Chapter 26
Overview: Safety and quality of fish

Femeena Hassan
Email: drfemeenahassan@gmail.com

Safety is an essential pre-requisite for quality and represents the minimum standard that guarantees seafoods on the hygienic-sanitary point of view. A further safety tool is represented by the product traceability and labelling that supply detailed and precise information to the chain operator, only some of them reaching consumers: identification number of each lot, identification number and name of the fishing vessel or name of the aquaculture production unit, date of catches or the date of production, quantities of each species (kg or no of individuals), name and address of suppliers, scientific name and commercial designation of species, relevant geographical area, production method (farmed or captured) and whether the fisheries products have been previously frozen or not (Reg. CE 1224/2009). Ethical aspects too are assuming an increasing importance for consumers, when they are sensitive to the fact that seafood they will use were obtained with sustainable fishery/aquaculture systems and with respect for animal welfare.

Product quality evaluation starts from a careful examination of the external aspect of the species under interest, on the basis of the distinctive features such as skin or carapace or valve colour, and morphological traits of commercial interest. Proper morphology and merchantable traits are evaluated through a series of length and weight measures. Length measures also have an important role at commercial level for the main species. A minimum size, below which fishing and marketing are not allowed, was fixed for each main species (Reg. EC 1967/2006, Annex III). This was decided because the smaller specimens, still juveniles, must be protected to assure a sustainable exploitation of resources. For commercial size fish the measures to be pointed out are gutted weight/ fillet yields, and condition factor. Condition factor (body weight/length ratio) indicates the fish corpulence within species, often related to body and meat adiposity. Apart from the feeding history, some quality aspects can also differ according to size because with increase in fish body weight and age, muscle and mesenteric fat incidences increase, while the one of bony tissue decreases. The fish reared in floating cages generally show less fat, both in viscera and in fillet, and better sensorial quality, in comparison to the ones reared in tanks. The different nutritional state, the higher energetic consumption/swimming activity and the streamlined flow in the cage are at the basis of the main differences, making them similar to the product captured in the wild. The chemical, nutritional and dietetic characteristics, peculiar of the species but markedly influenced by extrinsic parameters, such as quantity, quality and feeding modality.

The physical and organoleptic characteristics can be evaluated through the behaviour of rigor mortis phases (pre-rigor, full rigor, rigor release), the changes of dielectric properties (indices of fish integrity loss), pH, colour, texture and freshness/quality state. Freshness state evaluated by sensorial methods through examination of the general aspect of eyes, skin, gills, odour of gills, flesh texture, resilience and colour on the raw product, and flesh texture, colour, taste, flavour and juiciness on the cooked product is able, even alone, to be a reliable index of seafood quality. Evaluation methods more frequently used are the ones officially accepted in Europe (Reg. EU 2406/1996) distinguishing three freshness classes, very fresh (Extra), fresh (A), bad quality (B), below B fish being discarded for human consumption, or the Quality Index Method, a specific demerit index that assumes 0 value in very fresh fish, increasing value with quality worsening. In the case of reared product, freshness state of each species could even be estimated from the harvesting date, when a correct and uninterrupted cold chain has been assured. The time period in which seafood is marketable (shelf life) could also be evaluated both by sensorial methods, and as total viable count (TVC) or charge of individual specific spoilage organism (SSO), the latter are the ones better developing at the selected conservation conditions (for example Pseudomonas in refrigerated product, Photobacterium in Modified Atmosphere Packed, MAP product). Raw product is considered unfit for human consumption according to the sensorial parameters days before in comparison to the edibility threshold indication as TVC (107 cfu/g), the later resulting more fit as spoilage index in cooked product. Among the physical traits instrumentally determined, some of them are to be mentioned: skin and fillet colour, important for fish with pigmented flesh- evaluated (CIELab system) through the colorimetric parameters lightness (L*), redness (a*) and yellowness (b*), chroma and hue - and texture, important both as product sensorial aspect and for processing attitude. Texture increases with the muscular fibre density and diameter, and with the quantity and ageing of collagen structure. At the same weight, wild fish generally have flesh more consistent than those of cultured ones, also for their lower fat quantity and the greater muscular tissue activity for swimming. Texture decreases as fish freshness declines, and can be considered as a non-destructive index of freshness. Other useful aspects for the instrumental evaluation of quality changes in the final phases of shelf life are the levels of biogenic amine (histamine, putrescine, cadaverine) of malonaldehyde, secondary lipid oxidation compounds and odour volatile compounds.

Major developments in the field of fish safety and quality have had a significant impact on international trade during the last few decades. Technological developments in fish handling and processing coupled with increasing consumer food safety and quality awareness have resulted in the adoption of HACCP-based systems and scientifically-based risk assessment methodologies. This is reflected in international regulatory framework of the SPS and TBT Agreements of the WTO and the normative work of CODEX Alimentarius. Based on available food borne illness reports, the decrease in food borne diseases has coincided with the implementation of HACCP-based food safety assurance measures. However, fish safety and quality issues related to indigenous microorganisms, chemical or veterinary drugs are increasingly of concern. This reflects the need for a food chain approach in the analysis of hazards and risks to develop integrated risk management strategies. However, a food chain approach also requires substantial multidisciplinary scientific information given the need of science-based risk analysis.

FAO provides direct assistance to member countries via the CODEX Committees and other expert groups with a focus on training and capacity building in developing countries. In response to increasing demands for pertinent and succinct scientific and technical information upon which to conduct adequate hazard and risk analysis, the FAO has launched the Aquatic Food Programme in collaboration with the Canadian Food Inspection Agency with the expectation of creating a peer reviewed comprehensive knowledge base of integrated aquatic food to safety and quality information from a food chain approach. Safety and quality concepts are incorporated in the FAO Code of Conduct for Responsible Fisheries, particularly Articles 6 and 11.

ISO 8402: 1995 standard defines general quality as: “the totality of features and characteristics of a product or service that bears its ability to satisfy stated or implied needs.” The ISO 9000 standard quality system modified the quality concept, shifting the attention from the final product to all the processes contributing to its production. This integrated management system approach, in which planning, personnel involvement, documentation of activities and the attitude towards a continuous enhancement became the basis of the new management model. This is the background of the total quality concept.

In a fishery chain, total quality could be defined as the complex of the characteristics able to satisfy the organoleptic, health, use/price convenience requirements of the purchaser/consumer, constantly found and obtained through a correct management of the production chain, with respect of welfare and environment sustainability, and made known in full transparency through traceability and labelling.

Practical implementation of international regulatory frameworks commenced in the early 1980s when many countries engaged in reforming their fish inspection systems to implement preventive HACCP-based safety including quality systems and supporting hygiene and sanitary requirements. While there is growing and strong evidence that the implementation of HACCP based systems has contributed to improve fish safety and quality significantly, there has been recent growing awareness of the importance and need of an integrated, multidisciplinary approach to safety and quality, considering the entire fish food chain. FAO defines the food chain approach as recognition that the responsibility for the supply of food that is safe, healthy and nutritious is shared along the entire food chain by all involved with the production, processing, trade and not the least the consumption of food. Stakeholders include farmers, fishermen, food processors, transport operators, distributors, consumers, as well as governments obliged to protect public health. This holistic approach to food safety along the food chain differs from previous models in which responsibility for food safety concentrated mainly on the food-processing sector and government control services. The implementation of a food chain approach requires an enabling policy and regulatory environment at national and international levels with clearly defined rules and standards, establishment of appropriate food control systems and programmes at national and local levels, and provision of appropriate training and capacity building (FAO, 2003). Efforts to integrate these developments into fish safety and quality policies are ongoing at national, regional (e.g., European Union, EU) and international (e.g., Codex Alimentarius Commission) levels. Fish safety regulators have been applying a host of control measures, from mandating the use of HACCP to increasing testing, with varying degrees of success. However, the various scientific tools available to support the development of a food chain approach present limitations, which needs to be recognized and considered, including gaps in research data. Indeed, much of the data needed to develop science-based strategies are often incomplete, non-existent or require extensive resources to generate. In addition, the link between the food safety criteria and public health objectives is not always present in current safety regulations. Consequently, improved scientific tools must be adopted and novel approaches must be sought so that the need for regulatory control can be balanced with the need for regulatory flexibility and with the expectation that a regulatory agency's actions reflect the most current and effective scientific methods available to protect the public health.

In the fish industry, there are five broadly defined needs on which a strategy in support of a food chain approach to food safety should be based:

- Fish safety and quality from a food chain perspective should incorporate the three fundamental components of risk analysis–assessment, management and communication–and, within this analysis process; there should be an institutional separation of science-based risk assessment from risk management–which is the regulation and control of risk.
- Traceability from the primary producer, through post-harvest treatment, processing and distribution to the consumer must be improved.
- Harmonization of fish quality and safety standards, implying increased development and wider use of internationally agreed, scientifically based standards is necessary.
- Equivalence in food safety systems–achieving similar levels of protection against fish-borne hazards and quality defects whatever means of control are used–must be further developed.
- Increased emphasis on risk avoidance or prevention at source within the whole food chain–from farm or sea to plate–, including development and dissemination of good aquaculture practices, good manufacturing practices and safety and quality assurance systems (i.e., Hazard Analysis and Critical Control Point [HACCP]), are necessary to complement the traditional approach to fish safety and quality management based on regulation and control.

The principles of achieving harmonization of standards and equivalency in food control systems and the use of scientifically based standards are embodied in the two binding agreements of the WTO (the Agreement on the application of sanitary and phytosanitary [SPS] measures and the Agreement on technical barriers to trade [TBT]). The SPS Agreement confirms the right of WTO member countries to apply measures necessary to protect human, animal and plant life and health. The purpose of the SPS Agreement is to ensure that measures established by governments to protect human, animal and plant life and health, in the agricultural sector, including fisheries, are consistent with obligations prohibiting arbitrary or unjustifiable discrimination on trade between countries where the same conditions prevail and are not disguised restrictions on international trade. It requires that, with regard to food safety measures, WTO members base their national measures on international standards, guidelines and other recommendations adopted by the Codex Alimentarius Commission (CAC) where they exist. This does not prevent a member country from adopting stricter measures if there is a scientific justification for doing so or if the level of protection afforded by the Codex standard is inconsistent with the level of protection generally applied and deemed appropriate by the country concerned. The SPS Agreement states that any measures taken that conform to international Codex standards, guidelines or recommendations are deemed to be appropriate, necessary and not discriminatory. Finally, the SPS Agreement requires that SPS measures are to be based on an assessment of the risks to humans, animal and plant life using internationally accepted risk assessment techniques. The objective of the TBT Agreement is to prevent the use of national or regional technical requirements, or standards in general, as unjustified technical barriers to trade. The agreement covers standards relating to all types of products including industrial products and quality requirements for foods (except requirements related to SPS measures). It includes numerous measures designed to protect the consumer against deception and economic fraud. The TBT Agreement basically provides that all technical standards and regulations must have a legitimate purpose and that the impact or cost of implementing the standard must be proportional to the purpose of the standard. It also states that, if there are two or more ways of achieving the same objective, the least trade restrictive alternative should be followed. The agreement also places emphasis on international standards, WTO members being obliged to use international standards or parts of them except where the international standard would be ineffective or inappropriate in the national situation. The aspects of food standards that TBT requirements cover specifically are quality provisions, nutritional requirements, labeling, packaging and product content regulations and methods of analysis. Unlike the SPS Agreement, the TBT Agreement does not specifically name international standard setting bodies, whose standards are to be used as benchmarks for judging compliance with the provisions of the Agreement. Risk analysis is widely recognized today as the fundamental methodology underlying the development of food safety standard that provides adequate health protection and facilitates trade in food (FAO, 2001). There is a fundamental difference between a hazard and a risk. A hazard is a biological, chemical or physical agent in, or condition of food, with the potential to cause an adverse health effect. In contrast, risk is an estimate of the probability and severity in exposed populations of the adverse health effects resulting from hazard(s) in food. Risk analysis is a process consisting of three components: risk assessment, risk management and risk communication. Risk assessment is the scientific evaluation of known or potential adverse health effects resulting from human exposure to food-borne hazards. Risk management is the process of weighing policy alternatives to accept, minimize or reduce assessed risks and to select and implement appropriate options. Risk communication is an interactive process of exchange of information and opinion on risk among risk assessors, risk managers and other interested parties. The responsibility for the supply of fish that is safe, healthy and nutritious should be shared along the entire chain from primary production to consumption. Development and implementation of Good Aquaculture Practices (GAP), Good Hygienic Practices (GHP) and Hazard Analysis Critical Control Point (HACCP) are required in the food chain step(s). Government institutions should develop an enabling policy and a regulatory environment, organize the control services, train personnel, upgrade the control facilities and laboratories and develop national surveillance programs for relevant hazards. The support institutions (academia, trade associations, private sector, etc.) should also train personnel involved in the food chain, conduct research on quality, safety and risk assessments and provide technical support to stakeholders. Finally, consumers and consumer advocacy groups have a counter balancing role to ensure that safety and quality are not undermined by political considerations solely when drafting legislation or implementing safety and quality policies. They also have a major role in educating and informing the consumer about the major safety and quality issues. The general principles of GHP/HACCP were adopted by the Codex Alimentarius Commission (CAC) in 1997 and 1999 (FAO, 2001). They include requirements for the design and facilities, control of operations (including temperature, raw materials, water supply, documentation and recall procedures), maintenance and sanitation, personal hygiene and training of personnel. Similarly, the Codex Committee on Fish and Fishery products is working on a draft code of practice for fish and fishery products, including aquaculture products, which integrates these general principles and adapts them to aquaculture. However, this Code is not intended to cover extensive fish farming systems or integrated livestock and fish culture systems that dominate production in many developing countries. Control and prevention of chemical pollutants and biotoxins require the implementation of appropriate monitoring and surveillance programs. This is particularly important for mollusc culture, filter feeders that can concentrate pollutants, biological agents and biotoxins. The Codex Code of Practice describes the requirements for surveys and monitoring of the harvesting and growing areas to determine sources of domestic and industrial pollution, classification of the areas into suitable for harvesting, relaying or non-suitable for growing or harvesting, and the frequency and methods of monitoring.

Fish Safety and Quality Knowledge Base Fish and seafood are produced from a great variety of plant and animal aquatic species. A risk analysis focused on a specific hazard such as a pathogen or a contaminant requires a substantial amount of scientific and technical information. Each species has different safety and quality attributes related to local conditions and production methods in addition to the type of food commodity, which also has specific processing and preservation requirements. Better utilization of aquatic resources and the harmonization of fish safety and quality systems require access to updated scientific and technical information not the least in light of the SPS Agreement of the WTO that require science-based risk analysis of food hazards. Over the years, FAO has experienced this first hand in risk assessment exercises such as *Listeria monocytogenes* or Vibrio spp. These also proved to be cost and resource intensive given the often-lengthy time frames and the number of experts involved. Since the late 1990s, FAO has been aware of the need for integrated and succinct technical information. The current thinking of a food chain approach to safety and quality simply exacerbates this need. In addition to potential food hazards that may be introduced via handling and processing, fish and seafood production methods include the fisheries of wild populations and aquaculture where safety and quality also depends on the local conditions of the environment and habitat. Given FAO’s normative work and capacity building mandate in developing countries, FAO is launching the Aquatic Food Programme in collaboration with the Canadian Food Inspection Agency and other international organizations. Although the Internet offers a wide range of scientific information, finding adequate and pertinent information can be perplexing for a novice user of the Internet. In addition, today’s electronic information dissemination capabilities are less of a challenge than the work involved in updating information. The understanding and integrated management of risks along the entire food chain requires substantial integration of technical information based on the latest available scientific literature and knowledge.

Fishery products are the most traded food in the world. The globalization and further liberalization of world fish trade presents new safety and quality challenges. Upgraded scientific tools must be implemented and novel flexible methods to safety must be sought so that regulatory actions can reflect the most current scientific evidence, and this in turn helps to share the responsibility for safety among the stakeholders of food chain. Fish safety and quality assurance will require enhanced levels of international co-operation in promoting harmonization, equivalency schemes and standards setting mechanisms based on science. The SPS/ TBT agreements of the WTO and the benchmarking role of the Codex provide an international platform in this respect. Important reforms to tackle these issues have been initiated in the USA (NAS, 2003), the EU (2000) and many other countries. Unfortunately, developing countries are at a disadvantage because of insufficient/inadequate national capacities and resources. International organizations such as FAO must revamp their programmes and seek the necessary resources to assist in this endeavour.