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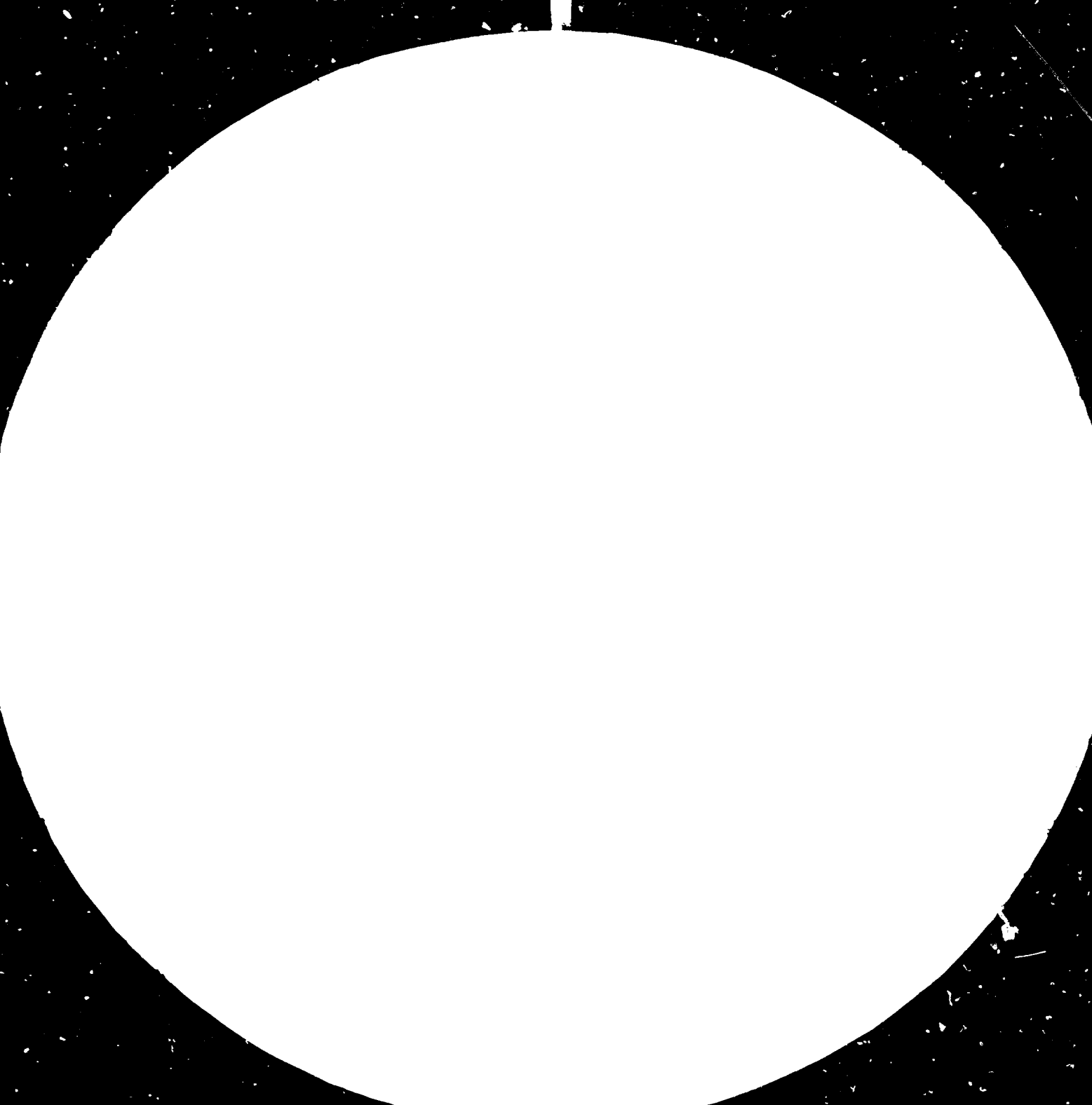
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RESEARCH AND DEVELOPMENT IN FOOD PROCESSING
AND PACKAGING TECHNOLOGY

DP/MEX/82/010

MEXICO

Technical report*- Fish Products Shelf-Life

Prepared for the Government of Mexico
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of Nelson Beraquet,
expert in shelf-life (fish products)

586

United Nations Industrial Development Organization
Vienna

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C O N T E N T S

	<u>Page</u>
A. SUMMARY	3
B. JOB DESCRIPTION AND BACKGROUND INFORMATION	4
C. INTRODUCTION	7
D. ACTIVITIES DURING THE MISSION	10
D.1. Appraising LANFI Facilities' Potential for Fish Studies	10
D.2. Training LANFI Staff	11
D.3. Lectures to the LANFI Staff	13
D.4. Fish Handling at Mexico City Viga Fresh Fish Market	36
D.5. Investigation of Fish Processing Factories	39
E. RECOMMENDATIONS	46
E.1. Research in Fish Handling and Processing	46
E.2. Expanding the Food Processing Pilot Plant to Study Fish	50
E.3. Extension Work	51
E.4. Further Technical Assistance and Training	52

ANNEXES

1	Contacts Made
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A. SUMMARY

This report concerns the mission on fish products shelf-life carried out between 21 November and 20 December, 1982 by UNIDO consultant Nelson J. Beraquet at the Sub-Direction of Food and Packaging Technology of the Laboratorios Nacionales de Fomento Industrial (LANFI) in Mexico.

The consultant worked mainly with members of the Section of Systems for Food Preservation, training them for research work on fish handling and processing. In this connection lectures, practical work and visits to fish markets, fishmongers, freezing and canning industries were carried out. With staff participation, the technological and sanitary conditions of establishments visited were assessed and recommendations issued.

The consultant also presented two conferences at the Instituto Tecnológico de Veracruz, Veracruz on "Handling of Fresh Fish" and "Aspects of Quality of Fishery Products related to Shelf-Life".

B. JOB DESCRIPTION AND BACKGROUND INFORMATION

JOB DESCRIPTION

DP/MEX/82/010/11-06/A/31.7.E

Post title	Expert on shelf-life (fish products)
Duration	1 month
Date required	November 1982
Duty station	Mexico City, with travel as required

Purpose of the Project

The purpose of the project is to collaborate with the Mexican Government programs, by participating with technical support in the areas of food processing and packaging technology. Some of the objectives of this project are: to develop the maximum advantages of food resources, to make process criterion homogeneous, to diffuse the use of packaging technology, to participate in the elaboration of new standards and in industrial training in the areas of food and packaging.

Duties

The expert will be assigned to the National Laboratories for Industrial Development - LANFI and will be expected to:

1. Visit to a series of fish industries in order to detect the main problems and needs.
2. Meeting with Fisheries Department and "CONACYT" (Science and Technology National Council) to discuss the main fisheries programmes in Mexico.
3. Training of LANFI staff through lectures and practical work on basic facts of fish and fish products related to its shelf-life.
4. Make an appraisal of LANFI facilities as well as programmes of work and prepare recommendations for:
 - 4.1 Equipment and apparatus for establishing at LANFI a pilot plant and laboratory for fish technology.
 - 4.2 Research topics concerning industry problems and needs.

5. Participate in a Seminar oriented to the fish and packaging industry, together with LANFI personnel and Mexican industries.

The expert will be expected to prepare a final report stating the results of his mission and his recommendations to the Government.

BACKGROUND INFORMATION

In April 1981 the Mexican Institute for Assistance to Industry (IMAI) and its personnel, equipment and budget were integrated to the National Laboratories for Industrial Development (Laboratorios Nacionales de Fomento Industrial - LANFI -) as a move for a more efficient public sector.

LANFI is a public decentralized organism dedicated to research and development in the areas of packaging, food and chemical products.

Because of the Mexican Government needs and LANFI structure, the IMAI Consolidation Project is continuing concentrating its activities in two main areas: food processing and packaging.

In the area of food processing LANFI has already set up a well-equipped Section of Food Quality Control and a Section of Systems of Food Preservation that is geared to food shelf-life studies. Presently a pilot plant of food unit operations that comprises two sections is being established - Section of Research and Development and Section of Food Processing and Packaging.

A large part of Mexico's population suffers from protein malnutrition and obviously the best use of any available protein source should be made, especially of high quality animal protein such as fish. Mexico has a large fishing fleet and a high volume catch (1,200,000 tons) and prevention of waste and better utilization of the catch for human consumption should be a major concern.

LANFI under the Subdirection of Food and Packaging Technology has well-equipped laboratories for food analysis, processing and packaging studies and design; and, although there are in the country a number of Institutions specifically involved in fish research, could take advantage of its facilities to form a group with knowledge to develop research on topics in fish handling and processing, particularly on fish handling. This has been recognized only recently. The "Gerente del Sistema Integrado de Abastos de la Coordinación de Proyectos de Desarrollo de la Presidencia de la República" (Manager of the Integrated Systems of Supplies of the Coordination of Development Projects for the Presidency of the Republic) required LANFI to develop a project with the aim of rationalizing the use of packs and systems of distribution for chilled fish and shellfish.

Thus making use of the experience of the expert on getting a fish pilot plant established at the Instituto de Tecnología de Alimentos (ITAL) (Institute of Food Technology), in Sao Paulo, Brazil, it was felt that the core of the consultancy should be the training of LANFI staff on the fundamentals of fish science and technology, while looking for relevant research topics and making a general appraisal of fish handling and processing in Mexico.

C. INTRODUCTION

1. The fish catch*

The Mexican catch in 1980 was 1,257,148 of which only 16,159 tons (1,2%) were from fresh water. In 1979 Mexico ranked nineteenth in the world list of nations in terms of total catch and the third in Latin America. Most of the fleet used for the marine catch is composed of boats with less than 10 tons of storage capacity.

A large number of different species are caught and a summary of the main types of fish from fresh water and from the marine catch, in 1980, by volume and value are given below.

Fresh water fish	volume (t)	Value (in 1000 pesos) **
Mojarra (<u>engerres</u> esp.)	17,997	455,354
Carpa (<u>Cyprinus</u> <u>Carpio</u>)	4,346	54,835
Charal	1,810	54,610
Marine fish		
Anchoveta Ind. (<u>Anchoa</u> <u>ischana</u>)	257,444	283,517
Sardina (<u>Sardinella</u> spe. <u>Sardinops</u> <u>sogax</u>)	100673	203,543
Sardina Ind. II	167,007	183,709
Atun (<u>Euthynnus</u> spe. <u>Thunnus</u> <u>albacares</u>)	20,417	570,787
Barrilete (<u>Euthynnus</u> <u>pelamis</u>)	13,263	304,123
Tiburón (<u>Seveval</u> <u>Familia</u>)	12,815	224,457
Cazon (<u>Seveval</u> <u>Familia</u>)	10,969	244,516
Bacalao (<u>Rachyantron</u> <u>canadus</u>)	9,490	569,299
Huacuinango (<u>Lutjanus</u> <u>campechanus</u>)	4,699	283,522
Mero (<u>Alphestes</u> <u>fasuatus</u>)	9,928	359,159

* All statistical data were taken from: Anuario Estadístico 1980. Departamento de Pesca - Dirección General de Planeación, Informática y estadística - México 1981
 ** 1000 pesos = US\$ 25 in 1980.

Fresh water fish	volume (t)	Value (in 1000 pesos) **
<u>Sierra (Scomberomorus maculatus)</u>	9,050	275,946
Crustacea		
Shrimp	51,726	7,141,188
Lobster	2,263	260,239
Squid	23,479	411,808
Ostion	41,021	345,796
Octopus	6,509	231,401

** 1000 pesos = US\$ 25 in 1980.

2. Disposition of the catch and processing

Process	Volume (t)	Net weight (t)
<u>Canning</u>	<u>138,993</u>	66,366
Tuna	30,979	14,524
Sardines and mackerels	95,102	45,199
Other	12,912	
<u>Freezing</u>	<u>122,755</u>	90,519
Shrimp	44,169	39,551
Squid	18,685	15,341
Other	59,901	
<u>Fish meal</u>	<u>586,096</u>	
Anchoveta	322,179	
Sardines	208,758	
Other	55,159	

Most of the catch, comprising sardines and anchovetas, is used for fish meal manufacture. Canning and Freezing use similar volumes of fish, although of course the value of the frozen products are much larger. Sardines and mackerels account for 68% of all

fish canned while tuna accounts for 22%. Shrimp is the more valuable and more voluminous of the frozen fish accounting for 36% of all frozen fish.

3. Catch trends

Tuna is about to have overriding importance in Mexican fisheries. The country is building one of the world's largest and most modern tuna fleets. This may mean an incredible challenge to overcome the demand for expanded unloading, storage, canning and freezing facilities. This at a time when Japan and France are reducing their tuna fleet, and demand for tuna is decreasing due to over-supply.

D. ACTIVITIES DURING THE MISSION

D.1. Appraising LANFI facilities' potential for fish studies

The food part under the Sub-director of Food and Packaging Technology is organized as shown below.

SUBDIRECTOR

<u>FOOD DEPARTMENT</u>		<u>FOOD TECHNOLOGY DEPARTMENT</u>	
Section of Food Quality Control	Section of Systems for Food Preservation	Section of Research and development	Section of Processing and Packaging of Food

The Food Department is concerned with general analyses of food as requested by government and private industries as well as with studies of processed foods' shelf-life and interactions between food and package. The Food Technology Department is mainly concerned with carrying out process development studies.

The Section of Food Quality Control is equipped with plenty of modern instruments (spectrofotometer, fluorimeter, gas chromatographs, amino acid analyser, automatic Kjeldhal, Soxhlet etc.) and can certainly carry out routine chemical and biochemical analysis of fish and any specific determination demanded by research.

The Section of Systems for Food Preservation is also adequately instrumented to develop research on fish products shelf-life making use of its equipment for package testing and storage chambers with climatic control.

The Sections of Research and Development and Processing and Packaging of Food are presently being settled but the equipment already available (retorts for can and pouch processing, seaming

machines, exhaustors, plastic sealing machines, etc.) indicates their general capability, as far as equipment and instruments are concerned, to develop studies on fish processing. Additional equipment particularly necessary for fish processing research will be listed at the end of the report.

There is some obvious overlapping of functions and activities among the different sections but the relations between them are good and joint work is possible. Thus the conclusion is that with the acquisition of a number of specific equipment coupled with staff training LANFI will be prepared to tackle research in fish technology.

D.2 Training LANFI staff

A fish working group was drawn from both departments referred to in the previous section, with the majority of the group belonging to the Section of Systems for Food Preservation. Although all participants had very little experience and knowledge in fish science and technology all of them had academic background in food science and technology which of course facilitated learning. With this background and considering the extension of the consultancy, a rapid short-term training in fish technology was designed with the aim of generating within the group enough fundamental knowledge, so that they can progress by themselves and be prepared to work on specific topics in any further consultancy.

The approach to achieve this was based on involving the group in intense fish related activities through a series of lectures on basic aspects of fish chemistry and processing in conjunction with some practical work and visits to fish markets, fishmongers, industries and ports. During lectures, questioning and discussion was encouraged and after each visit a round table was organized to discuss the observations made.

In the next section an outline of the aspects emphasized during the lectures is given; it must be pointed out that in these lectures stress was put on factors related to fish and fish products shelf-life, which should be one of the topics of major concern for LANFI.

D.3 LECTURES TO THE LANFI STAFF

1. INFLUENCE OF FISH ON HUMAN NUTRITION

Initially the need was stressed to regulate fishing efforts due to the dangers of overfishing extinguishing commercial species as almost happened with the herring of the North Sea and the shrimp of Sao Paulo, Brazil.

In spite of these risks, for a country open to the sea and in need of high quality protein the great advantage of fish is its immediate availability. World catch disposition up to 1978 has shown that most of the fish directed to human consumption is eaten fresh with the consequence that in this case, it will only be available in good condition to coastal communities unless proper handling and distribution chains are introduced. As most of the fish catch is used for animal feeding (as it happens in Mexico) research efforts are required to use the species concerned for direct human consumption.

It is also necessary to expand the number of species used as human food because a large part of the marine resources used as food are teleosteans. Procedures to increase participation of fish in the human diet would include: regulation of the catching to prevent overfishing of the presently most abundant species; improvements in fishing technology so that boats return to shore with their holds full; expansion of the number of species utilized using technical means as that provided by deboning machines; aquaculture.

It was shown that fish is a primary source of animal proteins to most of the world's population and that some of the factors controlling the use of fish are: ease with which spoilage changes can be controlled; ability to process fish in an economical way; efficient distribution network sales promotion and study of consumer food habits, to overcome taboos.

2. BASIC NOTIONS ABOUT FISH

Oceans are extremely dilute media with fertile regions having ten thousand less nitrogen than fertile land, so it cannot be considered an inexhaustible food source. Only 0.1% of the ocean's surface responds for more than 50% of the world's total fish catch; these represent areas of upwelling. Still 80-90% of total marine catch is in coastal areas in the continental shelves.

Fish are muscle foods but several factors demand separate studies from meat:

- a. The very large number of species eaten.
- b. Intrinsic factors like sex, season, condition and locality of catch determine its inherent quality on landing.
- c. The susceptibility of its protein to undergo denaturation when heated, frozen or dehydrated.
- d. Its difference in composition in relation to the relative amounts of connective tissue, sarcoplasmic and myofibrillar proteins compared with meat, partly account for fish being so perishable.

Fish digest food by muscular contractions of the stomach walls and by a battery of powerful enzymes in the digestive tract. If by mishandling the viscera (heart, kidneys, liver, stomach) break down, the enzymes will come into contact with the muscle tissue and will digest it.

The liver is important because it stores energy compounds such as glycogen and fat and also immobilizes toxins such as heavy metals.

The muscular system is arranged in blocks of fibres constituted mainly of the protein actomyosin. The blocks and individual fibres are separated by sheets of connective tissue that are very

fragile and break easily under mechanical stress and elevated ambient temperatures, particularly under rough handling when the fish is in rigor mortis.

When fish dies the enzymatic control is broken and several changes occur, rigor mortis being the one with great influence on post mortem quality. The longer the fish takes to enter rigor and remain in it the longer it will keep, for during rigor bacterial growth is slowed down, probably due to the low pH brought about by the formation of acid lactic. Rigor is influenced by species (chemical composition), condition, degree of exhaustion, size of the fish, handling and temperature of storage.

The fisherman and processor can extend fish shelf-life by using adequate methods of catch and by keeping the fish at ice temperatures. Careful handling is also necessary to prevent belly burst and muscle breakage.

3. CHEMICAL COMPOSITION OF FISH FLESH

Knowledge of the weight composition of the different parts of fish e.g. the percentage of head, viscera, skin, flesh, etc. is of importance in an industrial situation to predict yield and amount residues.

The chemical composition of fish flesh varies with age, sex, season, sexual maturity, migration and principally with the quantity and quality of the food available to the fish at the time of catch. Thus any composition table can only serve as a guide.

Water is the main component of fish muscle representing 70-80% of its weight. Crustacea also have around 90% water while molluscs tend to be higher, up to 90% as in oysters. In industrial processes most of the weight loss is represented by water - thaw drip losses of frozen fillets can exceed 15% - so it is important to the economy of the processes to know factors controlling water losses.

Protein in fish is fairly constant between 15-20% with values under 15% or above 25% being rare. Myosin, actin and tropomyosin account for over 50% of total protein, albumin representing 20%. Fish have low collagen content around 2-4% in bony fish up to 10% in cartilaginous fish (sharks and rays). Fish proteins are particularly rich in lysine and methionine which recommends its use to supplement cereal proteins.

The proportion of non-protein nitrogen compounds (NPN) in muscle varies with the different species: teleosteans from 0.3 to 0.6%; cartilaginous with 1.5 - 2.2%. NPN also varies with age, sex, condition, increasing during spawning.

NPN are of special significance for fish as they are responsible specifically for odour, flavour and taste. They are also more liable to the action of bacteria than proteins, their nature and content being directly related to the shelf-life of iced fish. The high perishability of fish is partly accounted to its higher content of NPN than other muscle foods.

The NPN compounds in fish are:

- a. Nitrogenous bases represented by the volatile bases ammonia and mono-, di-, and trimethylamine (TMA), occurring due to the action of bacteria.
- b. Trimethylammonium bases as trimethylamine oxide and choline, precursors to the formation of TMA.
- c. Free aminoacids.
- d. Acid amides represented by urea relevant to cartilaginous fish.
- e. Purine derivatives such as hypoxanthine, xanthine, adenine and guanine used as spoilage indices in the early stages of deterioration.
- f. Imidazole derivatives such as histidine that through the action of bacteria gives histamine a toxic substance.

Fat content is extremely variable in fatty fish the ratio between the higher and smaller fat content being 300 to 1. Fatty fish have most of its fat as triglycerides distributed mainly in the muscle whereas lean fish has more polar lipids (phospholipids) and most of its fat is stored in the liver. Fish fatty acids are

highly unsaturated and prone to oxidation, with the consequence that in fatty fish rancidity is the first signal of spoilage. This is a very important factor in processing and storage, because several of the products of oxidation like peroxide, aldehydes, ketones and fatty acids of low molecular weight are toxic.

Carbohydrates are of no dietary importance in fish being less than 1% in lean fish, reaching values of 2% in fatty species.

4. HANDLING OF FRESH FISH

Spoilage of fish during storage at temperatures above freezing may result from natural developments following death:

1) Bacterial decomposition; 2) autolytic enzyme action, either from tissue or digestive enzymes, leading to softening of the flesh and torn bellies; 3) oxidation of lipid material, resulting in rancidity. Spoilage can also be introduced by mishandling (bruising, contaminated shovels, etc.). The method of fishing can influence the quality of fish when harvested: fish caught in long lines and gill nets may be damaged by attacks from other fish or from struggling against the nets.

Once the fish is brought aboard the following procedures should be adopted.

Prior to icing the fish should be washed to remove blood, mud, and intestinal contents that might have been expelled from torn fish. Washing can be done manually with a hose or by use of washing machines.

Large fish should have its throat cut to cause bleeding resulting in a fish with lighter coloured flesh and in the removal of heme compounds that are prooxidants.

Gutting serves two purposes:

- a. removes the portion of the fish which is most heavily contaminated with microorganisms,
- b. Stops the action of the enzymes of the digestive system that would be involved in self-digestion.

Icing should be carried out as quick as possible since the most important factor controlling spoilage is storage temperature.

Temperature regulates the onset and resolution of rigor: the lower the temperature the fish is kept at, the longer rigor will last extending the lag period and growth rate of spoilage microorganisms. The amount of ice required will depend on the season, length of trip, size of catch and insulation of the boat.

Fish in all stages of transportation should be in intimate contact with finely crushed ice to be maintained as closely as possible to 0°C. Piles of ice in fish-holds should not have more than 1,2 m high and boxes should not be more than 50 cm deep.

The main advantage of filleting is the reduction of weight for distribution through the removal of 50-70% of inedible material. Filleting should be carried out after rigor mortis and on top of easily washable surfaces like hard plastic. Knives should be frequently dipped in detergent and sterilizing solutions. As with whole and gutted fish, fillets should be kept iced or under refrigeration.

5. SALTING OF FISH

Salt preserves fish by lowering its water activity (A_w). The ion Cl^- has also bactericidal effects and interferes in the proteolytic activity of enzymes. At high concentrations sodium chloride causes precipitation of proteins. A lower pH increases the bactericidal and bacteriostatic effects of salt.

Spoilage of salted fish is related to the binomial salt concentration and water content. Thus, very often, salting is followed by drying. There are two main types of curing. Dry salting is carried out by burying split fish in salt and allowing the brine liquor to escape. Pickle curing, in which fish is salted in a strong pickle formed in the body fluids, is used for fatty fish.

The following are the main factors controlling rate of salt uptake: muscle fat content; size of the fish or portions; ratio of salt to fish or concentration of the brine; salt impurities.

The presence in curing salts of calcium and magnesium sulphates and chlorides above 1,5% retards salt penetration, increases moisture absorption and confers bitter taste to the product, all factors reducing shelf-life. However in concentrations between 0,5-1% these impurities improve texture and appearance. Traces of copper and iron in the salt cause browning in the salted fish.

Salt is also the source of halotolerant bacteria causing pink spots in the end product producing off and putrid odours. Flesh becomes muddy brown and soft. These changes can be prevented by using old salt (3-5 years old) or salt that has been sterilized ($80^\circ C$ - 30 minutes). Fish with 10% or less of salt is not attacked by these bacteria.

A mould, picked from solar salts or storage yards, Sporendonema epizoun, can attack salt fish covering its surface with black, brown spots. It does not attack the flesh only affecting the product appearance. This so called "dun" spoilage can be prevented by dipping the fish in a 0,1% solution of sorbic acid.

Shelf-life of salted fish can be extended by proper control of salt and moisture content and use of packaging that minimizes the influence of storage conditions (relative humidity and temperature).

6. FISH SMOKING

Wood smoke is an aerosol in which vapours are a continuous phase and tarry droplets are the dispersed phase. It is mainly the vapours that are taken up by the fish during smoking and are responsible for the pleasant taste of smoked fish. Tarry droplets are not essential and can impart bitter tastes. The more moist the fish the more rapidly chemicals from the vapours are absorbed. Fish can also be smoked by being dipped into a solution of smoke chemicals distilled from wood but the fish still has to be dried.

Smoke is composed of a great number of substances which include acids like formic and acetic; phenols like cresols and syringols; carbonyls such as formaldehyde and acetaldehyde; alcohols such as ethanol and methanol and hydrocarbons like benzopyrene and naphthalene. To the acids and phenols is attributed the bacteriostatic and bactericidal action of smoke while mainly phenols would be responsible for the antioxidative properties of wood smoke.

Smoke composition and absorption is influenced by:

- a. Type of wood - hardwoods are considered to be superior to softwoods that generate excessive amounts of soot and impart resinous flavours to the food;
- b. Moisture content of wood - influences smoke generation temperature - 20-40% moisture is recommended.
- c. Combustion temperature - in the range 200-600°C the production of carbonils is increased; in the temperature range 400-600°C phenols are increased and polycyclic aromatic hydrocarbons increasing in the range 400°C - 1000°C. As some of these last compounds are cancerigens whenever possible combustion temperatures should be maintained below 400°C.

- d. Air flow - is essential to keep wood smouldering; influences the rate of surface dehydration and thus smoke absorption; an increase in air flow increases the release of vapours from the dispersed phase.

Smoking of fish generally follows the steps below.

- (i) Splitting and cleaning - care taken not to bruise or tear the fish; all pieces of gut, grill and kidneys must be removed otherwise will spoil the fish.
- (ii) Salting - A 70-80% brine is commonly used. If a 100% brine is used salt crystals will deposit on the surface of the finished product; with a 50% brine the fish swells.
- (iii) Smoking - Two main types of processes are used: 1) in cold smoking the temperature of smoke shall not exceed 30°C; 2) in hot smoking the smoke may reach 121°C and the product temperature may rise to 85°C. Length and temperature of smoking depends on the type of product aimed at.

Smoking kilns may be traditional chimney in which the fish are hung over a fire or mechanical. Mechanical kilns, with temperature and humidity controls in conjunction with separated smoke generators, permit more control, more uniform and cleaner product with less waste and less labour.

Smoked fish shelf-life is connected with the product's salt content, length of smoking, packaging and storage temperature.

7. FISH CANNING

Canning is the preservation of perishable foods through heating in hermetic containers. Heat inactivates intrinsic enzymes and microorganisms and if reinfection does not occur the product should last indefinitely.

"Commercial sterilization" is designed to kill substantially all microorganisms and spores which, if present, would be capable of growth under defined conditions of packaging and storage post process.

Canning is one of the most expensive ways of preserving fish but due to characteristics such as durability, ease of storage and preparation, and the large variety of products it appeals to many consumer groups.

A general technique to can fish includes the steps given below:

- a. Nobbing: removal of head and viscera can be done either by machines or manually. The nobbing machines are adjusted to cut the fish to suit the size of cans used.
- b. Brining: Apart from improving flavour, this operation removes blood stains and confers firmness to the skin. Breakage of skin in unbrined fish is 50% greater than in brined ones. It also prevents the skin from adhering to the can. For sardines, brining in 24-25° B_e brine for 15-45 minutes (size and fat content of the fish) is the normal practice.
- c. Pre-cooking: This operation fulfils the purposes of: removing the fluid that might otherwise cook out during the heat process; releasing excessive quantities of oil that might cause off-flavours, or other off-flavour volatiles; permit-

ting shrinkage to occur on skeleton before final trimming and filling into the can. Precooking can be carried out in a batch operation in autoclaves or in a continuous cooker that has two sections, the first for pre-cooking in steam at about 95°C and a second for drying in steam and hot air at 130°C.

- d. Filling - Normally carried out by hand; fish should not be packed too tightly to allow for expansion of contents during sterilization nor too loose that the fish may move about during handling and break.
- e. Filling with sauce and oil and seaming - Generally made with seaming machines which have units for coding lids, filling and seaming. It is essential that neither flesh nor liquid be entrained during the sealing. Seaming requires close control.
- f. Sterilization - Tables of recommended process times and temperatures for most products in standard containers are available. Deviation from a precisely defined pack, or development of a new product should require heat penetration and process evaluation studies.

Deterioration of canned fish can be of microbiological or chemical nature. In both cases the result is production of off-flavours and swelling of the can. Volatile sulphur compounds may attack tin or iron in the can with the formation of black stains. Proper lacquers containing zinc oxide or lacquers of epoxide prevent the problem. Corrosion of the can causes discoloration of content and formation of hydrogen that swells the can. When swelling does not occur the presence of discoloration and off-flavours and taste means that the raw material was spoiled.

8. FREEZING AND THAWING OF FISH

Frozen fish can be defined as fish which average temperature was reduced to -18°C . The aim of freezing is to obtain a product that can be stored for a few months keeping its original organoleptic properties. This is one of the main advantages of freezing over other processes. Landing of fish is unpredictable and stored frozen fish can serve as a means of regulating supply of raw material for other preservation techniques.

Fish muscle begins to freeze at -1°C and most of its water (85%) is frozen between -1°C - -5°C , the so called critical zone. In the recommended fast freezing processing the fish temperature should not remain in the critical zone more than 5-10 hours (depending on fish size) or bacterial development takes place and the fish on thawing exudes excessive drip. Below -10°C bacterial growth is inhibited but biochemical autolytic processes continue to take place even at -30°C . In consequence lean fish has good eating quality if stored less than: 1 month at -10°C , 4 months at -20°C and 8 months at -30°C .

Fish as other foods is frozen in air blast freezers, plate freezers (horizontal or vertical) or by immersion in refrigerant media (brines, freon, liquid nitrogen) according to product requirements.

During storage frozen fish loses inevitably its quality. Some of these changes that shorten shelf-life can be prevented. Dehydration and consequently freezer-burn and weight loss can be prevented by careful control of steady temperatures during storage. Fluctuations and high temperatures during storage causes increased protein denaturation; on thawing the fish will lose water as drip and will present an opaque, white discoloured

appearance. Dipping the fish (especially fillets) in polyphosphates solutions before freezing can help to prevent these changes.

Rancidity can be prevented by: removing fatty tissues; preventing oxygen reaching the product by proper packing; not allowing the flesh to become contaminated with copper and iron ions; not exposing the frozen fish to light; using steady low temperatures (below -18°C).

Increasing quantities of frozen fish are being used as raw material for further processing and often this involves a thawing operation therefore reliable methods of thawing have become essential to produce a raw material of first quality.

To thaw fish heat is applied to the surface of the fish by exposing it to still or moving air, by immersing it in water, or by allowing water vapour to condense on it.

Air thawing is the simplest technique. It is suitable to all kinds of products. Thawing rate will depend on the amount of natural convection, air temperature and humidity. Higher thawing rates can be achieved by blowing warm humid air over the surface of the frozen fish. Air temperature should not be higher than 18°C or the flesh of fish will soften and bacterial growth will occur with off odours and drip losses. The method is slow, labour intensive and not easily controllable.

Thawing in water may be carried out either by complete immersion of frozen fish or by spraying or by a combination of these methods. The method is not recommended for frozen fillets which tend to become leached and waterlogged. In this method the rate of heat transfer is high even with relatively low water velocities.

The water temperature should be kept below 18°C otherwise gaping will occur apart from bacterial growth. The water should be replaced once or twice daily or heavy contamination of the fish will occur.

Vapour phase - this system utilizes latent heat from the condensation of steam to thaw the fish. The process takes place under vacuum and the steam generated when heat is applied to the water in the bottom of a chamber is at low temperature, so there is no possibility of overheating.

The need to avoid cooking the fish and the slower rate of heat conduction as fish temperatures approach 0°C, impose a limit on the speed of the above thermal conduction methods of thawing. Research has conducted to electrical methods like dielectric heating and electric resistance but these methods are not generally used by the fish industry.

9. THE UTILIZATION OF FISH WASTE

Fish Meal

Fish meal is a solid product obtained by removing most of the water and some or all the oil from fish or fish waste.

An established method to process fish meal has the following steps -

- a. Grinding of fish offal or large varieties of whole fish.
- b. Cooking with live steam to coagulate the protein and to allow much of the oil and water to be released by a screw press. This operation is critical. If the fish is undercooked the liquor cannot be pressed out satisfactorily; if the fish is overcooked the material forms an emulsion that is too soft for pressing.
- c. Pressing is used (at the same time as cooking) to expel the liquid known as press liquor and to obtain a solid known as the press cake; during pressing the water content may be reduced from 70% to 50% and the oil content is also reduced.
- d. Liquor from the press is screened to remove all suspended fish solids that are returned to the press cake and then continuously centrifuged to remove oil. The water fraction known as stick water has proteins dissolved which may be discarded or concentrated to 35% solids and added back to the press cake.
- e. Drying the press cake. If the material is underdried moulds and bacteria may grow (above 10% moisture); if it is overdried the meal will be scorched and its nutritional value reduced.

Typical meals composition is - a) from fatty fish between 71% protein, 9% fat, 8% water and 12% minerals b) from white fish between 66% protein, 5% fat, 8% water and 21% minerals.

The main concern in the use of fish meal is with its protein quality, especially availability of lysine. Excessive heat treatment and oxidative rancidity may reduce lysine availability.

Fish Silage

Fish silage can be defined as a liquid product obtained by the addition of acid to whole fish or fish waste. Liquefaction occurs due to the action of proteolytic enzymes naturally present in the fish and the acid, generally formic acid, and prevents bacterial growth. Fish silage can also be prepared by adding carbohydrates to fish and preservation is achieved by the lactic acid produced by natural fermentation.

The process requires very little capital and the scale of operation can be adjusted to the amount of raw material available, making it attractive to areas where there are no fish meals or the supply of raw material is too scarce to run economically a fish meal factory.

Fish silage is made by grinding whole fish or fish waste and adding to the mixed material around 3% of 90% formic acid so that the pH of the mixture will be below 4.5. Mineral acids can be utilized but the pH has to be lowered to 2.0 and therefore neutralization of the silage is necessary to use it as a feed.

Thoroughly mixing is necessary to ensure that there are no pockets of untreated material that would be sources of bacterial contamination. For quick liquefaction environment temperature should be around 20°C.

Fish silage at the correct pH and provided it does not contain much oil developing rancidity can last up to two years. It is used for animal feed especially for pigs.

Changes affecting silage shelf-life are bacterial growth and development of free fatty acids content as a result of lipolysis, while oxidative changes cause the oil present to darken. Fish silage has been found to be as good a source of proteins for animal feeding as the traditional fish meal.

10. NEW FISH PRODUCTS

Retort pouch processing of fish products

Retort pouch technology (RPT) resulted from the availability of plastic materials resistant to thermal treatment and from the knowledge of the influence of heating on product quality and safety: products can be produced with shapes permitting milder heat treatments beneficial to texture, flavour and colour.

The usual retort pouch is a 3-ply laminated material consisting of an external film of polyester, an internal layer of polyolefin (polypropylene) that permits sealing and between the two a layer of aluminium foil serving as gas, water and light barrier.

Problems with RPT stem from the reduced strength of the seal at processing temperature, polyethylene softens at 120-130°C and polypropylene at 150°C, and the tendency of the material to puncture. Other problems may be the migration of food material between the inner layer and the aluminium foil, causing delamination. The integrity of the seal can be maintained using over-pressure re-torting and puncture can be prevented by enclosing the finished pack in cartons.

Normal steps in food retort pouch processing are:

- a) filling - can be a manual operation and the essential requirement is that the pouch seal be free from food particles contamination that would impair sealing;
- b) removal of air - necessary to prevent pouch burst, allow uniform heat transfer and detection of spoilage apart from increasing product stability;
- c) sealing and transport to a retort rack;

- d) sterilization - the operation is carried out under over-pressure that can be achieved either by processing under water or in special systems where air and steam are mixed.

All fish that are suitable for canning can be sent for retort pouch processing and the milder heat treatment may allow use of white fish that suffers extensive browning during normal canning processes.

Minced fish as human food

Minced fish is flesh separated in a comminuted form from skin, bones, scales and fins of the raw material. It can be generally stated that the properties of the minced fish will depend on the nature and quality of the raw material.

Raw material sources can be commercial fish, because of higher yield and utilization of filleting wastes, under-utilized fish due to consumer unfamiliarity and inherent quality, by-catch of shrimp fisheries and small pelagic fish presently utilized for fish meal manufacture. When using commercial fish the main problem is protein degradation due to the formation of formaldehyde from TMAO; some of the under-utilized species are toxic; by-catch use can be difficult if the number of species involved is too large, and colour problems and rancidity limits the use of small pelagic fish.

Mechanical separation is based on physical screening of flesh through a perforated cylinder. The relationship between pressure perforation size and perforation area is complex and some systems employ multipass operation where a low pressure zone allows a high quality flesh to be obtained and extra yield of low quality is obtained in a high pressure zone. Most important during separation is

removal of bone fraction; 2-3% of bones present toxicity level for fluoride content, and skin particles whose melanin pigments can darken the flesh.

Washing after mincing is used to remove inorganic salts, water soluble proteins, pigments, visceral contamination, with the aim of improving mince colour and stability.

Most important are procedures for mince stabilization. Change in fat antioxidants such as polyphosphates, EDTA, BHA, BHT, ascorbic acid, tocopherol and natural spices such as garlic, soy oil, curry, pepper and shrimp meat are used. The latter apart from the true antioxidant effect also have masking properties. In the course of mince preparation and specially after frozen storage proteins lose their functional properties namely gel forming, water binding and emulsifying capacity. Cryoprotectants like phosphates, glucose, sucrose, glutamate, gelatin, ethanol, etc., are incorporated into the mince to lessen the above changes.

Mince products established in the world market are dominated by black frozen materials in the West and surimi in Japan. Other potential uses are canning, extrusion formed portions, sausage pastes, extended meat products and intermediate moisture products.

D.4 Fish handling at Mexico City Viga fresh fish market

Mexico City took in 1980 138,000 tons of fish, that is, over 10% of all fish landed in Mexico and its consumption per capita in the same year reached 11.75 kg, the highest in the country for non-coastal towns. It is undoubtedly an important centre for fish distribution. All fresh fish that comes to Mexico City reaches the retailers and consumers via the Viga market.

The Viga market comprises some old dilapidated buildings where the first impression is a total lack of hygienic conditions. The market was jammed with lorries unloading fish, people washing canvas and moving about with fish in trolleys or baskets, and on the ground there were puddles of stagnant water.

The majority of the lorries seen on the occasion of the visit were not insulated, although some arrived after journeys of over 24 hours. Generally the containers of the vehicles are of wood whose side walls are lined with tin plates, wood boards or even cardboard. The uninsulated vehicles are covered with canvas. Fish are transported in bulk in piles that may reach 2.5 m. with plenty of ice that nevertheless was dirt, probably contaminated by rusty shovels and fish that had not been washed. Some of the fish in these lorries are brought in flat tin boxes or large wood boxes that can transport 150 kg of fish. Large size shrimp are transported in polyethylene boxes, well packed in ice, covered with heavy wood boxes tied up to boxes with metal wires. Pressure on the

bottom layers of shrimp if there is excess ice, can cause damage to the fish. The general picture that emerges is that handling of the fish during transport is certainly not good.

The mishandling the fish suffered previous to arrival at the market is reflected in the fish on display. Most of the fish on display were in advanced stage of spoilage. Fish had sunken, opaque eyes, mucous discoloured gills, bleached skin and showed extensive bruising, an evidence of previous mishandling. Most of the smaller shrimp on display presented black spot discolouration, which is evidence of a too long storage or lack of use of ice. Filleting was carried out in the open environment on top of not easily washable wood boards, a practice that can be strongly criticized. There was plenty of ice at the market (although not clean) but very little on top of the fish displayed on tin boxes or on top of wood boxes. Use of ice was erratic, some fish with lots of ice, some with little and some with none, but the general rule was piles of fish on top of a layer of ice. Eviscerated fish were mixed with non eviscerated fish; large fish such as shark were placed on the soil during the course of handling. The fish in better condition and that were fresh, were some red snapper and large shrimp.

The market also lacks refrigerated storage facilities.

Fishmongers at Viga

The fish on display at the fishmongers' shops close to the market were generally of better quality which is an indication that they buy fish as soon as the lorries arrive early in the morning and are able to select the best fish, probably those of the upper layers of the bulk inside the lorries. In these shops use of ice is also erratic, but the general rule again is piles of shrimps or fish on top of a layer of ice on the bottom of a tin tray,

which is a useless way of icing fish, since the top fish will be warm. Like in the market frozen products, shrimp and octopus, are sold exposed to the environment. Unsold products need refreezing, which causes surface dehydration in the product (freezer-burn). The shops also lack proper refrigerated storage facilities.

It is not worth to stress the inadequacy of the Viga market since the government recognizing this has planned to build a new fish market at the new Centre of Supplies (Central de Abastos). In this direction LANFI has been requested to make a diagnosis of the handling and distribution of fish reaching Mexico City.

However, it is necessary to point out that adequate market facilities will contribute very little to the freshness of the fish reaching the consumer, if handling and transport is not improved so that the fish arrive in good condition, and if the wholesalers at the market and fish retailers do not make use of correct icing and good handling practices.

D.5 INVESTIGATION OF FISH PROCESSING FACTORIES

1. Tepepan - Processing of breaded frozen minced fish portions

Most of the fish utilized in the preparation of the minced portions originate from shrimp by-catch. Species used include Berrugata (Menticimnhus species) and Mojarra (Eugennes species), the latter constituting 60% of all raw material. Fresh water fish such as Tilapia (Tilapia species) and Carpa (Cypri nus carpio) are also utilized.

The fish arrive in the factory frozen (eviscerated and beheaded) in large plastic bags containing 20 kg of fish. On arriving the frozen fish is sampled and analysed by organoleptic and microbiological tests. If totally rejected it is used for fish meal.

Thawing is carried out by water immersion overnight, in a cement tank. After thawing the fish is washed with chlorinated water and if rejection of the raw material was between 1-10% a selection is made to separate fish in bad condition. Lots of fish with 1% or less of rejects by-pass this selection step.

Next follows minced fish portions production traditional flow chart: deboning; washing of the mince obtained from dark flesh (carp, mojarra) to improve colour; blending of the different minces with antioxidants, umectants and spices; moulding of portions in machines of 1200 kg/h capacity; freezing the portions on a spiral Freon immersion tunnel. A liquid nitrogen freezer is also available but the width of the tunnel is too large for the output of one moulding machine.

The frozen portions are then immersed in battering solution and breadcrumbed. $\frac{1}{2}$ kg portions are placed in a polystyrene tray and overwrapped with polyolefin bags.

After each 800 kg batch is produced samples of the finished product are taken to the Quality Control Lab for evaluation.

The sanitary conditions of the plant are good but not excellent: there are broken walls and cold storage room doors are rusted. These doors do not have thermometers to indicate the room's temperature.

The plant has 5 cold storage rooms with a total capacity of 190 tons and nevertheless on the occasion there was no raw material to run the processing line. Considering a work shift of 8 h/day maximum production capacity is 19 tons/day, that is, the cold stores can supply raw material for at least 10 days. If the problem is occasional scarcity of raw material for a popular product like Pepepez, maybe to keep the plant running at full capacity, a more expensive raw material could be used to produce an upper grade product.

The plant experiments a problem with the liquid freon system because the overhead nozzles become blocked during operation with ice, and thawing this ice takes as much as 1 $\frac{1}{2}$ h. Unless the manufacturers have a specific solution to the problem, enveloping the nozzles with heaters could be tried, that, if proved practical, could reduce stoppage time.

We were informed that demand for the product is high and all production is quickly sold. Undoubtedly PPM has to be praised for marketing this product while other countries are still looking for solutions to use minced fish from by-catches.

The Quality Control Lab of PFM in Mexico City

The laboratory carries out microbiological, organoleptic and chemical analyses. There is a sampling plan in which 5 samples are collected, 2 samples being used for organoleptic evaluation and 3 samples for microbiological analyses.

For frozen fish microbiological analyses are those normally recommended for the assessment of the sanitary condition of the product, namely detection of Salmonella, coliformes (most probable number), yeasts and moulds. For canned fish counting of mesophilic and thermophilic microorganisms is done and a number of cans are stored at 37°, 45° and 55°C for a swelling test. The use of temperatures as 45° and 55°C is not usual and this means that the end product is going to be submitted to high environmental temperatures during commercialization. In this case the heat treatment during sterilization has to be more drastic than for products submitted to temperatures of 37°C.

The sensory evaluation is carried out by two persons. This evaluation involves appearance, odour and colour examination. For the breaded minced fish portions (Pepepez) colour is measured through a letra set colour matching system; texture evaluation includes terms like firm, soft, sticking; for appearance the uniformity of the product surface and areas without breadcrumbs and presenting freezer burn is observed. Odour is the critical factor causing rejection and fermentative off-odours are particularly looked for.

2. A vegetable and fish processing plant

The "Empacadora del Golfo de México" in Veracruz is a canning plant that packs vegetables, mainly chiles, and

sporadically cans fish such as sardines, tuna and mackerels. The intention was to observe fish processing practices but the plant had not been processing fish in the last six months allegedly due to the high price of raw material.

The immediate impression was that the plant does not have sanitary conditions to pack low acid foods such as fish.

There is no separation between the area of processing and reception of raw material and on the occasion there was a lorry inside the plant unloading chiles. Part of the processing area is open to the street and some of the equipment is exposed to the open air. There are no exhaustors to remove the steam condensing on the ceilings; the floor is broken allowing puddles of stagnant water. Other faults include: condensed or leaking water running on the walls; moulds on walls and ceilings. The equipment is old and in bad state.

The plant has a Quality Control Lab where pH, acidity and brix measurement are carried out.

It is not possible to make any particular recommendation for improvements because this would be more a work for a food plant sanitation expert and for this factory any change related to buildings, equipment, layout would have to be drastic.

3. The fresh fish market in Veracruz

The fish market is not really a market but a place with many fishmongers. Fish arrives from in-shore local fishing and from more distant larger parts as from Progreso, Tabasco and

Campeche. When coming from these parts the trip can take as long as 24 hours.

In the same fashion as in the Viga market most of the fish arrives in lorries without thermal insulation, covered with canvas and iced in bulk. Fish from local fishing is not iced. Similar inadequate handling practices observed in Mexico's Viga market are found here. Fish handled in wooden boxes without any ice; fish that had been in ice during transport is left to warm up in the environment before it is taken elsewhere; rough handling of fish in rigor mortis with rusted shovels. All this mishandling contributes to reduce fresh fish self-life.

In the largest fishmonger shop again hygienic conditions are poor.

Cold storage room walls were covered with moulds and dripping condensed water, one room being waterlogged: freezing of fresh shrimp was being carried out in one of the storage rooms; raw vegetables were stored in the same room in which fish was being handled, a procedure that can be strongly criticized since the vegetables are a source of contamination. With all these drawbacks, the market serves as an intermediate stop for changing lorries that will take fish to Mexico City from ports like Campeche.

4. Productos Pesqueros de Alvarado

The factory has lines for production of frozen, canned, salted and smoked fish. It is located by the sea and has a modern system of unloading fish by air suction.

The general impression is not good: hygiene is poor, disposition of rooms and layout of equipment are inadequate, there is a lack of

equipment maintenance, and apparently there are no supervisors in the processing lines. To point out particular failures and suggest corrective measures would be too long and therefore a list of poor manufacturing practices observed during the visit are given below.

- There is no separation between reception of raw material and processing area.
- Processing areas are open to the outside environment without windows and doors to prevent flies entering these areas.
- Processing tables are rusty and filleting boards are of wood, both a source of microbiological contamination apart from that iron ions are prooxidants.
- Eviscerated fish was washed in the same water receiving viscera residues.
- Fish waste such as filleting frames and shark viscera were laying on the floor.
- Workers' clothes were kept close to filleting tables.
- Cold storage rooms in the processing area have doors which are rotted and rusty; other cold storage rooms supposedly at -30°C were presenting temperatures (as indicated by the thermometers on the doors) as high as -15°C .
- Cans filled with fish and tomato sauce already cool after exhausting were left awaiting further addition of sauce: this procedure nullifies the purpose of exhausting apart from facilitating contamination.
- There are no thermometers in the autoclaves and temperature recorders are broken and located away from the autoclaves.
- Cooling of the cans after sterilization is carried out in the environment, when it is recommended that it is to be done in cool chlorinated water.

- Many of the measurement instruments such as thermometers are covered with dirt and reading is not possible.

The general conclusion is that this factory needs serious and extensive changes and improved organization to conform to good manufacturing practices covering all the failures pointed out above.

Recommendations for improvements in particular aspects of processing will not solve the problem.

One important conclusion resulting from all these visits is that the inspection services in these areas are not effective.

E. RECOMMENDATIONS

E.1 Research in fish handling and processing

There are a number of institutions in Mexico that already carry out research on fish processing such as the Instituto Nacional de Pesca, Productos Pesqueros Mexicanos, and other institutions developing such capability as the Instituto de Estudios Superiores en Ciencia y Tecnología del Mar of Veracruz who are establishing a pilot plant specifically for fish technology research.

However, there has been massive government investment in fisheries and, as already mentioned, today Mexico has one of the largest fleet to catch tuna in the world. Although the impressions formed during the visits of fish markets and factories cannot be generalized and extrapolated to the whole country, there are certainly serious deficiencies in the way fish is handled, distributed and processed at present in Mexico.

Although the expert is of the opinion that LANFI should include in its programme research on fish handling and processing taking advantage of its unique facilities for food analysis, industrial design, packaging testing, shelf-life studies and food processing, collaboration with the institutions mentioned initially could be more advantageous for both sides. Therefore the research programme is suggested and collaboration should be considered whenever necessary.

Handling of fish on board

It was not possible to make a proper assessment of the way fish is handled and stored on board, but the boats visited use bulk storage with piles over 1.5 m without shelving,

damaging fish in the bottom layers. Inshore boats do not seem to use ice. A more accurate evaluation of the way fish is iced and handled on board is an important investigation to be carried out. From the results obtained LANFI could prepare a code of practice on how fish should be iced and better stored on board, and investigate the possibility of widening the use of plastic boxes, one of the best ways to store fish on board.

Use of ice

The use of ice is the simplest and cheapest way of lowering fish temperature, preventing spoilage and increasing short-term preservation. It has been pointed out that fish from warmer waters last more in ice than those from colder ones, and literature for temperate waters fish may be of limited value.

The shelf-life in ice of the most important commercial species should be determined under ideal icing conditions. In this respect changes in fish during spoilage should be measured by sensory and chemical methods. Comparison should be drawn between fish stored under ideal icing conditions and those handled according to usual trade practices.

Handling during distribution

The way some fish is handled during distribution with bulk storage in lorries and use of large wooden boxes certainly contributes to cause mechanical damage to the fish and consequently increase spoilage curtailing shelf-life. Although the use of boxes and insulated lorries could bring great improvements to the fish quality, it is unlikely that such drastic changes could be carried out widely in a short

period of time. However, immediate improvements could be achieved if in bulk transport shelves were used to reduce pressure on the lower layers of fish and wooden boxes were substituted for plastic boxes, or metal containers that could be stacked.

Freezing and cold storage

Frozen fish, it seems, is not very popular in Mexico. Cold stores visited were not being operated properly. Some investigation of freezing practices such as measurement of temperatures used for freezing, temperatures the fish leaves the freezers and temperatures used in cold stores coupled with studies of shelf-life under different temperatures for the most important species could result in very useful information to the industry.

Salted and dried products

For countries with warm climates salted dried fish is especially important as a source of protein to inland communities. Many of the salted dried products examined during the mission were of low quality particularly when fatty species are utilized. LANFI could investigate the use of adequate packaging to protect salted fish.

Retort pouch technology

Most of the Mexican tuna catch is exported frozen or canned. However, there is a trend already developing in the catering markets of USA and Japan to use retortable pouches for fish, that allows for a product with better organoleptic properties than canned fish. It is expected that in the near future fish in pouch will be cheaper than canned fish.

The Section of Processing and Packaging of Food has an autoclave for processing retort pouches, and it is worthwhile to initiate research on the use of pouches for tuna products.

LANFI's Project on Diagnosis of Handling and Distribution of Fish and Shellfish

The suggestions for this LANFI comprehensive project whose aim is to rationalize the utilization of packing and containers and to evaluate the whole system of handling, distribution and storage for 32 species of fish and shellfish are:

- Establish the chemical composition of the 32 species by literature review or carrying out analyses, with particular attention to seasonal variations for fatty species.
- Reduce the number of species studied by regrouping according to chemical composition and average size.
- Extend the work to include assessment of the conditions of these species stored on board and ascertain how long the fish remain on board before being unloaded.
- Evaluate the methods utilized to unload fish with regard to mechanical damage (bruising) and exposure to environmental temperatures.

E.2 Expanding the food processing pilot plant to study fish

As already pointed out the pilot plant for food processing is well-equipped but the acquisition of some equipment of general use would also allow specific work on fish particularly with regard to shelf-life studies. The equipment recommended is -

- Air blast freezer (pilot freezer P-10004 Frigoscandia - Helsingborg, Sweden).

- Modulated cold storage chambers for 0, -20, -30°C.
- (20) Condensated polyethylene boards.
- Polyethylene boxes.
- Vacuum sealing machine for flexible materials.
- Horizontal plate freezer.
- Band saw.

With the exception of the air blast freezer which is an equipment designed especially for research, manufacturers' names are not given but can be supplied if required.

E.3 Extension work

LANFI has an efficient Information Section with information retrieval by computer, and therefore any necessary publication can be easily localized and requested. However to facilitate the work of the group that is to be involved in fish research, the library should acquire some reference books for immediate consultation. Recommended books to be acquired are:

- El Pescado y las industrias derivadas de la pesca. - Burgess, G.H.O. et alii (eds) - Editorial Acribia - Royo 23 Zaragoza España.
- El pescado y sus productos - Ludorff S. Meyer (eds) Editorial Acribia.
- Fishery by-products technology. Brody, J. AVI Publ. Co. Westport. Conn. 1965.
- Multilingual dictionary of fish and fish products. Fishing News Books Ltd., Surrey. England.

- Fishery Products - Kreuzer, R. (ed) Fishing News Books Ltd., Surrey. England 1974.
- Industrial fishery technology - Stansby. M.E. (ed) Reinhold Publ. Co. New York.
- Control de la Calidad del Pescado. Connell. i.j. Editorial Acribia - Zaragoza. - España.
- Microbial safety of fishery products - Chichester, C.O. & Spencer, R. (eds) Academic Press, New York 1973.
- Fish inspection and quality control, Kreuzer, R. (ed) Fishing News Books, Surrey, England 1971.
- Marine Products in Japan - Tanikawa. E. Koseisha- Koseikaku Co. Tokyo, 1971.

Up-to-date information on fish science and technology can be obtained from the Food Science and Technology Abstracts that the library subscribes.

As soon as the LANFI project mentioned in section E.2 is completed, a seminar on fish handling and good manufacturing practices on processing fish should be held. Leaflets with codes of practice should be issued and distributed to industry, fish markets and fishmongers.

E.4 Further Technical Assistance and Training

Considering the aspects of hygiene pointed out in this report, it is recommended that technical assistance should be obtained on microbiology and sanitizing of food fish processing plants. Inspection services and industry has to be alerted to the risks

of lack of hygiene and cleansing schedules.

It might be necessary that one member of the group trained receives training abroad on evaluation of iced fish quality.

Some of the recommended specific research topics if tackled may require further expert assistance.

A N N E X 1

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2. Visits

- TEPEPAN (Productos Pesqueros Mexicanos - PPM): manufacturer of breaded frozen minced fish portions.
Eng. Vicente E. Castro Ayon
- VIGA: Mexico City fish market and fishmongers.
- PRODUCTOS PESQUEROS MEXICANOS - Quality Control Laboratory, Mexico City. Dr. Maria Amelia Luna de V.
- Fishmonger at GRAN BAZAR - Mexico City
- Fish market and fishmongers - Veracruz. Mr. Manuel Hernández

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