SPOILAGE OF FISH AND ITS CONTROL

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Fish is a highly perishable food item. Spoilage of fish begins as soon as the fish dies. Immediately after the fish is dead, its muscles are relaxed and the condition is known as prerigor. Soon rigor mortis sets in, the muscles contract and the spine become rigid. Decomposition of the flesh is greatly retarded during rigor. After rigor ends (postrigor), the fish muscles relax and decomposition occurs much more rapidly. When decomposition occurs, it may not occur evenly within a single fish or between fish in a catch. Generally, decomposition occurs at first in the anterior end of a fish and in the belly flaps, but exceptions have been observed. The presence of decomposition can appear as: odours, especially in the gill and belly cavity area at first, and later in the muscle; changes in color of gills, eyes and skin; and, softening and loss of tonicity of the muscle.

Decomposition in fish and fishery products can be categorized as: (1) enzymatic spoilage, caused by the tissue enzymes of the fish itself; (2) oxidative spoilage, appearing as rancid odors and color changes; and, (3) spoilage, due to bacterial growth and its secondary products, primarily enzymes, causing decomposition of protein. These changes vary linearly with temperature and are twice more fast at 2.5∫C than at -1∫C. At 10∫C it is four times as fast as at 0∫C. Hence the temperature of storage of fish should be kept as low as possible to maintain the quality.

Enzymatic spoilage

Enzymes are powerful biological chemicals that occur in the tissue of all living animals. They perform important functions, either by breaking down large food compounds into smaller ones in the stomach and gut, as in digestion, or, by helping to make new compounds for building new body tissue or for producing energy. In the living animal the body keeps a close control on what enzymes do. However, when the fish dies the enzymes operate in an uncontrolled manner. The digestive enzymes that aid in the digestion of food when the fish is alive will attack the gut lining eventually breaking it and the surrounding tissue. This type of spoilage results in discoloration, off-flavours, and changes in the texture of the flesh. Ultimately, the belly area will turn brown and soft and may even split giving the condition known as belly burn which is very common in fishes like sardine.

The most significant enzyme deterioration is those that affect flavour. The nucleotide degradation in fish produces many flavor bearing compounds. These compounds are responsible for the desirable sweetish, meaty and characteristic fish flavour of different species. These compounds are formed by the degradation of ATP (adenosine triphosphate) by a series of dephosphorylation and deamination reactions. The ATP is progressively hydrolysed to ADP, AMP and IMP and ammonia. As autolysis proceeds, The IMP will be converted to neutral tasting inosine or bitter tasting hypoxanthine, contributing to the bitter taste to spoiled fish.

Oxidative spoilage

Fish lipid is characterized by high levels of polyunsaturated fatty acids (PUFA) which are highly prone to oxidation. In fishes like mackeral and sardine rancidity occurs on storage. Rancidity is initiated by heat, light, presence of several organic and inorganic compounds and moisture content of the fish. Rancidity is a more widely-used term for oxidation. It occurs when oxygen in the air reacts with oil or fat in the flesh of the fish. This leads to a sour or stale, unpleasant smell or taste. Fatty fish store fat in their flesh and can turn rancid quickly if not handled and stored properly.

Occurrence of black spot (melanin) in shrimp is a major problem caused by the oxidative reaction of tyrosinase on tyrosine faced during icing and frozen storage, rendering it unattractive. Tyrosine present in the crustacean's shell is oxidised by the enzyme tyrosinase which is found in the tissues and blood and in the hepatopancreas. Because tyrosine and tyrosinase are very stable during temperature changes, this enzymic activity continues if crustacea are under-cooked, even while frozen, resulting in black-spot or black-head. The pigment is formed on the internal shrimp surface and underlying shrimp meat. A dip in anti-oxidant 0.2-0.5% sodium bisulphate for one minute will help control this problem and is used widely by the shrimp processing industry.

Microbial spoilage

Fish carry millions of bacteria on their skin, gills and intestines, the composition of which depends on the bacteria present in the water where the fish dwells. A healthy, living fish uses its natural defence mechanism to protect it against the harmful effects of bacteria. However, when the fish dies, the defence mechanism stops working. The flesh of living fish is usually free of bacteria, but the normal barriers that protect the fish muscle from invasion by bacteria crumble rapidly after death. Initially there are many kinds of bacteria present. During spoilage, the composition of bacteria changes drastically due to competition between the bacteria. These bacteria produce a group of metabolic products and a certain group of odors that vary depending on several factors, including the time and temperature of spoilage.

The practices that contribute to the high bacterial load of fish and hence faster fish spoilage are;

1) Washing fish or surfaces that come in contact with the fish using seawater near the fishing harbour. The harbour water is often contaminated with sewage and may contain many enteric bacteria.
2) Sorting of fishes on the floor of fish markets or sea shores.
3) Preservation of fish in ice prepared from contaminated water.
4) Dragging of the ice blocks on floors and crushing it on floor.

Two types of bacteria that are of concern to the fish industry as well as the consumer are the spoilage bacteria and pathogenic bacteria.

Spoilage bacteria

The spoilage bacteria are responsible for the spoilage of fish. The major species of bacteria implicated in the spoilage of fish in tropical climate are *Pseudomonas, Vibrio spp., Flavobacteria, Acinetobacter, Aeromonas and Moraxella.* Spoilage becomes apparent when the bacterial count increases above 107/g. The flesh loses it culinary qualities like juiceness, firm texture etc. and as a result the product becomes soft with loss of flavour, discoloration and off flavour. The major deteriorative changes brought about by microorganisms in fish are the following:

Formation of ammonia

The free aminoacids present in the muscle of fish is readily utilized by spoilage organisms by the process of deamination. This results in the formation of ammonia which forms major component in the total volatile nitrogen (TVN) fraction. TVN content is often used as a quality indicator of fresh fish. In elasmobranches such as sharks and rays, urea present is degraded to ammonia by bacteria and results in an ammoniacal odour to fish on improper storage.

Formation of TMA

Marine fish is characterised by the presence of an odourless compound, Trimethylamine oxide (TMAO). Spoilage bacteria convert this substance into foul smelling trimethylamine (TMA). The amount of TMA in fish increases with time and the characteristic fishy odour of marine fish are due to the accumulation of TMA. Shark, rays and their group contain urea and trimethylamine oxide in their blood to balance the saltiness of the seawater. They must be bled quickly and thoroughly after being caught to prevent the formation of ammonia and trimethylamine that are indicators of decomposition.

Pathogenic bacteria

The pathogenic bacteria that are associated with fish are of two types:

1) Indigenous bacteria that are normal inhabitants of the aquatic environment. Their growth and multiplication in the fish will result in illness eg. Clostridium, Vibrio, Aeromonas etc. and
2) Non indigenous bacteria that occur in fish as a result of contamination from polluted aquatic environment, sewage, excreta of animals, birds and human beings, workers etc. eg: *E coli, Salmonella, staphylococcus aureus*

The microbial quality of fresh and frozen fish sold in reta markets of Cochin are far inferior in quality than the standard prescribed by any international organisation for wholesom market fish. A study conducted by V.N Nambiar and P. I surendran (2002) on the microbial quality of fish sold in ou local fish markets revealed the presence of *Salmonella* in 17.39 of fresh fish samples and 6.3% in frozen fish whil enterotoxigenic E. coli was present in 19% of fresh fish an 10.6% of frozen fish samples. The TPC was > 106/g in 72% o fresh fish samples and 77% of frozen samples. This study poin to the need for introduction of good handling practices an quality standards for fish and fishery products for interna markets.

Minimising spoilage in fish

The rate and type of spoilage can vary with the time of yea species being harvested, and method of harvest. However, all fis and fishery products are susceptible to decomposition whe mishandled through delays in removing fish from the line or ne allowing product to remain on deck of the fishing vessel in th sun, storage in warm, contaminated water in the hold and poo sanitation and temperature control during transportation an storage. When loss of quality occurs and spoilage begins, th process cannot be reversed and the product quality is lost. Fis and fishery products have limited shelf life and hence ear preventive measures are essential.

In order to minimise spoilage, it is necessary to combat th effects of enzymes, bacteria and oxidation. By understanding th conditions that they prefer, the opposite condition can be creat which helps to preserve and protect the food. For example, w know that bacteria and enzymes work best at ambie temperatures. If we change the temperature by lowering it, as chilling or freezing, the food can be stored much longer.

The factors that that contribute in minimizing the spoila of fish are:

1. Temperature

The most efficient way to prevent decomposition in fish an fishery products is to quickly cool the fish immediately aft capture and to hold it at a low temperature, ideally at -2∫C f marine species, -1∫C for freshwater species, and 10∫C for in-sh molluscan shellfish. Fish in the tropics are caught from war ocean waters (25 to 35∞C). The agents that cause spoila (enzymes and bacteria) are most active under these war conditions. Chilling food in the refrigerator or with ice slo down the destructive processes of enzymes and bacteria. T shelf-life of food can therefore be extended by many da Generally fish can be kept in iced condition for 3-15 da depending on the fish species.

The advantages of using ice to chill fish for preservation a the following:

- It is efficient in chilling fish quickly;

- It is usually fairly cheap;
- It is harmless (as long as it is made from potable water);
- It keeps the fish moist, shiny and attractive;
- It is easily transportable from the place to place
- It has a very large cooling capacity for a given weight or volume.

If the temperature is lowered further, as in freezing, much longer storage times of many months are possible because all bacterial action and virtually all enzymic action is stopped. When cooling is properly done, for every drop in temperature of 5 ∞C, the rate of spoilage is halved, which means that the shelf life of the fish is doubled.

Processes such as cooking (boiling, frying, baking, etc.), hot smoking, canning, pasteurising and so on can extend the keeping time of the food. The effects of these processes are due to the high temperature that will kill bacteria and destroy enzymes.

2. Drying or dehydration:

Removing water from the food by drying it in some way is an effective method of stopping bacteria and enzymes from spoiling food. Drying can take place under the sun and wind (natural drying) or in a mechanical drier. Salting of fish will help the drying process, as it binds the water, making it unavailable to bacteria. Some high-temperature processing such as hot smoking uses a combination of drying and high temperatures to control bacteria and enzymes.

3. Time

At tropical ambient temperatures (about 25 to 35 ∞C) fish can deteriorate in a very short time and can even spoil within 8 to 10 hours. Leaving fish in direct sunlight will heat up the fish further, producing ideal conditions for enzymes and bacteria to attack the flesh

4. Care

The enzymes and bacteria are found in large numbers in the gut of a fish. When a fish is damaged, by being gaffed carelessly, thrown on the deck or stepped on, the contents of the guts may spread out and contaminate that fish. The contaminated fish will deteriorate in quality quickly. Damaged fish can cause other good quality, undamaged fish to lose their quality and become spoiled.

Quality characteristics of fish

	High quality	Medium quality	Poor quality
Eyes	Clear, black, stand out from head, surface of eye convex	50% cloudy, surface of eye slightly concave	Opaque/brown, severely sunken
Skin Colour / Scale Condition	Skin/scales are bright. Scales are intact and undamaged. No evidence of sweating.	Skin/scales are pale/bleached due to ice treatment. No evidence of sweating	Evidence of heavy sweating.
Gill colour	Bright pink/red. No slime	Brown, small or medium amount of slime	Brown/putrid
Smell	No 'fish' smell or slight 'sea water' smell. No repugnant odour	Definite 'fish' smell	Pronounced putrid odour
Flesh texture	Firm and elastic (springs back quickly on pressing)	Soft (springs back slowly on pressing)	Very soft texture

5. Hygiene

Bacteria that cause spoilage are found everywhere but particularly so in places that have not been cleaned. Blood, slime, and pieces of rotten fish have millions of bacteria growing on them. Equipment that is not cleaned will often transfer bacteria onto good fish.

Although many bacteria will increase the rate of spoilage, some other types of bacteria produce toxins that are harmful to humans. This is another good reason for keeping all handling and processing equipment and areas very clean, by washing regularly with strong detergents.

Personal hygiene is equally important hands are used in many handling and processing steps. Dirty hands and clothing will help transfer spoilage bacteria, and pathogenic bacteria, that can make people sick.

To prevent oxidation of fat in fish the product must be protected so that oxygen in the air can not reach the product. The simplest way to do this is to pack the fish in plastic bags that do not allow air to pass through.

In addition to the use of preservation methods, spoilage can be reduced through careful handling and storage practices. Careful handling of fish means that at all stages, it is important to prevent damage to the fish. Any form of damage enables bacteria and enzymes to enter and contaminate the fish. Practising good hygiene through the use of very clean hands and clothing, equipment and work spaces is essential when handling seafood.

In our country, there has been little effort in improving the infrastructural facilities in fish markets. Fish is often handled on the floor of fish markets. The harbour water is usually used for washing fish due to non availability of potable water in fishing harbour and fish markets. The ice used for storage of fish is made from non potable water. Hence there is an urgent need to improve the standard of our fish markets and quality of fish for home consumption. These improvements should also aim to ensure that more fish are available for the home market. This can be achieved by reducing the wastage due to poor handling and by preservation of fish using cost effective technologies