear expansion of *keropok* on frying has been studied. Expansion at 60°C was negligible but increased with increase in temperature, reaching a maximum at 100°C. However, further increase in the temperature did not affect expansion levels.

Wang (1997) reported that waxy maize starch shows better expansion than common corn starch owing to the higher swelling power of the former, resulting from the absorption of more water molecules.

Cheow *et al.*, (1999) explained the effect of mixing and fish quality on expansion. The fish was comminuted with salt, sugar and MSG first before the addition of starch. This ensured that the fish was evenly distributed in the starch system. They observed that if the salt was added after the starch addition, the fish meat would form aggregates at the microscopic level and that these aggregates in the starch system had a negative effect on starch expansion. They found that insufficient mixing time (less than 20 min) and inadequate salt content (less than 20 gm/kg), poor quality fish and the improper sequence of addition of ingredients, reduced linear expansion.

Kyaw *et al.*, (1999) found that there was an optimum time for the steaming of *keropok* that gave the best linear expansion and hardest texture of steamed gel. This occurred when the starch granules were expanded to their largest sizes, but before fragmentation of the granules. According to them, as the starch granules swell owing to gelatinisation, water is absorbed, and the entrapped water molecules inside the swollen granules may contribute to a higher linear expansion of *keropok*. A steaming time of 20-30 min was found sufficient to cook the *keropok* gel.

2.4. Quality changes

Various parameters used for assessing the changes in quality of other fishery products during storage, can be used in the case of fish crackers also. These include various physical, chemical, microbiological and organoleptic tests.

Estimation of volatile bases, produced mostly by bacterial action, have long been used as a quality index of fish and fishery products (Stansby *et al.* 1957; Liston *et al.* 1961; Thimann, 1963; Hashimoto, 1965; Eskin *et al.* 1971; Gould and Peters, 1971). Total volatile base nitrogen content is a measure of ammonia, trimethyamine, dimethylamine, etc., and would be a useful indicator of decomposition as accoding to Paladino, (1943), Tomyami *et al.* (1951), Horie and Sekine, (1954), Wittfogel, (1958) but would be of little use as an indicator of early freshness (Moorjani *et al.* 1958; Farber, 1965; Ohishi *et al.* 1991). Some have reported variable results with TVB-N (Beatty and Gibbons, 1936; Tarr, 1940; Farber, 1956).

In 1936, Beatty and Gibbons first proposed trimethylamine as an index of freshness of fish, as production of TMA is almost entirely dependent on bacterial population. They introduced a modified microdiffusion technique for determining TMA content. Bacterial reduction of trimethylaminoxide was found to be a source of TMA (Beatty, 1938; Tarr, 1940), the oxide apparently been found only in marine fish (Beatty, 1939; Castell, 1946). Dyer (1945) developed a colorimetric method of determining TMA content.

According to workers like Beatty and Gibbons (1936), Fields *et al.* (1968), and Shewen *et al.* (1971), levels of TMA would serve as an excellent quality index which correlated well with sensory judgments. Studies on TMA in relation to spoilage of fish have been reviewed by Farber (1965), and Gould and Peters (1971). According to Gould and Peters (1971), TMA seems to reflect increasing spoilage rather than decreasing freshness, and correlation between TMA and sensory evaluation is not a direct one, and hence, the test cannot be considered as an adequate guide to early loss of quality.

Peroxide value is one of the first tests used to measure rancidity of frozen fish as an indicator of flavour deterioration according to Tarr (1944). However, he indicated that it becomes significant only after considerable reduction in quality. Liljemark (1959) pointed out that peroxide value could be used only as a rough index of the keeping quality of fish. Determination of peroxides may not be useful as a measure of lipid oxidation in seafoods during prolonged storage, especially for ground muscle (Melton, 1983). According to Coxen (1987), methods involving primary changes, such as formation of hydroperoxides (peroxide value and fatty acids), are most suitable to measure low levels of oxidation for products stored at low temperature.

Thiobarbituric acid test, developed by Bernheim *et al.* (1948), is another method to measure rancidity, and is primarily a quantitative method for malonaldehyde. Yu and Sinnhuber (1957) found it correlating with the sensory measurements of rancidity better than the peroxide number. Of the various methods available for determining TBA value, steam distillation is the most popular (Rhee, 1978). According to Melton (1983), of the various tests reported for measuring the extent of oxidation and deterioration of lipids in muscle foods, TBA test is the most widely used.

According to Tarr, (1940), the best simple test for bacterial quality of fish would be a determination of total bacterial population. According to Farber, (1965), the most common test for bacterial contamination is total viable count and its many variations. Microbial spoilage takes place when the water activity of the substrate is favourable for the multiplication and metabolic activity of microogrganisms involved (Troller and Christian, 1978). According to them the water activity influences the lag phase, the stationary phase and the death rate of the culture.

Organoleptic changes noticed in fish are the results of the various microbial and chemical changes taking place during storage. The subjective methods are the oldest and the most wide spread means of evaluating acceptability and edibility of fish (Farber, 1965; Gould and Peters, 1971). According to Ryder *et al.* (1993), sensory evaluation is the most reliable test for raw material and processed fishery products. The characteristic flavour and aroma, which are most complex in nature, can be measured successfully by none of the objective methods. Even the biochemical methods, often employed for determining freshness of flesh foods, cannot be singularly accepted as universal due to the complex nature of flesh foods (Fields *et al.* 1968; Edwards *et al.* 1983). According to Nunes *et al.* (1992), being a subjective method, sensory evaluation cannot be used singly. However, coupled with other methods, sensory evaluation forms an important quality index (Gill, 1992).

Just as any other dried product, fish crackers can be expected to undergo various changes during storage. It should be possible to monitor these changes using various tests mentioned. However, not much information is available on changes occurring during storage of fish crackers or wafers.

According to Venugopalan and Govindan (1967), fish flakes remained acceptable even at the end of four months storage at room temperature. They found that the product had the same extent of swelling and crispness upon frying as freshly prepared material. No rancidity was noticed, during the period probably because of low fat content.

Traditionally prepared fish crackers are of poor quality. In the traditional processing, the cooked rolls are left at room temperature to harden. Consequently spoilage, especially the growth of fungi, sets in very rapidly on these products. Because of this, shelf life of product will be reduced (Yu, 1986, Siaw *et al.* 1979 and Siaw *et al.*1985). Improvised methods have resulted in quality products (Yu, 1997).

Shojaei (1998) carried out storage studies on fish crackers prepared using the fish, 'kilka'. He found some changes in chemical and microbial parameters during a storage period of four months. The microbial load increased marginally and chemical parameters such as total volatile base nitrogen and peroxide value showed slight increases during this period. However, these changes did not significantly affect the acceptability of the products by the taste panel during the period of study.

Materials & Methods

3. MATERIALS AND METHODS

3.1 Collection of fish meat

Market fresh fish (*Nemipterus japonicus,* Bloch) was purchased from the local market and transported in an insulated box in iced condition, to the laboratory. Only fish that was iced immediately after catching was purchased. Fish was washed thoroughly in iced water, dressed and filleted. The meat was collected manually using a knife. The meat was strained using a hand extruder to remove small bones and connective tissue. The fish meat was packed in plastic bag and kept in iced condition without direct contact with ice, until the material was further processed.

3.2 Preparation of fish crackers

The method of Siaw *et al.*, (1985), with slight modifications, was followed as the base method for preparing fish crackers. The composition of various ingredients used in the base recipe is given in Table-1.

The fish meat was first comminuted in a food processor ('Crompton Greaves' make) for 15 min at about 2800 cuts per minute. Salt was added and ground for 3 min, followed by addition of sugar and monosodium glutamate (MSG), and the grinding continued for another 5 min. Iced water was then added followed by starch. The blending process was continued for another 10 minutes until a homogeneous mixture was obtained. The dough was then stuffed into high-density polyethylene casings of diameter 3 cms using a manual sausage stuffer

Table-1. Composition of ingredients used in the base recipe.

INGREDIENTS	COMPOSITION (gms)
Fish meat	50
Flour	50
Cane sugar	2
Table salt	1
MSG	0.2
Colour	as required
Iced water	30

and steamed for a period of 60 min at atmospheric pressure. The cooked rolls were then immersed in iced water for about 15 min until the interior temperature was lowered well below the room temperature. They were then chill stored at 5-10°C overnight. The casing was peeled off and the rolls were cut into slices of 3 mm thickness. The round slices were dried in a tray drier, at a temperature of 50°C for the first two hours, followed by drying at a temperature of 70°C, to final moisture content of less than 10%. The dried crackers were deep fried in refined groundnut oil at a temperature of 180-200°C for a few seconds until proper swelling occurred.

3.3. Standardisation of method

The method of processing fish crackers was standardised based on the following parameters: starch source, fish:starch:water proportion, mixing time, and cooking conditions. Percentage linear expansions of crackers upon frying and sensory evaluation by a taste panel were used for evaluating the quality of the product for standardisation. Samples that gave a linear expansion value of more than 70% only were subjected to sensory evaluation. Sensory evaluation of the fried samples was carried out by a taste panel consisting of 12 judges. Quality was evaluated on the basis of appearance, crispness and flavour, using a 5-point scale. The format of the score sheet is given in Appendix I.

3.3.1 Starch source

Fish crackers were prepared according to the base recipe using a fish: starch ratio of 1:1, but using different sources of starch, *viz.*, potato, tapioca, corn flour, refined wheat flour and sago. Crackers from starch source that resulted in 70% or more linear expansion were subjected to sensory evaluation. The type of starch that was found most acceptable to the taste panel was selected for further studies.

3.3.2 Fish: Starch: Water Proportion

The starch flour that was selected in the previous step was used for standardisation of fish: starch: water proportion. The effect of various proportions of fish: starch: water, *viz.*, 70:30:22.5; 60:40:27.5; 50:50:32.5; 40:60:37.5; and 30:70:42.5,on swelling and sensory quality of crackers, was determined. Fish crackers were prepared by the base method with these five proportions as variables. The proportions that gave a linear expansion value of more than 70% were then subjected to sensory evaluation, and the proportion that gave the highest scores was adopted for further studies.

3.3.3 Mixing Time

Various lots of ingredient mixtures were ground in a food processor for different durations, *viz.*, 2,5,10,15 and 20 min. Crackers were prepared and the extent of swelling upon frying determined. Products that gave expansion of more than 70% were subjected to sensory evaluation. The mixing time that gave the highest scores for sensory evaluation was adopted for further studies.

3.3.4 Cooking Conditions

Various lots of stuffed rolls of ingredients mixture were subjected to the following cooking conditions: steaming at atmospheric pressure for 20min, boiling in water bath at a temperature of 100°C for 60min, boiling in water bath at a temperature of 90°C for 30min and boiling in water bath at a temperature of 90°C for 60 min. Cooking conditions that resulted in a linear expansion of more than 70% upon frying of crackers, were found out. The most suitable set of cooking condition was adopted for further studies.

3.4 Storage Studies

Fish crackers were prepared using the standardised method and packed in 3 different forms *viz.*, i) dried, ii) dried and vacuum-packed and iii) fried. Each form of the product was packed in several lots, in laminated polyester/polyethylene (50/300 gauge) pouches, with polyethylene as the inner layer. The water vapour transmission rate (WVTR) of the packaging material was 3.62gms/m^2/24hrs/90±2%RH/37°C and air transmission rate was 65cc/m^2/24hrs/90±2%RH/37°C. The pouches were heat sealed using an electrical heat sealer ('Sevana' make). For vacuum packing, a vacuum heat sealer ('Sevana' make) at a chamber vacuum of 17 inches mercury was used. The samples were stored in a cabinet at ambient conditions. Both maximum and minimum temperature and percentage relative humidity inside the cabinet were monitored. Sampling was done every two weeks for dried, and dried and vacuum-packed products, and every 10days in the case of the fried product. One pouch from each lot was drawn at every sampling. Samples were subjected to various tests, *viz.*, linear expansion, moisture content, total volatile base nitrogen content, trimethylamine content, peroxide value, thiobarbituric acid value, total plate count, fungal count and sensory evaluation.

3.5 Tests

All the chemicals used in the various tests were of either AR or GR grade. The microbiological media were of 'HI Media' make. All biochemical and microbial tests were done in duplicate for each sample and the average values for each have been reported.

3.5.1 Linear Expansion

The percentage of linear expansion was determined according to the method of Yu *et al.*, (1981). Three samples of dried crackers were ruled with five lines across using a fine oil pen. The crackers were fried in groundnut oil at a temperature of 180-200°C for a few seconds until proper swelling occurred. Each line was measured before and after puffing and the average of each taken. The percentage of linear expansion was calculated as follows:

$$\%\ \text{Linear expansion} = \frac{\text{Length after puffing} - \text{Length before puffing}}{\text{Length before puffing}} \times 100$$

3.5.2 Moisture Content

Moisture content of fish meat and fish crackers was determined by the method of AOAC (1975). About 5 gms of sample was accurately weighed in a clean dry petridish using an electronic balance and was dried to a constant weight at a temperature of 105^0C in a hot air oven. The dried material was cooled in a desiccator. The moisture content was calculated as the percentage loss of weight of the crackers upon drying.

3.5.3 Protein Content

Protein content of fish meat and fish crackers was estimated by Microkjeldahl's Method (AOAC, 1984). One gramme of fish crackers was accurately weighed and transferred to a kjeldahls flask.In the case of fish meat, one gramme of dried sample was used. A pinch of digestion mixture ($CUSO_4$: K_2SO_4 1:8) and 10ml of concentrated H_2SO_4 were added and digested by heating at a temperature of 100°C for 12 hrs over a heating mantle. About 25 ml of distilled water was then carefully poured into the flask along the side. The flask was swirled to dissipate off the heat evolved. When the solution attained room temperature, it was quantitatively transferred to a 50 ml standard flask with distilled water washings. The solution was then made upto 50ml using distilled water and mixed thoroughly. Five ml of this solution was subjected to distillation using a distillation unit ('Kjelplus' make). 10 ml 10N NaOH solution was added to the sample solution for distillation. The vapors were collected in 5ml 2 % boric acid that was previously mixed with two drops of Tachirho's indicator. The boric acid was tritrated against standard N /70 H_2SO_4 to a pink end point.

$$\text{Protein (\%)} = V \times \frac{14 \times 100 \times 100}{1000 \times 70 \times 5 \times W} \times 6.25$$

where, V= volume of N/70 H_2SO_4 used

W=Weight of sample taken

3.5.4 Fat Content:

The Soxhlet Method of fat content estimation was followed (AOAC, 1990). A sample of about two gms of moisture free fish meat or fish crackers was taken into an extraction thimble. The electrical heating unit was adjusted so that the solvent, petroleum ether (60-80°C), siphons over 5 to 6 times per hr. The extraction was carried out for 16 to 20 hrs. The solvent was then transferred to a pre-weighed beaker and evaporated off on a boiling water bath, then cooled to room temperature in a desiccator, and weighed. The difference in weight was expressed as the percentage of sample weight.

3.5.5 Ash Content

Ash content of fish meat or crackers was determined by the method of AOAC (1984). About 3gms of the dried sample was weighed accurately in a silica crucible. It was then ignited in a muffle furnace at a temperature of 550^0C until the sample was free of carbon. It was then allowed to cool in a desiccator and weighed. The difference in weight was expressed as the percentage of sample weight.

3.5.6 Carbohydrate Content

Carbohydrate content of fish crackers was indirectly calculated by using Knauer's Procedure (Knauer *et al.*, 1994) using the following formula.

$$\% \text{ Carbohydrate content} = 100 - (\% \text{ protein} + \% \text{ lipid} + \% \text{ ash})$$

3.5.7 Total Volatile Base Nitrogen (TVB-N) content

TVB-N content was determined by Conway's Micro-diffusion Method (Conway, 1947).

A sample of 10 gms of pulverised fish crackers was extracted in 10% trichloro acetic acid (TCA) solution. One ml of this extract was pipetted out into the outer chamber of the Conway's unit and one ml of standard 0.02 N H_2SO_4 solution was taken in the inner chamber. Then, one ml of saturated sodium carbonate solution was added to the outer chamber. The unit was closed immediately. The solutions in the outer chamber were mixed by slow rotation of the apparatus. It was then incubated at room temperature overnight. The contents of the inner chamber were titrated against standard 0.02N NaOH solution using Tachirho's indicator. A blank was also run using 1 ml of 10% TCA solution in the outer chamber instead of the sample extract.

$$\text{TVB-N content (mg \%)} = \frac{(A-B) \times 0.28 \times 50 \times 100}{W}$$

where, A = Volume of NaOH solution required for control

B = Volume of NaOH solution required for test

W = Weight of sample

3.5.8 Trimethyl Amine (TMA) content

TMA content was determined by Conway's Micro-diffusion Method (Conway, 1947). The TCA extract prepared for determination of TVBN was used for TMA determination also. The procedure followed was similar to that for TVBN, except that one ml of formaldehyde was added to the TCA extract in the outer chamber of the micro-diffusion unit before adding sodium carbonate solution.

$$\text{TMA content (mg \%)} = \frac{(A-B) \times 0.28 \times 50 \times 100}{W}$$

Where, A = Volume of NaOH solution required for control

B = Volume of NaOH solution required for test

W= Weight of sample

3.5.9 Peroxide Value (PV)

The method of Connell (1975) was adopted for peroxide value determination. A sample of 10 gms of fish crackers was blended thoroughly with anhydrous sodium sulphate in a mortar. The blend was shaken with chloroform for 5 to 10 minutes and filtered using Whatman No.42 filter paper. Ten ml of the filtrate was taken in a pre-weighed beaker and the solvent evaporated off. From this the fat content of the sample was determined. To another 10ml of the aliquot taken in a flask, 20 ml of glacial acetic acid and a pinch of potassium iodide were added. After closing the flask the reagents were mixed carefully and incubated for a period of 30 min under dark at room temperature. Then the sides of the flask were washed with distilled water. A few ml of starch solution were added and titrated immediately against standard 0.002N sodium thiosulphate solution till the blue colour disappeared. PV was expressed as the number of ml of 0.002 N sodium thiosulphate required per gramme of sample.

3.5.10 Thiobarbituric Acid (TBA) value

The method of Yu and Sinnhuber (1957) was adopted. A sample of 10 grammes of fish crackers was weighed out into a blender. To this 50 ml of distilled water were added and blended. It was then transferred to a 500 ml round bottomed flask. The blender was washed with 47.5 ml distilled water and the washing was also transferred to the flask. To this 2.5ml of dilute hydrochloric acid (1:2) were added in order to adjust the pH to 1.5. The solution was distilled at a temperature of 100°C and 50 ml of the distillate were collected.

One ml of the distillate was taken in a test tube and diluted to 5 ml using distilled water. To this 1 ml TBA reagent (0.288 % thiobarbituric acid in glacial acetic acid) was added. It was heated in a boiling water bath for 30 min. The distillate was then cooled and the red colour developed was measured at 538nm using a spectrophotometer ('Jasco'make). A reagent blank was also run using distilled water instead of the sample distillate.

TBA value (mg MA/gm of sample) = Optical density of sample $\times$ 5 $\times$ 7.8

3.5.11 Total Plate Count

All media and diluents were sterilized by autoclaving at a temperature of 121°C for 15 min and all glasswares at 160°C in hot air oven for 2 hours.

Total plate count of the crackers was determined according to the method of Maturin and Peeler (1995). A sample of 10 grammes was aseptically transferred to a sterile blender and homogenized with 90 ml phosphate buffer (0.1M KH_2PO_4 + K_2HPO_4, pH-7.2) as a diluent. Appropriate serial decimal dilutions of 1 ml of the homogenate were made using phosphate buffer. Appropriate dilutions were plated, in duplicate, by pour plate technique using Plate Count Agar. The composition of medium is given in Table 2. Plates were incubated at a temperature of 37°C for 48 hours. Plates showing 30 to 300 colonies were counted. Counts were expressed as colony forming units (cfu) per gramme sample.

3. 5.12 Fungal Count

Fungal count was determined according to the method of Detroit (1971). The homogenate dilutions prepared for TPC determination were used for determining the fungal count also. Appropriate dilutions were plated, in duplicate, by pour plate technique using Potato Dextrose Agar (Table 2) containing 10% tartaric acid, and incubated at a temperature 20–25°C for 5 days. Plates showing colonies ranging from 30 to 300 were selected for determining fungal count.

3.5.13 Sensory Evaluation

A taste panel consisting of 12 judges carried out sensory evaluation of the fried samples. The quality characteristics assessed were appearance, crispness, flavour and rancidity of the product on the basis of a 5-point scale as suggested by Amerine *et al.*, (1965). Triangle test was conducted on the samples of the last sampling in order to detect any difference between ordinarily packed and vacuum-packed fish crackers. The method of Jellinek (1985) was followed. The format of the sensory evaluation score sheets is given in Appendix I and II.

3.6 Statistical Analysis

The experiments were carried out using Completely Randomised Design (CRD). Data obtained were analysed using Analysis of Variance(ANOVA) technique (Snedecor and Cochran, 1968). Pairwise comparison of treatment means were done wherever necessary using least significant difference. Sensory evaluation results were analysed using the Friedman test (Sprent, 1989).

3.6 Production cost

The expected production cost of manufacturing fish crackers on a small scale for one year has been worked our. The method recommended by Sarma (1971) was followed.

Table 2: Composition of microbial media

Ingredients	Composition (gm)	
	Plate Count Agar	**Potato Dextrose Agar**
1. Casein enzymic hydrolysate	5.00	-----
2. Yeast extract	2.50	-----
3. Dextrose	1.00	20.00
4. Agar	15.00	15.00
5. Potato infusion	-----	200.00
6. Tartaric acid (10%)	----	1.00 ml
7. Distilled water	1000ml	1000ml
8. pH	7.0 ± 0.2	5.6 ± 2

Results

Results

4. RESULTS

4.1 Starch Source

The results of statistical analysis with respect to selection of starch source are provided in Table-3. A significant difference is seen among treatments, *viz.*, corn flour (T_1), refined wheat flour (T_2), tapioca powder (T_3), sago powder (T_4) and potato powder (T_5). Crackers prepared using corn flour and refined wheat flour showed linear expansion of more than 70% upon frying, and was selected for sensory evaluation.

Average scores of sensory evaluation are given in Table 4. The scores were analysed by Friedman test, which showed significant difference between the treatments T_1 and T_2 with respect to appearance and crispness, at 1% level, whereas no significant difference was noticed between the two with respect to flavour. Fish crackers made from corn flour (T_1) gave highest average scores for all the three sensory characteristics.

4.2 Fish: flour: water proportion

Out of five proportions of fish: flour: water tested, three *viz.*, 70: 30: 22 .5, 60: 40: 27.5, and 50: 50: 32.5, gave linear expansion of more than 70% upon frying the crackers.

The ANOVA for the observations is given in Table 5. Significant difference is seen among treatments. However, results of pairwise comparison show that the three treatments belong to the same homogeneous group.

Table 3: ANOVA for percentage linear expansion of different starch sources

Source of variation	Sum of squares	Degrees of freedom	Mean sum of squares	F value
Treatment	4973.799	4	1243.449	259.918**
Error	47.844	10	4.784	
Total	5021.643	14		

** Significant at 1% level

Critical difference = 3.98

Treatment : (Starch source)	T_1: Corn	T_2 :Refined wheat	T_3 :Tapioca	T_4 : Sago	T_5 Potato
Means : (Percentage linear expansion)	81.74	74.28	54.51	60.13	29.16

Underscored means are not significantly different

Table 4: Average scores of sensory evaluation of different starch sources

Quality characteristics	Starch sources	
	Corn flour	Refined wheat flour
Appearance	4.50	2.75
Crispness	4.25	3.58
Flavour	3.75	3.58

Table 5: ANOVA for percentage linear expansion of different fish:flour:water proportions

Source of variation	Sum of squares	Degrees of freedom	Mean sum of squares	F value
Treatment	5032.784	4	1258.196	53.216**
Error	236.436	10	23.643	
Total	5269.220	14		

** Significant at 1% level

Critical difference = 13.8156

Treatments : T_3 :50:50:32.5 T_2:60:40:27.5 T_1 :70:30:22.5 T_4:40:60:37.5 T_5 :30:70:42.5
(fish: flour: water proportions)

Means : 80.72 79.87 78.38 59.6 33.28
(Percentage linear expansion)

Under scored means are not significantly different

Table 6: Average scores of sensory evaluation of fish: flour: water proportions

Quality characteristics	Fish: flour: water proportions		
	70:30:22.5	60:40:27.5	50:50:32.5
Appearance	3.33	4.58	3.75
Crispness	4.16	4.33	4.25
Flavour	3.66	4.16	4.08

Crackers were prepared using a fish: flour: water proportion of 30:70: 42.5 showed very dry region at the centre upon steaming/drying.

Crackers prepared using the three selected proportions of fish, flour and water were subjected to sensory evaluation. Average sensory scores are given in Table 6. Friedman test was carried out. Significant differences were noticed between the treatments with respect to appearance. No significant was notices between the two with respect to crispness and flavour. Based on the average scores for sensory quality characteristics, a proportion of 60:40:27.5 was selected.

Composition of the dough and the flow chart of the standardised method are given in Fig 1 and Table 7 respectively.

4.3 Mixing time

Crackers prepared by mixing ingredients for periods of 15 min (T_4) and 20min (T_5) resulted in linear expansion values greater than 70%. The results of statistical analysis are given in Table 8, which shows significant difference between the five mixing period tested. However, there was no difference between 15 and 20 min of mixing times.

Products prepared with mixing times of 15 min and 20 min of were further subjected to sensory evaluation. The results were statistically analysed by the Friedman test. Average scores of sensory evaluation are given in Table 9. Once again no significant difference could be established between the two treatments.

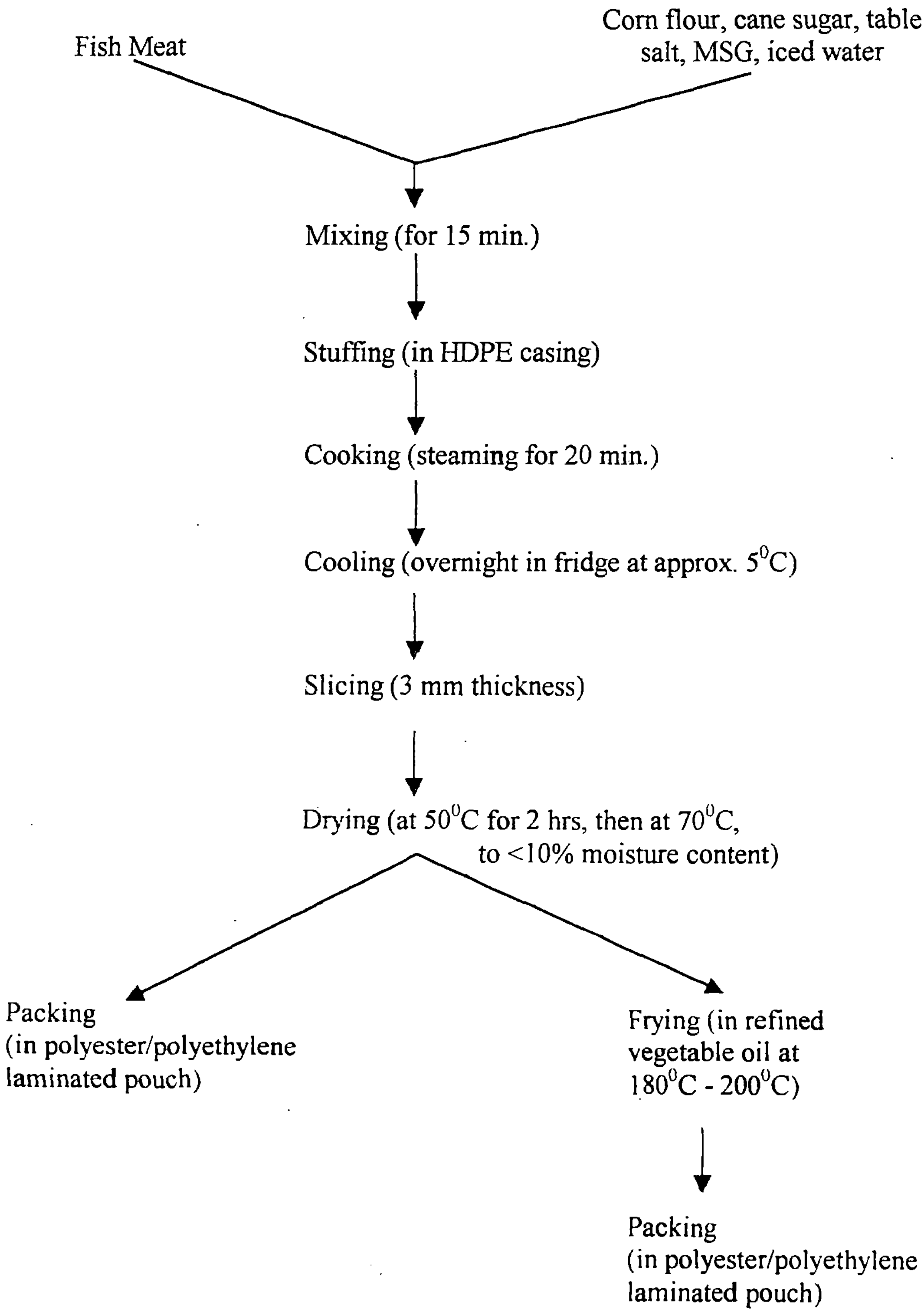

Fig-1: Flow chart for preparation of fish crackers

Table 7.Standardised composition of ingredients mixture

INGREDIENTS	COMPOSITION (gms)
Fish meat	60
Corn flour	40
Table salt	2
Cane sugar	1
MSG	0.2
Colour	as required
Iced water	27.5

Table 8. ANOVA for percentage linear expansion of different mixing times

Source of variation	Sum of squares	Degrees of freedom	Mean sum of squares	F value
Treatment	2272.168	4	568.042	113.813**
Error	49.9142	10	4.991	
Total	2319.083	14		

** Significant at 1% level

Critical difference = 4.064

Treatment: T_1 :2min T_2 :5 min T_3 :10 min T_4 :15 min T_5 :20min
(Mixing times)

Means :51 54.34 64.39 78.69 81.6
(Percentage linear expansion)

Underscored means are not significantly different

Table 9. Average scores of sensory evaluation of different mixing times

Quality characteristics	Mixing time (min)	
	15 min	20 min
Appearance	4.04	3.96
Crispness	4.33	4.29
Flavour	4.29	4.16

with respect to appearance, crispness and flavour. Mixing time of 15 min was adopted for further studies.

4.4 Cooking conditions

The results of statistical analysis on the effect of cooking conditions on the linear expansion of crackers are given in Table 10. No significant difference was seen among the treatments, *viz.*, steaming at atmospheric pressure for 20min, boiling in water bath at a temperature of 100°C for 60min, boiling in water bath at a temperature of 90°C for 30min and boiling in water bath at a temperature of 90°C for 60 min. Steaming at atmospheric pressure was however, selected for further studies.

4.5 Proximate composition

Results of proximate analysis of fresh fish meat, dried fish crackers and fried fish crackers are presented in Table 11. Fat content seems to have substantially increased and moisture content to have substantially decreased upon frying. However frying resulted in a weight gain by about 26%.

4.6 Storage studies

Fish crackers were packed in three forms, *viz.*, dried & packed, dried & vacuum-packed and fried & packed. For vacuum packing a chamber pressure lower than 17 inches mercury resulted in cracking of the fish crackers. During four months of storage of the crackers under various conditions of packing, the

Table 10. ANOVA for percentage linear expansion of different cooking conditions

Source of variation	Sum of squares	Degrees of freedom	Mean sum of squares	F value
Treatment	59.363	3	19.787	2.307
Error	102.898	12	8.575	
Total	162.261	15		

Treatment: (Cooking conditions)	T_1	T_2	T_3	T_4
Means (Percentage Linear expansion)	79.23	79.21	76.31	74.75

where,

T_1: Steaming at atmospheric pressure for 20min

T_2: boiling in water bath at a temperature of 100°C for 60min

T_3: boiling in water bath at a temperature of 90°C for 30min

T_4: boiling in water bath at a temperature of 90°C for 60 min

Under scored means are not significantly different

Table 11. Proximate composition of fresh fish meat (*Nemipterus japonicus,* Bloch), dried fish crackers and fried fish crackers* (percentage by weight)

Components	Fresh fish meat	Dried fish crackers	Fried fish crackers
Moisture	78.73	9.6	3.45
Protein	18.27	23.87	18.75
Fat	1.54	0.17	22.7
Ash	2.83	3.49	2.83
Carbohydrate	___	62.86	52.27

* Average of three replications

maximum and minimum surrounding air temperature were 34^0C and 23^0C, respectively. The maximum and minimum relative humidity were 80% and 55%, respectively.

4.6.1. Linear expansion

The observations on linear expansion upon frying of dried & packed and dried & vacuum-packed fish crackers are represented in Fig 2. The results of statistical analysis are given in Table 12, which shows no significant difference between the two forms. For proper swelling of cracker, a thickness of 3 mm was found to be most appropriate.

4.6.2 Moisture content

The variations in the moisture content of fish crackers during storage are presented in the Fig 3. The moisture content of dried fish crackers was 9.54% at the start of the storage studies. In the case of dried & packed fish crackers, moisture content increased to 10.05% in 120 days, whereas in the case of dried & vacuum-packed, it increased to 9.96%. However, no significant difference was noticed between the two forms of packing .the results of statistical analysis are given in Table13.

In the case of fried fish crackers the moisture content was 2.79% on the zero day of storage. After 52 days it increased to 3.96%.

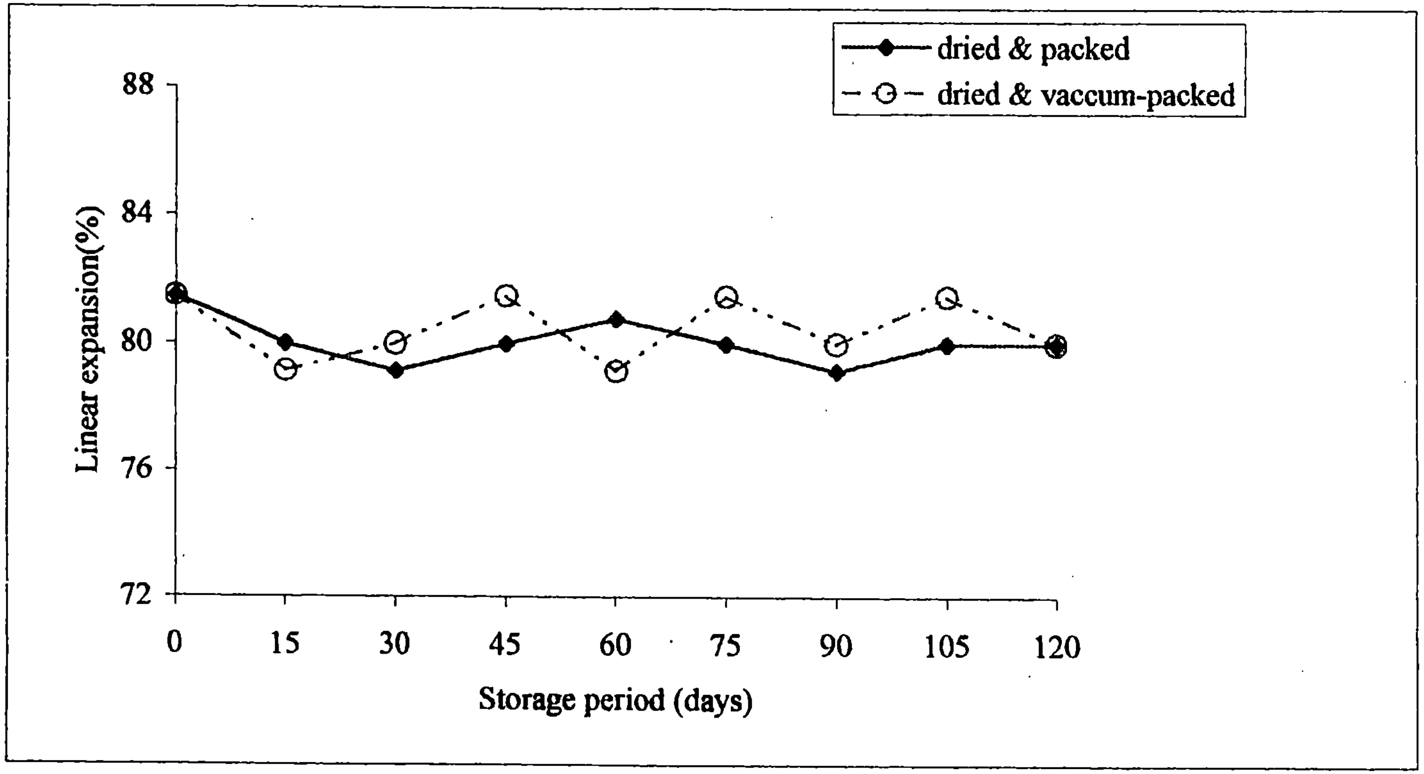

Fig. 2:- Changes in percentage linear expansion upon frying of dried & packed and dried & vacuum-packed during storage

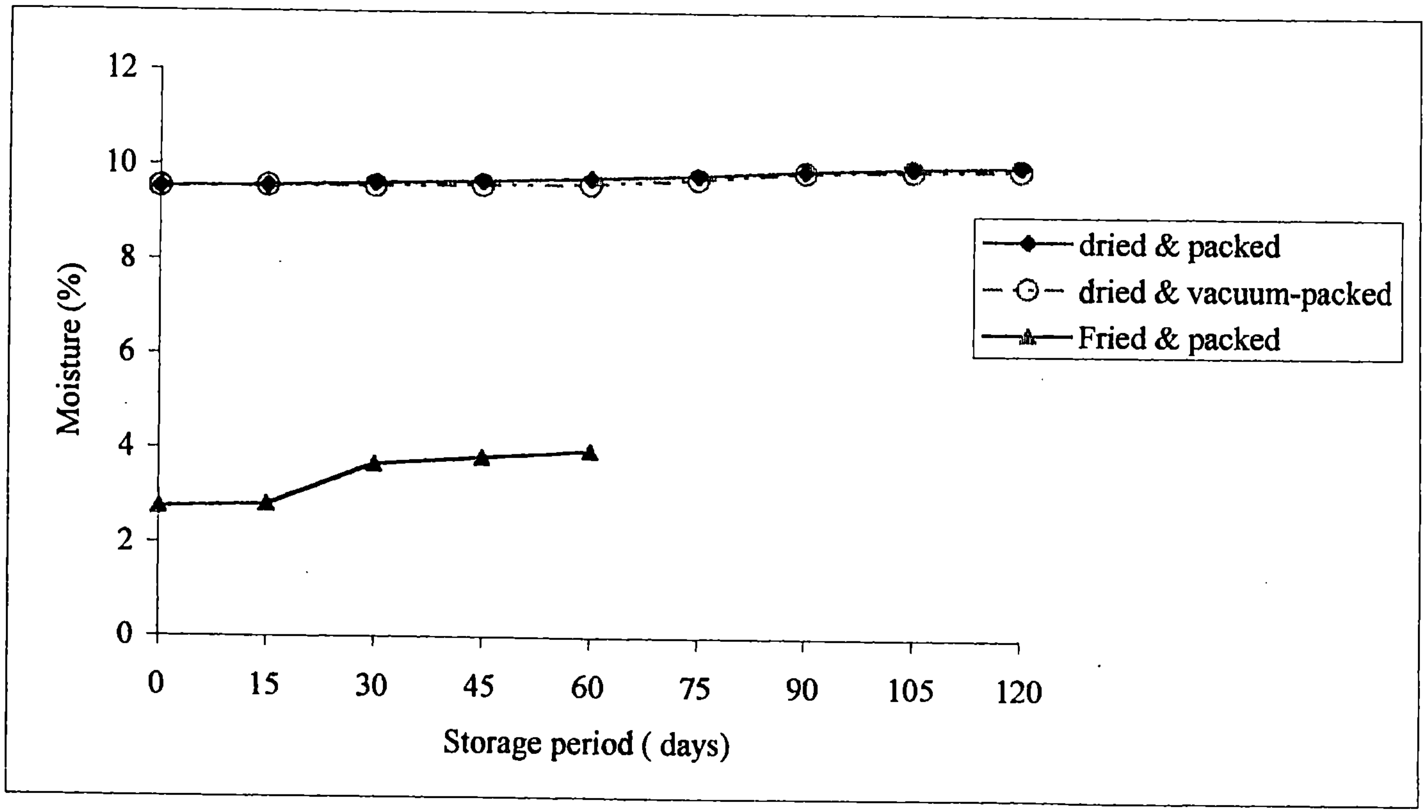

Fig. 3 :- Changes in the moisture content of fish crackers during storage under various conditions of packing

Table 12: **ANOVA for linear expansion upon frying of dried & packed and dried & vacuum-packed fish crackers stored at room temperature**

Source of variation	**Sum of squares**	**Degrees of freedom**	**Mean sum of squares**	**F value**
Between packing forms	0.752	1	0.752	1.234
Between Days	7.448	8	0.931	1.528
Error	4.872	8	0.609	
Total	13.072	17		

Table 13: **ANOVA for moisture content of dried & packed and dried & vacuum-packed fish crackers stored at room temperature**

Source of variation	**Sum of squares**	**Degrees of freedom**	**Mean sum of squares**	**F value**
Between packing forms	0.0151	1	0.0151	2.559
Between Days	0.4984	8	0.0623	10.559*
Error	0.047	8	0.0059	
Total	0.5605	17		

* Significant at 5% level

4.6.3 Total volatile base nitrogen content

TVB-N content of dried crackers increased steadily from an initial value of 8.4 mg% to 14.00 mg% in the case of dried & packed crackers and to 12.60 mg% in the case of dried & vacuum-packed ones. The observations were statistically analysed which showed a significant difference between the two (Table-14).

But in the case of fried & packed fish crackers TVB-N content increased rapidly from an initial value of 9.8mg% to 21 mg% within 52 days (Fig. 4).

4.6.4 Trimethyle amine (TMA) content

In the case of dried & packed crackers, the TMA content increased from 2.8 mg%, to 6.3 mg% in 120 days of storage and in the case of dried & vacuum-packed product, it increased from 2.8 mg% to 5.6 mg% (Fig. 5). Significant difference could once again be obtained between the two forms of packing (Table-15).

Fried fish crackers showed a rapid increase in the TMA content from 1.4 mg% to 11.9 mg% within 52 days of storage (Fig.5).

4.6.5 Peroxide value

The peroxide value varied from 0.23 to 1.24 mM/gm sample in the case of dried & packed product and from 0.23 to 0.92 mM/gm in the case of dried & vacuum-packed product during the four months of storage (Fig. 6).

Table 14: ANOVA for TVB-N content of dried & packed and dried & vacuum-packed fish crackers stored at room temperature

Source of variation	Sum of squares	Degrees of freedom	Mean sum of squares	F value
Between packing forms	1.337	1	1.337	7.878 *
Between Days	45.465	8	5.683	33.488 **
Error	1.3573	8	0.1697	
Total	48.16	17		

* Significant at 5% level

**Significant at 1% level

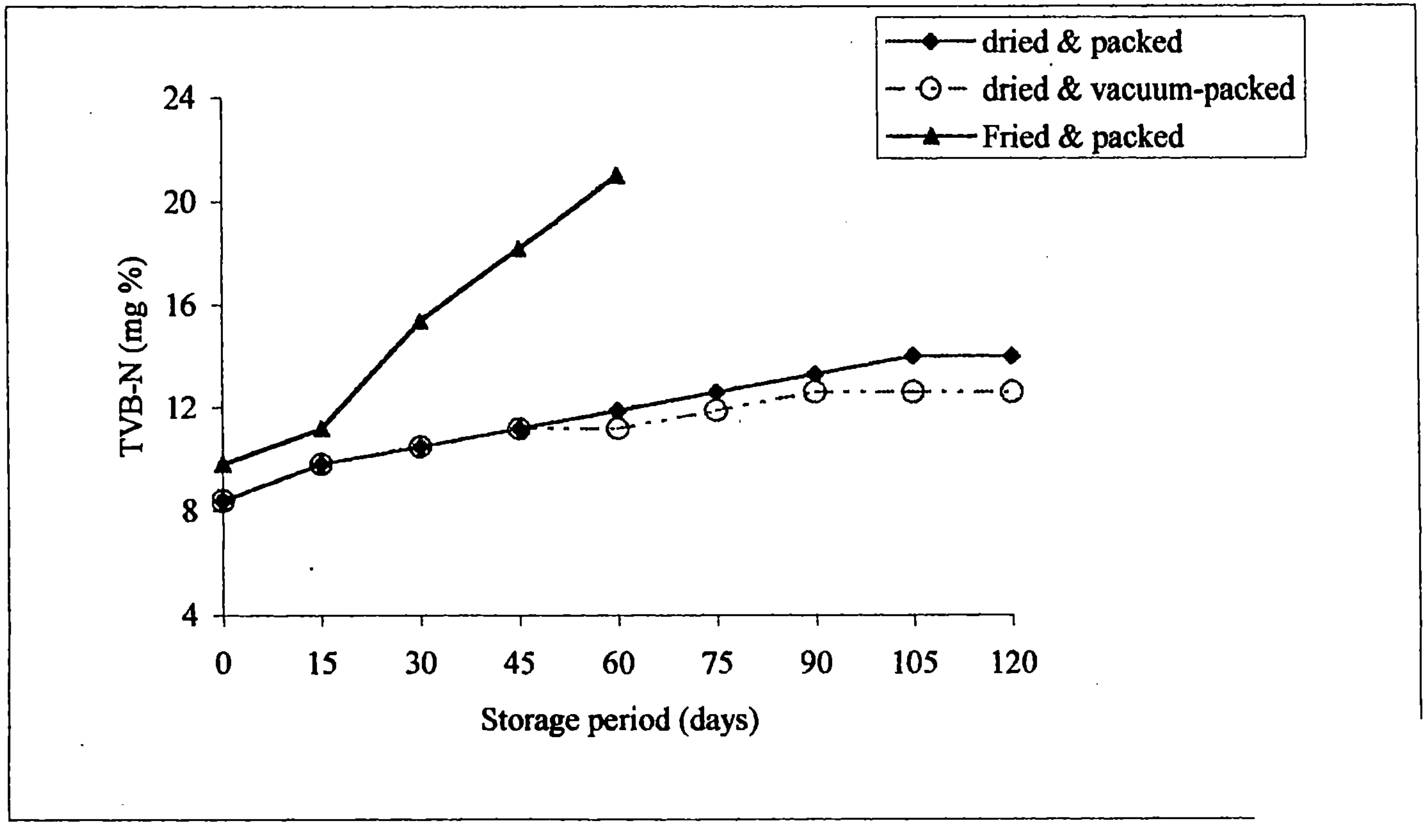

Fig. 4 :- Changes in total volatile base nitrogen content of fish crackers during storage under various conditions of packing

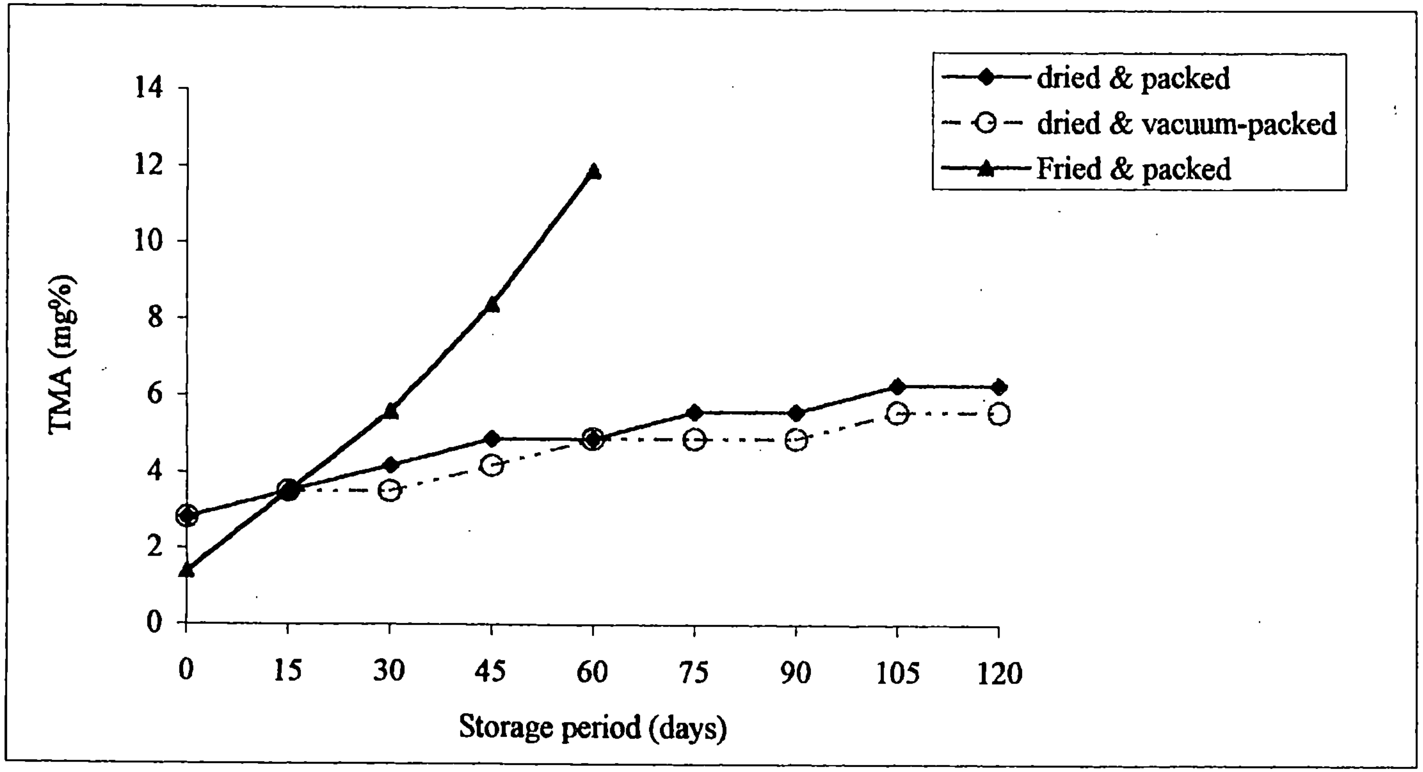

Fig. 5:- Changes in trimethylamine content of fish crackers during storage under various conditions of packing.

Table 15: ANOVA for TMA content of dried & packed and dried & vacuum-packed dried fish crackers stored at room temperature

Source of variation	Sum f squares	Degrees f freedom	Mean sum of squares	F value
Between packing forms	0.98	1	0.98	16.065**
Between Days	19.11	8	2.388	39.147**
Error	0.49	8	0.061	
Total	20.58	17		

**Significant at 1% level

Table 16: ANOVA for peroxide value of dried & packed and dried & vacuum-packed fish crackers stored at room temperature

Source of variation	Sum of squares	Degrees of freedom	Mean sum of squares	F value
Between packing forms	0.088	1	0.088	14.193**
Between Days	1.379	8	0.172	27.742**
Error	0.05	8	0.0062	
Total	1.517	17		

**Significant at 1% level

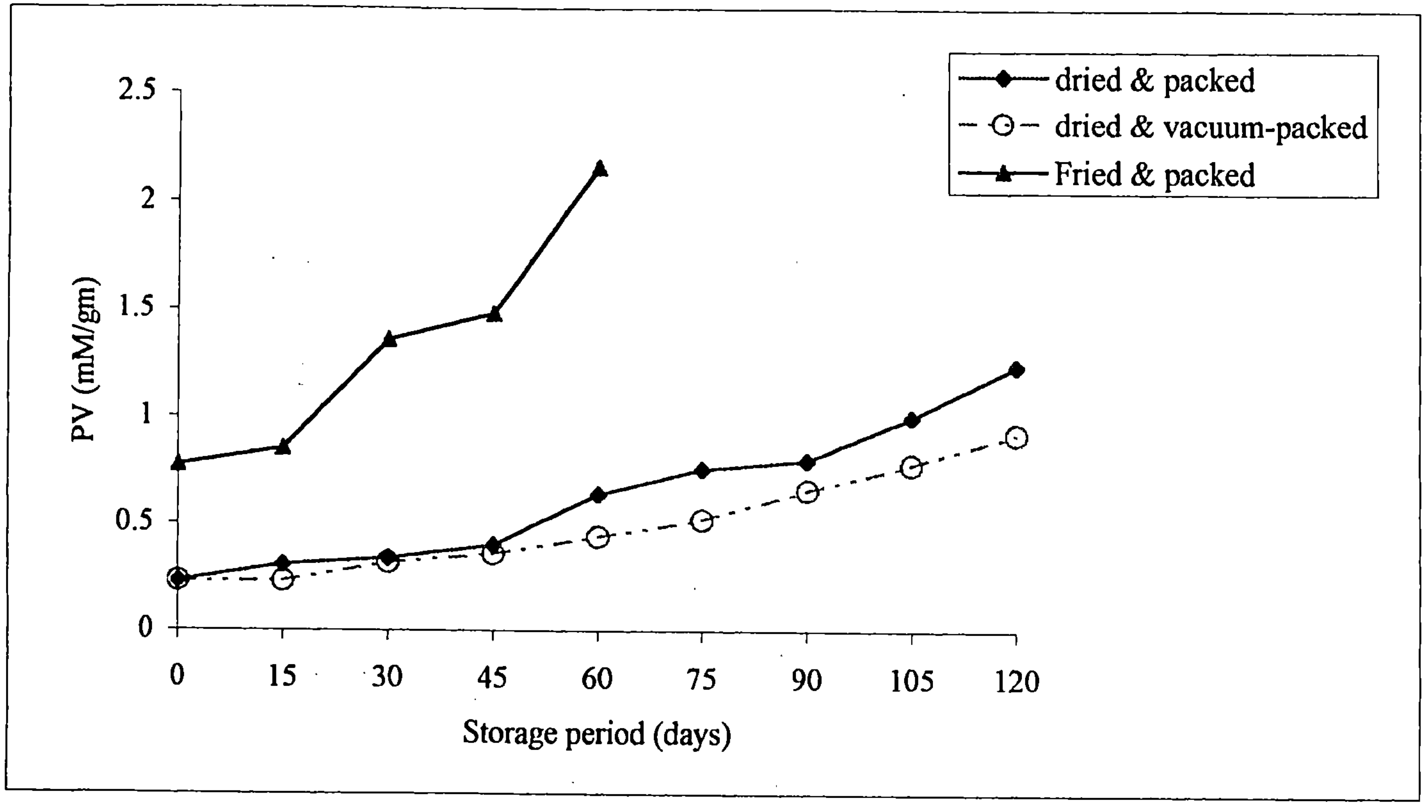

Fig. 6:- Changes in peroxide value of fish crackers during storage under various conditions of pakcing

Significant difference was noticed between the forms of packing (Table16).

In the case of fried & packed fish crackers peroxide value increased from 0.78 to 2.16 mM/gm during 52 days of storage as seen in Fig 6.

4.6.6 Thiobarbituric acid value

The TBA value of dried fish crackers was found to be 0.04 mg malonaldehyde (MA) per gm sample on the zero day of storage. This increased to 0.90 mg/gm in the case of dried & packed product and to 0.59 in the case of dried & vacuum-packed product by the end of the four months of storage as seen in Fig.7. However, no significant difference could be established, as seen from Table 17.

Fig .7 also shows the changes noticed in TBA value of fried fish crackers, from 0.195 mg/gm, to 1.33 mg/gm.

4.6.7 Total Plate Count:

Fig.8 shows the variations in the total plate count of crackers during storage. In dried & packed products TPC increased from 320 cfu/gm to 2960 cfu/gm and in dried & vacuum-packed products it increased from 320 cfu/gm to 1900 cfu/gm in 120 days of storage. Statistical analysis showed that the values were significantly different between the two forms of packing (Table 18).

In the case of fried and packed fish crackers, TPC increased from 100 cfu/gm to 2500 cfu/gm in 52 days.

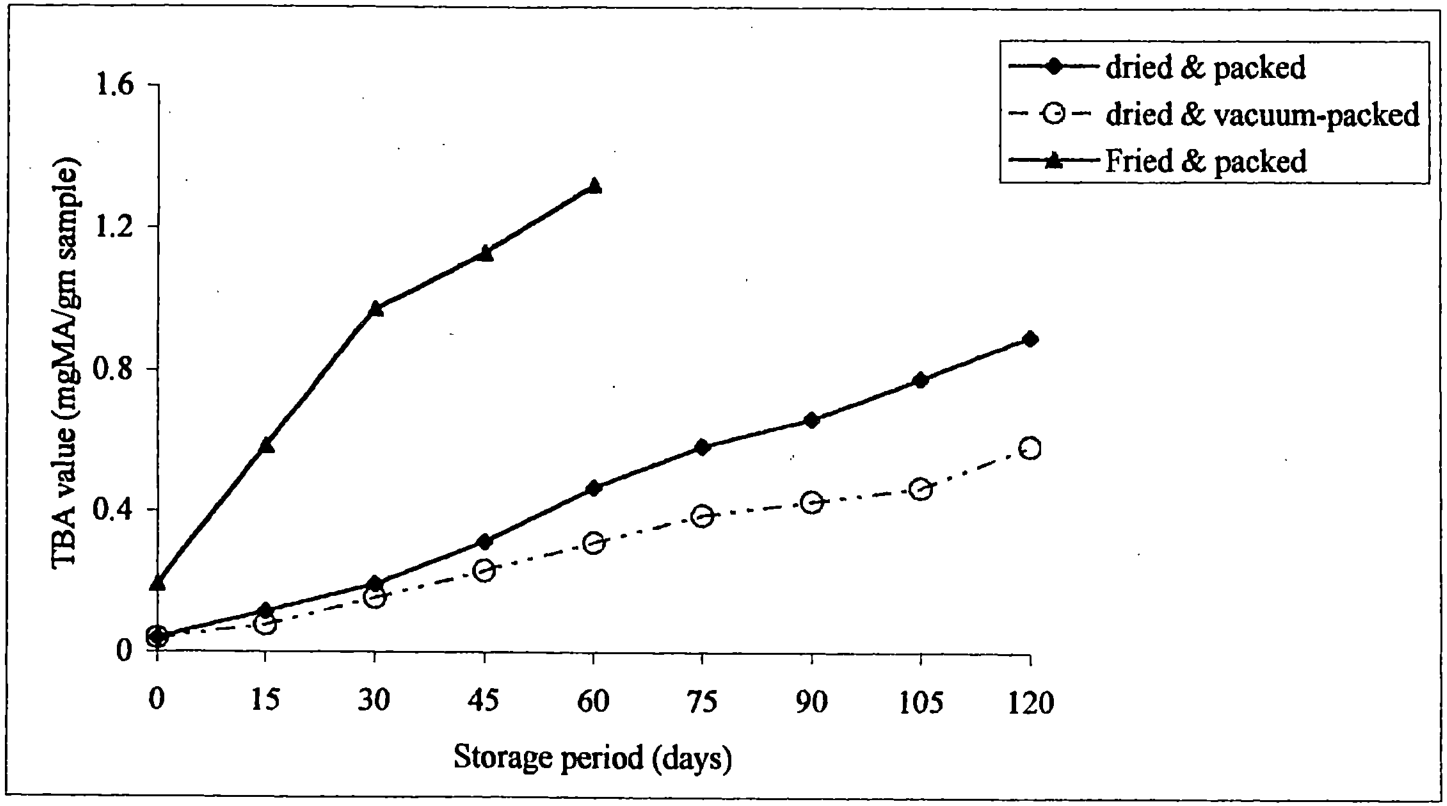

Fig. 7 :- Changes in thiobarbituric acid value of fish crackers during storage under various conditions of packing

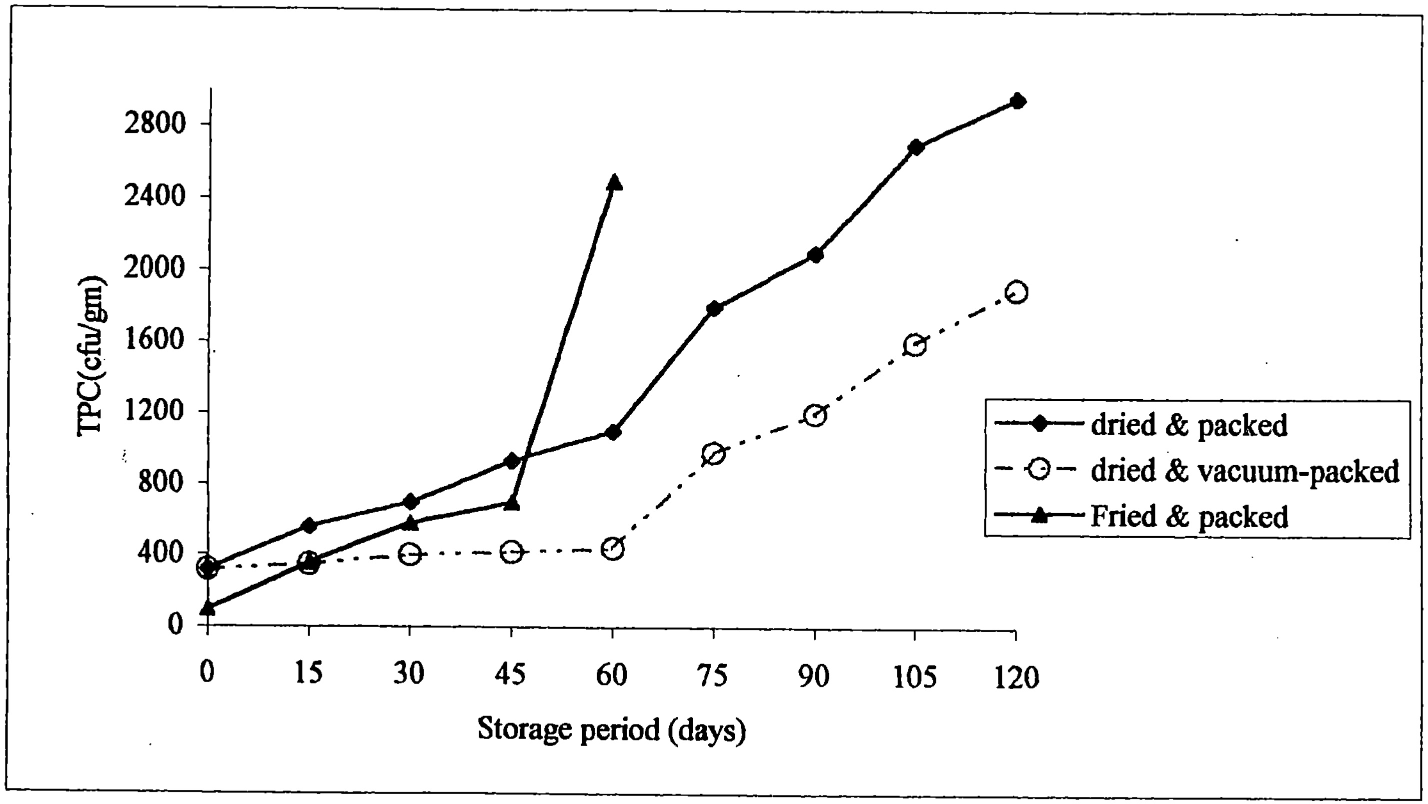

Fig. 8 :- Changes in total plate count of fish crackers during storage under various conditions of packing

Table 17: ANOVA for T BA value of dried & packed and dried & vacuum- packed fish crackers stored at room temperature

Source of variation	Sum of squares	Degrees of freedom	Mean sum of squares	F value
Between packing forms	0.1039	1	0.1039	0.821
Between Days	0.9555	8	0.1194	0.944
Error	1.0124	8	0.1265	
Total	1.1164	17		

Table 18: ANOVA for T PC of dried & packed and dried & vacuum-packed fish crackers stored at room temperature

Source of variation	Sum of square	Degree of freedom	Mean sum of square	F value
Between packing forms	171422.218	1	1717422.218	22.692**
Between Days	9695544.44	8	1211943.055	16.013 **
Error	605477.782	8	75684.722	
Total	12018444.44	17		

** Significant at 1% level

4.6.8 Fungal Count

Fig.9 shows variations in the fungal count of crackers during storage. Fungal count was nil in all the samples during the initial few weeks of storage, but increased to 390 cfu/gm and 330cfu/gm, in the case of dried & packed and dried & vacuum-packed products respectively (Table-19).

In the case of fried and packed sample, the count increased to 550 cfu/gm on the 52 days.

4.6.9. Sensory evaluation

Sensory evaluation was done only on fried samples irrespective of the form of packing. The samples evaluated on the zero day of storage were common for all the three forms of packing.

4.6.9.1. Appearance

The mean score for appearance decreased from 4.29 to 4.00 in the case of dried & packed crackers and to 4.08 in the case of dried & vacuum-packed ones, by the end four months of storage (Fig 10).

Friedman test was applied for the scores obtained for the last set of samples. No significant difference was noticed even after four months storage between dried & packed and dried & vacuum-packed fish crackers.In the case of fried and packed fish crackers, mean scores decreased from 4.29 to 3.58 by the end of the 52nd day. Scores obtained for 30th day and 45th day samples were analysed by Friedman test, but showed no significant difference.

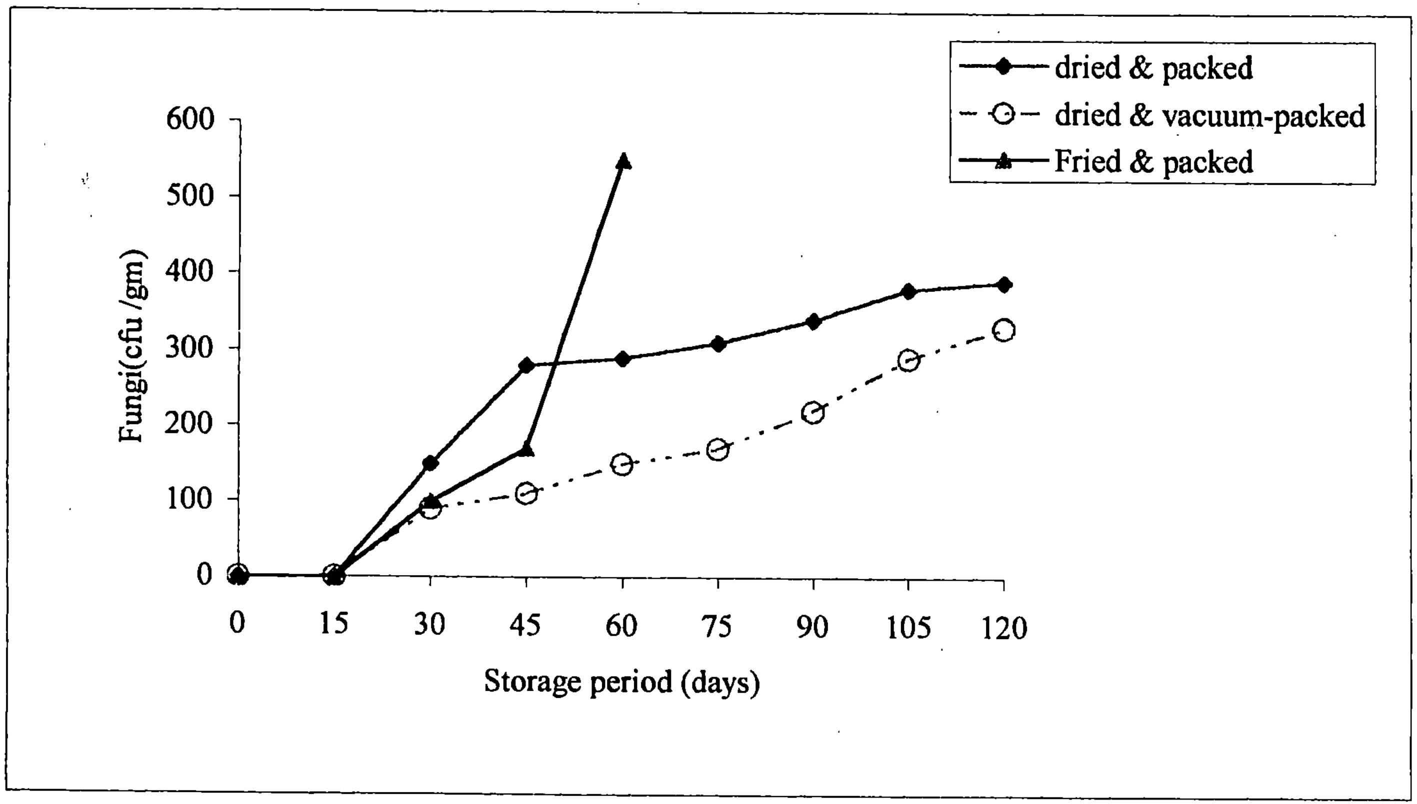

Fig. 9 :- Changes in fungal growth of fish crackers during storage under various conditions of packing

Table 19: ANOVA for fungal growth of dried & packed and dried & vacuum-packed fish crackers stored at room temperature

Source of variation	Sum of squares	Degrees of freedom	Mean sum of squares	F value
Between packing forms	49207.143	1	49207.143	74.880**
Between Days	96371.428	6	16061.904	24.442 **
Error	3942.857	6	657.143	
Total	149521.428	13		

**Significant at 1% level

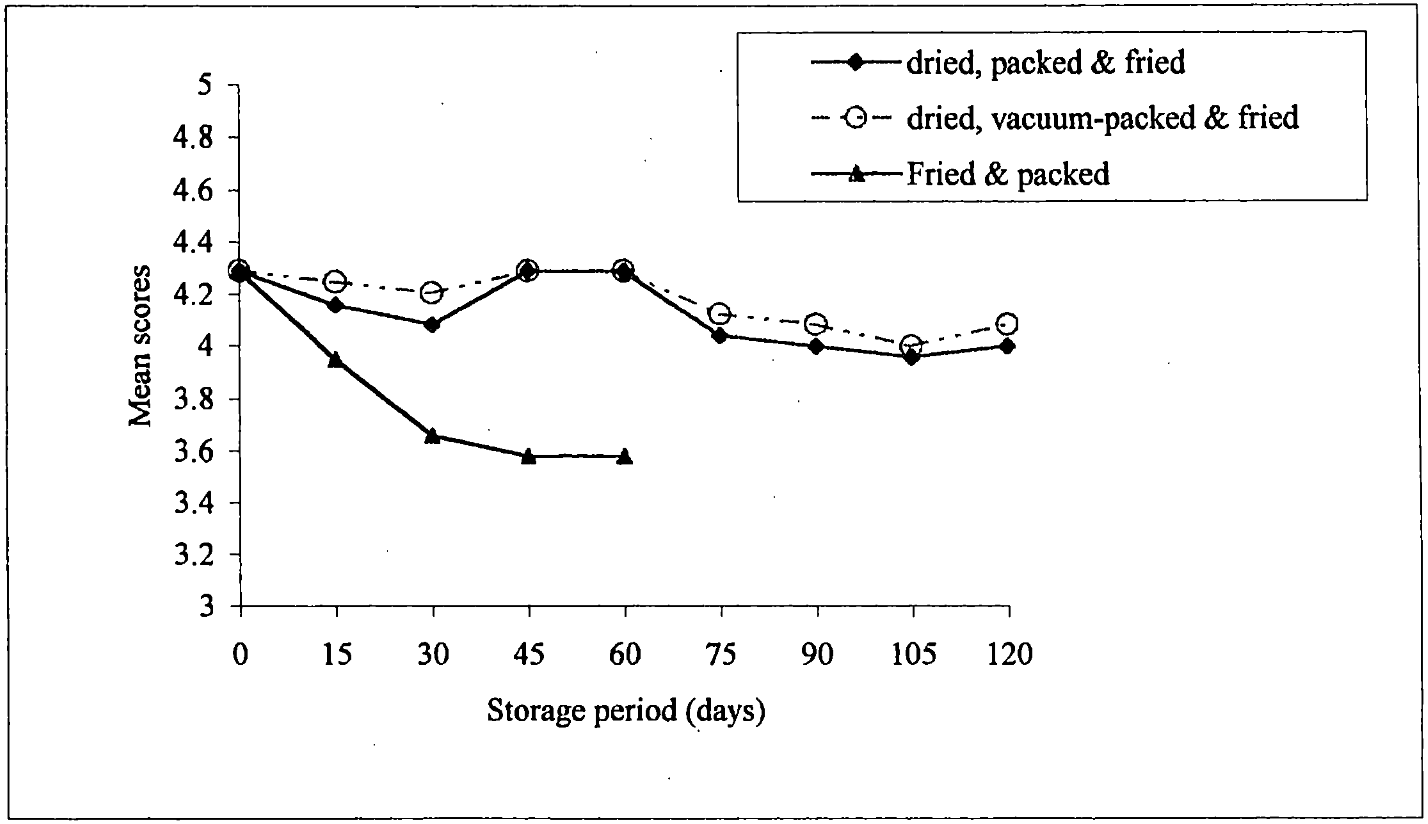

Fig. 10 :- Changes in appearance of fish crackers during storage under various conditions of packing

4.6.9.2. Crispness

A mean score of 4.46 was obtained for fried crackers on the zero day of storage (Fig.11). The mean score decreased to 3.83 and 3.88 in the case of dried & packed and dried & vacuum-packed products respectively, by the end four months of storage.

Friedman test was carried out for the crispness scores of 120th day samples. No significant difference was noticed even after four months storage between dried & packed and dried & vacuum-packed fish crackers.

In the case of fried and packed fish crackers, mean scores decreased to 2.75 by the end of the 52nd day. Sensory scores for 30th days and 45th day were analysed by Friedman test. No significant difference in the scores was seen between the 30th days and 45th day samples.

4.6.9.3. Flavour

For flavour a mean score of 4.33 was obtained for freshly prepared crackers which decreased to 3.83 in the case of dried & packed and 3.96in the case of dried & vacuum-packed samples by the end four months of storage. However, based on Friedman test, no significant difference was noticed between the two forms of packing even after four months (Fig 12).

In the case of fried and packed fish crackers, mean scores decreased from 4.33 to 2.5 by the end of the 52nd day. Friedman test on scores showed no significant difference between the 30th day and 45th day samples.

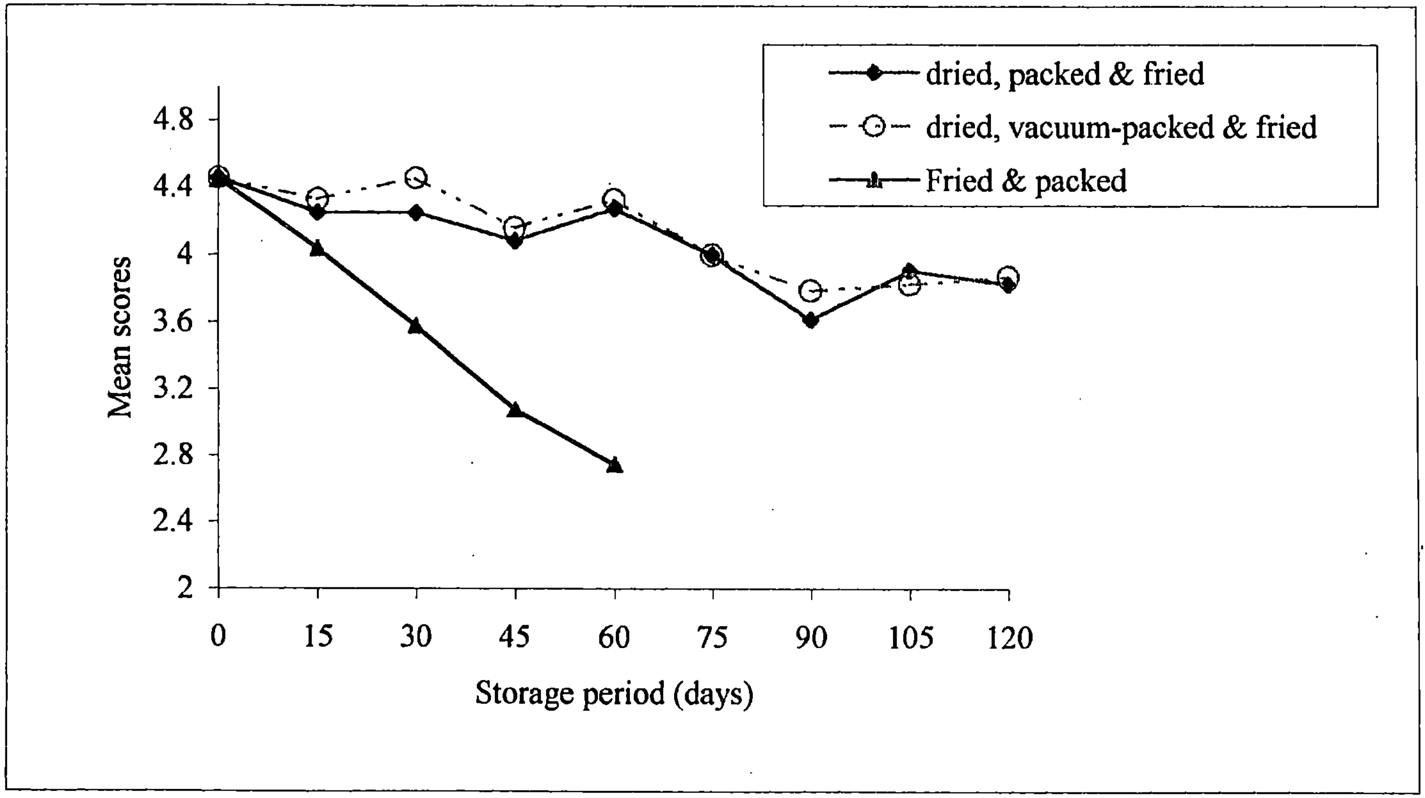

Fig. 11 :- Changes in crispness of fish crackers during storage under various conditions of packing

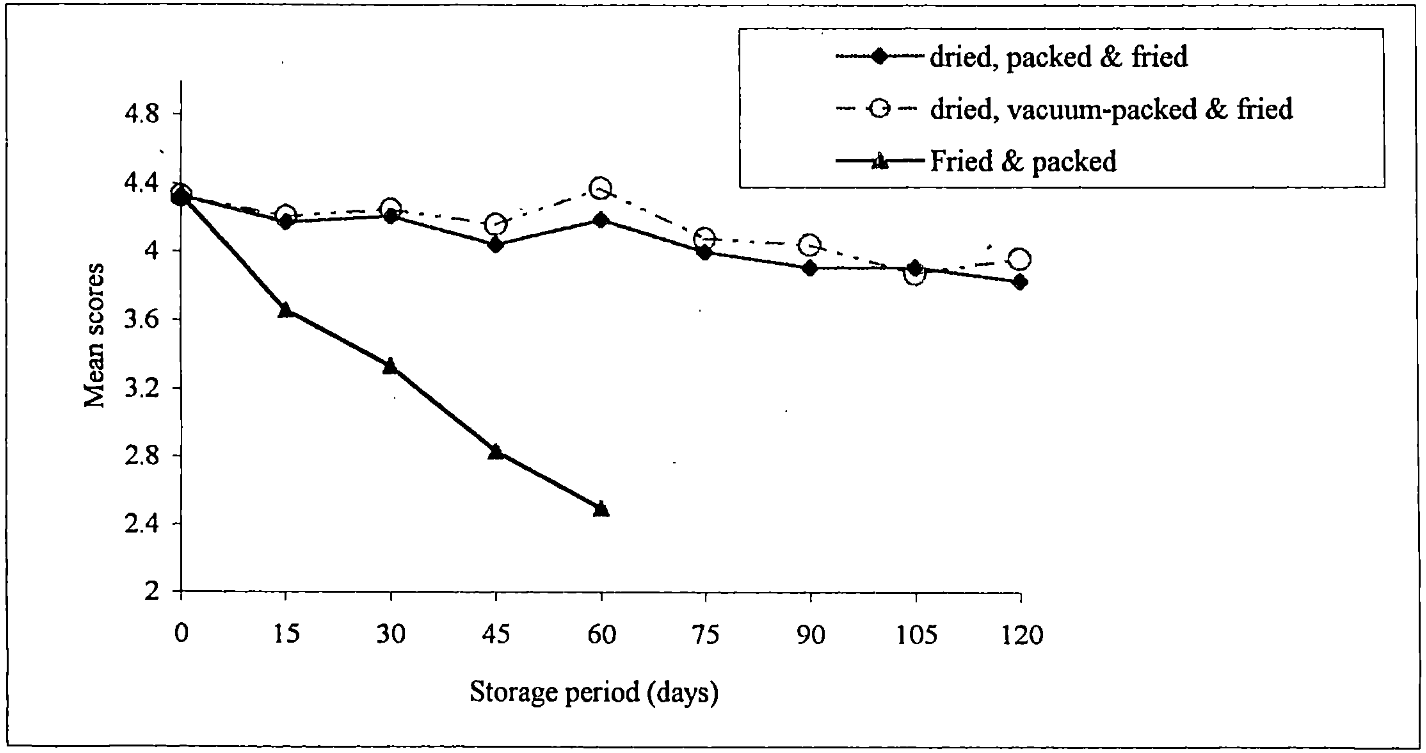

Fig.12:- Changes in flavour of fish crackers during storage under various conditions of packing

Triangle test was conducted on 120^{th} day, in order to find out difference between dried & packed and dried & vacuum-packed crackers. Panelists could not find difference between these two samples with respect to appearance, crispness and flavour.

4.6.10 Production cost

The production cost for manufacturing crackers on small scale is given in the production cost sheet (Appendix-III). Production cost of fish crackers is estimated to be Rs. 150/- per kg of dried fish crackers.

Discussion

5. DISCUSSION

5.1. Standardisation of method

It is evident from the literature that fish crackers of Malaysia, prepared by traditional methods, are generally of very poor quality (Yu, 1986, Siaw *et al.* 1979). This is mainly because of the improper quality control and sanitary measures adopted during their manufacture. Thus standardisation of method became essential and various methods have been suggested by Siaw *et al.*(1985) and Yu, (1997) for producing good quality crackers.

However, it may be observed that even amongst the standardised methods, variations occur with respect to type of food additives, processing conditions for different fish species used, etc., although the basic methodology is more or less the same. In addition, the preferences of the consumers can vary from place to place.

In the present study, the method of preparing crackers from the fish, *Nemipterus japonicus*, was standardised based on different parameters such as, starch source, fish: flour: water proportion, mixing time and cooking conditions.

Any product developed must be based on consumer acceptance. One of the most important properties required for all types of wafers or crackers is a high level of swelling upon frying as emphasised by many authors (Siaw, Yu & Chen, 1980, Siaw *et al.* 1985). The extent of puffing will decide crispness of crackers, and a good crispness is a fundamental requirement for developing consumer acceptance. For frying, the crackers were immersed in oil heated to a temperature of 180-200°C, which is the usual frying temperature. This will result in quick formation of steam from the water contained in the crackers and its release to the outside. Puffing may occur upon flash evaporation of water due to exposure to high temperature (Guraya, 1994). According to Lachmann (1969), the degree of gelatinisation of starch is one of the factors which influence the degree of expansion of products when immersed in hot oil. The entrapped water molecules in the swollen starch granules may contribute to a higher linear expansion of *keropok* as reported by Kyaw (1999). A convenient means of expressing the extent of swelling is percentage linear expansion of crackers upon frying. Thus, linear expansion is a measure of crispness (Siaw *et al.*, 1980 and Yu *et al.* 1981).

According to Siaw *et al.* (1985), fish crackers must show at least 77% linear expansion for obtaining good consumer acceptance. In the present study the crackers were found to be fairly acceptable even at about 70% linear expansion, and therefore, this was decided as the minimum linear expansion required for the samples for conducting further studies.

Out of the five starch sources tried, only fish crackers prepared from corn flour and refined wheat flour (*maida*) resulted in a linear expansion of more than 70% (Table 3). Significant difference is seen between the two starch types, with corn flour giving a higher linear expansion of about 81.74%. Other samples were harder in texture. This is in agreement with the findings of Venugopalan and Govindan (1967) who observed that out of the four starch sources used, *viz.*, *maida*, corn flour, tapioca and black gram, corn flour resulted in highest increase in the volume, by about 100.4%, upon frying. Findings of Yu (1991b) also support the idea that the type of flour is a controlling factor in the expansion of fish crackers. He prepared fish crackers using three starch sources *viz.*, tapioca, sago and wheat flour. Of these, crackers made from tapioca and sago flour had the highest linear expansion, being about 108% and 98.6%, respectively, and were preferred by the taste panelists. However, studies conducted by Shojaei (1998) demonstrated that incorporation of tapioca flour into fish crackers resulted in the highest linear expansion of about 98% whereas, corn flour resulted in a much lower expansion. Siaw *et al.*(1979) also found that fish crackers made from tapioca flour was preferred by taste panelists. Hence, there seems to be significant variation with respect to effect of starch type on the swelling characteristics of the product. Corn flour also resulted in highest sensory quality in fish flakes developed by Venugopalan and Govindan (1967) and also highest grades for the sensory characteristics, colour, taste and overall quality, whereas, Siaw *et al.* (1979) and Shojaei (1998) obtained higher scores for tapioca.

In the present investigation, the product prepared using corn flour and refined wheat flour were subjected to sensory evaluation, the results of which are represented in Table 4. Use of corn flour gave the highest sensory scores for texture (crispness) and is found to be significantly superior to refined wheat flour. Significant difference is noticed between the two with respect to appearance and crispness, but not with respect to flavour. Hence, the observations made in this study also support the idea that swelling characteristics and consumer acceptability are highly related. The difference seen in the studies conducted by various workers with respect to effect of type of starch on swelling characteristics may be on account of differences in the methods of preparation of the flour.

The proportion of fish: flour: water is important in providing proper swelling of crackers upon frying. In addition, it can also influence various sensory quality characteristics. The amount of water added was decided based on the amount of water contained in the fish and the amount of starch used. It is necessary to have sufficient quantity of water in the mixture for proper gelatinisation of starch. According to Kyaw (1999), one of the factors influencing the degree of gelatinisation is availability of water necessary for gelatinisation. It was observed in the present study that a proportion of fish: flour: water of 30:70:45.5 showed a dry region at the centre of the roll upon steaming which was never seen in the case of combinations having lower starch contents. This is probably due to improper gelatinisation of starch on account of insufficient water. As the rolls are heated, it is the outer layers that get gelatinised first. If the water content of the dough is less, more water will be absorbed from the inner layers for gelatinisation. Since the dough is stuffed into plastic casings there is little possibility of absorption of moisture from the steam surrounding the rolls. Thus, when the inner layers start getting heated, there is very little water available for proper gelatinisation.

Out of the five proportions studied, good swelling was obtained in the case of crackers prepared using the fish: flour: water proportions, 70:30:22.5, 60:40:27.5 and 50:50:32.5 (Table 5) whereas, the other two combinations resulted in linear expansion much lower than 70%. This again indicates that sufficient water should be available for obtaining proper gelatinisation and swelling. However, variation in starch and moisture content of the three combinations are not sufficient to cause a significant difference in swelling characteristics.

The three proportions that gave linear expansion of more than 70%, therefore, were further subjected to sensory evaluation. According to Friedman test there is significant difference between the three combinations with respect to the sensory quality characteristic *viz.*, appearance, but no significant difference is obtained between them with respect to crispness and flavour. Thus, the proportion giving highest scores for sensory evaluation, *viz.*, 60:40:27.5, was selected for further studies. Shojaei, (1998) obtained highest scores for sensory evaluation for the proportion of fish: flour of 50:50, but using tapioca flour.

Table 8 shows that the percentage linear expansion of crackers increases with the mixing time. This is in agreement with the finding of others such as Siaw *et al.* (1985), Shojaei (1998), and Cheow *et al.* (1999). According to Siaw *et al*, (1985), mixing is the most critical factor in the manufacture of crackers that influences the degree of gelatinisation. Mixing that is not homogeneous will result in decreased gelatinisation and hence, lower expansion ratio. Shojaei, (1998) obtained a good quality product by subjecting to a mixing time of 15 min, whereas, Cheow *et al.* (1999) observed that an insufficient mixing time (less than 20 min) resulted in reduction of linear expansion. In the present study, the mixing times of 15 min and 20 min resulted in linear expansion of more than 70%, and were significantly higher than those subjected to lower mixing times, *viz.*, 2 min, 5min and 10 min. However, no significant difference between 15 min and 20 min could be obtained with respect to linear expansion. The sensory evaluation based on appearance, crispness and flavour also could not detect any significant difference between the two periods of mixing times (Table 9). Therefore, the shorter of the two *viz.*, 15 min, was adopted for further studies.

Another factor that influences the degree of expansion of crackers, is the extent of gelatinisation of starch, and this in turn, is dependent on the cooking conditions. The importance of cooking condition has been stressed by several workers (Yu, 1986; Shojaei, 1998 and Kyaw, 1999, etc.). Controlled cooking ensures adequate gelatinisation of starch granules, which when fully gelatinised results in better rupture of starch cells during frying (Cheow, 1985 and Yu,1986).

In the present study, four conditions of cooking were tested and the linear expansion values of the product upon frying are presented in Table 10. Since no significant difference was noticed amongst the different cooking conditions, steaming for 20 min at atmospheric pressure was adopted, as it would be more convenient to use steam, rather than water bath under commercial conditions. In all the other three trials, a water bath was used. According to Colonna *et al.*, (1984) the starch granules were fragmented after 30 min of steaming. A longer heating period may result in fragmentation of starch granules, which in turn, will impact force of water vapour on the starch matrices and therefore, the linear expansion may be decreased.

The proximate composition of the fish used in the study, *viz.*, Japanese threadfin bream, as well as that of dried crackers and fried crackers, are given in Table 11. This indicates that the meat is lean, the fat content being only 1.54%. This is a requirement for making crackers, since higher levels of fat content will lead to rancidity (Coxon, 1987 and Melton, 1983). Dried crackers prepared in the present investigation contained less than 10% moisture, which is essential for storage at room temperature. Results show that dried crackers are particularly rich in protein and carbohydrate and upon frying, the fat content also increased. However, the moisture content decreased further upon frying. This is obviously because, upon frying, most of the moisture escapes as steam and a greater amount of oil is absorbed, and the net result is that the weight of crackers increases by about 26%.

5.2 Storage Studies

Changes during storage of fish crackers were studied based on various microbiological, physical, chemical and organoleptic tests. All the tests used are dependant on quality of the product and hence, are useful for determining their shelf life. In addition, sensory evaluation was used as a means of determining consumer acceptability of the products. It is well known that quality of fish products are most satisfactorily judged by organoleptic methods rather than by objective tests (Gould and Peters, 1971). It may be noted that most of the parameters used in the present investigation, are interrelated. For example, TVB-N and TMA are dependant on microbial activity (Beatty, 1938 and Castell, 1946, Connell, 1975), PV and TBA value are indices of the extent of fat oxidation (Tarr, 1944 and Melton, 1983). All these, in turn, can influence the organoleptic quality of the product.

Samples of fish crackers prepared by the standardised method, were stored at room temperature under different conditions of packing *viz*., i) dried & packed, ii) dried & vacuum-packed- both for a period of 120 days, and iii) fried & packed- for a period of 52 days. Dried crackers are expected to be fairly stable at room temperature, which could be better preserved by packing under vacuum.

Fried crackers are 'ready-to-consume', but can be expected to be have a shorter shelf life than the dried ones.

The packaging material used was polyester/polyethylene laminate that has a low permeability to water vapour (3.62gms/m^2/24hrs/90±2 %RH/37^{0}C) and air (65cc/m^2/24hrs/90±2%RH/37^{o}C). This is a necessity as both water vapour and oxygen can adversely affect the quality of crackers, particularly the fried ones.

For vacuum packing, a chamber vacuum of about 17 inches of mercury is recommended for dried crackers. Further increase in the vacuum resulted in breakage of dried crackers. Vacuum packing was not adopted for fried materials as it would be easily crushed.

Yu (1993) reported that for proper swelling of crackers, a thickness of 3 mm at the time of slicing, was most appropriate. According to him, at greater thicknesses, the product was too hard to chew and at lower thicknesses, the panelists commented that the product dissolved too quickly in the mouth. Similar observations were obtained in the preliminary trials conducted in this study, and therefore, a thickness of 3 mm was adopted throughout the study.

By the Friedman test it is seen that there is no significant difference between the two forms of packing of dried crackers – dried & packed, and dried & vacuum-packed, with respect to linear expansion, throughout the four months of storage (Fig. 3). This is probably due to the fact that the moisture content has remained more or less steady throughout the storage period in both the forms of packing as seen in Fig. 3 and that statistically no significant difference was seen between them. This is also supported by the observation that crispness of crackers, as evaluated by the taste panel, also did not show any significant difference between the two forms of packing (Fig. 11).

In the case of fried crackers, during storage, although the moisture content was considerably lower than the dried ones, the rate of increase in moisture content seems to be greater, being 2.79% on the zero day to 3.96% in 52 days. This increase is probably sufficient to affect the texture (crispness) as seen in Fig 11, which indicates a steady decrease in organoleptic scores with storage period.

The fried product has greater hygroscopicity than the dried samples, which is probably the reason for the greater rate of absorption of moisture from the surrounding air. Wetting of crackers will result in lowering of quality. A decrease in flavour score of fried & packed crackers was also noticed during storage (Fig 12), which may be partly on account of increase in the moisture content.

Increase in TVB-N and TMA contents are on account of spoilage bacterial activity and therefore, used as indicator of spoilage of fish and fish products (Stansby *et al.* 1957; Liston *et al.* 1961; Thimann, 1963; Hashimoto, 1965; Fields *et al.* 1968; Eskin *et al.* 1971). However, wide variations are generally seen in their values and therefore, not very dependable as quality indicators. But such methods can be used in combination with other parameters, such as organoleptic evaluation and microbial count, in order to study the quality changes in the product (Gould and Peters, 1971; Ryder *et al.* 1993). Both TVB-N and TMA contents of all the treatments increased during storage, so also the total plate count. Volatile bases including TMA, are chiefly produced by bacterial action. Hence, a correlation seems to exist between them, as seen in Figs 4,5,and 8. There seems to be a more rapid increase in the TPC, TVB-N content and TMA content of fried & packed crackers compared to other forms of packing. Values of all the three parameters seems to increase at the lowest rate in the case of dried & vacuum-packed crackers. Significant difference in TVB-N and TMA contents could be obtained between dried & packed and dried & vacuum-packed samples.

The results indicate that there was some microbial activity during storage of all the samples (Fig 8). However, it should be noted that the increase in microbial load was only by about one log cycle and the final counts were only 2500 cfu/gm in the case of fried & packed crackers and, 2960 cfu/gm and 1900 cfu/gm in the case of dried & packed and dried & vacuum-packed samples, respectively. The microbial counts are too low to cause any perceivable spoilage changes. This is evident from the sensory scores for flavour (Fig 12). Although a reduction in scores were seen in dried & packed and dried & vacuum-packed samples, all the samples were accepted by the taste panel even at the end of the storage period. However, fried & packed samples were accepted till the 45th day only. The reduction in the scores for flavour could be on account of reasons other than TMA, TVB-N, and bacteria.

Fungal count showed a trend similar to that of TPC (Fig 8). Fungi in general, are more tolerant to lower water activity than bacteria, and therefore, they may be involved in the spoilage of dried products (Katz and Labuza, 1981)). However, the extent of increase in fungal count may not be sufficient to cause any spoilage (decrease in quality) of the product. Further, no visible fungal growth was seen in any of the samples. Thus, it may be assumed that fungi may not have been involved in lowering the quality of any of the product during the entire period of study.

Peroxide value and TBA value are two commonly used indices of fat oxidation (Tarr, 1944, Bernheim *et al.* 1948 and Connell, 1995). PV is an estimate of intermediary compounds of fat oxidation and TBA value is a measure of malonaldehyde (MA) content formed as a final product of oxidation.

It is evident that fat oxidation, to a certain extent, has occurred in all the three lots. Both PV and TBA value progressively increased with the highest rate shown by fried & packed product followed by dried & packed product, and the lowest rate shown by dried & vacuum-packed samples (Fig 6,7). It can be expected that the extent of accumulation of oxidation products will be maximum in fried product on account of its considerably high fat content, being about 22.7% (Table 11).

A significant difference in PV was notices between dried & packed and dried & vacuum-packed samples (Table 16), with the latter showing lower values. This is obviously on account of the exclusion of much of the air from around the product in the vacuum-packed samples. But, it is probable that the extent of fat oxidation is only partial even after four months of storage. This is because, for TBA value, which is an indicator of the end products of fat oxidation, no significant difference is seen between the two forms of packing, although vacuum-packed products did show slightly lower values throughout the period of study (Fig. 7, Table 18). The decrease in flavour scores notices (Fig.12) could be partly on account of fat oxidation. A slight rancid flavour was detected by some of the panelists towards the end of the storage period of fried samples.

The parameters used for organoleptic tests were appearance, crispness and flavour. A briefing was given to the panelists before the test regarding the parameters. Appearance includes colour, shape, etc. Since the main textural characteristic of crackers is crispness, and is directly related to swelling, it was specifically asked for. Flavour is a very sensitive parameter, which includes various characteristics such as odour, taste and mouth feel (Amerine *et al.* 1965). The panelists were asked to judge each parameter according to their liking, as would be done by the consumers.

Scores for all the three sensory parameters showed a decreasing trend in all the lots (Figs 10, 11, 12). However none of the parameters showed significant difference between dried & packed and dried & vacuum-packed products according to Friedman test. It may be therefore, concluded that the storage periods is not sufficient for the various chemical and microbiological agents to bring about any noticeable changes in the product. However, the difference in the scores between the two forms of packing appears to be increasing with storage period. Such a patter may be observed even in the case of most of the objective tests such as TVB-N, TMA, PV, TBA value, TPC and fungal count (Figs 5, 6, 7, 8, 9). Thus, it appears that significant difference between the two forms of packing will occur on further storage, with better retention of quality in the vacuum-packed products.

In the case of fried & packed crackers a significant difference could not be established by the Friedman test between 30th and 45th day for appearance, crispness and flavour scores. Further, the decrease in organoleptic scores appears to be quicker in the case of fried & packed products than the dried samples, and were judged unacceptable by the 52nd day. As mentioned earlier, various physical, chemical and microbiological changes are more rapid in the case of fried sample.

The panelists could not find any significant difference between dried & packed and dried & vacuum-packed samples with respect to appearance, crispness and flavour even on the last day (120th day) of storage. Therefore, it was decided to conduct a triangle test for the same samples. Triangle test is a sensitive one useful in detecting any noticeable difference between samples (Jellinek, 1985). However, even this test showed no significant difference between two the forms of packing. Hence, it may be assumed that ordinary packing is good enough for storage of dried crackers at least for four months.

The production cost was worked out to be Rs 150/- per kg of dried fish crackers (Appendix-III). The cost is comparable with that of similar starch-based products available in the market, but the product developed, has the advantage that fish proteins are incorporated into it. It may be noted that the capital investment is only nominal, and that the product could be made viable even on small scale.

Summary

6. SUMMARY

1. The main objectives were to develop a suitable method of making the product, "fish crackers" from a low cost fish, *viz.*, *Nemipterus japonicus* (Bloch), and to conduct its storage studies.

2. Fresh threadfin bream was transported from the fish market/landing centre to the laboratory in an insulated box.

3. The base method used for making fish crackers was generally that followed in Malaysia.

4. Fish crackers were prepared by forming a dough by mixing and grinding comminuted fish meat, salt, sugar, flour, and iced water. The dough was shaped in the form of cylindrical rolls, boiled, cut into thin slices, and dried. The dried slices were fried in oil, where upon they puffed to give a porous, low-density, product.

5. The effect of various starch sources and combinations of fish, flour and water and the various processing steps, such as mixing time, and cooking conditions, on the quality of the product, were studied.

6. For evaluating quality, linear expansion and various organoleptic tests were carried out based on which additive combination and processing steps were standardised.

7. Corn flour was selected as the best starch source, and fish: flour: water proportion selected was 60:40:27.5.

8. A mixing time of 15 min and cooking using steam at atmospheric pressure for 20 min, were found to be most suitable.

9. The dried products were subjected to storage studies for a period of four months, under two packing conditions *viz.*, i) dried and packed and ii) dried and vacuum-packed. In addition, fried and packed products were stored for period of 52 days. Polyester/polyethylene laminated pouches having low permeability to water vapour and air, were used for packing these products.

10. Quality changes during storage period was monitored based on various tests, *viz.*, linear expansion, moisture content, total volatile base nitrogen content, trimethylamine content, peroxide value, thiobarbituric acid value, total plate count, fungal count, and sensory evaluation based on appearance, crispness and flavour.

11 The values of all the quality parameters generally showed a progressive change during storage in the case of all three forms of packing. Dried & vacuum-packed samples showed comparatively the lowest rate of change whole fried & packed samples showed the highest rate.

12. Samples packed as dried & packed, and dried & vacuum-packed remained acceptable for the entire storage period of four months and no significant difference in the sensory quality was obtained between the two. However, fried & packed samples were found to be acceptable only for 45 days.

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Abstract

DEVELOPMENT OF MALAYSIAN TYPE FISH CRACKERS FROM *NEMIPTERUS JAPONICUS* (BLOCH)

By

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ABSTRACT OF A THESIS

Submitted in partial fulfilment of the requirement for the degree

MASTER OF FISHERIES SCIENCE

Faculty of Fisheries

Kerala Agricultural University

DEPARTMENT OF PROCESSING TECHNOLOGY

COLLEGE OF FISHERIES

PANANGAD, COCHIN

2001

ABSTRACT

A study was undertaken for the preparation of fish crackers using a low cost fish, threadfin bream (*Nemipterus japonicus*, Bloch). A method was standardised for making crackers based on that generally followed in Malaysia. Fish meat was mixed with various food additives such as starch, salt, sugar, monosodium glutamate, colour and water, and stuffed into high-density polyethylene casings as rolls, cooked, cooled, sliced and dried.

The parameters used for standardisation were starch source, fish: flour: water proportion, mixing time and cooking condition. The various starch sources studied were corn flour, refined wheat flour (*maida*), tapioca powder, sago powder, and potato powder. The various fish: flour: water proportions used for the study were 70:30:22.5, 60:30:27.5, 50:50:32.5, 40:60:37.5, and 30:70.42.5. Ingredients were mixed for various periods, *viz.*, 2,5,10,15, and 20 min. The cooking conditions tried were steaming at atmospheric pressure for 20min, boiling in boiling water bath for 60min, boiling in water bath at a temperature of 90°C for 30min and boiling in water bath at a temperature of 90°C for 60 min. The effect of various additives and steps were assessed based on the extent of linear expansion and sensory evaluation of fish crackers after frying. Samples that gave linear expansion of more than 70 % alone were subjected to sensory evaluation. Based on the tests, the following conditions were selected: corn flour as starch source, fish: flour: water proportion of 60:40:27.5, mixing time of 15 minutes and cooking by steaming for 20 min at atmospheric pressure.

Fish crackers prepared by the standardised method, were subjected to storage studies at ambient temperature under various conditions of packing, *viz.*, dried & packed, dried & vacuum-packed, and dried, fried & packed, in laminated polyester/polyethylene (50/300 gauge) pouches. The pouch had low permeability to air and water vapour. Quality changes during storage were monitored at appropriate time interval based on various tests, *viz.*, total plate count and fungal count sensory evaluation, linear expansion, moisture content, total volatile base nitrogen content, trimethylamine content, peroxide value, thiobarbituric acid value.

Dried fish crackers packed with or without vacuum remained acceptable, with no significant reduction in sensory quality, for all the four months of study. However, packing under vacuum showed significantly lower values for moisture content, TVB-N content, TMA content, PV, TBA value, TPC, and fungal count, probably on account of lower amount of air contained in the pouch. Fried crackers, which are ready to consume, however, remained acceptable only for 45 days, possibly on account of its greater hygroscopicity and higher fat content.

APPENDIX-I

SCORE SHEET FOR SENSORY EVALUATION

Date: Time:

You are given samples of fish crackers. Kindly evaluate its appearance, crispness and flavour based on the scale shown below. Put the appropriate score against each quality characteristic under each sample code.

Quality rating scale:

Description of quality	Score
Excellent	5
Very good	4
Good	3
Fair	2
Borderline of acceptability	1
Unacceptable	0

Quality Characteristic	**Sample Code**				
	A	**B**	**C**	**D**	**E**
Appearance					
Crispness					
Flavour					
Rancidity Absent/Slight/Moderate/High					

Name of judge:

APPENDIX – II

TRIANGLE TEST FOR FISH CRACKERS

Date: Time:

Three samples of fish crackers, coded A, B and C, are presented. Two of the samples are identical and one is different. Taste the samples and indicate the odd sample by marking its code. In addition, indicate whether the odd sample is better or worse than the other two.

Sample code

A B

C

Preference

The odd sample is **BETTER/WORSE** than the other two.

Name of judge:

APPENDIX-III

PRODUCTION COST

Expected cost of manufacturing fish crackers on a small scale for one year has been worked out.

Production capacity: @ 20kgs per day for 200 days.

INITIAL INVESTMENT COST FOR EQUIPMENTS		RUPEES
1) Meat picking machine		50, 000.00
2) Grinder		10, 000.00
3) Stuffer		5, 000.00
4) Chiller		10, 000.00
5) Slicer		5, 000.00
6) Cooking facilities		5, 000.00
7) Drier		20, 000.00
8) Heat sealer		2, 000.00
9) Balance		5, 000.00
	Total	1,10,000.00

RAW MATERIAL		RUPEES
1) Fish (15,000 kgs @ Rs 20/- per kg)		3,00,000.00
2) Flour (3,000 kgs @ Rs 25/- per kg)		75,000.00
3) Salt (150 kgs @ Rs 5/- per kg)		750.00
4) Sugar (75 kgs @ Rs 16/- per kg)		1,200.00
5) MSG (3 kgs @ Rs 380/- per kg)		1,140.00
6) Iced water		10, 000.00
7) Carriage inwards		5, 000.00
8) Factory wages		96, 000.00
9) Packaging material		15, 000.00
	Prime cost	4,94,090.00

FACTORY EXPENSES		
1) Electricity		25,000.00
2) Fuel		5,000.00
3) Rent on factory building		30,000.00
4) Depreciation @ 10% of Equipments		11,200.00
5) Interest on investments @ 14%		15,400.00
6) Insurance		2,000.00
7) Miscellaneous		5,000.00
	Total	**6,00,000.00**

Production cost per kg of dried fish crackers **Rs150/-**