Fish Meal and Oil from Fish Waste: An Industrial Perspective

Elavarasan Krishnamoorthy

Fish Processing Division

ICAR-Central Institute of Fisheries Technology, Cochin

Email: elafishes@gmail.com

Introduction:

In the year 2016, 88.5% of the world fish production used for human consumption and the rest around 11.5 MT diverted for non-food uses which includes meal and manure. Fish processing generates a huge amount of raw material as waste (45-55%). The processing waste includes skin, scale, visceral mass, head, fins, filleting frame waste etc. If these fish processing wastes are left unattended, they create pollution problems, civic problems and can cause spread of diseases such as cholera. Hence, there is a need to convert these waste into stable products such as fish meal and oil to overcome the problems.

WORLD FISHERIES AND AQUACULTURE PRODUCTION AND UTILIZATION (MILLION TONNES)[a]

Category	2011	2012	2013	2014	2015	2016
Production						
Capture						
Inland	10.7	11.2	11.2	11.3	11.4	11.6
Marine	81.5	78.4	79.4	79.9	81.2	79.3
Total capture	**92.2**	**89.5**	**90.6**	**91.2**	**92.7**	**90.9**
Aquaculture						
Inland	38.6	42.0	44.8	46.9	48.6	51.4
Marine	23.2	24.4	25.4	26.8	27.5	28.7
Total aquaculture	**61.8**	**66.4**	**70.2**	**73.7**	**76.1**	**80.0**
Total world fisheries and aquaculture	**154.0**	**156.0**	**160.7**	**164.9**	**168.7**	**170.9**
Utilization[b]						
Human consumption	130.0	136.4	140.1	144.8	148.4	151.2
Non-food uses	24.0	19.6	20.6	20.0	20.3	19.7
Population (*billions*)[c]	7.0	7.1	7.2	7.3	7.3	7.4
Per capita apparent consumption (*kg*)	18.5	19.2	19.5	19.9	20.2	20.3

[a] Excludes aquatic mammals, crocodiles, alligators and caimans, seaweeds and other aquatic plants.
[b] Utilization data for 2014–2016 are provisional estimates.
[c] Source of population figures: UN, 2015a.

(Courtesy: FAO, The state of world fisheries and aquaculture, 2018)

Fish meal

Fish meal is a dry product having brownish grey colour and milled to a fine to course powder. It is produced by removal of 90 to 95% of water and fat present in the raw material. Generally oily pelagic fish is being used all over the world for fish meal manufacture. It is a good source of major nutrients such as protein and contains fair amount of fat. It is rich in essential minerals, namely phosphorus, calcium and iron. It is also a good source of micro minerals, oil soluble vitamins and water soluble vitamins.

Fish oil

Fish oil is a by-product obtained during fish meal production and then subjected through various steps in order to yield the final product. The oils contain mainly triglycerides of fatty acids (glycerol combined with three similar or different acid molecules) with variable amounts of phospholipids, glycerol ethers and wax esters. It is characteristic of the oils that they contain a wide range of long-chain fatty acids with the number of carbon atoms ranging mainly from 14 to 22, and high degree of reactivity (unsaturation) ranging up to six double bonds per molecule (FAO, 1986).Fish oil is high in unsaturated fats and also aids in reducing blood cholesterol level. They are imparting positive effect in powerful metabolic and physiological regulators, which also influence the excessive fat deposition in the arteries.

- body oil of fish is more important as an industrial product besides its limited use in human consumption.
- body oils have recently won much attention
- Contains poly unsaturated fatty acids (PUFA), particularly n-3 PUFA
- n-3 PUFA used in the control of heart ailments in humans
- known to haveanticholesterolemic effect
- highly unsaturated fish body oils can be used as drying oils in paints and varnishes
- as a medium in fish canning.
- finds use in margarine
- used as carriers of fat soluble vitamins A and D. find use in the manufacture of linoleum, detergents, artificial rubber, lubricants, printing inks, soaps etc.

Manufacturing Process

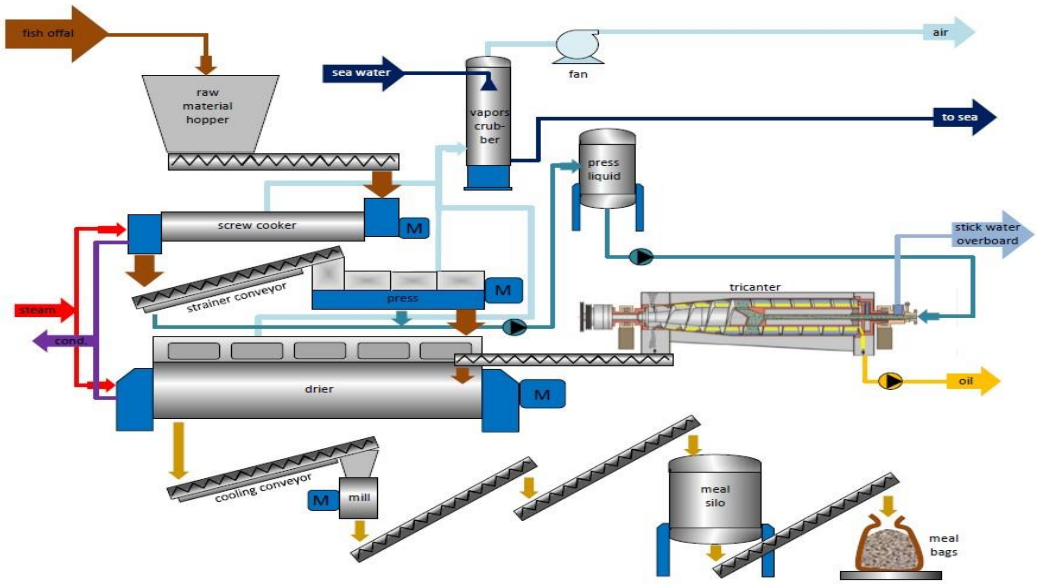
The main objective in the production of fish meal is to reduce the moisture content of fresh fish (70-80%) to about less than 10% in the meal. In other words, about 90-95% of moisture in fresh fish is to be removed. Oil content in the fish meal should not be more than 10%. Hence, 80 to 90% of oil present in fish has to be removed during fish meal production.

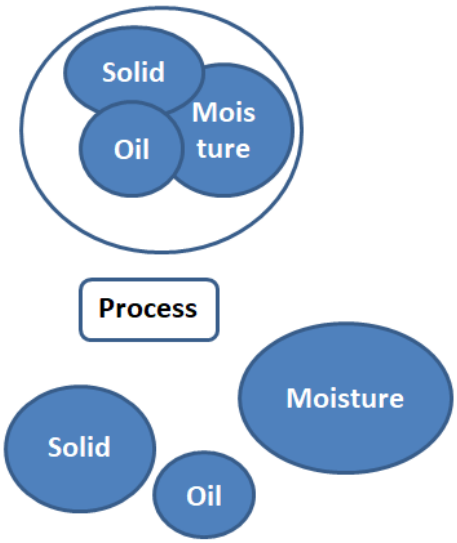
There are essentially two methods of fish meal production.

(1) Wet reduction method (suitable for low fat and high fat raw material)
(2) Dry reduction method (suitable for low fat raw material)

At present bulk of the fish meal is produced by wet reduction method all over the world including India. The main unit operations involved in fish meal production by wet reduction method is shown in the process flow.

Process flow in fish meal and oil production from processing waste





In India, oil sardine (*Sardinellalongiceps*) 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. Freshness of fish is very important in getting good quality fish meal. If the fish has lost its freshness, it will have high TVBN content and consequently, the meal produced from it will also contain high TVBN which is unacceptable to shrimp feed 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. In this case also, the quality parameters regarding freshness of waste have to be maintained. Generally, fish meal produced from fish processing waste; contain low percentage of proteins and high proportion of ash/minerals. Hence, it is not possible to produce Grade I fish meal using only wastes from fish processing industry.

Process steps in reducing the fish waste to fish meal and oil

- heating, which coagulates the protein, ruptures the fat depots and liberates oil and physico-chemically bound water
- pressing (or occasional centrifugation), which removes a large fraction of the liquids from the mass
- separation of the liquid into oil and water (stickwater). This step may be omitted if the oil content of the fish is less than 3%
- evaporation of the stickwater into a concentrate (fish solubles)
- drying of the solid material (presscake) plus added solubles, which removes sufficient water from the wet material to form a stable meal
- grinding the dried material to the desired particle size

Unit operations in fish meal production

1. Receiving of Raw Material

2. Cooking

In general, cooking is done at a temperature of 95 to 100oC within 15-20 minutes. Most manufacturers operate cookers to heat the fish mass rapidly to 95oC. 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.

3. Pressing

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

(1) Solid phase (press cake) and
(2) Liquid phase (press liquor).

Pressing is done using a screw press. The press may be a single screw press or a double screw press. At present, double screw press is preferred as it removes maximum quantity of oil and moisture from cooked fish.Usually press cake coming out of the screw press contains about 45-55% of water and 2 to 3% fat. Press liquor coming out of the press is saved for oil extraction.

4. 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. In the present day fish meal plants, this step is eliminated as press cake is disintegrated by the screw conveyor which transfers press cake from the press to dryer.

5. Drying

In the drying process, fluffed press cake containing about 50% moisture is dried to a moisture content of less than 10%. Two types of driers are commercially used.

1. Direct driers or flame driers

2. Indirect driers or steam heated driers.

At present, direct dryers are seldom used by large scale fish meal manufacturers for several reasons.

It takes about 20 minutes for the press cake to travel from hopper to the exit of the drier. The moisture content of press cake coming out of the drier should be 10% or less. The dried press cake is then passed through a magnetic separator to remove any steel contaminants.

6. Cooling

The fish meal is cooled in coolers. Cooler is equipment which is similar to the drier except that instead of steam, cold water is passed. In the cooler dried fish meal is cooled to room temperature.

7. Sieving

Dried press cake is passed through a vibratory screen specially those who use trawl bycatch to separate extraneous materials such as wood, cloth, fishing hooks, shells and nails prior to milling.

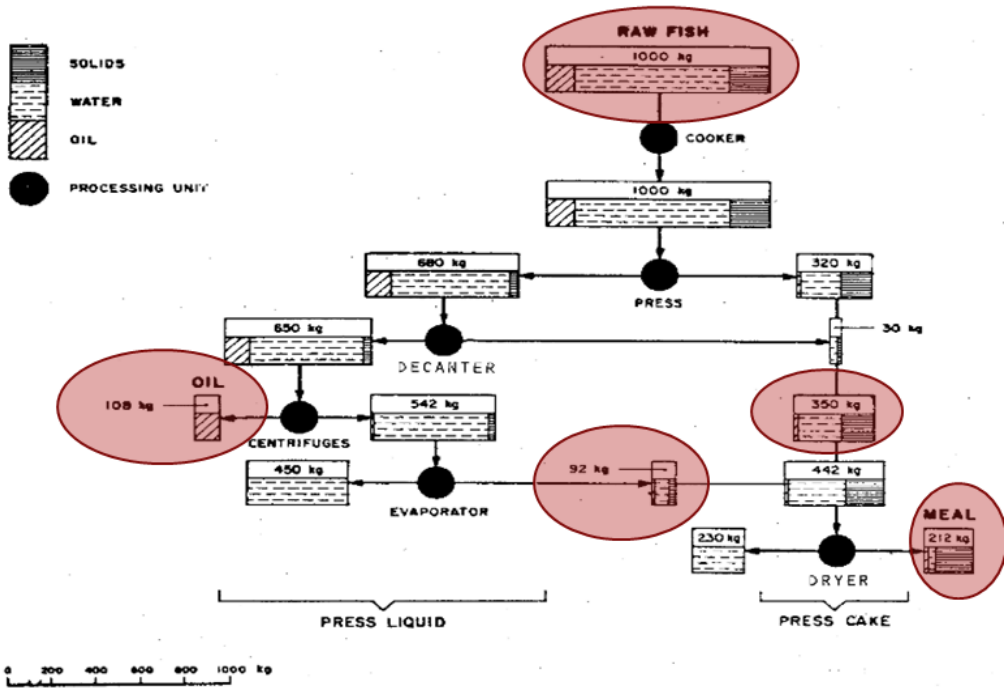
8. Milling

The important objective of milling is to produce fish meal with small particles averaging around No.40 mesh Tyler screen. 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 connected to a cyclone separator to reduce the problem of dusting.

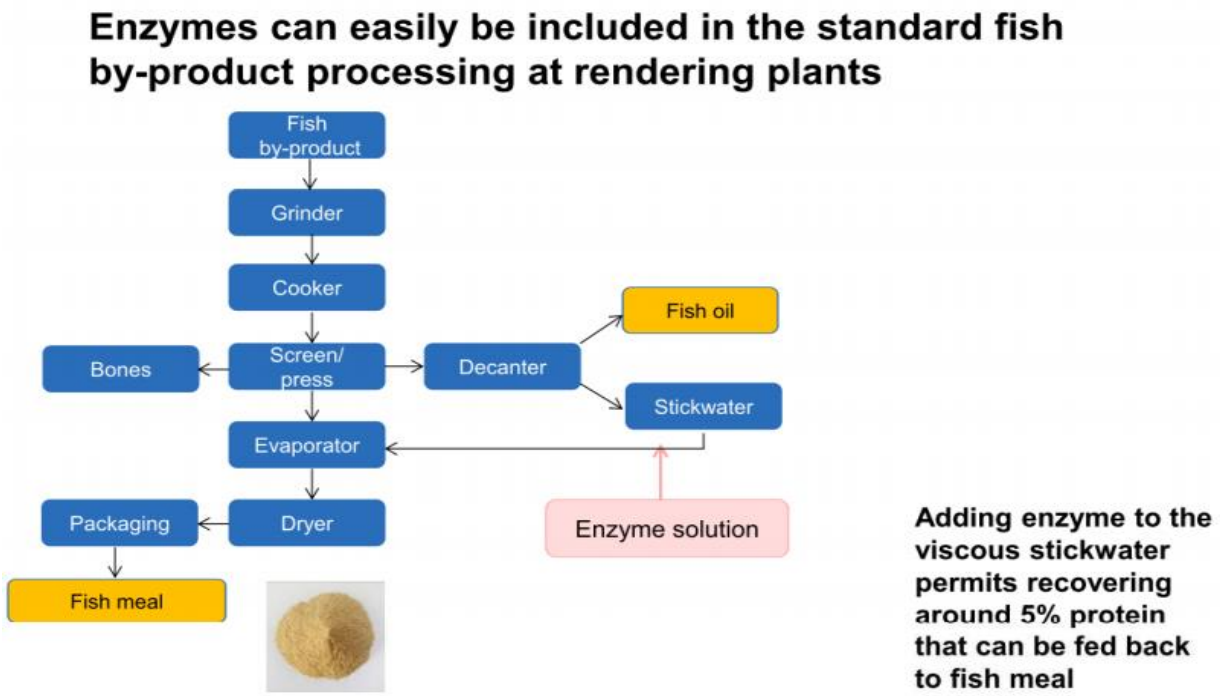
9. Packing, Labelling and Storage

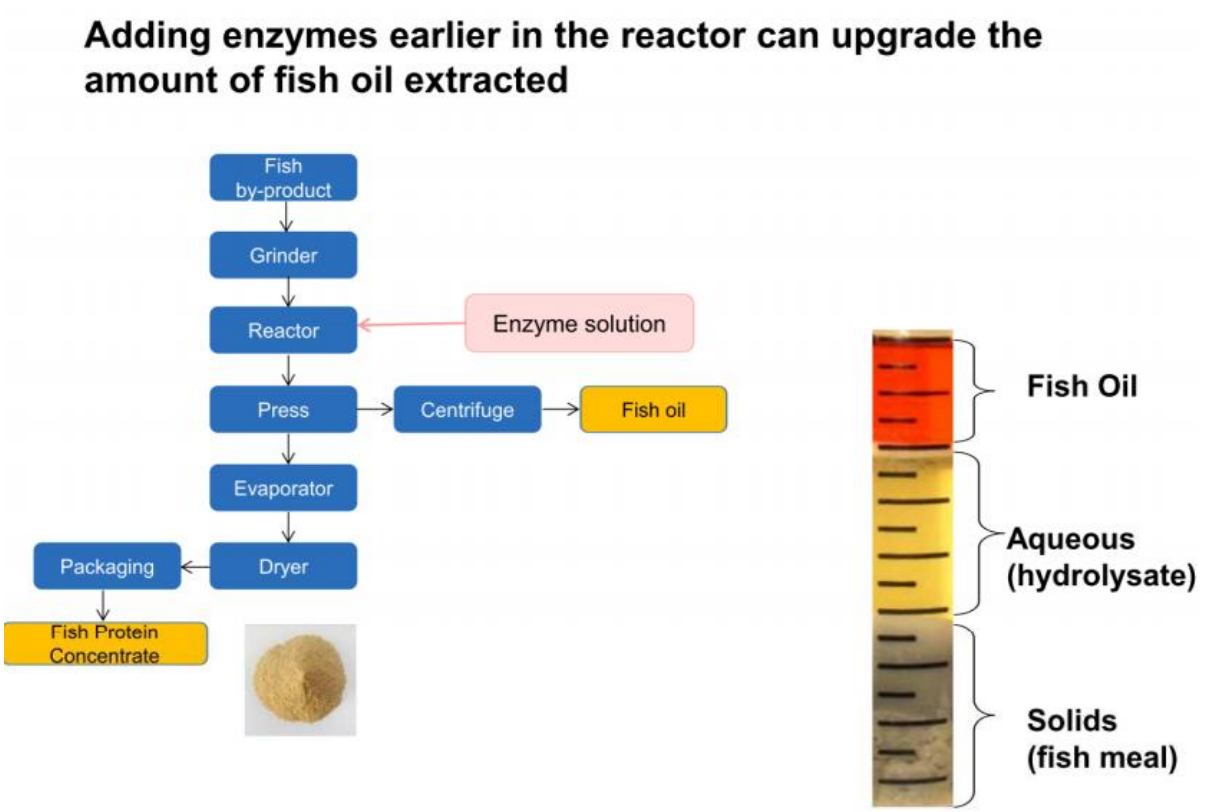
Fish meal is usually packed in polyethylene (PE) lined jute bags or PE lined paper bags or PE lined HDPE woven sacks. The outer packaging is then properly labeled.

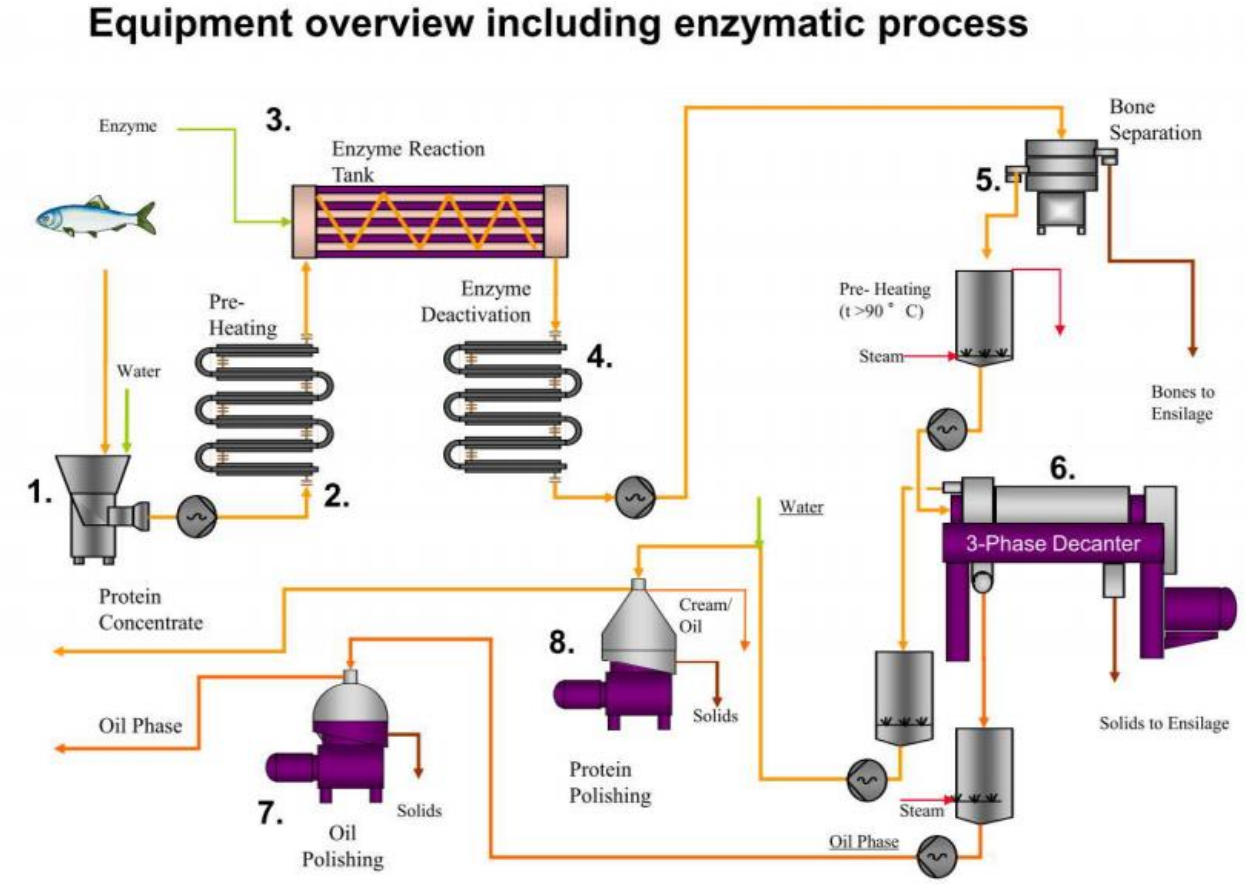
Mass balance



Enzymes in fish meal processing







Importance of Fish Meal

The nutritive components present in fish meal and their importance in animal, poultry and fish nutrition is discussed below.

1. Depending on the raw material used in its manufacture, its protein content may vary from 40% to 60%. Hence, fish meal is considered as a concentrated source of protein and it is easy to incorporate with other feed ingredients so that the desired protein level is maintained.
2. Protein present in the meal is a good source of all essential amino acids and hence must be provided in the diet. As protein of fish meal contains all essential amino acids, its nutritive value is high.
3. Fish meal protein is a rich source of amino acid lysine which occurs in deficient quantities in most of the cereals and legumes.
4. Fish meal supplies water soluble B group vitamins such as riboflavin, niacin pantothenic acid, choline, vitamin B12 in addition to oil soluble vitamins such as vitamin A and D. As fish is a good source oil, the meal produced from it contains oil to the extent of 6 to 10%. Oil present in meal contributes towards energy for fish, animals and birds. This oil helps in growth and fattening of fish, animals and birds.
5. Fish meal made from whole fish containing bones is a rich source of essential minerals such on calcium, phosphorous and magnesium. Calcium is required for bone formation in animals and birds. Fish meal is also a good source of iron. In addition to major minerals, fish meal also supplies trace elements such as iodine,

molybdenum, copper, zinc and manganese, all of which are required for various biochemical processes going on in the body of fish animals and birds.

6. Crude fibre content in fish meal is very low. Birds require low content of fibre in their diet. For proper digestion & absorption of nutrients, the feed should be low in fibre content, specially for fish and poultry. Hence, fish meal is particularly suitable for poultry feed.
7. Fish meal contains certain growth factors such as protein utilization factor and animal protein factor which make the feed with fish meal to give maximum nutritive value as these factors ensure that the dietary proteins are utilized to a maximum extent in their body.

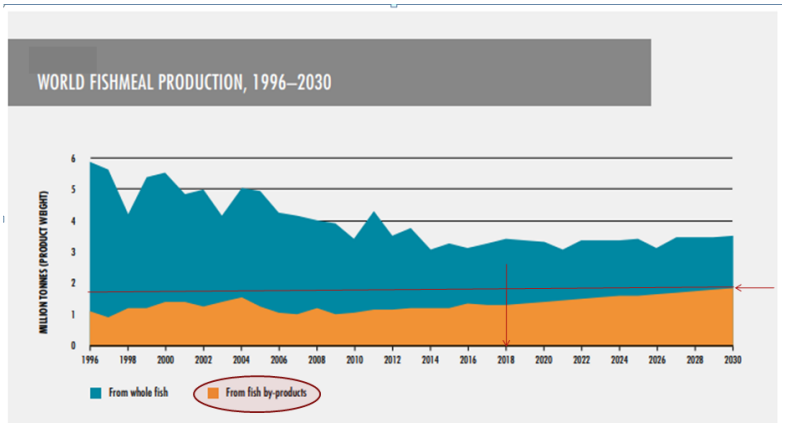
Fish meal-2030

- About 16 percent of capture fisheries yield will be used to produce fishmeal in 2030.
- The estimated fishmeal and fish oil production, in product weight, should reach 5.3 million tonnes and 1.0 million tonnes, respectively.
- In 2030, fishmeal production should be 19 percent higher than in 2016, but about 54 percent of the growth will derive from improved use of fish waste, cuttings and trimmings obtained from fish processing.
- Fishmeal produced from fish by-products will represent 34 percent of world fishmeal production in 2030, compared to 30 percent in 2016 (Figure 51).
- The fish model does not take into account the effects of the use of fish by-products on the composition and quality of the resulting fishmeal and/or fish oil.
- Possible effects include lower protein and increased ash (minerals) and small amino acids (e.g. glycine, proline, hydroxyproline) in comparison with products obtained from whole fish.

This difference in composition may hinder increased use of fishmeal and/or fish oil in feeds used in aquaculture and livestock farming.

(Ref: World bank report on Fish 2030)

According to FAO, in the year 2030, about 50% of world fish meal production will be manufactured from seafood processing waste.



References

- Windsor, M.L., 1971, Fish meal. TorryAdvis.Note, (49):12 p.
- FAO, 1986. The production of fish meal and oil.FAO fisheries technical paper – 142
- http://www.iffo.net/publications
- FAO. 2018. The State of World Fisheries and Aquaculture 2018 - Meeting the sustainable development goals. Rome. Licence: CC BY-NC-SA 3.0 IGO
- World Bank (2013) Fish to 2030: prospects for fisheries and aquaculture. World Bank, Washington

****