MODULE 1: EVALUATION OF FISHERY DISCARD AS A VALUE-ADDED PRODUCT

Developed by:

Prof. Dr. Ozgur ALTAN*
Assoc. Prof. Dr. Ilker AYDIN**

EGE University Faculty of Fisheries
*Department of Aquaculture
**Department of Fishing Technology
Bornova-Izmir, TURKIYE

Contents

Summary

A crucial concern for fishery management is lowering by-catch and discard rates. Worldwide, economic losses as well as ecological effects on biodiversity are gravely tragic issues. Fisheries engineers have conducted numerous studies to lessen these effects, particularly concerning the selectivity of fishing gear. It can be claimed that, despite the positive findings of many of these studies, the fishermen's practical success is limited by commercial considerations. Because of the multi-species nature of bottom trawl fishing, over 40 different species of fish are caught every operation, particularly in Mediterranean waters. Among these, a sizeable portion of the overall catch consists of species that are discarded for a variety of reasons other than those that are assessed commercially. Thirty-five percent of the world's harvest comes from fisheries, and a large portion of that is wasted or lost. Given this, it is now essential to develop strategic responses to the growing global population and depleting food supplies. To apply Project MARIPET, instruction on the potential uses of abandoned fishery products as pet food by bringing them ashore is intended.

1 Explanation of the Terms of Discarded Fish and Fish Meal

1.1 Discarded Fish

The word "discarding" refers specifically to the act of returning captured animal species back to the ocean instead of keeping them. The financial sustainability of fisheries as well as the sustainable exploitation of marine biological resources and marine ecosystems are all adversely impacted by discarding, which is a significant resource waste. An estimated 7 to 10 million tonnes of commercial fisheries catch are discarded each year worldwide. Fishermen discard for a variety of reasons, and the amount varies depending on the area, species, and fishery. This inefficient practice is intended to be discontinued by the EU's common fisheries policy. Since its introduction in 2015, the landing obligation has been in full effect as of January 2019. Although the products that must be landed in accordance with the established criteria cannot be used directly as human food, they can be made available as raw materials in the production of fish meal and pet food as a product with increased added value. Its goal is to eliminate discards by encouraging fishermen to fish more selectively and to avoid unwanted catches [1]. While the products that must be landed based on the established standards are not suitable for direct human consumption, they can be utilized as raw materials to produce higher-quality fish meals and pet food. The process of turning leftover fish into fish meals and its potential application as a raw material in the pet food sector are covered in this module.

1.2 Fish Meal

Fish meal is a proteinaceous flour material. It is produced by cooking, pressing, and drying, followed by grinding of complete fish or unwanted fish pieces to obtain fish powder. Fish meal is made from small, pelagic, oceanic fish such as menhaden, herring, anchovies and sardines. The small fish are pulverized, and the oil and water are pressed out. The remaining solids are cooked and pulverized into a meal. Water is separated from the remaining liquid to provide fish oil as a byproduct of fish meal manufacturing [2]

Fish meal is the primary protein source in aquafeeds, and concurrently it is a limiting factor in the aquaculture industry and conventionally used as a livestock feed supplement. For carnivorous fish species, as its crude protein levels are between 65-72%, aquafeeds have been mostly dependent on the FM as the principal protein source for several motives; for its superior essential amino acid profile, high protein content, better nutrient digestibility, and absence of antinutritional factors (ANFs) [3]. The inclusion of FM as the primary protein source in compounded aquafeeds is now a hazard that threatens feed manufacturers to depend on it. Accordingly, feed formulators look for alternative feedstuffs that can replace an FM with no adverse effects on fish performance [4]. In the meantime, the fish waste meal is

readily available, less expensive than FM, considered to be suitable, and has a sustainable supply for replacing FM in commercial aquafeeds [5].

Fish meal is also made from bycatch and processing wastes from the capture fishery for human food. Food and Agriculture Organization of the United Nations (FAO) estimates that 17.7 Mt of the global catch was for fish meal production [6]. This portion is called the reduction fishery. According to The Marine Ingredients Organization (IFFO), the usual yields of fish meal from live fish are 22.5% and 4.8%, respectively. The reduction fishery of 17.7 Mt in 2018 yielded an estimated 3.98 Mt fish meal. About 5.2 Mt of fish meal was produced in 2018 [7]. This suggests that around 1.22 Mt of fish meal was derived from bycatch, fish trimmings, and other processing waste.

Around 97% of the world's fish meal production is used in animal feeds, of which aquaculture feed requires the most (69%), followed by pig feed (23%), and poultry feed (5%). Over half of the fish meal used in aquaculture is included in salmonid and crustacean feeds [6].

The amount of wild fish embodied per tonne of feed is difficult to assess because many feeds do not contain fish meal or oil, some have fish meal only, some have fish oil only, and some have both. Most feed manufacturers are not willing to divulge the percentages or sources of fish meal and fish oil used in their formulations. The source is needed because fish oil and fish meal from fish processing wastes are not considered by most authors to contribute to wild fish use. The proportions of the fish meal and fish oil derived from fish processing waste may be subtracted from the inclusion rates. Fish meal and fish oil are coproducts from wild fish, and the ratio of fish meal to fish oil in a formulation determines whether all fish oil can be considered associated with the fish meal. If the ratio equals or exceeds 4.69 (the ratio of fish meal to fish oil yield from wild fish), all the fish oil can be considered a coproduct of the fish meal included in the feed.

1.2.1 Production Steps of Fish Meal

Catching: The majority of the feed-grade fish harvested for fishmeal production are small, oily, quickly growing fish with little demand for human consumption. Fishing nets with government-specified mesh sizes are used to catch them. Government controls will determine the time and place of catching in order to guarantee that quotas are met. Trackers that enable satellite tracking are carried by many boats. This helps the government monitor whether fishing is taking place within the designated zones and hours. Boats are also frequently inspected upon landing. We keep an eye on the kind, size, location, and timing

of the fish they catch. To keep the fish fresh and cold and prevent damage, refrigerated seawater is typically utilized.

Processing: As fish is discharged at the factory it is weighed and sampled. Most IFFO Members sample at this point to check fish freshness which is monitored using TVN; fishermen may be paid based on the weight of the catch and its TVN (freshness) to encourage high-quality raw material to be landed. Fish is first typically cooked to coagulate protein and allow some oil to be released, using a temperature of 85°C to 90°C. In addition, micro-organisms are killed by this process (see diagram). Clean conveyors, holds and storage pits, short storage time and reduced temperatures minimize micro-organisms and the spoilage they may cause. The lower temperatures also reduce fish enzyme activity (autolysis), another form of spoilage. Cooked fish then passes into a screw press where liquor is pressed out and the solids (press-cake) go to the drier. The liquor is decanted to remove further solids. It is then centrifuged to spin off oil and separate out an aqueous phase (stickwater). The stickwater passes through evaporators to reduce its volume (concentrate). This concentrated liquor (called stickwater because it tends to be viscous and sticky) is returned to the press cake entering the drier. A typical drier contains coils through which super-heated steam passes. These coils raise the temperature to 90°C (controlled by flow rate etc.) for drying to around 10% moisture after cooling. Low-temperature driers such as indirect hot-air or vacuum driers, operate at lower temperatures. Fish oil may go on to be purified to remove solid impurities; special filters can be used where appropriate to remove some fat-soluble impurities. More sophisticated refining is used to produce a clear odorless liquid for pharmaceutical/nutraceutical uses e.g. capsules.

Handling: Fishmeal contains no carbohydrates. At a dry matter content of 90%, it will not support microbial growth. But it can pick up micro-organisms from extraneous material. Hygiene throughout the process is extremely important. This is controlled using the schemes detailed below. During fishmeal handling cleanliness is paramount to ensure no cross-contamination. Fishmeal can be stored in 25kg bags, one-tonne bulk bags, or in bulk in warehouses, to await transport. Fishmeal plants must only handle fish - they cannot handle material from any other animal. Extremely tight controls are now in place in many countries including the European Union and Japan to monitor fishmeal to ensure it is free of land animal material, in common with controls on other raw materials. Most of the fish meal factories have in place Hazard Analysis Critical Control Points (HACCP) schemes to ensure safe production and assured quality. This involves outside inspectors who ensure critical control points are correctly identified and controls

carefully monitored and recorded e.g. product temperature, moisture, microbial count, etc. Any deviation outside tolerance limits is investigated and quickly resolved with full documentation for future reference.

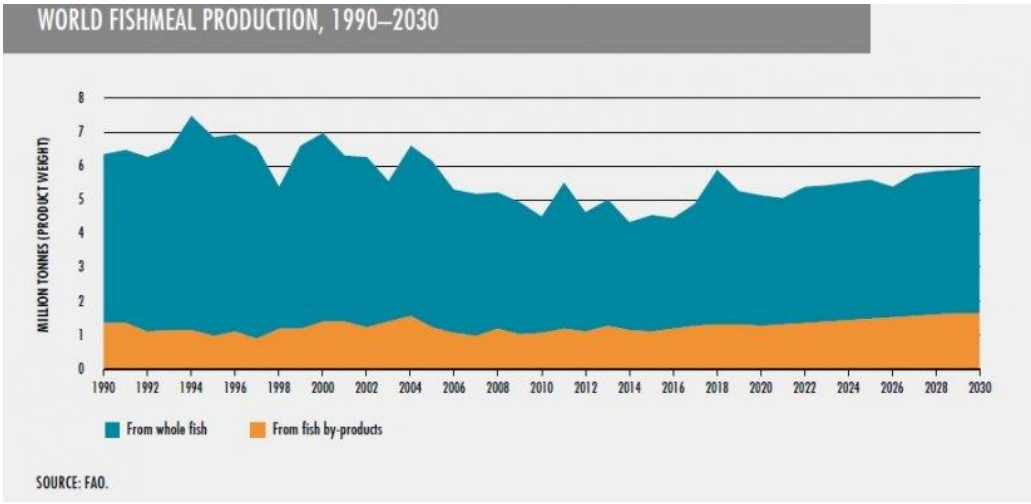
Producers supplying markets within the European Union are being encouraged to adopt the International Feed Standard Alliance (IFSA) quality assurance scheme. This covers quality assurance from raw material through the factory, storage and transport to the end user. It includes the Dutch GMP+ and UK Femas schemes and is expected to become the main quality assurance scheme for raw materials across Europe and elsewhere.

1.2.2 Product Composition

As fishmeal is produced from fish with some water and oil removed, its composition reflects that of the fish's raw material. Fish meal producers are committed to undertaking this production with minimal change in nutritional value. The raw material is handled rapidly and mainly chilled to prevent spoilage.

Standard fishmeal: they are referred to as "fair average quality" (FAQ) when the drying phase is direct hot air, and are ideal for poultry, ruminants and omnivorous fish. For carnivorous fish, crustacea and baby pigs, special products are more suitable. Although they cost more because of the need for even fresher raw materials and special drying, they have been shown to be cost-effective for these more sensitive species.

Figure 1. Global Projection of Fish Meal Production until 2030 [6]



Standard fishmeal typically has 64% to 67% crude protein with up to 12% fat. Special products tend to have more protein - 68% to 72%. They also have a lower amine content reflecting fresher raw material e.g. maximum 1000 ppm histamine. For standard/FAQ products amine limits are generally not needed and therefore not normally specified.

For special fishmeal products processing is gentle. Special driers are needed-typically indirect hot air or vacuum drying. A special product with low-temperature drying is referred to as a low-temperature (LT) or Super Prime meal. If the special driers are not available, a special product can be produced that is slightly less digestible - two or three units less as determined in fish. To check for gentle drying, pepsin solubility gives an approximate guide. For special products, it should be over 92%. Digestibility determined in the target animal is a more reliable method, but expensive. This should be 89% or higher for LT/super prime products. For standard meals, pepsin solubility will generally be over 85%.

2 Use of Discarded Fish in Raw Food Content

Discarded fish can be utilized as a raw material in raw food, which is used to make raw food that is sometimes referred to as "health from the sea" and whose significance in domestic cats' and dogs' nutrition is becoming more widely recognized. We should first discuss the state of the food industry, which supplies pet nutrition all over the world, before utilizing leftover fish as raw food ingredients.

2.1 Global View of the Pet Food Industry

With the emergence of the COVID-19 pandemic in 2020, with the emergence of working-from-home conditions and the closure of people in their homes, a significant activity has been observed around the world. In recent years, it has been determined that at least one pet is kept in 88 million households in the world, 25% of which are cats and 25% are dogs. The amount of food produced for the feeding of these animals has reached 8.5 million tons per year, which is estimated to be 102.6 billion dollars in monetary value. In the calculations, it was determined that the sector grew by 2.6% per year [8].

2.2. Diversity of Pet Food Types

2.2.1. Dyr Food and Canned Food

It would be useful to examine the food industry under three main headings. The first of these is the dry food sector. Thanks to today's developing mixed feed production technologies, the foods produced by the method called extrusion under a certain temperature and pressure are stored in the desired package size and offered for sale. When looking at the production stages, raw material supply, grinding to bring the raw materials to the same size, mixing that ensures homogeneous raw material distribution, the addition of vitamin and mineral premixes that support meeting the nutritional requirements of the animal, conditioning in which water vapor and oil are added, cooking in a feed shaping device called an extruder, It consists of stages that enable the food to be brought to room temperature, and finally packaging it to reach the user. The basic production steps are given in Figure 2.

Figure 2. Production Steps of a Dry Food

Source: https://www.feedpelletplants.com/pet-food-processing-technology.html

In the second place, canned products, which can also be defined as wet food, can be mentioned. In this type of product, it can be mentioned that animal foods that have been processed using heat treatment and that have been protected with various food chemicals. Wet food is produced in a very different process than dry food. Generally, meat by-products, vegetables, grains, minerals and fats are mixed with water and gelling agents and then ground into a puree. Then it is partially cooked in a steam

tunnel to solidify, and the products are cut into cubes by cutting with knives. Thus, the product looks like a real piece of meat and is filled with sauce or gel and placed in a can or container, then the container is closed and cooked in a pressure cooker for about two hours to ensure sterilization. Due to these process conditions, it is very difficult to produce a completely nutritionally balanced wet food and usually needs to be supplemented with a supplement in the daily diet.

2.2.2 Raw Food – Biologically Approved Raw Food (BARF)

Cats and dogs naturally have a raw diet. Many additives not found in these creatures' natural diet and support elements such as food processing technology are used in the contents of dry and wet foods, the production technologies of which are specified in the above sections. On the other hand, no heat treatment, food or digestive supplements can be used in raw food production, and it is stated that feeding in this way has a positive effect on animal health and lifespan. Animal-based products such as cow meat and fat, cow liver, cow trachea, calf spleen, chicken meat, tripe, anchovy, cow udder and egg are included in the raw foods produced using cold chain and HACCP principles in accordance with the nutritional requirements of cats and dogs. Vegetable and fruit products such as olive oil, rice, apple cider vinegar, beets, broccoli, carrots, zucchini, pumpkin, green apples and spinach, and all-natural products such as cinnamon, turmeric and cumin are available. In processes such as mixing and packaging these products, the cold chain is not allowed to be disrupted, and the cold chain is required for the products to be delivered to the end consumer, consumers should store these products in a deep freezer at -18°C.

The structural differences between dry food and raw food are shown in the table 1. The most important differences between feeding with raw food and feeding with dry and wet food are as follows;

- Animal health is maximized when pet owners switch to raw food;
- Disorders related to internal diseases, especially organ failures, are largely eliminated;
- The average life expectancy of animals increases.

Considering these differences, it can be thought that every pet owner will want to feed raw food. Despite these positive factors, it would be appropriate to mention the difficulties in raw food production and consumption.

Supply of raw materials: Raw materials of discarded fish and terrestrial animal origin (beef liver, cow udder, spleen and some offal products) used in raw food are used. It may not be possible to supply these products every day of the year and in the same quantity.

Transportation of raw materials: The products listed are products that are suitable for rapid microbiological and bacteriological deterioration. It must be transported using the cold chain absolutely.

Storage of raw material: Cold air environments at +4°C, 0°C, -18°C and -40°C are needed until it is used in production;

Delivery of the product to the end consumer - pet owner: It must be transported by cold chain within 24 hours at the latest, as shocked at -40°C.

Pet owner's storage conditions: Freezer for storage at -18°C, refrigerator for 0°C or +4°C.

Defrosting and use of raw food: It should be removed from -18°C and defrosted at +4°C in 36 hours. Once defrosted, it is not possible to freeze the product again. The daily usage rate is 2-3% of the average live weight of the animal.

Table 1. Basic Similarities and Differences Between Raw and Dry Food

Criteria	Raw Food	Dry Food
Production Technology	Raw material, grinding and mixing	Extrusion
Nutrient loss due to heat treatment in production	-	+
Grain content	-	+
Energy, protein and fat availability	Maximum level	Medium level
Food digestibility	Maximum level	Medium level
Increase in muscle mass	High	Low
Presence of additives in the content	-	+
Health of internal organs	High	Low
Daily defecation amount	1	2 - 4
Possibility of encountering allergic problems	-	+
The amount of milk and protein of the broodstock individuals	High	Medium
Protein content (%)	35 - 45	25 - 28
Level of omega 3 and 6	High	Low
Shedding and odor	Very little	High
Storage conditions	Deepfreeze-Refrigerator	Cool, dry and moisture-free environment

References

1. European Commission, https://oceans-and-fisheries.ec.europa.eu/fisheries/rules/discarding-fisheries_en).
2. Saleh, N.E., Wassef, E.A., Abdel-Mohsen, H.H. 2022. Sustainable Fish and Seafood Production and Processing. Academic Press, pp: 259-291. https://doi.org/10.1016/B978-0-12-824296-4.00002-5.
3. Masagounder, K., Ramos, S., Reimann, I., Channarayapatna, G. 2016. Optimizing nutritional quality of aquafeeds in Aquafeed Formulation, pp: 239-264.
4. Daniel, N., 2018. A review on replacing fish meal in aqua feeds using plant protein sources. International Journal of Fisheries and Aquatic Studies 2018; 6(2): 164-179.
5. Baeza-Ariño, R., Martínez-Llorens, S., Nogales-Mérida, S., Jover-Cerda, M., Tomás-Vidal, A. 2016. Study of liver and gut alterations in sea bream, *Sparus aurata* L., fed a mixture of vegetable protein concentrates. Aquac. Res., 47 (2016), pp. 460-471, 10.1111/are.12507.
6. FAO. 2022. The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation. Rome, FAO. https://doi.org/10.4060/cc0461en
7. IFFO (The Marine Ingredients Organization). 2017. Fish Meal Production. https://www.iffo.com/production (Access: May 2023).
8. Chaudhary, T., 2022. Pet Food Market Research. www.marketresearchfuture.com (Access: June 2023).