Fish Processing Waste: A Valuable Raw Material for Meal, Silage, Foliar Spray and Animal Feed

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Fish is a highly perishable food material because of its moisture and nutrient contents. It is undoubtedly one of the most nutritious of foods available for human consumption. Fish flesh on an average contains 15-20 percent protein. Processing of fish leads to enormous amounts of waste. It is estimated that fish processing waste after filleting accounts for approximately 75% of the total fish weight. The total fish weigh around 30% remains as waste in the form of skins, and bones during the preparation of fish sticks fish fillets and other products. This secondary row material is an important for the preparation of high-value products including protein foods. The important of secondary row materials helps to destroy harmful environmental aspects and improve quality in the fish processing industry. Fish processing generates solid wastes that can be as high as 50-80% of the original raw material. Skin and bone are sources of high collagen content. An important waste reduction strategy for the industry is the recovery of marketable byproducts from fish wastes. Hydrolyzed fish wastes can be used for fish or pig meal as well as fertilizer components. The three most common methods for utilization of aquatic waste (either from aquaculture or wild stock) are the manufacture of fishmeal, fish oil and healthy feed, the production of silage and the use of waste in the manufacture of organic fertilizer. The utilization of by-products is an important cleaner production opportunity for the industry, as it can potentially generate additional revenue as well as reduce disposal costs for these materials. The transportation of fish residues and offal without the use of water is an important factor for the effective collection and utilization of these by-products. Another important waste which can be used for industrial purpose is prawn shell waste and crab shell waste.

1. Fish meal

Fish meal is solid product which is obtained by grinding the fish and fish byproducts and removal of water and all/ some oil (Ruiter, 1995). Fish meal is generally sold as a powder, and is used mostly in compound foods for poultry, pigs and farmed fish; it is far too valuable to be used as a fertilizer. Fish meal is regarded as highly concentrated nutritious supplement in feeds which contains high quality proteins, vitamin-B, minerals, etc.

1.1 Raw material used for production of fish meal

Raw material used for production of fish meal varies from region to region depending on the availability. In general, three types of raw materials are used in fish meal manufacture which includes oily pelagic fish (oil sardine), low values whole fish containing more bones, inedible parts of fish and shellfish. Region specific raw materials are anchovy in Peru, Menhaden in USA, Pilchards in South Africa, Herring and Capelin in Norway, and oil sardine in India. Oil sardine is most commonly used for fish meal and fish oil production in India due to its availability.

1.2 Production of fish meal

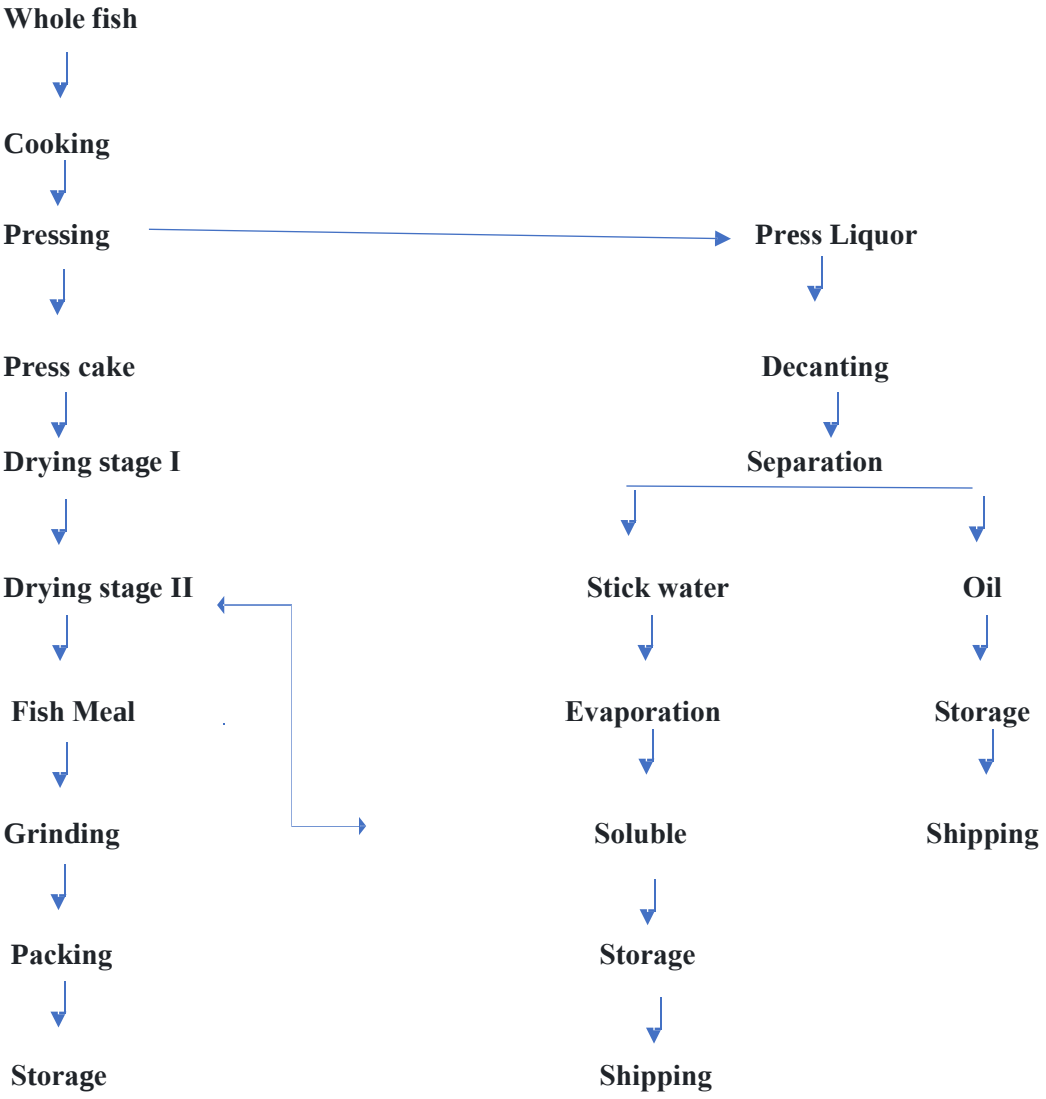
Methods of production of fish meal include; i) Dry rendering ii) Wet rendering

The dry rendering or dry reduction method is suitable for lean fish containing less than 2-3% oil. It is not a continuous process. The wet reduction method is continuous and can be used for the production of fish meal from fatty fish. Wet rendering is a commonly used method of fish meal production throughout the world.

Process of Fish Meal Production: The following steps will be followed for fish meal production;

1. **Cooking**: after grinding, the material is cooked at a temperature of 100°C for 20 minutes in indirect steam. This process stops microbiological and enzymatic activity in the product and helps to separate the oil.
2. **Pressing**: In this process, mechanical pressing is done to separate the material into two types of phases. The liquid phase and the solid phase.
3. **Decanting**: In this stage, the liquid phase is decanted to recover more solid products and add them to the solid phase.
4. **Centrifugation**: In this procedure, the liquid phase is centrifuged. As a result, oil and water will be obtained.
5. **Evaporation**: the evaporation is done in the "tailwater" which is excess liquid, it is intended to reduce the volume of the product to concentrate it better and obtain solids.
6. **Mixing**: The solids remaining from centrifugation are mixed with the solid cake obtained from pressing until a paste is obtained.
7. **Drying**: Drying extracts more water from this mixture until the moisture content is reduced to 5-10%. This prevents bacteria growth and reduces chemical reactions.

8. **Additives**: Additives such as antioxidants are added to fishmeal.
9. **Packaging**: Fish meal is stored at ambient temperature either in HDPE bags. The fish meal does not require any refrigerating during storage



Process flow diagram of fish meal and fish oil production

1.3 Chemical composition of fish meal

- In general, chemical components in fish meal are protein, fat, ash and moisture which are 50-70%, 5-10%, 12-33% and 6-10% respectively.
- Proteins in fish meal are rich in all essential amino acids which are not synthesized in body and need to be supplied from the diet. All essential amino acids present in fish meal makes it highly nutritive. Fish meal contains lysine in rich quantities which is deficient in cereals and legumes.
- Fish meal supplies vitamins such as riboflavin, niacin, pantothenic acid, choline, Vitamin B12 in addition to fat soluble vitamins such as Vitamin A and D. oil present in fish meal contributes to energy for fish and other animals.
- Average values of vitamins in fish meal are riboflavin – 7.3 mg/100 g of fish meal, niacin 126 mg/100 g of fish meal, pantothenic acid - 30.60 mg/100 g of fish meal,

Vitamin B12 – 0.25 mg/100g of fish meal, pyridoxine – 5.7 mg/100 g and choline – 4000 mg/100 g of fish meal. Fish meal also contains a significant quantity of Vitamin D due to residual oil in fish meal (5000 IU/ kg of fish meal).

- Inorganic constituents of fishmeal accounts for 11%. Indian fish meal exhibits higher proportions of phosphorus to calcium 1:1 against 1:2 proportions in other fish meals.
- Fish meal made from whole fish containing bones is rich in calcium, phosphorus and magnesium which are essential for growth. Mineral content in fish meal ranges from 25 to 30%. Mineral composition of fish meal involves zinc – 70 mg/kg, iodine – 70 mg/kg, iron – 250 mg/kg, copper – 7 mg/kg, manganese - 4 mg/kg, cobalt – 0.1 mg/kg
- Fish meal contains lower amounts of crude fibre in their diet which is good for proper digestion and absorption of nutrients in poultry and fish feeds.

1.4 ISI- Requirements for fish meal as poultry feed ingredient

1. Fish meal shall be in the form of powder ground to such fineness that 99 percent of material shall pass through 2.80mm IS Sieve.
2. The material shall have the characteristic odour and shall he free from any off-odour indicative of spoilage.
3. The material shall be free from adulterants, arthropod infestation, visible fungal growth and any harmful material.
4. **Packaging**: Fish meal shall be packed in high density polyethylene bags or jute bags with polyethylene lining inside. The mouth of each bag shall be either machine stitched or rolled over and hand stitched.
5. **Labelling**: Each bag shall be suitably marked or labelled with the following information: a) Name and grade of material, b) Name of the manufacturer, c) Batch or code number indicating the date of manufacture. d) Net mass in kg, and e) Guaranteed composition

ISI- REQUIREMENTS FOR FISH MEAL AS LIVESTOCK FEED INGREDIENT

Parameters	Grade I	Grade II
Moisture (%max)	10	10
Crude protein (% min)	60	50
Ammoniacal nitrogen (% max.)	0.5	0.5
Crude fat (% max.)	10	10
Acid insoluble ash (% max.)	3	3
Chloride (as NaCl) (% max.)	4	5

2. Fish Silage

Fish silage is a liquid product and it can be prepared from whole fish or fish waste by adding acid, enzymes, lactic acid producing bacteria or by naturally occurring enzymes in fish. Fish silage is rich in protein and aminoacids and it can be used as protein source for animal feeding. Production cost for fish silage is very cheap, cost effective and eco-friendly. Fish silage preparation usually depends on locally available raw materials and conditions (Hasan, 2003). Depending on the process employed, fish silage can be categorized into two methods, viz. acid silage and bio-fermented silage. Acid silage is produced by mixing fish waste with organic acid (formic acid, acetic acid, propionic acid), inorganic (sulphuric acid, hydrochloric acid) and or a mixture of both organic and inorganic acid. In case of bio-fermented silage, fermentation process is carried out by lactic acid bacteria (LAB) which are already present in a fish mass or added externally.

2.1 Fish silage preparation by Acid method

In this method, whole fish or fish waste are pulverized in mechanical mincer and then required quantity of acid is added and mixed well ensuring a pH of 4 for the acid silage prepared by using organic acid. Then it can be stored in containing with occasional stirring. During this process, the biomass gets liquefied by endogenous enzymes present in fish mass with the aid of added acid. Fish silage, a liquid product will be ready between 15-20 days. At 25^0C, the process takes two days for liquefaction, where as at 15^0C , it takes 5-10days. Moreover, if temperature $>40^0$C enzymes may get deactivated. Hence, ensilation process under higher temperature should be avoided. The degree of liquefaction in silage depends on the nature of raw material. The liquefied silage gets separate into 3-4 layers; an oily layer at top, liquefied protein at middle layer and undigested protein and sludge at the bottom. The incomplete protein digestion may depends on nature of raw material, pH, temperature and duration of ensilage. Moreover, all the layer can be separated and used as biofuels, agricultural fertilizers and feed for pet animals. Formic acid is most commonly used for silage production. Generally, 3% by weight of 98% formic acid is added to well pulverized fish waste. Silage prepared by using formic acid will have a shelf life of one year at room temperature in tropical countries.

2.2 Fish silage preparation by Fermentation

In this process, fermentation process is aided by addition of lactic acid bacteria and jaggery source. Since, the natural lactic acid bacteria in fish is limited, an external inoculum of lactic acid bacteria is needed. Molasses, a fermentable jaggery source are mostly used in fish ensilage

due to its low cost easy availability. The ratio of fish and molasses at 100: 10 will give stable silages with typical acid smell. The presence of sugar (jaggery), ensilation process gets initiate and prevents immediate deamination of amino acid by bacteria. Later, fermentation process dominated by lactic acid bacteria which results in pH reduction and it inhibits or reduces spoilage bacteria. The most commonly used lactic acid bacteria strains are *L. plantarum*, *L.acidophilus*, *Pedaucoccus halophilus* and *P.acidilactici*. The production of fermented ensilage depends on the in-situ production of lactic acid bacteria by added lactic acid bacteria to the fish or fish waste with a fermentable jaggery source. The concentration of lactobacillus used for fermentation is 10^6-10^8 cfu /ml.

2.3 Utilization of Fish Silage

2.3.1 Feed

Fish Silage are used for animal feeding, like powder fish silage is used to feed cattle, milk cow, swine, duck, sheep, mink and many other terrestrial animals (Rahmi et al., 2008, Al-Abri et al., 2014, Anuraj et al., 2014). Pigs resulting in higher growth rates improved health and reduced mortality. Fish silage rich in protein and it can be used as a protein source for broiler chicks alternative to fish meal to get increased weight and feed conversion ratio (Kjos et al., 2000). In many countries, it is used as bird feed (Arruda et al., 2007). It is also used as a feed supplement in aquaculture to convert nutrients into flesh. It has been reported that fish silage powder was found to give better growth than a fish meal in carp (Djajasewaka et al., 1986). Fish silage can be used directly as feed for pigs for improving higher growth rate, reduce the mortality and improving heath of animals. Fish silage can also mixed with other ingredients such as grains and dry flour for livestock feed. Since, fish silage contained hydrolysed protein it can be used as protein source by replacing fish meal at the level of 5-15% in fish feed preparation. It has been reported that inclusion of silage in pellet feed showed stronger, more resistant and reduce the waste during transportation and feeding.

2.3.2 Fertilizer

Fish silage is considered as potential source of Nitrogen, Phosphorus, Potassium, Calcium, magnesium and found to have application as a fertilizer. The quantity of nutrient present in fish silage differ depends on quality of raw material used and percentage of bones and fins. Moreover, adding 5-10 % liquid silage will meet the trace element required for plants.

2.3.3 Foliar spray

Foliar spray is a liquid fertilizer directly to their leaves by spraying. Plants are able to absorb essential elements and nutrients through their leaves and absorption takes place through the stomata of the leaves and also through the epidermis. Movement of elements is usually faster through the stomata and this result in faster growth and flowering. Some plants are also able to absorb nutrients

3. Feed from fish processing discards

Feed is considered as the major expense in fish farming, accounting for about 50– 60% of the total variable costs. Preparation of feed for aquaculture and poultry is an important option for utilization of general, unsorted waste from industry as well as fish markets. There is a growing demand for pellet feeds, due to the increase in aquaculture activity. Feed is also a major input affecting water quality and subsequently effluent quality in culture ponds. Fish feed management includes several factors viz. choosing the right feed, using a correct feeding method, calculating the feeding cost and ensuring the cost effectiveness of fish farm. Currently, aquaculture accounts for 40.33% of the world's fish production. Fish frames and other discards contain significant amounts of muscle proteins. They have a better balance of the dietary essential amino acids compared to all other animal protein sources. About, 25% of the protein requirement for feed is met from fish waste. The proximate composition and characteristics of many processing wastes suggest that it can be converted directly into feed. Most of these protein sources can be converted to fish flesh, which in turn provides quality protein for man. Utilization of these wastes can be direct or indirect. In direct utilization, either the wastes can be used as such as in the case of meals; cakes etc. or it can be used with some simple processes like fermentation, silage preparation etc. In indirect utilization, the wastes can be utilized as a substrate for the growth of single cell proteins for example, and these secondary products can be included in feed with or without primary substrate. Fish waste can be macerated into paste and prepared at farm site as meal and used for feed. Alternatively, fish waste may be initially converted to meal or silage, which later on can be made into feed after compounding with other essential nutrients like carbohydrate, fat, trace minerals and vitamins.

3.1 Quality of animal feed

Apart from nutritional composition, the quality of animal feed may be expressed in terms of physical quality and microbial quality. Physical evaluation is easy but tough in nature. One must be highly trained to identify the changes in the nature of the raw materials/ feeds. This

primarily involves parameters such as such as bulk density, colour, odour, hardness (force at rupture), durability, pellet size and water stability. Handling practices followed presently for fish processing waste are not adequate and hence may harbour a number of microbial hazards including lethal toxins and metabolites. Salmonella is a major bacterial hazard in animal feed. E. coli also has been detected in animal feeds. Similarly, the contamination of foods and animal feeds with mycotoxins is a worldwide problem. Mycotoxins are fungal secondary metabolites that have been associated with severe toxic effects to vertebrates produced by many important phytopathogenic and food spoilage fungi including Aspergillus, Penicillium, Fusarium, and Alternaria species.

4.0 Conclusion

Fish processing waste from seafood Industry and retail market leads to major issue in waste disposal and environment pollution. The most important products prepared from the fish waste are fish protein hydrolysis, fish collagen/Gelatin, antioxidants, fish sauce, biogas, and biodiesel. Most of the byproducts prepared from fish waste are used for the pharmaceutical purpose or for food purposes. Apart from extraction of biomolecules from fish waste, it can also be converted to fish silage to preserve the bioavailability of nutrient in fishery waste and reduce the environmental pollution.