Deterioration of Fish Quality in Terms of Changes in General Quality, Organoleptics and Microorganisms (a Review)

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ABSTRACT

Given that aquatic products, particularly those derived from fisheries, are often susceptible to change or deterioration in quality after being captured and dying, assurance of their quality and safety is a difficulty that must be overcome. The kind, size, fat content, environmental conditions at the time the fish were captured, initial microbial content, and storage temperature are just a few of the variables that might affect how quickly fish quality degrades. Human senses can detect changes when fish die, but specialized test tools can also quantify changes objectively through a sequence of measuring steps. The texture and observed characteristics of the fish will initially be affected by sensory alterations that are clearly visible. Rigor mortis occurs quickly after fish die, and it significantly alters the texture. Additionally, there are various numbers and kinds of microorganisms in fish sections. These can be used as a sign that both fresh fish and seafood that has been chilled are becoming of lower quality. In the expectation that different kinds of damage and quality deterioration might be prevented, this review intends to provide information on quality deterioration suffered by fishing commodities in terms of changes in general quality, organoleptic, and microbiological.

Keyword: *deterioration, fish, microbes, rigor mortis, sensory, post mortem*

1. INTRODUCTION

Aquatic products are a source of a number of important nutrients for human health. Assurance of the quality and safety of aquatic products, especially products from fisheries, is a challenge that must be faced because these products are easily subject to change or deterioration in quality after being caught and die. The quality deterioration that occurs is the result of a series of biochemical reaction mechanisms and microbiological activities.

The rate of change in quality deterioration depends on several factors that can come from fish, such as type, size, fat content, conditions at the time the fish were caught, initial microbial content, and storage temperature. [1], [2]. Tropical fish species (warm climates) can be kept longer in the ice than fish species that live in cold waters. This is due to the dominant microflora in tropical fish species, which is a microflora belonging to mesophyll which cannot develop too quickly in cold temperature conditions [3].

Given the importance of knowledge about the decline in the quality of fishery products, this paper will present brief theories regarding the deterioration of fish quality in general and accompanied by the results of several international journals. The results of the journals presented include the effect of delayed storage in ice on quality deterioration of Nile perch (*Lates niloticus*) [3]; Inhibition of chemical changes associated with decreased freshness during storage of horse mackerel (*Trachurus trachurus*) in ice powder [2]; Quality deterioration in three types of fish (*Gadus euxinus, Mugil cephalus, Engraulis encrasicholus*) intact, gutted, and filleted during frozen storage [4] and biochemical, sensory and microbiological attributes of wild turbot fish (*Scophthalmus maximus*) during storage [5]. This review aims to provide information on quality deterioration experienced by fishery commodities in terms of changes in general quality, organoleptic and microbiological in the hope that various types of damage and quality deterioration can be avoided.

2. POST MORTEM CHANGES IN FISH

2.1 Fish Quality

The quality of fish during post mortem can be described into four stages which are presented in Figure 1. In the first stage the characteristics of the fish species will develop. The decline in quality in the second stage was caused by autolysis and in the third stage by bacteria. At the fourth stage the fish can no longer be consumed.

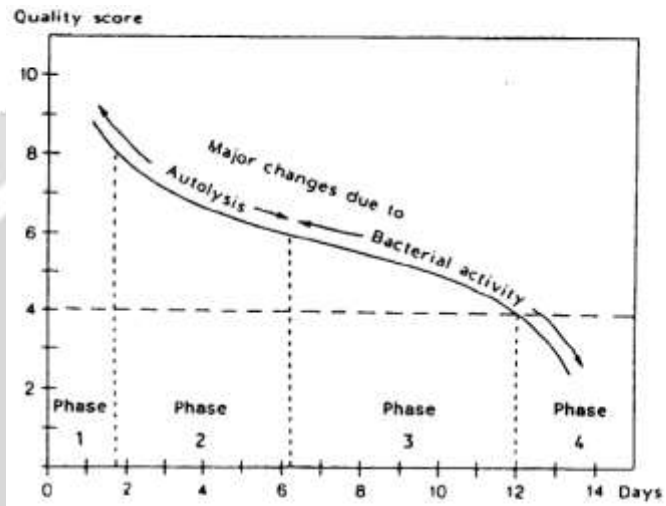

Figure 1. Changes in the quality of Cod at 0^{o}C storage[1]

Changes that occur after fish die can be observed subjectively by the human senses or objectively through a series of measurement procedures using tools. Sensory changes can be clearly seen and will first relate to the texture and appearance of the fish. An important change in texture is caused by rigor mortis shortly after the fish dies. At a further stage, the autolysis process as a result of enzyme activity in fish muscles will also affect the sensory assessment of the fish.

In addition to sensory, changes related to quality deterioration can also be observed chemically by measuring a series of substances whose amounts will change during the stages of deterioration, such as nucleotide content, TVB (Total Volatile Base), TMA (Trimethyl amine), TBA. (Thiobarbituric Acid) and other substances. After and during the autolysis process, nutrients in the form of components resulting from the breakdown of macromolecules become available to microorganisms and after this stage, fish are generally damaged and are not fit for consumption.

2.2 Rigor Mortis

After the fish dies, the fish's muscles will relax and have an elastic texture and usually last for several hours, only then will the muscles contract so that the fish's body becomes hard and stiff. After the rigor phase is complete the fish muscles will weaken again but become inelastic as before rigor. The rate of occurrence of rigor will vary greatly between species and is affected by temperature, handling, size and physical condition of the fish. Rigor mortis occurs shortly after death if the fish starves to death and their glycogen stores are low or if the fish is caught under stress. This situation is also influenced by temperature, usually the difference in water temperature and large storage areas will result in a rapid rigor process [6], [7].

Rigor mortis occurs as soon as muscle ATP stores fall to 1 mol/g. The ending phase of rigor is closely related to the autolysis process because of the activation of natural enzymes contained in muscle and can digest

1 1 http://www.fao.org/docrep/v7180e/V7180E06.htm

muscle tissue [6], [7]. Aerobic respiration will stop and anaerobic glycogen oxidation will cause accumulation of lactic acid so that the pH will decrease to 6.5-6.8. The final pH value will be contained in the type and composition of the fish [7].

If the fish is filet pre-rigor, the muscles will contract freely and the filet will be shorter and have a contracted surface. Red meat will shrink by up to 52 percent and white meat up to 15 percent of its original length. After rigor the muscle tissue returns to the relaxation stage. If experienced, it is possible to tell the difference between pre-rigor and post-rigor fish because pre-rigor fish are very flexible throughout and leave no pressure marks after being gently pressed. The time required for each stage of occurrence, duration and yield of rigor mortis depends on many factors such as species, size, fishing methods and methods of fish handling, temperature and physical condition of the fish [8].

Fish that have been exhausted or that have been held at high temperatures, such as trawled fish, enter the rigor quickly and exit. Large, flat fish typically require more time, but small, energetic, and floundering fish exhibit the same behavior. In some tropical fish, biochemical changes and therefore rigor mortis have been found to be more stimulated at 0°C than at 22°C, despite the fact that it is commonly thought that rigor mortis occurs and lasts longer more quickly at high temperatures. High temperatures will make the rigidity stiffer and more likely to damage the connective tissue and break the fillet structure, a condition known as "gaping."

When fish is frozen, particularly when it is filleted, the technological relevance of rigor mortis plays a significant role. The fish will shrink if it is filleted before refrigeration, and the texture and drip loss rates will often be worse if the filet is frozen. Fish filets often have acceptable quality when removed under rigor, but the procedure of cutting the fillets is more difficult and results in a lower yield. Fish handled poorly or roughly during rigor will also gape. Although cutting fish fillets during the post-rigor phase and freezing them would be safer in theory, this is frequently not practicable because the whole fish needs to be stored in a high-capacity refrigerator (before filleting) [8].

2.3 Mucus

Mucus is formed in certain cells in the skin of fish and its production becomes very active after the fish dies. This can especially be seen in the types of fish that live in fresh water which will secrete mucus as much as 2-3% of their body weight so that it will cause problems when processing them. Mucus contains a large number of nitrogen-containing components and is a source of nutrition for destructive microorganisms [7].

2.4 Sensory Change

Sensory changes are everything that can be judged by the senses such as appearance, odor, texture and taste. The first sensory changes that occur during fish storage are related to appearance and texture due to the occurrence of rigor mortis and autolysis. While the taste characteristics generally develop in the first few days during ice storage [6],[9]. The enzymes involved in autolysis can have an important effect on the loss of texture quality of fishery products, but do not cause aberrant aroma and taste where these two parameters are typical characteristics of the results of microorganism activity [10].

In general, aberrant odors can be detected first in the area around the abdominal cavity. In fish such as herring and mackerel that are not weeded immediately after being caught, it will be a long time before the rest of the fish show any signs of damage. In certain cases, high enzyme activity in the intestines of fish caught during feeding will cause complete degradation of the stomach and even cause the stomach to burst. This phenomenon is known as burst belly and can occur within a few hours after the fish is caught [8].

[4] research on three types of whiting fish (*Gadus euxinus*), gray mullet (*Mugil cephalus*) and anchovies (*Engraulis encrasicholus*) that were stored frozen, showed that fish in filet form showed maximum color characteristic values compared to fish in frozen form. Whole and gutted fish have maximum aroma and muscle value.

In turbot fish (*Scophthalmus maximus*), the most visible sensory change is the separation of mucus from the skin which will cause an unpleasant odor. In general, the skin and the aroma of the outer surface of the fish are limiting factors for the sensory quality of turbot fish, while the gills, consistency and aroma of the flesh are still acceptable up to 29 days of cold storage [1]. In a study on horse mackerel fish (*Trachurus trachurus*) stored in ice flakes and powder for 19 days, it was shown that the sensory parameters that had the worst values were eyes, gills and meat aroma and it was concluded that storing fish using powdered ice had better results. than shale ice seen from its sensory parameters [2].

Daily organoleptic testing of cooked fish meat can be used to monitor changes in the feeding quality of chilled fish throughout storage. Since boiling fish makes it easier to detect the majority of the aberrant flavors, this test is frequently conducted on boiled fish. According to [8], four phases make up the distinctive pattern:

1) Phase 1. Fish is very fresh and has a distinct flavor and smell based on the species. Typically, the flavor is smooth/thin/faint and resembles seaweed.
2) Phase 2. Taste and smell that are distinctive are lost. The taste of the meat is not changed but is neutral.
3) Phase 3: A number of altered flavors are the first indicators of harm. The distorted flavor may first taste like dried fish or be a little acidic, sweet, or fruity. Rancidity can be identified in fatty fish. The flavor of things like cabbage, ammonia, or sulfur is discovered in the following stage.
4) Phase 4. Fish that have been harmed and deteriorate can be classed into this phase

2.5 Deterioration by Microorganisms

Microorganisms are found naturally on all outer surfaces (skin and gills) and in the intestines of freshly caught fish. On the surface of the skin the normal amount is around 10^2 – 10^7 cfu/cm^2, while on the gills and intestines it is between 10^3 and 10^9 cfu/g. Fish that live in warmer temperatures have higher microbial counts. *Aeromonas* spp. is a typical bacterium that lives in freshwater fish while the bacteria that live in seawater fish are *Vibrio* sp., *Photobacterium* sp. and *Shewanella* sp. While bacteria from the genus *Pseudomonas* spp. role in spoilage of refrigerated fish [6],[11],[12].

Freshly caught fish from temperate waters typically contain gram-negative rods of the genera *Pseudomonas, Alteromonas, Moraxella, Acinetobacter, Flayobacterium, Cytophaga,* and *Vibrio* that are aerobic or facultative anaerobes. It was discovered that some tropical fish samples had higher concentrations of gram-positive bacteria like *Micrococcus, Bacillus,* and coryneform. Despite the fact that gram-positive bacteria typically do not survive in tropical fish microorganisms, it was also mentioned in one study. The temperature requirements for bacterial growth should be taken into consideration [8].

Freshwater fish have a distinctly different flora than marine fish. The genus *Aeromonas* is known to be present in all types of freshwater fish, although this genus is not frequently found in marine fish species. Gram positive bacteria such as *Streptococcus, Micrococcus, Bacillus,* and coryneform are all known to be present in considerable numbers.

The flesh of live or freshly caught fish is sterile because the fish's immune system prevents bacteria from growing in the meat. When fish die, the immune system becomes inactive and bacteria can multiply freely. On the surface of the skin, bacteria colonize in the crevices of the scales. During storage, bacteria will attack the meat by moving between the muscle fibers. The number of organisms that attack muscles is limited and many microorganisms grow, especially on the surface of the fish, but the impairment that occurs can be caused by enzymes produced by bacteria that diffuse into the meat so that nutrients diffuse to the surface. Most of the volatile components such as trimethylamine, volatile sulfur components, aldehydes, ketones, esters, hypoxanthine and some other low molecular weight components. The substrates for the production of volatile substances are carbohydrates (lactate and ribose), nucleotides (inosine mono phosphate and inosine) and other non-protein nitrogen molecules. Amino acids are important substrates for the formation of sulfide and ammonia compounds [6].

The number of microbial counts in turbot fish stored in ice showed an increase during storage from day 0 (3.3 log cfu g^{-1}) to day 19 (7.87 log cfu g^{-1}). If the number of 10^6 microorganisms per gram is considered as the limit for the maximum number of microbes that can still be accepted, then turbot fish has a shelf life in ice of 13-14 days because on the 15th day the number of microbes reaches 6.54 log cfu g^{-1} (equivalent to 10^6) [5]. The research of [3] showed that delaying the storage of perch in ice for 3 to 6 hours from the start of being caught would increase the number of mesophilic bacteria counted at the time of storage compared to fish stored on ice immediately after being caught. The number of psychrophilic bacteria was not affected by the delay in ice storage and the number increased after passing through the lag phase, namely after 5 days of storage.

When deterioration is apparent, the total number of bacteria in fish reaches 10^8–10^9/g of flesh or cm^2 of skin after entering an initial lag phase, the length of which is mostly influenced by temperature. In saltwater fish, *Pseudomonas* and *Alteromonas* spp. become the dominating genera independent of the original makeup of the flora, and at low temperatures, an increase in the quantity of bacteria was followed by a qualitative shift. This is because these genera generate more quickly at cold temperatures. Fish may degrade quickly (within 24–36 hours) under high ambient temperatures, however it is unknown what primary destructive organisms will be present at these temperatures or what the makeup of the flora will be.

Lower levels are seen, frequently about 10^6/g of fish, when anaerobic conditions, or low oxygen pressure, are present (vacuum packaging and storage in chilly saltwater). However, a significant shift in the flora's composition took place because facultative anaerobes may consume TMAO or other oxidizing substances in fish flesh under the right circumstances. Fish that spoil rapidly have a thin layer of skin that is easily damaged when handled, whereas fish that spoil more gradually have a thick coating of mucus that contains some lysozyme and a very tough dermis and epidermis (antimicrobial) [8].

3. CONCLUSIONS

The rate of change in quality deterioration depends on several factors that can come from fish, such as type, size, fat content, conditions at the time the fish were caught, initial microbial content, and storage temperature. Changes that occur after fish die can be observed subjectively by the human senses or objectively through a series of measurement procedures using certain test instruments. Sensory changes can be clearly seen and will first relate to the texture and appearance of the fish. An important change in texture is caused by rigor mortis shortly after the fish die. In addition, fish parts have different numbers and types of microbes. These can be used as an indication for a decrease in the quality of fresh fish and fish that have been refrigerated.

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