Design of Semi-Commercial Plant for the Production of Shark Liver Oil

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The design of a 1000 kg day^{-1} capacity shark liver oil plant is described. Process including refining operations, complete specifications and functions of individual equipment are described. A process flow sheet and equipment layout are also indicated.

Shark liver oil is an important source of Vitamin A and to a lesser extent Vitamin D. Oil can be extracted from shark liver by simple process. About thirty seven species of shark and thirtytwo species of skates and rays have been recorded in Indian waters, of which about a dozen are commercially important. Among them the most profitable sharks with regard to vitamin contents are *Carcharhinus melanopterus, Carcharhinus bleekeri, Sphyrna zygaena, Pristis microdon* and *Galocerdo tigrinus*. Total landing of Elasmobranch in India is estimated at 57,860t during 1980 of which more than fifty percent is shark.

Sharks vary in size from 30 cm to 6 m in length and livers also vary from few gram to two hundered kilogram by weight. Livers may weigh 10 to 25% of the total body weight and contain 60–75% oil. Oil yield and vitamin content have inverse relationship. Oil from bigger sharks contains more unsaponifiable matter and less vitamin as compared to livers from smaller shark which is valued more for its high vitamin A content. Several well defined processes have been developed from time to time as reported by Stanby (1967). Among them Milbu process, Lofoten and Finmark process, Islandic process, Schlotherhore German process, Titan process and De Laval process are commercially important. All these processes are basically same that is reduction of liver and release of oil by applications of steam but they differ in equipment used.

The present communication pertains to the design of a commercial production unit based on a simple process (Tressler & Lemn, 1951) and simpler form of equipment available within the country for the production of shark liver oil.

The process

The process of production of shark liver oil may be divided into three steps, namely, the preservation of raw liver, extraction of oil from liver and refining of oil. A process flow sheet and equipment layout are given in Figs. 1 and 2.

a) *Preservation of raw liver:* Livers are graded according to size, smaller liver rated higher and according to quality namely (1) firm and pinkish red (first quality) (2) firm greyish externally and reddish when cut out (medium quality) and (3) flabby whitish both externally and internally (inferior quality). The liver is treated within 6 h. of catch, gall bladder is removed and the gland washed well. Blood is bled out from veins, cut into small size and washed well. In case it is to be preserved and transported over a long distance the livers are packed in 5 kg G.I. drums with telescopic mouth in ice or it can be preserved for short time by putting little washing soda. For longer storage, the livers may be packed in sealed container and deep frozen at –29°C. It can also be stored for short duration using a mixture of 9 parts of carbonate of sodium

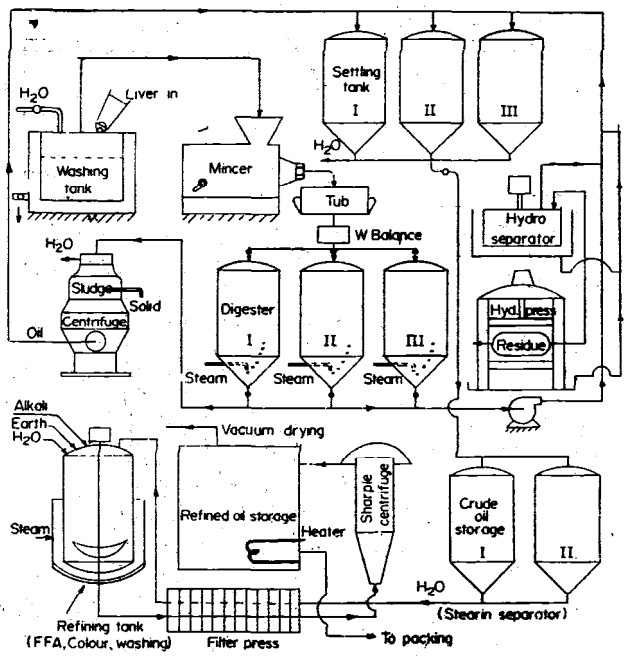

Fig. 1. Flow sheet for shark liver oil plant.

+1 part $NaNO_2$ + 10 parts water and mixed with liver in 5% level. Fresh liver is ideal as with storage free fatty acid increase and vitamin content goes down, specially if it comes in contact with light and air. Before processing, preserved livers should be washed well to remove all chemicals.

b) *Extraction of oil from liver:* Livers are washed well to remove blood and chemical preservatives, drained, weighed and ground coarsely in a mincer. Minced liver is then mixed with little water (5:1) to make a slurry and pumped into cylindrical digester tanks provided with open steam coil and cooked by passing open steam through the mass to disintegrate the liver tissue and release of oil. After digestion, t e released oil may be separated by gravity settling method or preferably by a three-phase De Laval sludge centrifuge to separate oil. In some case, solid and liquid is separaed by a hydro-separator (basket centrifuge) and solid can be further pressed in a hydraulic

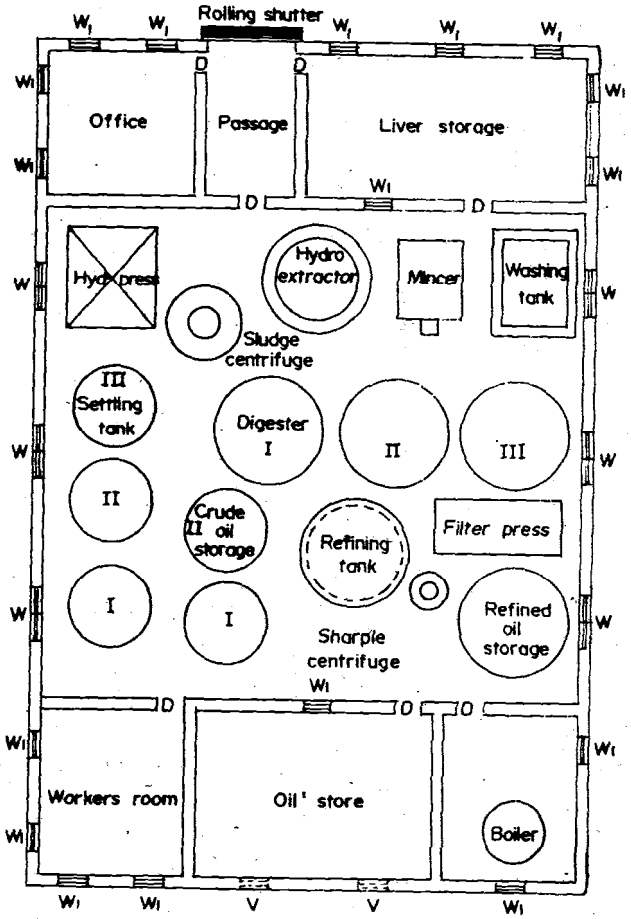

Fig. 2. General layout of shark liver oil plant

press to remove last traces of liquid. Gravity separated oil is further processed in a Sharple centrifuge to remove water from the oil. Solid is generally discarded.

c) *Refining of oil*

i) Stearin separation by winterization: Crude oil obtained above undergoes refining process to remove stearin, free fatty acid (FFA), colour and water. Stearin is separated by winterization process by holding the oil at O°C in tank provided with cooling coils for 14 to 20 h or more. Stearin is separated by filtration.

ii) Alkali refining: Alkali refining of oils is carried out in a special vessel called neutralisation tank to reduce the FFA value of oil to a desired level by adding alkali (1 to 6 N NaOH depending on FFA content). Alkali solution is sprayed on the oil in the neutralization tank under constant agitation and heating and then cooled down for 24 h. "Foots" settled at the bottom is removed by decantation. Bleaching earth or activated charcoal is added if oil is required to be bleached and filtered in a plate and frame filter press. After this step, the refined oil is washed in water to remove any free alkali and finally dried in a Sharple centrifuge. Refined oil which contains Vitamin A in concentrated form is stored in sealed containers.

Equipment and their functions:

1. *Boiler*

For generation of process steam Vaspa LB–5 model coal/wood fire small capacity boiler free from boiler act regulation. Working pressure: 5.5 to 7 kg cm^{-2}, Evaporative capacity: 100 kg h^{-1} (Approximately). Fuel consumption: 16 kg h^{-1} coal complete with all accessories and fittings feed water pump, burner, air blower, pressure reducer, all types of gauges etc.

2. *G.I. receiving tank*

Capacity 5 kg, 200 nos.

3. Cemented washing tank

Capacity 1 m^3 1 no. This is required for washing of liver for complete removal of blood, sodium carbonate or salt with soft water. The tank should have a water inlet pipe and a large diameter water outlet pipe covered with sink with valves. It is preferable, if the inside of the tank is lined with glazed tiles. The washed water is tested with phenolphthalin or silver nitrate solution to see that the water is free of carbonate or chloride.

4. *Helical screw type meat mincer: Capacity* 100 kg h^{-1}, 3 nos.

For mincing the liver into 1 mm size, complet with suitable hp geared motor, (440 volt, 50 Hz A.C.) helical screw, cutter blades and perforated disc, platform made out of aluminium, structure and reversing arrangement.

5. *Aluminium tubs and plastic buckets etc*

These vessels of various sizes and capacities are required to handle various materials such as livers, minced livers, oils, residue, water etc. Preferably a slurry pump may be used for pumping minced slurry to the digester.

Aluminium tubs

a) Capacity – 150 *l* (500 mm dia × 800 mm × 12 swg with cover) — 2 nos

b) Capacity 100 *l* (450 mm dia × 650 mm × 14 swg with cover) — 2 "

c) Capacity 200 *l* (550 mm dia × 850 mm × 10 swg with cover) — 4 "

d) Bucket 15 litres — 12 "

Bucket 10 litres — 4 "

e) Plastic mugs, 1 litre — 12 "

f) G.I. tubs 200 *l* (850 mm dia × 6000 mm) — 4 "

g) Forks with long handle, laddle, spoons, knives etc — 1 doz each

6. a) Platform balance – 100 kg capacity, 1 no.

b) Single pan balance – 10 kg capacity, 6 nos.

7. Digester (cooker) with steam coils - 3nos. Capacity 250 litres.

Type - 750 dia × 1,000 mm height with conical bottom, made of aluminium sheet (or stainless steel sheet) with open steam coil, easy charging and discharging arrangements with valves etc.

This is the most important equipment and should be properly designed. In this vessel minced liver is mixed with water (5:1) and cooked by passing open steam through the mass. Open steam cooks as well as agitates the mass, disintegrates the liver tissue and releases oil. The same vessel may be used as settling tank if gravity separation method is used. So the vessel should preferably be fitted with a glass window to see oil level.

8. Aluminium settling tank: 3 nos - capacity - 200 l (600 mm dia × 750 mm × 150 mm height conical bottom with 40 mm flange valve, made of 10 swg sheet mild steel stand etc, and level gauge indicator. These vessels are absolutely essential if gravity separation method is used.

9. Hydro-separator or basket centrifuge - 1 no.

Capacity - 500 mm dia × 300 mm height - stainless steel basket

Type – Top suspended, bottom discharge, variable speed drive (6,000 - 9,000 r.p.m. directly coupled to suitable 3 phase 440 volt 50 Hz A.C. motor, Basket (perforated) may be lined with stainless steel/nylon filter cloth. Complete, ready to install unit. This is required for removing solid residue and separation of oil - water slurry obtained from digester which goes to settling tank(8).

10. Hydraulic press, 1 no.

Pressure developed	–15 kg cm^{-2}
Press volume	0.5 × 0.5 × 0.5 m^3
Hydraulic fluid	Hydrocrabon oil

Completed with high pressure hydraulic pump, motor (3 phase, 440 volt 50 Hz A.C.), Strainer basket, ram, gauges and oil collection arrangement. This is to be used for removing liquid portion from cooked mass obtained from digester in case equipment no. 9 is not available. This is a filtration process using nylon bag and external pressure.

11. Three phase centrifuge (De Laval sludge centrifuge) Capacity, 250 l h^{-1}, 1 no.

Completed in all respect with accessories and necessary spares. By this equipment, oil, water and solid residue from the mixture obtained from digester can be individually and continuously separated. This is the most useful equipment and if available, all three equipment (8, 9, 10) can be avoided but this being not manufactured in India, it may be difficult to obtain.

12. Mild steel crude oil storage tank, 2 nos.

Capacity - 1,000 *l*

A cylindrical vertical tank made out of 3 mm m.s. plate provided with inlet and outlet pipes with valves. Here crude oil is stored and thereby stearin is precipitated. Better effect is obtained if these tanks are placed in rooms at lower temperature and provided with brine cooling coil.

13. *Plate and frame filter press - Capacity, 200 l h^{-1} 1no.*

May be made out of brass, stainless steel and completed with filter cloth, pumps etc. This filter press is used to filter outsolid stearine from oil as stated in 12. The filtered oil is sent to 14. In its absence, equipment No. 9 and 10 can also be used.

14. Steam jacketed neutralisation tanks (Refining tank) Capacity 250 l h^{-1} no.

This tank is used for alkali refining of oil to remove free fatty acid. This is a cylindrical tank with conical bottom similar to digester tank and is provided with steam jacket (or closed heating coil), agitation assembly by means of motor (or by hand laddle), caustic sprayer, inlet for bleaching earth, oil inlet and outlet and bottom drain valve for sediment ("Foots"). This tank is heated to 55–60°C with oil and alkali added (1 to 6 NaOH depending on FFA content of oil) under constant agitation and then cooled down for 24 h. Sediment is removed from the bottom by decantation. Bleaching earth or activated charcoal is added if oil is required to be bleached and oil mixture is again filtered using plate and frame filter press.

Some processors prefer FFA and stearin separation as well as bleaching to be performed at this stage and then single filtration step by plate and frame filter press.

After alkali refining, the oil is washed well with water to make it free of alkali (to be tested) by using the same vessel in the usual way.

15. Sharple super centrifuge–Capacity 100 l h^{-1}, 1 no.

This is a liquid-liquid centrifuge used for removal and drying of oil to make it free from water at the final stage after refining. Refined oil then goes to packing section. This standard equipment should be in assembled condition.

16. Pure oil storage tank: Capacity–2000 l, 1 no.

M.S. tank provided with a bottom outlet tap. The pure refined concentrated vitaminised oil is packed in 5 l tin cans manually or automatically.

Discussion

In the preparation of the design, special attention has been paid in the selection of equipment to keep the investment cost low by suggesting aluminium vessels wherever possible. In case of non-availability of a particular equipment, alternative equipment have been suggested thereby giving a wider choice for the selection of equipment. Another aspect is that this design is complete with refining unit which are not normally available with the existing plants in India. Due to this, the producer can supply high grade oil. Specifications for a few sophisticated equipment have been given here in case they are available along with non-sophisticated equipment.

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