Chapter 2
Trends in the Use of Seafood Processing By-products in Europe

Fatih Karadeniz and Se-Kwon Kim

Contents

F. Karadeniz
Marine Bioprocess Research Center, Pukyong National University,
Busan 608-737, Republic of Korea
e-mail: karadenizf@pknu.ac.kr

S.-K. Kim (✉)
Specialized Graduate School of Convergence Science and Technology,
Department of Marine-bio Convergence Science, Marine Bioprocess Research Center
Pukyong National University, 45, Yongso-ro, Nam-gu, Busan, 608-737, Republic of Korea
e-mail: sknkim@pknu.ac.kr

S.-K. Kim (ed.), *Seafood Processing By-Products: Trends and Applications*,
DOI 10.1007/978-1-4614-9590-1_2, © Springer Science+Business Media New York 2014

1 Background

1.1 Aquaculture

Aquaculture is the farming of marine organisms, including fish, shellfish, crustaceans, and plants. It is accepted as one of the fastest growing food industries and is a source of a notable amount of seafood consumed by people.

Aquaculture is also progressively improving industry in Europe, which directly has 65,000 employees and provides almost one-fifth of fish production. With the help of the latest technology and research, the European Union (EU) is known for its high quality production methods and high standards of processing units for aquaculture. However, the yield of EU aquaculture industries has been steady for a decade, while worldwide aquaculture production is reported to have grown by 30 % (Eurostat 2009). Hence, for the development of more competitive aquaculture industry, the EU is focusing on new funding and programs through the European Fisheries Fund. All these improvements and other alternatives are supposed to potentially generate a significant amount of waste; however, its utilization is under pressure from commercial and practical difficulties enforced by several European Committee regulations. Except the regulations for obtaining a waste utilization license, the treatment of aquaculture and capture fishery wastes is carried out with methods no different than those used worldwide.

Seafood waste is produced by several different methods in aquaculture, which can be grouped as follows;

Common deaths: Animal deaths can be observed regularly in aquatic farms in relatively low amounts mostly due to chronic diseases, equipment problems, and handling errors. Commonly, these wastes are blended, stored, and later removed according to waste management regulations with a predefined cost, which is around 100 Euros per ton (2007). Removal of these wastes mainly includes incineration, landfill, and export to countries that need it for value addition.

Destructive deaths: These wastes include the animals which are killed en masse from an external effect, such as algal invasion and other animal attacks. These wastes are usually treated directly in waste utilization plants.

Infected animals: Aquaculture disease control is tightly regulated in the EU as it is free of several diseases, such as infectious salmon anemia, viral hemorrhagic septicemia, and infectious hemorrhagic necrosis. In case of any signs of infectious diseases, all suspicious animal ponds are cleaned of organisms by slaughtering, storing, and exporting to countries with capable utilization plants, such as Norway. In addition to infectious diseases, animals which are contaminated with environmental pollution and not suitable for human consumption are also treated the same as infected animals (Anon 2000).

Processing by-products: After successful harvest, fishery animals are processed via several industrial equipments. In addition to main plants that process harvested seafood from numerous aquatic farms, some small farms have their own processing units, which makes waste production variable and something that needs to be controlled.

1.2 Wild Fisheries

Unlike aquaculture, the amount of waste from wild fisheries varies depending on the species and type of product that is to be obtained. Waste from catch animals mainly comes from on-shore processing, while a small amount of waste is also produced from processing at sea.

Processing on-board: The deep-sea catch is commonly processed at sea. The waste produced, which is mainly viscera and heads, rarely reaches land and is discarded into the sea.

On-shore processing: The remaining catch fisheries are processed mostly in on-shore plants, which results in the main waste production being on-shore as well. Depending on the type of desired product, some parts can either be defined as waste or removed for consumption, such as fillets, flaps, or lugs.

1. Waste Utilization and Disposal Regulation
   The decision of how and whether the waste will be disposed or utilized for value addition is strictly driven by official regulations. In the EU, both the European Committee and national regulations exist to control and regulate waste disposal and utilization in European countries.

The European Communities Disposal, Processing and Placing on the Market of Animal By-products Regulations (SI 257, 1994) have been laid down in order to control the use, sale, and disposal of high- and low-risk animal by-products and tightly limit the use of by-products compared to disposal. Moreover, EC Regulation No. 1774/2002 of the European Parliament (amended by EC No. 808/2003) exists for health concerns regarding the animal by-products which will be used for purposes other than human consumption. All these frameworks provide a regulation over the classification, hence the disposal and utilization mechanism of animal wastes which affect the wild fisheries and aquaculture wastes for the foreseeable future. Waste categorization can be seen in Table 2.1. These regulations put fish wastes mainly in category 2 rather than categories 1 or 3, while processing by-products are considered to be category 3. As the main focus is considered to be on category 2 wastes, it is further regulated by additional regulations to EC No. 1774/2002. The aforementioned regulation, Commission Regulation No. 811/2003, provides further concerns that ban intra-species recycling for fisheries, incineration of by-products, and additional details. Due to these and similarly tight regulations, the processing plants will inevitably be encouraged to develop alternative disposal techniques, such as composting and utilization by further processing.

Table 2.1 Animal-originated by-product categories

Category	Material	Risk and availability
Category 1	Infected suspected infected animal carcasses, toxic compounds, catering waste from international transport, animal material collected from wastewater treatment, contaminated animals, wild animals suspected for human communicable diseases	Very high risk Processing only approved – category 1 plants Incineration
Category 2	Aquaculture mortalities, digestive tract and manure components, animal parts that have been slaughtered for human consumption in case of diseases, animals with veterinary drug residues	High risk Incineration Processing only in approved categories 2 or 1 plants. Biogas production Landfill Feed for zoo and fur animals with prior authorization
Category 3	Parts of animals slaughtered for human consumption, sea animals caught in open sea, fresh fish by-products from processing plants for human consumption	Low risk Processing available in approved plants Raw material for pet food Biogas or biodiesel production Ensilage or composting Animal feed for farming and aquaculture

2 By-product Production by Waste Utilization

2.1 Fish Meal and Fish Oil

Fish meal and fish oil production is the most common way of adding value to fisheries processing waste and turn it into a useful by-product. The most tradition way to produce fish meal starts with breaking down the raw waste by mincing, including whole fish as well as waste parts, such as viscera, heads, and internal organs. Heating of the minced waste in order to overcome any pathogenic or microbial organisms is followed by pressing. The pressing stage separates the solid part of the mixture from the liquid phase, while the liquid phase is subjected to centrifuge and freeze-drying in order to obtain fish oil for further processes. In addition, the remaining pressed solid is processed for the production of fish meal. Air-drying at 60–65 °C is followed by grinding finishes the fish meal manufacturing process. Several countries buy the meal at this stage for further commercial processes; however, commonly, fish meal is bagged and sold after this stage to farms, including aquatic farms, for animal feed purposes after passing the regulations concerning the chemical contents of animal by-products (Tacon and Metian 2008).

The final product of this process results in a fish meal that contains 65–70 % protein, 8–10 % moisture, and 10–12 % oil, as well as varying small amounts of ash, salt, and sand. Although the content and quality of fish meal depend on several points such as plant technology, chemicals, and sterilization techniques used, contamination is unlikely to be preventable. One of the main and suggested preferences is 12 % fat, which prevents combustion.

Throughout the EU, fish meal is mainly used for fish feeds, pig feeds, and poultry feeds, 40 %, 7–12 %, and 2–4 % of the total utilization, respectively. For instance, in the United Kingdom, more than half of 235,000 tons of animal feed were provided by aquaculture by-products annually (Seafish 2001). Recently, the price of fish meal was around 500 Euros per ton in stores; however, the prices changes monthly according to environmental and climate conditions because governmental and EU regulations keep fisheries by-product utilization in a static state and tightly controlled. During the past several decades, fish meal production and use dropped according to the International Fishmeal and Fish Oil Organization (IFFO) annual statistics (IFFO 2003). The ban on fish meal in cattle and sheep feeds by the EU during 2003 is widely accounted for this drop. However, prices tend to remain the same due to high demand worldwide, especially from China and similar countries with improving aquaculture industries (Barlow 2002).

On the other hand, fish oil is also at high demand and is a quite valuable by-product compared to fish meal, which comes from the same source. There can be 20–80 kg of fish oil to be harvested from per ton of fish waste. In Europe, due to economic stability against the dollar and production amounts, fish oil prices stay the same, even after environmental crises, including storms and typhoons. Recently, due to the rising prices of soybean and other vegetable oils used in animal feed, fish oil been becoming more and more demand. However, because of its high free fatty acid content and the 25 % limit of fat in animal feeds due to EU regulations, fish oil is preferred in terrestrial animal feeds rather than aquaculture (Tacon 2004). EU regulations strictly limit the use of these by-products in aquaculture, human health and nutrition, and pet food. The market supply is utilized by other industries, such as leather tanning, lubricants, and supportive materials for the food industry, except for food additives. In this field, Norway leads the production, with 30,000 tons per year, while Chile follows, with a relatively small amount at 8,000 tons.

2.2 Enzymatic Hydrolysate

Enzymatic protein hydrolysate (EPH) is a protein concentrate obtained by the enzymatic breakdown of seafood waste proteins into smaller peptides or amino acids. This method is mostly applied to fresh wastes and, therefore, it is mainly used directly after fresh fish processing in an aquatic environment following oil removal. EPH process protocols differ in every country, and even among plants in the same country. It varies in time, temperature, and pressure used, as well as the types and amount of enzymes. During the process, any unbreakable parts such as skin and bones are used for other purposes, mainly fish meal production, as mentioned earlier in the chapter. Hydrolysates are obtained in liquid phase, further pasteurized, and dried before final utilization (Kristinsson and Rasco 2000). The drying process can be carried out by either a tunnel drier or a spray drier, which is a method used for obtaining krill hydrolysates without a need for pasteurizing. The hydrolysate method costs more and allocates more time and resources compared to other waste treatment methods; however, the price and benefits of hydrolysates in comparison to storage, incineration, and fish meal production are very favorable. Recently, the production of EPH has been increasing, with new plants and more funding throughout Europe. The hydrolysate plant in Boulogne, France produces 8,000 tons per year as one of the biggest plants in Europe, while Norway's new plants are expected to increase this output in the coming years. EPH is still very expensive at almost triple the price of fish meal, around 1,300 Euros per ton.

EPH can contain different amounts of protein and fat, while 80 % protein is suggested to be the optimum and is the most common. EPH is commonly used in Europe in animal feeds as milk substitute, pig weaning additive, salmon feeds, etc. The main drawback of seafood EPHs is the fishy odor, which makes it attractive for animal feeds, but also means that it is quite unusable for human consumption unless the smell is removed from it with further processes. Recent studies suggest new ways to deodorize the fishy smell from enzymatic hydrolysates and hydrolysate plants are planning to use these scientific developments to pave the way for seafood EPH utilization in human food applications (FAO 2010).

2.3 Alternative By-product Production

In addition to fish meal and protein hydrolysate production, there are several smaller fields that use seafood waste or discards and turn them into by-products, which are mostly on market. On the other hand, limitless options exist and numerous options are promoted by several studies; nevertheless, a couple of them have been considered by several processors.

Surimi: Surimi is a Japanese tradition food where fish fillets are ground, rinsed, flavored, and formed into little cakes and sold steam-cooked. Recent popular waves of East Asian culture increased the Asian-based food consumption in Europe. Surimi is one of them and surimi-based products now cover a significant proportion of European markets (Park 2005).

Fish sauces and flavorings: The production of fish sauce and similar derivatives is an important waste treatment method in Asian countries. As mentioned earlier, the popularity of Asian cuisine using fish sauce and flavoring in the European market has increased rapidly as well. However, these processes are quite new for European companies and very small numbers of plants are producing fish sauces and flavoring compared to Asian manufacturers. Companies in Norway and Ireland such as Icon Foods, Co Sligo produce these types of foods.

Biodiesel and biogas: Increasing interest in alternative energy sources other than fossil fuels has raised the utilization of biodiesel and biogas from natural wastes. Seafood wastes are also suggested to be available for biodiesel and biogas; however, there was not a suitable plant in Europe for a long time, except for those in Denmark. Recent plants and funding has promoted biodiesel and biogas production in Europe from seafood oil in the coming years.

Chitin and chitosan: One of the most recent research focuses is chitin and its derivative, chitosan, the second most abundant compound on earth after cellulose. Chitin can be extracted from crustacean shells in the seafood industry and is utilized in numerous industries, such as wastewater treatment, surgical equipment production, dietary supplement, and nutraceuticals. Today's markets for chitin and chitosan in Europe is shifting to dietary supplements as glucosamine and cosmetics for skin protection due to the compound's biosafety, high binding capacity, and dense viscosity.

3 Seafood Waste Treatment and By-product Utilization in Some European Countries

3.1 Norway

Norway is the leading country in Europe for its state-of-art seafood processing and waste treatment plants, supported by both national government and the EU. Norway has sufficient resources and technologies for renowned seafood waste treatment, as expected from the leading country in aquaculture and aquaculture-related research. Several EU countries are exporting their wastes to Norway, where wastes are turned into value-added by-products as an income for the country. In this context, the RUBIN foundation needs to be mentioned for an improved and more profitable use of seafood by-products. It works and tries to increase the utilization of seafood by-products from both wild fisheries and aquaculture supported by scientific developments and new technologies. The RUBIN foundation was founded in 1992 by the Norwegian Research Council, Norwegian fisheries and industry, and some ministries. The Norwegian Fishermen's Association and the Norwegian Seafood Association have owned the foundation since 1998. Up to now, no similar extensive operation has been seen in any other country that works with the aquaculture industry from the start to waste utilization.

Norway produces a notable amount of fish meal from wild fisheries waste, unlike other countries that need aquaculture waste for large amounts of fish mean manufacturing. In 2011, Norway produced 130,000 tons of fish meal from around one million tons of wild fish (USDA, Foreign Agriculture GAIN report 2012). After 2004, followed by Marine Bio Products' involvement in fish protein hydrolysates, Norway started to shift some of its fish meal production into this more profitable and extensive aquaculture waste treatment area dependent on the work of the RUBIN foundation. On the other hand, Silfas, which is the second largest fish meal producer, also developed ways to utilize seafood waste to produce by-products that can be used for human consumption, including protein hydrolysates.

3.2 Spain

Spain is one of the countries that lack a well-established waste treatment plant or industry thereof. Most of the harvested fish are sold to retail shops in unprocessed forms. Therefore, the waste is an individual problem for retailer rather than a large-scale issue for aquafarmers or wild fishers. In Spain, retailers mostly use the waste for direct dumping or bait and feed for further farming or catch. Surprisingly, Spain does not have a planned or funded (national government or EU) seafood waste treatment and by-product solution in spite of the large population and prominent seafood production.

3.3 Ireland

Ireland has a foundation for working at a solution to the disposal of seafood wastes of aquaculture, wild fishers, and final processors named the "National Fish By-products Working Group". In 2003, Ireland's fish waste was declared to be around 65,000 metric tons according to Nautilus Consultants Ltd., including mortalities in aquaculture as well as processing wastes (Anon 2003). Similar to the rest of Europe, Ireland mostly produces fish meal as a by-product of waste. In the light of mass kills and some disciplinary programs in 2003, Ireland's by-product manufacturing tended to be in a recovery state until late 2010, while starting to develop and improve in a steady manner recently.

3.4 Denmark

Denmark hosts two of the largest fish meal companies in all of Europe. Denmark has a role as an intermediate stop for the final processing of Norwegian aquaculture harvest on the way to other parts of Europe. However, Denmark is not usually known to manufacture by-products from aquaculture products. There are other processors in Denmark, such as Lumino for ensilage and composting manufacture and supplying a broad range of fields, mainly poultry and pig farms, with produced by-products from fisheries wastes. As Denmark focuses on producing fish meal, hence, the use of fish oil, it has recently become leading the biogas and biodiesel producer from fish oil and is paving the way for its wide distribution throughout Europe. In addition, Denmark is in competition with Norway for protein-enriched fish meal and protein hydrolysate production with its newly funded foundations for waste treatment.

References

Anon (2000) A code of practice to avoid and minimise the impact of infectious salmon anaemia. The Crown Estate, Edinburgh

Anon (2003) Disposal and re-utilization of fish and processing waste (including aquaculture wastes). Nautilus Consultants (Ireland) Ltd. DK/01/03

Barlow S (2002) Resources and markets: the world market overview of fish meal and fish oil. Paper presented to the 2nd seafood by-products conference, Alaska, Nov 2002

Eurostat (2009) Statistics in focus: aquaculture statistics; 1–5

FAO (Food and Agriculture Organization) (2010) The state of world fisheries and aquaculture (SOFA). Food and Agriculture Department of United Nations, Rome, pp 1–15

Kristinsson HG, Rasco BA (2000) Fish protein hydrolysates: production, biochemical, and functional properties. Crit Rev Food Sci Nutr 40(1):43–81

Mittaine JF (ed) (2003) Digest of selected statistics. IFFO, New Orleans

Park JW (2005) Surimi seafood: products, market, and manufacturing. Surimi and Surimi Seafood. In: Park JW (ed) Surimi and surimi seafood. CRC Press, Boca Raton, pp 375–433

Seafish (2001) Fish waste production in the United Kingdom; the quantities produced and opportunities for better utilization. Seafish report number SR537, pp 56–59

Tacon AGJ (2004) Use of fish meal and fish oil in aquaculture: a global perspective. Aqua Resour Cult Dev 1:3–14

Tacon AGJ, Metian M (2008) Global overview on the use of fish meal and fish oil in industrially compounded aquafeeds: trends and future prospects. Aquaculture 285(1):146–158