“EFFECT OF PROCESSING OPERATIONS ON THE QUALITY OF CANNED OCTOPUS”

YATHEESH., ***B. F. Sc.***

DEPARTMENT OF FISH PROCESSING TECHNOLOGY

COLLEGE OF FISHERIES, MANGALORE.

KARNATAKA VETERINARY, ANIMAL & FISHERIES SCIENCES UNIVERSITY, BIDAR.

2008

"EFFECT OF PROCESSING OPERATIONS ON THE QUALITY OF CANNED OCTOPUS"

YATHEESH., ***B. F. Sc.***

Thesis submitted to the Karnataka Veterinary, Animal & Fisheries Sciences University, Bidar.

in partial fulfillment of the requirements for the Degree of

MASTER OF FISHERIES SCIENCE
IN
INDUSTRIAL FISHERY TECHNOLOGY

MANGALORE **January, 2008**

DEDICATED TO
BELOVED PARENTS

DEPARTMENT OF FISH PROCESSING TECHNOLOGY
COLLEGE OF FISHERIES, MANGALORE.

KARNATAKA VETERINARY, ANIMAL & FISHERIES SCIENCES UNIVERSITY, BIDAR.

****

Certificate

This is to certify that the thesis entitled **"EFFECT OF PROCESSING OPERATIONS ON THE QUALITY OF CANNED OCTOPUS"** submitted by **Mr. YATHEESH** for the degree of **Master of Fisheries Science in Industrial Fishery Technology** of the Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar is a record of research work done by him during the period of his study in the University under my guidance and supervision, and the thesis has not previously formed the basis of the award of any degree, diploma, associateship, fellowship or other similar titles.

January, 2008

Mangalore.

(C.V. RAJU)
Assistant Professor (S.G)

"APPROVED BY"

Chairman: ______________
(C.V. RAJU)

Members: 1. ______________
(M.H. BHANDARY)

2. ______________
(B.A. SHAMASUNDAR)

3. ______________
(R.M.PRABHU)

4. ______________
(K.S. RAMESH)

ACKNOWLEDGEMENTS

I express my sincere and deep sense of gratitude to my major advisor Dr. C.V. Raju, Assistant Professor, Department of Fish Processing Technology, College of Fisheries, Mangalore for his invaluable guidance throughout the course of investigation and in preparation of this thesis.

My sincere thanks to my advisory committee members, Professor M.H. Bhandary, Dr. B.A. Shamasunder, Professor, Sri.R.M. Prabhu, Associate Professor, Department of Fish Processing Technology and Dr. K.S. Ramesh, Associate Professor Department of Aquaculture for his valuable suggestions and critical comments.

I am grateful to Dr. Y. Basavaraju, Dean and Dr. P. Keshvanath, former Dean for their encouragement and facilities accorded to carry out the investigation.

I warmly acknowledge the help rendered by Scientists of CIFT, Cochin in conducting heat penetration studies for canning of octopus in different styles.

My sincere thanks to Dr. Venkatappa, Assistant Professor (Fisheries) (SS), A R S, Kankanady, Mangalore for his timely help provided.

I owe lot to my Father, mother and sisters for their interest and wishes in my endeavors.

My sincere thanks to Mr. Chandra, Kiran, Nagesh and all my friends who directly or indirectly helped me during my research work and preparation of this thesis.

Mangalore
January, 2008

Yatheesh

CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS USED

^0C	:	Degree centigrade
^0F	:	Degree Fahrenheit
ANOVA	:	Analysis of variance
AOAC	:	Association of Official and Analytical Chemists
F_{250}	:	Process value at 250 ^0F
Hg	:	Mercury
H_2S	:	Hydrogen sulphide
MPEDA	:	Marine product export development authority
NaCl	:	Sodium chloride
NCA	:	National Canners Association
ND	:	Not done
Oz	:	Ounz
ppm	:	Parts per million
psi	:	Pounds per square inch
PV	:	Peroxide value
TCA	:	Trichloro acetic acid
TFS	:	Tin Free Steel
TMAN	:	Tri-methyl amine nitrogen
TN	:	Total nitrogen
TPC	:	Total plate count
TVBN	:	Total volatile base nitrogen

I. INTRODUCTION

I. INTRODUCTION

Canning is one of the food preservation method based on the application of heat to foods in sealed containers. The method was invented by a French Confectioner Nicholas Appert in the early years of the 19^{th} century. Even though, the method originated for the purpose of supplying good quality food grown on land to seafaring people and soldiers taking part in Napoleanic wars, it soon had the effect of making available the rich and nutritious food from the sea to people living far away from the sea coast in inland areas making their diet more complete and satisfying (Bitting, 1937). Thus within a few years of the discovery, seafoods canning industries were started in all important fishing countries of the world. At present, around 13 to 15% of the world fish production is utilized by canning, with the U.S. canning more than 20%, Japan canning around 35% and India using less than 1% of the annual landings for canning (Peddanna, 2005). Canned seafoods have not gained much acceptance in India for several reasons. The high cost of canned foods and their unfamiliarity to the Indian consumers can be considered to be the important causes.

Commercial canning of fish and fishery products in India as an industry was started in the 1950's. The main attraction at the time was the high export value for canned prawns offered by advanced western countries. Canneries for packing prawns were started along the coastline mainly around Cochin. The industry grew rapidly in the following two decades and during 1974-75, the number of fish canning factories in the country reached about 70 and foreign exchange earned by exporting canned prawns exceeded Rs. 5.0 crores (Saralaya, 1976). During this period, only small quantities of other fish such as mackerel and sardine were canned for supplying to the armed forces of the country.

In recent years the market for processed food in India has been growing at a greater rate partly due to change in life style and food habits of the people. This has been seen in increasing number of canned seafoods available in the market now in India in retortable pouches. The normal packing media like brine and oil are more commonly used to suit the western taste.

After 1975, however, the canning industry situation suddenly changed when the demand for canned prawn from foreign countries drastically declined. Within a year or two the export earnings cart wheeled to around 10% of the peak value. Sea food canners of India realized that it was a serious mistake to depend on one product (canned prawn) for one market (export). Analyzing the grave situation and the causes for the same, several fishery scientists pointed out that one of the main drawbacks of the industry was lack of diversification both in production and marketing (Govindan, 1975; Saralaya, 1976; Perovic, 1978). The much dwindled canning industry turned its attention to utilizing other sea food materials like mackerel and sardine and marketing them within the country. Small quantities of tuna, crab meat and also some shrimp were packed. As an attempt to assist the industry, research institutes and the government initiated the search for new raw materials suitable for canning, standardizing procedures for the same and adopting and publishing specifications for new canned fishery products, such as pomfrets, lactarius, tuna, etc. It is realized that even though India has rich raw material resources from its maritime fishing, several kinds of fish and shell fishes are not yet utilized by canners, mainly because of lack of standard procedures and know–how for canning these. Especially very little work seems to have been carried out with regard to the canning utilization of cephalopods such as squids, cuttlefishes and octopus for which there exists a wide market in foreign countries. This is the reason why octopus is selected for the present study.

Another fact that has been noticed in the case of canned sea food product of India is that they vary widely in quality from one producer to another or between different lots of the same producer. This is a factor that adversely affects the industry. According to Rogers (1952), it is upon quality that a lasting business is built and secure and well paid jobs are created for the industrial workers. However, control of quality in seafoods canning industry is really a difficult job. This is mainly because the quality of the raw material changes not only from day to day but also from hour to hour. Further, canning is a method involving a large number of individual operations carried out in a given sequential order, small changes in quality of material at each stage may have a cumulative effect, so that the final product may become much different in quality from what was intended. Hence, a close observation and strict control at each operational stage in canning of a specific item of sea food is essential to obtain a product of even, standard quality. In developing procedure for a new and modified product, it is necessary to make a scientific study of the effects of each particular treatment given to the material in process and also the over all effect of the whole method. This fact is borne in mind while conducting the present study on the canning of octopus.

The estimated cephalopod landing in the year 2003-04 in India was 1,17,289 tonnes (CMFRI, 2003). Japan is the largest producer and consumer of the cephalopods, it imports about 50% of the worlds production. There is a potential market for octopus and has been consumed in considerable quantity.

Canning of octopus with different filling medium was reported in Japan by Tanikawa (1965). Commercially important octopuses are *Octopus. vulgaris*, *O. dollfusi, O. indicus and O. membranaceus.* Among four species *O. vulgaris* is most suitable for canning because of its maximum canning yield. *O. vulgaris* weighing maximum weight of 10.0 kgs with total length of 1.30 meter has been reported by Mahadzir (1988).

In many parts of the world people hesitate to consume octopus regularly. The main reasons for this are; 1. General appearance 2. Tough texture of octopus mantles or tentacles when served at the table and 3. Lack of knowledge on nutritive value of octopus.

In India at present, octopus are mainly export-oriented commodities in frozen form. People of Japan, Korea, Mediterranean countries, Malaysia, Indonesia and Taiwan extensively utilize octopus as food in fresh, frozen and canned form. In some parts of the world it is utilized as bait for fishing. The meat of octopus is clean, attractive and has good flavour. It is also highly nutritive. The utility of meat as human food from the point of view of digestibility and nutrition has been extensively studied by Venkatappa and Dhananjaya (2006). In India, much more research work is required to exploit and utilize this potential resource and as raw material for canning, freezing and drying industry for internal and export markets.

The above considerations have been the main reason for selecting octopus as the material for the present study. It is planned to carry out experiments to standardize the method of canning of octopus using different filling media. Starting from the physical chemical and microbiological characteristics of the raw octopus, the changes brought about by each operation carried out in canning process are studied. Depending on the extent of quality changes and their desirability, each step is standardized, adopting variable operations procedure wherever feasible and the method of canning is decided. The final objective of the work is to obtain a suitable procedure following which canned octopus of superior quality acceptable both to Indian and foreign market can be produced by our canning industry. In this investigation, an attempt has been made to study the raw material characteristics and to arrive at a standard processing procedure and optimum thermal process for all the products, packed in tin coated, Sulphur Resistant lacqured metal cans. It is hoped that this study will be useful in attracting entrepreneurs to venture in producing a uniformly superior quality thermal processed products at affordable costs.

II. REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

In India, information available on processing and utilization of cephalopods is limited when compared to commercially important fishes. Among cephalopods, octopus, cuttle fish and squid form important marine fishery resources of India, ranking next only to finfish and shellfish. In this chapter, an attempt is made to review published literature on the raw material characteristics viz., physical, chemical and microbiological quality of the material used, freshness of the raw material as well as it's processing and utilization of octopus for canning industry. Also physical, chemical and organoleptic quality changes that take place in canned products during storage are reviewed. Since the canning procedures adopted in octopus are slightly different from those used for fish canning, comparisons are made and references are cited from the literature relating to canning of squids wherever found necessary.

2.1. General principle of canning

Canning is a method of food preservation by heat in hermetically sealed containers. This is a bactericidal method and requires application of sufficient heat to destroy the pathogenic and spoilage causing microorganisms in the product. The process involves enclosing of heat sterilized product in suitable containers and to prevent the recontamination of the product.

2.2. Microbiological aspects of canned product

The present knowledge of the microbiological aspects of canned foods has come through the efforts of several individuals and organizations (NCA of USA). Even though, **Nicholas Appert** himself was not a scientist in the conventional sense his method worked well and helped in establishment of several canning industries in different parts of the world. His book **" L art De conserver "** the first published literature in canning, formed the basis for a technology which remained poorly understood for several years till the correct explanation was given to it by Pasteur in 1861. Attempts to offer proper explanation for the success of the method till then even by leading scientists at the day were inadequate and sometimes gave wrong direction to the progress of canning industry. Occasionally, large spoilage losses were encountered, usually with the production of gas which would swell and burst the cans. This led to the studies by Prescott, Underwood and Russell in the 1890's. Prescott and Underwood also gave the concepts of cold spot as a reference point for determining the processing schedule for canned products. Soon the importance of ***Clostridium botulinum*** was recognized and it became the target microorganism for study especially by scientists of National canner association (NCA) of USA. It was realized that ***Cl. botulinum*** can pose the most dangerous health hazard that could threaten the survival of the canning industry. This is a spore forming obligate anaerobe and its spores possess the highest heat resistance among all food poisoning microorganisms. It was realized that destruction of this microorganism from canned foods ensures safety of the canned foods.

Studies on the maximum heat resistance of spore of ***Cl. botulinum*** were undertaken extensively by Esty and Mayer (1930) and the values of the heat resistance obtained by them formed the basis for recommending thermal processes for canned products. Bigelow *et al.,* (1920) came out with general method of determining thermal process schedules for canned foods wherein heat resistance data of Esty and Mayer was integrated with heat penetration data obtained for the cold spot of the canned foods. The integration of the sterilizing value received by a canned food at its cold spot was done graphically and F value of the process was used as a measure of sterilizing value. The heat treatment sufficient to destroy ***Cl. botulinum*** popularly came to be known as **"botulinum cook"** and was widely used by industry as an adequate heat process for commercial canning purpose (Gillespy, 1951). The fact that, certain spore forming bacteria can survive **"botulinum cook"** and can cause no health hazard or spoilage under certain conditions came as a surprise to the canning industry.

One of the most important problems facing the canning industry is bacterial spoilage of canned products. Fortunately, the actual incidence of spoilage of commercial canned foods is fairly low. Various types of microorganisms present in the slime and gut of fish find slow entry into the flesh after death. During processing the extraneous contamination is mainly by bacteria associated with surface of utensils and equipment, with which the material come into contact during transportation and processing. Further contamination of final products is due to use of cooling water. Riemann (1957) showed that infection usually takes place during cooling of the cans after processing and since the cooling water was usually chlorinated, all vegetative cells are killed and post processing infection would consist mainly of spore formers.

The most important test for bacteriological quality of fish and shellfish would be determination of total bacterial load as reported by Tarr (1961). Lang (1939) and Zaitsev *et al.,* (1969) reported that fish after frying are completely sterile and study concluded that it depends on the initial microbial load, thickness of pieces and temperature and time for frying. Choudhuri *et al.,* (1970) reported that partial destruction of total bacterial load took place during blanching process. Nambiar and Iyer (1970) have studied the bacterial flora of spoiled canned prawns. The microbiological contamination of the raw material and processing requirements for the final canned products are briefly discussed by Rai *et al.,* (1971). Nambiar and Iyer (1970) conducted the bacteriological survey of the nature and type of the microorganisms present in the factory environment and their role of causing contamination of the canned products.

Sarayala *et al.,* (1975) studied the effect of different types of steam cooking of mackerel fillets on total plate count and spore count. Karthiayani and Iyer (1971) have given a complete picture of the types of microorganism present in the canning factory environment and also to find out the portal source of contamination of canned prawns. Hersom and Hulland (1980) have discussed the entire thermal processing and microbiological aspects of canned products.

2.3. Fish canning in general

Bitting (1937) has given the history and development of canning technology in the U.S.A. The principles and methods of canning of fish and fishery products as followed in the U.S.A. have been reported by Jarvis (1943). Reviews on the canning of different marine fish and shell fishes are published in **"Fish as Food"** volume IV by Borgstrom (1965). This includes topics such as fish canning procedure by Broek, tuna canning by Larsen, heat processing of shell fishes by Tanikawa (1971) and squid meat and it's processing by Parshwanath (1989). Details regarding handling of empty cans, processing and storage of the final canned products have been presented in a report (Anon, 1965). Lampi (1977) has reviewed extensively on packaging and preservation of heat processed foods in flexible packs. Information related to aseptic package of heat processed canned products was given by Hersom and Hulland (1969). Adrian Carril (2002) has given a report on technology development in tuna canning and processing. Varma *et al.,* (1969) worked on canning of prawns. In India, canning as a method of preservation of fish was started in mid 1950's mostly confined to canning of shrimp. The Indian fish canning industry was at its glory with the export of canned shrimp in the late 1960's (Varma *et al.,* 1969 and Nandakumaran *et al.,* 1969). The initial demand for canned products mainly came from the need of the defence forces and to a lesser extent to the interior markets (Govindan, 1975). Balachandran *et al.,* (1984) developed a method for canning of edible oyster.

2.4. On diversification in sea food canning

Many experts suggested diversification in raw materials used, containers and filling media used. Diversification of products should go very well with building up of a strong internal market for canned fish in India, where taste, food habits, culture and preference of the consumer are so diverse. In this regard Saralaya (1976) emphasized on diversification of raw material base, variation in packing medium, containers and markets. Nandakumaran *et al.,* (1969) have analyzed the occurrence of blackening in the canned products. Chia *et al.,* (1983) have reported about the influence of culture oysters on the Korean sea food canning industry.

The standard canning operations for three species of lesser sardine have been carried out by Srinivasan *et al.,* (1966). They have also determined optimum brining, precooking and processing time for the three species of sardine which are landed in commercial quantities on the east coast of India. Madhavan and Balachandran (1971) studied the canning of three verities of tuna. Use of curry as filling medium in canning has been developed by Rai *et al.,* (1971). Sen and Revankar (1971) have developed canned sardine using sardine oil as a filling medium. Canning of oil sardine in natural pack was carried out by Nair *et al.,* (1974). In an attempt at diversification, a wide variety of feasible canned fishery products has been listed by Saralaya (1976). Saralaya and Nagaraj (1978) studied the physical and chemical characteristics of important species of bivalves found along Karnataka coast and standardized their canning operation. Apolinario *et al.,* (1979) have standardized the canning procedure for squids and green mussel products. Standardized procedure for canning of seer fish in three forms was developed by Nasser (1980). Saralaya *et al.,* (1975) investigated a canning operation suitable for packing mackerel in the form of skinless and boneless fillets in oil and the process was standardized.

An attempt has been made for the canning of squid by Varma and Joseph (1980) and Raghunath and Solanki (1986). Prabhu (1979), Ranganath (1981) Ganapathy Bhat (1983), Balachandran *et al.,* (1984), Suresh Kumar (1984), Jayasekaran (1985), Parshwanath (1989) and Peddanna (2005) have studied the canning operations and storage stability of products of smoked mackerel, giant cat fish, mrigal, edible oyster, pink perch, white sardine, squids & shrimp and squids, respectively.

Smoking is one of the important precooking steps for canned products. It will impart an attractive colour and characteristic flavour to the fish. Attempts have been made to develop canned smoked seafoods in India. Kandoran *et al.,* (1971) attempted canning of skinless fillets of smoked marine eel. Nair *et al.,* (1977) have studied suitability of different media like brine, tomato sauce and refined groundnut oil for processing of smoked sardine. Girijavarma and Venkataraman (1978) have briefly discussed a process for the preparation of a wholesome smoked and canned product from dhoma. Balachandran and Vijayan (1988) have given the results of examination of Rohu canned in different styles.

2.5. Utilization of octopus for canning

In the west and east coasts of Indian region cephalopods viz., octopus, squids and cuttle fish are less commonly utilized for canning. But in Japan canned octopus products are well accepted. The biochemical composition of squid meat shows that squid can be classified as medium protein low fat material (Suryanarayan *et al.,* 1973 and Joseph *et al.,* 1977). Varma and Joseph (1980) and Parshwanath (1989) have reported that squid is a good raw material for thermal processing due to their firm texture after blanching. An excellent account on utilization of squid for human consumption is given by Kreuzer (1984). A modified procedure for canning of shrimp and squid in masala was given by Peddanna (2005).

The spoilage of cephalopods including octopus in chilled storage is governed chiefly by gram negative bacteria whereas in vacuum packed samples, aerobic organisms are inhibited and spoilage is largely dominated by gram positive bacteria (Stammen *et al.,* 1990). Application of high pressure is effective method of prolonging the shelf life of octopus in chilled storage, mainly due to substantial reduction of total microbial load is given by Hurtado *et al.,* (2002). It is important to preserve the freshness of octopus, so quick chilling or freezing of octopus and storage at low temperature will arrest the microbial growth and reduce undesirable changes in quality (Venkatappa and Dhananjaya, 2006). But data on canning of octopus are very scanty.

2.6. Types of packing medium

Nair *et al.,* (1974) have developed a simple and economic process of canning of oil sardine in its own juice having very good sensory characteristics to reduce the cost of oil as a filling medium. Rai *et al.,* (1971) have developed curry as a suitable packing medium for canned mackerel, sardine and shrimp. The physical and chemical characteristics of the most important shell fishes have been studied and the method of canning were standardized for three styles of pack viz., oil, brine and masala and the products were assessed for their acceptability and storage life upto one year after production were determined by Saralaya and Nagaraj (1978). Vijayan and Balachandran (1986) have reported about consistency, flavour and taste of the curry medium after heat processing to satisfy the taste of different consumers. Balachandran and Vijayan (1988) have given the results of exanimation of rohu canned in different styles. Ravishankar *et al.,*(2002) have presented the results of studies on heat processing and storage of seer fish in curry using retortable pouches and further reported that samples remained in good condition for 24 months at ambient temperature. Peddanna (2005) has given modified procedure for canning of shrimp and squid in masala.

2.7. Containers

Earlier the glass bottle making was an important industry. The rapid development of glass containers started in the United States following the war of 1812. Glass bottles were widely used for food packing because of its useful properties. Nicholas Appert successfully developed canning as preservation method for the first time in the glass bottles. In most of the countries about 40%, 50% and 60% of the processed foods are packed in glasses, cans and plastic containers respectively. Balachandran *et al.,* (1998) suggested that the best promising alternative to the tin plate is aluminium. Balachandran (2001) discussed the advantages and disadvantages of aluminium alloys for can making. Lopez and Jimenez (1969) and Lahiri (1992) have reviewed the use of aluminium cans for canning of different food products. Srivatsa *et al.,* (1993) have studied the suitability of indigenous aluminium cans for canning different varieties of Indian foods. Ranau *et al.,* (2001) have given an account on change of aluminium concentration in canned herring fillets in tomato sauce and curry during storage and showed that the migration of aluminium from the canned product was very small.

2.7.1. Tin-free-steel (TFS) container

Hottenroth and Verpack Rdsch (1972) investigated the suitability of chromium coated steel plate for packing food products and compared with electrolytic tin plate. Pielichowska and chrzanowski (1972) have given the suitability of tin free steel cans for canning of various fish products and also compared with anodized aluminum and electrolytic tin plate cans. The results of the investigations carried out in India by Mahadevaiah (1984) have indicated the possibility of introducing tin-free-steel (TFS) containers for canning sulphur containing vegetable and fish products. Polymer coated TFS cans are now available in India but not much work has been carried out on the suitability of these cans for thermal processing of fish and fishery products. Mallick *et al.,* (2006) have reported on polymer coated tin free steel (TFS). Cans suitable for thermal processing of fish and also mentioned that, TFS cans are cheaper when compared to tin coated steel plate cans. Naresh *et al.,* (1989) have reported that the chromium coated steel plate as an alternative to tinplate for canning food products.

2.7.2. Retortable pouches

Retortable pouch is a recent development in processing of fishery products using various packaging media. The most common type of retortable pouch is 3 ply pouches, which has a sandwich of thin gauge aluminium foil between two thermoplastic films. The most extensive review on flexible packing material including the early history has been well documented (Mahadevaiah, 1976; Gopakumar, 1993). In India CIFT (Cochin), has currently practiced pouch packaging of seafoods. Vijayan (1984) has given general information on retort pouch processing of fish. Srinivasa Gopal *et al.,* (1986) have studied the suitability of flexible packages for fish pickles. The standardization of fish curry canning in traditional Kerala style recipe has been reported by Vijayan *et al.,* (1998). Gopal *et al.,* (1981) have reviewed the packaging of fish and fishery products in India, they have reported that retortable pouch can withstand the thermal processing and combines the advantages of metal cans and boil-in-bag pouches. Adams and Otwell (1982) have given a brief account on packaging of various species like fish, shrimp and crab meat. Madhwaraj *et al.,* (1992) have reported that spoilage in the flexible pouch is due to contamination of seal area. Bindu *et al.,* (2004) have developed a processing method to prepare ready to eat mussel meat in retort pouches for the retail and export market and also mentioned that vacuum packed retort processed samples were rated excellent by the taste panel and remained in good condition for at least a storage period of 1 year at room temperature.

2.8. Production of canned products

The production of canned products involved for the different types of fishes varies. Fish canning procedure can be broadly classified into two main groups (1) procedure involving no precooking step and (2) procedure involving precooking or blanching.

Fishes like mackerel and salmon inherently contain good characteristics like firm texture and optimum fat content and can be canned in **"Natural style"** or **"Salmon style"** which involved least amount of preparation steps for canning. In natural style of canning fishes are not subjected to precooking. Dressed and washed raw fish can be packed into cans with little salt for taste and then sealed and heat sterilized. The exudate coming out of the meat gets collected in the can and such products are called as fish canned in its own juice. Very few fishes can be canned in this way and most of the fishes require some form of preheating to remove the cook water that would otherwise get collected in the canned products, reduce the concentration of filling medium and affects the quality of the product (Broek and Vanden, 1965). Nair *et al.,* (1974) has developed a canning method for sardine in their own juice in natural style to reduce the cost of the product.

Precooking of fish serves several important objectives (Bitting, 1937; Jarvis 1943; Tanikawa and Doha, 1965). It improves the sensory quality characteristic like texture of the canned product. It also enables the addition of a suitable liquid filling medium which helped to modify the taste and flavour of the products. A liquid filling medium also increases the rate of heat transfer into the product during retorting thereby reduces the processing time. In products like shrimp dry pack and masala pack there is no liquid filling medium and such products require higher processing times. The method of precooking used in canning of sea food is different. Steam precooking is common in canning of most of the fishes, blanching in brine solution is commonly used in canning of shell fishes. Blanching time for squid rings in 7% brine for five minutes was recorded by Varma and Joseph (1980). They have also found that addition of 0.2% citric acid improved the texture of canned products.

Tuna fishes are cooked in open trays and air cooled overnight to facilitate the removal of red meat from the fillets. This procedure has given canned tuna a unique place among the other sea products. Precooking loss of 20-30% of their moisture weight during canning of sardine has been reported by Meesemaecker and Shier (1959). Broek and Vanden (1965) have reported that weight loss during processing was about 17.5% and 19-34% in case of tuna and sardine respectively. Zaitsev *et al.,* (1969) have reviewed in detail about different methods of frying and the sequence of operation for the canning of various fried fish in different packing media along with their processing times. Frying in oil was the method of choice for sardine in the early years of its canning which is reported by Chefter (1965).

Blanching is considered as an important step in the canning of shell fishes and cephalopods. This step causes considerable loss of soluble proteins and other taste components, due to this canning yield was very low for canned shell fishes and cephalopods. These soluble proteins which are not properly removed causes gel of coagulated proteins in the product affecting the quality of the products, like shrimp in brine. Proper balancing also helps in standardizing the pack weight for maintaining a designed drained weight in the end product. Varma *et al.,* (1969) have studied the factors controlling drained weight in canned prawns.

2.9. Thermal process calculation

Bigelow *et al.,* (1920) did the thermal process calculation by the combination of bacteriological data with the heat penetration studies and the method was referred to as the "Graphical" or "General" method. Formula or analytical method of process calculation was derived by Ball (1923) to reduce the time necessary to obtain the results as well as to obtain a basis for coordinating the various factors which enter into the calculation for canned products. Olson and Steven (1939) introduced the nomographical method applicable to canned food exhibiting straight line semi-logarithmic heating curves. Patashnik (1953) has developed an "equal time interval" method for thermal process calculation. Ball and Olson (1957) have improved Ball's method by introducing two parameters which were related to the sterilizing values of heating and cooling phases of heat process. Stumbo and Longley (1966) have given tables for the parameters f_h/U and g. Rao and Prabhu (1971) calculated the F_o by graphical and formula method for the standard wet pack of medium grade cooked shrimp. The comparison of general and Ball's formula method of process calculation for retorted pouches for pureed product has shown that the Ball's formula method is the more suitable for pouch process calculation was given by Stephen and Wiley (1982). Lu (1997) compared the thermal processing for metal cans and retortable plastic containers. They found that container materials significantly influence the critical heating point of canned products. Peddanna (2005) studied the heat penetration and process time required at 115.6 °C for squid and shrimp canned in masala pack.

2.10. Heat penetration of canned products

For the attainment of microbiologically stable state, the amount of heat received by the product during thermal processing need to be verified. Heat penetration is mainly influenced by several characteristics like containers, contents, retort and mode of heating. A plenty of literature is available for the above said factors. The important studies are those of Gillespy (1951); Stumbo (1953); Berry and Buch (1988) and Tang *et al.,* (1988). The review focusing on the thermal death time of microorganisms and the time temperature relationship within the can are available (Ball and Olson, 1957; Stumbo, 1973; Vinter *et al.,* 1975 and Scott, 1992). The standardization of process time for canned fishery products is reported by Saralaya and Bhandary (1978), Pujar (1988), Parshwanath (1989) and Peddanna (2005). Chia *et al.,* (1983) have reviewed the effect of thermal processing in cans and retortable pouch. Sonaji *et al.,* (2001) have determined the heat penetration characteristics using mathematical method for fish curry in pouches. Srinivas Gopal *et al.,* (2002) have determined the heat penetration characteristics of seer fish in curry in retortable pouch using mathematical method. Ravishankar *et al.,* (2002) have reported about the studies on heat processing and storage of seer fish curry in retortable pouches. The heat penetration rate in cans of mussels (*Mytilus*) in brine was studied by Casales *et al,* (1988). They also concluded that the head space inside the cans has significant influence on the heat penetration.

2.11. Effect of processing on quality of cephalopods

Berk and Pariser (1974) have shown that after 30 minutes in water at a temperature of 45 °C approximately 20% of the dry matter content was lost, in water of 65 °C the loss amounted to 45% and at 100 °C the loss was 40%. They also reported that washing, blanching, cooking etc. were preprocessing operations requiring special attention. By absorbing water squid meat gains weight but loses nutrients. Progressive structural changes in the squid mantle was studied by Otwell and Hamann (1979) they say that muscle fibers retain much of their original form at 50 °C, disintegration of myofibrils starts at more than 60 °C and protein will start denaturation. At 100 ^{0}C cooking for 5 min., original moisture content of over 80% was down to 75% and after 30 minutes boiling, it was reduced to 71%. Mantle fibers become a densely packed hardened mass of fibrillar proteins. They also reported that heat caused mantles to swell in thickness and at the same time shrink both length and breadth.

These authors also stated that cooking not only reduced the moisture content, but also leaching of water soluble proteins took place. Although relative, with decreasing moisture content, the protein content appears to increase. Textural change in mantle tissues was investigated by Guthworth *et al.,* (1982) during processing.

2.12. Effect of heat on nutrients in seafoods

Fish is a good source of nutrients like protein, fat soluble vitamins, PUFA and Iodine (Borgstrom, 1965). Tooley and Lawrie (1974) have reported that 25% of lysine level will be reduced during thermal processing. Piggot and Stansby (1956) investigated that processing time and temperature are the important factors on sulphide formation in canned products. Broek and Vanden (1965) reported that moderate heating of fish did not affect nutritive quality, while overheating leads to loss of nutrients (Ma *et al.,* 1983). Tanaka and Taguchi (1985) and George (1987) have reported about the changes in nutritional and sensory characteristics in canned fishery products. The effect of one - year storage on the organoleptic quality of canned pilchard in curry and sauce was reported by Atkinson (1973). Seidler and Boronowski (1987) undertook the study on effect of thermal treatment on the nutritive value of canned squid. Changes in composition of mussels packing place during thermal processing have been reported by Casales *et al.,* (1988). Fellows (1990) have reported that there will be reduction of amino acids in canned products to the extent of 10-20% of protein.

2.13. Indian work on processing of cephalopods

Cephalopods include squid, cuttlefish and octopus which form important marine fishery resources of India. In recent years some scientific work has been attempted in this field for commercial utilization (octopus) of the potential resource. The biochemical quality of the different species of cephalopods as food was studied by Pandit and Magar (1972).

Varma and Joseph (1980) have made some studies on canning of squid rings using brine as filling medium and showed that the storage stability of canned product was up to one year. Biochemical changes in cuttlefish during iced and frozen storage were carried out by Sastry (1981). Peddanna (2005) has developed a modified procedure for canning of shrimp and squid in masala and also mentioned that blanching step can be easily avoided in canning of shellfish and cephalopods in masala and curry packs to enhance the product quality and canning yields. Studies on the ice storage characteristics of octopus meat was found acceptable upto 15 days of storage but had fair quality at the end of 21 days of storage in ice (Venkatappa and Dhananjaya, 2006). Further, they have noticed that loss of sheen, flabby texture and discoloration with varying intensity as the progression of the storage period.

2.14. Keeping quality of canned cephalopods

The storage stability of canned products was studied over a suitable period. From the consumer point of view sensory quality is more important than the chemical characteristics of the canned products. Quality changes in canned products during storage are presented under this section. Organoleptic quality changes of canned squid stored for one year have been observed by Varma and Joseph (1980) and they have also concluded that blackening was noticed in squid rings packed without the addition of citric acid and it was found to increase with the storage period. Raghunath and Solanki (1986) have studied the keeping quality of canned squid mantle packed with modified blanching medium and brine separately for more than one year. Kolodziejska *et al.,* (1994) studied the changes in the dimethylamine and formaldehyde in squid during cooking. Ma *et al.,* (1983) have determined the changes in texture of canned shrimp by sensory and instrumental method. Madina *et al.,* (1995) have reported that filling medium influences the lipid changes during fish canning. The biochemical and organoleptic quality of different canned products for six months storage period has been reported in mrigal (Ganapati Bhat, 1983) and squid (Parshwanth; 1989, Peddannna; 2005).

III. MATERIAL AND METHODS

III. MATERIAL AND METHODS

3.1. Materials

3.1.1. Raw material

In all the experiments, medium sized octopus (***Octopus membranaceus***), locally known as **"Negal"** were used. These were obtained from the commercial trawlers operated along Mangalore coast.

Octopus for standardizing the canning procedure were obtained in fresh condition, brought to the laboratory in iced condition and used immediately after washing.

3.1.2. Salt, oil, tomato sauce, curry and masala

Commercially available table salt was used for blanching the dressed mantle and tentacles as well as for filling brine preparation. Double refined sunflower oil was used as a filling medium in oil packs and commercially available tomato sauce was used as filling medium in tomato sauce packs. The curry used was prepared according to the method and recipe described by Rai *et al.,* (1971). Masala was prepared as per procedure given by Saralaya (1976).

3.1.3. Containers

The containers used for packing the products were the round open top cylindrical (301 x 203) internally coated with sulphur resistant lacquer manufactured and supplied by M/S Poysha Industries Ltd, India. These cans are commonly known as 4 ½ Oz. shrimp cans.

3.1.4. Chemicals and glass wares

Most of the chemicals used were obtained either from E Merck India Ltd., Mumbai, Central Drug House (CDH), New Delhi, Ranbaxy Laboratory, Punjab or Nice chemicals, Cochin. All chemicals used were of analytical grade. The glass wares used are of Corning or Vensil make.

3.1.5. Media for microbiological study

The media for testing the microbiological quality of octopus were obtained from Hi-Media (Hindustan dehydrated media), Bombay and prepared according to the method of APHA (1976).

3.2. Equipments

3.2.1. Can closing machine

A semi automatic vacuum seamer (model 0) with four roll scanning heat manufactured by M/s Toyo Seikan Kaisha Ltd., Japan was used for closing the cans.

3.2.2. Sterilizing equipment

Thermal processing of the seamed cans was carried out in an autoclave fitted with air vent, pressure gauge and safety valve.

3.2.3. Heat penetration assembly

The time-temperature measurement during sterilization process was carried out using an ELLAB CTF 84 data recorder with printer. The heat penetration data includes retort temperature, product temperature, F_o value and cook value at one-minute interval.

3.2.4. Laboratory equipments

The general equipments used for analysis include homogenizer, balance, hot air oven, muffle furnace, water bath, nitrogen digestion and Kjeldahl distillation assembly. In addition the essential canning utilities such as steel vessels for blanching, enamel plates, laddles for stirring, chopping boards, grinder etc. were used.

3.3. Methods

3.3.1. Study of raw material characteristics.

The physical characteristics of octopus were determined by measuring the total length, weight of whole octopus at 20 numbers each selected of random. The yield of material at different stages of pre-processing was recorded and calculated on percentage of total weight of the material.

3.3.2. Sensory and microbiological characteristics

The sensory analysis of fresh octopus as well as finished product was carried out using descriptive analysis with scaling (Larmond, 1977). A group of 10-12 trained panelists were selected for panel test. Both raw and cooked samples were presented for freshness evaluation. The finished products were warmed to about 60 ^{0}C at the time of panel test. The raw material was analysed for total plate count (TPC) using standard methods (A.P.H.A, 1976).

3.3.3. Dressing of octopus

In the present study, the raw material was cleaned by cutting the tentacles just behind the eyes and the mantle was separated. Eyes were removed from the tentacle part. Skin is pulled from the cut end and peeled, suckers and small portion of the tentacles were trimmed off by knife. The mouth contains beaks which are also removed. Then skin of the mantle was removed by pulling / peeling it from the cut end of the mantle. By turning the inside of the mantle out, internal organs such as gills, heart, kidney, gonad, pancreas, liver, ink sac etc. were removed and washed thoroughly.

3.4. Analytical methods

3.4.1. Physical characteristics

At the beginning of the experiment, octopus were studied for total length, dorsal mantle length, total weight, dressed weight of mantle and percentage weight compositions of each body parts were determined.

3.4.2. Chemical analysis

General chemical quality of octopus was assessed by determining the proximate composition. Moisture content was estimated by the standard hot air oven method as per A.O.A.C. (1995). Crude protein content (Nx6.25) was determined according to A.O.A.C. (1995) by Micro Kjeldahl method. Fat content was determined by Soxhlet extraction method. Total ash content was estimated by ashing in muffle furnace at a temperature of 550-600 ^oC using moisture free samples.

Salt content in the raw material, blanched meat and canned product was determined as per the method of A.O.A.C. (1995) and expressed as NaCl percent on wet weight basis for all samples.

TVB-N and TMA-N contents of the different samples were determined by Conway's micro diffusion analysis described by Beatty and Gibbons (1937) using tri-chloro acetic acid (TCA) extract. For (TCA) extract, 10 g of meat was homogenized with 20% TCA solution and then filtered. The filtrate was made up to known volume (100 ml). The value of TVB-N and TMA-N were expressed mg / 100 g meat.

3.4.3. Microbiological examination

Samples were drawn from raw material, dressed, cleaned mantles and blanched meat (in 4% boiling brine for 4 min.), handled aseptically, homogenized in physiological saline, diluted as required and analysed for total plate count (TPC), and total spore count, thermophiles, mesophiles, aerobic and anaerobic spores. For spore counts, the homogenised samples were directly pasteurized in tubes on a water bath at 100 ^{0}C for 5 minutes plus two minutes for come up of tubes.

After plating for anaerobic growth, the plates were over poured with plain agar to prevent direct contact with air. After solidification mesophiles plates were incubated at 37 ^{0}C for mesophiles and 55 ^{0}C for thermopiles.

3.4.4. Effect of cooking / steaming / blanching on shrinkage and weight loss

In the preliminary study the dressed mantles and tentacles were studied for length and breadth wise shrinkage in boiling brine and water for different time intervals.

3.4.5. Standardization of packing operation

3.4.5.1. Size cutting

Octopus after blanching or steaming becomes rubbery and makes size cutting difficult. Based on the shrinkage study data, the size of the container was selected, size cutting was done by giving extra length for shrinkage. Usually in case of medium sized octopus, piece length cutting was done to 8.4-8.5 cm before blanching or steaming.

3.4.5.2. Suitable form of pack

In the initial trials, octopus was canned after blanching in 4% boiling brine for 4 minutes in two forms viz., mantle rings and tentacles in brine. Based on panel test, blanching in 4% boiling brine for 4 minutes was sufficient for octopus mantle and tentacle packs. For all the subsequent experiments, only mantle and tentacles were used for preparation of canned products. The salt content analysis showed that blanched in 4% boiling brine for 4 min. was sufficient for octopus mantle and tentacles.

3.4.5.3. Filling media

Different filling media such as brine, oil, curry, tomato sauce and masala were tried. Out of these filling media used, only in tomato sauce blackening of octopus mantles was observed. Hence tomato sauce was not used as filling medium in subsequent trials.

3.4.5.4. Standardization of blanching operation

The cleaned mantles and tentacles of 8.4-8.5 cm length were boiled in 4% boiling brine for varying periods of time namely, 4, 6, 8 and 10 minutes. After various periods of blanching, the material was taken and separately packed (150 g / can) using brine as filling medium. The blanching effect on weight loss and salt content as NaCl percent in blanched material and canned product were studied.

3.4.5.5. Standardization of retorting operation by thermal process evaluation

To standardize the process time, the thermal process requirement in terms of F_{250} values were calculated, for each type of pack using lethal rate tables given in Appendix. I.

3.4.5.5.1. Preparation of test cans

Sets of cans were prepared by filling thermocouple receptacles, so as to keep the tips of thermocouples at the geometric centre of the cans packed with octopus. The cans were prepared for both mantle and tentacles in all the five filling media.

3.4.5.5.2. Effect of pack weight on rate of heat penetration

In this experiment, different pack weights 150g, 160g, and 170g of octopus mantles and tentacles were packed and studied for rate of heat penetration by comparing different f_h values.

3.4.5.5.3. Study of heat penetration in cans

During each trial, 6 lead wires were attached to autoclave of which four were fitted to the test cans and other two were used to read the retort temperature. Temperatures were noted at intervals of five minutes right from **"steam on"** until the end of the process and cooling period. Heat penetration tests were conducted for octopus in different filling media adopting 115.6 ^{o}C (240 ^{o}F or 10 psi) as the retort temperature.

3.4.5.6. Plotting heat penetration data and calculation of F_0 value of process

Semi log heating curves were drawn for each pack to compare the rate of heat penetration. For calculation of F_{250} values at 115.6 ^{0}C of the process, the heat penetration data of the slowest heating can in each group were considered, lethal rates corresponding to cold spot were found out from standard tables (U.S. National Canners Association Laboratory Manual, 1969) and integrated by Patashnik's equal time interval method (1953) to arrive at F value of process. The process time required at the retort temperature of 115.6 ^{0}C (10 psi) for all packs were standardised to give a medium thermal process value of F_{250} = 12-13 min.

3.4.5.7. Effect of process variation on quality of canned octopus

From the heat penetration data F_{250} values of the process were calculated for different time intervals as mentioned below;

Canned mantles and tentacles were packed using own juice (natural pack) and oil as filling media and each set of cans were subjected to low process of F_{250}=5-6 min., medium process F_{250}=12-13 min. and high process of F_{250} =20-21 min.

After different process, the canned products were cut out and analysed for sensory characteristics.

3.4.5.8. Preparation of final products for quality and storage study

With the standard operation arrived at by the above experiments the final products were prepared for the storage study using the following filling media.

1. Octopus in natural style (own juice)
2. Octopus in brine
3. Octopus in oil
4. Octopus in curry
5. Octopus in masala

The adopted standard canning procedure is given in Fig. 2.

3.5. Quality evaluation and storage study

The final products were studied for their quality characteristics such as physical, chemical and organoleptic qualities for a period of 6 months of storage. The sample cans were drawn from each product at regular intervals during storage i.e. 0, 1, 3 and 6 months.

3.5.1. Cut out characteristics

The canned octopus products were studied for cut out characteristics such as gross weight, net weight of content, drained weight of solids, vacuum, head space, adhesion, condition of can (both out side and in side) etc. The results obtained were tabulated for each product in standard proforma.

3.5.2. Proximate composition of canned products

The products were analyzed for moisture, protein, fat, ash and salt content as mentioned in section 3.4.2.

3.5.3. Organoleptic quality of the canned products

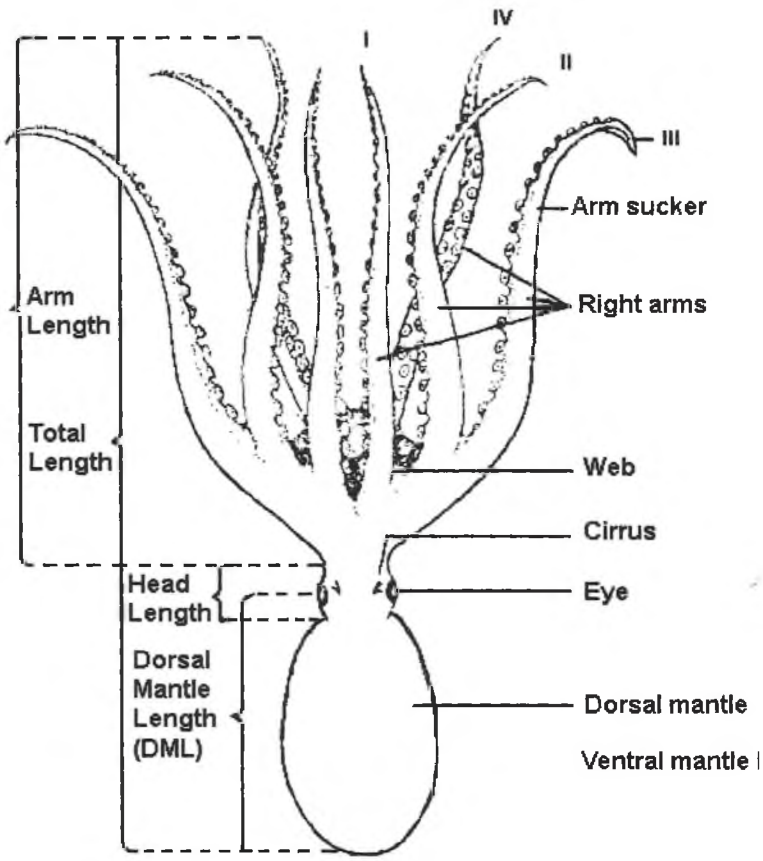
Sensory evaluation was carried out at each sampling for different canned products. The number of panelists varied from 10 – 12 numbers. The panelists assessed the different products for their quality characteristic such as appearance, colour, odour, taste, texture and overall quality. The model of the score sheet used during organoleptic test is given in Appendix-II.

3.6. Microbiological analysis

Sample cans of each of the 10 octopus packs were incubated at 37 ^{0}C for 8 days. After incubation, they were externally examined for bulging and other indications of spoilage. Each can was aseptically opened and cultured in glucose-tryptone broth and Thioglycollate broth with liquid paraffin layer. Half the number of tubes of each medium were pasteurized for 5 min. at 100 ^{0}C. Again, the pasteurized tubes were divided in to 2 parts and incubated at 37 ^{0}C and 55 ^{0}C. These cultures were examined for the growth of aerobic, anaerobic, spore forming mesophiles and thermophiles.

3.7. Statistical analysis

The results of the sensory quality evaluation of the products were statistically analysed. Analysis of variance (ANOVA) technique (Snedecor and Cochran, 1962) was used to determine whether any significant difference is present between the various sensory attributes, such as colour, texture, taste and odour between each attributes during storage period in all the products packed in tin container.



OCTOPUS (Dorsal view)

Fig.1. Diagrammatic representation of common octopus

Fig.2. Flow diagram for canned octopus with different filling media

Raw material (Fresh or iced octopus 1-2 days)

↓

Washing and weighing

↓

Dressing and washing

↓

Trimming

↓

Size cutting, 8.4-8.5cm

↓

Blanching in 4% brine +0.2% citric acid for 8 min.

↓

For natural pack no blanching, directly packing & pre cooking in steam at 0 psi for 30'. Draining excess cook liquor, adding 2% salt, exhausting and seaming.

↓

Packing Natural (dressed) (Except Natural pack, in other packs blanched material is used)
Brine 140g, oil 140g, octopus + masala 165g and curry 140g

↓

Adding filling media to net weight (Brine, oil, curry and masala) for 190g

↓

Exhausting for 10-15' and can sealing or vacuum seaming.

↓

Thermal processing at 10 psi (115.6 °C)
OCN 55, OCL 55, OC3 70, OC7 85 and OCM 95 min.

↓

Can cooling with chlorinated chilled water for 10-15 min.

Note:

OCN = Octopus in natural

OCL = Octopus in brine

OC3 = Octopus in oil

OC7 = Octopus in curry

OCM = Octopus in masala.

IV. EXPERIMENTAL RESULTS

IV. EXPERIMENTAL RESULTS

The results of the experiments carried out during the course of present work are summarized through tables and graphs.

4.1. Quality of raw material (*Octopus membranaceus*)

The raw material used for the present investigation is octopus, which is commonly available on west coast of India.

4.1.1 Physical characteristics

The physical characteristics such as total length, dorsal mantle length, breadth, thickness, total weight, total number / kg were recorded. The results are presented in the Table 1. Those belonging to **'large'** size had an average total length of 45.25 cm, dorsal mantle length of 10.40 cm, breadth of 7.05 cm and average mantle thickness of 0.65 cm.

In the **'medium'** size group the average total length was 23.15 cm, mantle length 8.30 cm, breadth 5.40 and thickness of 0.45 cm. The corresponding measurements for the octopus of **'small'** size group were 16.25, 5.15, 4.05, 0.32 cm respectively.

The average total weights of large, medium and small grades of octopus were, 58.00, 36.25, 22.15 g respectively. After dressing the octopus by removing head, ink sack, skin, suckers and tentacles the percentage yield of dressed mantle and tentacle for the large size was 62.15, for the medium size was 51.00 and for the small size was 47.00.

The Table 2 which gives the relative weight of the body parts, each expressed as % by weight of the whole octopus. It can be seen that dressed, skinless mantles forms slightly above 38% of total weight of an octopus without ovary, but when the octopus includes ovary, the yield is reduced to 26% of total weight. Head, tentacles and viscera including ovary, accounts for 28.24 to 39.64%. Skin and suckers weigh 10.00 and 12.25% of total weight. The share of other individual parts can also be seen from the table.

4.1.2 Bio-chemical characteristics

The proximate composition of octopus used for the present study is presented in the Table 3. It can be seen that octopus has moisture content of

Table 1. Physical characteristic of octopus*

Details	Large size	Medium size	Small size
Total length (cm)	45.25	23.15	16.25
Mantle length (cm)	10.40	8.30	5.15
Breadth (cm)	6.05	5.40	4.05
Thickness (cm)	0.65	0.45	0.32
Total weight (g)	58.00	36.25	22.15
Total number / kg	18	28	45
Dressed mantle yield (%)	62.15	51.00	47.00

* Average of 5 samples

Table 2. Weight composition of different body parts of octopus as % of total weight

Body parts	Medium size	Large size
Dressed skinless mantle	38.00	26.00
Head and tentacles	28.24	39.64
Skin	6.10	10.5
Tentacles	15.25	18.7
Viscera	10.50	14.15
Head	8.10	9.65
Suckers	4.15	6.25
Ovary	-	8.25

Medium size; All values are average of 10 samples.

Dressed yield - 50-58%

Canning yield - 20-23 %

Yield rate - 38 kg / case

Table 3. Chemical composition of raw octopus

Parameters (%)	Batch-I	Batch-II	Average
Moisture	84.36	84.64	84.50
Protein	13.01	13.01	13.01
Fat	1.14	1.16	1.15
Ash	1.35	1.35	1.35
Glycogen	0.16	0.15	0.15
Salt as NaCl	0.56	0.52	0.54

Note; All figures are expressed as percentage of octopus meat on wet weight basis.

84.50%, protein 13.01%, total ash 1.35% and lipid 1.15% all on wet weight basis. Glycogen and salt contents were found to be 0.15 and 0.49% respectively.

Table 4 shows the changes in proximate composition brought about by preliminary processing operation such as dressing and blanching the octopus. After dressing, cleaning and washing the mantles showed 84.86% moisture, 11.67%, protein, 1.12% fat and 0.52% ash. Dressed rings had the corresponding figures of 86.02%, 11.06%, 0.82% and 0.74% respectively. After blanching, the mantle and tentacles had 58.91% moisture, 21.68% protein, 2.18% fat and 4.04% total ash.

4.1.3. Microbiological Quality

It was found that raw, whole octopus had a total plate count of 4.6 x 10^6 cfu /g and total spore count of 208 no. / g. All spores were found to be mesophiles, anaerobic spores being the major component (180 no. / g) compared to aerobic (35 no. / g.) bacteria. After washing and cleaning the mantles and tentacles, the total count reduced to 5.2 x 10^5 cfu / g, total spore count reduced to 97 no. / g and the aerobic counts decreased to 40 no. / g. After blanching, total counts drastically reduced to 2.3x10^2 cfu / g, total spore reduced to 74 no. / g and aerobic spore count reduced to 28 no. / g. Mesophilic anaerobic spores, thermophilic spore formers were not found (Table 5).

4.2. Blanching or steaming of octopus

4.2.1. Effect of blanching

The results of blanching operation carried out on octopus mantles and ring either in water or 4% brine for different durations is given in Table 6. It can be seen that there was considerable shrinkage in length and breadth in both rings and mantle. The shrinkage of mantles varied from 40% to 44.5% in length and from 23% to 27% of its breadth. Weight loss was found to be varied from 50% to 59.8%. Incase of mantle shrinkage and weight losses were higher than tentacles for similar treatments. The highest weight loss observed was 60.12%, when tentacles were blanched in boiling water for 8 min.

Table 4. Changes in proximate composition (%) due to dressing and blanching operations

	Moisture	Protein	Fat	Ash
Raw material before processing	82.50	14.01	1.15	1.35
Dressed mantles	84.86	11.67	1.12	0.52
Dressed rings	86.02	11.06	0.82	0.74
Blanched mantles / tentacles	58.91	21.68	2.18	4.04

Note:

- Blanching; boiling in 4 % brine for 4 minutes.
- All figures are expressed on wet weight basis.

Table 5. Changes in microbiological counts of octopus during preparation

Sample	Total plate counts (cfu / g)	Total spore count / g	Spore count / g			
			Mesophiles		Thermopiles	
			Aerobic	Anaerobic	Aerobic	Anaerobic
Raw octopus	4.6×10^6	208	35	0	0	0
Cleaned mantles	5.2×10^5	97	40	0	0	0
Blanched mantles*	2.3×10^2	74	28	0	0	0

* Blanching in 4% brine solution for 4 min. at boiling point.

Table 6. Effect of blanching on physical characteristics of octopus*
(Shrinkage and weight loss).

Blanching time (min.)	Medium	Dressed mantle			Rings		
		Length	Breadth	Weight loss	Length	Breadth	Weight loss
2	Water	40.25	24.63	50.60	30.40	25.60	50.00
	4% Brine	43.15	25.40	52.15	30.15	40.45	52.25
4	Water	40.80	25.15	57.68	32.15	36.45	50.25
	4% Brine	41.70	27.15	54.28	34.65	44.25	58.15
6	Water	43.15	25.15	50.65	33.15	44.80	57.10
	4% Brine	41.40	26.80	56.32	38.10	42.70	59.80
8	Water	44.55	27.45	59.80	32.15	42.10	60.12
	4% Brine	42.20	24.80	57.15	-	-	-

* Average of 4 samples

Length and breadth are in cm,

Weight in grams

4.2.2. Comparison of blanching and steaming

The effect of blanching in water for 4 min. at 100 ^{0}C may be compared with the effect of steaming for 30 min. at 100 ^{0}C in an autoclave, from the results given in Table 7. Initial moisture content of 84.38% in dressed mantles was reduced to 45.24% by steaming operation and to 43.45% by blanching treatment. Length wise shrinkage due to steaming and blanching were 38.35 and 44.26% respectively, whereas, the corresponding values for breadth wise shrinkage were 23.42 and 21.28%

4.2.3. Comparison of forms of packs in octopus canning

The results of a preliminary test for deciding suitable form of pack for canning of octopus are presented in Table 8. The quality attributes judged by the panelists were the appearance, colour, texture, flavour, taste and over all acceptability in the canned product. All attributes of canned octopus scored above 6.0 out of possible maximum 10 a rating of **"good"**, in these two forms of packs.

4.2.4. Standardization of blanching operation

The results of standardization of blanching operation in canned octopus are presented in the Table 9. When blanched in 4% brine at boiling temperature, weight loss increased from 47.96% (for 4 min.) to 52.48% (for 10 min.). There was further loss of weight due to canning which ranged from 8.77% to 5.38% of blanched meat weight. The drained weight of solids in the canned products (blanched for 4 min.) were 138 g and 143 g (blanched for 10 min.), when 150 g of blanched meat was packed.

The salt content in octopus mantles after blanching for 4, 6, 8 and 10 min. were 1.36, 1.86, 2.10, 2.60 % (on w/w basis) respectively. The corresponding NaCl contents in the respective packs after canning were 1.42, 1.64, 1.78 and 1.88% respectively.

The sensory evaluation carried out on the canned octopus subjected to different blanching treatments resulted in the panel score (average of 12 panelists) for the several attributes as shown in Table 9. All the attributes scored between 6 and 8 out of 10.

Table 7. Comparison between blanching and steaming of octopus (medium size)

Processing steps	Shrinkage (%)		Weight loss (%)	Moisture content (%)
	Length (cm)	Breadth (g)		
Steaming for 30 minutes at 0 psi / 100 °C	38.35	23.42	53.28	45.24
Blanching in 4% brine for 4 minutes	44.26	21.28	52.48	43.45

Note: Initial moisture content in the dressed mantle 84.38%.

Table 8. Comparison of different forms of packs of octopus with respect to organoleptic quality.

Can used: (301 x 203) 7 ½ Oz.

Filling medium: 2% brine

Retorting: 70 min. at 115.6 ºC (10 psi)

Blanching: 4% brine for 6 min. at 100 ºC

Sensory characteristics	Scores on 10 point hedonic scale	
	Canned mantle	Canned tentacles
Appearance	7.85	6.51
Colour	7.0	6.58
Texture	7.87	6.22
Flavour	6.67	6.01
Taste	6.78	5.68
Overall acceptability	**7.48**	**6.02**

Table 9. Effect of blanching time on quality characteristics of canned octopus mantles.

Sl. No.	Blanching time (min.)	Weight loss during blanching (%)	Drained weight (g) of solid (% weight loss during canning)	NaCl (%)		Organoleptic scores of canned products					
				Blanched mantles	Canned mantels	Appearance	Colour	Odour	Taste	Texture	Overall quality
1	4	47.96	138 (8.77)	1.36	1.42	6.6	6.5	6.8	7.2	7.6	7.0
2	6	50.18	139 (8.10)	1.86	1.64	7.0	7.1	7.0	7.3	7.4	7.4
3	8	51.45	141 (6.68)	2.10	1.78	7.0	8.4	7.8	8.3	8.4	8.5
4	10	52.78	143 (5.38)	2.60	1.88	7.1	7.3	7.7	6.5	6.4	6.8

Note: NaCl content of raw material; 0.54 g / 100 g of meat.
Blanching in 4% brine, in each case 150 g of blanched meat was packed per can.
Heat processing of cans; 70min at 10 psi.
Filling medium ; 2 % brine
Panel test scores are out of a maximum possible of 10 for each attribute and average of 12 panelists.

The effect of blanching time on weight loss during blanching and later, during canning of octopus mantles can be clearly seen from Fig. 3. The difference in salt intake by octopus mantles due to variation in blanching time can be seen from the graph of Fig. 4. The effect of blanching time variation on the saltiness of final canned product also can be seen from the same figure.

4.3. Heat penetration in canned octopus (f_h values)

Results of heat penetration tests carried out on canned octopus in different filling media are presented in Table 10. The can center temperature was faster in natural pack and brine pack. In oil, curry and masala pack heat penetration was much slower. The F_o at the can centre for the natural pack, brine pack, oil pack, curry pack and masala pack of octopus were calculated by following the method of **Patashnik**, the results obtained are given in the Table 11. The process time required for the natural, oil pack and brine pack was 70, 85 and 90 min. respectively. In oil pack the F_o value was found to be 8.84 whereas, in curry pack and masala pack it was 10.98 and 9.73 respectively.

The rate of heat penetration in canned octopus packs may be easily visualized from the semi-log heating curves. As indicated in Fig. 5, 6, 7, 8 and 9, natural, brine, oil, curry and masala packs respectively. The f_h values varied from 12 min. in the case of brine pack to 30 min. in case of masala pack.

4.3.1. Thermal process levels

Thermal process levels to give F_0=5-6 min. (low process), F_0=12-13 min. (medium process) and F_0=20-21 min. (high process) at can centers for natural packs (OCN) and oil pack (OC3) of octopus calculated following Patashnik's method are given Table 12. The low process requires 30 min. for natural pack and 45 min. for oil pack. Medium process in the two cases was equivalent to retorting times of 55 min. and 75 min. respectively. High process was 85 min for brine pack and 100 min. for oil pack. All these retorting times were for processing in can size 301x203 and at retort temperature of 115.6^{0}C.

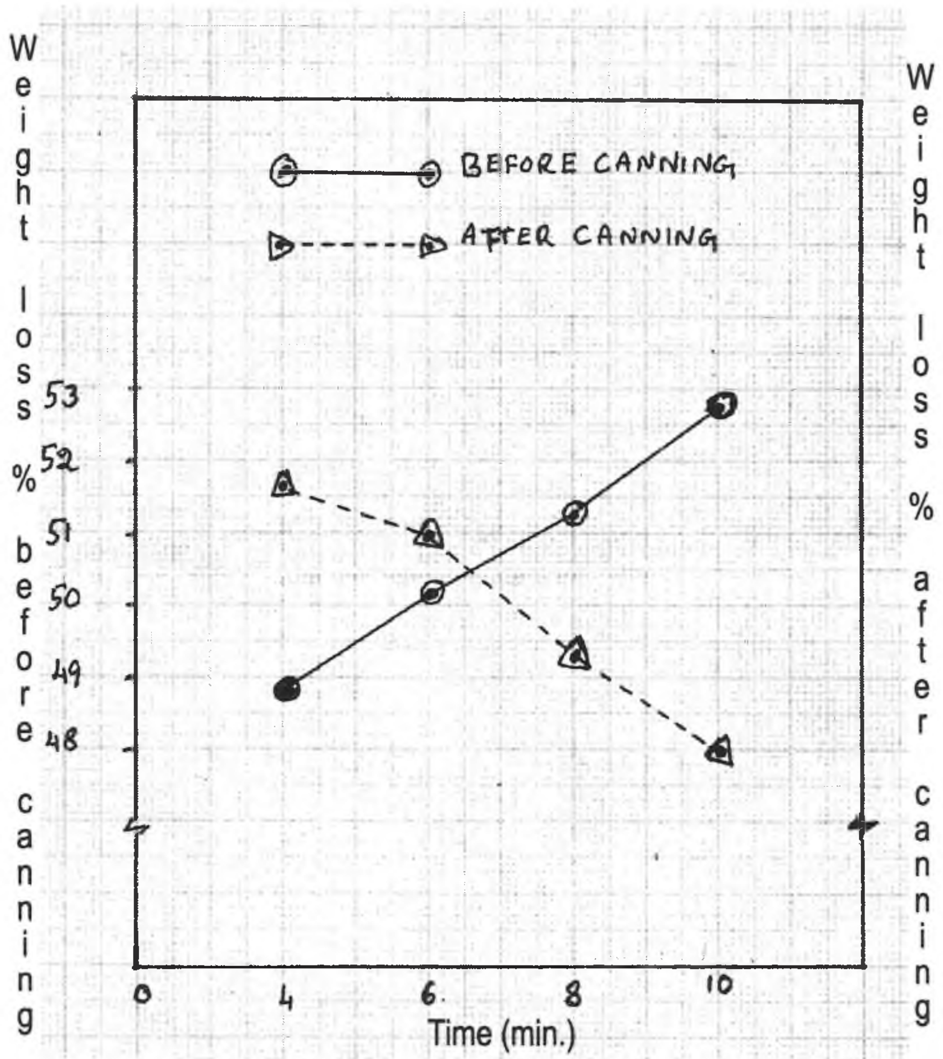


Fig. 3. Effect of blanching time on weight loss in octopus mantles before and after canning

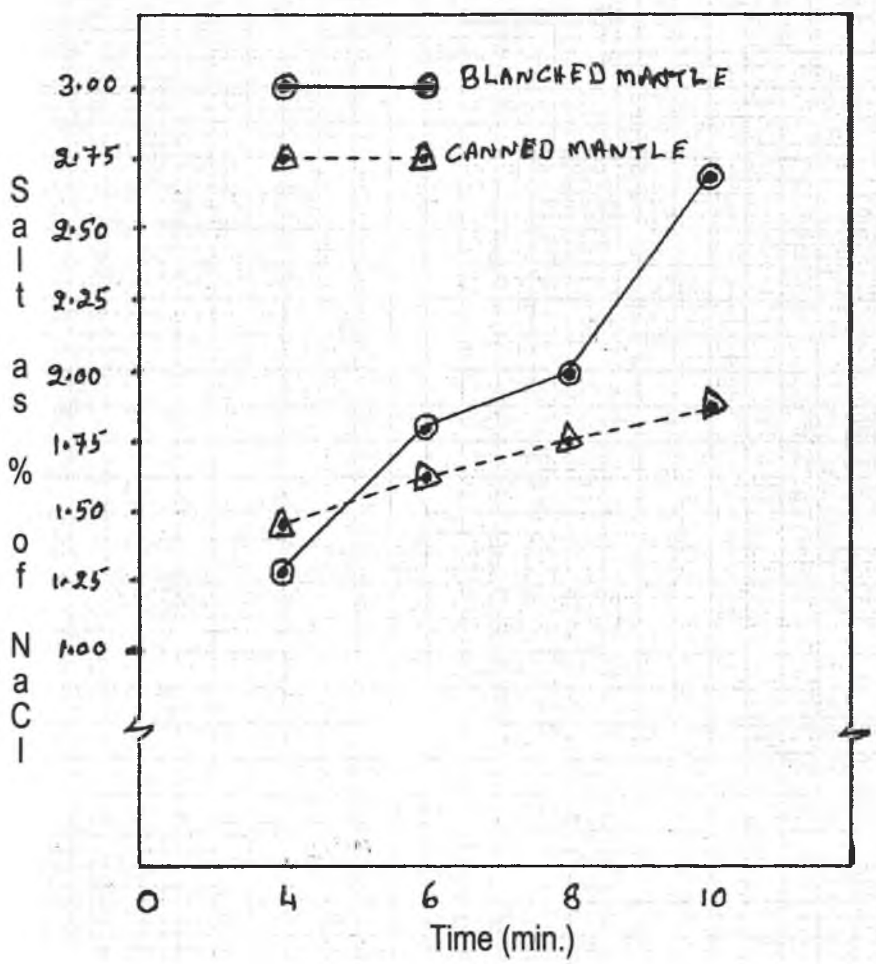


Fig. 4. Effect of blanching time on salt intake of octopus mantles

Table 10. Heat penetration in octopus mantles and tentacles canned in different media

Can size: 7 ½ Oz. (301x203)-SR

Pack weight: 160 g

Retort temperature: 115.6^{0}C (240^{0}F)

Time (min.)	Can centre temperature (^{0}C)					Retort temperature (^{0}C)
	OCN	OCL	OC3	OC7	OCM	
0	54.6	50.6	50.1	40.2	52.2	47.8
5	55.2	59.2	52.4	46.6	53.1	102.2
10	76.2	81.6	62.1	58.4	64.6	110.6
15*	102.2	105.2	78.2	76.8	79.1	115.6
20	114.4	112.6	92.6	89.9	89.3	115.6
25	113.6	114.2	102.3	97.6	96.8	115.7
30	114.4	114.6	108.4	102.6	100.2	115.6
35	114.6	115.1	111.2	106.8	105.6	115.6
40	115.1	115.1	112.6	109.5	108.6	115.6
45	115.2	115.2	113.7	111.2	110.4	115.6
50	115.4	115.3	114.3	112.6	112.0	115.7
55	115.5	115.3	114.6	113.4	113.2	115.7
60	115.5	115.3	115.0	114.0	114.2	115.6
65	115.6	115.4	115.2	114.5	114.6	115.7
70	115.6	115.4	115.4	114.6	114.0	115.6
75	115.6	115.4	115.5	115.1	-	115.6
80	115.6	115.4	115.5	115.2	-	115.6
85	115.7	115.5	115.6	115.4	-	115.6
90**	115.7	115.6	115.6	115.5	-	115.6
95	102.2	98.2	100.1	106.2	-	108.8

* Retort come up time

** Steam off

Pack used: OCN - Octopus natural
OCL - Octopus is brine
OC3 - Octopus in oil
OC7 - Octopus in curry
OCM - Octopus in masala

Table 11. Rates of heat penetration (f_h values) in octopus canned in different media.

Can size: 7 ½ 0_2 (301 x 203)

Pack weight: 160gm

Style of Pack	f_h Values (min.)	
	Mantles pack	Tentacles
Octopus in natural	15.0	16.5
Octopus in brine	12.0	13.1
Octopus in oil	18.5	20.0
Octopus in curry	25.0	27.0
Octopus in masala	35.0	37.0

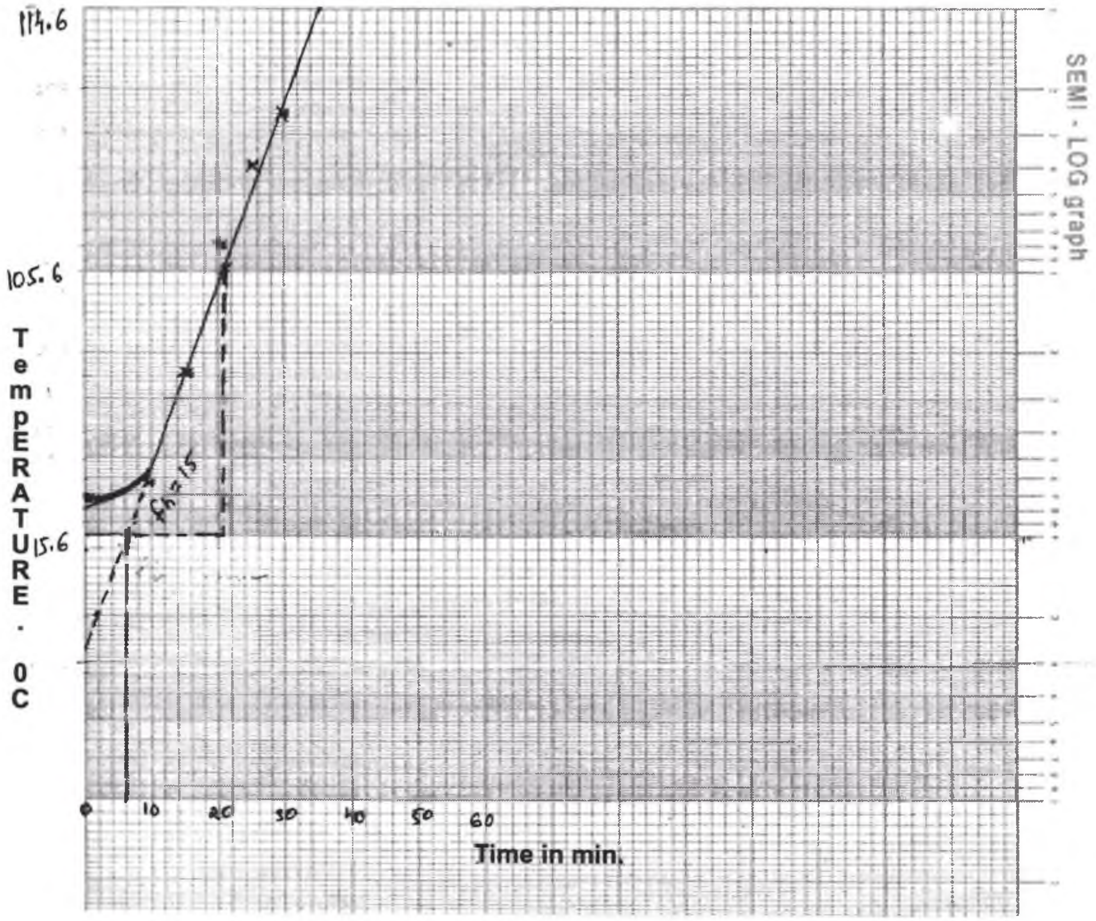


Fig.5. Semi-log heating curve for octopus canneed in natural style

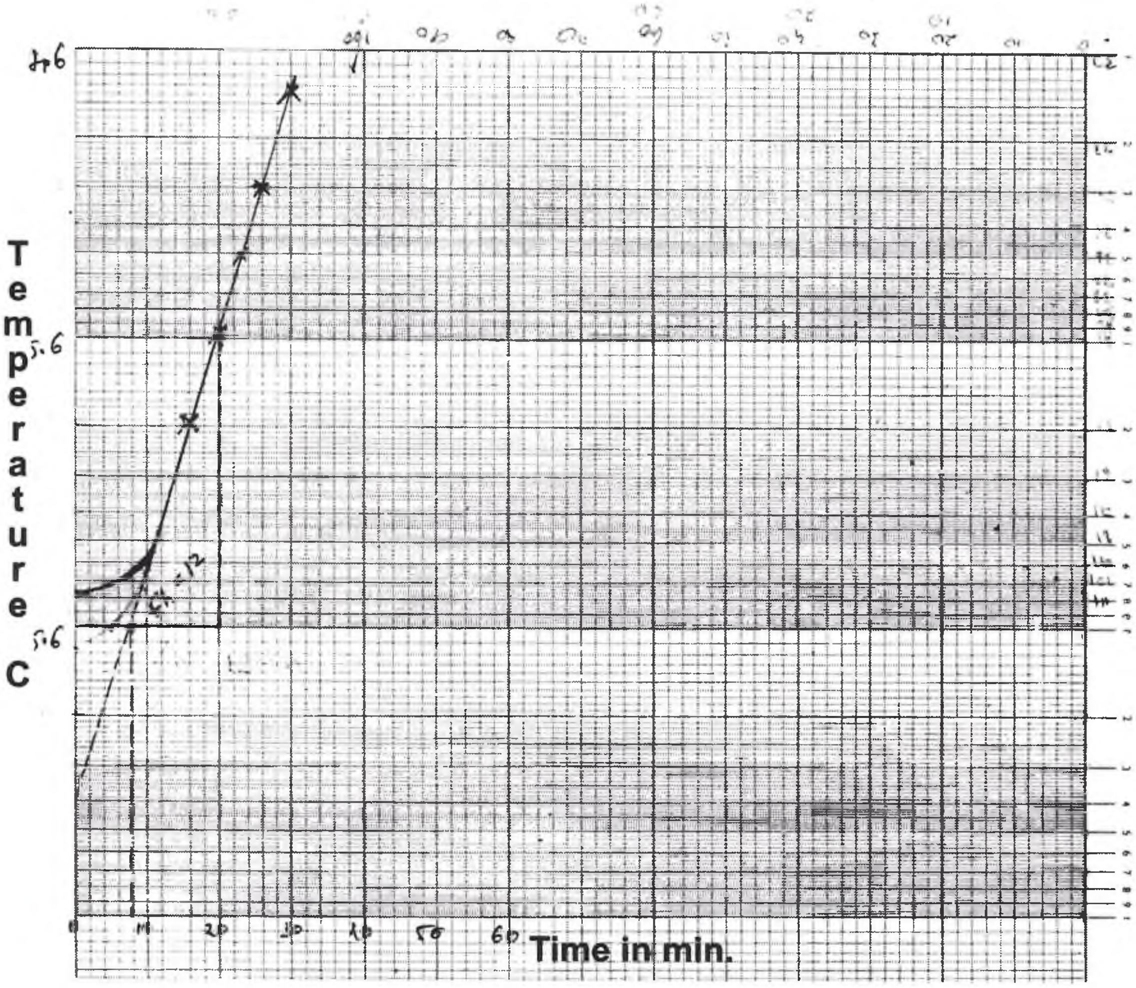


Fig.6. Semi-log heating curve for octopus canned in brine.

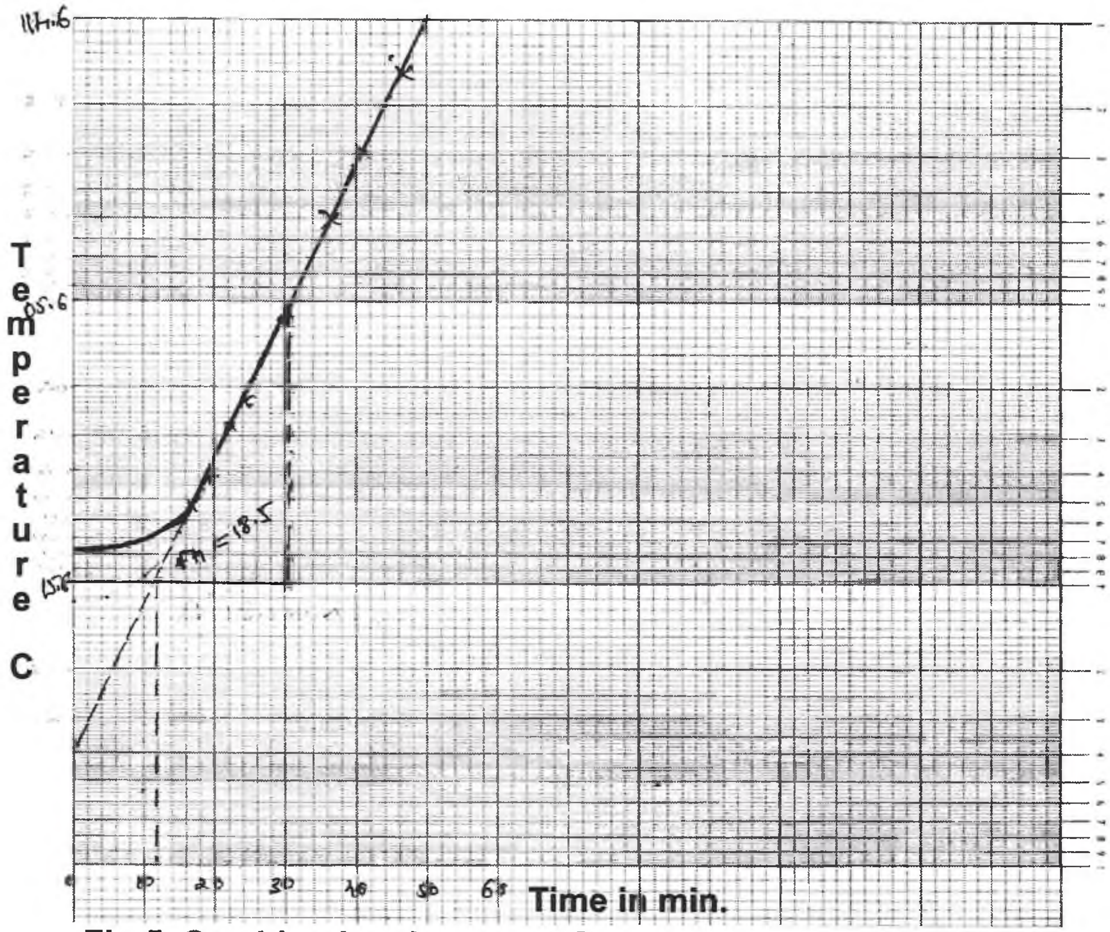


Fig.7. Semi-log heating curve for octopus canned in oil

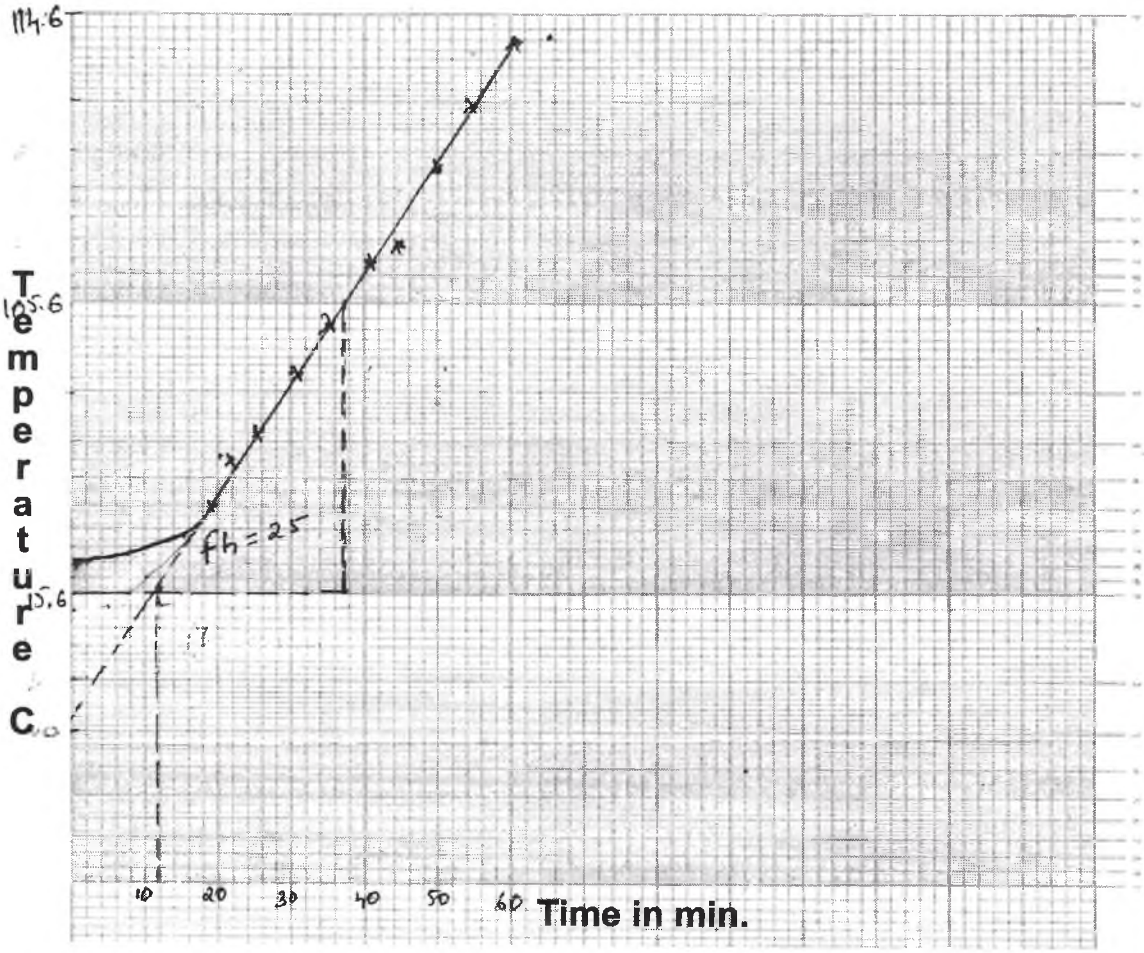


Fig.8. Semi-log heating curve for octopus canned in curry

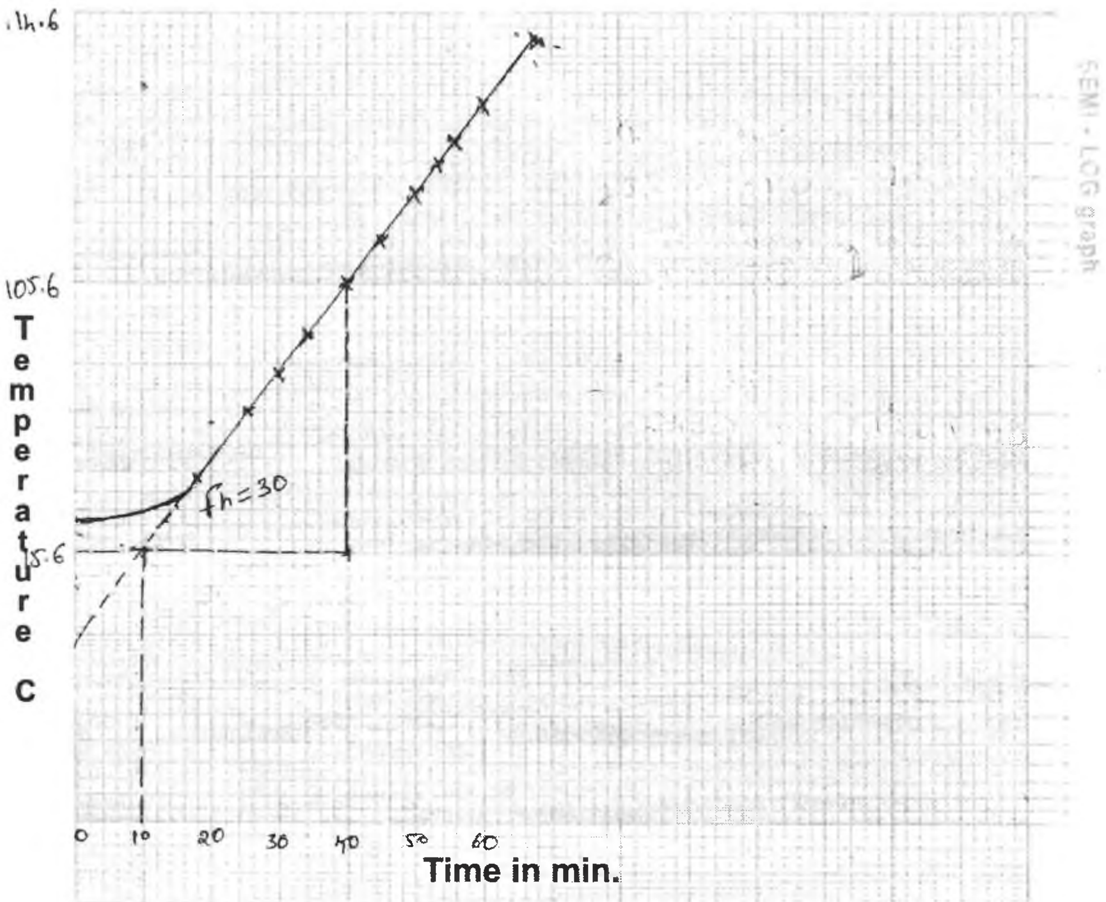


Fig.9. Semi-log heating curve for octopus canned in masala

Table 12. Retort processes at 115.6 ^{0}C required for canned octopus (natural and oil packs) to give F_o = 5-6 min., 12-13 min. and 20-21 min. at can centre.

Can size: 301 x 203

Pack weight: 300 g of dressed mantles for natural pack
150 g of blanched mantles for oil pack

F_{250} of F_o	Retort Processes (min.)	
	OCN	OC_3
Low process 5-6 min.	30 (6.32)	45 (5.89)
Medium process 12-13 min.	55 (13.07)	70 (12.63)
High process 20-21min.	85 (21.31)	100 (20.88)

Note: Figures within brackets are actual F_o values of the respective retort processes calculated on the basis of temperatures reached at can centre and corresponding lethal rates.

4.3.1.1. Effect of process variation on organoleptic quality of canned octopus

The panel test carried out on canned octopus (OCN and OC3) subjected to low, medium and high thermal process levels and the results are presented in Table 13.

It can be seen that all characteristics for all the packs scored between 6 and 8 out of maximum possible 10. Both in the case of natural and oil packs, medium process products scored higher value than either low or high process products for overall quality as well as most of the individual attributes.

4.3.1.2. Medium process retort operation for canned octopus packs

The retorting time required at 115.6 ^{0}C for each of the octopus packs to give medium thermal process (F_0=12-13 min. at can centre) are calculated and presented in Table 14.

The shortest retorting times required are 15 min. for octopus mantle in natural and brine packs and 55 min. for octopus tentacles in natural and brine packs. The longest retorting required are 90 min. and 95 min. for masala packs of octopus mantle and tentacles respectively.

4.4. Standard canning procedure for octopus

The Fig. 2 gives all the steps and operation sequential order for canning of octopus, using any one of the five filling media, namely, own juice (i.e., natural pack), brine, vegetable oil, curry and masala.

4.5. Evaluation of quality characteristics of canned products after processing and during storage

The Table 15 presents the cut out characteristics of canned octopus using own juice, brine, oil, curry and masala as filling medium immediately after production. The quality of all the cans were evaluated by cut-out tests, proximate composition analysis and by organoleptic evaluation soon after thermal processing (0 month) as well as after 1, 3 and 6 months of storage at room temperature.

It can be seen that the net weight of contents varied between 192 g to 199 g / can in case of natural, brine, oil and curry packs. In masala pack it varied between 144 to 160 g / can.

Table 13. Effect of process variation on organoleptic characteristics of canned octopus (natural and oil packs): panel test scores.

Attribute	OCN			OC3		
	Low process	**Medium process**	**High process**	**Low process**	**Medium process**	**High process**
Appearance	6.26	7.16	6.15	6.52	6.68	6.65
Colour	6.34	6.95	6.14	7.00	6.60	6.42
Odour	6.70	7.10	6.90	7.12	7.00	6.65
Taste	6.68	7.12	7.00	6.52	7.00	6.71
Texture	6.50	7.19	6.92	6.15	6.52	7.00
Overall quality	**6.50**	**7.34**	**6.10**	**6.70**	**6.42**	**6.54**

Note: Average of 10-12 panelists

Score grade used: 10 point hedonic scale (Appendix-II)

Table 14. Optimum processes (equivalent to F_o-12-13 min.) at 115.6 ^{0}C for octopus canned in different filling media.

Product	Process time (min.)	
	Octopus mantles	Octopus tentacles
Octopus natural style (OCN)	50	55
Octopus in brine (OCL)	50	55
Octopus in oil (OC3)	65	70
Octopus in curry (OC7)	80	85
Octopus in masala (OCM)	90	95

Table 15. Cut out characteristics of canned octopus mantles and tentacles stored up to 6 months after production.

Sl. No.	Pack / Style	Storage period (months)	Gross weight (g)	Net weight (g)	Weight of solids (g)	Net weight (%)	Gross head space (mm)	Exudates (%of total liquid)	No of pieces	Vacuum (cm of Hg)	Turbidity	Adhesion	Sulphur blackening
1	Natural	0	245	196	136	68.54	9	-	35.0	21.50	+	+	Nil
		1	240	199	134	70.20	7	-	38.0	22.00	+	-	Nil
		3	241	195	130	67.50	8	-	37.0	19.50	++	++	Nil
		6	239	193	132	68.25	8	-	36.0	20.00	++	-	Nil
		Average	241	196	133	68.25	8.0	-	36.0	21.00	-	-	Nil
2	Brine	0	240	192	132	64.99	7	-	34.0	28.00	-	-	-
		1	238	194	130	67.25	8	-	32.0	27.50	-	-	-
		3	236	193	134	69.07	7	-	33.0	27.00	-	+	-
		6	240	196	132	67.51	7	-	32.0	25.00	-	-	-
		Average	230	194	132	67.20	7.2	-	33.0	26.87	-	-	-
3	Oil	0	236	192	131	68.23	9	9.6	32.0	29.00	-	-	-
		1	237	193	130	70.47	10	10.3	34.0	27.50	-	-	-
		3	238	197	134	68.56	7	8.9	33.0	32.00	-	-	-
		6	241	194	132	67.01	6	9.8	32.0	30.50	-	-	-
		Average	238	194	132	68.56	8.0	9.65	33.0	29.80	-	-	-
4	Curry	0	212	166	131	67.10	6	-	39.0	23.70	-	-	-
		1	210	168	131	66.54	7	-	31.0	28.00	-	-	-
		3	209	177	130	67.01	8	-	32.0	23.70	-	-	-
		6	215	165	136	69.04	9	-	32.0	26.30	-	-	-
		Average	212	168	132	67.35	7.5	-	33.5	27.30	-	-	-
5	Masala	0	239	160	-	-	9	-	34.0	27.92	-	-	-
		1	240	160	-	-	7	-	32.0	28.6	-	-	-
		3	238	144	-	-	8	-	30.0	26.4	-	-	-
		6	241	147	-	-	9	-	31.0	23.0	-	-	-
		Average	239	146	-	-	8.0	-	31.0	26.70	-	-	-

The solid weight proportion in natural, brine, oil and curry packs varied between 67 to 70%. In masala packs weights of solids were not separately determined.

Gross headspace in the cans varied from a minimum of 7.0 mm to a maximum of 10 mm. Exudates was only found in oil pack and varied between 8.9 to 10.3% of total liquid contents of the can with an average of 9.65%.

The numbers of solid pieces ranged from 30 to 39 with an average of 32 to 33 nos. All cans showed vacuum of >20 cm of Hg at sea level.

Only in case of natural pack, turbidity of liquid was found. Adhesion of meat was present in natural pack and slightly in brine pack but, in all other packs no turbidity was observed. Sulfide blackening was not observed in any of the cans examined. The cut-out characteristics did not change to any observable extent during six months of storage period.

4.6. Proximate composition of canned octopus

Changes in proximate composition and salt content and pH in the case of canned octopus are presented in the Table 16. The average moisture content in natural pack was 69.29%, in case of brine, oil, curry and masala packs it was 69.97, 67.78, 68.80 and 60.61% respectively. Crude protein content (N×6.25) was 23.42, 23.58, 25.56, and 27.12% in natural pack, brine, oil, curry and masala respectively.

Average fat content was 2.07% in the natural pack, 1.84% in brine pack, 3.57% oil pack, 3.48% in curry pack and 7.88% in case of masala pack. Total ash in case of natural, brine, oil, curry and masala packs were 2.52%, 1.88%, 1.38%, 2.02% and 2.72% respectively.

The corresponding salt contents were 2.43, 1.95, 1.44, 1.79 and 2.55% respectively. The average pH was around 6.20 in natural pack, 6.10 in brine pack, 6.09 in oil pack, 5.52 in curry pack and 5.40 in case of masala pack.

4.7. Changes in organoleptic characteristics of canned octopus

Sensory evaluation scores obtained for each organoleptic attributes like appearance colour, odour, taste, texture and overall quality of canned octopus are indicated in Table 17.

Table 16. Proximate composition of canned octopus stored for 6 months

Sl. No.	Filling medium	Storage months	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Salt (%)	pH
1	Natural	0	71.04	22.68	2.38	2.35	2.24	6.2
		1	69.42	23.45	1.96	2.51	2.58	6.0
		3	68.58	23.68	1.92	2.64	2.49	6.3
		6	68.15	23.89	2.10	2.58	2.65	6.0
		Average	69.29	23.42	2.07	2.52	2.43	6.2
2	Brine	0	71.38	22.42	1.84	1.92	2.14	6.2
		1	69.64	23.84	1.79	1.87	1.82	6.3
		3	69.54	23.40	1.86	1.86	1.96	6.1
		6	69.32	23.43	1.86	1.87	1.90	6.0
		Average	69.97	23.58	1.84	1.88	1.95	6.1
3	Oil	0	67.82	25.24	3.23	1.20	1.60	6.04
		1	68.45	25.48	3.26	1.40	1.42	6.04
		3	67.18	25.84	3.80	1.45	1.42	6.20
		6	67.64	25.68	3.92	2.48	1.32	6.10
		Average	67.78	25.56	3.57	1.38	1.44	6.09
4	Curry	0	69.08	23.64	3.64	2.33	2.08	5.6
		1	68.10	23.92	3.52	2.01	1.64	5.4
		3	69.15	23.90	3.36	2.06	1.92	5.7
		6	69.20	23.74	3.42	2.08	1.53	5.4
		Average	68.80	23.52	3.48	2.02	1.79	5.52
5	Masala	0	60.25	23.54	8.02	2.84	2.86	5.4
		1	60.20	27.24	7.80	2.68	2.43	5.2
		3	61.64	27.46	8.02	2.62	2.49	5.6
		6	60.42	27.26	7.68	2.71	2.42	5.4
		Average	60.61	27.12	7.88	2.72	2.55	5.4

Table 17. Organoleptic characteristics of canned octopus stored for 6 months

Sl. No.	Product	Storage months	Appearance	Colour	Odour	Taste	Texture	Overall acceptance
1	Natural	0	6.40	6.30	6.50	6.80	6.60	6.50
		1	7.40	6.50	6.80	7.00	7.20	6.90
		3	6.30	5.90	6.40	6.30	6.90	6.40
		6	6.30	6.50	6.80	6.90	6.60	6.60
		Average	6.50	6.30	6.63	6.75	6.83	6.60
2	Brine	0	7.20	7.10	7.00	6.85	7.00	7.00
		1	6.80	6.80	6.48	6.55	6.58	6.60
		3	7.74	7.20	6.50	6.40	7.20	7.18
		6	7.68	7.60	6.62	6.46	7.15	7.20
		Average	7.35	7.14	6.65	6.56	6.98	6.99
3	Oil	0	7.80	7.00	7.00	6.88	7.20	7.10
		1	6.62	6.88	6.60	6.40	6.80	6.50
		3	6.90	6.52	6.50	6.71	7.00	6.70
		6	6.70	6.70	7.00	6.84	7.40	6.90
		Average	6.83	6.72	6.77	6.71	7.10	6.87
6	Curry	0	7.40	7.00	7.80	7.60	7.84	7.40
		1	6.84	6.80	7.20	7.20	7.64	6.92
		3	7.84	7.25	7.80	7.80	7.50	7.50
		6	7.80	7.40	7.35	7.45	7.10	7.25
		Average	7.40	7.11	7.54	7.51	7.52	7.24
5	Masala	0	7.20	7.30	7.00	6.84	7.10	7.14
		1	6.80	7.60	7.15	6.20	7.70	7.50
		3	7.10	7.80	7.15	7.50	7.10	7.30
		6	6.45	7.30	7.00	7.10	7.40	7.10
		Average	6.88	7.50	7.07	6.91	7.32	7.21

It can be seen that on an average, appearance scored 6.50, 7.35, 6.83, 7.40 and 6.88 (all out of maximum 10), for the natural, brine, oil, curry and masala packs. Corresponding scores for colour were 6.30, 7.14, 6.72, 7.11, 7.50. Further, odour scores were 6.63, 6.65, 6.77, 7.54, 7.07 respectively. With respect to taste, natural pack scored 6.75, brine pack 6.56, oil pack 6.71, curry pack 7.51 and masala pack 6.91. Corresponding texture score were 6.83, 6.98, 7.10, 7.52 and 7.32. Scores for overall quality were 6.60 for natural, 6.99 for brine, 6.87 for oil, 7.24 for curry and 7.21 for masala pack.

4.8. Microbiological quality of canned octopus

The sampled cans of octopus mantles and tentacles packed in different filling media were all found to be microbiologically sterile. There was no indication of any degree of can ends bulging. Cultures both in Glucose Tryptone and Thioglycollate media (pasteurized and unpasteurized), incubated at 37 °C as well as 55 °C did not show any indication of growth of microorganisms.

4.9. Statistical analysis

Table 18, 19, 20, 21 and 22 presents the analysis of variance (ANOVA) of canned octopus mantle and tentacles in different filling media. It shows whether there is any significant difference with respect to appearance, taste and overall quality characteristics of the products during the storage period.

Table 18. ANOVA table for canned octopus in natural style (own juice)

Attributes	Source of variation	Sum of squares	Degrees of freedom	Mean sum of squares	F ratio	Significance
Appearance	Between products	0.1524	1	0.1614	0.210	*
	Between days	0.23721	3	0.1147	0.145 3	*
	Error	0.2274	3	0.640		
	Total	0.6074	7			
Taste	Between products	0.24	1	0.24	54.01	**
	Between days	0.1642	3	0.0512	10.5	**
	Error	0.1470	3	0.0032		
	Total	0.4318	7			
Overall quality	Between products	1.001	1	1.0011	46.26	**
	Between days	0.2426	3	0.0810	4.214	*
	Error	0.0426	3	0.0131		
	Total	1.2416	7			

* Not significant at 5% level

** Significant at 5% level

Table 19. ANOVA table for canned octopus in brine pack

Attributes	Source of variation	Sum of squares	Degree of freedom	Mean sum of squares	F ratio	Signifi-cance
Appearance	Between products	0.1631	1	0.1714	0.214	*
	Between days	0.42815	3	0.1164	0.1478	*
	Error	0.1494	3	0.684	-	-
	Total	0.7816	7	-	-	-
Taste	Between products	0.46	1	0.46	48.01	**
	Between days	0.1684	3	0.0543	14.5	**
	Error	0.1470	3	0.0046	-	-
	Total	0.6210	7	-	-	-
Overall Quality	Between products	1.021	1	1.124	38.10	**
	Between days	0.2438	3	0.0912	4.215	*
	Error	0.0426	3	0.0314	-	-
	Total	1.2413	7	-	-	-

* Not significant at 5% level

** Significant at 5% level

Table 20. ANOVA table for canned octopus in refined oil

Attributes	Source of variation	Sum of squares	Degree of freedom	Mean sum of squares	F ratio	Signifi-cance
Appearance	Between products	0.2432	1	0.02461	5.1018	*
	Between days	0.1862	3	0.5512	12.1410	**
	Error	0.0014	3	0.0045	-	-
	Total	0.2254	7	-	-	-
Taste	Between products	1.2645	1	1.2649	124.2	**
	Between days	0.1252	3	0.0348	6.1412	**
	Error	0.0214	3	0.0062	-	-
	Total	0.2419	7	-	-	-
Overall Quality	Between products	1.2419	1	1.2419	84.148	**
	Between days	0.3246	3	0.1114	6.143	**
	Error	0.0349	3	0.0132	-	-
	Total	0.6348	7	-	-	-

* Not significant at 5% level

** Significant at 5% level

Table. 21. ANOVA table for canned octopus in curry pack

Attributes	Source of variation	Sum of squares	Degree of freedom	Mean sum of squares	F ratio	Signifi-cance
Appearance	Between products	0.2112	1	0.1613	0.316	*
	Between days	0.3842	3	0.1127	0.1342	*
	Error	0.1345	3	0.5210	-	-
	Total	0.5418	7	-	-	-
Taste	Between products	0.39	1	0.39	81.24	**
	Between days	0.1513	3	0.0424	14.30	**
	Error	0.1240	3	0.0039	-	-
	Total	0.4315	7	-	-	-
Overall Quality	Between products	1.041	1	1.130	36.10	**
	Between days	0.3213	3	0.0814	4.134	*
	Error	0.0410	3	0.0325	-	-
	Total	1.2814	7	-	-	-

* Not significant at 5% level

** Significant at 5% level

Table 22. ANOVA table for canned octopus in masala pack

Attributes	Source of variation	Sum of squares	Degree of freedom	Mean sum of squares	F ratio	Significance
Appearance	Between products	0.2760	1	0.02760	5.1128	*
	Between days	0.1970	3	0.06572	12.1640	**
	Error	0.0014	3	0.0052	-	-
	Total	0.2262	7	-	-	-
Taste	Between products	1.3690	1	1.3690	128.4	**
	Between days	0.1384	3	0.0460	6.1730	**
	Error	0.0224	3	0.0072	-	-
	Total	0.5310	7	-	-	-
Overall Quality	Between products	1.3528	1	1.3528	86.721	**
	Between days	0.3356	3	0.1118	7.170	**
	Error	0.0467	3	0.0154	-	-
	Total	0.7332	7	-	-	-

* Not significant at 5% level

** Significant at 5% level

V. DISCUSSION

V. DISCUSSION

5.1. Raw material quality as a factor affecting quality of canned product

In any processing method, the starting point is the raw material. In canning, a large number of operations are carried out in a predetermined sequence until the finished product is obtained. However, the quality characteristics of the final product depend equally on the initial quality of the raw food item just as on the various treatments to which it is subjected. Since a good canned product cannot be obtained from a bad quality raw material, it is necessary to study the quality of the raw material in the beginning and then follow the changes caused by the processing operations subsequently. Thus a study of physical chemical and organoleptic attributes of raw octopus is essential for deciding optimum processing conditions for its canning.

5.1.1. Physical, chemical and microbiological quality of octopus

These are the important quality aspects of raw material which not only influence the quality of the final product, but also decide the suitability for canning in a particular form or for selecting a proper filling medium, container, packing method and process. The cephalopods are generally canned in the industry is of the smaller size according to Kreuzer (1984), the large sizes going for freezing. The samples of octopus obtained for the present experiments belong to the majority size group in commercial landing in India, being neither too large nor too small. The division again into three size groups (Large, medium and small) as shown in Table 1 is for convenience only. The physical characteristics listed in the table shows that even though the total lengths vary from 16.25 cm for the small size to 45.25 cm for the large, the mantle lengths do not vary as much (5.15 to 10.40 cm). Considering the further shrinkage in length during blanching, whole mantles are suitably canned in small size cans for length wise packing. The number (count) per kg of material indicated that for the **"medium"** group more than 28 octopus were required to make one kg. Since dressing yield was less than 50% of raw weight and further reduction upto 58% is encountered in blanching treatment, it may be possible to obtain just 4 cans or a little more from a kg of raw octopus, when small size containers (301 x 203 mm) are used for packing, as in the present study.

The weight composition of body parts of the octopus is shown in Table 2. both for those with and without ovary. Dressed mantle in octopus (without ovary) constitutes 38% of total weight. The value is in close agreement with 38.56% obtained by Venkatappa and Dhananjaya (2006). The percentages of other parts are also in general agreement, except the skin and suckers, which together constitute only 14% in this analysis, whereas in the reference cited these together form 21% of the total.

The results of chemical analysis of octopus meat shown in Table 3. Indicated that octopus were of low fat (just over 1.14%) material with comparatively higher moisture content (over 84.36%) in muscle tissue. The analysis values were more or less in general agreement with those obtained by the earlier workers mentioned above. Proteins (N x 6.25) constitute 13.01% and ash 1.35% on wet weight basis in the present work whereas in that of Venkatappa and Dhananjaya (2006), proteins vary between 11.54% and 11.68% and ash between 1.45 and 2.15%. Ha (1982) reported that the total lipid content of 0.5% in *Octopus vulgaris* and 0.8% in *Octopus variabilis*. Pandit and Magar (1972) however, reported slightly different values for ash, it was 8.41% and 7.40% in case of *Sepia inermis* and *Loligo vulgaris* respectively. The difference could be mainly due to variation in species. Thus octopus may be considered as a good source of animal proteins. The proximate composition changes during the dressing and blanching operations carried out in canning. The changes can be visualized from the results in Table 4. It may be noted that the blanching operation reduces moisture content from the original value of over 84.36% to 58.91%. The increase seen in protein, fat and ash contents after blanching are mostly relative to moisture reduction, since these are expressed on wet weight basis.

The microbiological quality of octopus seems to be normal, considering the total plate count at the raw material. The cfu/g of 4.6×10^6 is of the same orders as in average quality fish of many species when landed. Nearly 90% reduction is obtained in washing and cleaning the mantles and very drastic reduction to $2.3x10^2$ cfu/g results after blanching (Table 5). Total spore counts also do not seem to be high in the raw material. Since the thermophilic spores were not present, no special hazards in the thermal processing may be anticipated, provided further contamination by these does not occur in the cannery. It is interesting to note that Joshi and Saralaya (1981) found that in precooking sardine fish for canning, the reduction in the original microbial load of raw material was also of similar order (from an average value of $2.97x10^6$ to $1.97x10^3$ cfu/g). Similarly, with previous work of Dileep (2002) who reported the values of $5.2x10^5$ and $4.0x10^6$ cfu/g in fresh shrimp and squid respectively.

5.2. Effect of blanching or steaming

Octopus meat looses moisture to great extent when subjected to any form of heating or cooking, resulting in shrinkage in length and breadth as also appreciable loss of weight. Therefore in canning operation of octopus as in the case of canning of prawns, determining not only moisture content of solids after canning, but also their drained weight, salty taste, texture of neat, turbidity of brine and several other characteristics is important. Thus it is necessary to control this operation property.

5.2.1. Comparison of blanching and steaming

Some effects such as, removal of excess moisture, reducing and stabilizing the solid weight, firming of texture etc. may be achieved either by blanching the octopus in water or brining or steaming.

Table 7 shows the results of steaming and blanching tests carried out on octopus meat. It can be seen that 30 min. steaming at 100 ^{0}C has almost similar effects as blanching in 4% brine for 4 min. on weight loss of octopus mantles and tentacles. Some difference was noticed in the length and breadth wise shrinkages due to the two operations. The moisture content, which was originally over 84.38% has reduced to 71.34% by steaming and 75.49% by blanching.

From processing point of view, blanching to achieve the same changes in octopus meat should be preferred, since the steaming operation is much more time consuming. Further, imparting necessary salty taste to the meat can be achieved simultaneously by blanching in salt solutions, whereas the similar effects cannot be achieved by steaming.

5.2.2. Standardisation of blanching operation

The results of varying the blanching time, from 4 to 8 minutes in boiling hot water and 4% table salt solution are shown in Table 9. The dressed octopus was used for blanching. The length wise and breadth wise shrinkage in dimension as well as percentage weight losses suffered by any one form may be compared from the tabulated figures. It may be observed that over 52.78% loss of weight could be achieved by blanching of mantles in 4% boiling brine for 8 min. As the blanching time and salt concentration of brine are increased, the weight loss also increased, as in the case of prawns (Varma *et al.,* 1969; Rai *et al.,* 1975). Similar effects were observed by (Raghunath and Solanki 1986; Parshwanath; 1989; Peddanna, 2005). In the case of squids blanched under varied conditions. Since further weight loss occurred during heat processing of canned octopus, the standardization of initial blanching assumes major importance, as in the case of prawns. By adjusting the pre canning, blanching operation, further loss of weight during retorting can be reduced to negligible levels. It was found that when the blanching is such that the resulting weight loss is around 50-55% and moisture content of blanched octopus meat was 70-72%, a state of equilibrium was achieved between the meat and filling brine in the can, so that further loss in solid weight was reduced to near 6-8%. Blanching in hot, 4% table salt solution for 4 min. in case of mantles and 6 min. in case of tentacles was also found to yield canned products at optimum salty taste (Table 8).

5.3. Packing operation

As already mentioned two forms of packs in canning of octopus were initially tried in this experiment are canning of octopus. These were: (a) mantles (b) tentacle. On blanching and canning, the acceptability of these two forms of pack was compared in preliminary trials and finally, proper weight for packing into the selected can size was decided.

5.3.1. Forms of pack

Of the two forms of pack namely; mantles and tentacles, canned mantles were judged as the best, tentacles as the second best, as can be seen from the data tabulated in Table 8. Overall quality score for mantle form of octopus was 7.48 and for tentacles form it was 6.02, out of a possible maximum of 10.

5.3.2. Filling media

As mentioned earlier in material and methods, five different filling media were used to can the octopus mantles and tentacles, these being, (a) Own Juice in natural pack, (b) 2% table salt brine solution, (c) double refined sunflower oil, (d) curry and (e) masala. Tomato Sauce was not tried, as the product was found to acquire light blue colour after canning in a preliminary trial. It was found that all the five media mentioned could be used either for canning of octopus mantles or tentacles.

5.3.3. Packing weight for can size and different filling media

In deciding a suitable pack weight for any canned product, the factors to be considered are, the can size and its water holding capacity, the optimum net weight of contents, ratio of solids to liquids, the usefulness of the filling medium for consumption along with the solid contents or for heat penetration characteristics.

In most of the canned fish packs standard specifications prescribe over 60% of solids up to 70% of net weight of contents as the minimum required. Indian standard specification for prawns canned in brine require at least 64%

solids, for mackerels solid weight required is not less than 65%, for pomfret 66%, for sardines and tuna canned in brine of oil, the minimum solids should not be less than 70% at the net weight of contents or water holding capacity at the container used. For curry packs of fish or prawn, Rai *et al.*, 1971 consider a fish to curry ratio of 60:40 as proper for ready consumption. Standards for canned tuna observed in Japan and the United States of America, prescribed limits of solids to filling medium nearer to 75 or 80% of total contents in the finished products.

Octopus mantles and tentacles canned in the five different filling media also could be in the ratio of 65% of solids to 35% of liquids in the can. The packing weights of blanched meat should adjust to give at least this ratio in the canned product. In so much as the heat treatment involved in final sterilization is likely to result in 5 to 8% further increase in solids, 75% of the water capacity of the can may be taken as suitable pack weight for octopus mantles and tentacles canned in media such as brine, oil or curry. In the case of natural pack, since unblanched mantles or tentacles have to be filled in the can and these loose more than 50% of their weight in processing, at least double the weight solids finally required should be packed, tuna, for the 301x203 can, since the net weight of contents is fixed at 190g per can (and weight of solids required is 135-140g) at least 280g of mantle should be taken for packing. It could be necessary to discard some of the cook juice before can closing to give sufficient head space. In the case of masala pack, 165g of octopus and masala mix (120g solids and 45 g of masala) was found to be proper pack weight.

5.4. Thermal Processing of canned octopus

Thermal processing by retorting is perhaps the most important operation in the canning method of food preservation. The adequacy of processing should be evaluated both from the consumer safety point of view and spoilage and quality consideration. In the couple of published Indian paper on canning of squids (Varma and Joseph, 1980; Raghunath and Solanki, 1986), the sterilization effect of the processes applied have not been defined in terms of F value at can centre, and it is necessary to determine this scientifically.

5.4.1. Heat Penetration in canned octopus

Effect of heat sterilization in canned products is evaluated scientifically by carrying out heat penetration tests, recording the can centre temperatures reached during processing calculating the total effect in terms of total lethality achieved (F value or F_o-value) and comparing this against the heat resistance of known pathogenic or spoilage and bacterial spores.

The results of heat penetration, test carried out in the present study with regard to the form of pack and the five filling media (own Juice, brine, oil, curry and masala), are presented in Table 10. The rates of heat penetration in terms of the slops of semi log heating curves (expressed usually as f_h value) for the several canned samples may be compared from the data presented in Table.11.

5.4.2. Effect of form of pack, pack weight and filling media

Form the results in Table 11, it can be seen that between the two forms of pack (mantles and tentacles), heat penetration is always faster in the small sized mantles than in the tentacles. The difference in the values between tentacles and mantles f_h found to be 16 to 20% in the faster heating brine and natural packs and 8 to 10% in the slower heating oil, curry and masala packs. The relative rates can be readily seen from the semi- log heating curves at Fig. 5, 6, 7, 8 and 9 for natural, brine, oil, curry and masala packs respectively. These findings are in general confirmation of the results of earlier studies (Venkatesh murthy, 1981; Rosalind George, 1987; Pujar, 1988; Parshwanath, 1989; Shantha Kumar, 2004; Peddanna 2005; and Chandra, 2007). One difference that can be noticed is that the earlier workers found the oil pack to be slower than the curry pack, the present tests showed the curry pack as the slowest of the two. The difference is probably due to the fact that there might have been some difference in the curry consistency caused by variation in formulation.

5.4.3. Process levels and quality of canned octopus

The heat penetration data when used to calculate thermal process of three different degrees of severity ('**Low**' F_o =5-6 min. '**medium**' F_o 12-13 and '**High**' F_o= 20-21min. at can centre) For the octopus mantles in own juice and oil packs (OCN and OC3), yielded retorting operations shown in Table 12. These were the process levels used by Rosalind George (1987) and Pujar (1988) for checking the effect of thermal process levels on quality of canned mackerel and sardines, respectively. The canned octopus packs produced by applying these processes. When evaluated for quality attributes, yielded the results summarized in Table 13. It may be seen that in the case of all organoleptic characteristics, the can receiving the medium process was judged to be better than those receiving either low or the high process, In octopus canned as **"Natural"** (OCN). In the case of oil packed octopus also, overall quality was found to be better in the medium processed product than in other two. One or two attributes of the low processed (F_o: 5-6 min.) product scored slightly higher, but this may be due to the flavour being marked by that of the filling oil. The finding that the organoleptic quality of canned product subjected to processes equivalent to F_o=12 min. was much better than those of lower or higher processed packs of the same kind, is in complete agreement with the earlier findings of Rosalind George (1987), Pujar (1988) and Chandra (2007) with respect to canned mackerel, sardine and ribbon fish.

Based on these findings, retort operations at 115.6 ^{0}C suitable for the octopus product in the five different media were calculated to give F_0 = 12 min. in each case and these are presented in table 14. The same processes were applied to prepare final products for quality evaluation and storage studies.

5.5. Microbiological Quality

Samples of all the products of canned octopus were found to be microbiologically sterile, since none of the cultures exhibited any positive indication of growth. The tests included culturing in glucose tryptone broth and Thioglycollate broth for anaerobes. Therefore both aerobes and anaerobes can be assumed to be absent. Since pasteurized and unpasterurized cultures were absent, the products cultured could not have had spore forming or non-sporing bacteria. Further, incubation of the cultures at 37^0C and 55^0C also did not result in positive growth. Hence neither mesophiles nor thermophiles were presents.

This is understandable because all the cans had received thermal processes equivalent to F_o=12 min. at can centre. This process is about four times the process required to destroy *Clostridium botulinum* spores which have the maximum heat resistance among pathogenic organisms, equal to about F_o-2.5 min. Thus the canned octopus packs may be assumed to be quite **"safe"** for consumption. Further, the process F_o=12 min. seems to be adequate to destroy spoilage organisms having much higher heat resistance than *Cl. botulinum* such as *Bacillus circulans* reported as the spoilage agent in marine products by Tanikawa (1971). The adequacy of the process used was also influenced by the fact that the raw octopus used in preparing the products did not have any thermophilic spore formers. Therefore, the given processes may be adopted as suitable for the packs, unless further contamination by thermophilic spore formers occurs through subsidiary materials used for curry and masala or from the canning line. Reviewing the thermal process requirements for low acid foods. Hersom and Hulland (1969) have stated that there is no general agreement regarding the F value of processes required in such cases, except that **"botulinum cook"** should be considered as the minimum level.

In the present study, the processes used for canned octopus packs, therefore, can be considered as adequate not only from the public health point of view but also from that of product spoilage.

5.6. Standardisation of canning procedure for octopus

It is clear from the results discussed here before that each of the canning operations applicable to octopus packs can be optimized and when such optimum treatments are applied, best quality products may be expected to result in. The selected optimum operations are shown in proper sequence in Fig. 2. The octopus mantles and tentacles canned in own juice, brine, vegetable oil, curry and masala were prepared according to this standard procedure, were subjected to several tests for quality evaluation upto 6 months after production, for confirming the suitability of the procedure and to estimate shelf life.

5.7. Quality evaluation of canned octopus packs

The common practice in judging the quality of canned products is to take samples of the same and carry out a series of tests on them, gather all the information on the different quality aspects of the product such as physical, chemical, organoleptic, microbiological characteristics and statistical analysis, and then draw the final inference.

Since the microbiological examination showed that all samples were sterile (the individual incubation and culture tests being negative), the results were not presented separately in tabular form. However, the physical and cut-out characteristics of the products are presented for canned mantles in Table 13 and 14 represent the summarized chemical quality of packs and table 15 present the results of sensory evaluation tests. Considered together, these results help as to draw the conclusion regarding the suitability or adequacy of the whole procedure evolved in this study for canning of octopus in different forms and filling media.

5.7.1. Cut-out characteristics

The significant, Physical and other general characteristics of canned products are judged by the results of Sample cutting or cut-out tests.

The results presented in Table 13 shows such characteristics of the octopus packs canned in different media. The net weight of contents in the natural, brine, oil, and curry packs are all above the required minimum of 190 g of for the selected can (301 x 203). For only the masala packs 160 g of may be taken as standard for this can size, and all the samples were above this value. The weight of solids (except in masala pack) were sufficiently over the generally required 65%. Gross head space and vacuum were also quite good. Exudates in the oil packs were less than 10% of total liquid on an average. Turbidity of liquid contents and adhesion of meat to can were slight in natural packs and absent in other cans. Sulphide blackening was not found in any of the cans. Similar findings were recorded in the case of canned octopus tentacles in the same five packs. The main difference was in the number of pieces contained per can. There were 31 to 39 numbers in each can including mantles and tentacles. Also the average exudate in oil packed products was around 10% of total lipid, which value is slightly higher than the same for mantle packs. This may be due to the fact that the final heat treatment involved in retorting causes a little more of the juice to come-out from the mantles than the tentacles.

Parshwanath (1989) is of the opinion that the brine, oil and curry packs require a min. net weight of 190 g whereas for masala pack, it is 165 g for 301x203 sized cans. Similar values were also observed in the case of unblanched squids in masala was 165 g for 301x203 sized cans by Peddanna (2005).

5.7.2. Chemical Characteristics

Chemical characteristics of canned octopus and tentacles packed in different filling media can be seen from table 14. The proximate composition values show that except for the masala pack, the moisture contents were between 67 and 70%. In the masala packed octopus products it was around 60%. The similar values were observed by earlier work of Parshwanath (1989) and Peddanna (2005). All the packs showed high protein contents ranging from 22.42% to 27.46% on wet weight basis. This compares very well with the protein contents of other canned fish products. Total lipids, however were low in natural and brine packs, bring around 2%. In the oil, curry and masala pack the lipids were much higher ranging from 3.23 to 8.02%. This is because of the oil used in filling media.

Total ash contents were normal, varying around 2% and the salt content (as NaCl) showing slightly lower values. The salt content was found to give adequate salty taste to the products as evidenced from the sensory evaluation test results. The pH values of curry and masala packs were lower than those of the natural, brine and oil packs, because of the acidic tomato and tamarind used in the preparation of these filling media, namely curry and masala. Slightly lower ash content was observed in the present study compared to the study conducted by Parshwanath (1989) and Peddanna (2005).

5.7.3. Organoleptic quality attributes

The sensory evaluation scores of the different packs of octopus are shown in Table 15. It may be noticed that with respect of all the individual attributes i.e., appearance, colour, odour, taste and texture as well as overall quality, several products scored between 6.4 and 7.35 out of a possible maximum of 10.0. Thus, all the products of canned octopus have been judged as good on a five point scale ranging from "**excellent**" to "**very poor**". Comparatively, both in the case of mantles and tentacles, the curry and masala packed octopus scored higher on an average, than the natural, brine and oil packs with respect to all attributes, the natural packs scored least (6.50) for overall quality. Maximum score (7.80) was obtained for the curry pack. Among canned mantles and tentacles, the masala pack had a slight edge over the curry pack (6.88) in overall quality. These values are in good agreement with previous works of Parshwanath (1989), Dileep (2002) and Peddanna (2005).

In all the cases, the mantles and tentacles in the several packs had attractive appearance, white colour, good odour, necessary salty taste and appropriate chewable texture.

5.7.4. Statistical Analysis

The mean panel scores obtained for five different products were analysed by conducting two way analysis of variance techniques (ANOVA) to find out whether any significant difference between the products with different filling media. The results are presented in the table 16,17,18,19 and 20. The tables show that the appearance of the octopus products indicated no significant difference due to products and storage days. With respect to taste there a significant difference due to products and storage days. And also observed that there is a significant difference in overall quality due to products, but due to storage days there was no significant difference. These values are in good agreement with previous works of Parshwanath (1989), Dileep (2002) and Peddanna (2005).

5.8. Changes during storage and keeping quality of canned octopus

The present study was carried-out for a period of six months from the date of production of canned octopus. The results of quality evaluation tests carried-out immediately after production (0 month) and after 1, 3 and 6 months of storage at ambient temperatures (30±2^{0}C) are also included in table 13. These values are in good agreement with previous works of Parshwanath (1989), Dileep (2002) and Peddanna (2005).

It may be seen that within the period of 6 months of storage, no observable change had taken place in the products, with respect to physical characteristics (as shown by cut-out tests), chemical composition and organoleptic attributes, in any of the canned octopus samples. This means that octopus canned as described herein following the standard procedure would remain quite stable at least for 6 months in tropical climate.

VI. SUMMARY

VI. SUMMARY

The present study was carried out on the effect of several processing operation on the quality of canned octopus (*Octopus membranaceus*) which is an underutilized but important potential marine resource of India. Based on the results, procedures were standardized for canning of octopus in five different filling media.

The raw octopus samples used in the experiments were around 17 cm in length weighing on an average 35g each. Cleaned and dressed octopus mantle and tentacles used for canning constituted about 50-58% of the round weight of octopus.

The chemical analysis showed that the octopus had about 84.5% moisture, over 13.01% protein, around 1.15% of lipids and 1.30% of ash. Thus, the material could be classified as "low fat – medium protein" fishery product, when blanched in boiling brine the moisture content was reduced to about 72%.

Microbiological examination showed that the octopus had an initial total bacterial count of 4.6×10^6 cfu / g, out of which 208 no. / g were spores. The TPC was reduced to 2.3×10^2 cfu / g on blanching. Thermophilic spore formers were absent in raw material.

Blanching in boiling hot 4 % brine for 4 to 8 min. caused shrinkage in length and breadth and also weight losses ranging from 30-60% of original weight of octopus. This resulted in proper salty taste and suitable texture in the final product.

The preliminary trials showed that octopus meat canned in own juice, 2% brine, vegetable oil, curry and masala were satisfactory, but those canned in tomato sauce resulted in discoloration and found to be unacceptable.

Blanching and precooking are the two important steps in general canning procedure and serve several objectives. No such benefits are seen in blanching of octopus in curry and masala packs. In fact the products showed better organoleptic quality in terms of taste and texture. The product in natural packs retained valuable taste components of the meat which would have been otherwise lost in blanching. These soluble proteins and other substances gave a good taste and jelly like consistency to the curry and

masala, which was appreciated by most of the panelists. It resulted in increased juiciness of octopus while eating. The blanched products lost some moisture and become tough. This difference had an impact on pack weight and heat penetration characteristics of the product. The pack weight for blanched products was 165 g; however, it was possible to pack 165 g for unblanched products while maintaining a uniform gross head space of 10 mm in five types of products. This is because the jelly like curry and masala could fill up the gaps properly between the pieces in the products and contributes to the higher pack weight. However, this decreased the rate of heat penetration in the unblanched (natural pack) product compared to other four types of products.

Heat penetration experiments were conducted to assess the heat penetration characteristics of the products and recommend appropriate thermal processing schedules for all the five products. The canned octopus products were subjected to a processing schedule of 60, 60, 70, 85 and 90 minutes processing time for natural, brine, oil, curry and masala products respectively with come up time of 15 minutes during the heat penetration studies. The F_o values were calculated by both general and formula method for all the products and they were less than 5 minutes.

The values of f_h were obtained from the semi log heat penetration curve, it can be seen that the rate of heat penetration was slower in canned octopus in curry and masala than in natural, brine and oil packs. The corresponding f_h values being 15, 12, 18.5, 25 and 30 minutes in natural, brine, oil, curry and masala packs respectively.

For actual storage studies, all the canned products were subjected to a common processing schedule at 115.6 ^{o}C with a come up time of 10 min. of the retort. The F_o value obtained by the octopus in natural, brine, oil, curry and masala were 10.08, 10.69, 8.84, 10.98 and 9.73 min. respectively.

The cut out test showed that drained weight of solids was over 65% of the net weight, with good vacuum in all cans ranged from 19 to 30 cm of Hg. The slight turbidity of liquid and adhesion of meat to can were observed only in natural pack. Sulphide discoloration was absent in all cans and all the products remained in good condition, retaining all their desirable quality till the end of the period of storage study.

The canned product had protein contents around 24% in all the packs. Total lipids were ranged between 1.8 to 2.4% in case of natural and brine packs, whereas in other packs it ranged between 3-8 %. The salt content was around 2% in all the packs.

The organoleptic evaluation of the canned products showed that the canned octopus were of superior quality being rated as 'good' for all attributes judged. On the basis of overall quality, octopus canned in curry and masala media were rated slightly higher than the products like natural, brine, and oil packs. All the products remained quite stable with respect to organoleptic attributes judged such as appearance, color, odour, taste and texture. The study shows that by following procedures as mentioned here in, octopus products of highly acceptable quality can be prepared by canning in five different filling media, providing a few more diversified cephalopods products with special taste and flavour.

VII. BIBLIOGRAPHY

VII. BIBLIOGRAPHY

A.O.A.C. 1995. Official Method of Analysis of A.O.A.C International. Vol. II 16th Edition. Conniff p. (Ed). Association of Official and Analytical Chemists International,Virginia, USA, P.39-I.

A.P.H.A. 1976. Compendium of methods for the microbiological examination of foods. APHA, New York, 701p.

ADAMS, J.P and OTWELL, W.B. 1982. Suitability of seafoods to report pouch processing. Proceeding of the 7th annual tropical and sub tropical fisheries technologicaql conference of the Americas. pp; 48-57. Nicklson, R., II comp. Texas A. And M. Univ.Vollege station, UAS.

ADRIAN CORRIL. 2002. *Infofish International* : 4; pp 53-56.

* **ANON,** 1965. Cans for the canning industry part II- Recommendations for handling, processing and storage. *Fd.Technol. in Australia* **17**(3) 152-156.

* **APOLINARIO, K.M. POLOMARES, T.S., HEDRIANA, L.B.D.** and **GONZALES, O.N.** 1979. Standardization of canning produce for squid (*Loligo plei*) and green muscle (*Mytiles*) smaragdines chemistry products, *Fish res. J. Phillip.* **4** (2): 18-31.

ATKINSON, A. 1973. Storage life of canned pilchard in curry-sauce. *FIRI Ann. Rep.* **27**: 14-15.

BALACHANDRAN, K.K. 2001. Canning In; post harvest technology of fish and fishery products. pp: 158-220. *Daya publishing House*, New Delhi.

BALACHANDRAN, K.K. and **VIJAYAN, P.K.** 1988. Development of process for canning of fresh water fish Rohu. (*Labeo rohita.*) *Fish Technol.* **25** (1); 40-43

BALACHANDRAN, K.K., GOPAL T.K.S., and **VIJAYAN P.K.** 1998. Aluminium containers for fish canning. *In: Aluminium in packing of packaging* (Ed) pp: 570-576. E2 MIBC.

BALACHANDRAN, K.K., VIJAN, P.K and **PRABHAU, P.V.** 1984. Canning of edible oyster meat. *Fish. Technol.* **21**(1): 47-50.

BALL, C.O and **OLSON, F.C.W.** 1957.Sterlization in food technology Mc. *Graw-Hill Book o*, New York. p:654.

* **BALL, C.O.** 1923. Thermal process time for canned foods. *Bull. Natl. Research council. 7 part 1.* No. 37. pp.76.

BEATTY, S.A. and **GIBBONS, N.E.** 1937. The measurement of spoilage in fish. *J. biol. Bd. Can.*, 3(1): 77-91.

BERK, Z and PARISER, E.R. 1974. Squid processing machine. Proc. Gulf Carrib Fish Inst, 26; 54-58, *cited in FAO Fisheries Technical paper.* **254** (Ed) by Kreuzer, R (1984).

BERRY, M.R and **BUCH, R.C.** 1988. Thermal processing restorable plastic containers with metal lids in steam and water comparison to metal cans. *J. food Sci.,* 53: 1877-1886.

* **BIGELOW, W.D., BHOART, G.S., RICHARDSON, A.C** and **BALL, C.O.** 1920. Heat penetration in processing of canned foods. *National canner's Assoc. Bull.* 16-L, 128pp.

BINDU, J., SRINIVASAGOPAL, T.K. and UNNIKRISHNAN NAIR, T.S. 2004. Ready to eat mussel meat processed in retortable pouches for the retail and export market. *Package Technol. Sci.* **17:** 113-117.

* **BITTING, A,W.** 1937. The canning of fish, In Appetizing or the art of canning, its history and development. *Trade press, room, San Francisco, California*, 784-852.

BORGSTROM, G., 1965. (Ed) Fish as food-**IV**. *Academic press, New York London.* pp: 518.

BROEK, C.T.H. and VANDEN, 1965. Fish canning. pp: 127-194, *In: Fish as Food **IV***, Borgstrom, G., (Ed). Academic Press. New York and London.

CASALES, M.R., DELVALLE, C.E. and **SOULE, C.L.,** 1988. Heat penetration in canned mussels during agitated retorting. *J. Food. Sci* **53** (1):4-5.

CHANDRA, M.V. 2007. Studies on use of tin free steel can for canning of ribbon fish. *Master's Thesis,* Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar.

CHEFTEL, H. 1965. The canning of sardine *Clupea pilchards* in *Fish as Food* **IV**. (Ed) Academic press, New York London. pp: 247-262.

CHIA, S.S., BAKER, R.C., and **HOTEHKISS, J.H.** 1983. Quality comparison of thermo processed fishery products in can and retortable pouches. *Journal of Food Sci.* **48.** (4): 1521-1525.

CHOUDHURI, D.R., IYER, T.S.G. and PILLAI, V.K. 1970. Factors controlling sterility in canned prawns. *Fish Technol.* **7** (1): 73.

CMFRI. 2003. Annual Report: 2003-04. *Central Marine Fisheries Research Institute, Cochin:* 134p.

DILEEP, A.O. 2002. Development of new seafood's by thermal processing. *Master's Thesis,* University of Agricultural Science, Bangalore.

ESTY J.R. and **MAYER K.F.** 1930. The heat resistance of the spores of Botulinum and allied aerobes. *J. Infectious Disease.* **31**: 68-72.

FELLOWS, P. 1990. Food packaging technology, Principles and practices. *Ellis hor wood Ltd.* England pp: 492.

GANAPATHI BHAT, A. 1983. Canning of Indian major carp Mrigal. *Master's Thesis,* University of Agricultural Science, Bangalore.

GEORGE, M.R. 1987. Studies on effect of thermal process variation on the quality of canned Indian mackerel. *(Rostrelliger kanagurta), Master's Thesis,* University of Agricultural Science, Bangalore.

GILLESPY T.G., 1951. Estimating the sterilizing valve of process as applied to canned foods. 1: packs heating by condition. *J. Sci. Food Agric.* **2**: 107-125.

GIRIJAVARAMA, P.R. and **VENKATARAMAN, R.** 1978. Canning of smoked Dhoma. (*Sciaenid sp.). Fish. Technol.,* **15:** 27-29.

GOPAKUMAR, K., 1993. Retortable pouch packaging. *In: Fish packaging technology,* Concept publishing company, New Delhi, pp: 127.

GOPAL, T.K.S. ANTONY, K.P. and GOVINDAN.T.K. 1981. Packaging of fish and fishery products. Present status and future prospectus. *Sea food export journal.* **13** (1): 15-22.

GOVINDAN, T.K. 1975. Research on fish canning in India – A review. *Ind. Fd. Packer,* Jan – Feb. **26** (1): 25-31.

* **HERSOM, A.C.** and **HULLAND, E.D.,** 1969. Canned foods – An introduction to their microbiology (Baumagartner) 6th Ed. – *J. and A. Church hill Ltd.* London.

* **HERSOM, A.C.** and **HULLAND, E.D.,** 1980. Canned foods-thermal processing and microbiology, (7thEd.), pp: 319. *Church hill Livingstone Edinburgh.*

* **HERSOM, A.C.,** 1975. Thermal processing: *In: Food Technology in the*

* **HOTTENROTH, V. and VERPACK-RDSCH, 1972.** Storage test with fish in chromium coated can and tin plate cans. *Techno. Scient suppl.* **23**: 49-52.

HURTADO, J.L, MONTERO, P. and BORDERÍAS, J. 2002. Chilled storage of pressurized octopus (*Octopus vulgaris*) Muscle. *J. Food Sci.* **66** (3): 334-340.

JARVIS, N.D. 1943. Principles and methods in the canning of fishery products. US Fish Wildlife service, Research report No. **7**: 366.

JAYASEKARAN, G. 1985. Studies on the effect of handling methods on the quality of canned white sardine (*Kawala covala) Master's Thesis,* University of Agricultural Sciences, Bangalore.

JOSHI, V.R. and SARALAYA, K.V. 1982. Studies on the effect of precooking in sardine canning V. Factors influencing the pre cooking effect. *Mysore. J. Agric. Sci.* 16: 338-345.

KANDORAN, K.K., SOLANKI, K.K. and **VENKATARAMAN, R.** 1971. Canning of smoked eel. *Fish. Technol.,* **8** (1): 98-100.

KARTHIAYANI, T.C. and **IYER, K.M.** 1971. Seasonal variation of bacterial flora of fresh oil sardine. *Fish. Technol.* **8** (10): 69.

KOLODZIEJSKA, I., NIECIKOWSKA, C. and **SIKORSKI, Z.E.** 1994. Diethyl amine and formaldehyde in cooked squid muscle extracted and mantle. *Food Chemistry.* **50** (3): 281-283.

KREUZER, R. 1984. Cephalopods: handling, processing and products. FAO. *Fisheries Technical paper.* **254:** p 108.

LAHIRI, A. 1992. Aluminium rigid containers for processed foods, *Packaging India: 19-29.*

LAMPI, R, A. 1977. Flexible packing for thermo processed foods. *Adv. Fd. Res.* **23**: 306-426.

LANG, O.W. 1939. Thermal process for canned marine products. *Univ. calif. Publis. Public Heath.*

* **LARMOND, E.** 1977. Laboratory method for sensory evaluation of food. Research Branch. Canada. Department of Agricultural Publication, 1637. pp: 47-48.

LOPEZ, A. and **JIMENEZ, M.A.** 1969. Canning of fruits and vegetable products in aluminium containers. *Food Tech.,* **23** (10): 1200-1206.

LU, S.N. 1997. Effect of thermal processing on purine content of grass shrimp *(p. monodon), Food-science -Technology.* **24** (4): 438-447.

MA, L.Y., DENG, J.C., AHED, E.M. and ADAMS, J.P. 1983. Canned shrimp texture as function of its heat history. *Journal of food science 48:* 983.

MADHAVAN, P. and BALANCHADRAN, K.K. 1971. Canning of tuna in oil. *Fish. Technol,* 8 (1): 23-26.

MADHWARJ M.S., SATHISH H.S., VIJAGENDRA RAO A.R. and MAHENDRA-PANDIAN. S. 1992. Filling of retort pouch -a simple device to obtain clean seal area. *Indian food Industry-* II. **(12):** 47-48.

MADINA, I., SACCHI, K. and AUBOURG, S. 1995. ABC NMR- Study of lipid deterioration during fish canning, effect of filling medium. *J. Sci. Food. Agric.* **69** (4): 445-450.

MAHADEVAIAH, M. 1976. Plastic containers for processed food products. *Indian food packer,* **30** (4): 35-46.

MAHADEVAIAH, M. 1984. Development of indegenious tin plates and tin free steel for processed foods. *Indian food packer,* **38**: 34-48.

MAHANDZIR. 1988. Cephalopods. *Infofish International.* 44-47.

MALLICK, A.K., SRINIVASA GOPAL, T.K., RAVISHANKAR, C.N., VIJAYAN, P.K. 2006. Polymer coated tin free steel cans for thermal processing of fish. *Fishery Technology,* Vol. **43** (1) pp: 47-58.

MEESEMAECKER and SHIER, Y. 1959. Study of the different methods of cooking sardine. *Kept. Inter. Paramet Comm. of canned foods Paris,* 34 pp.

NAIR, U.T.S., BALACERAN, K.K. and MADHAVAN, P. 1977. Canning of smoked sardine. *Fish Technol.,* **14** (1): 49-52.

NAIR, U.T.S., MADHAVAN, P., BALACHANDRAN, K.K. and **PRABHU, P.V.** 1974. Canning of oil sardine *(Sardinella longeceps)* - natural pack , *Fish. Technol.,* **11** (2): 151-155.

NAMBIAR V.N. and **IYER K.M.** 1970. Common micro flora involved in spoilage of canned prawn. *Fish. Technol.* **7**: 92- 116.

NANDAKUMARN, M., CHOUDHURI, D.R. and PILLI, V.K. 1969. Studies on blackening of canned prawns. Influence of copper and iron on product blackening. *Fish Tech.* ***6*** (1): 49-54.

NARESH, R., MAHADEVAIAH, M., GOWRAMMA, R.V. and SWAMY, B. 1989. Chromium coated steel plate as an alternative to tin plate for canning of food products. *J. Food Sci. Technol.* **17:** 283-286.

NASSER, M.M. 1980. Studies on the canning of seer fish. *Master's Thesis,* University of Agricultural Sciences, Bangalore.

OLSON, F.C.W. and STEVENS, H.P. 1939.Thermal processing in tin containers for non-acid food exhibiting straight line semi logarithmic heating curves. *Food Research,* **4**:1.

OTWELL S.W. and **HAMANN, D.D.** 1979 (B). Textural Characterization of squid (Loligo Pealie) instrumental and panal evaluation. *J. Food Sci.* **44** (6): 1636-43.

OTWELL, S.W and **HAMANN, DD.** 1979, Textural characteristics of squid (Loligo Peallie) scanning electron ariuoscopy of cooked month *J. food science*. **44** (6): 1629-35.

PANDIT, A.R. and MAGAR, N.G. 1972, Chemical composition of *Sepia orientalic* and logic fish. *Technol.* **9** (2):127-125.

PARSHWANATH, P. 1989. Effect of processing operation on the quality of canned squid (Loligo spp.). *Master's Thesis,* University of Agricultural Sciences, Bangalore.

PATASHNIK, M. 1953. A simplified procedure for thermal process evaluation. *Food Technol.* **7**:1-6.

PEDDANNA, V.C. 2005. Modified procedures for canning of shrimp and squid in masala. *Master's Thesis,* Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar.

PEROVIC, V and SAMUEL,G.E. 1978. The canning of Indian pelagic fish in a Yugoslavian canning plant. In; *Proc. I. P. F. C;* 18 (3) : 273–287.

* **PIELICHOWSKA, J. and CHRZANOWSKI, S.** 1972. Zeszyty Central nego lobratorium parzemyslu Rybegon, 20 (18) 37, FSTA, 1973, 5 (8) 32.

PIGOTT, G.M. and STANSBY, M.E. 1956. Iron sulphide discolouration of tuna cans. 4. Effect of retorting and cooling canned fish. *Com. Fishery Rev.* **18** (12): 13-16.

PRABHU, R.M. 1979. Studies on canning of smoked mackerels. *Master's Thesis,* University of Agricultural Sciences, Bangalore.

PUJAR, B.R. 1988. Some important factors influencing the rate of heat penetration and sterilization (F_0) value in canning of oil sardine (S. longiceps). *Master's Thesis,* University of Agricultural Sciences, Bangalore.

RAGHUNATH, M.R. and **SOLANKI, K.K.** 1986 A new procedure for canning of squid. *Fish Technol.* **23** (2): 199-203.

RAI B.S., SARALAYA, K.V. and **PARASHURAM, P.** 1971. Curry as a packing medium for canned fishery products, *Ind. Fd. Pack. 25* (2): 19-23.

RAI, B.S., SARALAYA, K.V. and **PARASHURAM, P.** 1975. Studies on the control of pack weight by blanching in the canning of prawns. *Mysore J. Agric. Sci.* **9** (1): 319-329.

RANAU, R., OCHLENSCLASER, J. and **STEINHART, H.** 2001. Aluminium content of stored industrially manufacture canned herring products. *Arhiv-fuer labensmittelhygiene.* **52** (6): 135-139.

RANGANATH. 1981. Canning of the gaint cat fish (*Tachysurus thalasginus*) *Master's Thesis,* University of Agricultural Science Bangalore.

RAO, C.V. and PRABHU, P.V. 1971. Heat distribution pattern in canned prawns. *Ind. Food. Packer.* **25** (4): 20-24.

RAVISHANKAR, C.N., SRINIVASGOPAL, T.K., and VIJAYAN, P.K. 2002. Studies on heat processing and storage of seer fish curry in retort pouches. *Packing technol Sci.* **15:** 3-7.

RIEMANN, H. I957. Bacteriology of canned fish. *1 and 2 Food Manual. Bull. NO.502 Rockford. Illinois.*

ROGERS JOHN, L. 1952. A course in canning-III Edn., *Food trade press Ltd. London.*

ROSALIND GEORGE, M. 1987. Studies on the effect of thermal process variation on the quality of canned Indian mackerel. *Master's Thesis,* University of Agricultural Science Bangalore.

SARALAYA K.V. and BHANDARY, M.H. 1978. **Studies on canning of fish sausage, 1. Heat penetration pattern and thermal process requirement.** *Mysore. J. Agri. Sci.* **12**: 479-484.

SARALAYA K.V. and NAGARAJ, A.S., 1978. Studies on the utilisation of shell fish's of Karnataka coast by canning. *Mysore. J. Agri. Sci.*, **12**: 484-490.

SARALAYA K.V. PARASHURAM, P. and RAI, P.S. 1975. Studies on canning of Mackerel fillets in oil. *Fish Technol,* **12** (2): 120-126.

SARALAYA, K.V. 1976. On diversification of canned fishery products of India. *Sea food Export J.* **8** (8): 9-17.

SASTRY H.M.G. 1981. Biochemical changes in cuttle fish (sepia aculeate) during iced and frozen storage *Master's Thesis* University of Agricultural Science, Bangalore.

SCOTT, G.M. 1992. The application of heat penetration model to the dynamic simulation of a hydrostatic retort. *Technical memorandum no. 657. campdes food and drink research association, chipping compdes, U.K.*

SEIDLER, T. and BRONOWISKI, M. 1987. Effect of storage time and thermal treatment on the nutritive value of squid. *(Illex argentius). Nahrung. Food,* 31 (I): 949- 957.

SEN, D.P. and REVENKAR, G.D. 1971. Use of sardine oil in oil sardine pack. *Sea food export. J.,* 3 (12): 13-17.

SHANTHAKUMAR, G. 2004. Utilization of Tilapia by canning. *Master's Thesis* University of Agricultural Science, Bangalore.

SNEDECOR, G.W., and COCHRANJ .A. 1962. Statistical methods, *Oxford and IBH. Public. Co., Calcutta.* 564p.

SONAJI, E.R., MANJU, S., RASHMY, S., GOPAL, T.K.S, RAVISHANKAR, C.N., VIJAYAN, P.K. and NAIR, T.S.U. 2001. Heat penetration characteristics of Rohu curry *In: Riverine and Reservoir fisheries of India.*

SRINIVASAGOPAL, T.K., JOSE JOSEPH., BALACHANDRAN, K.K., and GOVINDAN, T.K. 1986. Development of flexible packages for fish pickles. *Packaging India.* **27** (1); 5-8.

SRINIVASAGOPAL, T.K., VIJAYAN, P.K., BALACHANDRAN, K.K., MADHAVAN and IYER, T.G.S. 2002. Traditional kerala style fish curry in indigenous retort pouch. *Food control.* **12** (8): 523-527.

SRINIVASAN R., JAYACHANDRAN P. and PITCHAIAH, P. 1966. On canning of *Sardinella fimbriatm, S. gibbosa, S. serum* In oil pack. *Fish Technol.,* 3 (2): 118-123.

SRIVASTA, A.N., RAMAKRISHNA, A., GOPINATHAN, V.K., NATARAJU, S., LEELA, R.K., JAYARAMAN, K.S. and **SANKARAN, R.** 1993. Suitability of indigenously fabricated aluminium cans for canning of Indian foods. *J. Food Sci. Technology,* 34 (6): 429-434.

STAMMEN, K. GERDES, D., CAPORASO, F. 1990. Modified atmosphere packaging. *Crit. Rev. Food. Sci. Nutr.* **29:** 301-331.

STEPHEN, H.S., and WILEY. 1982.Comparison of general and formula Method was made for pouches processed under vertical retort. *Journal of Food science.* 47: 880-884.

STUMBO, C.R. 1953. New procedures for evaluating thermal processes for foods in cylindrical containers. *Food Technol.,* 7:309.

STUMBO, C.R. 1973. Thermobacteriology in food processing-2 Ed. *Academic Press. New York.*

STUMBO, C.R. and LONGLEY, R.E. 1966. New parameters for processes evaluation. *Food. Technol.* 20: 109.

SURESH KUMAR, M. 1984. Studies on the canning of pink perch, *Nemipterus Japonicus. Master's Thesis,* University of Agriculture Sciences, Bangalore.

SURYANARAYANAN, H., SHYLAJA KUMARI R. and ALEXANDER K.M 1973. Biochemical investigation on the edible molluscs of Kerala. II. A study on the nutritional value of some Gastropods and Cephalopods. *Fish. Technol.* 10 (2): 100-104.

TANAKA, M. and TAGUCHI, T. 1985. Non-enzymatic browning during thermal processing of canned sardine. *Bull. Japan Soc. Sci. Fish.,* 51 (7): 1169-1173.

* **TANG, M.A. MORELLO, F. and RAMASWAMY, H.S.** 1988. Food properties, heat transfer condition in retort process. NATO, ASI, Series, Kulwer Academic Publ. Dorecht.

TANIKAWA, E. 1965. Canned octopus. *Marine products in Japan*: 240-242.

TANIKAWA, E. 1971. Canned main products in Japan. *Koseisha Koseikakee Company,* Tokyo: pp;71-211.

TANIKAWA, E. and DOHA. 1965. Heat processing of shell fishes, pp: 305-335 **In:** Fish as a food IV (Ed) Borgastrom G., *Academic press, London, New York.*

TARR, H.L.R. 1961. Chemical control of microbiological deterioration. In: *Fish as Food* (I), Borgstrom, G. (Ed*), Academic Press, New York,* pp. 639-680.

TOOLEY, P.J. and LAWRIE, R.A. 1974. Effect of deep fat frying availability of lysine in fish fillets. *J. Food. Technol.* **9**: 247-253.

VARMA, P.R.G. and **JOSEPH, J.** 1980. Canning of squid. *Fish Tech.* 17 (2): 93-94.

VARMA, P.R.G., CHOUDHURI, D.R. and PILLAI, V.K. 1969. Factors controlling drained weight in canned prawn. *Fish. Technol. 6* (2): 134-139.

VENKATAPPA and DHANANJAYA, S. 2006. Studies on the ice storage characteristics of octopus, *Octopus membranaceus* (Quoy and Gaimard). *Fishery Technology,* Vol. **43** (2) pp: 154-161.

VENKATESH MURTHY, S. 1981. Factors influencing rate of heat penetration and F value in the canning of seer fish. *Master's Thesis,* University of Agriculture Sciences, Bangalore.

VIJAYAN, P.K and BALACHANDRAN, K.K. 1986. Development of canned fish curry. *Fish, Technol.* **23** (1): 57-60.

VIJAYAN, P.K. 1984. Report on training programme on retortable pouch processing of fish and fish analysis at Tropical development and research institute and Metal Box (R&D), U.K. and Central Institute of Fishery Technology (CIFT) Cochin.

VIJAYAN, P.K., SRINIVASGOPAL, T.K. and MADHAVAN, P.K. 1998. Fish curry in retort pouches. In: *Advances and priorities in Fisheries Technology.* pp: 232-235.

VINTERS, J.E., PATEL, R.H. and **HALALY, G.A.** 1975. Thermal process evaluations by progressible computer. *Food Technol.* **29** (3); 42-48.

* **ZAITSEV, V., KIZEVETTER, I., LAGNOV, L., MAKARVA, T., MINDER, L. and PODSEVALOV, V.** 1969. Fish curing and processing, MIR. Publisher Moscow. pp: 24-27.

....

* Not referred to the original

VIII. APPENDIX

APPENDIX - I

LETHAL RATE TABLE $LR = \frac{1}{\log^{-1}\left(\frac{121.1 - CT}{10}\right)}$ OR $\frac{1}{\log^{-1}\left(\frac{250 - CT}{18}\right)} = F_0$

°C	°F	LR	°C	°F	LR	°C	°F	LR	°C	°F	LR
91.1	195.98	0.0010	96.1	204.98	0.0032	101.1	213.98	0.0100	106.1	222.98	0.0315
91.2	196.16	0.0010	96.2	205.16	0.0032	101.2	214.16	0.0102	106.2	223.16	0.0323
91.3	196.34	0.0010	96.3	205.34	0.0033	101.3	214.34	0.0104	106.3	223.34	0.0330
91.4	196.52	0.0011	96.4	205.52	0.0034	101.4	214.52	0.0107	106.4	223.52	0.0338
91.5	196.70	0.0011	96.5	205.70	0.0035	101.5	214.70	0.0109	106.5	223.70	0.0346
91.6	196.88	0.0011	96.6	205.88	0.0035	101.6	214.88	0.0112	106.6	223.88	0.0354
91.7	197.06	0.0011	96.7	206.06	0.0036	101.7	215.06	0.0115	106.7	224.06	0.0362
91.8	197.24	0.0012	96.8	206.24	0.0037	101.8	215.24	0.0117	106.8	224.24	0.0371
91.9	197.42	0.0012	96.9	206.42	0.0038	101.9	215.42	0.0120	106.9	224.42	0.0379
92.0	197.60	0.0012	97.0	206.60	0.0039	102.0	215.60	0.0123	107.0	224.60	0.0388
92.1	197.78	0.0013	97.1	206.78	0.0040	102.1	215.78	0.0126	107.1	224.78	0.0397
92.2	197.96	0.0013	97.2	206.96	0.0041	102.2	215.96	0.0129	107.2	224.96	0.0407
92.3	198.14	0.0013	97.3	207.14	0.0042	102.3	216.14	0.0131	107.3	225.14	0.0416
92.4	198.32	0.0013	97.4	207.32	0.0043	102.4	216.32	0.0135	107.4	225.32	0.0425
92.5	198.50	0.0014	97.5	207.50	0.0044	102.5	216.50	0.0138	107.5	225.50	0.0435
92.6	198.68	0.0014	97.6	207.68	0.0045	102.6	216.68	0.0141	107.6	225.68	0.0446
92.7	198.86	0.0014	97.7	207.86	0.0046	102.7	216.86	0.0144	107.7	225.86	0.0456
92.8	199.04	0.0015	97.8	208.04	0.0047	102.8	217.04	0.0148	107.8	226.04	0.0467
92.9	199.22	0.0015	97.9	208.22	0.0048	102.9	217.22	0.0151	107.9	226.22	0.0477
93.0	199.40	0.0015	98.0	208.40	0.0049	103.0	217.40	0.0154	108.0	226.40	0.0489
93.1	199.58	0.0016	98.1	208.58	0.0050	103.1	217.58	0.0155	108.1	226.58	0.0500
93.2	199.76	0.0016	98.2	208.76	0.0051	103.2	217.76	0.0162	108.2	226.76	0.0512
93.3	199.94	0.0017	98.3	208.94	0.0052	103.3	217.94	0.0166	108.3	226.94	0.0523
93.4	200.12	0.0017	98.4	209.12	0.0054	103.4	218.12	0.0169	108.4	227.12	0.0536
93.5	200.30	0.0017	98.5	209.30	0.0055	103.5	218.30	0.0173	108.5	227.30	0.0548
93.6	200.48	0.0018	98.6	209.48	0.0056	103.6	218.48	0.0177	108.6	227.48	0.0561
93.7	200.66	0.0018	98.7	209.66	0.0057	103.7	218.66	0.0182	108.7	227.66	0.0574
93.8	200.84	0.0019	98.8	209.84	0.0059	103.8	218.84	0.0186	108.8	227.84	0.0587
93.9	201.02	0.0019	98.9	210.02	0.0060	103.9	219.02	0.0190	108.9	228.02	0.0601
94.0	201.20	0.0019	99.0	210.20	0.0062	104.0	219.20	0.0194	109.0	228.20	0.0615
94.1	201.38	0.0020	99.1	210.38	0.0063	104.1	219.38	0.0199	109.1	228.38	0.0629
94.2	201.56	0.0020	99.2	210.56	0.0064	104.2	219.56	0.0204	109.2	228.56	0.0644
94.3	201.74	0.0021	99.3	210.74	0.0066	104.3	219.74	0.0208	109.3	228.74	0.0659
94.4	201.92	0.0021	99.4	210.92	0.0067	104.4	219.92	0.0213	109.4	228.92	0.0674
94.5	202.10	0.0022	99.5	211.10	0.0069	104.5	220.10	0.0218	109.5	229.10	0.0690
94.6	202.28	0.0022	99.6	211.28	0.0071	104.6	220.28	0.0223	109.6	229.28	0.0706
94.7	202.46	0.0023	99.7	211.46	0.0072	104.7	220.46	0.0229	109.7	229.46	0.0723
94.8	202.64	0.0023	99.8	211.64	0.0074	104.8	220.64	0.0234	109.8	229.64	0.0739
94.9	202.82	0.0024	99.9	211.82	0.0076	104.9	220.82	0.0239	109.9	229.82	0.0757
95.0	203.00	0.0024	100.0	212.00	0.0077	105.0	221.00	0.0245	110.0	230.00	0.0774
95.1	203.18	0.0025	100.1	212.18	0.0079	105.1	221.18	0.0251	110.1	230.18	0.0792
95.2	203.36	0.0026	100.2	212.36	0.0081	105.2	221.36	0.0256	110.2	230.36	0.0811
95.3	203.54	0.0026	100.3	212.54	0.0083	105.3	221.54	0.0262	110.3	230.54	0.0830
95.4	203.72	0.0027	100.4	212.72	0.0085	105.4	221.72	0.0268	110.4	230.72	0.0849
95.5	203.90	0.0027	100.5	212.90	0.0087	105.5	221.90	0.0275	110.5	230.90	0.0869
95.6	204.08	0.0028	100.6	213.08	0.0089	105.6	222.08	0.0281	110.6	231.08	0.0889
95.7	204.26	0.0029	100.7	213.26	0.0091	105.7	222.26	0.0288	110.7	231.26	0.0910
95.8	204.44	0.0029	100.8	213.44	0.0093	105.8	222.44	0.0294	110.8	231.44	0.0931
95.9	204.62	0.0030	100.9	213.62	0.0095	105.9	222.62	0.0301	110.9	231.62	0.0953
96.0	204.80	0.0031	101.0	213.80	0.0097	106.0	222.80	0.0308	111.0	231.80	0.0975

°C	°F	LR	°C	°F	LR	°C	°F	LR
111.1	231.98	0.0998	116.1	240.98	0.3154	121.1	249.98	0.9974
111.2	232.16	0.1021	116.2	241.16	0.3228	121.2	250.16	1.0207
111.3	232.34	0.1044	116.3	241.34	0.3304	121.3	250.34	1.0446
111.4	232.52	0.1068	116.4	241.52	0.3380	121.4	250.52	1.0688
111.5	232.70	0.1094	116.5	241.70	0.3459	121.5	250.70	1.0934
111.6	232.88	0.1119	116.6	241.88	0.3539	121.6	250.88	1.1192
111.7	233.06	0.1145	116.7	242.06	0.3622	121.7	251.06	1.1452
111.8	233.24	0.1172	116.8	242.24	0.3706	121.8	251.24	1.1719
111.9	233.42	0.1199	116.9	242.42	0.3792	121.9	251.42	1.1992
112.0	233.60	0.1227	117.0	242.60	0.3881	122.0	251.60	1.2271
112.1	233.78	0.1256	117.1	242.78	0.3971	122.1	251.78	1.2561
112.2	233.96	0.1285	117.2	242.96	0.4063	122.2	251.96	1.2850
112.3	234.14	0.1315	117.3	243.14	0.4158	122.3	252.14	1.3149
112.4	234.32	0.1346	117.4	243.32	0.4255	122.4	252.32	1.3455
112.5	234.50	0.1377	117.5	243.50	0.4354	122.5	252.50	1.3769
112.6	234.68	0.1409	117.6	243.68	0.4455	122.6	252.68	1.4089
112.7	234.86	0.1442	117.7	243.86	0.4559	122.7	252.86	1.4418
112.8	235.04	0.1475	117.8	244.04	0.4665	122.8	253.04	1.4753
112.9	235.22	0.1570	117.9	244.22	0.4774	122.9	253.22	1.5097
113.0	235.40	0.1545	118.0	244.40	0.4885	123.0	253.40	1.5449
113.1	235.58	0.1581	118.1	244.58	0.5000	123.1	253.58	1.5808
113.2	235.76	0.1618	118.2	244.76	0.5116	123.2	253.76	1.6170
113.3	235.94	0.1655	118.3	244.94	0.5235	123.3	253.94	1.6553
113.4	236.12	0.1694	118.4	245.12	0.5357	123.4	254.12	1.6938
113.5	236.30	0.1733	118.5	245.30	0.5481	123.5	254.30	1.7354
113.6	236.48	0.1774	118.6	245.48	0.5609	123.6	254.48	1.7737
113.7	236.66	0.1815	118.7	245.66	0.5740	123.7	254.56	1.8151
113.8	236.84	0.1857	118.8	245.84	0.5873	123.8	254.84	1.8573
113.9	237.02	0.1901	118.9	246.02	0.6010	123.9	255.02	1.9006
114.0	237.20	0.1945	119.0	246.20	0.6150	124.0	255.20	1.9449
114.1	237.38	0.1990	119.1	246.38	0.6293	124.1	255.38	1.9902
114.2	237.56	0.2037	119.2	246.56	0.6440	124.2	255.56	2.0365
114.3	237.74	0.2084	119.3	246.74	0.6590	124.3	255.74	2.0840
114.4	237.92	0.2133	119.4	246.92	0.6744	124.4	255.92	2.1325
114.5	238.10	0.2182	119.5	247.10	0.6901	124.5	256.10	2.1822
114.6	238.28	0.2233	119.6	247.28	0.7061	124.6	256.28	2.2330
114.7	238.46	0.2285	119.7	247.46	0.7226	124.7	256.46	2.2850
114.8	238.64	0.2338	119.8	247.64	0.7394	124.8	256.64	2.3382
114.9	238.82	0.2393	119.9	247.82	0.7566	124.9	256.82	2.3927
115.0	239.00	0.2448	120.0	248.00	0.7742	125.0	257.00	2.4484
115.1	239.18	0.2505	120.1	248.18	0.7923	125.1	257.18	2.5054
115.2	239.36	0.2564	120.2	248.36	0.8108	125.2	257.36	2.5638
115.3	239.54	0.2624	120.3	248.54	0.8296	125.3	257.54	2.6285
115.4	239.72	0.2685	120.4	248.72	0.8490	125.4	257.72	2.6847
115.5	239.90	0.2747	120.5	248.90	0.8687	125.5	257.90	2.7472
115.6	240.08	0.2811	120.6	249.08	0.8890	125.6	258.08	2.8112
115.7	240.26	0.2877	120.7	249.26	0.9097	125.7	258.26	2.8767
115.8	240.44	0.2944	120.8	249.44	0.9309	125.8	258.44	2.9437
115.9	240.62	0.3012	120.9	249.62	0.9525	125.9	258.62	3.0122
116.0	240.80	0.3082	121.0	249.80	0.9747	126.0	258.80	3.0824

Appendix - II

Quality evaluation of canned Octopus

Can size: 301 x 203 Date:

Instructions: Place examine the samples of canned mackerel carefully. Judge each of the quality characteristics independently. Give scores to each according to the following scale.

Grade	Equivalent score
Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike verymuch	2
Dislike extremely	1

Note: Please do give your comments/remarks on specific differences you perceive among the products

Sample characteristic	1	2	3	4
Appearance				
Texture				
Flavour				
Overall liking				

Comparative remarks:

Name of the judge Signature

"Thank You"