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Review on Evaluation of Safety of Fish and Fish Products

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Abstract
The quality of fish and fishery products is a major concern in fish industry worldwide. Essentially, the objective of fish and fish product assessment is to avoid the ingestion of contaminated food; to evaluate the nutritive value of food by detecting the presence of biological, chemical and physical hazards and in the end to ensure the safety of the consumer. To assess the safety of fish and fish products both instrumental and sensory methods are used. Sensory methods are the most satisfactory way of assessing the spoilage and freshness of fish and fishery products. The use of raw, inadequately cooked, salted or smoked fish, common in many countries, has zoonotic potential and has been reported to cause serious disease conditions in humans. To avoid disease problems caused by parasite, bacteria and autolytic activity, fish that is going to be used for food should be frozen and cooked before use.

Keywords: *Aquaculture, fish freshness, zoonoses, evaluation techniques*

Introduction
Aquaculture has developed to become the fastest growing food producing sector in the world. A large proportion of fish products come from small-scale producers in developing countries or low income deficit countries. More than 80% of global aquaculture products are produced in fresh water. From its early development in Asia, aquaculture has undergone huge development and is highly diversified. Aquaculture consists of a broad spectrum of systems, from small ponds to large-scale, highly intensified commercial systems (Håstein *et al*., 2006) [21].
The quality of fish and fishery products has become a major concern in fish industry all over the world (Huss *et al*., 2003) [23]. Fish, being one of the exceptionally perishable foods and as a result of globalization of food trade fish products tend to be more susceptible to rejection due to poor quality especially if the initial raw materials are of poor quality despite the technological developments in fish production (FAO, 2009).
Seafood health hazards have been outlined in several guides in the literature (FDA, 2001) [15] and can be classified as (i) biological hazards (biogenic amines - in some literature is classified under chemical hazards or bio toxins, parasites, pathogenic bacteria, viruses, bio toxins and allergens), (ii) chemical hazards (chlorophenicol and other antibiotic residues for farmed fish, fish originated from contaminated waters such as heavy metals, dioxins, chemical contaminants originated from processing areas, chemicals formed by fish processing such as nitrosamines and polycyclic aromatic hydrocarbons and (iii) physical hazards such as bones, plastic, glass and metals (Huss *et al*., 2003) [23]
Preservation techniques are needed to prevent fish spoilage and lengthen shelf life. They are designed to inhibit the activity of spoilage bacteria and the metabolic changes that result in the loss of fish quality. Traditionally processed fish products (TFPs) are reported to carry high potential risk for human health for halophilic pathogenic bacteria, histamine and parasites (Hansen, 2008) [44].
Therefore, the objectives of this seminar paper are:
- To highlight better evaluation techniques of fresh fish
- To Characterize different hazards and to give guidelines for prevention of these hazards

2. Type of Hazards on Fish and Fish Product
2.1. Biological Hazards
2.1.1. Pathogenic bacterial
Bacteria represent a major and important group of microorganisms because of their frequent occurrence and activities that may have a negative impact on fish quality. Generally, seafood

from cold waters harbors lower numbers of potentially pathogenic micro-organisms than seafood from warmer waters. The presence of human pathogenic bacteria in fish and fish products may also be attributed to contamination during processing. Several bacteria are, however, reported to cause infection and mortality in both fish and humans, and these represent a particular hazard, caused either by handling infected fish on fish farms, in grocery stores or by the ingestion of raw or inadequately processed infected fish and/or contaminated fish products (Austin *et al.,* 2005) [5].

Pathogenic and potentially pathogenic bacteria associated with fish and shellfish include mycobacteria, *Streptococcus iniae*, *Vibrio vulnificus*, Vibrio spp., aeromonads, Salmonella spp, *Clostridium botulinum* type E, Erysipelothrix *rhusiopathiae*, Listeria and others (Chattopadhyay, 2000). People most often get infected as follows Aschfalk and Muller (2002) [4]: (i) through contact with infected fish while handling them, water or other constituents of fish life environment; the following cases of transmissions have been recorded so far: after injury by cleaning aquarium with bare hands, after exposure to fish tank water, by handling tropical fish ponds, by contact with rare tropical fish (Bhatty *et al.,* 2000) [6], after injuries from fish, e.g. by thorns, after fish bite (Seiberras *et al*., 2000) [37], through contact with fish living in the wild, by contact with a fresh or salt water environment (Jernigan and Farr, 2000) [26], infection of young children who are in contact with a fish tank, through processing fish in the food industry and preparation of dishes or (ii) orally by consumption infected fish or related products or food contaminated with water or other constituents of water environment. Apart from factors relating to the living environment (exposure), the development of an infectious disease is markedly affected by internal factors such as the physiological status of consumer, particularly by immune suppression and stress as in the case of HIV/AIDS (Novotny *et al*., 2004) [33].

Aeromonad bacteria are ubiquitous in the environment and several Aeromonas species have been reported to cause disease in fish, as well as being potential food-borne pathogens that may cause disease in humans (Håstein *et al*., 2006) [21]. Although Salmonella spp. May be harboured and survive in fish, sea foods seldom harbour Salmonella. Fish may be exposed to Salmonella through consumption of contaminated feed or living in contaminated water. The occurrence of Salmonella in feed has, for a long time, been a well-recognized problem worldwide. However, research has shown that the level of Salmonella contamination in the feed must be extremely high if the bacteria are to persist in the fish for more than a few days (Nesse *et al*., 2005) [32].

If Salmonellosis present in freshwater or marine fish species, this is mainly due to faecal contamination. Food-borne pathogenic bacteria such as Campylobacter, Shigella and Yersinia are seldom associated with fish. Nevertheless, the fish pathogenic bacteria *Y. ruckeri* has been reported to occur in humans. *Edwardsiella tarda*, which causes 'red disease' in eels as well as enteritis in penguins, is also sporadically reported as causing gastroenteritis and septicaemia in humans (Håstein *et al*., 2006) [21].

Microbiological examinations are the prerequisites for correct diagnosis. However, quantification of the occurrence of these diseases is difficult because many cases, typically gastrointestinal illness, go unreported; the symptoms usually do not last long and are self-limiting in healthy people. It can be extremely difficult to detect certain slow growing causative agents of diseases such as those of mycobacterial infections or infections caused by anaerobic pathogens. Mycobacterial infections are quite often misdiagnosed with subsequent inappropriate therapy. Consequently, the disease can last for years (Ang *et al*., 2000) [3].

2.1.2. Parasites

Among the animals, fishes are the most important hosts for maintenance of parasites mainly helminthes. Most of fishes have parasites and they not only serve as hosts of different parasites but also serve as carrier of many larval parasitic forms that mature and may cause serious diseases in many vertebrates including man (chandra, 2006) [9].

Fish borne parasitic infections have recently been identified as an important public health problem with considerable economic impact in terms of morbidity, loss of productivity and healthcare costs. Poor sanitation and traditional methods of food preparation have accelerated the spread of fish borne parasitic infection (Ibrahim, 2014) [24].

The most important of helminths acquired by humans from fish are the anisakid nematodes (particularly anisakis simplex and pseudoterranova decipiens), cestodes of the genus *diphyllobothrium* and digenetic trematodes of the families hetero phyidae, Clonorchis, opisthorchiidae and nanophyetidae. The effect of parasites on the value of the fish is perhaps greater than their impact on human health. In addition to the health effect parasites can reduce the value of fish to harvesters by damaging the skin, infesting the meat, or spoiling the flavour or condition of the fish (Omar, 2014) [35].

Parasites are the most difficult hazards to monitor in marinated fish products since acidic pH conditions are not usually effective in preventing parasites, especially anisakid nematodes (Murrel, 2002) [4]. The fish borne zoonotic trematodes (FZT) are well known causes of liver and intestinal trematode (fluke) diseases in humans (Chai *et al*., 2005) [8]

The strong cultural preferences in many countries for eating raw or insufficiently cooked infected fish are believed to be the greatest risk factor for human infection (WHO 2004, Chai *et al*., 2005) [40, 8]. It has been estimated that about 680 million people worldwide are at risk of infection apart from more than 20 million humans already infected with liver flukes (*Clonorchis sinensis* and *Opisthorchis* spp.) (Keiser and Utzinger, 2005) [27].

2.2. Chemical Hazards

2.2.1. Formation of biogenic amines and involved products

Biogenic amines (BAs) are mainly formed in fish products by microbial decarboxylation of amino acids and transamination of aldehyde and ketones. Certain biogenic amines such antihistamine, cadaverine, putrescine and tyramine are of importance due to the risk of food intoxication and also they serve as chemical indicators of fish spoilage (Kim *et al*., 2009). Histamine is one of the main concerns in fisheries products formed by microbial decarboxylation of histidine as a result of time/temperature abuses in certain fish species. Histamine poisoning is often referred to as 'scombrotoxin poisoning' because of the frequent association of the illness with the consumption of spoiled scombroid fish such as tuna, bonito and mackerel. However, non-scombroid fish such as herring, anchovies and mahi-mahi have also been implicated in out breaks (Huss *et al*., 2003) [23].

2.2.2. Nitrosamines

Nitrosamines are reported to cause cancer and are often associated with TFPs such as smoked, fermented, salted and salt-dried products. Although various causes have been indicated with the formation of nitrosamines in foods, the mechanisms of nitrosamine formation in fish products and factors influencing their formation have not been clearly elucidated. Nitrosamines are generally formed through reactions between secondary and tertiary amines and nitrite under certain conditions (Al Bulushi *et al*., 2009) [2].

The presence of secondary amines such as dimethylamine (DMA) and tertiary amines such as TMA has been found to be implicated in nitrosamine formation. In fish products such as salted, pickled, smoked, fermented and canned fish, the presence of nitrosodimethylamine (NDMA) which is formed from DMA and nitrite, has been widely reported. Primary amines such as putrescine and cadaverine have been suggested to cyclize during heating to secondary amines such as pyrrolidine and piperidine, which react with nitrite to form carcinogenic nitrosamines (Al Bulushi *et al*., 2009) [2].

The International Agency for Research on Cancer (IARC, 1978) classified a number of NAs with respect to the cancer risk for humans. The IARC considers NDMA and nitrosodiethylamine (NDEA) into the group of probably carcinogenic to human, and nitrosodibutylamine (NDBA), nitrosopiperidine (NPIP) and nitrosopyrrolidine (NPYR) into the group of possibly carcinogenic to human (Yurchenko and Mölder, 2006) [42].

3. Evaluation of Safety of Fish and Fish Products

3.1. Traditional methods for evaluation of fish and fish products

3.1.1 Sensory evaluation

Considering all the developments in instrumental methods that have occurred in the last decade, sensory methods remain the most satisfactory way of assessing the freshness of fish and fishery products. Objectives seafood sensory tests, based on certain attribute of raw fish (skin, eyes, gills, texture, etc.), are the most commonly used methods for quality assessment of raw whole fish in the inspection service and fishing industry (Martinsdottir *et al.,* 2009) [30].

Sensory evaluation of food is defined as the scientific means of quantifying and interpreting the variations in food characteristics (odour, taste, tactile, appearance) by using human senses of sight, smell, taste, touch and hearing. Studies have shown that assessment of food freshness/ characteristics using sensory methods are capable of giving objective and/reliable results when assessments are done under controlled conditions. Generally, trained and experienced taste panel is essential to obtain accurate and reproducible result. Sensory methods are divided into two groups; discriminative and descriptive tests however, the most commonly used is the descriptive test which measures the difference or absolute value indicating the different quantitative levels. There are several grading methods used to assess freshness in fish and fish products for instance the European Union (EU) scheme and the Torry system (Connell, 2001) [11].

Nonetheless, other new sensory schemes exist like the quality index method (QIM), originally developed in Tasmania (Bremner *et al*., 2002) [7]. QIM is a tool, for estimation of the quality attributes in a more objective way, based on the significant parameters for raw fish with a score system ranging from 0-1; 0-2; 0-3; 0-4 or more, demerit points (Frederiksen, 2002) [45]. The main advantage of the quality index method when compared to EU scheme is that quality index method is species specific and confusion about attributes is minimised. Each fish species has its own characteristic sensory attributes (flavour, appearance, odour, and texture) which change with time and temperature after harvest (Martinsdóttir, 2002) [29]. Quality index method schemes have been developed for species such as European cuttlefish (*Sepia officinalis*) Arctic charr (*Salvelinus alpines*) fresh cod (*Gadus morhua*) and fillets (Martinsdóttir, 2002) [29].

However, sensory methods in general are known to be irrationally expensive due to the high training requirement of the panel; cost of running, need for individual scheme for individual fish species given the different spoilage patterns and physiological and psychological limitations of the analyst (Connell, 2001) [11].

3.1.2. Microbiological methods

The major changes in fish freshness for instance unattractive change in food characteristics such as, flavours, odours and colour are largely due to bacterial growth and activity. Microbiological methods are used to estimate bacterial numbers, in order to determine fish freshness, hygiene and or evaluate the possible presence of bacteria or organisms of public health. Microbiological prediction/estimation of bacterial numbers therefore, in order to serve the purpose of food safety and shelf life determination, is expected to relate quantitatively to the characteristics of the food during storage (Dalgaard, 2002) [12].

3.1.3. Chemical methods

The evaluations of food using chemical methods are considered to be more objective than sensory methods especially when it is done accurately using appropriate method. These methods involve determination of the concentration of a specific chemical in the food. Chemical methods of food evaluation are normally used to indirectly predict the level of a sensory attribute, which allows for immediate determination of freshness. To use chemical methods to serve this purpose, well set, quantified and standardized tolerance levels of chemical spoilage indicators need to be established. (Chebet, 2010) [10]

With regard to evaluation of fish quality using chemical methods, the total volatile basic amines constitute to the commonly measured chemical indicators. Total volatile base is a general phrase used to include volatile amines such as, tri methylamine, ammonia produced by spoilage bacteria; di methylamine and produced by autolytic enzymes during frozen fish storage. The concentration of these chemicals in fish tissues can be determined by steam distillation method. Conversely the measurement of the amount of hypoxanthine in fish is one of the chemical methods of determining fish freshness. Hypoxanthine is one of the products of nucleotides degradation mediated by bacterial activity (*Proteus bacterium*) is known to be responsible for bitter, off flavours of spoilt fish. Freshness can be determined by calculating the ratio of inosine and hypoxanthine to the sum of ATP and all the other products of ATP degradation multiplied by 100 (Haard, 2002) [20].

3.2. Alternative "Rapid" methods of evaluation of fish and fish products

3.2.1. ATP determination technique

The measurement of the concentration of adenosine triphosphate (ATP) in foods is considered as a "rapid method" for the assessment of bacteriological quality of food. The basis of this technique is the inherent existence of ATP molecule in all living organism. ATP is a nucleotide, found in all living cells, including bacteria and is the universal agent for the transfer of free energy molecule. ATP technique of bacteriological assessment of food quality correlate well with bacterial counts in food however, caution must be taken in samples whose somatic cells dominate in the sample to avoid alteration of the measurement (Chebet, 2010) [10].

3.2.2. Redox potential (Eh) technique
The measurement of the variation in Redox potential (Eh) is considered to be one of the "rapid" ways for the estimation of bacteriological quality of food Metabolically active microorganisms; especially aerobic microorganisms are capable altering the Eh their substrate (i.e. food), leading to lower Eh values (Jay *et al.,* 2005) [25].

The measurement of redox potential can be done by using an appropriate instrument such as redox electrodes and expressed in millivolt. The common electrodes used to serve this purpose are, silver Chloride electrodes and platinum electrodes with calomel reference electrodes. Similarly, the Dye reduction technique constitute to one of the ways of determining the bacteriological quality of food by estimating the detection time indicated by the dye discolouration time in hours (Adams and Moss, 2008) [1].

The common redox dyes used to serve this purpose include; Resazurin, methylene blue, 2, 3, 5-triphenyltetrazolium Chloride expressing the result as; Dye Reduction Time in hours (h). Longer Dye Reduction time is used to indicate lower bacterial numbers and shorter Dye Reduction time has been found to indicate higher bacterial numbers. However, the principle of operation of redox electrode and dye-reduction techniques in the method of microbial estimation is based on the variation in the Eh of the food due to microbial activity and their related metabolic by products, associated with spoilage (Chebet, 2010) [10]

3.2.3. Electronic nose techniques
The electronic nose technique is used to detect and quantify the concentration of volatile compounds (bioamines) in fish, which occur during spoilage. The principle of operation of the Electronic nose involves the transfer of the total headspace of the sample to a sensor array that detects the presence of volatile compounds in the headspace and a pattern of signals is provided that are dependent of the sensors‟ selectivity and sensitivity and the characteristics of the volatile headspace. The electronic nose technique is considered produce as objective information as can be obtained by sensory panellist regarding the freshness of fish during storage (Olafsdóttir, 2005) [34].

3.2.4. Electrical technique
The change in the electrical properties, such as conductance; capacitance or impedance is one of the pertinent indicators of food quality deterioration due to microbial growth. Microbial growth in a substrate is known to lead into change in the chemical composition of the growth medium and may consequently lead to change in the electrical properties (capacitance, impedance and conductance) of the medium (Adams and Moss, 2008) [1]. The measurement of these changes can be done using instruments operating under the same principle and these include; Torrymeter, RT meter and Fischtester VI, Bactometer, Malthus system, BacTrac, and Rapid Automated Bacterial Impedance Technique (RABIT). This method has been applied with success in the analysis of variety of foods such as milk, meat, and fish to test for total counts of aerobic and selected groups of organisms such as coliforms, Salmonella and yeast as well as measurement of niacin (Chebet, 2010) [10]

3.2.5. Texture measurement
The change in texture, resulting from autolytic, bacterial and chemical changes in fish during storage has a direct relationship to change fish freshness. The measurement of textural changes is considered as one of the ways of determining food quality deterioration. Fish texture can be determined by using Texturometer, a hand held device utilizing a cylindrical probe that is exerted on the food product with force, *F* that increases the present value the measurement of firmness using this technique has been found to correlate well with the sensory textural attributes like dehydration and firmness. This measurement is considered as a direct extension of the human sensory assessment "figure press test" (Bremner *et al*., 2002) [7].

3.2.6. Immunological methods
Immunological methods include enzyme-linked rapid methods, referred to as "ready to use kits". The principle of operation of immunological technique lies on the detection of the presence of gram-negative microorganisms and food borne pathogens through a chemical reaction between the kits with the substrate (food product) leading to specified indication (colourations). Some of the examples of these kits include; Latex, agglutination kits, Quik Alert kit, SDI Rapid Chek, Path-CHEK swab, Transia card/plate and Assurance EHEC & Gold EIA (Fung, 2002) [17].

4. Factors Affecting the Safety of Fish and Fish Products
4.1. Pre harvest related factors
Wild fish are harvested by a large variety of methods, such as different kind of nets, hooks, pots, and so on. Depending on the method used the capture of wild fish involves various degrees of desperate struggle followed by a period of asphyxiation once the fish is on board. To control stress produced by these conditions it is necessary to control mainly the fishing method and time; however, the method is often dictated by commercial considerations, and it is difficult to modify (Wiley *et al*., 2011) [41].

Incorrect handling at this point will be detrimental to the quality during ice storage. Fish that have been trawled are subject to more stress from fighting the net for hours, and this stress has been shown to affect ice-storage quality. In the case of some species like tuna, when they are caught in a highly stressed state, the buildup of lactic acid in the muscle, combined with high muscle temperatures results in a dull muscle and acidic and metallic aftertaste. This has been reported in other species; for instance, wild salmon caught by gill netting die after stress exhaustion (Wiley *et al.,* 2011) [41].

Handling of farmed fish has certain differences compared to wild fish and depending of species. The first operation for farmed fish is to carefully separate fish from the main cages into smaller holding units without causing more stress than necessary. At this stage, the fish are kept at a density of around 5 to 10 kg/m^3 until ready for collecting (Gelman *et al*., 2005) [18].

The second very important operation is starvation for as long as is necessary to ensure that gut contents are evacuated. During feeding periods, the digestive tract of the fish contains many bacteria that produce digestive enzymes capable of causing intense postmortem autolysis, resulting in strong odors and flavors, especially in the abdominal area. By reducing the amount of feces in the intestines, spoilage is delayed, and digestive enzyme activity is reduced. If further processing steps are considered, for example, filleting and freezing, feeding interruption may be a determinant of the product shelf life (Huidobro and Tejada 2004) [22].

Starvation is also very important to prevent feces trailing from the anus, which is off-putting for consumers. In general, the starvation period is 1 to 3 days depending on temperature. Ferreira *et al*., 2007) observed that 1 d was considered to be the minimum feeding interruption period in sea bream, with 8 d being the maximum. Reasons for extending this period in some cases beyond 48 h included variations in the market price for the fish and the time needed to empty the fishpond. One problem is that around 1% of weight can be lost due to starvation at higher temperature than 20 °C. Mechanical properties of sea bream muscle change as the starvation time progresses, so the flesh is firmer when they are starved for up to 8 d compared to the standard 1 to 3 d, due to changes in protein solubility and pH (Gines *et al*., 2002) [19].

4.2. Post harvest related factors

Stress in wild and farmed fish, which are very active before slaughter, can affect the quality of the fish in a physical and a biochemical way. From a biochemical point of view, if the fish is killed after muscle activity, its cells will contain more lactic acid from anaerobic respiration, so that ATP synthesis is stopped and *rigor mortis* sets in sooner. Spiking to instantaneously destroy the brain by puncturing, and so prevent muscle activity, delays the onset of *rigor mortis* as compared to a slower death such as immersion in chilled water. This happens because it retards the drop in ATP, which is the agent that prevents interlocking of thin and thick filaments. However, there is no difference in the final post slaughter pH of stressed and unstressed fish of the same species, despite differences immediately postmortem (Robb, 2001) [36].

The degree of muscle activity prior to slaughter also affects how firm the flesh becomes during *rigor mortis.* Lactic acid concentration is lowest when horse mackerel (*Trachurus japonicus*) are killed by spinal cord destruction as opposed to other slaughtering methods, such as struggling and temperature shock; this slow *rigor mortis* onset results in slower muscle degradation in the course of iced storage, as measured by the ratio between nucleotides and nucleosides, degradation products from ATP, which is called the K-value (Mishima *et al*., 2005) [31].

Storage temperature masks most of the effects produced by pre slaughter stress; however, it is important to follow the stress management protocols when fillets are kept at the common storage temperatures under 4 °C. The temperature of the fish just after death will affect the course of various biochemical reactions during storage. This is caused by the reduction in ATPase activity as the temperature decreases, and by a reduction in the uptake of Ca^{++} (Robb, 2001) [36].

In highly stressed fish, all muscles enter rigor very quickly and at the same time. As a result, the whole fish is very stiff and difficult to process. In fish with a low level of activity, only some muscles have been used and these are the ones that first enter *rigor mortis*, while the others do so later. Because of this difference in timing, not all the muscles are in *rigor* at the same time, so that the fish as a whole is less stiff (Robb, 2001) [36].

Pre mortem handling stress significantly affects several color parameters of salmonids flesh this loss of color is caused by insolubilization of muscle proteins as a result of low pH and subsequent drip loss occurred in the prerigor and development of *rigor mortis* (Erikson and Misimi, 2008) [13].

Slaughtering by electrical stunning can produce enough active movements to break vertebrae, rupture blood vessels, which can result in blood spots. Electricity as better method for salmon stunning than carbon dioxide as this causes an earlier onset and resolution of *rigor mortis*. Bleeding is frequently used in farmed fish. Large farmed fish needed to have the blood removed from the muscle and recommended cutting the gills with a sharp knife; this allows the fish to swim and so die from anoxia caused by blood loss (Van de Vis *et al*., 2003) [39]

Industrial gutting and beheading are mechanized in developed countries today, but on board this operation is traditionally done by hand with a knife, and only in large ships are machines used. The main reason for gutting is to prevent autolytic spoilage rather than bacterial spoilage. Gutting is usually done by cutting, but there are machines that perform gutting by sucking the viscera out and cleaning the belly part through the mouth. This method obviates the need to open the belly, but it makes it difficult to be sure how well the fish is cleaned. When gutting is performed, fish should be thoroughly washed to remove traces of blood and debris and to wash bacteria and intestinal content out of the gut cavity, skin, and gills of the fish. The practice of washing after gutting is more effective in removing remnants that in eliminating bacterial contamination (Erkan, 2007) [14].

5. The Effect of Preservation on Fish and Fish Products

Ancient methods of preserving fish included drying, salting, pickling and smoking. All of these techniques are still used today but the more modern techniques of freezing and canning have taken on a large importance. Preservation techniques are needed to prevent fish spoilage and lengthen shelf life. They are designed to inhibit the activity of spoilage bacteria and the metabolic changes that result in the loss of fish quality (Köse *et al.*, 2009) [46].

Spoilage bacteria are the specific bacteria that produce the unpleasant odours and flavours associated with spoiled fish. Fish normally host many bacteria that are not spoilage bacteria, and most of the bacteria present on spoiled fish played no role in the spoilage. To flourish, bacteria need the right temperature, sufficient water and oxygen, and surroundings that are not too acidic. Preservation techniques work by interrupting one or more of these needs (Özdan and Varlık, 2004) [47]. The effect of preservation can be summarized as (1) Surface drying providing physical barrier to bacterial pathogens and preventing aerobic microbial proliferation, (2) Salting decreases water activity and has inhibition effect on pathogenic bacteria (although a certain salt content is required), (3) Deposition of phenolic antioxidant substances delaying autoxidation (and rancidity), (4) Deposition of antimicrobial substances such as phenols, formaldehyde and nitrites. Heat can also be added as a preservative factor, especially for hot smoked fish products in killing some pathogens, histamine forming bacteria (HFB) and parasites. Additionally, packaging methods and storage conditions such as freezing can also help as preventing food safety hazards in smoked products. However, vacuum packing can also create bacterial health hazard if not applied appropriately (Zaitsev *et al*., 2004) [43].

6. Conclusion and Recommendations

Seafood derived from wild fish as well as farmed fish has always been an important source of protein in the human diet. On a global scale, fish and fish products are the most important source of protein and it is estimated that more than 30% of fish for human consumption comes from aquaculture. The first part of this paper outlines the hazards and challenges associated with handling fish during farming and capture. The authors describe infectious agents that cause disease in fish as well as humans, zoonotic agents, intoxications due to bacteria and allergies caused by the consumption of fish. Although only a few infectious agents in fish are able to infect humans, some exceptions exist that may result in fatalities. However, the greatest risk to human health is due to the consumption of raw or insufficiently processed fish and fish products.

Therefore, based on the above remarks, the following recommendations are for warded:

- In wild fish, it is important to use methods of capture that do not exhaust the fish as is the case of harvesting by hook and line.
- In farmed fish, quick slaughtering after non stressful handling make for a more humane death and the product will have better quality and a longer storage life. Also, starvation is an important step in farmed fish.
- An optimal slaughtering method from the standpoint of quality and welfare should render fish unconscious as soon as possible.
- Electrical stunning is an option, but blood spots sometimes appear on the muscle, so the electrical parameters need to be optimized.
- Every processor shall conduct a hazard analysis to determine whether there are food safety hazards that are reasonably likely to occur for each kind of fish and fishery product processed by that processor and to identify the preventive measures that the processor can apply to control those hazards.

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