## Spoilage of fresh and processed fish and fishery products

### Spoilage of fish and shellfish

Owing to their high nutritive value the spoilage of fish and fishery products proceeds at a faster rate. Spoilage of fish and shellfish is the result activities of autolytic enzymes, oxidation and associated microorganisms.

### Enzymatic spoilage

Enzymatic spoilage is caused by the autolytic fish enzymes. Fishes are highly perishable than meat because of more rapid autolysis by fish enzymes, and favorable conditions for microbial growth due to less acid reactions. The autolytic spoilage can be prevented by reducing the activity of enzymes by lowering the temperature.

### Oxidation or non-enzymatic spoilage

Oxidation or non-enzymatic spoilage is caused by the oxidation of fish fat. The oxidative deterioration of many unsaturated fish oils leads to spoilage of fish. Thus, the fatty fishes spoil much faster than lean fishes.

### Bacterial spoilage

Bacterial spoilage is caused by the activities of microorganism associated with the fish. Bacterial spoilage of fish begins only after the completion of rigor mortis, which results in the release of products of protein denaturation due to decrease in pH, which is utilizable by bacteria. Thus, prolonging rigor mortis helps to delay spoilage and thereby keeps fish fresh.

Rigor mortis is hastened by struggling of the fish, lack of oxygen and warm temperature. However, rigor mortis can be delayed by reducing enzyme activities by lowering pH and adequate cooling of fish. The pH of the fish has important influence on perishability because of its influence on growth of bacteria. Lower the pH of fish, slower will be bacterial decomposition of fish. Lowering of pH occurs during rigor mortis when muscle glycogen is converted to lactic acid.

Spoilage of both marine and fresh water fish occurs in the same manner. Fish contain high levels of protein and non- protein nitrogenous constituents (16~20 %), lack carbohydrate, and have varying amounts of fat depending on the species of fish. The non-protein nitrogenous compounds in fish include free aminoacids, volatile nitrogen bases- ammonia and trimethyl amine (TMA), creatine, taurine, betaines, uric acid, anserine, carnosine and histamine. Spoilage of fish begins from the surface, gill and intestine because of high bacterial load. From gills, intestine and surface microorganisms ¬gradually migrate to adjacent tissue and cause spoilage. Spoilage organism first utilizes simpler compounds and later fish protein releasing various off-odour compounds converted to lactic acid.

### Factors affecting spoilage

The kind and rate of spoilage of fish is affected by several factors.

**1. Kind of fish**

Fishes differ considerably in perishability. Some flat fishes spoil more readily than round fish because they pass through rigor mortis more rapidly. Certain fatty fishes (oil sardine) deteriorate rapidly because of oxidation of unsaturated fat/oil. Fishes high in trimethyl amine oxide (TMAO) spoil quickly and produce stale fishy smell by producing TMA.

**2. Conditions of the fish when caught**

Fishes that are exhausted due to struggle while capture (Ex: gill netting, long lining), lack of oxygen and excessive handling spoil rapidly. This is because of exhaustion of glycogen during struggling and causing smaller drop in pH. Feedy fish (fishes with full of food in stomach) are more easily perishable than those with empty intestine.

**3. Kind and extent of contamination of fish**

Contamination of fish with bacteria from various sources (mud, water, handlers, contact surfaces, slime etc.) increase bacterial load. Bacterial from slime, gill and intestine invade the flesh and cause spoilage. In general, greater the load of bacteria of fish the more rapid the spoilage. In ungutted fish (whole fish) decay of food in the gut may release odorous substances enabling diffusion of decomposition products into the flesh. Gutting the fish on boat spreads intestinal and surface slime bacteria to flesh. But, thorough cleaning will remove most bacteria, and adequate chilling will inhibit bacterial growth. Any damage to fish skin or mucous membrane will reduce the keeping quality of the product.

**4. Temperature**

Warmer the temperature faster will be the bacterial growth and quicker will be the spoilage. Reducing the temperature of fish by chilling will delay bacterial growth, hence, spoilage slows. Cooling temperature around zero degree celecius ($0^{o}C$), helps to delay spoilage.

**5. Use of preservatives**

Use of preservatives including antibiotics will prevent bacterial build up thus extend shelf life of fish.

**Characters of spoiling fish**

Change in external characteristics as the fish spoilage progresses can be used to indicate spoilage. The sequences of changes taking place as the spoilage proceeds are,

- Bright characteristic colour of fish fades, and fish becomes discoloured (appear dirty yellow or brown).
- Increase in slime on skin especially on gills.
- Eyes gradually sink and shrink, pupil becomes cloudy and cornea turns opaque.

- Gills turn light pink and finally to pale yellow colour.
- Softening of the flesh and exude juice when squeezed and easily indented by pressing with fingers.
- Flesh can be easily stripped from along the back bone / vertebral column.
- Release of odourous substances- the normal, fresh, seaweedy odour will change to sickly sweet, stale fishy odour due to TMA and other malodorous substances. Fatty fishes also show rancid odour.

**Spoilage of crustaceans (Shrimps, Crabs and Lobsters)**

Spoilage of crustaceans is essentially same as fishes. Spoilage differs depending on the handling and chemical composition. Crustaceans differ from fish in having carbohydrate (about 0.5%), higher content of free aminoacids than fish, and enzymes that rapidly break down proteins. Bacterial flora of crustaceans includes bacteria from the water from which harvested and also contaminants acquired during fishing, handling, transportation, processing etc).

Spoilage generally begins at the body surface. Presence of higher concentration of free aminoacids and nitrogenous extractives make them susceptible to rapid attack by spoilage bacteria. Initial spoilage is by production of large amounts of volatile base nitrogen (VBN). Some amount of VBN is also produced from the reduction of TMA. Subsequent spoilage results in production of off-odour substances, making it unfit for consumption.

**Spoilage of Molluscs**

Spoilage of molluscs is different from fish/shrimp because of difference in chemical composition. These have high carbohydrate content and low total nitrogen when compared to fish/shrimps. Carbohydrate content, mostly in the form of glycogen, is noticed in clams (3.40%) and oysters (5.60%). Fermentative type of microbial spoilage is noticed because of presence of glycogen. These also contain high levels of nitrogen bases (free arginine, aspartic acid, glutamic acid) than fish. Higher carbohydrate content is responsible for different spoilage pattern of molluscs over other seafood. The filter feeding molluscs have high bacterial load and are involved in spoilage.

The fermentative type of spoilage causes reduction in pH as spoilage progresses. This decrease in pH is used as inductor of extent of spoilage. Thus, pH is used as best objective criteria for examining microbial quality of oysters. Besides pH, organoleptic quality and microbial load are also desired as microbial quality indices. Using pH scale as microbial quality indicator, oysters can be grouped as good (pH 6.5 – 5.9), off (pH 5.8), musty (pH 5.7 – 5.5), and sour/putrid (pH 5.2 or below).