fish preservation and processing

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CHAPTER 1

1.0 INTRODUCTION

Fish is one of the protein foods that needs careful handling (Eyo, 2004). This is because fish spoils easily after capture due to the high tropical temperature which accelerates the activities of bacteria, enzymes and chemical oxidation of fat in the fish. Due to poor handling, about 30 – 50% of fish harvested are wasted in Nigeria. These losses could be minimized by the application of proper handling, processing and preservation techniques (Bate and Bendall, 2010).

The purpose of processing and preserving fish is to get fish to an ultimate consumer in good, usable condition. The steps necessary to accomplish this begin before the fishing expedition starts, and do not end until the fish in eaten or processed into oil, meal, or a feed (Karube *et al*., 2001). Fish begins to spoil as soon as it is caught, perhaps even before it is taken out of the water. Therefore, the key to delivering a high quality product is close attention to small details throughout the entire process of preparation, catching, landing, handling, storage, and transport. Fish that becomes spoiled or putrid is obviously unusable (Gopakumar, 2000). Fish that is poorly cared for may not be so obviously bad, but it loses value because of off-flavors, mushy texture, or bad color that discourage (Burt, 2003), a potential purchaser from buying. If customers have bought one bad fish, they probably won't buy another. On the other hand, if you consistently deliver good quality at a fair price, people will become loyal customers (Nelson *et al*., 2004).

Spoilage proceeds as a series of complex enzymatic bacterial and chemical changes that begin when the fish is netted or hooked (Burt, 2003). This process begins as soon as the fish dies. The rate of spoilage is accelerated in warm climates. The fish's gut is a rich source of enzymes that allow the living fish to digest its food (Lima Dos Santos *et al*., 2011). Once the fish is dead, these enzymes begin digesting the stomach itself. Eventually the enzymes migrate into the fish flesh and digest it too. This is why the fish becomes soft and the smell of the fish becomes more noticeable.

There are countless bacteria naturally present on the skin of the fish, in the gills, and in the intestines (Karube *et al*., 2001). Normally, these bacteria are not harmful to a living fish. Shortly after death, however, they begin to multiply, and after two to four days they ingest the flesh of even a well-iced fish as enzymatic digestion begins to soften it. The bacterial load carried by a fish depends on its health, its environment, and on the way it was caught. Healthy fish, from clean water, will keep better than fish dragged along the bottom of a dirty pond in a trawl net. Both enzymatic digestion and bacterial decomposition involve chemical changes that cause the familiar odors of spoilage (Putro, 2005). Oxygen also reacts chemically with oil to cause rancid odors and taste. The aim of fish processing and preservation is to slow down or prevent this enzymatic, bacterial, and chemical deterioration, and to maintain the fish flesh in a condition as near as possible to that of fresh fish (Bate and Bendall, 2010).

CHAPTER 2

2.1 FISH

A fish is any member of a group of animals that consist of all gill-bearing aquatic craniate animals that lack limbs with digits (Flajnik and Kasahara, 2009). Included in this definition are the living hagfish, lampreys, and cartilaginous and bony fish as well as various extinct related groups (Helfman *et al*., 2004). Tetra-pods emerged within lobe-finned fishes, so sadistically they are fish as well. However, traditionally fish are rendered obsolete or paraphyletic by excluding the tetrapods (i.e., the amphibians, reptiles, birds and mammals which all descended from within the same ancestry) (Helfman *et al*., 2004). Because in this manner the term "fish" is defined negatively as a paraphyletic group, it is not considered a formal taxonomic grouping in systematic biology. The traditional term pisces (also ichthyes) is considered a typological, but not a phylogenetic classification (Nelson and Joseph, 2006).

The earliest organisms that can be classified as fish were soft-bodied chordates that first appeared during the Cambrian period. Although they lacked a true spine, they possessed notochords which allowed them to be more agile than their invertebrate counterparts. Fish would continue to evolve through the Paleozoic era, diversifying into a wide variety of forms (Johnson, 2005). Many fish of the Paleozoic developed external armor that protected them from predators. The first fish with jaws appeared in the Silurian period, after which many (such as sharks) became formidable marine predators rather than just the prey of arthropods (Nelson , 2006).

Most fish are ectothermic ("cold-blooded"), allowing their body temperatures to vary as ambient temperatures change, though some of the large active swimmers like white shark and tuna can hold a higher core temperature (Goldman, 2011;). Fish are abundant in most bodies of water. They can be found in nearly all aquatic environments, from high mountain streams (e.g., char and gudgeon) to the abyssal and even hadal depths of the deepest oceans (e.g., gulpers and anglerfish). With 33,100 described species, fish exhibit greater species diversity than any other group of vertebrates (Lecointre, 2007).

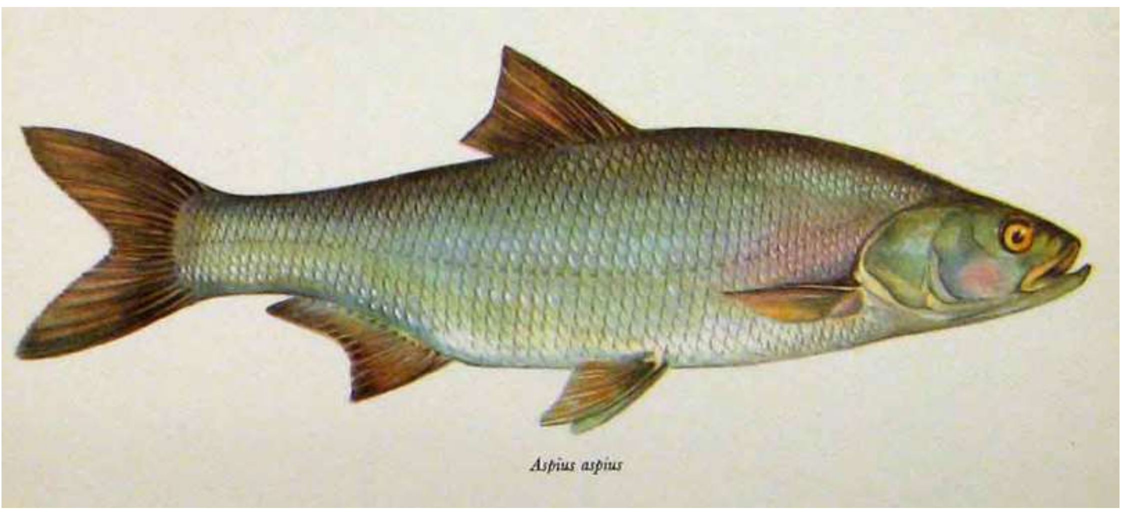

Fig 1: Typical fish (source: www.wikipedia.com)

2.1.1 Taxonomy

Fish are a paraphyletic group: that is, any clade containing all fish also contains the tetrapods, which are not fish. For this reason, groups such as the "Class Pisces" seen in older reference works are no longer used in formal classifications.

Traditional classification divide fish into three extant classes, and with extinct forms sometimes classified within the tree, sometimes as their own classes: (Romer and Parsons, 2011; Benton, 2005)

- ❖ Class Agnatha (jawless fish)
  Subclass Cyclostomata (hagfish and lampreys)
  Subclass Ostracodermi (armoured jawless fish)
- ❖ Class Chondrichthyes (cartilaginous fish)
  Subclass Elasmobranchii (sharks and rays)
  Subclass Holocephali (chimaeras and extinct relatives)
- ❖ Class Placodermi (armoured fish)
  Class Acanthodii ("spiny sharks", sometimes classified under bony fishes)

2.1.2 Freshness of fish

Freshness is usually judged in the trade entirely by appearance, odour and texture of the raw fish (Karube *et al*., 2001). Since assessment depends upon the senses, these factors are known as sensory or organoleptic. The most important things to look for the freshness of fish are:

1. The general appearance of the fish including that of the eyes, gills, surface slime and scales and the firmness or softness of the flesh.
2. The odour of the gills and belly cavity;
3. The appearance, particularly the presence and absence of discoloration along the underside, of the backbone.
4. The presence or absence of rigor mortis or death stiffening;
5. The appearance of the belly walls (Bate and Bendall, 2010).

2.2 CAUSES OF SPOILAGE OF FISHES

Spoilage and freshness are the two qualities that have to be clearly defined (Gram and Huss, 2000). A fresh product is defined as the one whose original characters remain unchanged. Spoilage therefore is the indicative of post-harvest change (Hui, 2006). This change may be graded as the change from absolute freshness to limits of acceptability to unacceptability. Spoilage is usually accompanied by change in physical characteristics. Change in colour, odour, texture, colour of eyes, color of gills and softness of the muscle are some of the characteristics observed in spoiled fish (Baird-Parker, 2000). Spoilage is caused by the action of enzymes, bacteria and chemicals present in the fish. In addition, the following factors contribute to spoilage of fish (Abbas and Saleh, 2009).

- High moisture content
- High fat content
- High protein content
- Weak muscle tissue
- Ambient temperature
- Unhygienic handling

2.2.1 Process of spoilage

Fish is highly nutritive. It is tasty because of its constituents. The main components of fish are water, protein and fat (Adebowale *et al*., 2008). The spoilage of fish is a complicated process brought about by actions of enzymes, bacteria and chemical constituents. The spoilage process starts immediately after the death of fish. The process involves three stages (Amos, 2007).

1. Rigor mortis
2. Autolysis

3. Bacterial invasion and putrefaction

2.2.2 Types fish spoilage

2.2.2.1 Enzymatic spoilage

Shortly after capture, chemical and biological changes take place in dead fish due to enzymatic breakdown of major fish molecules (FAO, 2005). Hansen *et al*. (2003) stated that autolytic enzymes reduced textural quality during early stages of deterioration but did not produce the characteristic spoilage off-odors and off-flavors. This indicates that autolytic degradation can limit shelf-life and product quality even with relatively low levels of spoilage organisms (FAO, 2005). Most of the impact is on textural quality along with the production of hypoxanthine and formaldehyde. The digestive enzymes cause extensive autolysis which results in meat softening, rupture of the belly wall and drain out of the blood water which contains both protein and oil (FAO, 2005).

A number of proteolytic enzymes are found in muscle and viscera of the fish after catch. These enzymes contribute to post mortem degradation in fish muscle and fish products during storage and processing. There is a sensorial or product associated alteration that can be contributed by proteolytic enzymes (Engvang and Nielsen, 2001). During improper storage of whole fish, proteolysis is responsible for degradation of proteins and is followed by a process of solubilization (Lin and Park, 2006). On the other hand, peptides and free amino acids can be produced as a result of autolysis of fish muscle proteins, which lead towards the spoilage of fish meat as an outcome of microbial growth and production of biogenic amines (Fraser and Sumar, 2008). Belly bursting is caused by leakage of proteolytic enzymes from pyloric caeca and intestine to the ventral muscle. The proteases have optimal pH in the alkaline to neutral range. Martinez and Gildberg (2011) reported that the rate of degradation by proteolytic enzymes was reduced when the fish was kept at 0°C and a pH of 5.

2.2.2.2 Microbial spoilage

Composition of the microflora on newly caught fish depends on the microbial contents of the water in which the fish live. Fish microflora includes bacterial species such as Pseudomonas, Alcaligenes, Vibrio, Serratia and Micrococcus (Gram and Huss, 2000) Microbial growth and metabolism is a major cause of fish spoilage which produce amines, biogenic amines such as putrescine, histamine and cadaverine, organic acids, sulphides, alcohols, aldehydes and ketones with unpleasant and unacceptable off-flavors (Dalgaard *et al*., 2006; Emborg *et al*., 2005; Gram and Dalgaard, 2002). For unpreserved fish, spoilage is a result of Gram-negative, fermentative bacteria (such as *Vibrionaceae*), whereas psychrotolerant Gram-negative bacteria (such as Pseudomonas spp. and Shewanella spp.) tend to spoil chilled fish (Gram and Huss, 2000). It is, therefore, important to distinguish non spoilage microflora from spoilage bacteria as many of the bacteria present do not actually contribute to spoilage (Huss, 2005). Trimethylamine (TMA) levels are used universally to determine microbial deterioration leading to fish spoilage. Fish use Trimethylamine Oxide (TMAO) as an osmo-regulant to avoid dehydration in marine environments and tissue waterlogging in fresh water.

Bacteria such as *Shewanella putrifaciens*, Aeromonas spp., psychrotolerant Enterobacteriacceae, P. *phosphoreum* and Vibrio spp. can obtain energy by reducing TMAO to TMA creating the ammonia-like off flavors (Gram and Dalgaard, 2002). *Pseudomonas putrifaciens*, *fluorescent pseudomonads* and other spoilage bacteria increase rapidly during the initial stages of spoilage, producing many proteolytic and hydrolytic enzymes (Shewan, 2001).

2.2.2.3 Chemical spoilage

Lipid oxidation is a major cause of deterioration and spoilage for the pelagic fish species such as mackerel and herring with high oil/fat content stored fat in their flesh (Fraser and Sumar, 2008). Lipid oxidation involves a three stage free radical mechanism: initiation, propagation and termination (Frankel, 2005; Khayat and Schwall, 2003). Initiation involves the formation of lipid free radicals through catalysts such as heat, metal ions and irradiation. These free radicals which react with oxygen to form peroxyl radicals.

During propagation, the peroxyl radicals reacting with other lipid molecules to form hydroperoxides and a new free radical (Fraser and Sumar, 2008; Hultin, 2004). Termination occurs when a build up of these free radicals interact to form non radical products. Oxidation typically involves the reaction of oxygen with the double bonds of fatty acids. Therefore, fish lipids which consist of polyunsaturated fatty acids are highly susceptible to oxidation. Molecular oxygen needs to be activated in order to allow oxidation to occur. Transition metals are primary activators of molecular oxygen (Hultin, 2004). In fish, lipid oxidation can occur enzymatically or non-enzymatically. The enzymatic hydrolysis of fats by lipases is termed lipolysis (fat deterioration). During this process, lipases split the glycerides forming free fatty acids which are responsible for: (a) common off flavour, frequently referred to as rancidity and (b) reducing the oil quality (Huis in’t Veld, 2006; FAO, 2005). The lipolytic enzymes could either be endogenous of the food product (such as milk) or derived from psychrotrophic microorganisms (Huis in’t Veld, 2006). The enzymes involved are the lipases present in the skin, blood and tissue. The main enzymes in fish lipid hydrolysis are triacyl lipase, phospholipase A2 and phospholipase B (Audley *et al*., 2008; Yorkowski and Brockerhoft, 2005).

Non-enzymatic oxidation is caused by hematin compounds (hemoglobin, myoglobin and cytochrome) catalysis producing hydroperoxides (Fraser and Sumar, 2008). The fatty acids formed during hydrolysis of fish lipids interact with sarcoplasmic and myofibrillar proteins causing denaturation (Anderson and Ravesi, 2009; King *et al*., 1962). Undeland *et al*. (2005) reported that lipid oxidation can occur in fish muscle due to the highly pro-oxidative Hemoglobin (Hb), specifically if it is deoxygenated and/or oxidized.

CHAPTER 3

3.0 METHODS OF PRESERVATION OF FISH

Preservation can be done, both for short and long duration: (Eyo, 2002)

3.1 Preservation for short duration

3.1.2 Chilling

The first and simplest method to both preserve and process fish is to keep it cool. Cool fish keeps longer than uncooled fish, although both will spoil in a matter of hours (Tawari and Abowei, 2011). This is obtained by covering the fish with layers of ice. However, ice alone is not effective for long preservation, because melting water brings about a sort of leaching of valuable flesh contents which are responsible for the flavour. But ice is effective for short term preservation such as is needed to transport landed fish to nearby markets or to canning factories, etc. Here autolytic enzymic activities are checked by lowering the temperature (FAO, 2007).

Most fish caught are preserved with ice at some stage in their processing. Trained taste panels are usually unable to distinguish well-iced fish kept less than six or seven days from fresh fish, and storage life can be extended somewhat if antibiotics are added to the ice. Ice works in two ways: (Idachaba, 2001).

1. It reduces the growth rate of bacteria by reducing the temperature of the fish; and
2. It also washes the bacteria and slime away as it melts. Because of this, it is important to keep melt water drained away from the fish.

3.2 Preservation for Long Duration

3.2.1 Salting

There are many different kinds of salt, some being better than others for fish curing. However, in islands or in outlying places there is often no choice, and whatever is available in the way of salt has to be used, whether it is bought in a shop, prepared on the spot, or extracted from earth containing salt. A distinction must be made between the two chief techniques of salting: wet salting and dry salting (FAO, 2005)

3.2.1.1 Wet Salting

The principle is to keep the fish for a long time in brine. The equipment needed consists of a watertight container, which can be a tin, drum, canoe, barrel, etc. To make the brine, one takes four parts of clean water (sea or fresh water) and one part of salt. If the salt is coarse, it has to be ground or pounded first (Tys and Peters, 2009). It is then dissolved into the water by stirring with a piece of wood. To be good, the brine must float a fish. The next step depends on what kind of fish one wants to salt. It is best first to cut off the head, and gut and clean the fish, though small fish can also be salted whole. Large fish must be cut open, and it is preferable to take out the backbone. Fish with a heavy armour of scales must be scaled. In places where the flesh is thick, slashes must be made so that the salted brine can penetrate the flesh. Very large fish should be cut in thin fillets. After the fish has been prepared according to its size, it must be cleaned and put in the brine (FAO, 2008). A plank or matting is laid over it and weighted with rocks so that the fish is entirely covered with brine. This salted fish can be kept for a long time in a dark or at least a shady place (Leistner and Gould, 2002).

The remaining brine can be used three times, but water and salt must be added every time until a fish can again float on the liquid. In any case, fresh brine is always best.

3.2.1.2 Dry Salting

In this method the fish is salted but the juices, slime and brine are allowed to flow away. Dry salting can be done in an old canoe, or on mats, leaves, boxes, etc. In any case, the brine formed by the fish juices and the salt must be allowed to run away. For two parts of fish, one needs one part of salt (Kauffeld *et al*., 2005).

Layers of fish must be separated by layers of salt. It is a valuable method when one has no containers. This method is used to salt down flying fish in open fishing boats while at sea, and the fish in this case are kept whole. Some people like the salty taste of fish prepared in this way, but it is always possible to wash the salt away by soaking it in fresh water before use (FAO, 2005).

3.2.2 Drying

Very small and thin fish can be dried straight away in the sun if they are brought in early enough in the morning (and if, of course, the sun is shining). If these conditions are not fulfilled the fish must be put for one night in brine, or dry salted. They can then be dried the next morning (Deepchill, 2010). If it happens to be raining the next day, it is necessary to wait until the weather has cleared up, which could take from a few hours to a couple of days. In this latter case it will be necessary to wash the salt away from the fish by soaking it in fresh or sea water for a couple of hours before drying it; this depends again on the tastes of the consumers and on the purpose for which the fish is cured (Huss, 2009).

Small fish are mostly sun dried on mats, or suspended. When it rains the fish must be kept dry by covering or transferring them under shelter. If fish are laid on mats or other material to dry, it is best to turn them over every two hours so that they will dry quickly and not become maggotty. In the case of large fish, hanging is better if they are merely split (Ananou *et al*., 2007).

Dry salted fish can also be dried, but they should first be cleaned in water. Normally the fish will be dried after three days. If a great quantity of fish has been dried and is to be kept for some time, the best way is to pile it up in a dark place, off the ground and preferably on wooden boards. It should then be covered with a sack or mat.

After a fortnight the fish should again be laid in the sun for one or two hours and then put away as before. These are only indications of the main principles of fish drying; variations are possible (Leister and Gould, 2002).

3.2.3 Smoking

Any kind of fish can be smoked. There are three main methods of smoking:

(a) Smoking and roasting;

(b) hot smoking;

(c) long smoking.

Smoking and Roasting*:* This is a simple method of preservation, for consumption either directly after curing or within twelve hours. Re-smoking and roasting can keep the product in good condition for a further twelve hours (Kauffeld *et al*., 2005). Fresh unsalted fish is put over a wood or coconut husk fire. This should be kept very small and the fish turned over every five minutes. In about half an hour the fish is ready for consumption or, if it is the intention to keep it for a while, it should be put in an aerated container (Tys and Pieters, 2009).

Fish can be preserved in this way even in open fishing boats, but the smoking has to be done in a tin or a half-drum. Salted fish can also be smoked by this method, but this is used mostly for immediate consumption or in order to bring the produce in smoked form to a nearby market.

Hot Smoking: The hot smoking system can be used for immediate consumption or to keep the fish for a maximum of 48 hours. Small fish can be salted first for half an hour (see wet salting). After salting they are put on iron spits and dried in a windy place or in the sun for another half hour. It is necessary to have an oil drum to make the smoking stove. The top of the drum is cut out and holes are made 8 inches below the rim to place spits. Near the bottom a rectangular opening is made to control the fire. This opening should be closed with a small door or piece of steel plate. A fire of hardwood or coconut husks is made in the stove, and once it is well started it is regulated so as to give no flames (Tys and Pieters, 2009). The fish are then placed over the spits. During the smoking operations the top of the drum must be covered with a sack or with palm fronds laid as close together as possible; the fire control opening should also be closed. The fire must be watched from time to time. The fish will be ready in about one hour. An indication that they are done will be found in the golden yellow colour of the skin. For big fish, l i to 2 feet long, the best method is to split them in halves, to the right and left of the backbone. Each half fish is fixed between two flat bamboo slats or sticks. These halves are then rested head down on racks built four feet above ground. A number of split fish can be lined up next to each other.

A fire of hardwood or coconut husks, or several separate fires, are then lit under the rack. The number of fires depends on the quantity of fish one has to smoke. There should be a slow fire for about half an hour followed by a brisk one for one hour. A small fire is then kept going for six hours (just smoking) (Alasalvar *et al*., 2011).

After this treatment the fish is ready for transport and will keep in good condition for two to three days under tropical conditions. This method is used in particular in the Celebes for skipjack and other tunas (Ananou *et al*., 2007).

Long Smoking: If fish must be kept in good condition for a long time, for instance, two or three months or even longer, it can be done by smoking, provided the fish is not oily.

For this purpose, a small closed shed made of palm leaves or other local material can be used. The dimensions of the shed depend, of course, on the quantities of fish to be smoked, but the height should in no case be less than six feet. In this shed, racks are built to hang the fish from or to lay them upon. Hanging the fish on spits is the best method, but they can also be laid on loosely-woven matting. One can start hanging fish three feet from the bottom up to the roof (Deepchill, 2010).

The preservation of fish is effected by smoke only in this method, and it is best to use coconut husks which should burn very slowly so that the fish is dry smoked after 48 hours. After such a treatment the flesh is dried throughout. If it is necessary to transport these fish to other islands, they should be packed in small packages wrapped in dry leaves and reinforced with bamboo or sticks. In Eastern Indonesia, packages of smoked fish are sent over great distances (Idachaba, 2001).

3.2.3 Fish canning

This is a process involving heat treatment of fish in sealed containers made of tin plates, aluminum cans or glass, until the product has been fully sterilized (Idachaba, 2001). During caning, heat treatment should be sufficient to destroy all heat sensitive bacterial and spores, in activate, the enzymes and cook the fish so that the product remains acceptable to the consumer after prolonged storage i.e (FAO, 2005) commercialized sterilization this is used in thermal processing to describe the heat treatment designed to kill substantially all microorganisms and spores which is present and cable of growing in the product (FAO, 2008). The canned food fish is also prevented from contamination by pathogenic organisms by storing them in a virtually airtight package. If heat treatment is properly carried out canned fish may remain in storage for several years without refrigeration (Leistner and Gould, 2002). Traditional canned fish are obtained from small pelagic fish species such as herrings (*Clupea spp*), Sardines (*Sardinella sp*), Mackerels (*Scomberomerus sp*), Anchovies (*Engraulis sp*), Tuna (*Thunnus sp*). Bonga (*Ethmalosa sp*) (Gopakumar, 2010). Fish intended for canning must be in first class condition and must be handle in hygienic manner to reduce microbial load on the fish. Poor quality fish will produce canned fish with offensive odour and flavour, poor texture (Burt, 2003).

3.3 DEMERITS OF FISH PRESERVATION

Although the preservation and processing constitute a very important aspect of the fish industry, it has certain draw backs; (Bate and Bendall, 2010).

1. Chilling brings about denaturation of flesh. This is because of ice crystals formed during chilling and causing mechanical damage to the muscles. Cell walls burst, structure gets deformed and the flesh loses much of flavour and taste. The flesh also becomes dehydrated and losses texture (FAO, 2008).
2. If proper hygienic measures are not taken during the processes like washing, guttation and evisceration, etc. more harm would be done to the preserved material, owing to increase in the bacteria population.
3. Incomplete or poor preservation leads to decarboxylation of histidine of fish flesh into histamine. The latter some other related substances, collectively called saurine, are common causes of food poisoning (Karube *et al*., 2001).
4. Drying reduces weight, nutritive value and the digestibility of the flesh.
5. Excess salting allows growth of salt tolerant bacteria, causing pink eye spoilage of fish flesh.

6. Salting combined with smoking results in loss of protein, about 1 to 5 % due to salting and 8 to 30 % due to smoking.
7. Smoking also accelerates rancidity of fat and so reduces digestibility of fat products.
8. Canning leads to much loss of vitamin B1, panthotenic acid, vitamin-C and pteroxylglutamic acid (FAO, 2005).

CHAPTER 4

4.1 PROCESSING OF FISH

4.1.1 Handling the catch

When fish are captured or harvested for commercial purposes, they need some preprocessing so they can be delivered to the next part of the marketing chain in a fresh and undamaged condition. This means, for example, that fish caught by a fishing vessel need handling so they can be stored safely until the boat lands the fish on shore. Typical handling processes are (FAO, 2011).

- transferring the catch from the fishing gear (such as a trawl, net or fishing line) to the fishing vessel
- holding the catch before further handling
- sorting and grading
- bleeding, gutting and washing
- chilling

- storing the chilled fish
- unloading, or landing the fish when the fishing vessel returns to port

The number and order in which these operations are undertaken varies with the fish species and the type of fishing gear used to catch it, as well as how large the fishing vessel is and how long it is at sea, and the nature of the market it is supplying (FAO, 2011). Catch processing operations can be manual or automated. The equipment and procedures in modern industrial fisheries are designed to reduce the rough handling of fish, heavy manual lifting and unsuitable working positions which might result in injuries (FAO, 2011).

4.1.1.1 Handling live fish

An alternative, and obvious way of keeping fish fresh is to keep them alive until they are delivered to the buyer or ready to be eaten. This is a common practice worldwide. Typically, the fish are placed in a container with clean water, and dead, damaged or sick fish are removed. The water temperature is then lowered and the fish are starved to reduce their metabolic rate. This decreases fouling of water with metabolic products (ammonia, nitrite and carbon dioxide) that become toxic and make it difficult for the fish to extract oxygen (FAO, 2011).

Fish can be kept alive in floating cages, wells and fish ponds. In aquaculture, holding basins are used where the water is continuously filtered and its temperature and oxygen level are controlled. In China, floating cages are constructed in rivers out of palm woven baskets, while in South America simple fish yards are built in the backwaters of rivers (Bremner, 2003). Live fish can be transported by methods which range from simple artisanal methods where fish are placed in plastic bags with an oxygenated atmosphere, to sophisticated systems which use trucks that filter and recycle the water, and add oxygen and regulate temperature (FAO, 2011).

The time lag between catching, transportation and landing encourages fish flesh quality deterioration and short shelf-life for such fish. This could be prevented by observing the following rules:

1. Kill the fish immediately after been caught by piercing the head with a needle or any sharp object, this prolong the period the fish will stiffen.
2. Cut the fish immediately and remove the gills and cut off the head.
3. Wash with clean running water.
4. Put the fish on ice in insulated boxes. In the absence of ice, the fish should be kept in the shade in clean containers away from intense sunlight.
5. Get the fish as fast as possible to the landing area for further preservation and sales

4.1.2 Removal of the Scales

For a whole flat fish, wash and cut off the head. Holding the fish by the tail and using a sharp knife, Scale it by scrapping toward the head. Scrap until all the scales are removed (UNDFFW, 2003). Turn the fish and scale the other side. (Fig. 2a and 2b).

Fig 2a: Cut off to remove the head

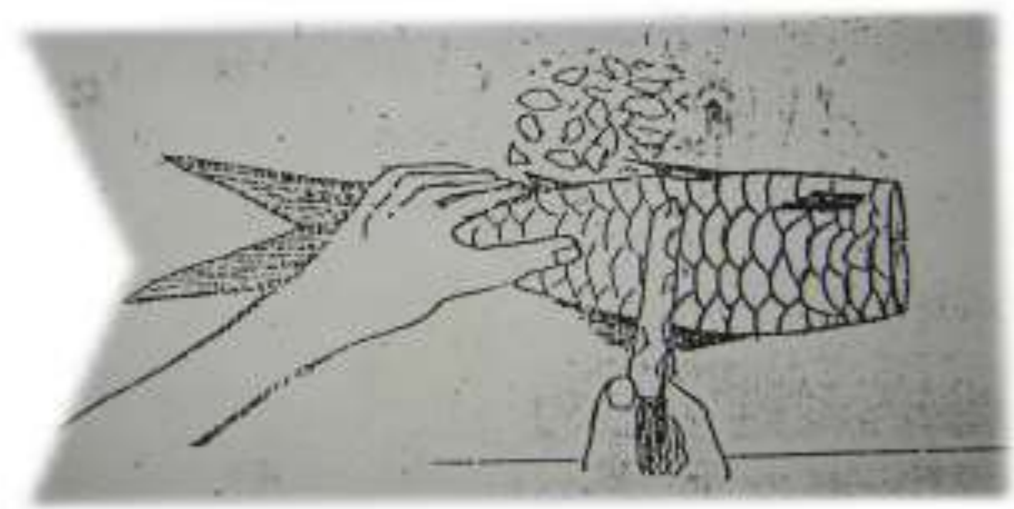

Fig 3a: Scrap to remove scales (Source: UNDFFW, 2003).

4.1.3 Cutting

Cutting the removal of the guts (intestines) of the fish. Gutting should be carried out on fish no matter what method of preservation is going to be applied. After gutting, the fish should be washed thoroughly with clean running water. Gutting and washing of the fish helps to prevent bacterial attack before and during processing, preservation and storage (Silva, 2015).

4.1.4 Filleting of fish

The processing industry also adopted freezing of fish in the form of fillets at times when prawns are not available. Fillets are nothing but the strips of flesh cut parallel to the backbone of the fish. Fishes like milk fish, cat fish, perches, mullets, carps, eel, etc (Bekker-Nielsen, 2005) are suitable for filleting and freezing (Luten *et al*., 2006). Filleting can be done by hand which is economical or by using a filleting machine. Fillets may be with or without skin and it fetches a much higher price in the luxury market.

Fillets are dripped in brine to enhance their appearance and to reduce the amount of drip and it also gives a salty flavor (Bekker-Nielsen, 2005). The freezing of fillets can be an individual quick freezing of block freezing (Zohar *et al*., 2001).

After dropping in brine, the fillets wrapped in polythene sheet are frozen in contact plate freezer at -35^{0}C to 40^{0}C. In block freezing the fillets in known weight 500grm, 1Kg, 2Kg. are packed in polythene bags lined with wax and sufficient quantity of glazed water is poured to cover the fillets (Bremner, 2003). The fillets are put in a freezer at -35 to 40^0 C and stored at -23^{0}C.

4.2 SOME PROCESSED FISH PRODUCTS

4.2.1 Fish mince

This can be defined as flesh separated in a communited form, from the frames, scale, bones and fins of fish. Fish mince can be prepared either mechanically by the use of flesh bone separator or non-mechanically (Royal society of Edinburgh, 2004).

A flesh/bone (or meat/bone) separators also called Deboning machines can be used to retrieve flesh attached to bones and frames of fish and thus make them better utilized instead of discarding them as a waste (Garcia *et al*., 2015). Prepared fish by removing the head, skin, bone, internal organs such as gut, kidney, liver, air bladder and blood vessel before passing it into flesh/bone separator. When this prepared fish are fed into d machine it is squeezed between the feed belts and perforated drums in such a way as to allow only flesh to pass through, while the bones and skin are collected separately. These are utilized thus maximizing the profit from the landings and fish is still made available cheaply to the consumers (Zohar *et al*., 2001).

Minced fish is obtained from filleting leftovers to headed and gutted fish using a bone/flesh (meat-bone) separator to remove bones from the edible flesh. Fish mince is very versatile and can be used to make a variety of products such as fish portions, fish fingers, fish cakes, fish sausage and fish cheese (Sun and Da-Wen, 2008).

4.2.2 Surimi

This is a wet concentrate of proteins of fish muscle that is mechanically deboned water washed fish flesh. It is prepared from marine fish. Minced fish is cooled water-washed to remove fat and water soluble components (Garcia *et al*., 2015). The end product is frozen and is used in the preparation of diverse fish foods such as Kamaboko, Tempura and Chikwa (Japanese Surimi based products) fish sausage fish ham, fish stick, fish balls hamburger. Difference between minced fish and surimi is that while minced fish is the fish flesh which is separated from bones and skin (usually mechanically) surimi is prepared after minced fish have been washed in water to remove fat and wet soluble components (Royal society of Edinburgh, 2004).

4.2.3 Fish sauce

This is an amber-colored liquid extracted from the fermentation of fish with sea salt. It is used as a condiment in various cuisines. Fish sauce is a staple ingredient in numerous cultures in Southeast Asia and the coastal regions of East Asia, and features heavily in Burmese, Cambodian, Filipino, Thai, Lao and Vietnamesecuisines. It also was a major ingredient in ancient European cuisine, but is no longer commonly used in those regions (Royal society of Edinburgh, 2004).

In addition to being added to dishes during the cooking process, fish sauce is also used as a base for a dipping condiment, prepared in many different ways in each country, for fish, shrimp, pork, and chicken. In parts of southern China, it is used as an ingredient for soups and casseroles. Fish sauce, and its derivatives, impart anumami flavor to food due to their glutamate content (Tys and Pieters, 2009).

4.2.4 Fish meal

Fishmeal, is a commercial product mostly made from fish that are not generally used for human consumption; a small portion is made from the bones and offal left over from processing fish used for human consumption, while the larger percentage is manufactured from sustainable, managed, and monitored fish stocks of wild-caught, small marine fish (FAO, 2008). It is powder or cake obtained by drying the fish or fish trimmings, often after cooking, and then grinding it. If the fish used is a fatty fish it is first pressed to extract most of the fish oil (Garcia *et al*., 2015).

CHAPTER 5

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

Fish preservation and processing is a very important aspect of the fisheries. Normally the fish farms or other fish capturing sites are located far off from the market place and there is chance of fish decomposition and the uncertainties of their sale in market. When the fishes are caught in numbers, greater than the amount of consumption, their preservation becomes a necessity for their future use. Preservation and processing, therefore become a very important part of commercial fisheries. It is done in such a manner that the fishes remain fresh for a long time, with a minimum loss of flavour, taste, odour, nutritive value and the digestibility of their flesh.

5.2 RECOMMENDATION

The preservation and processing of fishes should be taken seriously by all as to avoid wasting of the fish products.

Government should invest more on the fish processing as a lots of Economic benefits could be derived from proper processing and preservation of the fishes.

It is recommended that more research should be carried out on the processing of the fishes as not much research work has been done on it.

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