Determination of chemical and biological contaminants in Seafood

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Food safety is a prime concern for everybody in this era and no one can be found who has not encountered an unpleasant moment of foodborne illness at least once. Seafood is considered as a part of a healthy diet and its consumption is increasing everyday as it is associated with potential health benefits such as neurologic development during gestation and infancy and reduced risk of heart disease. Along with the nutrients and benefits coming from seafood, consumption may lead with the potential risks of eating contaminated seafood. Chemicals, metals, marine toxins, and infectious agents have been reported in seafood across world. Infectious agents associated with food-borne illness include bacteria, viruses, and parasites, and the illnesses caused by these agents range from mild gastroenteritis to life-threatening syndromes.

Many chemical pollutants concentrate in fish and shellfish by accumulating in fatty tissues or selectively binding to fish muscle tissue. Even extremely low concentrations of bioaccumulation of pollutants detected in water or bottom sediments may result in fish or shellfish tissue concentrations high enough to pose health risks to seafood consumers. Lipophilic contaminants, particularly certain organochlorine compounds, tend to accumulate in the fatty tissues of fish. Consequently, fish species with a higher fat content may pose greater risks from some contaminants than leaner fish. Although exposure to some contaminants may be reduced by removing the fat, skin, and viscera before the fish is eaten, other contaminants, such as methylmercury, accumulate in the muscle tissue of the fish & shellfish and therefore cannot be removed by trimming. Under these conditions, the entire body burden of bioaccumulative contaminants contained in the fish would be ingested by the consumer. Chemical contamination can happen at any stage in food production and processing. Potential risks to consumers increase when chemicals are not controlled or the recommended treatment rates are exceeded. The presence of a chemical may not always represent a hazard.

Bacteria, viruses, parasites and biotoxins in fresh and processed seafood can cause foodborne illnesses. Fish may get contaminated by substances or organisms introduced into the environment through animal and human pollution or agricultural runoff. Other factors that can increase the risk of

illness include environmental conditions in the growing waters, harvesting methods, processing operations, and handling during marketing. The efforts for the discovery of new emerging pathogens for which little information is available and dramatic improvements analytical technology that allow for detection of low levels of microbial and chemical contaminants in foods to provide safe fish. The global nature of seafood trading issues and the worldwide implementation of new preventative food safety programs such as hazard analysis for critical control points are driving some of the efforts to build new scientific bridges that may re-evaluate current risk analysis strategies.

Chemical contaminants can be separated into three categories:

1. Naturally Occurring Chemicals (including allergens)

These chemicals are derived from a variety of plants, animals or microorganisms. In most cases, these naturally occurring chemicals are found prior to or during harvest. Although many naturally occurring toxins are biological in origin.

Examples: *Certain fish species* (e.g., tuna, mahi-mahi); *Molluscan shellfish*

- Scombrotoxin (histamine)
- Ciguatoxin
- Shellfish toxins comprising Paralytic shellfish poisoning (PSP), Diarrheic shellfish poisoning (DSP), Neurotoxic shellfish poisoning (NSP), and Amnesic shellfish poisoning (ASP)/Domoic acid

2. Intentionally added chemicals.

These chemicals are intentionally added to food at some point during the food's growth and distribution. Intentionally added chemicals are safe when used at established safe levels but can be dangerous when those levels are exceeded.

Example: The following are examples of food additives that may be chemical hazards if used improperly: *Sodium nitrite* (preservative); *Vitamin A* (nutrient supplement); *Sulfiting agents* (preservative)

- Food additives
  - Direct (allowable limits under GMPs) : Preservatives (e.g., nitrite and sulfiting agents), Nutritional additives (e.g., niacin), Color additives

3. Unintenionally or incidentially added chemicals.

Chemicals can become part of a food without being intentionally added. These incidental chemicals might already be in a food ingredient when it is received. For example, certain seafood may contain small but legal residues of approved antibiotics. Packaging materials that are in direct contact with

ingredients or the product can be a source of incidental chemicals, such as sanitizers or inks. Most incidental chemicals have no effect on food safety, and others are only a concern if they are present in too high an amount. Incidental chemicals also include accidental additions of prohibited substances such as poisons or insecticides that may not be allowed at any level. *Example: Agricultural chemicals* (e.g., pesticides, herbicides); *Cleaning chemicals* (e.g., acids, caustics); *Maintenance chemicals* (e.g., lubricants, paint)

- Agricultural chemicals (e.g., pesticides, fungicides, herbicides, fertilizers, antibiotics and growth hormones)
- Prohibited substances (Code of Federal Regulations, chapter 21, section 189)
- Toxic elements and compounds (e.g., lead, zinc, arsenic, mercury and cyanide)
- Polychlorinated biphenyls (PCBs)
- Plant chemicals (e.g., lubricants, cleaning compounds, sanitizers and paints)

Quantification of metals can be done by inductively coupled plasma mass spectrometry (ICP-MS); measurement and quantification of PCDD/PCDFs, PCBs, HCB, PCNs, PBDEs and PCDEs can be performed by high-resolution gas chromatography/high resolution mass spectrometry (HRGC/HRMS), analyses of PAHs were done by high pressure liquid chromatography (HPLC).

Table: Tolerances limits for chemical contaminants in fish and fish products

Substance	Maximum levels		Food commodity
	US (ppm)	EU (mg/kg wet weight)	
Arsenic	76-86		molluscs, crustaceans
Cadmium	3-4	0.05-1.0	fish, molluscs
Lead	1.5-1.7	0.2-1.0	fish, molluscs
Methyl mercury	1.0	1.0	all fish
PCB	2.0		all fish
DDT, TDE	5.0		all fish
Diedrin	0.0		all fish
Dioxin		0.000004	

Source: FAO, 2004

Table: List of antibiotics and pharmacologically active substances prohibited in any unit processing seafood.

Name of Antibiotics	Tolerance Limit in Mg/Kg (PPM)
Tetracycline	0.1
Oxytetracycline	0.1
Trimethoprim	0.05
Oxolinic acid	0.3

Source: FSSAI, 2011

Biological Contaminants:

Bacterial hazards are defined as those bacteria that, if they occur in food, may cause illness in humans, either by infection or intoxication. Foodborne infections are caused by swallowing live pathogens that grow within the body, usually in the intestinal tract. They differ from food-borne intoxication, which is a condition caused by swallowing preformed toxins
(i.e., toxins produced by microorganisms in the food before it is eaten). Bacterial hazards can also be grouped into sporeformers and nonsporeformers. Certain types of bacteria (e.g., *Clostridium* and *Bacillus* spp.) pass through a dormant stage in their life cycle called a spore.
Although the microorganism exists as a spore, it is very resistant to chemicals, heat and other treatments that would normally be lethal to nonsporeforming bacteria. Because they are dormant, spores are not hazardous as long as they stay spores. Unfortunately, if they survive a
processing step designed to kill nonsporeforming bacteria, they may become a hazard in the food if they are allowed to grow. When sporeformers are a concern, the process steps used to control them are often much more severe than if only nonsporeformers need to be controlled.

I. Bacteria

A. Sporeformers

Clostridium botulinum
Clostridium perfringens
Bacillus cereus

B. Nonsporeformers

Brucellaabortis, B. suis
Campylobacter spp.
pathogenic*Escherichia coli* (e.g. *E. coli* O157:H7)
Listeria monocytogenes
Salmonella spp. (e.g., *S. typhimurium, S. enteriditis*)
*Shigella*spp. (e.g., *S. dysenteriae*)
Staphylococcus aureus

Streptococcus pyogenes
Vibrio spp. *(e.g., V. cholerae, V. parahaemolyticus, V. vulnificus)*
Yersinia enterocolitica

II. Viruses

Like other microorganisms, viruses exist everywhere. They are very small particles that cannot be seen with a light microscope and cannot reproduce by themselves. Although they are alive, viruses differ from other microorganisms in what they need to live and how they multiply. Viruses exist in foods without growing, so they need no food, water or air to survive. They do not cause spoilage. Viruses cause illness by infection. They can infect living cells and reproduce inside the host cell using material from it. Viruses only grow once they enter a suitable host. Only some viruses consider humans a suitable host. Viruses can survive inhuman intestines, contaminated water and frozen foods for months.

- Hepatitis A and E
- Norwalk virus group
- Rotavirus

Viruses can be found in people who were previously infected but are no longer ill. Viruses can also be present in people who show no outward signs of illness (carriers). Transmission of viruses to foods is usually related to poor hygienic practices. People who have viruses shed the particles when they defecate. Food handlers with viruses can transmit them to food if they forget to wash and sanitize their hands properly. This route can also result in contamination of food with bacterial hazards.

III. Parasites *(Worms and Protozoa)*

Parasites are organisms that need a host to survive, living on or within it. Thousands of kinds of parasites exist worldwide. Only about 20 percent can be found in food or water, and less than 100 are known to infect people through consumption. There are two types of parasites that can infect people through food or water: parasitic worms and protozoa. Parasitic worms include roundworms (nematodes), tapeworms (cestodes) and flukes (trematodes). These worms vary in size from barely visible to several feet in length. Protozoa are single-cell animals, and most cannot be seen without a microscope.

For most foodborne parasites, the food is part of their natural life cycle (e.g., nematode worms in fish and meat). They have the opportunity to infect humans when people eat them along with the food. The two factors most important to parasitic survival are a proper host (i.e., not all organisms can be infected by parasites) and a suitable environment (i.e., temperature, water, salinity, etc.).

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Parasites in foods comprises:

- *Anasakis simplex*
- *Ascaris lumbricoides*
- *Cryptosporidium parvum*
- *Diphyllobothrium latum*
- *Entamoeba histolytica*
- *Giardia lamblia*
- *Pseudoterranova dicepiens*
- *Taeniasolium, T. saginata*
- *Trichinellaspiralis*

Measures to eliminate/reduce chemical and biological contaminants:

Control strategies to prevent seafood-associated illnesses include monitoring harvest waters, identification and implementation of process controls, and consumer education. Every seafood harvester and processor must use a HACCP-based system. Consumers should be aware of the potential health risks associated with eating seafood. Seafood-borne infections can be prevented by cooking seafood thoroughly, storing foods properly, and avoiding cross-contamination after cooking. However, some seafood is commonly consumed raw or minimally cooked. Persons with underlying medical conditions such as liver disease, diabetes, or immunosuppressing conditions are at higher risk of acquiring severe infection and should be especially careful. Educational strategies have focused particularly on those persons.

The "WHO Five keys to safer food" for food handlers and educate the consumers, has been published especially for preventing from foodborne illness. The Five keys includes:

- Keep food surfaces clean. Wash all utensils, plates, platters, and cutlery as soon as used.
- Separate raw food from cooked food.
- Cook food thoroughly, to the appropriate temperature.
- Keep food at safe temperatures, both for serving and storage.
- Use safe water and raw materials.

Ensuring food safety starts with production, at the farm level. Misuse of agro-chemicals, including pesticides, growth hormones and veterinary drugs may have harmful effects on human health which need to be effective controlled. The microbial and chemical risks could be introduced at the farm-level (e.g. using water contaminated by industrial waste or poultry farm waste for irrigation of crops). Good practices should be applied to reduce microbial and chemical hazards. For clinicians and laboratorians, prompt recognition of infection in patients who seek medical attention for illness after eating raw or undercooked seafood is important for appropriate testing and early treatment, as necessary. Rapid reporting of these cases to public health authorities is critical to identify both contaminated seafood and risky harvest areas in order to implement timely control measures. Prevention of seafood-associated infections requires an understanding not only of the etiologic agents and seafood commodities associated with illness but also of the mechanisms of contamination that are amenable to control. Defining these problem areas, which relies on surveillance of seafood-associated infections through outbreak and case reporting, can lead to targeted research and help to guide control efforts. Coordinated efforts are necessary to further reduce the risk of seafood-associated illnesses. Continued surveillance will be important to assess the effectiveness of current and future prevention strategies.