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Traditional Fish Handling and Preservation in Nigeria

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Abstract: The time elapsing between lifting of the nets and delivery to the shore can vary with the distance that has to be covered. It can at times be a period of several hours. The fish, when brought aboard is usually more or less alive. It is stored simply on the bottom of the canoe, lying there in a pool of warm, dirty water. The fish is never gutted and freely exposed to the sun. Needless to say the product thus handled has an extremely short keeping period that could be improved by more hygienic handling and by keeping the fish in shade. The ultimate aim at least for the fish to be entered into the fresh fish trade should of course be to have the fish iced. The same applies to the handling after landing. No precautions are taken to prevent the fish from being covered with sand, leaves, sticks, etc. Better handling practices would be a prerequisite to the development of a fresh fish export trade towards the larger towns in the north and south. It is a well known fact that fishes' rigor mortis period lasts longest with fish kept at a low temperature and is also favourably influenced by killing the fish as soon as possible after catching; in other words by shortening its death struggle and avoiding chemical and enzymic deterioration after passing the rigor mortis period at the lowest possible level. It is recommended that future research tries to establish whether the relationship between killing the fish right after landing on board and a consequent extension of the rigor mortis period is of sufficient significance to be taken up in a programme of improvement of fish handling. Fish handling, filleting, fish preservation, chilling, super chilling, freezing, drying, smoking, salting and fermentation are reviewed in this article to provide information for improvement of culture fisheries management and practices in Nigeria.

Key words: Fish, handling, Nigeria, preservation, spoilage, traditional

INTRODUCTION

Fish is an extremely perishable food item (Agbon *et al*., 2002). Soon after death, fish begins to spoil. In the healthy live fish, all the complex biochemical reactions are balanced and the fish flesh is sterile. After death however, irreversible change that results in fish spoilage begins to occur. The resultant effect is the decomposition of the fish (Akinola *et al*., 2006). Various factors are responsible for fish spoilage. The quality of capture is important at determining the rate of spoilage. Notably are the fish health status, the presence of parasites, bruises and wounds on the skin and the mode by which the fish was captured. The caught fish quality depends on the handling and preservation, the fish received from the hands of the fishers after capture. The handling and the preservation practice after capture affects the degree of spoilage of the fish (Akinneye *et al*., 2007).

The quality of the freshly caught fish and its usefulness for further utilization in processing is affected by the fish capture method. Unsuitable fishing method does not only cause mechanical damage to the fish, but also creates stress and the conditions which accelerate fish deterioration after death. Fish is highly susceptible to deterioration without any preservative or processing measures (Clucas and Sctcliffe, 1987; Okonta and Ekelemu, 2005). Emokpae (1979) reported that immediately the fish dies, a number of physiological and microbial deterioration set in and thereby degrade the fish. The Traditional and Improved Fish Processing Technologies in Bayelsa State, Nigeria 540 aquatic food production globally has more than double since 1970, with a total of approximately 93.2 million metric tones in 1997 (Delgade *et al*., 2003).

Fish is a major source of protein and its harvesting, handling, processing and distribution provide livelihood for millions of people as well as providing foreign exchange earning to many countries (Al-Jufaili and Opara, 2006).

Appropriate processing of fish enables maximal use of raw material and production of value-added products which is obviously the basis of processing profitability.

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Freshwater fish processing, like the processing of the other food raw materials should: assure best possible market quality, provide a proper form of semi-processed final product, assure health safety of products, apply the most appropriate processing method and reduce wastes to the barest possible extent. Akinneye *et al*. (2007) and Davies (2005) reported that the development of appropriate fishing machinery and techniques that employed effective production, handling, harvesting, processing and storage, cannot be over-emphasized especially in the age when aquaculture development is fast gathering momentum in Nigeria.

Opara and Al-Jufaili (2006) reported high incidence of fish losses as a major impediment to the realization of government goal towards increasing the contribution of the sector to the overall national economy. The use of appropriate technology which is a radical approach to stem up production and processing technique, has become subordinate to social need, and is of paramount importance. The need to mechanize fish processing techniques has drawn the attention of national agricultural research to devote utmost interest and resources to engineering research in operation, to minimize the drudgery, reduce labour operation, and unsanitary and inherent unhygienic handling that are mostly involved in the traditional manual operations. Eyo (1997), reported abundant fish catch in the dry season.

During this period, ponds, lakes and streams experience reduced water level, for easy harvest. Thus, period of fish scarcity is often encountered especially during the flood and raining seasons, during which fish are in short supply. Thus, it is imperative to process and preserve some of the fish caught in the period of abundance, so as to ensure an all year round supply. This will invariably reduce post harvest losses, increase the shelf-life of fish, and guarantee a sustainable supply of fish during off season with concomitant increase in the profit of the fisher folks. Akinola *et al*. (2006) reported different types of preservation methods; drying, smoking, freezing, chilling and brining. But the most prominent fish preservation in Niger Delta is smoke drying. This could be adduced to the fact that most of the fish communities have no access to electricity to freeze their products. Electricity itself is fast becoming a less reliable source of energy for fish processing and preservation.

Akinola *et al*. (2006) reported that despite the rudimentary nature of process of traditional methods, lack of control over the drying rate, sometimes results to under-drying or over-drying, expose the fish to unexpected winds, dust, dirt, insect infestation, and contaminants such as flies. These methods still remain predominant in Nigeria. To reduce post harvest losses and to improve the quality of fish and fishery products, traditional processing technology must be improved upon in Nigeria. This includes upgrading the traditional fish processing technology and adoption of solar dryer. Artificial dryers such as solar dryer, kiln, oven and so on have long been in existence, some of them are powered electrically, by sun, gas or natural fuel such as firewood, charcoal, wood and saw dust (Bolaji, 2005; Olokor, 1997; Igbeka, 1986).

The drying of fish in oven consists of a period of several hours in which the fish is cooked and dried with low burning fire for a period, producing only a moderate amount of smoke. The length of this latter period varies with the required keeping quality. The moisture of the dried products varies between an estimated 40% in the higher ranges and 10-20% in lower. The quality of the product is judged on degree of drying, appearance, damaged and insect infestation is influencing the price. Smoked fish as source of foreign exchange is gradually losing ground. This is adduced to the fact that exportation of processed fish to developed countries is becoming increasingly stringent because of the emerging set of Food Safely and Agricultural Health Standard, along with buyers changing their requirements (Ito, 2005; Oyelese, 2006).

In tropical environments, spoilage will proceed very rapidly. Since it is irreversible, it cannot be stopped completely after death. However, techniques are available to slow down the decomposition or spoilage of fish so that it reaches the consumer in reasonably acceptable condition.

Fish spoilage is brought about mainly by, the enzymes present in the live fish. The enzymes begin to break down fish tissues. Prior to death, the enzymes were involved in the digestion of ingested food and all enzymatic reactions are controlled. In the dead fish, the control system fails and the enzymes begin to act on the alimentary system and fish flesh, thereby resulting in soft destructive changes. This process is referred to as autolytic spoilage (FAO, 1985).

Bacteria are present in the gut, gills and skin surfaces of live fish. The live fish defense mechanism is able to combat the action of these bacteria. However, some after death, this defense mechanism also fails. Consequently, the bacteria invade the gut, gills and skin, and cause the decomposition from within and the exposed surfaces of the fish.

Enzyme and bacteria spoilage of fish can be reduced or temporarily halted by various techniques. The traditional and popular methods employed include:

- Temperature reduction by the use of ice (freezing or ice blasting)
- Drying to reduce or completely remove water
- Salting to reduce water and stop enzymatic decomposition
- Application of heat e.g. canning and smoking to destroy the enzymes and kill all bacteria

All the techniques employed in the preservation of fish can be used in isolation or in combination. For example, fish may be generally held in ice before canning, sun drying or smoking.

Another factor taken into consideration is the location or locality where the fish are captured. Water bodies polluted by spoilage bacteria will affect dead fish adversely, resulting in rapid spoilage. Also, if dead fish are held in polluted water, spoilage will proceed at an accelerated rate. The personal hygiene of the fish farmer is another important factor, which determines how fast fresh fish will spoil. This article reviews fish handling, filleting, fish preservation, chilling, super chilling, freezing, drying, smoking, salting and fermentation to provide information for improvement of culture fisheries management and practices in Nigeria.

FISH HANDLING

Fresh fish after capture should be properly handled if the keeping quality and shelf life are to be improved reasonably (Anthonio, 1970). One of such good handling practices is to ensure that, captured live fish are not allowed to struggle and die of asphyxia or oxygen starvation. Struggling after capture, except in the case of the catfishes, will hasten spoilage post-mortem by accelerating chemical reactions in the flesh of the fish. This will reduce the period the fish will remain in rigor or stiffened; thereby, accelerate bacteria attack and spoilage. Catfishes are known to remain alive for a long time after capture and should not be stunned (Ayuba and Omeji, 2006). Other species should be demobilized by piercing the brain with a sharp object or by giving a blow to the head to ensure instant death. Fresh fish deteriorates very rapidly. It is necessary to ensure that fish and fish products get to the consumer in acceptable quality. The initial handling of freshly caught fish prior to processing must fulfill certain conditions to maintain the acceptable quality (Azeza, 1976).

Microorganism contamination of fresh fish is a major cause of spoilage (Clucas, 1981). It is common knowledge that if fish are kept clean and are at low temperature, growth of bacteria, consequently spoilage is kept at minimum. There are numerous requirements, which include adequate supply of clean water. The water should preferably be chlorinated. Chlorinated clean water will remove over 90% of the bacteria invading fish surfaces. Fish preparation surfaces, equipment and tools should depend largely on the materials from which they are made. Metal working surfaces, holding equipment, and tools are preferred since they are easily cleaned using soaps and detergents. Fish are easily bruised (Davies, 2006). It is mandatory that they should not be walked over, instead, they should be kept in boxes, or baskets at chilled temperature shielded from direct sunlight. Fish deteriorate very rapidly in the tropics especially when they have been gutted or filleted due to the high temperature and the increased exposed surfaces. These should be kept chilled to minimize microbial spoilage (Davies *et al*., 2008).

Here are a few terminologies used in fish preparation. These include filleted and gutted fish. Fillets are referred to as the strip of flesh cut from a fish parallel to the line of the backbone. Fillets differ in shape according to the fish. The fillet is a block if both sides of the fish are joined together along the dorsal side of the backbone. When the strip of flesh is from only one side, it is referred to as simple fillet. When fish have been filleted, the surface area available to invading bacteria is considerably increased (FAO/UN, 1970a).

Fillets may be sold fresh or may undergo further processing. It is important to note that a fish filleted before stiffening of the body (rigor-mortis) sets in, may undergo shrinkage. The shrinkage is due to muscular contractions. Skill is however required to produce fillets that will command premium prices when sold fresh. There are the crosses out fillet, which are fillets from that fish (FAO/UN, 1970b).

Filleting: The process of filleting involves laying the fish on one side and cutting from behind the base of the pectoral fin, surrounding the back of the head. The cut portion is then extended towards the tail along the backbone. The rib bones are freed from the flesh, which is also carved of the skin muscle covering the abdomen. The tail is then separated from the block of flesh. The fish is then turned and the other side treated in the same vein. This method if expertly handled produces simple fillets. Block fillets are simply produced with slight modifications. The modifications include not freeing the flesh from the region aspect so that when the fish is turned on the new side and filleted; the two helves produced are formed along the dorsal region (FAO/UN, 1963).

Gutted fish is a fish from which the viscera have been removed. This is achieved by cutting along the ventral surface from the operculum to the anus. The intestines, viscera and gills are removed. The removal of the head is optional. The removal of the gut implies that the storehouse of enzymes responsible for autolytic spoilage has been removed. Gutting of fish is a normal process. Large volumes of water are required for washing gutted fish. The water should be chlorinated and under slight pressure to blood reaching the bone (FAO/UN, 1969).

Fish may be split. This involves cutting open fish from head to tail and the removal of the gut. Splitting of fish may be done prior to drying, smoking or salting. In addition, large fish may be cut into pieces. This facilitates fast cooling down with ice, prior to further processing. In all the processes, large quantity of water is required. The use of chlorinated water enhances product quality. The

recommended chlorine dose is 0.3 mg/L for washing fish. Utensils and premise clean up may require water with chlorine concentrations over 25 mg/L (FAO, 1971a).

There are other terminologists, which are commonly used in fish handling and preparation. These include terms in salt application to fresh fish. Brine salting implies submerging fish in solution of salt water. Where granular salt is rubbed on fish, the term is dry salting. A further advance to dry salting is when spilt fish is rubbed with dry salt and stacked with salt between each layer. The liquid is allowed to drain away. The terminology is kench salting. In pickle salting, fish are covered in slat in watertight containers (FAO, 1971b).

In fish smoking, there are two common terms, cold smoked and hot smoked. Cold smoked implies the maintenance of less than 40ºC while the fish are being smoked. By contrast, hot smoking involves applying heat to cook the fish during the smoking process.

Personal hygiene of the staff is very important in fish handling and preparation. Adequate clean up and washrooms must be provided. Fish processing areas must be washed everyday using detergents. These are a few but very essentials for adequate fish handling. As soon as, fish are harvested from ponds, processing and packing should effectively be carried out in one location. (FAO/UN, 1981). Let the floor be smooth, non slippery, well drained and water proofed. Drainage channels should be well arranged and maintained. The walls should be smooth surface tiled. This makes for easy cleaning. The doors and windows should be fly screened with efficient ventilation. Aluminum alloy equipment is preferred. Electrical installations should be well insulated. Adequate water supply via high-pressure hoses for wash down is necessary (FAO/UN, 2002).

Fish preservation: Nigeria exists in three climatic zones: the lowland humid zone (Niger-Delta falls within this zone), the guinea savannah of the middle belt and semi-arid parts of the north. It is eminent to recognize climatic diversities, thus storage system will differ from one zone to another zone. The Niger Delta covers 30,000 km^2 within wetland of more than 70,000 km^2 formed primarily by sediments disposition. It is located between latitudes 4º2″ and 6º2″ North of the equator and longitude 5º2″ East of the Greenwich meridian (Tawari, 2006). The processing and preservation of fresh fish were of utmost importance since fish is highly susceptible to deterioration immediately after harvest and to prevent economic losses (Okonta and Ekelemu, 2005). If fish is not sold fresh, preservation methods should be applied to extend shelf-life. These include freezing, smoking, drying and heat treatment (Sterilization, pasteurization, etc). Efficient preparation of fish is important when top quality, maximum yield and highest possible profits are to be achieved.

According to Davies *et al*. (2008) the processed fishery products were still stored using traditional storage technologies. The long distance of distribution necessitates some processing and storage since preservation through refrigeration is not readily available (Agbon *et al*. 2002). Lack of adequate fish handling, processing techniques and storage facilities contribute significantly to the low supply of fish to poor rural dwellers that form three quarters of the population in developing countries (Ayuba and Omeji, 2006). Ayuba and Omeji (2006) reported that the insect infestation is the cause of most prominent losses in quality and quantity of stored, dried fish in Nigeria.

They are of two types:

- Initially when the moisture content of the fish is high, it provides suitable breeding ground for several species of flies
- When the moisture content is low dermestes beetles ravish the product causing severe loss

The eggs laid on the dried fish during processing, consequently, the product is transferred to the storage with substantial level of infestation, especially the eggs and early larvae. This undergoes rapid development under the warm conditions while fish are still in storage system. The extent and value of quantitative losses caused by dried fish by insect pest (Dermestes species) have been assessed by various authors such as Azeza (1976) and FAO (1981) estimated range from negligible up to 50% weight losses depending on length of storage, salt content, moisture content, climatic condition and general hygienic during processing and storage.

Fish is a good rich source of some amino-acids, vitamins, minerals and poly-unsaturated fatty acids not found in other sources of fat from aquatic environment. It's harvesting, handling, processing, storage and distribution provide livelihood for millions of people as well as providing valuable foreign exchange earnings to many countries (Al-Jufaili and Opara, 2006). In 2002, total world trade of fish and fish products increased to US $58.2 billion (export value), representing a 5% increase relative to year 2000 and 45% increase since 1992. In terms of quantity, exports were reported to be 50 million tonnes (live weight equivalent), having grown by 40.7% since 1992, showing a slight decline (1%) compared with year 2000 level (Opara and Al-Jufaili, 2006).

The development of fishing machinery and techniques that can be employed for effective fish handling, harvesting, processing and storage can never be over-emphasized especially in the age when aquaculture development is fast gathering momentum in Nigeria (Akinneye *et al*., 2007). Fish processing is to give the product a form which is attractive to the consumers and storage life of fish is extended. The characteristics of

processed fish to be stored should ensure full health safety of the product, proper sanitary conditions as well as rendering it impossible for the development of harmful micro-organisms and toxins (Ita, 1972).

High quality products which are safe and satisfied the consumers can be reached by compliance with processing parameters from the start of the operation to the storage and distribution of the final products. With improved technologies, fresh fish can be stored for period wanted without any significant losses of quality. Presently in Nigeria, the mechanization level of fish processing is low which results from the overall limited production, seasonal availability of fish, poor information dissemination of the available improved technology to processors, and lack of inexpensive equipment adaptable for processing and storage of various fish species. Davies (2005) suggested appropriate processing technologies to enable maximal use of raw material and thus contribute to increase economic profit ability (Jenness, 1970).

The continuing increase in fish export income corroborates the government's growth strategy for the sector as articulated in vision 2020 to raise the share of GDP from 1.1% in 1995 to about 5% in 2020. Realization of this vision for the fisheries sector is dependent on the harvesting, landing, processing and storage of consistent good quality fish to both the domestic and export markets. With continuing growth in population, income and urbanization in Nigeria, West Africa, sub region and globally, consumer theory assures a future demand for good quality fish and other animal products (FAO, 2002). According to Jenness (1970), the storage life extension of smoked fish can be from the combination of lowered water activity and the uptake by the product of bacteriocidal and antioxidant components of wood smoke.

Jenness (1970) indicated that before packing, fish is to be cooled, since while cooling a great deal of water evaporates. When fish is packed while it is warm, moisture will condense on the surface and that encourages the growth of mould. Packaging forms an important part of food processing because it facilitates handling during storage and distribution within the marketing chain. Packaging material must possess certain characteristics, such as adequate strength to protect the packaged product from damage. It must be readily available and easy to use, and should be clean to prevent contamination by undesirable substances. In Niger Delta, the commonest fish processing and preservation methods is smoke-drying.

Tawari (2006) reported 10-15% losses during fish drying and 12-20% during storage in Niger Delta. Eyo (1997) reported a loss of 1000 metric tonnes of fish to 35% in Kainji Lake which was estimated to about N80 million was lost during handling of fresh fish alone in 1995. The problem of high incidence of losses has been recognized as a major impediment to realization of the Nigeria government goal of increasing the contribution of the fish industry sector to overall national economy. Although this estimate did not highlight the potential problems facing the fisheries post harvest sector, there is a dearth of information on the exact magnitude of losses and the steps where they occur in the post harvest system. Such data would be valuable in developing appropriate technologies and intervention to mitigate the problem. Preservation is carried out for the purpose of extending the self-life of fish (Ita, 1972). The major preservation methods are:

Chilling: Chilling may be defined as cooling of fish to low temperatures without necessarily hardening fish. Chilling does not prevent spoilage. However, the colder the fish the better and the lower are the incidences of microbial or enzymatic spoilage. Bacteria or enzyme action are not completely stopped but they may be temporarily halted by chilling. To chill fish, the fish has to be surrounded by colder medium, which could be solid such as ice or liquids such as refrigerated water (Ita, 1972).

Super chilling: This is not a common method. Super chilling implies reducing the temperature of fish uniformly below 0ºC. At this temperature half the water in the fish freezes, bacteria action is greatly reduced and self-life is extended. Fish are initially chilled using ice before storage in refrigerator holds at temperatures below freezing of ice. The temperature in the hold is maintained by means of cold or circulating refrigerated brine. This method is known to extend shelf life of fish by up to 14 days (Ita, 1972).

Freezing: Freezing is distinct from chilling of fish. Freezing can keep products in near prefect condition for very prolonged periods. Freezing is essential for export purposes. Freezing becomes extremely effective, if it is combined with cold storage (Anthonio, 1970).

Fish that have to be preserved by freezing should be cleaned and packed before rigor mortis sets in for easy operation and maximum use of freezing space. Fresh fish have a characteristic sweet flavor, which is due in part to inosinic acid. The breakdown of inosinic acid during autolytic spoilage resulting in the production of hypoxanthine results in the loss of the sweet flavor to bitter flavor. Sugar is produced by enzymatic action, which in turn reacts with the amino acids to produce the brownish or yellowish color found in frozen fish (Azeza, 1976).

Pure water freezes at 0ºC. Fish contains about 80% water, salts and minerals. As would be expected therefore, fish can be frozen at temperatures lower than 0ºC. As the water freezes out, the concentration of salts and chemicals increase thereby lowering the freezing temperature. At

about -5ºC, up to 20% of water in fish is still unfrozen. The freezing stage in fish has been divided into three. The first stage includes the period when the temperature falls rapidly to about -1ºC. At -1ºC, the temperature remains fairly constant and up to 75% of the water freezes. This is the thermal arrest stage of which there is no change in the temperature. In the third stage, the temperature begins to drop and most of the remaining water freezes (Bolaji, 2005).

These stages in the freezing of fish should be the guided in the operations of freezing fish. In particular, is the thermal arrest stage. If this stage is prolonged, some mechanical damage to fish tissue will occur. For example, slow freezing will produce large ice crystals in the cells, which rupture the cell walls. The salts and minerals become concentrated as the water freezes. The phenomenon also applies to enzymes, which can introduce autolysis. Some bacteria remain active at about 0ºC, causing spoilage. When slowly frozen fish are allowed to thaw. Spoilage could be excessive (Clucas, 1981).

In the process of freezing, heat is transferred from the fish to be frozen to some surrounding of adjacent material. It is necessary that a sufficiently cold surrounding must be supplied to effect this change (Davies, 2006). The cold temperature is supplied by, a refrigeration plant. Most refrigeration plants operate by the following method:

- A gas is piped into a compressor, which causes the temperature to rise at higher pressure
- The compressed gas is released into a cooled condenser, where at the high pressure, the gas condenses into gas liquid. The latent heat of the compressed gas is transferred to the coolant
- The liquid gas is passed to evaporator, where at the lower pressure, the liquefied gas boils and evaporates into a gas. Heat is drawn from the surrounding, which cools down
- The gas is directed back to the compressor and the cycle is repeated

It is obvious that fish in the vicinity of the evaporator looses heat as the liquid boils and evaporates. The refrigerant is kept in a closed circuit of pipes and heat is drawn from the fish through the pipes in the evaporator section of the plant (Davies, 2005).

Drying: Drying is defined as the removal of water by evaporation. When applied to fish, drying is the removal of water by any method as a means of fish preservation to prolong the shelf life. In areas where sun drying is used traditionally, the effects of wind and weather conditions are important. Basically, the drying effect of the sun depends on the emission of heat from the sun. This is transferred to the fish and; it is accompanied by, heat transfer within the fish. During drying, the fish shrinks and undergoes irreversible changes. Water is removed from the surface in the following sequence. Firstly, water on the surface of fish evaporates. Water migrates to the surface of the fish from within fish tissues and evaporates. The air surrounding the fish then experiences a drop in temperature. This is accompanied by cooling of the surface of the fish. The energy required to drive the moisture from the surface of the fish can be obtained from a variety of sources including wood smoke, sun drying, solar drier electricity and mechanical driers (Davies *et al*., 2008).

During drying, water is removed from the surface of the fish. As the surface water is removed, it is replaced by water drawn up from the fish tissue, which leaves the fish surface. The rate of drying, consequently, the rate of removal of water is dependent on the air speed, relative humidity and temperature of the surrounding air (Delgade *et al*., 2003).

The surrounding air conditions remain constant. The rate of drying will also remain constant. This stage of the process of drying is referred to as the "constant rate drying". As the removal of moisture from the fish continues, the drying effect continues. Eventually, the concentration of the moisture at the fish surface falls consequently, the movement of moisture to the surface also drops and the drying rate slows down. This stage is referred to as the "falling rate drying" (Emokpae, 1979).

Both rates drying are under the influence of numerous factors. Notably is the relative humidity of the air. If the air is fully saturated with water vapor, drying will not take place. The relative humidity must be less than 100% for drying to occur. It is obvious therefore that the lower the relative humidity, the faster the drying rate. Increased air speed results in faster drying rates (Eyo, 1997).

Distinct striate of air surround the drying fish. The layer nearest to fish is called the stationary layer. The stationary layer is saturated with water. Accelerated drying rates may be achieved to increase the surface area. If the environmental conditions, air speed and temperature are conducive, drying is achieved faster (FAO, 1969).

Smoking: Smoking (Fig. 1-4) is a popular traditional method of fish preservation in most developing countries. Smoking combines the effect of the destruction of bacteria by compounds in the smoke, such as phenols and the cooking of the fish, since, high temperatures will be generated. Smoked fish products have long shelf life, which has been attributed to the drying and cooking effects. When wood and sawdust are burnt, smoke is produced as a result of incomplete combustion. The smoke produced depends on the amount of air available

Fig. 1: A traditional smoking oven

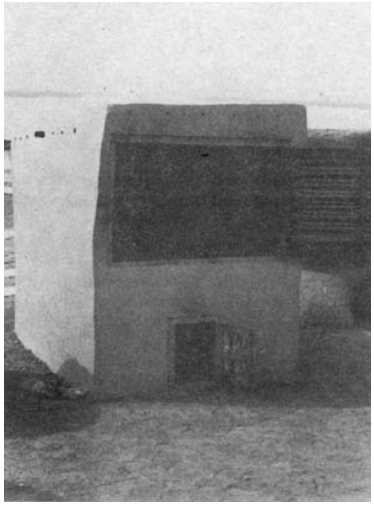

Fig. 2: A 3-tray mud smoking kiln

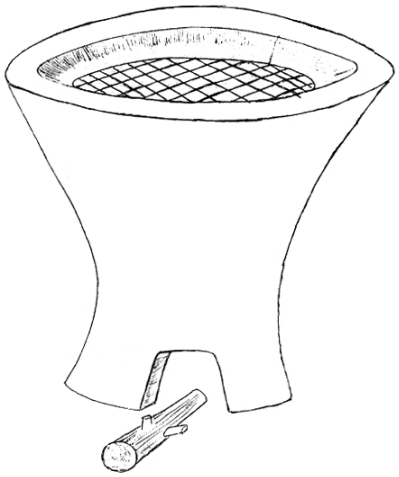

Fig. 3: An hour-glass shaped smoking oven

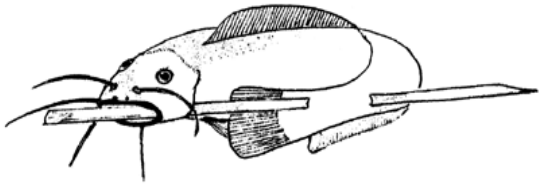

Fig. 4: Fish skewered on a stick prick to smoking

and the quality of wood or sawdust. Soft woods produce a lot of smoke, which may lead to blacking of the finished products. Wood smoke is a mixture of complex chemical product gases, vapor and volatile substances. The volatile substances are absorbed on the wet surfaces of fish during the smoking and produce the characteristic aroma (FAO/UN, 1970a).

As it is frequently seen in fish markets, properly smoked fish products are dark brown in color and are mostly near perfectly dried. This ensures that the shelf life is prolonged and the products get to the consumer in relatively good state (FAO, 1971a).

Salting: There are four standard methods for salting fish. These are brine, dry, kench and pickle salting methods. In brine salting, the fish are immersed in a solution of salt in water. Where granular salt is rubbed into the surface of fish, the process is referred to as dry salting. Granular salt is also used in kench salting. In this process, the salt is rubbed into the surface of split fish and the fish are stored with salt placed between each layer of fish. The liquid formed is not allowed to drain off the fish, which will eventually become covered with the liquid. The liquid is referred to as pickle. In pickle salting, the fish are packed in watertight containers with salt between each layer of fish. If the pickle formed does not cover the fish within 4 h, saturated brine is added to the fish so that, it becomes immersed by the pickle. Otherwise, the fish may spoil (FAO, 1971b).

In brine salting, a saturated brine solution is used. Brine is prepared by dissolving 270-360 g of salt in one liter of water. Fish are then completely immersed in the solution. Due to uptake salt, the concentration in brine drops as consequence of water exuding from the fish. Fish may be stirred occasionally to enhance the uptake of salt. The latter may be eliminated if the brine is much (FAO, 1981).

In dry and kench salting, the fish are packed, surrounded by dry granular salt. The salt dissolves on the fish surface. The liquid, which exudes from the fish, does not cover the fish thereby exposing surface of the fish to air. It is therefore the practice to keep fish in saturated brine until salt has been rubbed into fish. Otherwise, fat oxidation, discoloration of fish flesh and the development of rancidity ensure. During pickle curing of fish, the large quantity of salt used, ensures that the salt is available in sufficient quantity to form the prickle in which the fish is

eventually immersed. The person who now contains blood as well as other compounds in solution reduces fat oxidation and the development of rancidity (FAO, 2002) Different fish species have different rates of salt uptake.

Fatty and thick fish fillets tend to absorb salt slowly. The thicker the fish fillet the slower is the rate of uptake towards the center of fish. Fresh fish may absorb salt readily but slowly (FAO, 1985).

Salt uptake by fish increases with increasing temperature up to an optimum. It is known that increased temperature also enhances fish spoilage. Salt replaces the water in fish. Therefore, there is less water to be reduced by drying. The higher the salt content, the less is the water to be removed. However, during sun drying, salted fish dry very slowly. The obvious reason is that, salt tends to absorb water in the air surrounding the dry fish. In the humid areas, excess salt may make absolute drying possible. It is recommended to begin the initial salting at reduced temperature up to an optimum (Igbeka, 1986).

Fermentation: Majority of the methods used in fish preservation involve the removal of water. These processes involve drying by the use of either heat or heat and smoke. The method that may be employed determines the end product flavor and texture. Fermentation methods have been widely employed to conserve or utilize surplus products. For fish products, this has been categorized into four divisions (Ita, 1972).

Division one includes those employing high salt concentrations containing salts in the range of 15 to 20% of the final product. The high salt content limits the protein intake by man. Consequently, this is mainly used as condiment (Ito, 2005).

In division two, strong mineral acids are employed as preservatives and the acids include hydrochloric acid (HCL) and sulphuric acid (H_2SO_4). The method is confined to silage of forage crops, which have to be neutralized before feeding animals. The third division employs doses of organic acids. To produce fish silage, formic acid is added (Jenness, 1970).

The last division is that of generating organic acids by facilitating lactic acid bacteria growth. This division produces the apparently safe and easy to handle product. In fermentation process, the enzymes within the fish are allowed to break down the protein within fish under controlled factors. The end products of fish fermentation are stable of normal temperature. The breakdown may be partial or entire. Three different products may emerge. The first type of product may retain the original form or large chunks of the fish. The end product may be a paste or the fish flesh may be reduced to liquid (Okonta and Ekelemu, 2005).

Many factors govern the end product of the fermentation process. These include the initial preparation of the fish, whether the fish was gutted or whole, the fat content of the fish, the amount of salt added and at what stage, salt was added and the temperature at which the fish is allowed to ferment (Olokor, 1997).

Fish preservation by fermentation is traditional. Small size fish that will not command premium price in the markets are generally used. Fatty fish such as Brycinus and Lates species when used are burnt in earthen pots and allowed to ferment for a period ranging from 6 to 12 months. The end product is filtered. The bones are removed and the paste is sun dried. Fermentation by this method results in the incomplete oxidation of nutrients and the end product is alcohol and organic acid. The flavor and odor depend on the length the fish is allowed to ferment. Salt may be added (Opara and Al-Jufiaili, 2006).

Mackerel species are also frequently fermented. They are gutted, cleaned of the gills, salted and are placed in concrete tanks. Organic acid is added and the fish remain in the brine for about four months. The end product keeps for up to one year. Where fermentation is allowed to continue for a very long time, sauces are produced. Sauces are liquids containing mixtures of amino acids and protein degradation products. They have very high salt content and may provide a good flavor. In preparing fish sauces, the fish is submerged in brine for up to 18 months. The ripen sauce color ranges from yellow to dark brown. The aroma and flavor are characteristic and determine the grade. Sauces are stable and may be kept for extremely long time (Oyelese, 2006).

The successful preservation of fish by biological fermentation method is depended on the production of lactic acid. Lactic acid bacteria ferment the sugars present to organic acid resulting in the lowering of $_pH$. The low $_pH$ inhibits growth of pathogen organisms and putrefactive organisms. Since fish contains only small amount of fermentable carbohydrates. Mixtures of malt, corn or tapioca should be added (Tawari, 2006).

CONCLUSION

Fish handling, filleting, fish preservation, chilling, super chilling, freezing, drying, smoking, salting and fermentation are important information the fish farmer need to know for the improvement of culture fisheries management and practices in Nigeria.

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