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Some Basic Principles of Fish processing in Nigeria

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Abstract: Some basic principles offish processing in Nigeria is reviewed to provide information for fish culturist to effectively manage the processing of their products. Processing of fish into forms for human consumption or suitable to be used as a supplement in animal food has been neglected in fish culture practices. This may be due to the high technology required in some of the processes and the fact that those involved in actual fish production are ignorant of the different processing methods. In other to prevent fish deterioration, every fish processor must strive to employ the best method possible in handing fish to maximize returns on processing investment. Fish canning, mince fish, fish silage, acid silage, fermented silage, composition of silage, nutritional value of fish silage, fish meal, raw materials for fish meal production, general processes in fish meal production: wet process, dry process, composition and quality, problems in fish processing, production of fish meal locally, local alternatives, comparison between fish silage and fish meal, product evaluation, quality control assessment methods, fish storage, fish anatomy and physiology, chemical composition of fish, fish spoilage types, fish off-flavor management and control, off-flavor mechanism, off-flavor in live fish, other causes of off-flavor in fish, natural chemicals in fish, culture system and fish off-flavor control are reviewed to provide information for fish culturist to effectively manage the processing of their products.

Key words: Fish, fish canning, fish meal, fish silage, local alternatives, processing

INTRODUCTION

Fish is nutritious aquatic animal. It constitutes reasonable percentage of the dietary of human consumption when processed (Adair, 1976). The principal nutritional, constituents of fish in nearest analysis include the following: water, protein, lipid, mineral and vitamin B2. The importance of fish production on the tropics in particular and the world large can never be over emphasized; it is a source of stable food, raw materials for our growing factories and job opportunity for the teaming population (Alamu, 1990).

Fish production from tropical waters increased in recent years reaching about 15milloion tonnes in the 191' Century up till date and forming 17% of the world's total catch. The production is composed of 11 milloion tonnes of marine fish (80%) and 4 million tonnes of fresh water fish (20%) (Eyo, 1999). Fish when out of water deteriorates fast except immediate step are taken to preserve its duality. Despite the subsistence nature of our capture fisheries in Nigeria As much as 50; postharvest losses are recorded, that is half of the total subsistence productions are wasted. The result of this is economic losses to farmers, fish processors and marketers (Bolorunduro, 1996).

Processing can be defined as a method applied to the fish from the time of harvest to the consumption period. Processing of fish into forms for human consumption or suitable to be used as a supplement in animal food has been neglected in fish culture practices. This may be due to the high technology required in some of the processes and the fact that those involved in actual fish production are ignorant of the different processing methods. In other to prevent fish deterioration, every fish processor must strive to employ the best method possible in handing fish to maximize returns on processing investment (Davies, 2005).

Modern smoking kilns that are more efficient and economical to processors include modified Altona (waterable) kiln, modified drum kiln. and Katnji Gas kiln, some steps in fish smoking are highlighted below--VVash the fish with clean water as it is being removed from the handing platform fr Sort the fish out into sizes. Bleed the fish by making a cut around the head region near the

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operculum. Cut the by the abdomen and empty the viscera, clean the fish again thoroughly in clean Water. Brine the fish in salt water for 30-45 min in the ratio (1:5) of salt to water solution at 2 cups of salt to 10 cups of water. Remove the fish and allow the water to drain. Then load the fish in the smoking-chamber with gentle heat to ensure uniform smoking.

This is common in areas with abundant sunshine. To have a good sun-dried product, protect the fish with fine wire mesh to avoid menace of flies (Davies, 2006).

Salting is used in combination with smoking or sun drying. Salting facilitates fish drying, preserves it from insect infestation and improves the quality and taste. Icing is one of the best methods, of reducing spoilage of fish. The right quality of ice must be applied at all times. Iceboxes have been developed to transport and preserve fish. The National Institute for Freshwater Fisheries Research Kainji has established that 50 kg of fish can be conveniently preserved with 20 kg of ice i.e. Ratio of 5-2 with layers of ice and fish alternating. Using the icebox it has been reported that tilapia and catfish will remain edible for 25 to 30 days and 16 to 20 days respectively if buried in ice. Better results are obtained if the fish are gills are removed and wrapped (Bolorunduro, 1996).

The common cabinet freezer popularly called deep freezer can be used. With regular light supply the keeping quality of the fish will be guaranteed, temperature of freezers often fluctuates in response to opening and closing of the equipment. So frequent opening and over load the freezer should be avoided. Alamu, (1991) stated that marketing is the most important stage on the various stage of the fishing industry. The efforts of the fishermen or women cannot be adequately compensated for. The existing traditional practice of smoking salting and sun drying can be improved upon. The commonest processing methods are canning and mince fish, fishmeal and fish silage (Delgade *et al*., 2003).

This article reviews fish canning, mince fish, fish silage, acid silage, fermented silage, composition of silage, nutritional value of fish silage, fish meal, raw materials for fish meal production, general processes in fish meal production: wet process, dry process, composition and quality, problems in fish processing, production of fish meal locally, local alternatives, comparison between fish silage and fish meal, product evaluation, quality control assessment methods, fish storage, fish anatomy and physiology, chemical composition of fish, fish spoilage types, fish off-flavor management and control, off-flavor mechanism, off-flavor in live fish, other causes of off-flavor in fish, natural chemicals in fish, culture system and fish off-flavor control are to provide information for fish culturist to effectively manage the processing of their products.

FISH CANNING

Canning is a modern technological advancement in food processing. Canning improves shelf life enabling storage of the canned product for several years. The canning process involves hermetically sealing the product in a container, heat sterilizing the sealed product and cooling to room temperature for storage (Emokpae, 1979).

Fish may be easily damaged during handling. Therefore, most operations involving handling in the canning industry, such as filing of containers are manually carried out. Certain services like the addition of brine; edible oil and sauces are metered into containers mechanically. The usual pre-canning operations include heading, gutting, cleaning and cutting to sizes, addition of oils, sauces salt or brine, and cooling. The pre-canning operations ensure that the fish are easier to handle once the products are less fragile. Excess moisture are removed from the fish during the processing operations. The removal of excess water ensures that shrinkage due to water exuding from the fish is reduced inside the can during the final heat treatment stage. This may be the factor responsible for the tight packing given to sardines in cans (Eyo, 1999).

During canning process, heat is normally transferred through the fish by conduction. This is a very slow process, which could result in uneven cooking of the fish. Using heat transfer by convection, shorter time is required to heat the can and produce even cooling of the fish. This is achieved by surrounding the can in fluid. Heat transfer involves the use of rotary retort. The movement of the headspace bubble during rotation forces an increase in the liquid movement within the can. This consequently causes an increase in convection heat transfer. Even cooking of the product within the can is assured. The headspace also allows for the expansion of the content during heating. An ideal headspace is achieved by sealing can under pressure. If air is present in the headspace, oxidation of the content may occur. The lid is attached in two double seaming operations using solder and a plastic sealing compound on the inside of can. The operation using the rotator retort is referred to as heat sterilization (Ito, 2005).

The application of heat sterilization calls for an understanding of the effect of heat on fish tissue. The fish to be canned must be in the prime condition. It must be free from any form of spoilage. During heat treatment, water exudes from the fish. This may cause problem in non-fatty fish. If the fish is fatty or oily, the oil may act as physical barrier to water exuding from the fish. The latter enable canned oily fish retain their succulence through heat process. The heat treatment given to canned food is generally that, which gives complete protection from spoilage organisms (Okonta and Ekelemu, 2005).

Fish spoilage, particularly canned fish have to be protected against *Bacillus mophilus* and *Clostridium botilium*. This is achieved by the use of condensed steam under pressure in a sterilizer. When the cans are sealed in the network, steam is admitted and the temperature of the retort is allowed to rise to 100^0C. This temperature is maintained for sufficient time to allow all air be flushed from the retort. The drain and steam exit are shut while allowing steam into the retort. Air entering the retort with the steam can escape. Temperature range of 115 to 120^0C is attained. The pressure and temperature are both automatically controlled soon after the required steam has been admitted (Olokor, 1997).

In cooling the cans, chlorinated water is used. The pressure in the retort is initially maintained by admitting compressed air into the retort. Loss in pressure can cause distortion and damage to cans. Chlorinated cooling water is then admitted to the retort. At this stage, the internal sealant is still molten and the vacuum created in the scan may cause suction of drops of chlorinated water into the can. If the water has no residual chlorine, this may be the source of bacteria responsible for food poisoning. The residual chlorine level generally does not exceed 20 mg/L. As the cooling continues, the pressure is reduced till normal atmospheric temperature is attained. The cans are mechanically removed to the can drier to prevent contamination. The cans are labeled, and parked into cartons (Opara and Al-Jufiaili, 2006).

Canning is an expensive venture. Therefore, a number of factors would have to be considered when setting up a canner. The market for the canned products must exist. The consideration for export market for canned products is generally based on the product line. For example, fish such as tuna are highly priced. Therefore, it makes sense to export these lines. The species of fish desired must be in limitless supply. Since fresh fish is preferred in the case of small sized fish, canning industries should be sited not too far from ports/harbors. A considerable proportion of landed fish head of live weight. Disposal of waste is therefore an important factor considered. There must be and gut will become waste to be used for fish meals. For sardines, such waste constitutes 50% enough and suitable labor and management staff (Oyelese, 2006).

Since fish and fish products are perishable. It is essential that products be rendered safe and bacteriological stable by the use of heat. This heat process must be limited so as to change the flavor and texture as little as possible (Tawari, 2006).

Mince fish: Mince fish are fish flesh separated from the skin and bones. Separating methods may be mechanical using deboning machines or combined chemical and physical methods. The separated flesh could be processed into delicatessen fish products such as fish fingers, fish cakes, fish sausage etc. Almost any type of fish could be processed into mince. The fillet is blended and mixed with other ingredients in a mixer. The mixture is spread on trays and frozen. The slabs are cut into rectangles 75 mm × 50 mm dipped in butter and breadcrumbs and then refrozen. The product is now ready for sale either frozen or part-fried in oil (Tawari, 2006).

Fish silage: Fish silage or liquefied fish protein is a mixture of fish liquid by enzymes in the presence of acids. The commonly used acids are formic and mineral acids. The acid acts as bacteriostatic agent by lowering the $_p$H of the fish waste to a point where pathogenic and putrefying organisms are not viable. The enzymes are involved in the breakdown of proteins and lipids to amino acids and free fatty acids respectively (Opara and Al-Jufiaili, 2006). These enzymes are referred to as digestive enzymes.

This simple technology of processing fish or fish waste into silage is scarcely utilized in developing countries, because acids have to be imported. Formic acid is expensive and scarce, unlike mineral acids such as sulphuric acids and hydrochloric acid. A combination of formic acid and mineral acid at low pH is bacterio-static in action (Opara and Al-Jufiaili, 2006). The raw material for silage production can be provided locally from the following:

- Catches from another fishery
- Artisan seasonal glut
- Products of fish processes

There are two methods of producing fish silage:

- Addition of acid to minced or chopped fish (Acid silage), which lowers the $_p$H sufficiently to prevent microbial spoilage. The fish silage becomes liquid, because the tissue structures are degraded by enzymes naturally present in the fish
- Bacterial fermentation (fermented silage) initiated by mixing minced or chopped fish with a fermentable sugar, which favors growth of lactic acid bacteria

Acid silage: An outline of the steps involved in the preparation of acid fish silage is shown in Fig. 1.

- The raw material should be very fresh
- This may include whole fish, filleting waste, offal or other suitable protein materials
- The fish are then comminuted by, mincing, cutting or chopping. This operation may be manual or mechanical

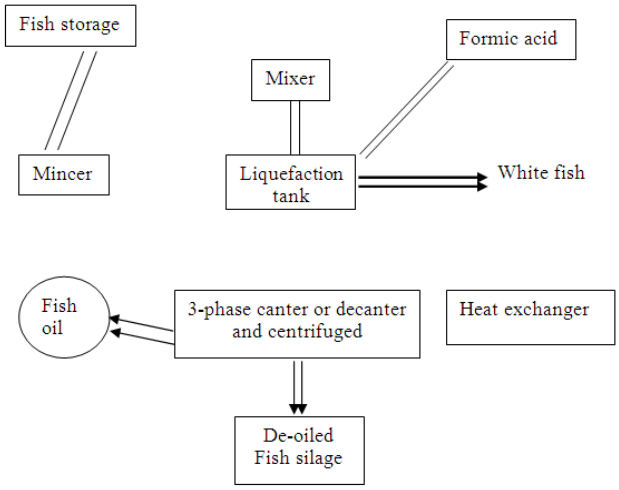

Fig. 1: Sequence of fish silage production

- For manual preparation, 10-15 kg of minced fish is placed in a suitable container. This must be acid resistant.
- Immediately after mincing, 3.5% by weight of 85% formic acid is added, that is 35 kg or about 30 L of acid to one tone of fish. Alternatively, a combination of formic acid and mineral acid may be used. It is important to mix thoroughly so that all the fish comes into contact with the acid, because pockets of untreated materials will putrefy. Acidity of the mixture must be pH 4 or lower to prevent action and at the same time allowing optimal enzymatic activities (Eyo, 1999).
- This container is left covered for the mixture to liquefy. This could take 3 or 4 days. The rate of liquefaction depends on the type of raw material, its freshness and the temperature of the process. Fatty fish liquefy more quickly than white fish offal and fresh fish liquefy more quickly than their stale fish. The higher the mixture temperature, the faster the process. Silage made from fresh white fish offal takes about two days to liquefy at 20ºC, but takes 5-10 days at 70ºC, and much longer at lower temperatures (Eyo, 1999).

There is no problem with the storage of fish silage. If the desired acid level is maintained, the storage life is measured in years. During storage, the silage tends to become smooth and develops a meaty odor. It could be transported and pumped easily. However, it can sediment easily during prolonged storage. Therefore, it is necessary to mix thoroughly before removal from the tanks. This maintains the quality of the silage. Changes could occur during storage. The proteins become more soluble. This increases the amount of free acids in any fish oil. However, feeding trials did not prove these changes to be nutritionally detrimental (Okonta and Ekelemu, 2005). If the silage is made from oily fish, it is advisable to separate the oil for two reasons:

- Oily materials are not good for feedstuff and could cause a tinge in the flesh of animals
- Fish oil is economically valuable and its separation will gives additional revenue

Oil separation is more difficult and expensive than the production of silage itself, but the extracted oil is valuable, and can be sold to offset the capital cost of the extra equipment required for separation. De-oiling should take place as soon as possible after liquefaction and involves three stages:

- The temperature of the silage is raised from 70ºC to 90ºC by a heat exchanger or by direct heating.
- Coarse suspended solids are removed by decantation or by screening.
- Oil is removed from the liquid mass by centrifugation. It is worthwhile de-oiling silage. The value of the oil per tone will far exceed that of the silage. This also reduces the risk of causing tinge. In general, a level of 2% oil causes tinge. The level of 2% oil in the finished silage is acceptable to the user.

Fermented silage: The media containing sugars and lactic acid producing bacteria produce large amounts of lactic acid that decreases the pH. This renders the medium unsuitable for the growth of most other microorganisms. The growth of lacticacid bacteria is apreservation

Table 1: Proximate analysis of four fish silages made from different raw materials

	Type of silage			
Proximate composition	Herring offal	Herring offal de-oiled	White fish offal	Mackerel
Crude protein (%)	13.5	14.5	15.0	16.9
Oil content (%)	8.7	2.0	0.5	12.0
Moisture content (%)	75.4	80.8	78.9	70.2
Ash content (%)	2.6	2.8	4.2	2.1

technique for feed. In addition to the acid, some lactic acid bacteria produce antibiotic, which contribute to their preservation action. These bacteria prevent microbial spoilage of feeds and add flavor to the products. This may prevent rancidity and other chemical reactions that cause quality reduction.In general, lactic acid bacteria such as *Lactobacillus plomtarum* ferments sugars to organic acids, thus, lowering the $_{p}$H of the mixture (Eyo, 1999).

Fish contains only small quantities of fermentable carbohydrates. It is therefore advisable to add suitable carbohydrates to facilitate its conversion to acid. Addition of mixtures of malt and cereal meal, molasses and cereal meal, malt and tapioca meal and; molasses and tapioca meal all contain sufficient amount of carbohydrate. The fermentation process for conversion of carbohydrate to lactic acid is anaerobic and can be divided into three stages:

- The starch of the carbohydrate source is hydrolyzed to maltose by B-amylase
- Glucose is converted to lactic acid by bacteria. Small amounts of other substances such as acetic acid and alcohol are also formed
- Maltose is broken down to glucose by maltose

Since fish do not contain many lactic acid bacteria, it is essential to add a starter culture (Lactobacilli) for successful fermentation. In addition, it is also necessary to add a source of amylase since; the first step in the fermentation relies on the hydrolysis of carbohydrate. In most process, the amylase is provided by the addition of malt to the mixture, because malt is a rich source of amylase (Okonta and Ekelemu, 2005).

The production of fermented silage like the acid preserved silage required that, the fish be comminuted. A carbohydrate source is then mixed with the fish and a starter culture of a suitable bacterium added. Fish preserved by lactic acid bacterial fermentation or added carbohydrate, has an acceptable hygienic quality, though the process of preservation may not be descent (Okonta and Ekelemu, 2005).

Since fermentation is normally carried out in full airtight containers (anaerobic conditions), the growth of Clostridium sp. may occur. *Coliforms*, typhoid bacteria and coagulase positive *Staphilocolli* are destroyed in silage. The low $_{p}$H and presence of antibiotic substances produced by lactic acid bacteria destroys the spores of *Clostridium botulinum*. The growth of yeast and fungi on the other hand may occur if the silage is exposed to air resulting in loss of protein (Okonta and Ekelemu, 2005).

Composition of fish silage: The composition of fish silage is very similar to that of the material from which it is made. The proximate analysis of four fish silages made from different raw materials is shown in Table 1. The proximate analysis results are sufficient information for an assessment of the value of the product to be made and, the protein and oil content are the two most important quantities (Opara and Al-Jufiaili, 2006).

Nutritional value of fish silage: Fish silage is a good source of protein and that its nutritional value is comparable to that of fishmeal when included in cereal rations for animals. Fishmeal contains about 65% protein; whereas, fish silage contains only 15%. That means about four times, as much silage is required for the same protein intake. The most suitable outlet for silage appears to be in big farms, since it can be used in liquid feeding systems. Silage can be used alone or with fishmeal. Feeding trials showed that pigs grows as fast as on silage as on fishmeal. The quality and flavor of the meat was good. Fish silage is used in Danish pig industry, and most nutritional work is being carried out there. Other animals fed with silage grow fast and look healthy (Opara and Al-Jufiaili, 2006).

Silage based moist pellets are excellent diet for salmon fish in Norwegian fish farms. In the diets of carps, fish silage is good source of protein, particularly when the fish is boiled prior to ensiling. In a study carried out at the Nigerian Institute of Marine Research (NIOMR), fish silage enhanced the growth of *Clarias gariepinus* but unequal to fishmeal. Partial or complete replacement of fishmeal by fish silage is also good because it results in good conversion and protein efficiency ratios. There is also an overall mean weight gain of the fish silage in animal rations (Opara and Al-Jufiaili, 2006):

- Acid silage produced with sulphuric acid must be neutralized before it is fed to animals
- At high inclusion rates in the final feed, fish silage may cause reduced feed intake and growth
- To avoid carcass of flavor, the inclusion rate should be adjusted so that the fish lipid level in the complete diet does not exceed 1% of the dry weight

FISHMEAL

The production of fishmeal and oil is the predominate method of processing the world's supply of non-edible fish and fish frames from filleting operations. The early industry was geared to the production of fish oil for leather and soap industries. The solid residue is being used as a high nitrogen and phosphorus fertilizer. This solid residue is now too expensive for use as fertilizer. However, the high protein content makes it very suitable as an animal feedstuff. Fish spoils easily. Therefore, without the production of fishmeal, it is difficult to imagine how such large quantities of highly perishable material could be relatively inexpensively produced and transported across the world (Oyelese, 2006).

Raw materials for fishmeal production: Fish may be caught in quantities exceeding the local processing or freezing capacities. There is also the possibility of extra harvest of fresh water fish during dry season as in stunted species of Tilapia. Artisan fishers experience seasonal glut of fish due to transportation problems and lack of processing facilities. Preservation and storage as fishmeal or silage seem to be a most convenient way of salvaging these resources (Oyelese, 2006).

Fish is always caught in the shrimp trawl. Most of this catch is discarded at sea. From the shrimp trawlers viewpoint, by-catch is not a problem because the average by-catch fish is very low compared to that of shrimps. With the present design of vessels, it is certainly more economical to use the refrigeration capacity aboard for shrimp and to dump the majority of the by-catch.

The by-catch from tropical seas consists of a large number of different fish species, which are extremely variable in size and chemical composition. Most by-catch is too small to be considered, for normal commercial marketing as human food. Some species have a taint, which will contaminate food dish when stored together. Others are too bony or with many scales. If all the by-catch of shrimp is landed, then a potential source of raw material for the fishmeal industry must have been created (Tawari, 2006).

The remnants from fish processing (heads, skin, bones and viscera) for human consumption yield about 40% edible flesh and 60% by products. These by-products can either be processed into fishmeal or silage. The meal or silage so produced slightly varies in composition to that of the whole fish. There is therefore the need for the two to be handled and processed differently. The establishment of three canneries for sardine, mackerel and herring provides a good source of raw material for fish meal or silage production. Fish heads and offal are readily available from the important industry.

General processes in fishmeal production: Several processes are involved in the production of fishmeal and oil from whole fish or waste products from the consumption industry. The wet process is by far the most widely used, because it is continuous and capable of handling large quantities of oily fish. The solvent extraction processes can be used with only oily fish, but several disadvantages have hindered its application in fishmeal production. However, it represents the basic procedures for the production of edible fish protein products. These products are known as fish protein concentrate (FPC). Dry reduction processes have been used for non-oily raw material. Various digestion processes involving chemical and enzymes are seldom used on similar materials (Tawari, 2006).

Wet process: This process is used almost exclusively for processing oily fish such as herring, pilchard and tuna cannery waste. In the wet process the raw material is initially steamed continuously in cooker, then pressed in a screw-type continuous press. The pressed cake is dried in a rotary drier, while the press liquors are centrifuged to separate the oil from the stick water. The stick water contains a water-soluble nitrogenous matter called "gluey". Stick water also contains some residual oil, suspended fine solids and dissolved minerals and vitamins. Stick water concentrated to 50% solid is marketed as condensed fish soluble. The oil fraction may undergo various refining steps depending on the end use for which it is intended (Tawari, 2006). The advantages of this process are:

- Good quality oil is produced
- The process is faster
- Lower installation and operational cost
- Suitable for processing large quantities of material
- Can yield valuable by product (fish soluble)

The disadvantages are:

- Meal is low in water-soluble unless concentrated stick water is added
- Lower yield
- Rigid operational conditions

World wide, the bulk of fishmeal and oil is produced by, a wet process. The various steps involved in this process are shown in Fig. 2. The process involves steam cooking, which coagulates the fish protein, ruptures oil deposits and detaches physiologically bound water; pressing, which removes large fractions of the liquids from the mass; drying which removes the appropriate amount of water from the wet press cake and grinding the dried material to the desirable granular form (Olokor, 1997).

Cooking: When fish are heated to about 100°C, changes take place in the process. This coagulates and breaks cell walls, so that oil and water can be extracted by pressure.

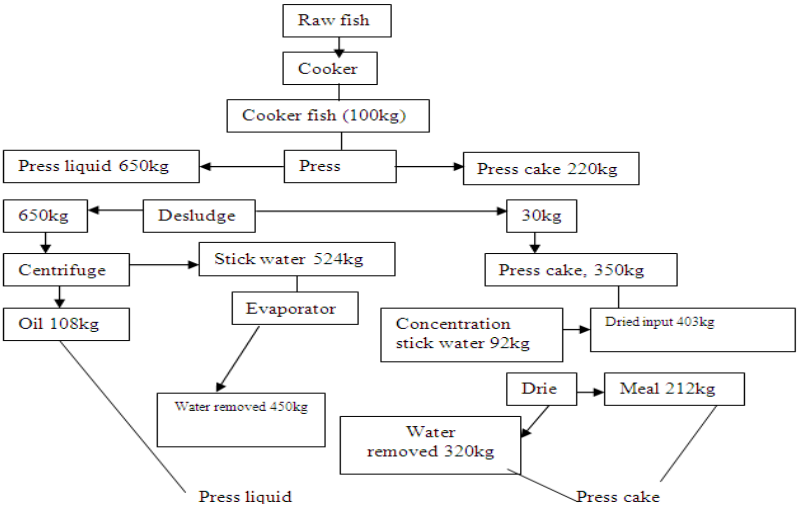

Fig. 2: An outline of a typical fishmeal manufacturing process

Without cooking, the raw material will withstand considerable pressure without significant release of oil and water. The weight of liquor released by cooking can be higher than 60% of the weight of raw material. Direct steam is used for heating the mass of fish (Tawari, 2006). In its mos t common form the cooker is a horizontal cylinder from 4.6 to 12.2 m long and from 38.1 to 76.2 cm breadth with a conveyor screw to move the fish through. Steam is introduced through a series of pipes leading from one or more manifold that run the length of the cooker. It is difficult to generalize an ideal cooking condition because of the variability of raw materials. These are determined by trail and error like those that give a press able mass leading to a meal with low oil content. There is an optimum cooking procedure. Inadequate cooking hinders the removal of liquor and oil content by pressing. When over cooked, the cooked mass can become too soft to press. There is also an increase in the proportion of suspended particles in the pressure liquor. This can create difficulties for the later evaporation press (Oyelese, 2006).

Pressing: Pressing of cooked fish, often preceded by straining, removes much of the oil and water. The fish is conveyed through a perforated tube while being subjected to increasing pressure by means of tapered shaft on the screw conveyor. The press liquor, a mixture of water and oil, is squeezed out through the perforations. The solid (press cake) emerges from the end of the press. During the pressing process, the water content may be reduced from about 70 or 80% to about 50% and the oil content reduced to 3%.

The ability to process the fish to form a good press cake is the ultimate for the fishmeal process and depends on the adequacy of the cooking process and the quality of raw material. Poor quality raw materials are difficult to press because, its semi-liquid condition scarcely lead to a firm mass in the press. This is the case with the occurrence of enzymatic spoilage. There is therefore the problem of poor pressing and increased sludge in the liquors extracted. The use of good quality raw material solves these problems. In the case of deterioration, there is seldom a solution. However, formaldehyde can be added to improve the firmness (Olokor, 1997).

Treatment of press liquor: After screening to remove coarse pieces of solid material, the liquor from the press is continuously centrifuged to remove the oil. The oil is further refined in a final centrifuge, a process known as polishing before being pumped into storage tanks. The refined oil is valuable and is used in the manufacture of edible oils and fats such as margarine (Olokor, 1997).

The aqueous portion of the liquor, known as sticker, contains up to 9% by weight of dissolved material and fine solids in suspension. The solids are mostly protein. By evaporation, the stick water is concentrated to thick syrup containing 30-40% solids. The concentrate can either, be marked as condensed fish soluble or added back and dried along with the press cake to make what is known as whole meal (Olokor, 1997).

Drying: In the drying process, the press cake and concentrated stick water is dried from 50 to 10% moisture content. At this lower moisture content, the product is stable and not liable to bacterial or enzyme deterioration. Therefore, it is important to know the adequate condition of drying. If the meal is not dried properly, moulds or bacteria can grow during storage. If it is over dried heat would be wasted and reduction in output may occur, if the process is not carefully controlled. The meal does not reach the temperature of the

Table 2: Composition of various stages of fish meal production

Material	Water (%)	Solid (%)	Fat (%)
Raw fish	70	18	12
Press cake	53	44	3
Press liquor	78	6	16
Dilute stick water	94	5	1
Concentrated stick water	65	53	2
Fish meal	9	85	6

Table 3: Proximate analysis of fatty and lean fish

	Type of fish	
Parameter	Fatty fish	White fish offal
Moisture (%)	9	0
Protein (%)	12	66
Lipid (%)	6	6
Ash (%)	13	21

hot air, because rapid evaporation of water from the surface of each particle of fish causes cooling of the product as air leaves the drier at 80ºC. The most common type of indirect drier consists of either a steam jacket cylinder or cylinder containing steam heat dishes. The meal moves through the drier slowly but, due to the lower temperature, there is little change of heat damage (Emokpae, 1979).

Grinding and bagging: The final operations are grinding to break down any lump and particle of bones, and packing of meal into bags or storing it in silos for bulky delivery. The objective of milling is to produce a homogenous powder free from foreign matter and good appearance, which can be weighed, bagged and transported; and readily mixed into feed rations. Before milling, a vibratory sieve and magnet remove foreign matter such as woods, nails, fishhooks and plastic bags (Emokpae, 1979).

Composition and quality: The composition of the raw material, the intermediate products and the finished meal for a typical fishmeal process using fatty fish is shown in Table 2. A yield of whole fishmeal of over 20% weight of raw material would be expected. In practice processing may slightly reduce the yield. A further analysis of meal made from fatty fish and whole white fish plus offal are shown in Table 3.

Fishmeal is valuable for the quality of its protein. The amino acids that make up the protein are present in the correct balance for animal or human nutrition. The availability of ten essential amino acids is also greater in fishmeal than meat meal. Fishmeal is also a valuable source of minerals such as phosphorus; magnesium and potassium, vitamins B_1, B_2, B_6, B_{12} and trace elements (zinc, iodine, iron, copper, manganese, cobalt, selenium and fluorine) are abundant in fishmeal (Emokpae, 1979).

Since fishmeal contributes many ingredients to a diet, the quality can be measured based on feeding trials. It is the best standard but, expensive and time consuming. Alternatively, the availability of an amino acid like, lysine in a measure. An important measure of fishmeal quality is its freedom from microorganisms that cause disease in man through the consumption of an infected animal. *Salmonella* is a typical example. Good hygiene and house keeping will prevent this organism (Emokpae, 1979).

The dry process: The dry process is useful when a relatively small quantity of fish is handled. It can also be used for species with low oil content. For example, shark has oil content of less than 3%. The essential steps in the dry process are:

- Fish are coarsely ground in a hacker grinder.
- The hacked fish are cooked in a strain jacket cooker with a stirrer. The cooker also acts as a fryer and is referred to as a cooker/drier.

The dry process has the advantages of:

- High yield of oil for non-fatty fish
- Suitable for small batch operation
- Easy to manipulate cooking and drying time
- Greater flexibility
- Produces whole meal including soluble

The disadvantages of the dry process are:

- Oil of inferior quality
- High installation and operation costs
- Production is low

Fishmeal can be produced by, drying the fish in the sun and grinding the dried product. This is not regarded as an approved process, since the fishmeal obtained in this way is of poor quality and prone to heavy insect and bacterial infestation. Modern fishmeal plants are available which combine the manufacture processes of cooking, pressing, drying and grinding the fish or fish waste. The outline of a typical fishmeal manufacturing process is shown in Fig. 3. Thus, 100 kg of raw fish are reduced to 212 kg of meal, which is one - fifth of the raw material. The 108 kg of oil produced are refined and used in the manufacture of edible fat and oils (Delgade *et al*., 2003).

PROBLEMS OF FISH PROCESSING

The fishmeal processing business is not a quick and easy way to get rich. Pit falls and problems are many (Delgade *et al*., 2003). These include:

- **Raw material:** This is the greatest problem because the demand for fish outweighs the supply. The miscellaneous fish species and shrimp by-catch routinely turned into fishmeal are consumed locally. Hence, increase in price for the raw material.
- **Processing plant:** Scarcity of well cited processing plants to process both small size fish and wastes from the consumption industry.

- **Quality:** Since the source of raw material is not stable locally, it is difficult to maintain good quality standards.

Production of fishmeal locally: The production of fishmeal locally employs the same principle used in the wet process. It involves the selection of raw material, cooking, pressing, drying, grinding, bagging and storage (Fig. 3).

Raw material: Raw materials such as stunted tilapia species obtained from the fish farm or wild can be used. Seasonal gluts of bonga fish in riverside areas are also good source of raw material.

Cooking: Cooking is carried out in aluminum pan or any other container, using firewood to generate heat. A typical cooking procedure is to place 20 L of water in a 50 L capacity aluminum pan and allowed to boiling point. Fish is then added and cooked for 15 min. Gently move the top layer to the bottom and vice versa. Then extend the cooking to 25 min. The cooked fish is removed, ready for pressing. Cooking of the fish is a vital step and must be properly controlled to make subsequent handling of the product easier. During turning, the fish should not scatter. Otherwise, the fish would be mushy. This makes processing and drying very difficult. The required depth of the cooking pan is important. It should be shallow enough to allow easy turning of fish to avoid the danger of over cooking the bottom layer. A half 44-gallon drum is adequate and handy for the cooking operation (Delgade *et al*., 2003).

Pressing: Pressing of the cooked fish locally can be carried out by, placing the product on a sisal cloth. This dehydrates the cooked fish. Another way is by using the same procedure that operates in garri processing. The press liquor in this case can be used for more than one operation without adversely affecting subsequent handling of the cooked product. The resultant liquor contains quite substantial amounts of nutritious materials. Since oil and solute separation is difficult at the local level, other ways of utilizing this nutritious materials are (Delgade *et al*., 2003):

- Feeding of pigs and ducks when mixed with wheat offal or maize bran
- Used as fertilizer when buried in the soil

Drying: Drying of the press cake is by sun drying on corrugated iron sheets. Under good processing practice and environmental conditions, the product dries within two days. A solar tent dried can improve the drying process because it prevents flies from the product.

Grinding: The dried product can be milled in the ordinary maize mills. Alternatively, the traditional mortar and pestle will serve the purpose.

Bagging and storage: At the local level, storing the meal in covered pots, drums, tins etc; seem to be the best and most economical means. In this way, dust, insects, rodent and rain are prevented from interfering with the quality of the finished products.

LOCAL ALTERNATIVES

Blood meal: Although fishmeal is an ideal animal protein source for poultry and fish, blood meal which is a bye-product of slaughter houses/abattoirs is a good substitute which is yet sufficiently utilized. The addition of blood meal to broiler diets improved the growth rate more than rations containing only vegetable proteins. The inclusion of 8% of blood meal resulted in better growth rate than the inclusion of 6% of fishmeal. f adequately processed, blood meal is highly acceptable in poultry feeds and fish feeds. Currently, blood meal is mostly sun dried after cooking. This method is limited to dry seasons (Bolorunduro, 1996).

Feather meal: This is a by-product of poultry processing plants. The feathers are usually steam cooked under pressure and intermittent agitation for a maximum of 60 min. This renders the keratin type of protein digestible in animal feeds.

Chicken offal: These can be obtained from broiler processing plants. The method of processing chicken offal and fishmeal are similar. Chicken offal is good substitute for fishmeal. This was demonstrated at the Nigerian institute of Marine Research (NIOMR). The inclusion of 8% of chicken offal in diets resulted in similar growth response to that containing 6% fishmeal. A combination of 4% fishmeal and 4% chicken offal resulted in better growth response than 6% fishmeal (Bolorunduro, 1996).

COMPARISON BETWEEN FISH SILAGE AND FISHMEAL

There is greater awareness and interest for the production of fish silage in both industrialized and developed countries. This may be due to the fact that fish silage production is a means of utilizing wasted fish in the place of conventional fishmeal production. Since fish landings are sometimes irregular and scattered or the quantity of fish are too small or the processes of a fishmeal plant; fish silage have become comparable to fishmeal (Bolorunduro, 1996). Despite these conditions, fishmeal still supersedes fish silage due to two main reasons.

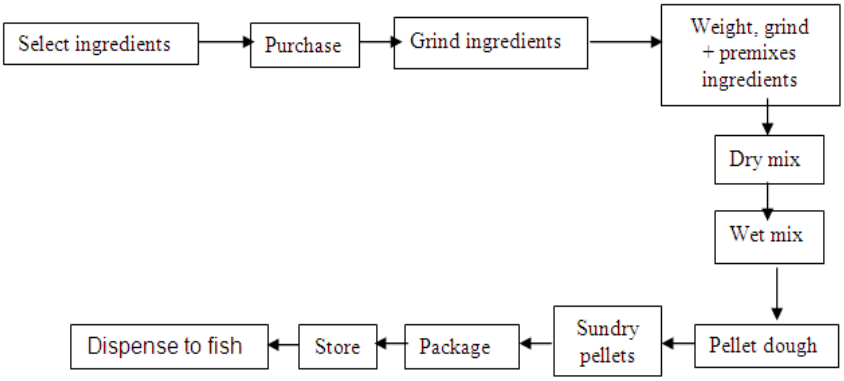

Fig. 3: Processes of preparing fishmeal

- The products are well known in the world markets and therefore can readily be sold. Fish silage, is yet known by, nutritionist and farmers and some marketing effort is necessary as it is a liquid product.

PRODUCT EVALUATION

The entire fish handling, preparation and processing processors are aimed at reducing fish wastage through deterioration. Fish processors have their standards, which are determined by the consumers' choice. The quality of fish as desired by the consumer determines the pricing. The consumer therefore will pay high price for fish considered to be of good quality. Consumers taste preferences vary with the geographic region of the world. The qualities of fish are therefore determined by the consumers demand. The consumer accesses fish quality using numerous factors (Bolorunduro, 1996).

The general patterns of assessment are fish species, odor, flavor, freshness, size, the presence of bones, appearance or processed state and packaging. In developing countries, the consumer is not aware of some legislation affecting fish quality. In the above context, there are prohibitions on the use of certain chemicals either as additives or used in fishing (Davies, 2006).

In processing fish, the maintenance of a particular fish at an acceptable standard, which satisfies the consumer, is referred to as quality control. Quality control is an integral part of any fish processing and preservation under the inspectorate division. The normal functioning is the visual, physical, analytical and microbiological examination of fish, so that, the end product meets the standards of their establishment. The successful implementation of the above function satisfies the customer and could increase profit for the establishment (Davies, 2006).

The quality control inspection is not restricted to the choice. The inspection is aimed at ensuring that the fish may be sorted according to sizes and species. The inspector enforces strict hygiene situations. It is also a function of the inspectorate to ensure that prime products enter the chilled and cold stores. During processing, the inspectorate monitors chlorinity of the water supply, cleanliness of the equipment and facilities (Davies, 2006).

Quality control assessment methods: There are two basic quality control methods, passive and active. The passive method includes inspection of the fish or fish product while the active method includes physical, analytical and microbiological procedure (Davies, 2005).

In the fishing industry, the first assessment method is visual inspection. The points to note are color of whole fish, condition of the eyes, gills, presence of slime and bruises on the body. Clear eyes and bright colored gills indicate fresh good quality fish.

Physical inspection is usually on the firmness. Soft fish indicates fish that is going bad. The acceptability as food depends on the odor of flavor, either fresh or cooked. Cooked fresh fish have sweet taste. Fish going bad may have bitter taste and repulsive odor.

Physical and chemical methods: A known instrument is the GR Torry-meter, which is used for checking and monitoring fish quality. The machine is cal liberated for each fish species and it is independent of all human judgment and errors. In chemical methods, bacterial activities are measured by estimations of Trimethylamine in saltwater species, total volatile bases and total reducing substance. The self-destruction or autolytic activity can be measured by the determination of $_{p}$H, and lactic acid levels, sugars and enzyme assay of nucleotide breakdown products (Davies, 2006).

Microbiological methods: The microorganisms in fresh fish may be classified as either spoilage or pathogenic organisms. Apparently sterile fish tissue is homogenized in de-ionized water, diluted and used to inoculate an agar medium and the plates are incubated. The colonies of bacteria are then counted.

FISH STORAGE

Fish that has been processed and preserved by drying and smoking needs to be adequately packed and stored. Otherwise, the labor employed in the entire exercise is wasteful. Dried fish are brittle and can be damaged easily. Physical damage may occur during storage, transportation and during the process of marketing. The containers commonly used for transportation are wick baskets, wooden boxes and cardboard cartons (Davies, 2005).

Dried and smoked fish storage: Dried fish, particularly sun dried salted fish tends to absorb moisture because, salt is hygroscopic. The uptake of moisture can be checked by, placing dried fish in polyethylene bags. This poses problem and make the processed fish prone to fungal and bacterial attacks. Losses due to the uptake of moisture and consequently microbial damage can be prevented by storage in dry well aerated rooms. If the storage time will be prolonged, the fish can be re-dried in the sun or over a fire periodically. Where wick baskets have been used as container, it may not be necessary to unpack the fish before re-drying using fire or hot smoking.

A common problem during storage is insect attack. Salt dried fish are less susceptible to insect attack. The traditional method employed to check insect infestation is keeping the fish dry by periodic hot smoking. The storage area must be clean, well aerated and dry. The controlled use of insecticide may be employed. Dried and smoked fish have previously been sealed in plastic bags before package. The plastic cover prevents dampness of the dried fish.

Chilled and frozen fish storage: The terminologies, chilled and cold storage have a similarity in that both methods employ temperature reductions to store fish. In chilling, the temperature reduction delays and reduces fish spoilage. The general chilling agent is ice. Chilled stores are designed to hold fish at the temperatures at which they are received. It may be inferred therefore; that additional chilling effect may not be impacted on the chilled fish, rather, the temperatures at which the fish is received is maintained (Davies, 2006).

Chill stores employ the use of ice. Ice is harmless and cools fish quickly. The ice on melting, in addition to the cooling effect, keeps the fish moist and cleans the surface. Since the temperature of melting ice is 0^0C, the fish is maintained at this temperature.

In chill stores, there are other methods for maintaining low temperatures. Solid carbon dioxide can be packed around fan blowers. Circulating cold air over fish is frequently used. The later method has the advantage of freezing fish in the path of the cold air. In addition to freezing, the cold air removes moisture from the fish body surface. Consequently, dehydration may occur in the surface facing the blast of cold air. The latter is a major disadvantage to fish storage employing fan blowers, blowing a steam of cold air over fish in chill stores (Adair, 1976).

In chill stores, fan assisted circulating cold air at 1^0-2ºC is used in addition to fish packed in ice. The circulating cold air slows down the rate at which ice in the store melts down. Fish in chill stores are held in rigid containers to withstand stacking and create adequate spacing so that the cold air can circulate freely.

Frozen storage: Frozen fish are held in cold stores. Cold stores operate at freezing temperatures several ^{0}C below water freezing temperature. Cold stores are designed to hold fish at the temperatures in which they are received and to maintain that temperature. Cold stores will not freeze fish. Frozen fish are either wrapped or glazed before entry into cold stores to main their integrity. Fish are glazed when they are coated by a film of ice. This is achieved by spraying water on or by dipping frozen fish in water (Adair, 1976).

The sprayed water or the coal of water is allowed to freeze before storage. Storage glazing prevents loss of water directly from the fish surface; consequently, the fish body surface and tissues are prevented from dehydration. Fish, which are kept in cold store without glazing, present wrinkled surfaces and tough texture due to the loss of water from fish. This phenomenon is referred to as freezer bum. Freezer bum occurs because water vapor freezer coils. Eventually, the store becomes depleted of water vapor resulting in reduced water vapor pressure. This reduction in water vapor pressure exerts an outward movement of water from exposed fish surfaces to compensate for the water vapor removed from the air in the store. As water is removed from the fish, surface tissue ice sublimes, leaving partially dried fish tissue (Adair, 1976).

When fish have been glazed, the fish surface and tissues are shielded from the direct effect of the cold blast. Any compensation for reduced pressure is exerted on the film of ice. Oxidative changes are characteristic of fatty and oily fish. Fatty fish such as mackerel are rich in labile polyunsaturated fats. Cold stores operate at temperatures as low as -30ºC. For fatty fish to keep well in cold stores, they must be quickly frozen. Storage of frozen fish depends on the containers in which fish are held. Although cardboard cartons and plastic cases are in use, large sized fish are mainly held in sacs. In the cold stores, wooden pallets are placed on the floor and fish containers are stacked on them. The stacking should leave sufficient spacing to allow free airflow (Adair, 1976).

Chilled fish may commonly be stored in cardboard boxes. The depth of the box depends on the type of fish in storage. Fish fillets for example, are held in shallow boxes of 10-12cm deep. Chilled fish when entering chill or cold stores should contain some ice. The boxes are arranged in such a way to leave some air spaces between each box. The boxes must be supported on pellets and they must not

touch the walls of the cold store. Boxes are commonly used for storage of small and medium sized fish (Adair, 1976).

FISH ANATOMY AND PHYSIOLOGY

Fish is an aquatic vertebrate whose flesh is eaten as food. Fish are the most numerous of the vertebrates with 20,000 species known and probably many more unknown (Alamu, 1990).

Being a vertebrate, fishes have a vertebral column, the backbone and a cranium covering the brain. The backbone extends from the head to the tail fin and is composed of segments (vertebral). These vertebra are extended dorsally to form neural spines and in the trunk region, they have lateral processes that bear ribs. The ribs are cartilaginous or bony structures in the connective tissues (Myocommata) between the muscle segments myotomes. Usually there exist a corresponding number of false ribs or "pin bones" extending more or less horizontally into the muscle tissue (Alamu, 1990).

There are two bundles of muscles on each side of the vertebral column and each of these bondless is further separated into an upper mass above the horizontal axial septum and a ventral mass below this septum. The muscle cells run in a longitudinal direction separated perpendicularly by sheets of connective tissues (myocomata). The muscle segments lying between the sheets of connective tissues are called myotomes. The longest muscle cells are found in the twelfth myotome counting from the head and the average length of these is around 10 mm in a cod that is 60 cm long. The length of the cells, as well as the thickness of the myocommata, increases with age (Alamu, 1990).

The muscle tissue of fish is composed of striated muscle. The functional unit, i.e. the muscle cell consists of sarcoplasma with nucleus, glycogen grains, mitochondria etc; and numbering up to 1000 myofibrils. The cell is surrounded by, a sheath of connective tissue called the sarcolema. The myofibril contains the contractile proteins, actin and myosin. These proteins or filaments are arranged in a characteristic alternating way making the muscle look striated on microscopic examination.

Most fish muscle is white. However, depending on the species, many fish have certain amount of dark tissue of a brown or reddish color. The dark muscle is located beneath the skin along the side of the fish flesh. Certain active species have the dark muscle located in a band near the spine (Alamu, 1990).

The proportion of dark to light muscle varies with the activity of the fish. In pelagic fish species such as herring and mackerel, which swim more or less continuously, up to 48% of the body weight may consist of dark muscle. In demersal fish species, which feed on bottom sediments and move periodically, the amount of dark muscle is very small. There are many differences in the chemical composition of the two muscle types. Among these are the higher levels of lipid, haemoglobin, glycogen and most vitamins in the dark muscle. From a technological viewpoint, the high level of lipid content of dark muscle is important because of problems with rancidity. The reddish meat color found in salmon and sea trout does not originate from myoglobin but is due to the red carotionid, astaxanthin. The function of the pigment has not been clearly established.

Chemical composition of fish: The chemical composition of fish varies greatly from species to species and also from individual to individual depending on age, sex, environment and season. These variations in chemical composition of fish are closely related to the feed intake. During periods of heavy feeding, at first the protein content of the muscle tissue will increase slightly and the lipid content will show a marked and rapid increase. The lipid fraction is the component, which shows the greatest variation. Fish muscle is mainly composed of protein, lipid and water.

Proteins: The protein in fish muscle tissue can be divided into:

- Structural protein (actins, myosin, tropomyosin and actomyosin). This component constitutes 70-80% of the total protein in the fish. They are soluble in neutral salt solution.
- Sarcoplasmic protein (myoalbumin, globulin and enzymes) also soluble in neutral salt solutions of low ionic strength. This fraction constitutes 25-30% of the total protein in the muscle tissues
- Connective tissue protein (collagen). This constitutes approximately 3% of the total protein in teleosmobranchic fish species.
- N-containing extractives. These are water-soluble, low molecular weight, nitrogen-containing compounds of non protein nature. This non-protein nature, NPN - fraction (non-protein nitrogen) constitutes 9 to 10% of the nitrogen in teleosts fish species. The major component in this fraction are volatile bases such as ammonia and trimethylamine oxide (TMAD), cretin, nucleotides and purine bases and in case of cartilaginous fish, urea.

Trimethylamine oxide constitutes a characteristic, an important part of NPN (non protein nitrogen) fraction in all marine fish species in quantity from 1-7% of the muscles (dry weight). But virtually not in fresh water species and terrestrial organisms. Trimethylamine oxide is formed by biosynthesis in certain zooplankton species.

These organisms posse an enzyme, trimethylamine mono oxygenase that oxidizes trimethylamine to trimethylamine oxide and is commonly found in marine plants. Plankton eating fish may obtain trimethylamine from feeding on these zooplanktons (exogenous origin).

Principal constituents of fish:
Protein, 16-21% (Normal variation) fish filet.
Structural protein: 70-80 Actin, Myosin, Tropomyosin and Actomyosin, soluble in neutral salt solution.
Sarcroplasmic protein: 25-30% Myoalbumin, Globulin and Enzymes,soluble in neutral salt solution of low ionic content.
Connective tissue protein: 3% in *Teleosms branchli* sp.
Nitrogen containing compounds: Mainly volatile bases such as ammonia and timethylamine oxide. Cretin free ammonia and nucleotides and purine Bases, and in cartilaginous fish is urea.

- Lipid: 0.2-25%
- Carbohydrate: <5%
- Ash: 1.2-1.5%
- Water: 66-81%

Fish spoilage: As soon as the fish dies certain irreversible changes take place within a few hours. The muscles gradually harden along the body until the whole fish becomes rigid (stiffened). It can be rigid for a number of hours or several days depending on the species, condition and temperature. The body muscles then soften again. The stiffening of the body muscles of fish is known as rigor motis, which is caused by changes in the muscle protein resulting from biochemical reactions in the flesh following death of the fish. Enzymes and bacteria in the body are responsible for these changes.

Types of fish spoilage: The major types of spoilage which cause off-flavor in fish are:

Autolytic spoilage: Enzymes in the fish body cause this. Enzymes are natural chemicals in the body muscles. They are protein catalyst, which changes substances without themselves being used up. They continue to function even when the fish is dead, the enzymes continue to function in the body of the dead fish in a process called Autolysis (self destruction). Since they do not die, their function after the death of the fish is to break down other compounds into smaller units. This breaking down of body tissues into smaller units also affects the fish flavor.

Bacterial spoilage: When the fish dies, the bacteria present in the surface, gills and gut rapidly multiply and invade the flesh which provides an ideal medium for growth and further multiplication. Bacteria can also break down skin and muscles and; feed on smaller units produced by autolysis. The increase in number and feeding activity of bacteria can result in heavy slime on the skin and gills, an unpleasant ammonia sour odor and taste. Eventually, the fish flesh softens.

Oxidation: The oils and fats of fish generally have a much high level of unsaturated fatty acids than other foodstuffs. For this reason, there is the likelihood that a reaction between oxygen in the air, the fats and oils to occur. In fatty fish such as mackerels, chemical changes involving oxygen and fats may produce rancid odor, off-flavor and color change. As the spoilage process continues, three major changes occur. These include off-flavor, change in body texture and body appearance.

Fish off-flavor management and control: The characteristic sweetly meaty taste of fresh fish is due to a compound called Inosinic acid in the flesh of fresh fish. Off-flavor means the removal of such characteristic sweetly meaty taste from the fresh fish flesh by causative agents/compounds especially during spoilage processes (Bolorunduro, 1996).

Fish is one of the most highly perishable food items known in the world (Clucas *et al*., 1985). Spoilage begins shortly after death as soon as it is being caught. In the tropics with high ambient temperature, the rate of spoilage is accelerated. It has been estimated that, about 8% of the food fish does not reach the market, post harvested loses are very significant in the fresh and cured fish sectors. The important thing is that the technology for preventing loses is available but needs to be effected (Bolorunduro, 1996).

Estimation of fish spoilage in Nigeria ranges from 20-50% of the domestic production. This implies that a significant part of fishers catch is lost before getting to the final consumers (Clucas *et al*., 1985). All stake holders in the business of fish food including fish culturist, fish farmers and fish processors should endeavor to maintain the natural fish quality to achieve the primary objective of profit making.

Ordinarily, quality means “the degree of excellence”. For fish, it is a standard, which determines the acceptability of the fish. This will affect the price obtained. A high quality product attracts high price and a poor quality attracts low price. The factors, which determine the quality of fish, are flavor (taste), texture and appearance. Spoilage is one of the major causes of loss of fish quality. When decomposition sets in, the fish loses these three values. Once the quality of fish is allowed to deteriorate, it can never be regained.

Off-flavor mechanisms: Off-flavor occur in various ways. Oneof such ways is by causative agents/compounds

during spoilage processes. As the spoilage process continues the inosimic acid monophosphate, which carried the characteristic sweet meaty flavor is broken. It produces another compound called hypoxanthine, which gives the bitter sour taste in fish.

TMAO → TMA → HX

Trimethylamine (TMA) is chemically similar to ammonia (NH_3). It is however not normally found in fresh water fish species but common in marine fish species and crustacean at a level, which is related to the salinity of the habitat. Fresh water species have however been found to contain TMAO when fed on fishmeal made from marine species. TMA is commonly found in marine plants, as are many others by biosynthesis methylamine (Monoethylamine and dimethylamine). So, plankton-eating fish may obtain TMAO from feeding on these zooplanktons.

(Bolorunduro, 1996) has shown that certain fish species are able to synthesis MAO from TMA. TMAO reducing system is present in the dark muscle of certain pelagic fishes. The amount of TMAO in the muscle tissue depends on species season, fishing ground etc. The highest amount is found in elasmobranches and squids, while the least amount is found in fatty pelagic fish.

Off-flavor in live fish: Off-Flavor in live fish may be attributed to their feeding on certain organisms such as, a planktonic mollusk. *Spiratella helicina* or larva of a *Mystillus species* is often described as "mineral oil" or petrol. It is caused by dimethyl – N - propiothelin, which is converted to dimethylsulphide in the fish. Those that feed on *Mystilus* is claimed to have a bitter taste in herring species.

Fish species that inhabit muddy fresh water area results to off-flavour with muddy earth taint. The reason being that the taint is caused by the consumption of an *Actimomycetes* species with a similar odor. Seasonal variation in fish quality is the change related to the reproduction cycle. In fish whose reserves have been severely depleted prior to spawning (e.g. cord fish) with a corresponding reduction in both water quality and nutritional values, also reduces the flavour of the fish (Bolorunduro, 1996).

Other causes of off-flavor in fish: There are several other factors responsible for off-flavour in fish. Among these are:

- **Natural chemicals in fish:** One of such factors includes causative agents/compounds. These agents/compounds are natural chemical (enzymes) found in the body muscles of fish. Whenever condition becomes favorable for these agents/compounds to operate, there activities result to fish off-flavour. The agents/compound include Actinomyces, *Oscillateria teninus, Sumploca muscrum, Anabaena circinalis, and Volvox aurenys*. The causative compounds include geosmin, micidone and 2-methyliso bornerl (Bolorunduro, 1996).
- **Culture System:** A culture system, which uses much of fertilizers especially organic fertilizers, can cause off-flavor in fish. Discourage the use of organic fertilizers in commercial scale catfish production where the end product is food, because fertilization is not essential in successful catfish production. A bloom of those zooplanktons, which has the ability to synthesis TMAO through biosynthesis, can result to off-flavor in fish (Bolorunduro, 1996).

In fresh water culture system where, fish feeds formulated from marine species are used as fishmeal, fish off-flavor can occur. This is as a result of possible transfer of TMAO from marine species to fresh water species(Alamu, 1999):

- **Fish off-flavor control:** Off-flavor in fish can be controlled by:
  - **Control in culture systems:** One could apply practical measures by minimizing feed waste through exchange of water. Stop the use of fish species known to have TMAO in their muscle tissue for feed formulation (Alamu, 1998).
    The fish farmer should avoid the bloom of zooplanktons known to have TMAO in the culture system by limiting the use of fertilizers that promote the growth of such organisms.
  - **Control in water quality:** In stagnant water environments like ponds, lakes etc, especially those connected to or linked with polluted streams or water shed; inorganic or organic pollutants which are soluble in water can eventually affect the taste of the fish. Chemicals may be found in fish tissue as a result of biomagnifications (concentration of chemicals in higher trophic levels of the food chain) or bioaccumulation (increasing concentration of chemical in the body tissue accumulated over the life span of the individual). In the case of fish species, it can be controlled by frequent exchange of water with fresh one.
  - Sal tcan be added toachieve10 %salinity in close raceways.
  - **Processing:** smoke drying, precooking and addition of vegetable oil, in case of canning, could reduce Off-flavor.
  - Off-flavour from affected fish can be removed by keeping the fish in charcoal-filtered clean flowing water.

- **Temperature change:** The affected fish could be subjected to temperature change e.g. in cold storage temperature of about-360ºC. This would tremendously reduce the activities of these causative agents.
- **Sensory evaluation:** This involves using human sense to evaluate fish samples. It can be used to evaluate the appearance, texture, odor and off-flavour. However the disadvantage of sensory method is that it is subjective and depends on the individual judges Individuals may have different likes, dislikes, prejudice, fatigue and ability to express sensations when testing a fish product (Alamu, 1991).

CONCLUSION

Fish canning, mince fish, fish silage, acid silage, fermented silage, composition of silage, nutritional value of fish silage, fish meal, raw materials for fish meal production, general processes in fish meal production: wet process, dry process,composition and quality, problems in fish processing, production of fish meal locally, local alternatives, compariso between fish silage and fish meal, product evaluation, quality control assessment methods, fish storage,fishan at my and hysiology, chemical composition of fish, fish spoilage types, fish off-flavor management and control, off-flavorme chanism,off-flavorin livefish,other causes of off-flavorin fish,natural chemicals infish,culture system and fish off-flavor control arevery important elementin fish processing fish culturistneed knowin other to effectively manage the processing of their products.

REFERENCES

Adair, D., 1976. Handling processing and marketing of tropical fish. Proceedings of the conference on the handling processing and marketing of tropical fish tropical products institute 56162 Gray's Inn Road London WUX 8LU 1977- pp: 183.

Alamu, S., 1990. Assessment of women contribution to fishing industry and fish marketing in Kainji Lake Basin. Annual Report, pp: 184-190.

Alamu S., 1991. Impact of women fish mongers on commercial fish Handlings and marketing in Kainji Lake Basin. Annual Report, pp: 205-213.

Alamu, S.O., 1998. Women in artisanal fish production, comparison of Kaiji: and jebba lake Basins Annual Report. pp: 46-47.

Alamu, S., 1999. The roleof women in artisanal fish production in Jebba. Lake Areas. Annual Report, pp: 6.

Bolorunduro,P..1996.Livestock and fisheries productionte chnology for women in Agriculture. Inproceedings of the National trading workshop held of NAER1, pp: 65-68.

Clucas, I.J., R.C. Cole and T.W. Bostock., 1985. Fish handling preservation and processing in the tropical part I, Tropical Development and Research Institute Ginisby College of Technology, pp: 33-53.

Davies, R.M., 2005. Development of Appropriate Technology of fish processing in Nigeria.Apaper presented at a one-day workshop on intensive fish farming on Thursday, 24th February.

Davies, R.M., 2006. Mechanization of fish industry in Nigeria status and potential for self sufficiency in fish production. A paperpresented ataone-day workshop on intensive fish farming. 19th August. pp: 10.

Delgade, C.L., M.W.N. Wada, S.M. Rosegrant and M.Ahmed., 2003. Fish for 2020: Supplyand demand in changing global markets. International Food Policy Reseach Institute,Washington, D.C. and World Fish Centre, Penanng, Malaysia.

Emokpae, A.O., 1979. Organoleptic assessment of the quality of fresh fish. Nigerian Instituteof Oceanography and Marine Research (NIOMR) Occasional Paper, No.12, pp: 1-4.

Eyo, A.A., 1999. The effect of traditional handling, processing and storage methods on the quality dried fish in small scale fisheries in Nigeria in Proceedings of the 13' Annual Conference of fisheries society of Nigeria, pp: 50-54.

Ito, S., 2005. The Distribution Effect of Compliance with Food Safety and Agricultural HealthStandards on Small producers in Developing Countries. Proceedings for the Japan Society for International Development, pp:113-116.

Okonta, A.A. and J.K. Ekelemu., 2005. A prelimnary study of micro-organisms associatedwith fish spoilage in Asaba, Southern Nigeria. Proceedings of the 20th Annual Conference of The Fisheries Society of Nigeria (FISON), Port Harcourt, 14-18th November, pp: 557-560.

Olokor, I.O., 1997. Solar tent, an adaptable fish preservation technology in Kainji Lake Basin. In Kainji Lake Fisheries Promotion Project. A Promotion Project. A bulletin of the Nigeria/ Traditional and Improved Fish Processing Technologies in Bayelsa State, Nigeria, 548 German Kainji lake Fisheries Promotion Project, New Bussa, Niger State, Nigeria. January, 1997.

Opara, L.U. and S.M. Al-Jufiaili, 2006. Status of fisheries pot harvest industry in the Sultaneof Oman: Part 2 Quantification of fresh fish losses. J. Fisher. Int., 1(2-4): 150-156.

Oyelese, O.A., 2006. Quality assessment of cold smoked, hot smoked and oven dried Tilapianilotica under cold storage temperature conditions. J. Fisher. Int., 1(2-4): 92-97.

Tawari, C.C., 2006. Effectiveness of Agricultural agencies in fisheries management and production in the Niger Delta. Ph.D. Thesis, Rivers State University of Science and Technology, Port Harcourt, Nigeria (Unpublished), pp:180.