UNIT 1 PRODUCTION OF FISH MEAL AND OIL

Structure

1.0 OBJECTIVES

After reading this unit, you will be able to:

- identify the raw materials used for the production of fish meal and oil;
- describe the principle behind production of fish meal and fish body oil;
- analyse the various machineries and requirements used in the production of fish meal and oil;
- identify the problems involved in the production of good quality fish meal, fish body oil and liver oil; and
- evaluate the methods to overcome the problems in production of meal and oil.

1.1 INTRODUCTION

You will be surprised to know that out of total world production; one third of the total fish landed is not used for human consumption for various reasons like size, species, quality, quantity, non-availability of processing or transportation facility. Even in the case of good quality fish, only 50% is used for human consumption and rest is being thrown out as waste.

These wastes disposed off on the beaches without any treatment, leads to production of bad smell which may create civic problems as explained earlier. Production of fish meal and oil from low value fish and discarded parts of fish not only solves many of these health and civic problems but also add to the overall economy of fishing and fish processing industries.

1.2 RAW MATERIALS FOR PRODUCTION OF FISH MEAL AND OIL

For the manufacture of fish meal, the following three types of raw materials are generally used.

1) Inedible parts of fish and shell fish such as head, viscera, fins, bones, frames and shell waste.

2) Whole fish of low market value or underutilized fish such as lesser sardine which contain more bones.

3) Oily pelagic fish like oil sardine (*Sardinella longiceps*).

Some varieties of fish used all over the world for fish meal production are listed below:

1) Anchovy in Peru

2) Menhaden in USA

3) Pilchard in South Africa

4) Herring and capelin in Norway

In India, oil sardine (*Sardinella longiceps*) (Fig.1.1) is extensively used for the production of fish meal and oil. Most of the pelagic fishes mentioned earlier are rich in body oil. Hence, both fish meal and fish body oil are produced in the same industry. In addition to oil sardines, fish dressing waste or cutting wastes (head and viscera) of surimi industry are also used in fish meal manufacture in India.

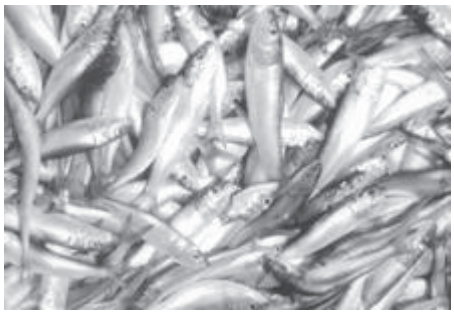

Fig. 1.1: Oil Sardine (*Sardinella longiceps*)

1.3 HANDLING AND PRESERVATION OF RAW MATERIALS

Fish meal (Fig. 1.2) is usually manufactured by handling large quantities of fish. Many of the small-scale fish meal plants have a capacity of 50 tonnes per day and all the fish may be dumped into the fish hold of the plant at a time. As fish is highly perishable, meal and oil prepared as soon as the fish arrived will be of good quality, but the one that is manufactured towards the end may result in poor quality if adequate care is not taken to preserve the fish. Therefore, handling and preservation of fish for meal production becomes important. Due to rough handling of raw material, the quality in fish is likely to get affected which leads to poor yield and lower protein content in the meal. In other words, poor quality fish meal is obtained.

Fig. 1.2: Fish meal

Some of the common preservation methods for fish are salting, chilling and freezing. Salting leads to high salt content in the meal which is not desirable. Freezing and chilling are too expensive methods for preserving fish for meal production. Hence, use of chemical preservatives is the only method to preserve fish for meal introduction. The most commonly used chemical preservatives are Formaldehyde and Sodium nitrite. The storage life (shelf life) of fish preserved with preservatives depends on three factors namely:

a) initial freshness of fish;

b) concentration or level at which the preservatives are used; and

c) temperature of storage.

If the initial quality of the fish is high, the longer is the shelf life and the quality will be better for the corresponding period of storage. The higher the concentration of the preservative, the more is the shelf life and the better is the quality. If the temperature of storage of fish during meal production is high, the quality of fish will be low.

Generally, a solution containing 0.1% of sodium nitrite or formaldehyde is applied either by dip treatment of fish or by spraying the solution on to the fish. Use of excessive preservative like formaldehyde not only creates problems during pressing and drying operations, but also creates toxicity problems and causes reduction in nutritive value. The use of excessive sodium nitrite, leads to formation of nitrosoamines, which are toxic.

Check Your Progress 1

Note: a) Write your answers within the space provided.
b) Check your answers with those given at the end of the unit.

1) In addition to whole fish, name two important sources of raw material for fish meal manufacture.

   a) ……. b) ……..

2) ……..…. species of fish is predominantly used in India for the manufacture of fish meal and oil.

3) Name at least four different species of fish used for fish meal and oil manufacture all over the world.

   a) ……. b) ……

   c) …….. d) …….

4) In addition to oil sardine, fish dressing waste of ……. industry is also used for fish meal production in India.

5) The quality of fish meal and oil will be poor, if the quality of fish used in its manufacture is …….

6) …….. and …….. are the preservatives used in the preservation of fish intended for meal and oil manufacture.

Activity 1

Visit a fish-landing centre in your neighbourhood and find out the species of fish being purchased by the fish meal industry and make a list. Also find out the freshness of the fish going to fish meal plant. Note down whether the same species of fish going to fresh fish market is of better quality than the one going to fish meal plant. Observe whether any preservation method is being adopted for fish in the fish hold intended for meal and oil manufacture. Give details?

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1.4 MANUFACTURE OF FISH MEAL

You must remember that the main objective in the production of fish meal is to preserve the fish by reducing the moisture content of fresh fish (70-80%) to about less than 10% in the meal. In other words, about 90-95% of moisture in fresh fish is to be removed. Oil content in the fish meal should not be more than 10%. Hence, 80 to 90% of oil present in fish has to be removed during fish meal production. There are essentially two methods of fish meal production.

1) Wet reduction method

2) Dry reduction method

Dry reduction method is suitable only for lean fish, which contains less than 2-3% oil in it. Also the method is not a continuous process. Wet reduction method can be used for any fish both lean as well as fatty. Wet reduction method is primarily used for meal manufacture from oily fishes such as capelin, herring, pilchard, anchovy, menhaden and oil sardine. Wet reduction method can be continuous and particularly suitable for large-scale operations. Bulk of the fish meal is produced by wet reduction method all over the world. The main unit operations involved in fish meal production by wet reduction method are shown in the flow diagram (Fig. 1.3).

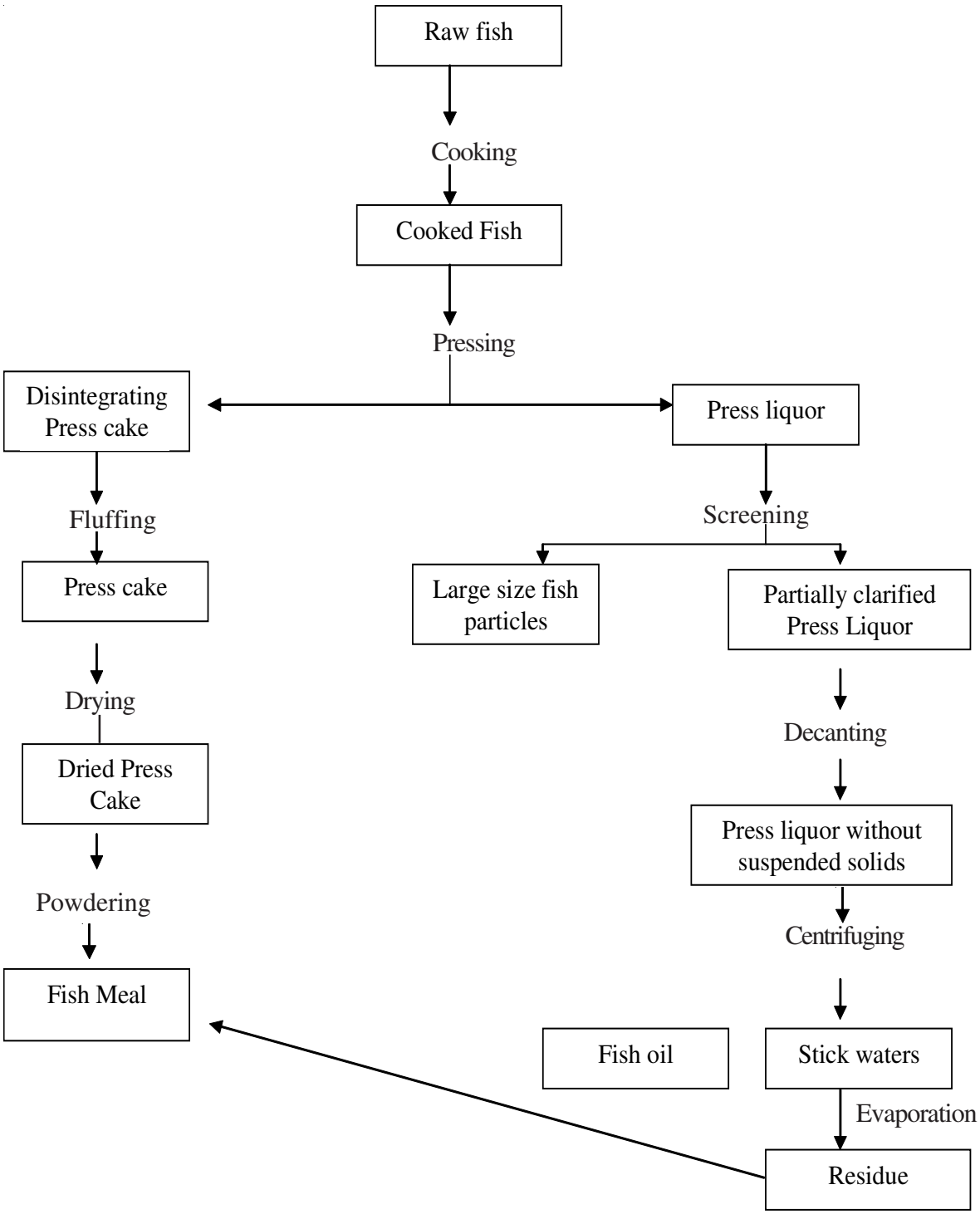

Fig. 1.3: Wet Reduction Method for Fish Meal and Oil Manufacture

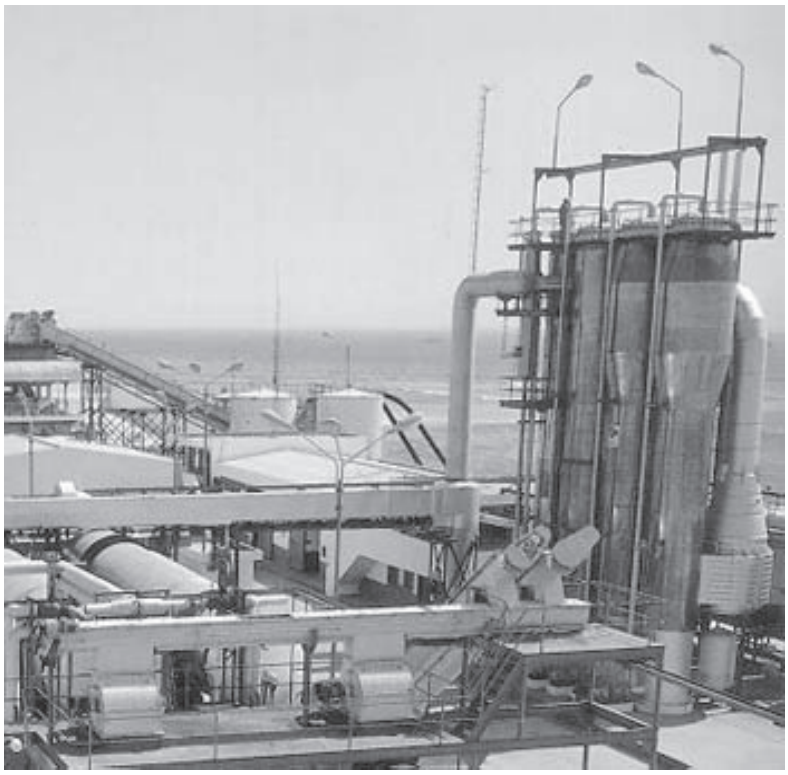

Fig. 1.4: Fish meal and oil plant

1.4.1 Cooking

In wet reduction method, the fish is dumped in the fish hold in bulk. This fish is carried to the cooker (Fig.1.5) by a screw conveyor and fed into the continuous cooker. The cooker consists of a long, jacketed cylindrical vessel having a hopper at one end and an exit for the cooked fish to come out at the other end. The cylindrical vessel has a false bottom of perforated plate and a wire mesh to drain the cooked and pressed liquid from fish. It is also fitted with screw conveyor and the shaft of the screw conveyor is also heated. In some cookers, steam may be directly injected into the fish mass through the nozzles fixed to the shaft. Cooker may be fitted with automatic level controls for the raw material, temperature controls, a trap for collecting foreign materials and also has removable panels for inspection and cleaning. In general, cooking is done at a 95 to 100°C within 15-20 minutes. Most manufacturers operate cookers to heat the fish mass rapidly to 95°C.

You must understand that cooking is one of the most important steps in fish meal manufacture. The fish should neither be overcooked nor undercooked. The purpose of cooking is to denature or coagulate the proteins of fish and to rupture the cell wall of tissues of fish so that it helps in separating oil and water present in fish. If the quality of fish is poor, addition of coagulating agents such as formaldehyde makes the fish firm and tough and hence facilitates easy handling in addition to giving some preservation to fresh fish.

After cooking, the fish is conveyed to the press by a screw conveyor, at the same time strained to remove cooked liquid. This is done by using strainer conveyor. The strainer conveyor consists of screw conveyor having a jacket with a false bottom and a wire mesh. This type of conveyor not only transfers the fish from the exit end of the cooker to the press, but also separates the liquid coming out of cooked fish. Often, straining is done in the cooker itself.

Fig. 1.5: Cooker for cooking fish in fish meal plant

1.4.2 Pressing

Pressing operation separates two distinct phases of cooked fish. They are:

1) Solid phase (press cake)

2) Liquid phase (Press liquor)

The success of pressing depends on cooking operation and quality of fish. Pressing is done using a screw press. The press may be a single screw press (Fig.1.6) or a double screw press (Fig. 1.7). At present, double screw press is preferred as it removes maximum quantity of oil and moisture from cooked fish.

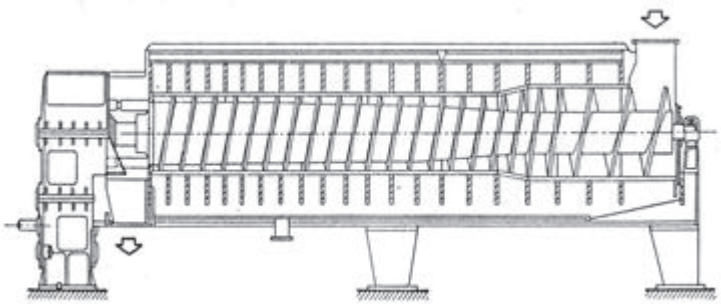

Fig. 1.6: Single screw press

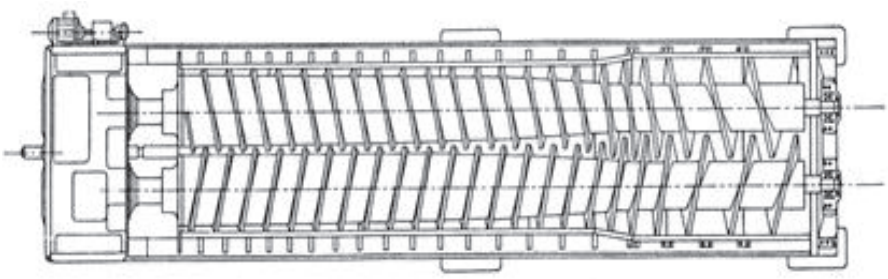

Fig. 1.7: Double screw press

The screw press consists of a cylindrical vessel constructed using thick steel plate with perforation on the sides and bottom for drainage of press liquor. A tapered helical screw rotates inside the vessel with an axis similar to that of the cylindrical vessel. When the screw rotates, it exerts minimum pressure at the entry point and maximum pressure at the exit as a result the space available for the cooked fish gets reduced as it moves towards the exit and hence it get pressed. In a double screw press, two screws are kept side by side, along the cylindrical vessel. The screws rotate in opposite direction. Usually, press cake coming out of the screw press contains about 45-55% water and 2 to 3% fat. Press liquor coming out of the press is saved for oil extraction.

1.4.3 Fluffing

Press cake coming out of the press is in the form of large lumps. In order to increase the efficiency of drying and to reduce drying time, the large lumps have to be broken down to small pieces of about 1cm size. This is done by low speed hammer mill; by feeding the large lumps to the hammer mill, small sized pieces of press cake is obtained.

1.4.4 Drying

In the drying process, fluffed press cake containing about 50% moisture is dried to a moisture content less than 10%. Two types of driers are commercially used. Direct driers or flame driers and indirect driers or steam heated driers (Fig. 1.8 and 1.9).

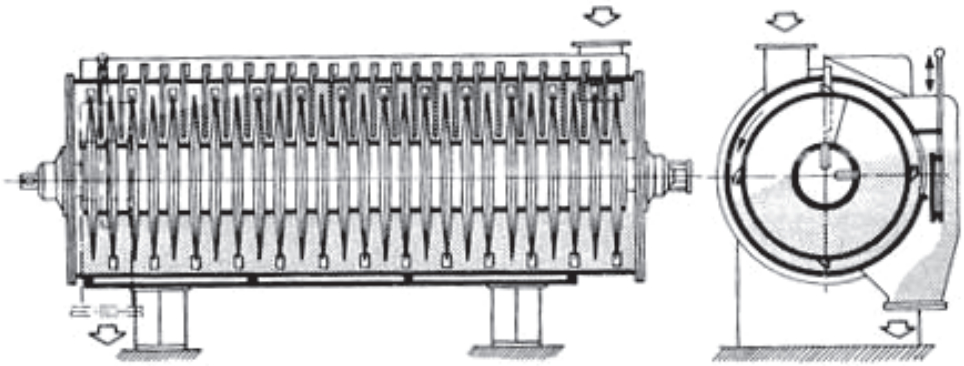

Fig. 1.8: Disc type indirect steam drier

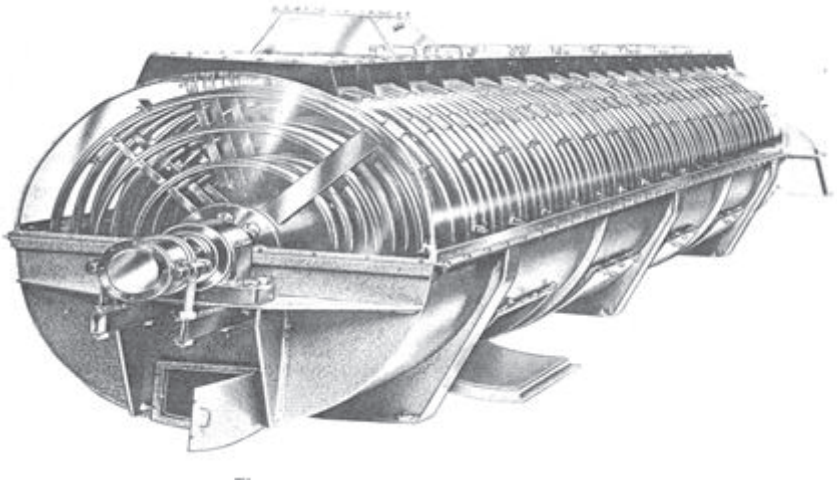

Fig. 1.9: Coil type indirect steam drier

In direct driers, light diesel or furnace oil is burnt in a furnace and the hot flue gases from the furnace is mixed with some atmospheric air and directed into a dying chamber. The drying chamber consists of a large rotary drum of about 4' diameter and 20 to 30' length. Flights are fitted along the length of the rotary drum. The flights carry the dried press cake particles to the top position inside the drum and drop it as the drum rotates. This provides cascading effect. As the drum rotates the meal particles are moved forward due to rotation of the drum as well as due to the cyclone separator connected at the exit end. When the rotary drier is working, the temperature at the inlet end is about 500-600°C. As the wet cake is fed near the flue gas inlet end, the flue gases immediately get cooled and therefore the temperature of the press cake particles inside does not exceed 80°C. In about 20 minutes, the moisture content of the press cake particle gets reduced to less than 10% when it comes out of the drier. Direct driers have the advantage of high capacity for the space they occupy and greater fuel economy. However, there is always a possibility of overheating and catching of fire by the meal in the drier, a possibility that the nutritive value of the meal gets reduced due to oxidative polymerization of oil present in it and darkening of the meal and odour problems are encountered in the neighbourhood when direct driers are used.

The indirect driers make use of indirect steam for drying the fish. The press cake having 40-45% moisture is forwarded to the "Steam Drier", so as to reduce the moisture to about 9-10% with the help of indirect steam at a temperature of 80-90°C inside the drier.

1.4.5 Milling

Dried meal is passed through a vibratory screen and then over a magnet to separate extraneous materials such as wood, cloth, fishing hooks and nails prior to milling. The important objective of milling is to produce fish meal with small particles averaging around no. 40 mesh Tyler screen. Milling is done by using hammer mill. It consists of a chamber in which a shaft fitted with heavy hammers rotates at a speed of about 3000 rpm. or more. The small sized particles thus produced pass through the sieve fixed at the bottom of the chamber. Normally, the exit end of the hammer mill is again connected to a cyclone separator to reduce the problem of dusting.

1.4.6 Evaporation of Stick Water

After recovery of the oil from the stick water, the remaining liquid is evaporated and the residue is added to the fish meal which increases the protein content and nutritive value of fish meal.

1.5 PACKAGING AND STORAGE

Fish meal is usually packed in polyethylene (PE) lined jute bags or PE lined paper bags or PE lined woven sacks. Precautions must be taken to select proper packaging material and storage condition for the following reasons:

1) As fish meal contains unsaturated fats, it gets easily oxidized and sometimes spontaneous fire may occur during storage. This problem may be minimized by incorporation of antioxidants such as ethoxyquin at 0.2% level before the dried meal goes to milling. Also, the problem can be minimized by cooling the fish meal before packing and storage in bulk stacks. Selection of proper packaging also helps in minimizing this problem.

2) The selected packaging material should exclude insect and rodent infestation.

3) Seepage of meal through the packing (as in jute bags without lining) not only causes loss of material but also causes pollution and pest infestation.

4) Fish meal is likely to absorb moisture from the atmosphere and become lumps, which is not desirable to feed manufactures. Also, microbial attack can occur due to higher moisture levels in the meal. Therefore, the selected packaging material must have water vapour barrier property.

1.6 RECENT DEVELOPMENTS IN FISH MEAL MANUFACTURE

As fish used in meal production contains highly reactive oil components, the quality of meal is likely to deteriorate during its production and storage. Also, the aquaculture feed manufacturers, especially, shrimp feed manufactures require high quality fish meal. Therefore, certain changes in fish meal manufacture have been incorporated as follows:

1) ***Indirect drying or use of indirectly heated steam driers:*** After pressing the cooked fish, the press cake is directly conveyed to indirectly heated steam drier without fluffing. This indirect drier is also a rotary drier consisting of a large cylindrical drum in which press cake is dried, but the heat is supplied indirectly by passing steam through the shaft and discs. Dried meal is removed from the drier by a conveyor system. The hot meal coming out of the drier is conveyed by screw conveyor to a cooling system.

2) ***Cooling of dried meal:*** The fish meal coming out of the drier is cooled by the cooling equipment. The cooling equipment consists of a series of 5 to 6 screw conveyor having a jacket for the outer trough. Cold water is passed through the jacket. Hot fish meal from one screw conveyor gets cooled and drop to the next screw conveyor kept below. Thus, when fish meal travels through the screw conveyor, it attains room temperature and finally goes for packing. This kind of fish meal is often called as sterilized fish meal by shrimp feed manufacturers.

? Check Your Progress 2

Note: a) Write your answers within the space provided.
b) Check your answers with those given at the end of the unit.

1) Name two primary methods of fish meal manufacture

a. …… b. ……..

2) Dry reduction method is only suitable for …….fish which contains less than ……% oil in it.

3) In the cooker, on an average, fish is cooked at temperatures of about ……to …… ^{o}C within 15 to 20 minutes.

4) Cooked fish is pressed using a …….. in fish meal manufacture.

5) Name two types of driers used in fish meal manufacture.

a. …… b…….....……

1.7 MANUFACTURE OF FISH BODY OIL

As you have already learnt, during fish meal manufacture the cooked fish is pressed in twin-screw press and the liquid coming out during pressing in known as press liquor. The press liquor is an emulsion and in general contains 78% water, 6% solids and 16% oil.

Press liquor coming out of the screw press may contain larger sized suspended solid particles in which case they are immediately removed by using vibratory screens. Fine suspended solids are removed from the press liquor by using three phase decanters. The press liquor coming out of three phase decanters will contain very low quantity of solids. This press liquor is fed into a Sharple's super centrifuge to separate almost pure oil, water and solids. For better separation of oil and to get more oil yield, process should be completed when it is hot.

Fish body oil from most of the oily pelagic fish is considered as a semi drying oil and hence finds application in many industrial uses. Sardine body oil can replace part of linseed oil in paint and varnish industry and also finds application in leather processing. Fish body oils are used as insecticide and wetting and sticking agent after its conversion to soap. Recently, it has been used in the manufacture of concentrated omega-3 (ω_3) fatty acid rich oils. Details on the uses of fish body oil are presented in next unit (Unit 2: Uses of fish meal and oil).

1.8 FISH LIVER OILS

You will be surprised to know that about 300 years back, fish liver oils were used in the treatment of rickets and night blindness. Early in the 20th century, with the development of vitamin chemistry, it was established that the deficiency of vitamin A and D caused night blindness and rickets, respectively. Liver oils are being used for feeding animals and as pharmaceutical product for humans. Some liver oils such as cod liver oil are used in the manufacture of omega-3 (ω_3) fat concentrates.

Liver oils are manufactured from liver of fish in which fat storage depot is liver. Liver oils are extracted from fish such as shark (Fig.1.11), cod (Fig.1.10), haddock, hake and grey fish. Fish livers are classified into three important groups as follows:

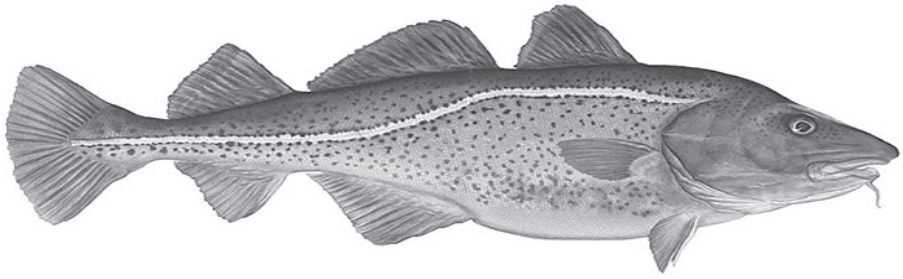

Fig. 1.10: Atlantic Cod

Fig. 1.11: Shark

Class A - high oil content – Low Vitamin A potency

Class B - Low oil content - High Vitamin A potency

Class C - High oil content - High Vitamin A potency

The important reason for this type of classification was that each type of liver requires a special oil extraction procedure especially in the case of low oil content high vitamin A potency liver. In other words, a process suitable for class A liver may not be suitable for processing class B livers. Therefore, this type of classification helps in selecting a process for manufacture of oil from a particular type of liver.

Livers of cod, haddock, hake, gray fish are classified as class A. Livers of such fishes contain 50 to 75% oil on weight basis and the vitamin potency in the oil range from 500 to 20,000 USP (US Pharmacopia units). This type of liver can be treated for oil extraction by the following methods:

1) Direct steaming with agitation

2) Percolator method

3) Cold extraction method

4) Oil floatation process

5) B.E. Bailey procedure

6) Reduced pressure vacuum cooking method

However, only one of the method is commonly adopted and that is direct steaming method. This method involves direct heating of livers using steam at low pressure through the pipe having nozzles to inject steam into the cooker. Cooking leads to thermal denaturation and rupture of liver cells which release the oil. Oil rises above the water phase in the cooker which may be scooped off manually or overflows into and adjacent storage tank. Final purification of the oil may be done by centrifugation (Fig. 1.12) of the oil. If the livers are heated indirectly using a steam jacketed kettle instead of by direct steam injection, they should be mechanically stirred to facilitate the disintegration of the liver. Livers are heated only to 70 to 75°C.

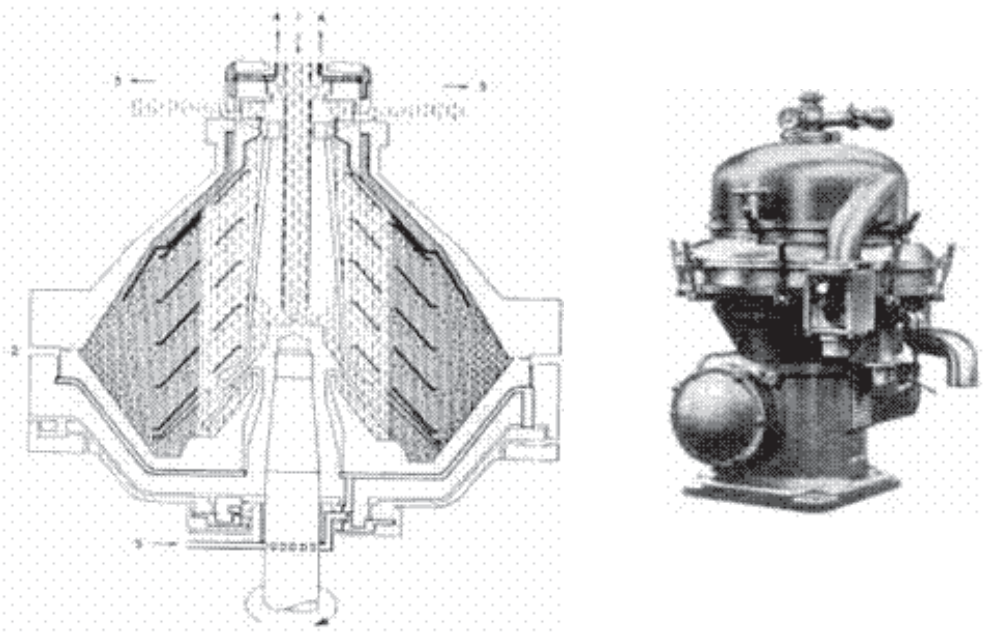

Fig. 1.12: Conical disc type centrifuge

Low oil content-high vitamin A potency livers come from fishes such as halibut, tuna, rock fish, ling cod and sable fish. The livers of these fishes contain 4 to 28% oil by weight and the range of vitamin A potency in the oil is 25,000 to 6,00,000 USP. However, the liver oil of these fish are rich in vitamin D. For successful extraction of oil from these livers, digestion and solublization of proteins present in the liver is essential. These processes would release the enclosed oil and vitamins present in it. The following methods are used for digestion and solublization of proteins of fish liver:

1) Alkali digestion method

2) Enzyme and alkali digestion method

3) Acid digestion method

In alkali digestion method, livers are solublized with 1-2% (by weight of liver) sodium hydroxide or 2-5% of sodium carbonate along with cooking at 75-85^{o}C using steam. This process gives rise to liquefaction of the liver and the liquefied mass is immediately centrifuged to separate almost pure liver oil. In enzyme and alkali digestion method, livers are ground, diluted with water, the pH is adjusted to 1.2 to 1.5 using 25% hydrochloric acid (HCl) and 0.05% of the enzyme and the commercial pepsin is added in the form of aqueous suspension. Enzyme hydrolysis in carried out at 37-40^{o}C. On the completion of hydrolyses, pH is adjusted to 9.0 using saturated solution of sodium carbonate and digested at around 80^{o}C. Finally, the liquefied mass is centrifuged to get almost pure oil.

The last category of the livers is class C liver which has high oil content as well as high vitamin A potency. The best example for this class is shark liver oil. These livers do not come under earlier mentioned categories. For extraction of oil from this type of liver, any method mentioned for class A or class B livers can be adopted.

Livers may undergo various types of spoilage which may be classified as follows:

1) **Chemical spoilage** is caused by oxidation of oil present in the liver by atmospheric oxygen. This leads to rancidity in the liver and the oil will have high peroxide value.

2) **Biochemical spoilage** mainly caused by the enzymes present in the fish itself.

3) **Putrefaction** is caused by the growth of bacteria in the livers.

In order to preserve, the livers must the separated from the carcass of the fish as soon as possible. Fresh livers, should be separated from gall bladder, blood and slime and washed thoroughly. Fish livers can be preserved by several methods as follows:

1) Freezing and frozen storage at -20^{o}C. If atmospheric air is excluded during frozen storage, they can be preserved for 6 to 7 months. However, thawing makes the liver soft and vulnerable to microbial, biochemical and chemical changes. In addition, loss of oil and proportional quantity of vitamin A occurs. Use of frozen livers requires rigid conditions during processing for oil extraction.

2) Another method of preserving liver is by salting. Cleaned livers are salted, packed in container and stored; salted liver can be stored for several months without spoilage. However, salt coagulates the tissues of liver and makes it hard in texture, making it more difficult for oil extraction than from frozen or fresh livers.

3) Livers can also be preserved by using preservatives such as formaldehyde. Combination of base to adjust the pH to 9.0 and preservatives such as phenols is also practiced for preservation of fish livers.

Storage conditions for fish liver oils

Quality of liver oils is affected by various factors namely:

1) Storage temperature,

2) Types of container,

3) Presence of moisture in the oil,

4) Exposure to sunlight, and

5) Atmospheric air.

Considering these factors, moisture free liver oils must be stored in containers which act as a barrier to light and air. Liver oils must be stored in cool, dry place.

Liver oils are good sources of oil soluble vitamins such as Vitamin A and D and used as an inexpensive source of these vitamins for feeding animals and human beings. Some liver oils are rich in omega 3 (ω_3) fats and used in the manufacture of pharmaceutical products as explained earlier. Dogfish (a kind of shark) liver oil is rich in squalene (a hydrocarbon) which is used in the manufacture of cosmetics and perfumery.

? Check Your Progress 3

Note: a) Write your answers within the space provided.
b) Check your answers with those given at the end of the unit.

1) In a fish meal plant, the liquid coming out of the press is known as ……

2) The press liquor is an emulsion and in general contains …… % water, ……% solids and ……. % oil

3) For better separation of oil from press liquor and to get more …… , press liquor should be processed when it is still hot.

4) ……. and ……. are the two important vitamins present in fish liver oils?

5) Cod liver oil is used in the manufacture of ……..…. fat concentrate.

6) Name any three methods for extraction of oil from class A livers

a) ……..

b) …….

c) …….

Activity 2

Visit a fish-landing centre nearby and observe various species of fish which are dressed. Find out the species from which fairly large sized liver is obtained. Also visit a fish liver oil extraction unit and find out types livers used for oil extraction, quality of fish livers, preservation methods adopted for fish livers and the yield of oil obtained for each type of liver.

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1.9 LET US SUM UP

For the production of fish meal and body oil, generally, low value, oily pelagic fish are being used. In India, oil sardine (*Sardinella longiceps*) is extensively used for this purpose. When these fishes are landed in large quantities, it is necessary to convert these fishes into stable products such as fish meal and oil. Most of the times, these products are obtained from the same industry. Poor quality raw material fish gives meal and oil of unacceptable quality. Hence, there is a need to preserve fish till it is utilized by the industry. Now-a-days wet reduction method is being most commonly adopted by the industry for fish meal preparation as this is suitable for any type of fish and better quality finished products are obtained. Press liquor when it is still hot is strained, decanted and centrifuged to get body oil. After separation of oil, the press liquor is evaporated and protein recovered is added to the fish meal. Fish liver oil is not a product of fish meal and oil industry. It is manufactured by a separate industry. Liver oils are valued for their content of oil, soluble vitamins such as vitamin A and vitamin D. Some liver oils such as cod liver oil is valuable not only for the vitamins, but also for its content of omega 3 (ω_3) fats which finds application in the manufacture of pharmaceutical products. Both fish body oil and liver are highly reactive and hence care is to be taken to preserve during packaging and storage.

1.10 GLOSSARY

Body Oil : Oil present in whole fish especially under the skin layer.

Civic : Relating to, or belonging to a city, a citizen, or citizenship; municipal or civil.

Coagulate : To change from a liquid into a soft semisolid mass.

Cyclone Separator : It is an equipment which collects small sized particles (dust) and drops it at one place.

Denature or Coagulate Proteins : Changing the structure of native proteins which results in its loss of water holding capacity.

Flue Gases : Hot carbon-dioxide and other gases produced when a fuel is burnt.

Hammer Mill : An equipment used for milling hard material to get powder.

Inedible Parts of Fish : Parts of fish other than muscle or meat.

Lumps : Compacted large sized mass of a material.

Obnoxious : Repulsive.

Potency : Capacity to produce strong physiological or chemical effects.

Putrefaction : Bacterial degradation of fish tissues.

Sharple's Super Centrifuge : A kind of centrifuge which separates oil, water phase and suspended solids.

Three Phase Decanters : An equipment, which separates solid phase from liquid phase.

1.11 SUGGESTED FURTHER READING

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1.13 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1) a) Inedible parts of fish and crustaceans of fish freezing industry.

   b) Fish dressing waste of surimi industry.

2) Oil sardine.

3) a) Anchovy b) menhaden c) pilchard d) herring

4) Surimi

5) Poor

6) Sodium nitrite and formaldehyde

Check Your Progress 2

1) a) Wet reduction method b) Dry reduction method

2) Lean, less than 2-3 %

3) 90 – 95°C

4) Screw press

5) a) direct drier b) indirect drier

Check Your Progress 3

1) press liquor

2) 78, 6, 16

3) Yield

4) Vitamin A, Vitamin D

5) ù $_3$(Omega 3)

6) a) Direct steaming with agitation

   b) Percolator method

   c) Cold extraction method