MICROBIOLOGY OF MARINE FOOD PRODUCTS

CHAPTER 4: MICROBIOLOGY AND PROCESSING OF FINFISH

4.1. Introduction

Finfish are commonly considered as protein muscle foods. Due to the presence of large quantities of non-protein nitrogenous compounds in the fish muscle, it is highly perishable. During spoilage, bacteria actively use compounds consisting of volatile nitrogen bases and free amino acids, for example, histamine, trimethylamine, the betaines, ammonia, uric acid, taurine, carnosine, creatine, and anserine (Jay1986). The water's temperature from which finfish are obtained is also one of the factors that affect their perishability. Refrigeration efficiently inhibits the bacterial flora harvested from warm tropical waters as compared to bacterial flora belonging to species of cold-water fish. Normally, tropical fish species are less like to spoil rapidly, when handled appropriately and show a more extended refrigerated shelf life than cold-water species (Disney1976; Poulteretal. 1981; Sumneretal.1984). Regardless, this comprehensive concept needs to be re-evaluated. A study based on the preservation of tropical fish through the ice by Limados Santos (1981) claims that are numerous variables for direct comparisons, and there are examples of cold-water fish like halibut and grenadiers that, on ice, exhibit a shelf life for about 3 weeks. It is normally known that healthy and live fish possess a sterile inner flesh. Mostly the intestines, external lime layers of the skin and the gills contain the natural bacterial flora in feeding fish. The number of bacteria varies from 10^2 to 10^6 colony forming units (CFU) per square centimeter on the skin, in the intestine; from extremely minimal in non-feeding fish to 10^7 or more in feeding fish, and 10^3 to10^5 per gram on the gills (Liston et al. 1976). While the primary microflora is directly connected to the environment, the entire microbial load is influenced by seasonal variations (Liston1956; Shewan1961). Shewan (1977) pointed out that cold-water fish mostly bear a Gram-negative psychrophilic population (Vibrio, Pseudomonas, Moraxella, Flavobacterium and Acinetobacter) whereas; warm-water fish possess more mesophilic, Gram-positive microflora (bacilli, micrococci, coryneforms). Despite the differences in the primary microflora, the spoilage method of finfish during iced storage is generally very much alike and brought about by *Alteromonas Putrefaciens* and *Pseudomonas spp*. (Barileetal.1985b). This chapter will explain the factors that influence the invasion and development of these spoilage-causing bacteria during harvesting and refining eventually affecting quality.

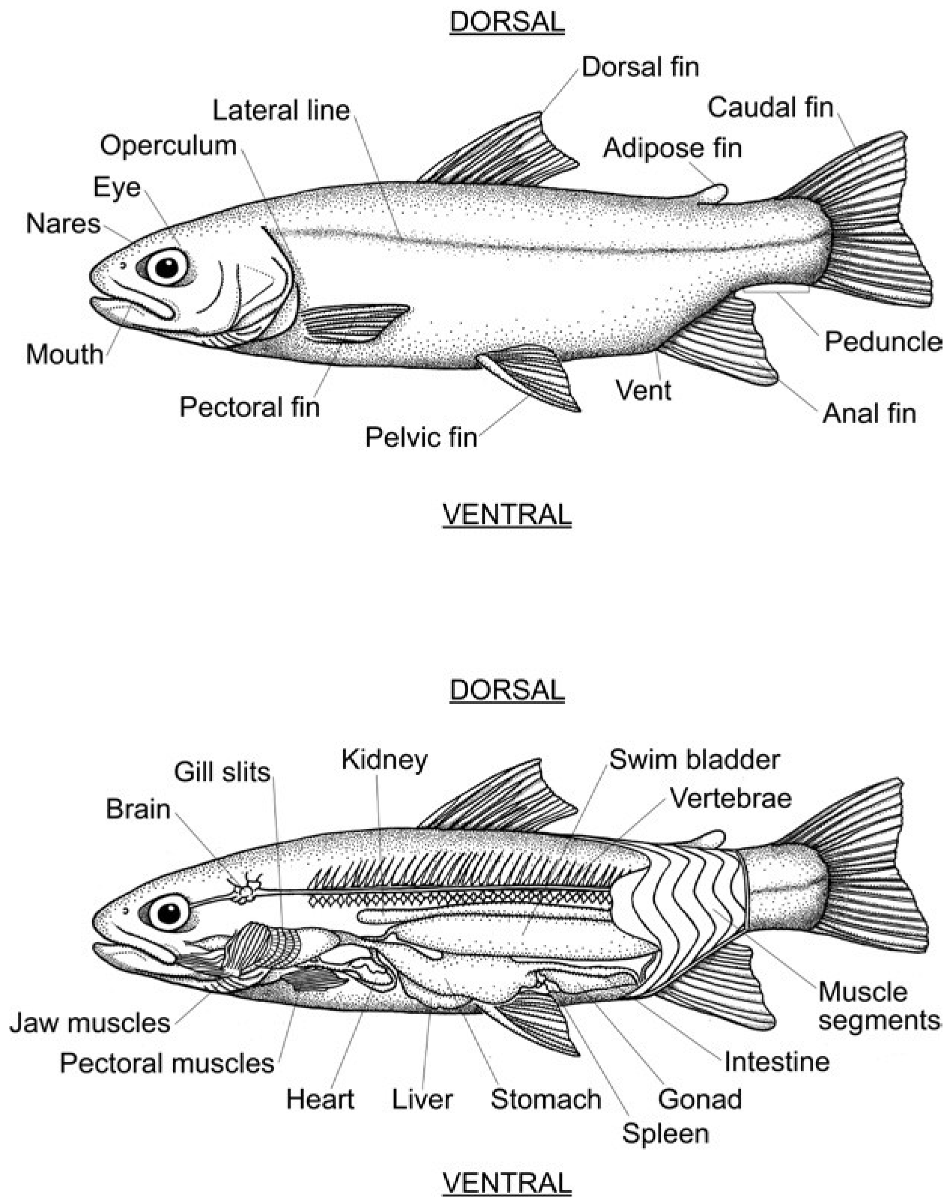

Figure 4.1. Anatomy of finfish

[Source: https://www.researchgate.net/figure/Finfish-Morphology-Virge-Kask_fig37_296089219]

4.2. Harvesting and Onboard Handling

The procedure employed for harvesting affects the microbial load and the primary quality of fresh finfish. Hence, quality maintenance must be initiated at this stage. Improper handling during harvesting will be harmful to the ensuing shelf life and quality at the retail level (Denevet al., 2009; Pullela et al., 1998). Commercial harvesting of finfish involves a wide range of procedures and fishing gear including hook and line techniques, numerous kinds of nets, and traps and barriers (Alverson 1976). Even though little quantitative data is present to compare the microbial load of various harvesting techniques, Shewan (1949) suggested that trawled fish normally retain a microbial load that is 10-100 times bigger than of line-caught fish. This increase is a result of the drag along the ocean's base, which makes the mud move up and confines the fish, leading the gut contents to be indicated. Commonly, during trawling lower tows produce lower quality (Costakesetal.1982). During heavy fishing the end of the cod becomes extremely full causing the catch, which may have been lifeless for hours, to become damaged and crumbled due to compression. Additionally, larger catches require appropriate longer stowing. The fish are then, exposed to the abuse of sliding on the deck of the boat as well as the environment's temperature and sunlight. Hence, quality is negatively affected because of fishing for quantity (Hackney et al., 1980; Himelbloom et al., 2000).

The postharvest quality also seems to be affected by the stress level experienced by the fish after they are caught, just before dying. Fish, like mackerel and tuna, are generally very active and may become excited and die in a hyperactive state when harvested through purse-seining. Other species differ from tuna based on the natural physiological attributes possessed by it. W+++ith a burst speed for yellowfin stated to be as 21 body lengths per second by *(T.albacores),* they are one of the fast-moving fish (WaltersandFierstine1964). Tuna exhibit a very high metabolic rate with some species being capable enough to modify their body temperature. A serious defect of the flesh, a condition known as burnt flesh is experienced when tuna is caught in an extremely stressed state, causing the lactic acid present in the muscles to combine with the increased muscular temperature (Goodrick1987). This results in the production of an acidic flavor, accompanied by a metallic after taste in the flesh which no longer seems to be bright red. The tuna is still adequate to be canned; however, it is unsatisfactory for the extremely extensive Japanese sashimi market. Therefore to reduce stress and to regulate tuna's postharvest quality, the long lining technique is employed for desirable harvesting (Orth et al., 1981). The impact of stress has also been observed in other species of fish. Salmon die after a tiring struggle when harvested through gill netting. Consequently, the process of rigor mortis is triggered as well as initial signs of deterioration that take place during icing (Dassow1976). By harvesting through the method of hook and line, the fish are rapidly moved aboard the vessel and killed, decreasing the stress and the quality deterioration related to it. This idea of "clean kill" quite famous in the slaughter of poultry and livestock (Roelofs&Stapley, 2004). Research on the harvesting of Atlantic cod suggested that the degree of sniggling largely affected the flesh's caloric and protein content by decreasing the moisture (Bottaetal.1987a). A concurrent analysis by the same researchers implied that the technique used for capturing Atlantic cod was more important than the time of the season in its influence on sensory quality (Bottaetal.1987b). The shelf life and quality of rainbow trout are negatively affected by stress as indicated by studies of Herborg and Villadsen(1975) it also explained that the extent of bacterial infection increases with it (Jemmi et al., 2000).

Since it is not always feasible to be selective concerning the harvesting techniques used for numerous commercial fish species, the fish need to be managed in a quality conscious way once they are placed on the vessel. Handling with forks, gaff hooks or picks should be prevented or at least restricted to the head region. Tears in the head and gashes in the flesh rapidly introduce spoilage bacteria and quicken the process of quality deterioration. Subsequently, to avoid bruising, there should be no stepping on or standing on the fish (Ward et al., 2012).

Finfish are mostly harvested in an isolated place and need to be stored for a lot of hours or days aboard the vessel before processing as compared to the poultry and red meat industry, in which animals are in a satisfactory physiological state and are delivered live to the processing units. *Code of Practice for Fresh Fish* was published by the Food and Agricultural Organization in 1973 which focused on the appropriate handling when at sea. As fish are highly perishable their handling requires great care and application of procedures that inhibit microbial growth at all times. Rapid spoilage of quality and decrease in the possible keeping time is observed when fish is improperly handled or preserved. Most of the fish harvested for the consumption of man is handled in quite a crude manner. Fish should be cleaned with a lot of care and cooled down till it reaches the temperature at which ice melts .i.e. 0°C, as soon as possible. However, it should not be subjected to the drying effect of wind or direct sunlight. Any negligence in treatment or delay in decreasing the temperature of fish will have a pronounced effect on its possible keeping time.

Figure 4.2. Harvesting step of finfish processing

[Source: https://www.youtube.com/watch?v=FUJzxJlvCCQ]

One the point mentioned above emphasizes on the fish to be carefully "cleaned". Although the term "cleaned" has not been defined, multiple states demand the particular groundfish be bled, gutted, and gilled aboard the fishing vessel. Shewan (1961) suggests that the chief benefit of gutting is the prevention of autolytic spoilage except for bacterial deterioration. FAO (1973) concluded that "bad gutting might be worse than no gutting" as it accelerates bacterial entry into the flesh. Stansby and Lemon (1941) claimed that there could be an increase in bacterial numbers rather than a decrease if fresh mackerel is gutted. At a New England trawler (Samuels et a. 1984), a recent study proposed that as compared to an immediately captured cod, a gutted haddock and cod have lesser psychrotrophic counts, however, there were no major differences found. Additionally, it was discovered that cleaning gutted fish in circulating seawater before ice storage did not have any effect on the bacterial count but this helped in removing mud and other external particles (Adams et al., 2001).

Research on spiny dogfish by Ravesicta1(1985) explained that the number of microbes on fillets were the result of processing and the degree of handling before the removal of fillets. To put it in other words, dogfish preserved as whole possesses lesser counts as compared to gutted fish which has a lower count than the ones which are headed and gutted. However, researchers suggested gutting if the fishing trip exceeds two days as it boosts bacterial counts as well shelf life. In case the trip is shorter than two days, it would be appropriate for the fishermen to focus on proper icing and eventually rapidly chilling the entire dogfish. It was further reported by researchers that heading and gutting were not functional as discarding the head will lead to the formation of another surface for possible bacterial deterioration which does not benefit health. A comparison was conducted between the sensory and microbiological analysis of fully headed and gutted orange roughy while they were stored in ice, in a research by Scott et a1. (1986). the whole fish along with the headed and gutted fish were cleaned in seawater, before the storage. According to the sensory results, the shelf life of ice stored, whole orange roughy was within 11 to 13 days with only a minimal increase due to the heading and gutting. On the other hand, the microbiological analysis revealed that there were no big differences between the counts of bacteria of the two groups. The authors stated that the small increase in the shelf life of headed and gutted fish was because of the decrease in autolysis instead of the diminished microbial activity. The digestive enzymes more prevalently cause autolytic spoilage in fish that are eagerly feeding at the time they are caught (Dassow 1976). Bleeding and gutting the fish before storage on board the vessel has been suggested by many sources (Costakes et al. 1982; Strom and Lien 1984; Valdimarsson et al. 1984). The Canadian grading standards for Atlantic groundfish declared that the hue of the flesh should be indicative of bled fish (DFO 1983). The issue, however, is if during harvest the bleeding of fish facilitates the quality in all cases. A collective program started by the Maine Groundfish Association and the Maine Department of Marine Resources signified that before gilling and gutting, the bleeding of live-captured fish seemed to exhibit no major effect on the shelf life or quality in comparison with similarly harvested but un-bled cod specimen from the same tow (Moser 1986). In this research, samples were exposed to torrymeter readings, determination of trimethylene and hypoxanthine (spoilage indicators) concentrations, color measurement with a color difference meter, surface bacterial load tests, and sensory panel evaluations. There were no major variations found between bled and un-bled fillets in any of the scenarios. The author highlighted that Maine boats seem to fish deeper waters and/or form longer tows as compared to the boats in New Bedford fishery, where previous information on bleeding was produced. A collection of dead, live and stunned fish are brought in by the Maine boats while New Bedford fishery, mainly captures live fish.

Research by Botta et a1. (1986) explained that the bleeding of northern cod, which were captured by the Canadian Otter trawlers, was advantageous to quality only if carried out within 1-2 hours of the fish being delivered aboard. These analyses were established on either a one- or two-phased bleeding process. The author emphasized that the advantages of bleeding may differ depending on the time of year, and the site of the catch. The shelf life of bluefish does not increase because of onboard processing (bleeding, gutting, and gilling), as the sensory scores of fillets from these fish resembled the fillets from fish boxed and wholly stored. Yet, the author asserts that because the entire bluefish was only iced for a day or two before processing, there may not have been enough time-lapse to observe ant quality advantage from onboard refinement. This complies with the recommendations of Ravesiet a1. (1985).

It is clear from the contradictory conclusions in the literature that the global practices of bleeding and gutting techniques should not be used in all fish harvesting procedures. Every fishery will have to make its own decision established on the method of harvest and the species. Any conduction of on-board processing should not expose the fish to extensive delays in icing. To enhance on-board fish handling and processing methods, the application of ergonomic principles has presently been recommended (Rodman 1987).

The report by FAO (1973) suggested that fish should be cooled down to the temperature at which ice melts, 32°F (0°C), as soon as possible. The reason for this is clear. Barile et al. (1985a) discovered that the shelf life of Faughn's mackerel, on ice was decreased by 1 day for every hour delay in icing or exposure to environmental temperatures of 82.4-86°F (28—30°C). Furthermore, at the area of rejection by a trained taste committee, the samples of fish had the respective aerobic plate counts at 68°F (20°C): fish iced instantly, 10' organisms/g; fish iced after a 3-hour delay, 107; fish iced after undergoing a 6-hour delay, 106; and fish iced after 9- and 12-hour delays, 105. There was also a prominent change in the microflora. The basic organisms of spoilage are Pseudomonas spp. and Alteromonas putrefaciens, after a delay of W hours in icing while a lengthy delay (9—12 hours) ended in a complete spoilage flora of Bacillus spp., Pseudomonas spp, and Aeromonas hydrophila. The west coast of the Philippines was from where these fish were purse-seined off.

Surprisingly, research on trench sardines (Chinivasagam and Vidanapathirana 1986) showed a slight difference between the standard of fish ice instantly following landing and after a 5-hour delay. Various studies (DeSilva 1978; Jayaweera 1980) have also claimed not to have harmful effects from delayed icing, for certain fish, for about 12 hours. Two scenarios as to why procrastination in icing is supposedly harmful are proposed by Chinivasagam and Vidanapathirana. The first is the marginal incidence of Pseudomonas organisms on tropical fish, while Poulter et a1. (1981) examined the second, according to which when warm-water fish are stored at high temperatures, the beginning of rigor is delayed and of a longer period hence delaying the development of bacteria. Regardless, the studies conducted by Barile et al. (1985a), that discovered that shelf life was decreased by 1 day for each hour in icing was performed on a tropical species.

Figure 4.3. Onboard handling and processing of finfish

[Source: https://www.slideshare.net/MuhammadLeaque/presentation-on-fish-processing-preservation-and-trasporting]

Most lucrative, commercial fishing vessels residing in the mid-Atlantic and New England districts preserve their catch in ice present in the ship's hold. Smaller vessels that depart from the docks in the early morning and come back later in the day may be an exception. These vessels are usually known as day boats, they keep fish in the holds, but mostly without ice. Samuels et al. (1984) informed that on the surface of non-iced bluefish, there was a great increase in the psychrotrophic counts while they were kept in the hold of the vessel, from the moment they were captured till they arrive at the dock. There was no considerable increase in the fish capture at the same tie but stored in the ice coolers.

Due to the likelihood of developing histamine poisoning, delays in the icing of fresh fish are of significant concern with fish of the Scombridae family (tuna, mackerel, and bonito). Other fish such as mahi-mahi and bluefish have been implicated. Caused due to the consumption of foods that consist of a high amount of histamine, histamine poisoning happens to be a chemical intoxication. The microbial enzyme histidine decarboxylase is responsible for the decarboxylation of the amino acid histidine which ultimately forms histamine. Since the creation of histamine is the result of microbial enzymatic activity, the easiest prevention procedure involves rapid chilling if harvested fish and the regulation of low temperature through consumption. Chen et al. (1987) claimed that the particular histamine-producing bacteria, Morganella morganii, Klebsiella pneumoniae, and Hafnia alvei have been separated from fish inducing scombroid or histamine poisoning. Enterobacter aerogenes, Pseudomonas putrefaciens, Clostridium perfringens, Aeromonas hydrophilia, Vibrio alginolyticus, and Proteus vulgaris are included in the collection of fish isolates that have exhibited histidine decarboxylase activity (Middlebrooks et al. 1988).

Boxing at sea and short-shelving have been used by fishermen in place of the traditional procedure of packing fish in a mass of ice kept in the hold of the vessel. Fish are mostly stacked in 5-6 feet down in ice when they are packed in a bulk. The fish near the base are under a huge amount of weight, leading to reduced shelf life, inferior quality, and lower yields as a consequence of the increase in pressure. The decrease in the pressure on the fish is the advantage of short-shelving. Short-shelving involves layering ice and fish between shelves which helps support the weight. These shelves should be situated 18-22 inches apart. Removable shelves such as corrugated aluminum are required for shelving as they can be easily cleaned. Boxing at sea can be a very efficient technique to maintain quality if possible economically. Plastic boxes present in numerous sizes and layouts are being utilized for it. Practically all fishing nations around the globe use boxing to some extent. Being a known practice in countries like Iceland and Norway, boxing is a rather new concept in North America. Not only does it provide a reduction in compression, but boxing also facilitates faster unloading at dockside and less harmful handling. Based on a research by the New England Fisheries Development Foundation (Costakes et al. 1982), boxing extends shelf life for 2- to 6-day as well as a 7—159a boost in landed weight over conventionally bulk stowed fish. In other words the longer the journey the more dramatic the distinction in quality.

Even though ice has its benefits in the conservation of fish quality, it also comes with its disadvantages. Some of the drawbacks explained by Holston and Slavin (1965) include its potential to bruise and damage the flesh as well as the draining of flavor, nutritionally valuable minerals and water-soluble proteins. Additionally, it can be very costly and labor-intensive, considering the large catches that are common for some fisheries (Lee and Kolbe 1982; Reppond et al. 1985). Hence, systems utilizing some type of mechanically refrigerated seawater (RSW) have started to replace ice in specific fisheries, particularly in the Pacific Northwest (Lee and Kolbe 1982).

Co-modified refrigerated seawater (MRSW) and RSW have exhibited a delay in the spoilage of both fish and shrimp in contrast to storage on ice (Bullard and Collins 1978; Reppond et al. 1979; Reppond and Collins 1983). Roach et al. (1967) emphasized on the significance of adequate sanitation, particularly on RSW installations: “While with iced fish only a part of a load may spoil, with fish held in tanks of RSW even under proper conditions there is a danger that all, or nearly all, the fish will be rejected if spoilage occurs.” The contents of this statement have been demonstrated in the study undertaken by Lee and Kolbe (1952). In their research, aerobic plate counts (APC) [at 77°F (25°C)] of RSW obtained from a commercial vessel were discovered to be 7.7 X 104 organisms/ml on day 1, increasing to 1.5 X 106/ml on day 8. The authors informed that due to improperly cleaned surfaces of the fish hold and waste residing in the pipes as well as on the wooden bin boards the re-circulated seawater got contaminated rapidly. When the remains of the ceiling of the fish tank exhibited a microbial count of 4.5 x 108 organisms /g, even being sanitized and washed, the author’s concerns were supported even more.

The storage of ice dressed salmon in refrigerated freshwater, seawater, and diluted seawater was analyzed by Bronstein et al. (1985). Even though the distinctions among the storage media were not constantly statistically considerable, bacterial development in fish kept in ice seemed to be more rapid than the one stored in chilled-water systems. The authors indicated that the dissimilarities maybe because of the elevated aerobic conditions experienced during iced storage, which permit the common aerobic spoilage flora to develop more rapidly.

Numerous studies have claimed that the MRSW system, in which CO_2 is introduced to maintain bacterial development by decreasing the pH of the brine (Nelson and Barnett 1973), to be greater in quality than both RSW and ice in retarding product deterioration (Barnett et al. 1971; Bullard and Collins 1978; Lemon and Regier 1977; Longard and Regier 1974). Tomlinson et a1. (1974), evaluated that the inclusion of CO to RSW did aid in limiting bacterial development it was harmful to particular sensory factors of the fish stored. In their research, gutted lingcod and salmon were placed in RSW and MRSW. The authors concluded that the introduction of CO contributed to salt uptake, increased the sensitivity of fish to rancidity while they were stored, and caused the flesh color the fade in salmon. Reppond and Collins (1983) discovered that for 6 days in ice, the quality of Pacific cod was satisfactory, whereas in MRSW it was 9 days. However, they also specified that during MRSW storage, the absorption of salt may be an issue.

4.3. Fishing Vessel Sanitation

The cleanliness of food handling equipment and food-contact surfaces is commonly given great importance in the food industry. However, onboard fishing vessel practices by the food industry are not appropriate. Counts aboard the vessels are very high due to the natural presence of high bacterial load on fish. Samuels et al. (1984) stated the logos psychrotrophic counts/ inch^2 of the contact surfaces as hand gaffs, 8.2 organisms; decks, 7.3; fish hold, 6.5; and shovels/pushes, 7.7. Analyzers described that even though the sanitary environment amidst the commercial fishing vessel could be made better; it is not harmful to a well-iced catch. This recommendation has coincided with the studies of Huss et al. (1974). Proper maintenance of sanitation is required to prevent cross-contamination of the fish stored in dirty ice from the past trips or with bilge oil even if it may not benefit the shelf life and quality of whole fish which are well-iced. The execution of onboard processing can promote reduced shelf life and quality by exposing the earlier sterile flesh to an immense amount of spoilage bacteria due to an unsanitary environment. Fish holds should be built or modified to make them facilitate sanitary practices. Wood, for instance, cannot be sanitized adequately.

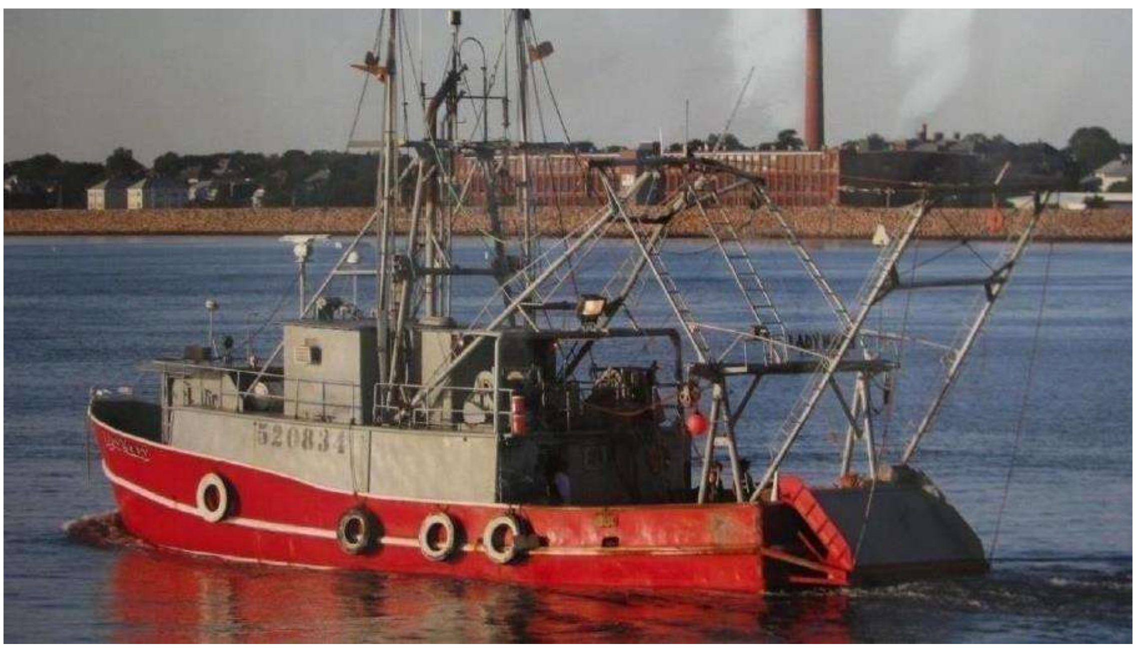

Figure 4.4. A fishing vessel ready for its expedition

[Source: https://www.maritime-executive.com/blog/fishing-vessels-avoid-them-and-avoid-the-consequences]

4.4. Processing

The word "processing" can include procedures that can range from the extremely easy to the most complicated, keeping in mind the variety of commercially exploited species and the products created through them. Additionally, in terms of processing, evidence from most of the food industry suggests that the cleanliness conditions of the plants processing seafood correspond with the microbial quality of the completed product (Phillips and Peeler 1972; Wentz et al. 1985).

A contamination "saturation point" seems to be attained in some processing lines as hinted by the research performed by Samuels et al. (1984). Fish present in the boats rapidly contaminated the processing equipment (cutting boards, weigh scales, knives, seaters, sorting tables, totes) with considerable levels of psychrotrophic spoilage bacteria (1.05 CFU/inch2). According to the authors, the enhancement of product quality and shelf life could be possible if an efficient in-plant sanitation program was implemented. However, operational sanitation would be dependent upon decontaminating or decreasing microbial loads on fish before they enter into the processing lines. To achieve this, a high- pressure wash is utilized to get rid of the slim and the microflora accompanying it on the surface. The psychrotrophic counts got lowered by 999a with this treatment. Furthermore, taste panel examinations found flounder fillets processed under the suggested procedures to have a shelf life of 11—12 days, as compared to 7—8 days for fillets processed conventionally.

The use of fish tanks is an area of study concerning the microbial deterioration of finfish during processing. However, they can be a source of microbial contamination even after being efficient in eliminating blood and physical debris. Research by Mayer et al. (1986) showed that when similar masses of fish were processed at close processing plants, the microbial load varied significantly depending on the use of high-pressure washing or wash tanks. When moved through a wash tank, APC [68°F (20°C)] of dressed Atlantic mackerel, were 4.0 X 105 CFU/ inch2 greater than high-pressure washed fish. Dressed porgy and dressed sea bass also delivered similar results. More studies supported the fact that the quality of a finfish fillet can be maintained best by high- pressure washing whole fish before filleting except for high-pressure washing the fillets themselves. A high-pressure spray can easily damage the physical appearance of the fillets, particularly the ones with a soft flesh.

The efficiency of high-pressure washing along with surfactants on decreasing surface microflora was also examined by Mayer et al. (198d). When the whole croaker is washed with high pressure, using a solution of 0.he cetylpyridinium chloride, a 1.08 log CFU/inch2 reduction was obtained over high-pressure washing with tap water only. An additional 0.88 log (average APC 2.43 log CFU/inch2) reduction was observed when the fish were scaled before high-pressure washing with 0.1% cetylpyridinium chloride.

The influence of microbial decontamination on the preservation stability of finfish was reviewed by Kosak and Toledo (1981). Before the packing of fish, chlorine dip was applied for microbiological decontamination. The collective effects of a 3.5-minute dip in a 1,000 pg/ml free chlorine solution accompanied by packaging under vacuum or in polyethylene bags resulted in the doubling of shelf life as claimed by the authors. Despite that Samuels et al. (1984) discovered that dipping in a 200 ppm hypochlorite solution for 4 minutes and then overwrapping in an oxygen-permeable film was only slightly beneficial as compared to dipping in water. The application of,000 ppm of free chlorine solution spray declined the aerobic plate count of gray sea trout from 4.18 to 2.98 log CFU/g according to Mayer et al. (1986). Even at this increased concentration 1.20 log units was the total decrease. Chlorine application is only effective to some extent at declining the spoilage microflora on fish surfaces.

Ravesi et al. (1987) analyzed the influence of ozone on the iced storage life of fresh gutted Atlantic cod. The ozone was covered in either chilled seawater, ice or rinse water. The authors explained that shelf life, as evaluated by microbiological, sensory and chemical assessments, was not adequately increased by any of the treatments.

It can be difficult to control highly inflexible standards regarding microbial numbers on processing-plant equipment because of the exceptional nature of seafood and seafood processing activities. Samuels et al. (1984) stated one of the plants to be functioning under satisfactory sanitary conditions contained psychrotrophic levels on equipment surfaces ranging from 1.3 X 10' to 2.5 X 107 organisms/ inch2.

Because of the overall contamination following the contact with excessively contaminated surfaces, an investigation focused on the advantages of delayed processing was carried out. While analyzing cod, Shaw et al. (1984), discovered that maximum net shelf life could be achieved by delayed filleting, hence decreasing the stored as fillets. The data showed a 2-log difference in the entire APC [69.8°F (2l°C)] from fillets sliced from 1-day postmortem fish. The logic counts were 7.3 and 5.3 CFU/g, successively (These fillets were from cod that had been prepared at sea.)

The chances of delayed preparation were reviewed by Townley and Lanier (1981). No benefits of delayed processing were declared while working with Atlantic croaker and gray trout. In reality, fish prepared right after landing sustained class 1 quality 7—10 days more than ice fish prepared 3 days after harvest or unprepared fish. During a 2-week storage period [32—33.8°F (0—l°C) with top icing], microbial populations were claimed to have stayed lower in filleted fish, for both species.

The outcomes of delayed processing of bluefish boxed at sea were researched by Mayer et al. (1986). Instantly processed bluefish exhibited a shelf life of 10- days [tray-packed fillets, 33°F (0.55°C)], meanwhile, whole fish stored for 4-7 days on ice before processing displayed a shelf life of nearly 11 and 13 days from the day of catch. The authors declared that extension in shelf life was based on if fish were feeding actively, before harvest. Fish feeding actively have faster quality deterioration when held unprepared.

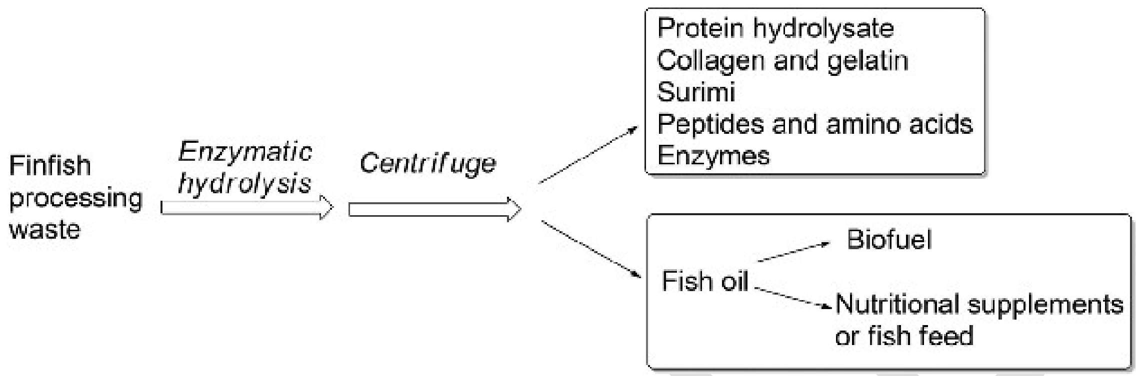

Figure 4.5. Waste processing of finfish

[Source: https://www.researchgate.net/figure/Possible-scheme-for-isolating-valuable-by-products-from-finfish-waste-streams_fig8_281751600]

4.5. Preservatives

Seafood happens to be extremely perishable, therefore, to provide quality and a continuous supply with the least possible amount of waste, designing a technique that increases the shelf life of chilled products has been one of the greatest goals. Research with specific preservatives to help in this endeavor has met with various levels of success.

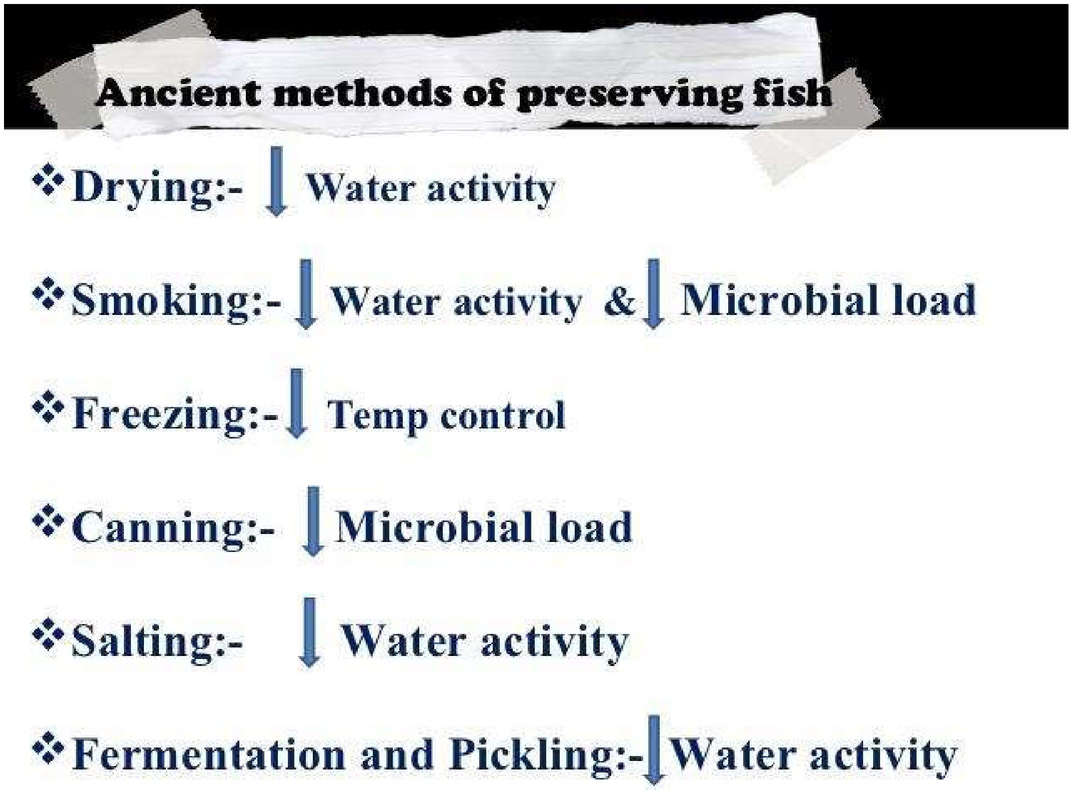

Figure 4.6. Methods of seafood preservation

[Source: https://www.slideshare.net/irshad2k6/novel-approaches-in-seafood-preservation-techniques]

Potassium salt and sorbic acid have been the topic of major research activities. According to Fey and Regenstein (1982), potassium sorbate dips seem to be of negligible value in increasing the shelf life of salmon and red hake. While Chung and Lee (1981) pointed out that the retardation of microbial growth by potassium sorbate was dependant on concentration. Concerning the English sole, the effects of retardation at 0.1'FO concentration were hardly noticeable but those at 1.0% concentrations were very prominent. A delay recorded in the microbial lag phase was 1 day and 6 days, respectively. The reporters urged that the common spoilage pattern was unaltered with Pseudomonas spp. being the main spoilage flora for samples both treated and untreated.

The impact of 3% potassium sorbate applications on the shelf life of Atlantic cod was examined by Shaw et al. (1983). The results revealed that sorbate dips were capable of increasing the shelf life of cod fillets however; it was unsuccessful in case of gutted fish. The development of A. putrefaciens on sorbate-dipped fillets was greatly repressed in comparison with the control but there was no reduction in the aerobes overall.

Miller and Brown (1984) suggested the best method to preserve the fresh aspects of rockfish fillets after 14 days of storage was through dipping them in a combination of 1% potassium sorbate plus 5 ppm chlortetracycline and finally vacuum packaging and storing them at 35.6°F (2°C). On the other hand, studies by Statham et a1. (1985) related to the Australian fish morwong specified that the most functional treatment that can increase the shelf life of fillets stored at 39.2°F (4°C) can be done by dipping them in a combined solution of 1.2'7r potassium sorbate and 10% polyphosphate, accompanied by packaging in 100% CODE.

Another try towards the chemical preservation of finfish was reported by Wesley (1982). Enzyme treatment comprising of glucose oxidase, catalase, as well as a glucose solution used in three forms: as immobilized in algin blankets, a dip and as enzymatic ice, were given to whole flounder and flounder fillets. Glucose oxidase being an enzyme is responsible for catalyzing the oxidation of glucose to gluconic acid, with the breakdown of molecular oxygen to hydrogen peroxide. Commercial enzyme preparations allow catalase, to break down the formed hydrogen peroxide, and glucose to make sure that there is an adequate supply of carbohydrates to initiate the reaction. The formation of gluconic acid along with the resultant drop in pH on the fish surface is recognized by the retardation of spoilage microorganisms. Based on the results, treated samples are admissible for 15 days, while untreated controls were only acceptable for 8. Studies surrounding the preservation of cod fillets with glucose oxidase dips and gluconic acid dips were reported by Shaw et al. (1986). Only slight differences were indicated in the outcomes related to the admissibility of either treatment over that of the controls. Eventually, the researchers interpreted that there was little potential in these treatment methodologies.

The consumer's negative attitude towards the use of chemical preservatives in food products has made it highly unlikely for their application to become widespread for fresh finfish.

The utilization of chemical preservatives for the delay of microbial development should not be necessary if the processors and fishermen are accurate about the factors discussed earlier, affect the shelf life and quality of fresh finfish. It is essential to bear in mind that quality is affected throughout all the steps of handling, from harvest to ingestion. Fishermen should refrain from abusive handling on the fishing vessels whereas; processing plants should maintain adequate sanitary conditions and precise temperatures. A collective effort is needed to meet the consumer's demand for quality finfish.

4.6. Valorization of Fishery Byproducts

In the last few years, the fishery wastes problem has increased and become a universal concern that is being affected by numerous operational factors, technical and biological along with socio-economic drivers (Kim & Mendis, 2006; Arvanitoyannis & Kassaveti 2008). Many by-catch products having low or no commercial value or fish species, damaged or undersized commercial species along with species of commercial value but not caught in enough amounts to warrant sale are termed as the “fish wastes”. The use of fish, however as feed cannot be controlled only through fishery market forces and, in contrast, the need for aquaculture development and responsible fisheries has just been emphasized to preserve aquatic biodiversity.

It has been projected that over 50% of fish tissues are considered as the “wastes” like viscera, heads, skin, and fins and they are discarded. Discards from the world's fisheries every year cross 20 million tons which is about 25% of the entire production of marine fishery catch and contains fish processing wastes, by-products, and "non-target" species. A total of ca. 5.2 million tons represented by the discards in the European Union per year.

For the fishing areas the composition and the amount in types of fishery wastes are different, the total amount of discarding, therefore, is extremely variable. Researchers have reported that in the Mediterranean Sea, significant amounts of trammel net (a fishing net that has large mesh at the edges and smaller mesh in the middle) discards, with a total discard rate ranging from 15 to 49% for Greece to Portugal of the total of 137 discarded species (79.7% of the total). Furthermore, it is estimated that the discards of fish processing industry would reach up to 75% of the total volume of products.

The environmental impact is another important feature that fish wastes might have on aquatic ecosystems, the biodiversity of the benthic and community assembles as the release of organic wastes change significantly. To reduce this pollution source and to look for the best ways to solve this problem the management of fish discards involves several aspects. The new Common Fisheries Policy (CFP) for example, in Europe, aims to decrease the discard rate.

Along with the enormous economic loss, fish waste for farmed fish could be planned as a source of feed. Last year the increasing trend shown by aquaculture production has been documented by various studies, however, by a significant blockage, the future aquaculture development is being constrained. On the availability of fish oil and meal, aquaculture productions are reliant on, which are for fish feeds to become an important lipid and protein source. The total costs of production could significantly be affected by the production of aquafeeds; on average, there is 4 to 6 kg of fish required for the production of 1 kg of fish meal, whereas the 10-50 kg of fish is required for the production of 1 kg of fish oil. It has been estimated that the aquaculture field consumed about 80% of fish oil and 60% fish meal of the world total production yearly and this percentage is likely to increase to warrant future aquaculture growth. Fish oil and fish meal signify the most valued products got from marine byproducts and are not useful for human consumption. For the production of fish oil and fish meal in 2012, 15 million tons of fish were caught. Per year globally among 5.5 to 7.5 million tons of fish oil are produced but in the future, further growth of the intensive aquaculture productions will be limited by the availability of fish oil and fishmeal.

Chile and Peru are the most important countries for the production of fish oil which contributes to 13% and 52% respectively of the total world production. Norway and Iceland can fulfill the whole European need and contribute to 7% of the world’s fish oil production. The fishery by-products could be used as the alternative source for the supply of fish oil and fish meal and the fishing pressure on the species selected for oil and meal production could be reduced and, simultaneously, for sustainable aquaculture productions it could contribute.

Despite the low traditional value that assigned to fishery by-products, a great number of bioactive compounds with wide biotechnological and pharmaceutical applications could be produced from this huge mass of under-utilized/unused resources, like proteins (collagen, enzymes), protein hydrolysates, chitin, astaxanthin, lipids. Among the bioactive compounds take out from fishery by-products and wastes, oils and proteins rich in PUFAs (Polyunsaturated Fatty Acids), particularly DHA (Docosaesaenoic Acid) and EPA (eicosapentaenoic acid) are mainly interesting for their possible use as fish feed components along with their high marketable value. As fishery wastes are rich in high-quality nutrients, they have a great potential to utilize and convert a large portion of these useful products in marine bioprocess industry.

In terms of environmental and management impacts, on the other hand, fishery by-products and discards may guide to significant problems. Particular importance in many countries is given to discover the possibility of using by-products of fishing, traditional fishing, and aquaculture instead of facing the problem of their disposal. For the valorization of fishery discards and by-products at a regional or local level, the use for aquafeeds production of the wastes from the fish processing and fishing industry could be an important tool.

From European fleets, fishery discards are not insignificant, and their decrease is a socio-economic, ecological and moral imperative. By significant fishing fleets, the countries bordering on the Mediterranean Sea are characterized; as a source of aquafeeds along with bioactive compounds based on these considerations, this basin may play a significant role. To remove discards and decrease unwanted by-catches in European fisheries the EU (European Union) has just launched a joint policy, but an execution of the EU (European Union) Regulation for the decrease of fish wastes is still needed. By establishing technologies to transform and increase fish wastes in an economic resource the goal of decreasing fishery discards can be accomplished, for instance by developing techniques of concentration and extraction of the bioactive compounds they defining and containing policies for their use for fish oil and meal for animal feeding. Furthermore, an ecosystem method instead without an important interference on the selectivity of the used fishing equipment specifies that policy for the effective decrease is not possible.