CONTAMINATION AND QUALITY ASSURANCE OF FISH PRODUCTS IN NIGERIA

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ABSTRACT
This paper reviews contamination and quality assurance of fish products in Nigeria, with highlights on benefits, public health hazards and risks associated with fish consumption. Fish has become an increasingly important source of protein and other minerals essential for the maintenance of healthy body among the populace living in urban and rural areas. The quality of fish products being consumed in different parts of the country has been an issue to the food processors, consumers and public health authorities. Conversely, provisions of safe, wholesome and acceptable fish and its product as food to consumers and control of microorganisms especially bacteria is essential to meet these objectives. The quality of fish degrades, due to a complex process in which physical, chemical and microbiological forms of deterioration are implicated. To ameliorate this phenomenon, the general public should be enlightened on the inherent danger that may accompany handling fresh fish or consumption of improperly cooked fish. Hazard Analysis Critical Control Point (HACCP) Programs designed to prevent unsafe foods from reaching the consumer should be employed. Also, good hygienic practices should always be observed by producers and traders in fish products to minimize the risk of contaminations associated with the consumption of seafood products.

Key words: Fish Processing, Contamination, Quality assurance, Nutritive Composition

1.0 INTRODUCTION
Fish has been acknowledged as an important source of animal protein all over the world, it contributes significantly to the survival and well being of a large number of the people around the world. Fish is known to be efficient converter of food for human consumption. It helps in nourishing a large proportion of children in tropical countries, due to low protein intake and unbalanced diet and there is little or no religious restriction on its consumption [1]. Conversely, fish is an important source of essential nutrients such as protein, lipids, vitamins and minerals in the right proportions [2]. Many people around the world depend on fish as a supplement of their food nutrients; this is because fish has become an increasingly important source of protein and other elements necessary for the maintenance of a healthy body [3]. Throughout history; humans have used fish as a source of protein [4]. Fish is the third staple animal protein and forms a cheap source of protein. Fish and fish products constitute an important part in the international trade; more than 50 billion fish are eaten annually indicating increasing consumer interests in the commodity [5]. Fish has traditionally been a popular part of the diet in many parts of the world and in some countries constituted the main supply of animal protein. Today, even more people are turning to fish as a healthy alternative to red meat [6].

Conversely, fish is generally believed to be reasonably cheaper and available source of protein in most countries around the world including Nigeria. Fish is one of the most important animal protein foods available in the tropics [7]. They are a lean, low-calorie, high quality source of protein. They contain essential nutrients and omega-3 fatty acids, and are low in saturated fat. Fish is one of the most
perishable food products and therefore quality deterioration of fresh fish occurs rapidly during handling and storage and limits the shelf life of the product [8]. Fish is a food that must be handled hygienically. Fresh fish spoilage and high perishability are primarily due to large amount of non-protein nitrogen (like free amino acids), volatile nitrogen bases (ammonia, creatine, taurine, uric acid, carnosine and histamine) which support post mortem bacteria growth [9]. Fish and fish products are often associated with human disease especially when consumed raw or when undercooked. Some of these diseases have been specifically associated with pathogens which are resistant to antibiotics [10]. The quality of fish could be tarnished through a complex process in which the physical, chemical and microbiological forms of deterioration are involved. The enzymatic and chemical reactions are usually responsible for the initial loss of freshness whereas microbial activity is responsible for the obvious spoilage and thereby establishes product shelf life [11].

In recent times in the country, the quality of fish from the wild and aquaculture has been a major concern to the food processors, consumers and regulatory authorities in charge of fisheries activities. However, provisions of safe, wholesome and acceptable fish and its product as food to consumers and control of microorganisms through adequate processing methods are essential in achieving these objectives from time to time [12]. Hence, there is the need to assess the sources and level of contamination in the fish being consumed, and the need for control of quality of these fishes through appropriate government agencies, so as to ensure availability of high quality fish food across the country. This paper therefore, reviews the levels of contamination and quality of fish and fishery products in Nigeria.

1.1 Importance of Fish in Human Diet

The importance of fish in human diet is of paramount importance in both rural and urban areas in Nigeria [13]. Fish are being consumed widely by both old and young, with no religious or cultural barriers. Fish is a major source of cheap and available nutrients such as: proteins, minerals and vitamins and are also low in saturated fats. They account approximately for the 17% of the global animal protein intake [14]. Fish has a high biological value in terms of high protein retention in the body, low cholesterol level and essential amino acids [15]. Fish and seafood constitute an important food component for a large section of world population [16].

Protein is needed for normal growth and development in children and to maintain muscles in adults. Fish helps to lower the risk of cardiovascular diseases. They are a source of unsaturated fats called omega -3-fatty acid which affect cardiac functions including hemodynamic and arterial endothelial function [17]. In addition to having a healthy heart, fish helps in having a healthy brain. The omega-3-fatty acids, particularly EPA (Eicosapentaenoic acid) and DHA (Docosahexaenoic acid), help in the brain and vision development of infants while still in the womb and also help the adult to reduce the incidence of cardiovascular disease (Table 1).

2.0 FISH QUALITY

Most often "quality" refers to the aesthetic appearance and freshness or degree of spoilage which the fish has undergone (Table 2). It may also involve safety aspects such as being free from harmful bacteria, parasites or chemicals. It is important to remember that "quality" implies different things to different people and is a term which must be defined in association with an individual product type. For example, it is often thought that the best quality is found in fish which are consumed within the first few hours post mortem. However, very fresh fish which are in rigor mortis are difficult to fillet and skin and are often unsuitable for smoking. Thus, for the processor, slightly older fish which have passed through the rigor process are more desirable [18].
Table 1: Beneficial effects of consumption of fish oils (ω-3 PUFAs)

<table>
<thead>
<tr>
<th>Age group</th>
<th>Prevents</th>
</tr>
</thead>
</table>
| Pediatric | Childhood asthma  
Attention deficit hyperactivity disorder (ADHD) |
| Adult     | Cardio-vascular disease (CVD)  
Hypertension  
Idiopathic oligoasthenoteratozoospermia |
| Geriatric | Dementia  
Age-related macular degeneration (AMD)  
Alzheimer’s disease (AD)  
Mood disorders |

Source: WHO [18]

2.1 Methods of Assessment of Fish Quality

2.1.1 Sensory Evaluation

Sensory evaluation is one of the most important methods for assessing freshness and quality in the fishing sector and in fish-inspection services. Sensory methods performed in a proper way are a rapid and accurate tool providing unique information about the food [19]. They can be very fast, reliable, non-destructive on raw fish and no expensive instruments are needed. They give direct measurement of the perceived attributes and provide information assisting in better understanding of consumer responses. However the panelists need training and retraining under the supervision of experienced panel leaders using fish samples of known freshness stage [20].

Table 2: Assessment Freshness in Fish

<table>
<thead>
<tr>
<th>Body Characteristics</th>
<th>Fresh fish</th>
<th>Spoiled fish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Odor</td>
<td>Light, desirable characteristic of the water weeds</td>
<td>Undesirable, acrid, acid, putrid, ammonia-like,</td>
</tr>
<tr>
<td>Rigidity of the body</td>
<td>Rigid body. Firm and elastic</td>
<td>Flaccid body. A slight pressure by finger leaves a mark</td>
</tr>
<tr>
<td>Secretions</td>
<td>No visible secretions</td>
<td>Presence of sticky secretions</td>
</tr>
<tr>
<td>Scales</td>
<td>Bright and firmly attached</td>
<td>Come out easily</td>
</tr>
<tr>
<td>Eyes</td>
<td>Clear and bright pupil, (bulging),</td>
<td>opaque pupils, completely sunken</td>
</tr>
<tr>
<td>Abdomen</td>
<td>Neither swollen, saggy, tight or cut</td>
<td>Flaccid, deformed, often swollen, with dark blue, green or black spots</td>
</tr>
</tbody>
</table>
Flesh | Firm and elastic, smooth surface, red colored, especially along the vertebral column

Source: Hyldig et al. [19]

Moreover, sensory evaluation (Table 3) can be practiced at different levels in fish processing such as after landing, arriving at the fish plant (whole), at the reception, or processing halls of fish factories; evaluation of raw, cold and cooked fillets at the reception, or processing halls of fish factories, or at auction sites [19]. Traditionally, sensory methods have been seen as a subjective assessment of the quality. However, they can be turned into an objective tool [20]. Progress has been made in sensory evaluation during the last years mainly because of the use of computers and data analysis. The work of collecting and analyzing data is not time-consuming and the information on the results can be used and correlated with other information on the products as well. No single instrumental method has so far been foreseen to replace the sensory methods [20].

Table 3: Determination of Fish Quality Using Sensory Evaluation

<table>
<thead>
<tr>
<th>Sensed Used</th>
<th>Aspects of Quality Determined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sight</td>
<td>General appearance and condition, size, shape, physical blemishes, colour, gloss, identity.</td>
</tr>
<tr>
<td>Smell</td>
<td>Freshness, off-odours, taint, oiliness, rancidity, smokiness.</td>
</tr>
<tr>
<td>Taste</td>
<td>Freshness, off-flavours, taints, oiliness, rancidity, smokiness, astringency, the primary tastes of acidity, bitterness, saltiness, sweetness.</td>
</tr>
<tr>
<td>Touch (using fingers and mouth)</td>
<td>General texture, hardness, softness, elasticity, brittleness, roughness, smoothness, grittiness, wetness, dryness, crispness, presence of bones.</td>
</tr>
</tbody>
</table>

Source: FAO/WHO [21]

2.1.2 Biochemical and chemical methods

The appeal of biochemical and chemical methods for the evaluation of seafood quality is related to the ability to set quantitative standards. The establishment of tolerance levels of chemical spoilage indicators would eliminate the need to base decisions regarding product quality on personal opinions. Of course, in most cases sensory methods are useful for identifying products of very good or poor quality. Thus, biochemical/chemical methods may best be used in resolving issues regarding products of marginal quality. In addition, biochemical/chemical indicators have been used to replace more time-consuming microbiological methods. Such objective methods should however correlate with sensory quality evaluations and the chemical compound to be measured should increase or decrease with the level of microbial spoilage or autolysis. It is also important that the compounds to be measured must not be affected by processing [19].

2.1.2.1 Measurements of oxidative rancidity

The highly unsaturated fatty acids found in fish lipids are very susceptible to oxidation. The primary oxidation products are the lipid hydroperoxides. These compounds can be detected by chemical methods,
generally by making use of their oxidation potential to oxidize iodide to iodine or to oxidize iron(II) to iron(III). The concentration of the hydroperoxides may be determined by titrimetric or by spectrophotometric methods, giving the peroxide value (PV) as milliequivalents (mEq) peroxide per 1 kg of fat extracted from the fish [20].

2.1.3 Physical methods

2.1.3.1 Electrical Properties

It has long been known that the electrical properties of skin and tissue change after death, and this has been expected to provide a means of measuring post mortem changes or degree of spoilage. However, many difficulties have been encountered in developing an instrument: for example, species variation; variation within a batch of fish; different instrument readings when fish are damaged, frozen, filleted, bled or not bled; and a poor correlation between instrument reading and sensory analysis [21].

2.1.3.2 pH

Knowledge about the pH (Table 4) of fish meat may give valuable information about its condition. Measurements are carried out with a pH-meter by placing the electrodes (glass-calomel) either directly into the flesh or into a suspension of fish flesh in distilled water. Measurements of pH are not carried out routinely, but it is likely that a freshness test can be based on this principle [21].

Table 4: pH Values for Meat Products

<table>
<thead>
<tr>
<th>Product</th>
<th>pH value (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meat mixes in jelly + vinegar added</td>
<td>4.5 to 5.2</td>
</tr>
<tr>
<td>Raw fermented sausage</td>
<td>4.8 to 6.0</td>
</tr>
<tr>
<td>Beef</td>
<td>5.4 to 6.0</td>
</tr>
<tr>
<td>Pork</td>
<td>5.5 to 6.2</td>
</tr>
<tr>
<td>Fresh Fish</td>
<td>5.8 to 6.2</td>
</tr>
<tr>
<td>Curing brines</td>
<td>6.2 to 6.4</td>
</tr>
<tr>
<td>Processed fish</td>
<td>6.5 to 7.8</td>
</tr>
<tr>
<td>Muscle tissues,</td>
<td>7.0 to 7.2</td>
</tr>
<tr>
<td>Blood</td>
<td>7.3 to 7.6</td>
</tr>
</tbody>
</table>

Source: Yang et al. [22]

2.1.4 Microbiological methods

The aim of microbiological examinations of fish products is to evaluate the possible presence of bacteria or microorganisms of public health significance and to give an impression of the hygienic quality of the fish including temperature abuse and hygiene during handling and processing. Microbiological data will in general not give any information about eating quality and freshness. Traditional bacteriological examinations are laborious, time-consuming, costly and require skill in execution and interpretation of the results. It is recommended that such analyses be limited in number and extent. Various rapid microbiological methods have been developed during the last decade and some of these automated procedures may be of use when large numbers of samples are to be analyzed [23].

3.0 FISH CONTAMINATION

Most contaminations in fish are due to microorganisms rather than chemical and physical contaminants. These organisms are capable of rapid growth under favourable storage conditions and cause disease in their hosts by successfully invading them. They include bacteria, viruses and protozoans. It is well known
that fish and fish products are often associated with human diseases. They have been recognized as a major carrier of food-borne pathogens [24]. Hence, it is necessary to study the prevalence of pathogens in fish to ensure the safety of fish products and environments.

Chemicals discharged from urban, industrial and agricultural sources can enter water bodies and settle in sediments. These contaminants include a wide variety of toxic chemicals, including metals such as mercury, polychlorinated biphenyls (PCBs), chlordane and DDT. These chemical contaminants persist for long periods in sediments where bottom-dwelling animals accumulate and pass them up the food chain to fish. Levels of these contaminants may increase as they move up the food chain, so top predators in a food chain (such as largemouth bass or walleye) may have levels several orders of magnitude higher than the water. They then pose a health risk to people and animals that consume them [23].

Fish ingest a large quantity of microorganisms into their gut from water, sediment and food [14]. It has been established fishes from both fresh and brackish water harbor human pathogenic bacteria particularly the coliform group [14]. Faecal coliform in fish demonstrates the level of pollution in their environment because coliform are not named flora of bacteria in fish [14]. Fish contamination can also be linked to raw material, personnel, processing tools such as forklifts through leakage, opening in building and pests. Some pathogens may even become established in the processing plants from niches where they can survive for a long period of time [6].

3.1 Sources of Contamination in Fish

Contamination of fish with primarily arises from two different origins.

(a) Water
The first level of contamination is through the surrounding water, bacteria that occur naturally in the marine environment which, when consumed in seafood in large enough numbers, will cause illness in humans. This primarily relates to the vibrios. Some species of the genus Aeromonas are considered to some to possibly cause gastro-enteritis in humans and these may also be present naturally in the marine or, more especially, the estuarine environment. Seafood products harvested from contaminated waters or which have been improperly preserved after harvesting are known to play an important role in infections by Vibrio spp. especially crustaceans [17]. It is estimated that 80% of all illnesses are linked to use of water of poor microbiological quality [24]. One of the strategies for tackling this problem is the provision of protected sources such as boreholes, standpipes, protected wells and springs. However, such facilities are located some distances requiring transportation to homes. During transportation, water gets contaminated with bacteria which grow and proliferate during storage in the homes [24].

(b) Cross-contamination
Cross-contamination may take place in the processing environment or during food preparation prior to consumption. Such contamination may be from the environment to the food, from a contaminated food batch or item to a previously uncontaminated one, or from an infected food handler to one of more items of food. Some pathogenic bacteria can become established in the processing environment and, if not eradicated, can be a long-term source of contamination of batches. This applies particularly to L. monocytogenes in fishery product establishments. Once this organism becomes established in a factory it can be difficult to remove by normal cleaning procedures [26].

(c) Hygiene Practices of Food Processors/ Handlers
Fish food processors/ handlers may be a veritable source of microbial transfer from one person to another. This phenomenon can leads to inoculation, poison, intoxication and spoilage of fishery products. Therefore, fish processors/handlers in various communities may be responsible in some cases for public
health vulnerability and loss of resources [27]. Moreover, in a study carried out by Bankole et al. [27] on microorganisms associated with the palms of food vendors in Abeokuta Metropolis, the result indicated that some of the respondents harboured *Staphylococcus aureus* in their palms. However, the vendors/retailers should observe strict hygienic measures so that they will not serve as source of chance inoculation of microorganisms and contamination of these processed frozen seafood products [28].

**4.0 PREVENTION AND CONTROL OF PATHOGENIC CONTAMINATION**

A wide range of disparity in distribution of microflora in fish has been reported and this depends on the sources and other environmental factors [16]. The hygienic conditions under which fishes are reared or cultured in ponds should be improved by following measure or good practices; such as use of good quality water, use of feeds with high microbial quality, regular draining of pond water after specific period of time, closure of ponds to the public among other things [16]. In order to control the presence of bacterial pathogen in seafood, Good Manufacturing Processes (GMP) should be used [29].

The effective use of safety and quality assurance systems in place by seafood processors in most cases is based on the Harzard Analysis Critical Control Points (HACCP) principles. [30]. HACCP involves outside inspectors who ensure critical control points are correctly identified and controls carefully monitored and recorded. Any deviation outside tolerance limits is investigated and quickly resolved with full documentation for future reference. Proper sanitation of the food processing environment using the right sanitizers in correct concentrations is paramount to keeping the initial microbial load to the minimum [30].

Personal hygiene of the personnel and training in sanitation methods should be upheld. The workforce should be educated on the maintenance of good hygienic practices, and should be provided with necessary working and safety equipment [31]. There should be use of portable clean water in all cleaning and sanitation procedures are indispensable in attaining this objective. The use of oxidizing agents to ensure fish quality and safety in fish processing environment. The use of selected sanitizing agents and Ultra Violet radiation in fish processing. UV radiation damages DNA hindering gene expression processes. The use of chlorine, Ozone and H2O2 that damage microbial structural and functional components causing metabolic paralysis and cell death have been proposed [32].

According to Salam [33], other measures to be taken to ensure seafood safety includes the following:

- Landed fish should not be exposed to the sun and should be iced.
- Inspect fish for appearance and odour and reject fish of unacceptable quality.
- Periodically perform bacteriological tests on representative samples.
- Follow a cleaning schedule for all work areas and surfaces, using water containing 5 to 10 ppm of free chlorine.
- Remove all fish slime and blood by hosing down with chlorinated water. At the end of the day, rinse all surfaces with clean water having 5 ppm of chlorine.
- Apply personal hygiene rules strictly to prevent contamination of fish. Smoking and spitting in work areas should not be permitted. Hands must be washed with bactericidal soap prior to handling fish and after a visit to the toilet.
- Check that water supply and treatment systems are in order.
- The harbour should be free from litter and other wastes.
- Check to ensure that all drainage systems are in good working order.
The harbour should be free of animals, rodents and pests.

Ensure that there are no bird nests in the fish handling area.

Check that wastes are being disposed of sanitarily.

Check cold storage equipment to ensure that the right temperature is being maintained.

Ensure that all precaution and warning signs are readable.

5.0 QUALITY ASSURANCE

From the outset, a distinction needs to be drawn between Quality Assurance and Quality Control as the difference between them has been blurred due to indiscriminate use of these two terms. According to the International Standards Organization (ISO), Quality Assurance (Q.A) consists of all those planned and systematic actions necessary to provide adequate confidence that a product or service will satisfy given requirements for quality. In other words it is a strategic management function which establishes policies, adapts programmes to meet established goals and provides confidence that these measures are being effectively applied. Quality Control (Q.C) on the other hand consists of the operational techniques and activities that are used to fulfill requirements for quality. It is a tactical function which carries out the programmes established by Q.A [34]. Proper handling of fish between capture and delivery to the consumer is a crucial element in assuring final product quality. Standards of sanitation, method of handling and the time/temperature of holding fish are all significant quality factors. With a few exceptions, fish are considered free of pathogenic bacteria of public health significance when first caught. The presence of bacteria harmful to man generally indicates poor sanitation in handling and processing and the contamination is almost always of human or animal origin [35].

Quality assurance is the combination of measures applied to assure the quality and safety of a product, and ideally involves the stakeholders from all stages of the production process. One well-known and important example of such a measure is Hazard Analysis Critical Control Points (HACCP), which is required by legislation for food production in and imports[36]. If the values of measurements at the CCPs exceed a certain threshold value, the product is considered unsafe and appropriate corrective actions have to be undertaken. In addition, records of the controls must be kept to facilitate monitoring, while audits are carried out regularly to verify compliance with the HACCP principles [37]. To promote the compliance of fish smokers with HACCP, a number of prerequisites need to be fulfilled. For example, personnel must be trained to carry out controls, keep records and perform audits. In addition, HACCP commonly represents an extension of previously implemented ‘good manufacturing [38].

5.1 Microbiological testing

A number of microbiological tests (Table 5) of fish and fish products are used by authorities to check that the microbiological status is satisfactory. The purpose of these tests is to detect pathogenic bacteria (Salmonella, Staphylococcus aureus, E. coli) or indicator organisms of fecal pollution (fecal coliforms, fecal streptococci) or other types of general contamination or poor handling practices (coliorm bacteria, faecal streptococci, total viable count). [39,40]Microbiological testing can be costly and time-consuming. Estimation of bacterial numbers in fish is frequently used to retrospectively assess microbiological quality or to assess the presumptive safety of the product. The number, size and nature of the samples greatly
influence the results and even the most elaborate sampling cannot guarantee the safety of the product. However, it is still worthwhile; if substandard consignments are found, the psychological effect on the seller is high, especially if the consignment is deemed for export to countries that have established microbiological criteria[41].

Table 5: Guidelines for Pathogens Concentration in Fish

<table>
<thead>
<tr>
<th>Bacterial</th>
<th>Recommended limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total viable count</td>
<td>Not to exceed 100,000 per gram</td>
</tr>
<tr>
<td>Salmonella</td>
<td>Not to be detected in 25g of meat</td>
</tr>
<tr>
<td><em>E. Coli</em></td>
<td>Less than 10 per gram</td>
</tr>
<tr>
<td><em>S. aureus</em></td>
<td>Less than 1000 per gram</td>
</tr>
<tr>
<td>Faecal coliforms</td>
<td>None</td>
</tr>
</tbody>
</table>

Source: Ponce et al. [42]

6.0 SUMMARY AND CONCLUSION

Fish is very beneficial to mankind, and widely consumed among all and sundry, as it contains high quality proteins, minerals and vitamins. However, fish consumption in some cases have reported to be an harbinger of some diseases, due to the potential hazard of some pathogens, Therefore surveillance of potential contaminant bacteria in harvested fish products is essential for the sustenance of public health. It is therefore recommended that people should be educated on the unhealthy implication of water pollution as this goes a long way in contaminating fishery products. To protect fish and human health, internationally agreed maximum permitted levels have been set for different pollutants at different thresholds. National and international monitoring programmes exist to ensure that the levels present are acceptable. In addition, aquaculture industries should use hazard analysis critical control point principles to ensure the acceptable quality of their products. However hygienic qualities of fish tank water in particular the source water for keeping live fish food is also important in ensuring good and standard measures for reducing contamination in fish, which will lead to the sustainability of fisheries activities in Nigeria.

REFERENCES


