Biodegradation and bio-deterioration in fish

Spoilage is any change that makes food unfit for consumption, and includes chemical and physical changes, such as bruising and browning; infestation by insects or other pests; or growth of microorganisms, such as bacteria, yeast, and moulds. Spoilage of food products is due to chemical, enzymatic or microbial activities. It is estimated that one-fourth of the world's food supply and 30% of landed fish are lost through microbial activity alone. Proper handling, pretreatment
and preservation techniques can ensure good quality of fish and fish products and increase their shelf life. Around 4-5 million tons of trawled and shrimp fish are lost every year due to enzymatic and microbial spoilage because of improper onsite storage.

Forms of Fish Spoilage include:

Microbiological Spoilage

Live fish is normally considered to be sterile, but microorganisms are found on all the outer surfaces (skin and gills) and in the alimentary tract of live and newly caught fish in varying numbers with a normal range of 102-107 cfu/cm2 on the skin and between 103 and 107 cfu/g in the gills and intestine. When fish dies, its entire body resistance mechanisms breakdown, giving way to microorganisms or the enzymes they secrete to invade or diffuse into the flesh where they react with the complex mixture of natural substances present.

Bacteria are able to decompose proteins and other nitrogen containing compounds to ammonia and hydrogen sulphide, which produce an unpleasant and disgusting flavour. Trimethylamine oxide (TMAO), mostly found in marine fish, is broken down to trimethylamine (TMA), dimethylamine (DMA) and ammonia (NH_3), which are responsible for off-odours in fish undergoing spoilage.

The general pattern of microbial spoilage of fish preserved by chilling is illustrated in Figure 1.

Figure 1: Changes in total viable count (TVC), specific spoilage organisms (SSO), and chemical spoilage indices during chilled storage of a fish product.

Source: Dalgaard, 1993.

2.5.1.2 Chemical Oxidation

Chemical spoilage processes are changes that take place in the lipid fraction of the fish. Lipids are oxidised to peroxides, aldehydes, ketones and lower aliphatic acids. The hydro-peroxides are tasteless but can cause brown and yellow discolouration of the fish tissue. The degradation of hydro-peroxides gives rise to the formation of aldehydes and ketones that result in rancid offflavours.

All the chemical by-products eventually reach a level where the fish is rejected.

High temperatures are partly responsible for the speed of oxidation processes. In addition, direct sunlight, wind, heat, light (especially UV-light) and several organic and inorganic substances may also accelerate oxidative processes. Living cells in fish have enzymatic protection mechanisms against lipid oxidation by having an enzyme, glutathione peroxidase, which acts by reducing hydro-peroxides in cellular membranes to corresponding hydroxyl-compounds. This reaction requires a supply of the enzyme in a reduced form and thus the reaction stops when the fish dies.

2.5.1.3 Autolytic changes (Bio-deterioration)

As fish dies, its enzymatic activity doesn't stop immediately but continues resulting in proteolytic changes that are responsible for early quality loss in fresh fish. The more these enzymes get in contact with the fish's flesh the greater the spoilage. Adenosine triphosphate (ATP) is broken down through a series of products such as adenosine diphosphate (ADP), inosine monophosphate (IMP), inosine and hypoxanthine (HX). IMP and HX may be responsible for the sweet and mild tastes in the later stages of shelf life and these products accumulate especially when the respective step is rate-limiting. Generally, these changes precede microbiological spoilage and have been seen to contribute very little to spoilage of chilled fish and fish products.

Factors that influence the rate of Fish spoilage

Time/Temperature

The most crucial factors determining the quality of fishery products are time and temperature. The rate of spoilage is dependent upon the holding temperature and is greatly accelerated at higher temperatures, due to increased bacterial action. The shelf life at different storage temperatures (T°C) has been expressed by the relative rate of spoilage (RRS), defined by the equation:

Relative Rate of Spoilage = Keeping time at 00 C

Keeping time at T0C

Hygiene

Apart from the microorganisms that fish harbours at the time of capture, more is added via unhygienic practices and contaminated equipment such as trawling and storage facilities. The design of a fish hold is of great importance as far as hygiene in the hold is concerned. Hold design should enable the purge (drip loss) to be collected easily. The amount of purge is higher at 5-7ºC compared to 0oC; at which temperature there is greater spoilage, since the purge is a very good medium for bacterial growth.

Handling

Rough handling usually results in faster spoilage. This is due to the physical damage to the fish, resulting in easy access for enzymes and spoilage bacteria. Physical mishandling in the net, such as very large catches, fishermen stepping on fish or throwing boxes, containers and other items on top of the fish, may cause bruises and rupture of blood vessels. When fish is in rigor mortis, rough handling can cause gaping.

Bacterial Load and type

The microflora on tropical fish often carries a slight ly higher load of Gram-positive and enteric bacteria but otherwise is similar to the flora on temperate-water fish. Bacteria populations on temperate fish are predominantly psychrotrophic reflecting water temperatures of about 10oC while fish from the tropics have largely mesophilic bacteria.

Method of Capture

The fishing gear and method employed determines the time taken between capture and death. Fish caught in gillnets struggle much to escape, and in so doing, are bruised by the net which increases exposure to microbial entry and subsequent deterioration. Fish caught by hook and line methods, on the other hand, die relatively quickly and therefore bruises and stresses are likely to be minimal. Physical mishandling in the net due to long trawling nets and large catches accelerates spoilage. Large catches in the net are compacted against each other resulting in the fish getting bruised and crushed (especially small sized fish) by the heavy trawl net.

Mode of Storage

In bulk-storage, the weight of the pile may crush the fish at the bottom, leading to a loss of weight (yield) as well as other physical damage. Crushing of fish by ice or other fish can seriously affect the quality of fish by releasing enzymes from the gut into the fish muscle thereby accelerating autolytic processes.

Shelf life

The length of time within which seafood remains acceptable and palatable is defined as the shelflife or storage life of the product. The storage life for fish to remain in good eating quality is about half the total storage life (Archer, 2009). Different fish species have different shelf lives depending on their type, oil levels, moisture content, intrinsic condition of the seafood and how they have been handled since capture.

Shelf life is also dependent on time and temperature of storage. Table 2 shows variation in the shelf-lives of a range of products held at different temperatures and the relative rates of spoilage (RSS).

Table 2: Shelf life at different storage temperatures and relative rates of spoilage (assuming 0oC as 1)

	0oC		5oC		10oC	
	Shelf life (days)	RSS	Shelf life (days)	RSS	Shelf life (days)	RSS
Crab claws	10.1	1	5.5	1.8	2.6	3.9
Salmon	11.8	1	8.0	1.5	3.0	3.9
Sea bream	32	1	--	--	8.0	4.0
Packed cod	14	1	6	2.3	2.3	4.7

Source: Archer, 2009.

Assessment of Freshness and Eating Quality of fish

The freshness quality of fish is extremely important as it is a measure of the age of the fish outside water (i. e. Postharvest). Eating quality is however more important to the final consumer and is usually judged by the odour, flavour and texture of the fish. There are two main ways of determining the freshness quality of seafood: **Sensory or non-sensory methods**.

Sensory methods rely on the appearance, odour and texture of the seafood, whereas non-sensory methods typically use analytical, chemical, physical or biochemical indices.

Non-sensory indices for determining the freshness quality of seafood include: total volatile base nitrogen (TVBN), Total viable counts (TVC) or aerobic plate counts (APC).