Chapter 19

Fish production chain: safety and quality for consumers

19.1 Fish and aquaculture products and human nutrition

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Historical evolution

Fish and aquaculture are both an important source of highly nutritive food and source of employment and economic benefit. Since ancient times fish has represented food for human populations. Mediterranean civilization, born and developed along the Mediterranean coast, is full of cultural connections and traditions regarding fish and fishery. Fish farming is also an ancient activity.

In the past, fish was primarily consumed by populations living along the coasts and processed by smoking or salting. In Italy, at the end of the 19th century, meat and fish, rich in essential nutrients, were almost absent in the diet, which was little varied and with a prevalence of bread, legumes and soups as main dishes. At that time, the health conditions of Italian population reflected the inadequate diet: malnutrition, poor children growth rate, anaemia, rickets and high mortality were common events until the economic status improved and protein sources like milk, cheese and meat were accessible to most people. Seafood started to be regularly present in the diet of Italians only in the 1990s, with the development of aquaculture and the improvement of fishery techniques as well as modern fish storage and processing technologies (Salza Prina Ricotti, 1998-1999; Capatti *et al*., 1998; Terzi, 1987).

Physicians and nutritionists recommend to include seafood twice a week in a balanced diet, as a source of high quality proteins and lipids. Currently the contribution of seafood to the diet of industrialized, as well as of developing countries, is quite high. While in the past the Italians diet was poor of essential nutrients and fish consumption was a necessary integration of proteins, vitamins and mineral elements, nowadays an excess of food intake, together with a sedentary lifestyle, may be considered the cause of several diseases. The current western diet is characterized by an increment of the consumption of fats, particularly saturated fats, trans-fatty acids, essential n-6 fatty acids and by a low intake of n-3 polyunsaturated fatty acids (PUFA). As a result of an excessive intake of n-6 PUFA, human diet in industrialised countries suffers from a fatty acid imbalance. This results in a high risk to develop cardiovascular disease, high cholesterol serum levels and altered lipid metabolism.

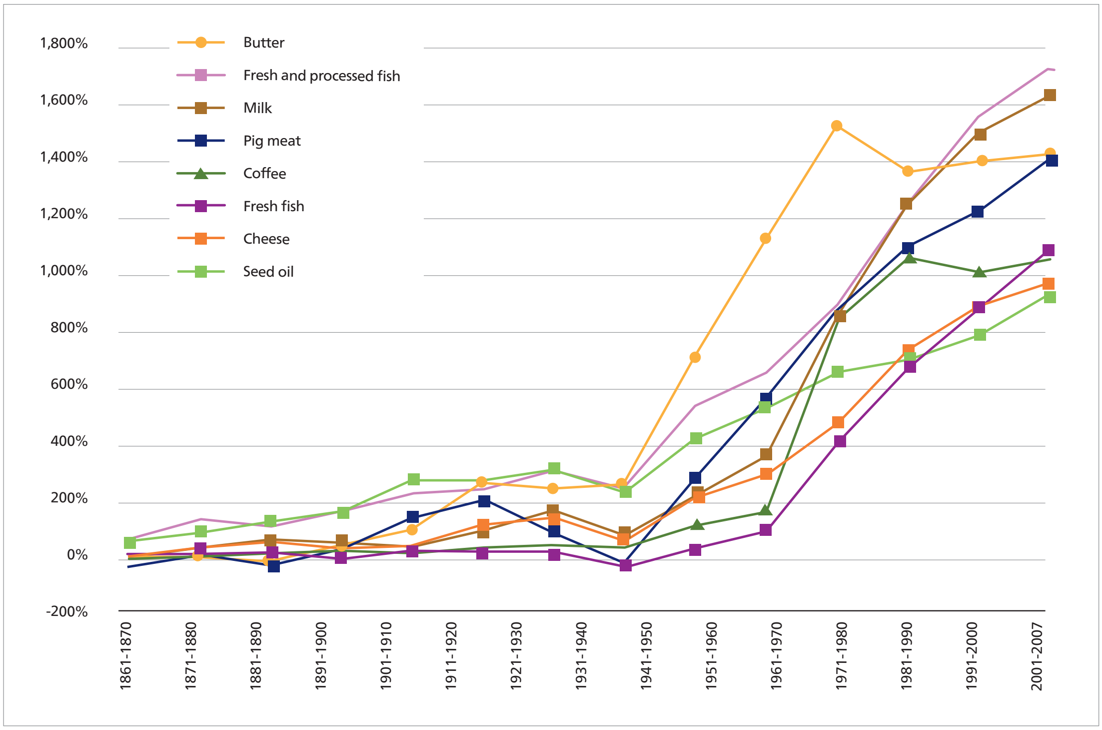

Figure 19.1 - Food consumption in Italy (1861-2007) - INRAN elaboration (2011) on ISTAT and FAO data.

The Dietary Guidelines of International Committees dealing with human health and nutrition, in particular the Guidelines of the American Cancer Society and the Guidelines for a Healthy Diet of the Italian National Research Institute for Food and Nutrition, include the recommendation to reduce the caloric intake and to increase physical activity and the consumption of vegetables, fruits and seafood. Adequate intakes of n-3 PUFA (at least 0.5% of total caloric intake, amounting to 1 g/day for an adult on a 2000-kcal diet) are included in dietary recommendations of national and international nutrition and health societies. In consideration of the nutritional, economic, social and cultural importance of fisheries and aquaculture, FAO assists nations, particularly developing countries, to achieve a successful management of these activities. Aquaculture enabled a worldwide consumption of freshwater fish species like trout, tilapia, catfish, pangasius, as well as of marine species like seabream, seabass, shi drum, shrimp, salmon and bivalve shellfish. In developing countries, small-scale fishery and aquaculture allow a precious integration of the diet with an highly nutritious food.
In Italy, modern aquaculture started in 1950-60 but only in 1980-90, with the development of supermarket chains, it became an economic activity with a high impact, able to address consumer choices towards farmed species like seabream, seabass, trout, mussels and carpet shells. The evolution of Italian aquaculture is tightly connected to new consumption models.
Once the primary nutritional requirements were met, consumers became more interested in the quality of products, their traceability and healthiness and also to the environmental sustainability of fishery and aquaculture. With the development of new processing and packaging technologies, ready-to-eat products, based on farmed fish, have found a market also with the contribution of modern catering, that has become an important commercial tool of aquaculture products.

Nutritional composition of fishery and aquaculture products

Fish products are important in human diet because of their digestibility and high nutritional value, mostly characterised by the presence of high quality proteins, rich in the amino-acids methionine and lysine. This latter aspect makes seafood a valuable protein source also to populations of developing countries, whose diet is often characterised by tubers and cereals as staple food, where these two amino-acids are present in limited amounts.

Seafood plays an important role in human diet due also to its peculiar lipid composition, quite different from that of terrestrial animals. Fish lipids are rich in long chain polyunsaturated fatty acids belonging to the n-3 series, particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), important constituents of cell membranes and essential in human brain and retina development. In human organism n-3 PUFA undergo metabolic reactions to form biologically active molecules known as eicosanoids (prostaglandins, thromboxanes and leukotrienes), playing a role in platelet aggregation, vasoconstriction and blood pressure regulation. Mineral elements like selenium, iodine (in marine species), phosphorus and zinc are present in significant amounts in many fish species. Fatty fish store vitamins A and E in muscle tissue, while low-fat fish accumulate fat-soluble vitamins in the liver. Shellfish and crustaceans have a chemical composition similar to that of low-fat fish; bivalves are particularly rich in iron, zinc and magnesium.

All fish species have a specific chemical profile changing with seasons, reproductive phase, geographic origin and characteristics of the aquatic environment.

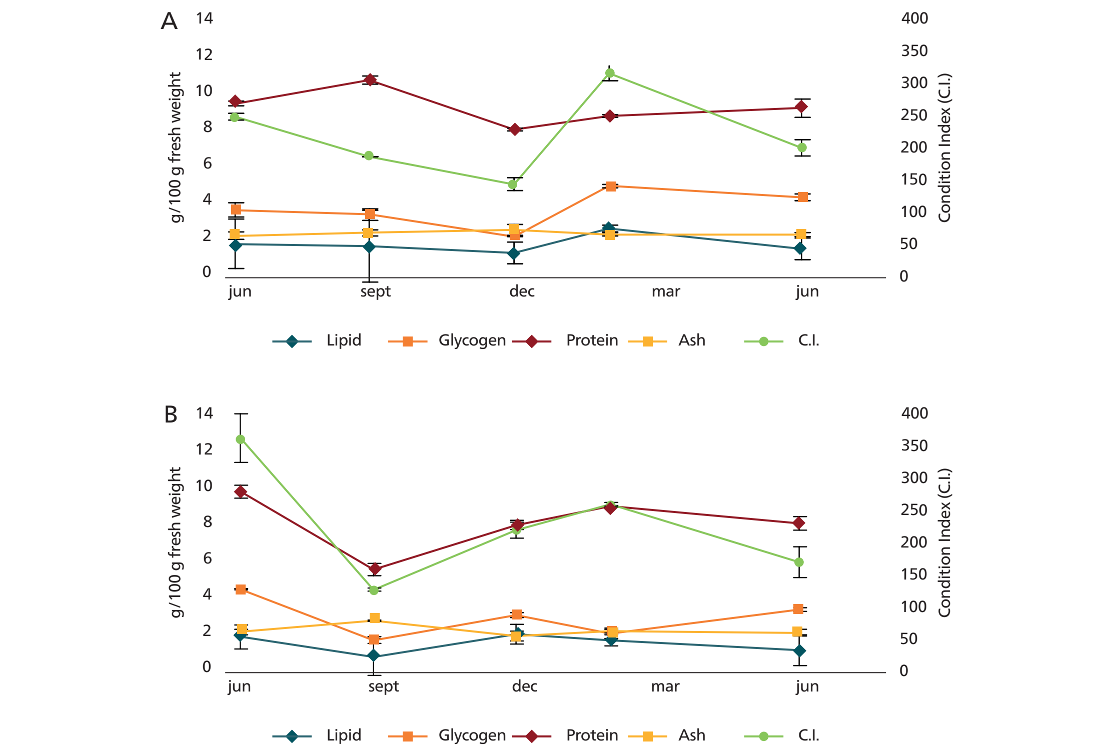

Figure 19.2 - Seasonal variation of Condition Index and nutrients (g/100 g fresh weight) in mussels *M. galloprovincialis* from the Adriatic Sea, A) (Cattolica) and from the Tyrrhenian Sea, B) (Sabaudia).

The different rearing techniques (extensive, intensive in cage or in tank, semi-extensive) allow a constant control of the quality of fish produced. In recent years increasing concern has been registered on the sustainability of aquaculture. Fishmeal and fish oil, ingredients of traditional feeds, are becoming a limited resource. The global demand of fish oil for aquaculture is likely to exceed its supply within the next few years. Therefore, the partial replacement of fish ingredients in aquaculture feeds with alternative ingredients of plant origin is a necessary strategy.
The study of the nutritional value and sensory quality of seafood is necessary to provide correct information to consumers. The European Parliament on 6th July 2011 approved new rules on food labelling with the obligation to provide nutritional information on food labels.

Table 19.1 - Chemical composition of seabream (*Sparus aurata*) from intensive rearing, from coastal lagoons and from the wild (range of values in 100 g edible portion).

	Intensive rearing	Coastal lagoon	Sea
Weight (g)	200-400	200-700	200-700
Water (g)	67.1-73.3	66.6-73.4	72.1-75.4
Protein (g)	18.2-20.5	19.6-21.0	20.4-22.9
Lipid (g)	5.8-12.7	1.6-14.6	1.2-5.9
Saturated (g)	1.2-2.4	1.6-4.9	0.3-2.0
Monounsaturated (g)	1.4-3.2	1.8-5.5	0.2-2.0
Polyunsaturated (g)	2.4-4.9	0.9-2.1	0.3-1.0
Ω-3 fatty acids (g)	1.0-2.2	0.6-1.4	0.3-0.7
Ω-6 fatty acids (g)	1.1-2.8	0.3-0.7	0.1-0.3
Cholesterol (mg)	61.0-72.0	52.3-79.7	46.7-73.6
Vitamin E (mg)	0.9-2.5	0.4-2.3	0.4-0.7
Ash (g)	1.3-1.5	1.4-1.5	0.9-1.6
Potassium (mg)	430-480	400-480	400-900
Phosphorus (mg)	220-250	230-250	225-250
Sodium (mg)	35-55	30-39	30-38
Iron (mg)	0.3-0.4	0.3-0.7	0.3-0.7
Energy value (kcal)	134-185	130-210	102-135

The values reported were produced by the Research Group on Seafood Quality at the Italian National Research Institute for Food and Nutrition (INRAN) of Rome.

From product quality to the concept of food production chain quality

The peculiar chemical composition of seafood is also responsible for their high perishability. The high content of water, non protein nitrogenous compounds and unsaturated fatty acids, the presence of bacterial flora on the skin surface and in the gastro-intestinal tract and the activity of endogenous enzymes are all factors contributing to the high perishability of seafood. Starting from their capture, fish undergo a series of chemical and physical transformations gradually leading to the loss of their species-specific characteristics: nutritional properties, flesh texture and aroma. The rate of fish spoiling varies with the species but is also dependent on fish handling, transportation and storage from harvest to the consumer’s table. Until some years ago food hygiene was warranted by controls and analysis on the final product and in some cases by the promulgation of standards. Since the late 1980s the need to use new strategies to preserve the hygienic quality of food emerged in the

European Community. The realization of the European Common Market allowed a comparison among different national situations and stimulated the need to validate behaviours and legislations to warrant the consumer a safe product of high quality. Currently all controls are made on the entire production process. Food quality, safety and consumer information are themes of concern in the EC White Paper on Food Safety (2000). The Code of Conduct for Responsible Fisheries issued by FAO (1995) and the numerous EEC Regulations ensued introduced in the seafood sector concepts already known in other food industry sectors: sustainability, production chain, safety, management responsibility, traceability, consumer information, product certification, quality label.
As already mentioned, the quality and safety of a fish product depend on the quality of the production chain. To this purpose any step of a process should be accurately programmed and realized to warrant the environmental respect and the products quality and safety.
In Italy the increment of seafood consumption registered in the last years is partially due to a growing import of seafood from European and extra-European countries. Imported products are often in market competition with products from national aquaculture and in some cases raise safety concerns. With market globalization the urgency of product traceability has become evident. Starting from these considerations and from the growing interest of consumers for a healthy diet, scientific research and market have focused on the quality of aquatic products and their certification also through advanced communication strategies.

References

- Capatti A., De Bernardi A., Varni A.(1998) - *Storia d'Italia*. Annali, 13: *L'Alimentazione*, Einaudi, Torino:1052 p.
- Salza Prina Ricotti E. (1998-199) - L'importanza del pesce nella vita, nel costume e nell'industria del mondo antico, in Rendiconti della Pontificia Accademia Romana di Archeologia Vol. LXXI: 111-165.
- Terzi A. (1987)- *L'evoluzione dei consumi in Italia, 1940-1986*, Longanesi, Milano.

19.2 Total quality in the fisheries chain

Poli B. M.

The concept of total quality

The food quality concept has improved in time, from being practically limited to hygienic aspects – already in Pasteur era (1870-1920), to also considering in the 1950s chemical characteristics, then extending to health hazard residues. But the keystone in quality culture spreading dates back to 1987, when the International Organization for Standardization published the ISO 9000 family of standards, the basis of the quality management system.
ISO 8402-95 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." Such definition has to be considered as a dynamic concept, the purchaser needs variation in time and in space, according to his ethical and ethnical limits, also gradually evolving in time. 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.

The basics of seafood quality are related to merchantable parameters, organoleptic, chemical and nutritional characteristics, and technological attitude to conservation and processing. All these quality aspects differ according to animal species and feeding, quality of water and environment where these species live, their physiological state, welfare and health, the correct technological management and environmental sustainability of fishery and aquaculture activities, the catch/harvest and post harvest procedures, such as sorting by species, washing, handling, processing, and modality of conservation (refrigeration, freezing, processing). Moreover, *conditio sine qua non* the large-scale organised distribution requires constancy, that product traits can exclusively be guaranteed by the application of a continuous monitoring of the critical control points over the several phases of production and distribution chain. Compulsory for the chain operators is the assurance of traceability and a correct and product exhaustive information through labelling. Nowadays the convenience of its use is also particularly awarded by purchasers. Product preparation for a simpler and quicker use, through gutting, filleting, cutting, packing in ready-to-cook or even precooked and only-to-heat portions, offers undoubted advantages to consumers with little experience of gastronomic practices and with little time available.

Figure 19.3 sums up the several components contributing to the total quality of seafood. On the whole, the peculiar characteristics of the species derive from the interaction between the individual genetic inheritance and environmental factors exerted *in vita* and after harvest, leading to the differences found within species, according to the environment and eventual production typology (captured or farmed).

Therefore 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 animal welfare and environment sustainability, and made known in full transparency through traceability and labelling.

Hygienic-sanitary safety
Species, Sex, Age, Physiological Status
Environment and sustainable production (fishery or aquaculture)
Diet composition, Finishing, Fasting
Ethical aspects, Welfare
Catching, harvesting, killing procedures
Post harvest procedure
Quality/price
Size and yield. Chemical composition, nutritional/dietetic properties
Physical and organoleptic traits. Freshness, Shelf life
Processing attitude
Constancy in quality traits
Convenience of use
Traceability and labelling. Fresh or tawed

TOTAL QUALITY

Figure 19.3 - Seafood total quality.

Parameters of seafood quality

Safety is an essential pre-requisite for quality and represents the minimum standard that guarantees food 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 o captured) and whether the fisheries products have been previously frozen or not (this last four information in italics must be also given to consumers) (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. Moreover, the protection of fishery stocks and environment – in addition of being a certifiable quality parameter itself – is at the basis of human welfare and job opportunities both in the present socio-economic systems and for future generations. Good animal welfare conditions – guaranteed during the rearing cycle thanks to the control of a set of parameters relative to water and feed quality, fish density and state of good health – is at the basis of a good meat animals growth and development, in order to turn into an excellent product for the market. Moreover, similarly to what has been verified in animal husbandry, the correct catch/harvest procedures are determinant for obtaining a final product reflecting the *in vita* animal quality. Severe stress conditions in animals affect several endocrine/physical/biochemical answers before death and physical/ biochemical changes after death able to impair the quality and conservation attitude potentially possessed by the product, giving rise to: *rigor* development, muscular pH decrease and compactness/firmness loss speeding up; water holding capacity lowering, dielectric properties impairing, higher meat lightness, shelf life shortening (Poli *et al.*, 2005).

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^3 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 in particular – are described in the first section of chapter 19 to which readers can refer.

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 (Luten, Martinsdòttir, 1997). 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 (10^7 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.

Different kinds of seafood

The raw material – that is captured or cultured product, national or imported, whole or processed in different ways – can be submitted to refrigerated conservation (vacuum- or modified atmosphere- packed as well) supplying a fresh product; or to operations modifying anatomical integrity and supplying a prepared product; or to more drastic treatments (salting, smoking, marinating, drying, fermentation, cooking, pasteurization, sterilization) supplying a processed product. Other raw material will be supplied by living molluscs, bivalves, echinoderms, tunicates and marine gastropods, wild or cultured, prepared and preserved in different ways (see figure 19.4). A definition of frozen product can not be found in the European hygiene rule set. There are references to factory and freezer vessels and to freezing plants, each of them needing to have freezing equipment with sufficient capacity to lower the temperature rapidly so as to achieve a product core temperature of no more than - 18 °C. The use of freezing and deep freezing allows a longer product stability, independently from season, catching condition and fish species “quota” in the different fishing zones. Correctly deep frozen products don't show no significant differences in nutritive value in comparison with fresh products and results of good quality, especially if cooked within 24 hours from thawing out.

Afterwards, rapid changes begin in muscular structure integrity, lipids and protein that speed up degradation process, lipid oxidation in particular, and a rapid microbial proliferation, all processes that keep from doing a new freezing or deep freezing (see compulsory information in label whether the fisheries products have been previously frozen or not according to Reg. CE 1224/2009). D.Lgs.110/1992 "Accomplishment of 89/108/CEE directive in the subject of deep frozen food destined to human feeding" art. 2 says: "Deep frozen food means a food product submitted to a special freezing process, deep freezing, that allows to go over with the needing speed, according to the product nature, the maximum crystallization zone and to maintain the product temperature in all its points, after unceasing stabilization at -18 °C or below." The raw material destined to deep frozen food production must be wholesome, in good hygienic condition, of proper merchantable quality and have the needing freshness degree.

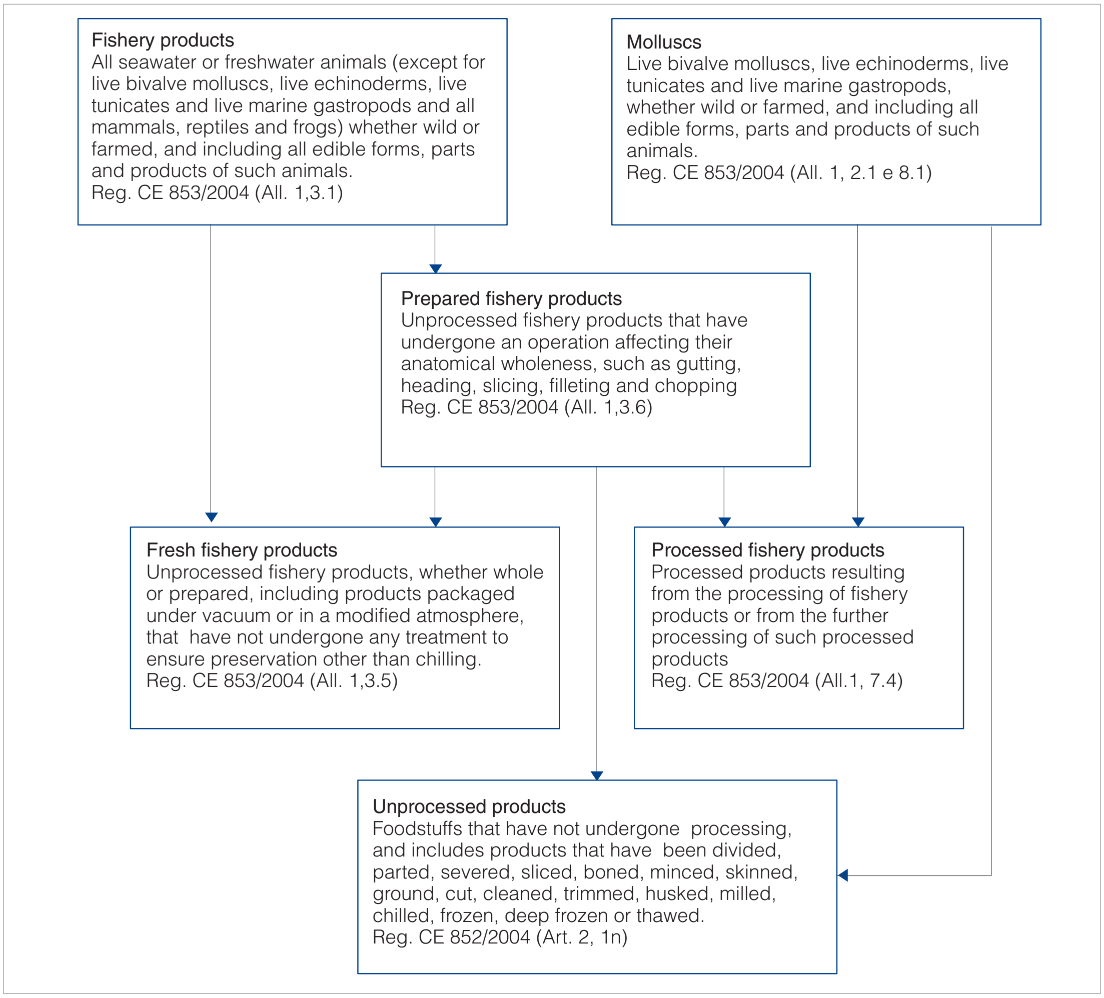

Figure 19.4 - The different kinds of seafood.

The preference is given to products frozen on board of factory and freezer vessels immediately after catching and essential preliminary operations of cleaning, gutting, beheading and bleeding. Moreover, the suitable and whole fish gutting and the rapid freezing after catching represent important prerequisites of food safety, also in order to reduce parasites risk.
According to the kind and size of the product to be frozen, technology make available to seafood enterprises the more suitable devices to perform the process in a few minutes. Very important for deep frozen seafood quality is glazing (considered tare according to art. 16 of D. lgs. 109/92), i.e. the ice film applied on seafood, through nebulisation or immersion in water, immediately after the exit from freezing tunnels. The optimal ice covering application prevents or reduces the possibility that along the following phases of storage, transport and selling, qualitative alterations due to dehydration, oxidation, push, contamination, etc. could take place. Deep frozen food addressed to the consumer must be sold in original packaging closed by the producer or by the packer and prepared with material suitable to protect the product from microbial or other kind of contamination or from dehydration. The Maximum Storage Time is fixed for frozen food according to the kind of product, the specific experience of each operator and reference data and can vary from 15 to 24 months from production date and must be expressed in the label. The storage is the most significant phase from the food safety point of view, because it is determinant in cold chain maintaining.

Good manufacturing practices along seafood chain

Fishery products safety and quality much depend on the application of a series of good manufacturing practices and systematic control of critical points by operators along the whole process of primary production, conservation, possibly handling/cutting and/or processing and marketing (Huss *et al*., 2004), in other words, along the national fishery chain as summarised in figure 19.5. There are significant differences in catch or cultured productive phases, whereas the product quality preservation procedures in post harvest phases are quite similar. The operations relative to captured product are made more complex by the fact that control is only carried out after capture and that in the Mediterranean area the catch is a multi-species one.
On the contrary, in the case of farmed product the number of species is limited and there is the maximum potential in obtaining the control over the whole productive chain. For this reason, captured product evaluation begins from catching ahead, while for cultured product the attention also goes backwards, considering all the several influence factors reported in figure 19.3 exerting *in vita*, as well as post harvest steps, all able to condition product quality.
The most important factors able to influence catch quality and its variability are fishing gears, dragging time, fish catch quantity, size, weight and fish/ice ratio in boxes. The fishing method in particular influences general quality of catch. As already underlined for the farmed fish harvest, a fishing system determining a stress condition in catch is able to speed up the physical-microbial deterioration processes, therefore causing preservation shortening (for example the trawl-net worsening of red mullet quality). Fishing by flying net can cause asphyxia and crushing phenomena. The nets used in small scale fishing can also show problems relative to product hygiene and quality due to the drift net long time and death after long agony, predator or parasites attack, wound and excoriation caused to fish convulsing to free themselves. Putting the catch in a container filled with sea water and ice can also give problems if not correctly applied: gathering different species in one single container of limited dimensions can cause an overload and crushing, with catch deterioration, and the slow down of cooling capacity of chilled water.

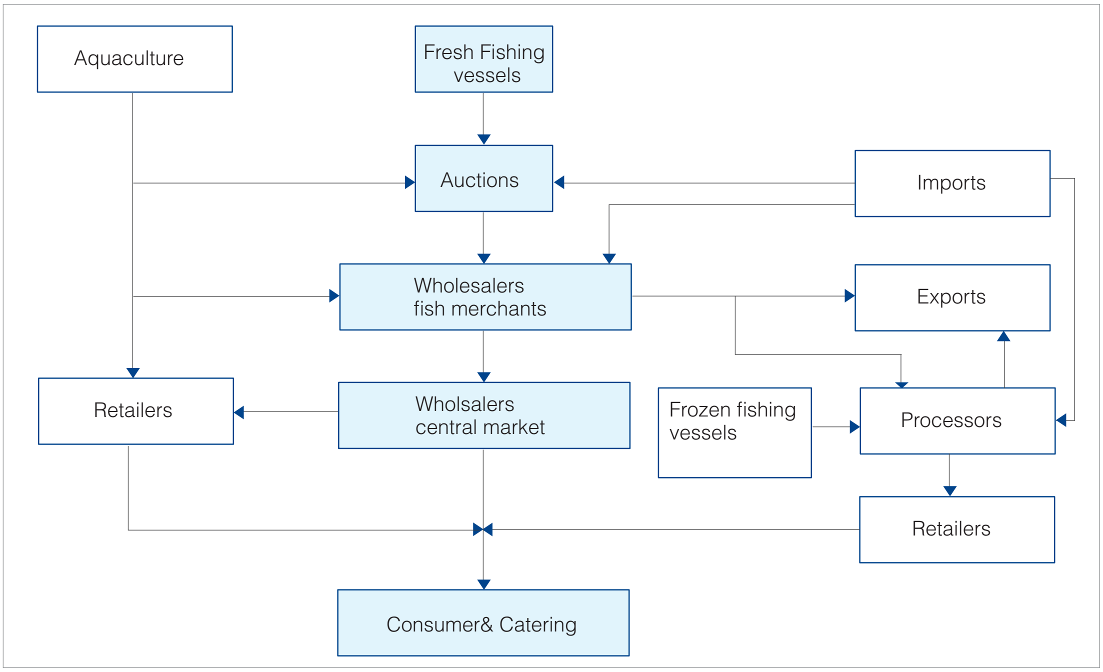

Figure 19.5 - National fishery chain.

Fish body must be in *rigor mortis* and very cold, with perfect general physical integrity, without lacerations or skinning and with skin and scales well sticking on it. As regards in general the GMP standards, it is necessary overall to control cooling of the working area, in containers and of the products on board, also in relation to an eventual gutting. The room must always be clean and not contaminated. It is necessary to carry out safety controls and controls of hygienic conditions on board and of the containers and refrigerators along the distribution chain. The kind of container and the ice/fish ratio are important for the hygienic conditions and for the shelf-life of seafood. The unloading phases must take place quickly, complying with the chilling chain, and paying attention to guarantee catch protection from every contamination and no direct contact with the ground.
At fishing boat, harbour and auction level, the objective is to obtain a product of the best quality, putting on market homogeneous lots (selected and correctly placed in boxes according to species, size, freshness class, with the suitable quantity of good quality ice), applying GMP in fish handling, that must be reduced to the minimum (possibly only once). Captured and farmed product best icing is necessary for the preservation of fish organoleptic characteristics, correct *rigor post mortem* development and flesh texture behaviour. Moreover, although quality begins "on board" or in farms, a risk factor that can negatively reflect on final product quality can be present at each ring of the fishery productive and distribution chain of captured and cultured product. Seafood can be handled, cut, sold again and/or mixed with fish from other sources, therefore loosing both qualitative standard and traceability along the way. Uninterrupted cold chain, traceability and labelling must be assured anyway to maintain the safety and quality of captured and cultured fish. A wise management of fishing and farming methods, the optimization of captured and cultured product selection and treatment processes, with the implementation of the correct cooling and preserving procedures, are often sufficient in assuring a perfect hygienic-

sanitary quality of product on sale. The purchaser must always look at selling information: species commercial denomination, origin as relevant geographical area or Nation of culture, production method (farmed or captured) and whether products were previously frozen or not. National/European products, captured or farmed, offer very high levels of hygienic-sanitary safety, freshness and quality in comparison to imported products, it is convenient to prefer local products, an individual choice that will have positive repercussion on national/European fisheries and aquaculture.

References

- Huss H.H., Ababouch L., Gram L. (2004) - *Assessment and management of seafood safety and quality.* FAO Fisheries technical paper, 444: 1-230.
- Luten J.B. & Martinsdòttir E. (1997) - QIM – A European Tool for Fish Freshness evaluation in the Fishery Chain. In: G. Olafsdòttir *et al*. (eds), *Methods to determine the Freshness of Fish*. Proceedings of the Final meeting of the Concerted Action "Evaluation of Fish Freshness", AIR3CT942283, Nantes, Nov. 12-14, 19997, "International Institute of Refrigeration", 287-296.
- Poli B.M., Parisi G., Scappini F., Zampacavallo G. (2005) - Fish welfare and quality as affected by pre-slaughter and slaughter management. *Aquaculture International*, 13: 29-49.

19.3 Hygiene and safety in the fish supply chain

Guandalini E.

Principles of food safety legislation

Food safety is still one of the main objectives of EC policies. This principle was established after the serious food crises that occurred in Europe from 1996 (e.g. BSE, dioxin contamination of food and avian flu) and which brought to light an inconsistent application of laws on behalf of Member States and a lack of organisation in control systems. These factors led the European Commission to undertake an extensive revision of food safety laws through the publication of Regulation 178/2002, which lays down the general principles of food safety, as well as the obligation of traceability for all food and feed.

The European Commission subsequently updated and reorganised the fragmentary EC regulations on food hygiene, with the publication of the "Hygiene Package", a group of four Regulations (Reg. EC 852/2004, Reg. EC 853/2004, Reg. EC 854/2004 and Reg. EC 882/2004) aimed at ensuring a comprehensive and integrated approach to food safety based on risk analysis, with full involvement by primary production and full accountability on the part of industry operators. Article 5 of Regulation 852/2004 also requires food business operators downstream from primary production to put in place, implement and maintain procedures based on the HACCP (Hazard Analysis Critical Control Points) principles, to ensure self-regulation in health and hygiene matters.

Biological contamination

Viruses in fish products

Food-borne viruses are the second most important cause of food-borne outbreaks in the European Union (EU) after Salmonella (EFSA, 2011). In 2009 viruses were responsible for 19% of all outbreaks in the EU, with over 1000 occurrences that affected more than 8700 citizens. The total number of outbreaks caused by viruses has been increasing since 2007. Food can act as a vehicle for transmitting certain viruses to humans, which in some cases are highly contagious and may lead to widespread outbreaks (OMS/FAO).

EFSA's scientific opinion looked at norovirus and hepatitis A viruses in fresh products, ready-to-eat foods and bivalve molluscs such as oysters, mussels, and scallops, as these are ranked as priority hazards by the WHO.

According to the EFSA Scientific Panel on Biological Hazards (BIOHAZ), effective measures to control the spread of these viruses should focus on preventing contamination at all levels of production rather than on trying to remove or inactivate these viruses from contaminated food. Thorough cooking is currently the only efficient measure to remove or inactivate norovirus or the hepatitis A virus from contaminated bivalve molluscs or contaminated fresh produce.

In regard to fish products, the viruses of significance for public health (hepatitis A, calicivirus and norovirus) are isolated in fish products, particularly molluscs. Viral diseases transmitted by molluscs have always had and continue to have a large impact on public health: for example, hepatitis A, of which molluscs are the main carrier after water, and noroviruses, which are the most frequent cause of disease transmitted by molluscs at an international level. A detailed study (Guyader, 2000) has confirmed the diffusion of enteric viruses in bivalve mollusc populations, observing positivity percentages of between 17% and 50% for the viruses examined. Data from the Integrated Epidemiological System for Acute Viral Hepatitis (SEIEVA, Istituto Superiore di Sanità) allowed a risk assessment estimating that 50-60% of hepatitis A can be correlated to the consumption of raw or partially cooked mussels.

Viruses that are found to cause disease through transmission food and water can be divided into 3 main groups:

1) viruses that cause gastroenteritis: rotavirus, adenovirus type 40 and 41, and two types of human enteric caliciviruses: noroviruses (NV) and sapoviruses (SV);
2) oro-faecally transmitted hepatitis viruses: hepatitis A virus (HAV) and hepatitis E virus (HEV);
3) viruses that replicate in the human intestine but provoke diseases in other organs, such as the central nervous system or liver (enteroviruses).

Microbial contamination of fish products

The microbial flora of fish and molluscs is closely related to the microbiological characteristics of the environment in which they live. Microorganisms in fish are mainly located on skin, on gills and in gut, whereas muscle masses are sterile. These can, however, become contaminated during gutting. Molluscs, which are mainly sessile or sedentary organisms, are capable of filtering several litres of water a day and their filtering activity varies according to size and species. For example, oysters can concentrate *Vibrio* spp. at levels 100 times greater than those found in the surrounding water.

The only bacteria that are certainly pathogens for humans and natural constituents of the microbe flora of marine environments and animals are the vibrionaceae and *Clostridium botulinum*. All other pathogen species come from human contamination of water and acquire particular relevance in the case of bivalve molluscs.
The *Vibrio* genus includes gram-negative bacilli. Some species of vibrios are of significant importance to health, because they cause infections requiring quarantine, such as cholera (*V. cholerae*), or because they are known to be associated with cases of mortality (e.g. *V. vulnificus*) or are the cause of a high number of toxic infections, particularly in Asian countries (e.g., *V.parahaemolyticus*). Other species, such as *V. mimicus*, *V. alginolyticus* and *Photobacterium damselae*, are also recognised as human pathogens. Currently, *V. parahaemolyticus* is the species most commonly associated with toxic infections in humans, followed by *V. cholerae non O1*, *V. hollisae*, *V. alginolyticus* and *V. fluvialis.* In addition to bivalve molluscs, fish products that can carry various species of vibrios also include shrimps, prawns and crabs, when eaten raw or undercooked.

Clostridium botulinum is mainly found in the sediment of aquatic environments. The E serotypes and the non-proteolytic type B and F strains can be isolated from the intestines of fish, but rarely from the skin. Botulism is a rare neuroparalytic syndrome provoked by the action of the toxin produced by the bacterium *Clostridium botulinum*. The toxin is easily destroyed by heat (80 °C for 15 minutes, for types A and B); the spores, however, can survive at up to 120 °C. Most food-borne intoxications are caused by the consumption of traditionally made vegetable preserves in oil or brine (example mushrooms, eggplant, etc.) or from home-made sausages. Fish products that cause intoxication also include poorly prepared traditional preserves, such as tuna, mackerel and anchovies in oil, or vacuum-sealed artisanal smoked products.

Listeria monocytogenes is a microorganism commonly found in the environment and has been isolated from various sources, including soil, plants, grass silage, faecal matter and surface wastewater. Infection occurs through the consumption of contaminated food. *Listeria monocytogenes* is capable of surviving and multiplying in conditions considered unfavourable for other bacteria. In fact, it survives freezing and drying, and can multiply at refrigeration temperatures (4 °C), at acid (4.4) and alkali (9.6) pH levels and in the presence of kitchen salt (NaCl 10-12%). Fish products that carry this infection mainly consist of culinary preparations (seafood salads, sushi) and smoked products (salmon, swordfish). This infection can be dangerous, particularly for certain sectors of the population, such as pregnant women (transplacental infection), newborn babies and the elderly. (EFSA, 2011).

Staphylococcus aureus is a microorganism capable of synthesising numerous thermostable toxins, known as “staphylococcal enterotoxins” (SEs). When present in sufficient quantities in food, these provoke a common form of staphylococcal food poisoning. *S. aureus* is a bacteria present on the skin and in the mucus of humans and other mammals. Humans are mainly responsible for the contamination of foods, particularly those that are handled during production, marketing and serving. Fish products can also be exposed to this contamination and become a vehicle of infection.

The genus *Salmonella*, which belongs to the family *Enterobacteriaceae*, is composed of gram-negative micro-organisms typical of the intestinal microbial flora of warm-blooded vertebrates and, as a consequence, becomes part of the secondary or allochthonous microflora of the catch. Because the main source of diffusion in the environment always consists of waste from livestock and humans, it is likely that fish products can become contaminated with *Salmonella* spp. through contact with coastal, fresh or brackish waters contaminated by sewage and through secondary handling during the processing phases (decapitation, filleting, etc.), with contaminated work utensils and surfaces. Among fish products, bivalve molluscs are the most at risk, followed by filleted fish and cooked shelled crustaceans. Of the approximately 2500 serotypes or serovars of *Salmonella* identified today, *S. enteritidis*, *S. typhimurium*, *S. newport* and *S. heidelberg* are among the most frequently involved in cases of food poisoning.

Escherichia coli, a gram-negative bacterium, is one of the most important species of bacteria that live in the lower intestine of warm-blooded animals. Its presence in water is a common indicator of faecal infection. Some strains of *E. coli* are toxigenic, i.e. they produce toxins that can be a cause of diarrhoea and intestinal and extra intestinal diseases. Other strains, the so-called enterohemorrhagic strains of *E. coli* (EHEC), whose progenitor is the serotype O157:H7, are of significant importance to health and are carried by infected meat that is insufficiently cooked and unpasteurised milk and cheese.

Algal biotoxins

The risk of infection from algal biotoxins is mainly linked to the consumption of bivalve molluscs (mussels, oysters and clams), which can accumulate these substances from the high concentration of various toxic single-celled algae species in the water. Algal biotoxins are divided, according to their solubility characteristics, into hydrosoluble and liposoluble.

Paralytic Shellfish Poisoning (PSP): saxitoxin (hydrosoluble) is responsible for this type of poisoning. The algae responsible for the production of these toxins belong to the genus Alexandrium. In Europe, the countries on the North Atlantic Coast are most exposed to the risk of PSP contamination. The tolerable limit of PSP concentration in bivalve molluscs is 800 µg/kg.

Amnesic Shellfish Poisoning (ASP): domoic acid and its isomers (hydrosoluble) are responsible for this type of poisoning. Diatomal algal blooms of the genus *Nitzschia*, which produce this toxin, mainly occur in the coastal waters of Northern Europe. The presence of ASP in the Mediterranean basin has so far not been reported. The tolerable limit of ASP concentration in bivalve molluscs is 20mg/kg.

Diarrethic Shellfish Poisoning (DSP): okadaic acid (OA) and its derivatives, known as dinophysis toxins (DTXs), which are liposoluble compounds, are responsible for this type of poisoning. The biotoxins responsible for the DSP syndrome are all lipophilic compounds, divided into 4 structural classes. Yessotoxins (YTXs) and pectenotoxins (PTXs), found in the Adriatic Sea, seem not to have any toxic effect on humans. Azaspiracid (AZP) is present in the coastal areas of Northern Europe. The planktonic microalgae species that should be considered as producers of DSP biotoxins, or in any case potentially toxic, are dinoflagellates belonging to the genus *Dinophysis* (*D. fortii*, *D. tripos*, *D. caudata*, *D.* cf. *acuminata*). The tolerable limit of DSP concentration in bivalve molluscs is DSP 160 µg/kg; YTXs 1 mg/kg; AZA 160 µg/kg.

Precautions
These biotoxins are thermostable compounds and therefore cooking the molluscs does not reduce the risk of poisoning.

Poisonous fish
Regulations EC No 853/2004 and No 854/2004 and Regulation EC No 2074/2005 state that fish products obtained from poisonous fish of the following families: Tetradontidae, Molidae, Diodontidae and Canthigasteridae should not be placed on the market.

Histamine

The toxic action in consumers is caused by fish products, including mackerel, tuna, sardines, salmon, anchovies, dolphinfish, bluefish, marlin and, in general, all species whose flesh has a high histidine content. If these fish are badly preserved, numerous bacteria (*Proteus vulgaris*, *Escherichia coli*, *Salmonella* spp., *Enterobacter aerogenes*, *Morganella morganii*, *Clostridium* spp., *Klebsiella pmeumoniae*, *Vibro alginolyticus*, *Aeromonas* spp., *Acinetobacter* spp. and *Lactobacillus buchneri*) convert the histidine into histamine through the activity of an enzyme (histidine decarboxylase). The minimum temperature for the formation of histamine by the producing bacteria is around 0 °C, while the optimal range is between 0 °C and 10 °C. The production tends to be blocked at temperatures below zero. Cooking, smoking and preservation through canning do not eliminate the toxin produced. The tolerated limit for histamine is 100 ppm.

Chemical contamination

Trace elements

Among the numerous inorganic elements found in nature, some, such as cadmium (Cd), mercury (Hg), lead (Pb) and arsenic (As), are considered potentially dangerous for human health if absorbed beyond certain limits. The amount of contamination is relevant near specific sources of emission related to extraction or industrial activities, the disposal or incineration of waste, certain agricultural and animal husbandry practices (e.g. the use of fertilisers, antiparasites and feeds containing metals) and natural causes (geochemical and volcanic features). For these reasons, acceptable limits have been established for fish products and safe consumption limits for consumers.

Table 19.2 - Limits for metals in fish products according to Commission Regulation (EC) No 1881/2006 of 19 December 2006, which defines the maximum levels for certain contaminants in food products (OJ L 364 of 20/12/06).

Lead (Pb)

Product	Maximum levels (mg/kg wet weight)
Muscle fish flesh	0.30
Crustaceans, excluding crab brown flesh and excluding head and thorax flesh of lobster and similar large crustaceans (*Nephropidae* and *Palinuridae*)	0.50
Bivalve molluscs	1.5
Cephalopods (without viscera)	1.0

Cadmium (Cd)

Product	Maximum levels (mg/kg wet weight)
Muscle fish flesh except for the species listed below:	0.05
Muscle flesh of the following fish: anchovy (*Engraulis species*) bonito (*Sarda sarda*) common two-banded sea bream (*Diplodus vulgaris*) eel (*Anguilla anguilla*) grey mullet (*Mugil labrosus*) horse mackerel or scad (*Trachurus species*) louvar (*Luvarus imperialis*) sardine (*Sardina pilchardus*) sardinops (*Sardinops species*) tuna (*Thunnus* spp., *Euthynnus* spp., *Katsuwonus pelamis*) wedge sole (*Dicologoglossa cuneata*)	0.10
Muscle flesh of sword fish (*Xiphias gladius*)	0.30
Crustaceans, excluding brown flesh of crab and excluding head and thorax flesh of lobster and similar large crustaceans (*Nephropidae* and *Palinuridae*)	0.50
Bivalve molluscs	1.0
Cephalopods (without viscera)	1.0

Mercury (Hg)

Product	Maximum levels (mg/kg wet weight)
Fish products and muscle fish flesh, excluding the species listed below:	0.50
Muscle flesh of the following fish: anglerfish (*Lophius* spp.) atlantic catfish (*Anarhichas lupus*) bonito (*Sarda sarda*) eel (*Anguilla anguilla*) emperor, orange roughy, rosy soldierfish (*Hoplostethus* spp.) grenadier (*Coryphaenoides rupestris*) halibut (*Hippoglossus hippoglossus*) marlin (*Makaira species*) megrim (*Lepidorhombus* spp.) pike (*Esox lucius*) plain bonito (*Orcynopsis unicolor*) poor cod (*Tricopterus minutes*) portuguese dogfish (*Centroscymnes coelolepis*) rays (*Raja species*) red mullet (*Mullus* spp.) redfish (*Sebastes marinus, S. mentella, S. viviparus*) sail fish (*Istiophorus platypterus*) scabbard fish (*Lepidopus caudatus, Aphanopus carbo*) seabream, pandora (*Pagellus* spp.) shark (all species) snake mackerel or butterfish (*Lepidocybium flavobrunneum, Ruvettus pretiosus, Gempylus serpens*) sturgeon (*Acipenser* spp.) swordfish (*Xiphias gladius*) tuna (*Thunnus* spp., *Euthynnus* spp., *Katsuwonus pelamis*)	1.0

The joint FAO/WHO expert committee on food additives (JECFA) establishes precautionary weekly consumption limits (PTWI), expressed in mg (or µg) per kg of body weight. These are doses of each element, weighted on a weekly basis, to which people can be exposed for long periods of time without appreciable effects on health.
Mercury: PTWI of 5 µg/kg b.w., equivalent to 350µg/week for a person weighing 70 kg.
Arsenic: PTWI of 3.0 µg/kg b.w., equivalent to 210 µg/week for a person weighing 70 kg.
Lead: PTWI of 25µg/kg, equivalent to 1750 µg/week for a person weighing 70 kg.
No intake limit has been established for cadmium.

European Commission information note on methyl mercury in fish and fishery products.
What advice should be given to populations at risk, without creating unnecessary and inappropriate alarm? Firstly, the risk groups for the EU are: women who might become pregnant (therefore all women of childbearing age: 15-44 years), pregnant women, breastfeeding mothers and small children. These should not eat tuna more than twice a week (two 80 g cans of tuna or one 160 g can). Furthermore, they should not consume more than 100 g per week (equal to one slice or a small steak about once a week) of large predatory fish, such as swordfish, shark, marlin and pike. If persons in these risk groups have consumed the recommended portion, they are advised to eat no more fish during the same period.

Polycyclic aromatic hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons (PAHs) form a large class of organic compounds all structurally characterised by the presence of two or more benzene rings fused together. A few hundred different PAHs can be formed through the incomplete combustion of carbon, crude oil and waste. They are never found as individual compounds but as part of mixtures containing dozens of different PAHs in various proportions. Precisely due to the fact that exposure is to a mixture of compounds, and in irregular proportions, it is difficult to attribute the toxic effects produced on the body to a specific hydrocarbon. These are highly lipophilic compounds, i.e. they tend to accumulate in fatty tissues.
PAHs are normally divided, according to their molecular weight and number of atoms, into light PAHs (2-3 condensed rings) and heavy PAHs (4-6 rings). The name PAH refers in particular to those compounds only containing carbon and hydrogen atoms, whereas the more general name “polycyclic aromatic compounds” also refers to their functional derivatives (nitro-PAHs) and similar heterocyclics (aza-arene).
In aquatic fauna, concentrations of PAH are more likely to be found in fish that live in inland waters and are therefore more exposed to sources of anthropic pollution, as well as in medium and large-sized fatty fish species, such as salmon and eels.
Another important source of contamination is food processing and treatment by grilling and smoking.

Table 19.3 - Limits for PAHs in fish products according to Commission Regulation (EC) No 1881/2006 of 19 December 2006, which defines the maximum levels for certain contaminants in food products (OJ L 364 of 20/12/06).

Polycyclic aromatic hydrocarbons (PAHs): Benzo(a)pirene

Product	Maximum levels (mg/kg wet weight)
Smoked fish muscle and smoked fish products, excluding bivalve molluscs. The maximum levels are applied to smoked crustaceans, excluding brown flesh of crab and excluding head and thorax flesh of lobster and similar large crustaceans (*Nephropidae and Palinuridae*)	5.0
Muscle flesh of non-smoked fish	2.0
Non-smoked crustaceans and cephalopods. The maximum levels are applied to crustaceans, excluding brown flesh of crab and excluding head and thorax flesh of lobster and similar large crustaceans (*Nephropidae* and *Palinuridae*)	5.0
Bivalve molluscs	10.0

Dioxins and PCBs found in feed and food

Dioxins are substances that are formed unintentionally as undesirable products of waste incineration and other industrial processes. They are compounds also found in PCBs or formed during their use. The term dioxin indicates a group of 75 polychlorinated dibenzo-para-dioxin (PCDD) congeners and 135 polychlorinated dibenzofuran (PCDF) congeners, 17 of which can have toxicological effects.

Polychlorinated biphenyls (PCBs) are a group of 209 different congeners which can be divided into two groups according to their toxicological properties: a small number exhibit toxicological properties similar to dioxins and are therefore often termed “dioxin-like PCBs”. Most of them do not exhibit dioxin-like toxicity but have a different toxicological profile. In order to be able to sum up the toxicity of these different congeners, the concept of toxic equivalency factors (TEFs) has been introduced as an aid to risk assessment and regulatory control. This means that the analytical results relating to all the individual dioxin and dioxin-like PCB congeners of toxicological concern are expressed in terms of a quantifiable unit, namely the “TCDD toxic equivalent” (TEQ).

PCBs are chemical compounds containing chlorine, which were used in the past to produce anti-parasites, herbicides, paints, solvents and in certain industrial processes for electrical components. They are poorly biodegradable, resistant to high temperatures and insoluble in water. They are, however liposoluble, and therefore tend to accumulate in the fat of animals and humans.

Dioxins and PCBs are considered as highly toxic substances and have been shown to exhibit neoplastic action.

Assessment of the risk to consumers. Consumption of foods contaminated by dioxins and PCBs is the main source of accumulation for humans. Meat, eggs, milk and farmed fish can be potentially polluted by dioxins and PCBs absorbed through feed. Even wild fishery products from contaminated sea areas can contain concentrations of dioxins that enter the human food cycle. Farmed fish, on the other hand, can be contaminated through fish meal or oil, which form the basis of their feed.

Table 19.4 - Maximum levels of dioxins and dioxin-like PCBs in fish products and their derivatives (Regulation (EC) No 199/2006)

Food	Maximum levels. Sum of dioxins and furans (WHO-PCDD/F-TEQ)	Maximum levels. Sum of dioxins, furans and dioxin-like PCBs (WHO-PCDD/F-TEQ)
Muscle flesh of fish and fishery products and their derivatives	4.0 pg/g fresh weight	8.0 pg/g fresh weight
Muscle flesh of eel and derived products	4.0 pg/g fresh weight	12.0 pg/g fresh weight
Marine oil (fish body oil, fish liver oil and oils of other marine organisms intended for human consumption)	2.0 pg/g fat	10.0 pg/g fat

(the other food matrices are not shown in this table).
Key: Dioxins- sum of polychlorinated dibenzo-para-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF), expressed in WHO-TEF toxicity equivalents (equivalent toxicity factors) and the sum of dioxins and dioxin-like PCBs (sum of polychlorinated dibenzo-para-dioxins (PCDD), polychlorinated dibenzofurans (PCDF) and polychlorinated biphenyls (PCB).

Parasitic zoonoses transmitted by fish products

Parasitic infections related to the consumption of fish products are a serious public health problem at a worldwide level. The WHO estimates that around 60 million people have contracted these infections. The situation is not alarming in Italy, mainly due to the dietary habits, which do not include regular consumption of large quantities of raw or lightly cooked fish products, whether from the sea or from freshwater. In addition to the problem of genuine infections acquired through consumption of fish products, mention should also be made of the recent increase in allergies related to the consumption of fish products infected by parasites, even though these are eliminated by cooking.

Anisakiasis is a zoonosis provoked by larval forms of ascaridoid nematodes belonging to the genera *Anisakis* and *Pseudoterranova* (family Anisakidae). Marine mammals, the final hosts (mainly cetaceans for the genus *Anisakis* and fin-footed mammals for the genus *Pseudoterranova*), are infected by swallowing fish and/or cephalopods containing parasites. Humans become part of this biological cycle as accidental hosts, through infection by live larvae found in the intestines or muscles of the fish.
Anisakis larvae are generally found on the surface of the gastrointestinal cavity in fish that have been dead for only a few hours. The larvae can be eliminated by freezing at -20 °C for at least 24 hours or by heat treatment at a minimum of 60 °C for 10 minutes. Smoking and marinating are not sufficient to safely eliminate anisakis larvae. Dry salting can eliminate the parasite if the salt reaches all muscle parts.
The presence of larval forms of *Anisakis* is also considered to be a cause of IgE-mediated allergic reactions, with clinical symptoms ranging from rashes and asthma to anaphylactic shock. (Genchi *et al*., 2004).

Bothriocephalosis is caused by various species of cestoda (tapeworms) belonging to the genus *Diphyllobothrium*. *D. latum* is certainly the most important of these from a health perspective. Humans and other final hosts contract the infection by eating raw or undercooked fish.
The regions in which the infection is found in humans are located in subarctic and temperate

regions of Eastern Europe and in the states of the Russian Federation. 13 million people are estimated to be infected by this parasite at a worldwide level.
In Italy, *D. latum* has been identified in the large lakes of the North, particularly in Lake Maggiore, Lake Como and Lake d'Iseo, where the parasite is considered to be endemic. The increase in the consumption of raw fish (fillet of perch with lemon, carpaccio, tartare or raw fish salad) could have facilitated recent cases of this infection.
The fish that can transmit this infection to humans belong to the family Percidae (perch, *Perca fluviatilis*; ruffe, *Gymnocephalus cernua*; zander, *Stizostedion lucioperca*), Esocidae (pike, *Esox* spp.), gadiformes (burbot, *Lota lota*) and Salmonidae (rainbow trout, *Oncorhynchus mykiss*; and arctic char, *Salvelinus alpinus*).

The adult *Opisthorchis felineus* worm is orange in colour, flat, lance-shaped, and about 1 cm in length and 2-2.5 mm wide. This trematode lives in the bile ducts of certain carnivores and humans. It is commonly found in lakes and watercourses in various countries of the Russian Federation (in particular the Ukraine and Kazakhstan), where it is estimated that around 1.6 million people are infected by the parasites. Certain cases of human infection due to consumption of fish caught in a lake in central Italy have recently been described. It is believed that these infections were caused by the introduction of fish from endemic regions or by infected immigrants from these regions, whose faeces contaminated the lake waters containing the intermediate hosts required to complete the parasite cycle.

Veterinary treatments in aquaculture: the problem of residues

Farmed aquatic organisms, including bivalve molluscs and crustaceans, are exposed to a range of diseases caused by viral agents, bacteria, fungi and parasites. The use of veterinary drugs in EU countries is governed by extensive regulations, which have evolved up to the most recent ones: Regulation EC No 470/2009, Regulation EC No 37/2010. This body of provisions specifies that only the active substances authorised by the European Medicines Agency (EMA) can be administered to animals. For certain substances, an MRL, i.e. an acceptable maximum residue limit (without risk to consumers) that may be found in the tissue of treated animals, has been established.
The use of certain substances (e.g. chloramphenicol, chlorpromazine, dimetridazole, nitrofurans) has been prohibited (Annex IV of Regulation 2377/90). Other regulations (Legislative Decree 158/2006 sostituire con Directive 2003/74/EC) also prohibit the use of other substances in the field of animal husbandry (anabolic steroids, stilbenes, steroids, beta-adrenergic agonists).
The problem of residues of veterinary medicines or disinfectant substances in the tissues of farmed aquatic organisms can arise when:

1) the established MRL is exceeded, i.e. an authorised medicine has been used but not in an adequate manner (doses, frequency, suspension periods);
2) illicit use has been made of a medicine or an unauthorised or prohibited substance.

At an international level, legal and organisational discrepancies remain between the various States in matters of local control and this creates some problems with regard to imported products, which at times have been found to be contaminated by substances that are not authorised in EU countries.

References

- Borgstrom G. (1961) - *Fish as food*. New York, London: Academic Press.
- Butt *et al.*, Aldridge K.E., Sanders C. (2004) – Infections related to the ingestion of seafood, Part I: viral and bacterial infections. *Lancet*, 4: 201-212.
- EFSA (2009) - EFSA Panel on Contaminants in the Food Chain (CONTAM Panel).
- EFSA (2011) - European Union Summary Report on Trends and Sources of Zoonoses, Zoonotic Agents and Food-borne Outbreaks in 2090, 9 (3): 378 p.
- Genchi C. & Pozio E. (ed) (2004) - *Parassitologia generale e umana*. Milano: Casa Editrice Ambrosiana: 552 p.
- OMS/FAO (2008) - Viruses in food: scientific advice to support risk management, MRA Series 13.