2. MICROBIAL QUALITY OF SEAFOOD AND ITS SAFETY

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Introduction

Fishes are classified as cold-blooded aquatic vertebrates of the super class Pisces typically showing gills, fins and a streamline body. In addition, 'fish' also refers to the flesh of such animals used as food. There are about 22,000 species of fish that began evolving around 480 million years ago (Pal and Mahendra, 2015). Fish is an important part of a healthy diet due to its high quality protein, other essential nutrients and omega 3-fatty acids, and its low fat content as compared to other meats (Rhea, 2009; Pal, 2010). Fish and seafood products constitute an important food commodity in the international trade due to its ever increasing consumption demand. Fish contributes about 60% of the world supply of protein, and 60% of the developing world derives more than 30% of their animal protein from fish (Emikpe et al., 2011). Fish allows for protein improved nutrition in that it has a high biological value in term of high protein retention in the body, low cholesterol level and presence of essential amino acids (Emikpe et al., 2011). Fishes are generally regarded as safe, nutritious and beneficial but aquaculture products have sometimes been associated with certain food safety issues (WHO, 2007). There are more kinds of fishes than all other kinds of water and land vertebrates put together, and fish differ so greatly in shape, colour, and sizes (Adebayo-Tayo et al., 2012). The contamination often occurs from human and animal sources, and thus, fish and seafood can be involved in the transmission of pathogenic microorganisms and toxins (Pal, 2012).

Consumption of fish and shellfish may cause diseases due to infection or in toxication, some of these diseases have been specifically associated with pathogens, which are resistant to antibiotics (Adebayo-Tayo et al., 2012). Microbial contamination on environmental surfaces may be transferred to the food products directly through surface contact or by vectors such as personnel, pests, air movements or cleaning regimes (Pal, 2010). Bacteria may also infect the fish from outside during careless handling of landed fish, its stowing and cutting. Among major external sources of bacterial contamination are ice and salt, crushed ice is known to carry heavy bacterial loads. Microorganisms exist on the skin/slime, gills and the gut of live and newly caught fish. The proportion of commencially occurring microorganisms on the surface and guts of fish are 102107 colony forming units (cfu) /cm^2 and 103-109 cfu/g, respectively (Huss,1995). The microbiological flora in the intestines of seafoods such as finfish, shellfish, and cephalopods is quite different being psychotrophic in nature, and to some extent believed to be a reflection of the general contamination in the aquatic environment (Adebayo-Tayo et al., 2012). Several studies have demonstrated a number of bacterial species encountered in different fish, which are potentially pathogenic under certain conditions as reported for Pseudomonas angulluseptica and Streptococcus spp. (Emikpe et al., 2011). It is estimated that there are more than 80 million cases per annum of seafood borne illnesses on antibiotic resistance in the USA, and that the cost of these illnesses is in many billions of dollars per year (AdebayoTayo et al., 2012). The economic losses due to spoilage are rarely quantified but a report by the US National Research Council Committee (FND/NRC) estimated that one-fourth of the world food supply is lost through microbial.

Microbial Quality of Fish and Fish Products

Humans and microbes have a long history together. The normal microbial flora consists of organisms that make their home on or in some part of the body. In a healthy person, such organisms rarely cause disease. Microorganisms of the normal flora may be in symbiotic relationship, where both microorganism and host benefit. The enteric bacteria that form the normal flora of the intestine assist in the synthesis of vitamin K and some of the vitamins of the B complex. In commensalism, microorganisms are neither beneficial nor harmful to their host as in the case of the large group of microbial flora that live on the skin, and the mucous membranes of the upper respiratory tract, intestines and vagina. Fish is very important foodstuff in developing countries due to its high protein content, and nutritional value. Fish provides more than 50% of the animal protein for the populations of 34 countries (Pal, 2010). However, it spoils easily, especially in hot climates and tropical areas where cold preservation techniques are often missing. Fish salting or brining, drying or smoking, are the traditional techniques for the improvement and storage of fish (Pal, 2010).

Fish Spoilage

Fish spoilage is a complex process, in which physical, chemical and microbiological mechanisms are implicated (Adebayo-Tayo et al., 2012; Pal, 2012).Many spoilage producing bacteria (*Aeromonas, Alcaligenes, Bacillus, Enterobacter, Enterococcus, Escherichia coli, Listeria, Pseudomonas, Shewanella*) and fungi (Aspergillus, Candida, Cryptococcus, Rhodotorula) are isolated from fresh and spoiled fish and other sea foods (Pal,2012). Reports on spoilage mechanism and quality assessment of the storage quality of frozen/chilled tilapia are still not comprehensive (Sil et al., 2008; Liu et al., 2010; AdebayoTayo et al., 2012). Degradation of lipids in fatty fish produces rancid odors. In addition, marine fish and some freshwater fish contain trimethylamine oxide that is degraded by several spoilage bacteria to trim ethylamine (TMA), the compound responsible for fishy off odors. Iron is a limiting nutrient in fish and this favors growth of bacteria such as pseudomonads that produce siderophores that bind iron. Spoilage is the result of a series of changes brought about in the dead fish mainly due to enzymatic and bacterial action (Pal, 2012). It starts as soon as a fish is caught and dies. In areas where temperature is high, fish spoils within 15-20 hours depending on the species and the method of capture (Adedeji and Adetunji, 2004). Fish is extremely perishable commodity due to its high water content (Pal and Mahendra, 2015). Spoilage is defined as a change in fish or fish products that renders it less acceptable, unacceptable or unsafe for human consumption (Pal,2012). Fish undergoing spoilage has one or more of the following signs, discolouration, slime formation, changes in texture, off-odors, off –flavors, and gas production (Adedeji and Adetunji, 2004; Pal, 2010). Properties of spoiled fish compared to fresh fish are strong odour, dark-red gills with slime on them instead of bright red ones, soft flesh with brown traces of blood instead of firm flesh with red blood, and red, milky pupils without slime instead of clear ones (Pal,2010).

Food Processors/ Handlers

Persons serving in food processing industries may be sources of microbial inoculation, food poisoning, food intoxication and food spoilage. A number of organisms including Staphylococcus aureus have been isolated from the hands of employees working in food establishments (Pal, 2012; Pal and Mahendra, 2015).Hence, it is important to mention that any person with purulent skin lesions or having respiratory infections should not be allowed to work in food industry (Pal and Mahendra, 2015).

Fish Related Food Borne Illness and Diseases

The subsurface flesh of live, healthy fish is considered sterile, and should not present any bacteria or other microorganisms. On the contrary, as with other vertebrates, microorganisms colonize the skin, gills, and the gastrointestinal tract of fish. The number and diversity of microbes associated with fish depend on the geographical location, the season and the method of harvest. In general, the natural fish microflora tends to reflect the microbial communities of the surrounding waters (Rhea, 2009). The autochthonous bacterial flora of fish is dominated by Gramnegative genera including: Acinetobacter, Flavobacterium, Moraxella, Shewanella and Pseudomonas. Members of the families Vibrionaceae (Vibrio and Photobacterium) and the Aeromonadaceae (Aeromonas spp.) are also common aquatic bacteria, and typical of the fish flora. Gram-positive organisms such as Bacillus, Micrococcus, Clostridium, Lactobacillus and coryneforms can also be found in varying proportions (Huss, 1995) Human pathogenic bacteria can be part of the initial microflora of fish, posing a concern for sea food borne illnesses (Davies, et al., 2001). These pathogens can be divided into two groups: organisms naturally present on fish such as Clostridium botulinum , pathogenic Vibrio spp. , Aeromonas spp., and Plesiomonas shigelloides; and those not autochthonous to the aquatic environment, are present there, as result of contamination or are introduced to fish during harvest, processing or storage (Listeria monocytogenes, Staphylococcus aureus, Salmonella spp., Shigella spp., Escherichia coli, and Yersinia enterocolitica) (Huss, 1997).

Annual burden of foodborne diseases in the WHO South- East Asia Region includes more than:

• 150 million illness

• 175 000 deaths

• 12 million DALYs Source: FERG Report 2010

The disability-adjusted life year (DALY) is a measure of overall disease burden, expressed as the number of years lost due to ill-health, disability or early death. It was developed in the 1990s as a way of comparing the overall health and life expectancy of different countries. The DALY is becoming increasingly common in the field of public health and health impact assessment (HIA). It "extends the concept of potential years of life lost due to premature death...to include equivalent years of 'healthy' life lost by virtue of being in states of poor health or disability." In so doing, mortality and morbidity are combined into a single, common metric.

Despite significant success at improving the safety of the food supply, current science on which safety is based does not sufficiently protect consumers from emerging issues inherent to a complex food supply. The evolving characteristics of food, technology, pathogens and consumers make it unlikely the marketplace will be entirely free of dangerous organisms at all times for all consumers. This is the conclusion made in the report, Emerging Microbiological Food Safety Issues: Implications for Control in the 21st Century was released today at IFT's International Food Safety and Quality Conference and Expo in Atlanta one and half decades back.

The report, drew upon experts specializing in food borne pathogens and microbial evolution, food borne illness, food production and processing, testing methods and regulatory measures, reveals that diligent adherence to current methods that create and monitor the food supply cannot eliminate the risk of food borne illness. The report also offered the recommendations for providing the greatest possible reduction in food safety risks.

Among its seven important issues addressed were:

- Procedures from farm to table to significantly reduce illness due to mishandling
- Processes to recognize and respond to outbreaks and to reduce their scope.
- Poor habits that make consumers more susceptible to foodborne illness,
- Education and training recommendations necessary for reducing pathogenic influence at every step
- From production to consumption (pond to plate/farm to fork
- Recommendations to enhance monitoring, data generation, and risk assessment.
- The current state and future potential of rapidly evolving illness-causing pathogens and other key issues.

To gain the greatest measure of food safety, the report stressed on the necessity of implementing flexible food safety measures so as to utilize as quickly as possible the latest scientific information as it evolves. The report also urged manufacturers, regulatory and public health agencies and allied organizations to develop partnerships to improve risk assessment and food safety management.

Seafood safety goals must achieve more than end-product probes

The absence of pathogens in final-product testing does not ensure food free of virulent microorganisms, according to a new expert report on food safety issues, and as pathogen contamination decreases this form of testing becomes more deficient. So as today's food safety continues to improve, more emphasis should be placed on monitoring processing capabilities and conditions through the application of science-based food systems.

The microbiological testing of finished sea food products and can be misleading for the following reasons

- ✓ Due to statistical limitations based on the amount of product sampled,
- ✓ The percentage of product contaminated,
- ✓ The uniformity of the contamination distributed throughout the food.

The above mentioned negative results imply an absence of pathogens in foods, the report states, and can cause consumers to assume proper food selection and handling practices are unnecessary. Instead, the report urges everyone along the farm-to-fork seafood chain to be responsible for an important role in food safety management. According to Douglas L. Archer of the University of Florida who contributed to IFT report "Current safety evaluations focus on microbes that may or may not be harmful to humans," he added,. "For example, some subtypes of *Listeria monocytogenes* found in or on food may not be associated with food borne illness. Yet their mere detection can be grounds for legal action against the manufacturer and force recalls of food that is unlikely to cause illness in the general population." The need science-based approach called Food Safety Objectives that would place specific values on public health goals, with reassurances those values are reached at key points along the pond to plate process. Those values would be flexible as hazards and public health goals change, science progresses, and unfettered data sharing improves, allowing for the quickest implementation of new safety improvements as they evolve, and a safer food supply. The report urges intentional interaction of public health, regulatory, industrial and consumer agencies, calling the implementation of a flexible, science-based approach involving all these parties "as the best weapon against emerging microbiological food safety issues."

Steps in seafood Safety Management

Foodborne illness in India is a major and complex problem that is likely to become a greater problem as we become a more global society where every 5th person walking on this planet is going to be Indian. Nearly 10 million foodborne illnesses occur per year in India. To adequately address this complex problem, the need is to develop and implement a well conceived strategic approach that quickly and accurately identifies hazards, ranks the hazards by level of importance, and identifies approaches for microbial control that have the greatest impact on reducing hazards, including strategies to address emerging hazards that were previously unrecognized. Policy Development Scientific research has resulted in significant success in improving seafood safety, but the current science supporting the safety of our seafood supply is not sufficient to protect us from all the emerging issues associated with the complexity of the food supply. As new issues emerge, some will be best addressed through the application of control technologies during seafood production and processing, but others may be best addressed at the consumer level through modification of exposure or susceptibility. Food safety policies should be developed as part of national initiatives, with input from all stakeholders. In addition, international coordination of food safety efforts should be encouraged. Globalization of the food supply has contributed to changing patterns of food consumption and food borne illness, and global food trade has the potential to introduce pathogens to new geographic areas. To achieve the maximum benefits, our food safety efforts and policies must be carefully prioritized, both in terms of research and in application of controls. As scientific advances provide a better picture of pathogenicity, the need of the hour is whether to focus the efforts on those pathogens that cause many cases of minor illness or instead focus on those pathogens with the greatest severity, despite the relatively low number of cases. In the move toward making decisions based on risk, the food safety policies need to weigh these issues, and communicate information about risk to all stakeholders, especially the public. The body of scientific knowledge must be further developed, with the research efforts carefully prioritized to yield the greatest benefit. Food safety and regulatory policies must be based on science and must be applied in a flexible manner to incorporate new information as it becomes available and to implement new technologies quickly. The seafood industry, regulatory agencies and allied professionals should develop partnerships to improve food safety management.