

Aquaculture Feed and Food Safety

The Role of the Food and Agriculture Organization and the Codex Alimentarius

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The ultimate objective of an aquaculture feed manufacturer and aquaculture food supplier is to ensure that the feed or food produced is both safe and wholesome. Reported food safety risks, which may be associated with the use of commercial animal feeds, including compound aquaculture feeds, usually result from the possible presence of unwanted contaminants, either within the feed ingredients used or from the external contamination of the finished feed on prolonged storage. The major animal feed contaminants that have been reported to date have included *Salmonellae*, mycotoxins, veterinary drug residues, persistent organic pollutants, agricultural and other chemicals (solvent residues, melamine), heavy metals (mercury, lead, cadmium) and excess mineral salts (hexavalent chromium, arsenic, selenium, flourine), and transmissible spongiform encephalopathies. Apart from the direct negative effect of these possible contaminants on the health of the cultured target species, there is a risk that the feed contaminants may be passed along the food chain, via contaminated aquaculture produce, to consumers. In recent years, public concern regarding food safety has increased as a consequence of the increasing prevalence of antibiotic residues, persistent organic pollutants, and chemicals in farmed seafood. The important role played by the Food and Agriculture Organization of the United Nations (FAO) and the Codex Alimentarius Commission in the development of international standards, guidelines, and recommendations to protect the health of consumers and ensure fair practices in the food trade is discussed.

Key words: animal feeds; aquaculture; contaminants; FAO; food safety

Introduction

Recent reports concerning the contamination of aquaculture feeds and farmed produce with banned substances and contaminants has placed aquaculture feed and food safety in the spotlight, and the critical need for all feed manufacturers, farmers, processors, and distributors to be especially vigilant regarding their feed and food quality-control measures.^{1,2} It is imperative that the aquaculture feed and food industry ensure that the aquaculture food produce reaching the consumer is safe and wholesome.

Food safety risks associated with the use of compound animal feeds, including aquafeeds, may include^{3,4}:

- *Salmonellae*⁵
- Mycotoxins⁶
- Veterinary drug residues^{4,7}
- Persistent organic pollutants⁸⁻¹¹
- Other agricultural chemicals and solvent residues¹²
- Metals and mineral salts (e.g., mercury, lead, cadmium, hexavalent chromium, arsenic, selenium, flourine)⁴
- Transmissible spongiform encephalopathies¹³

As a result of the preceding food safety concerns, trade problems related to food control

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often arise, with many constraints being applied in both domestic and international trade to protect the health of consumers, ensure fair trade practices, prevent consumer fraud, and prevent the entry of diseases that threaten animal and plant health or life.

Role of the Food and Agriculture Organization and the Codex Alimentarius Commission

In order to determine how to better address problems of feed ingredients and contaminated feed, the Food and Agriculture Organization of the United Nations (FAO) first organized an Expert Consultation on Animal Feeding and Food Safety in Rome (March 10–14, 1997), and the consultation produced the first FAO Draft Code of Practice on Good Animal Feeding for consideration by the Codex Alimentarius Commission as advice to member countries.³

The Codex Alimentarius Commission, “Codex” for short, was created in 1961/1963 by FAO and the World Health Organization (WHO) to develop international food standards, guidelines, and recommendations to protect the health of consumers and to ensure fair practices in the food trade (for review see Bruno¹⁴). As of September 2007, the constituency of Codex comprises 174 member countries and one member organization (the European Community). Codex is essentially an international risk-management body that develops food safety and quality standards. These standards are used by policymakers and regulators of countries in building a sound national food control system to provide food of adequate quality and safety, and to protect the health of consumers at the national level.

The organizational structure of Codex currently comprises: (a) the Commission (which meets annually), (b) the Executive Committee, and (c) Codex subsidiary bodies (10 general subject committees, 11 commodity committees, 6 regional coordinating committees, and 5 *ad hoc* intergovernmental task forces; Fig. 1).

Codex Standards and World Trade Organization/Sanitary and Phytosanitary Agreement

It is important to mention at this point two World Trade Organization (WTO) agreements which are of particular significance for international food trade, namely, the “Agreement on the Application of Sanitary and Phytosanitary Measures” (commonly referred to as the SPS Agreement) and the “Agreement on Technical Barriers to Trade” (known as the TBT Agreement). On a general basis, the SPS Agreement concerns measures applied to protect human, animal, and plant health, whereas the TBT Agreement refers to technical regulations and conformity assessment procedures and applies to all commodities, not just food.

While the food standards, guidelines, and recommendations adopted by Codex do not have a binding effect on national food legislation, WTO members are encouraged to harmonize national regulations with the international standards. Furthermore, these standards may be used as a reference in case of a food-trade dispute. Since the SPS Agreement specifically identifies Codex standards, guidelines, and recommendations as the international benchmark for food safety, national regulations consistent with Codex standards are deemed to meet the requirement of the SPS Agreement. Codex standards and related texts, including on food labeling, are relevant under the TBT Agreement. For food safety, the SPS Agreement refers to standards developed by Codex concerning hygienic practices, contaminants, food additives, methods of analysis and sampling, and veterinary drug and pesticide residues.

The standards, guidelines, and recommendations developed by Codex are based on the principle of sound scientific analysis and evidence, involving a thorough review of all relevant information, in order that the standards assure the quality and safety of the food supply. Scientific advice is usually provided to

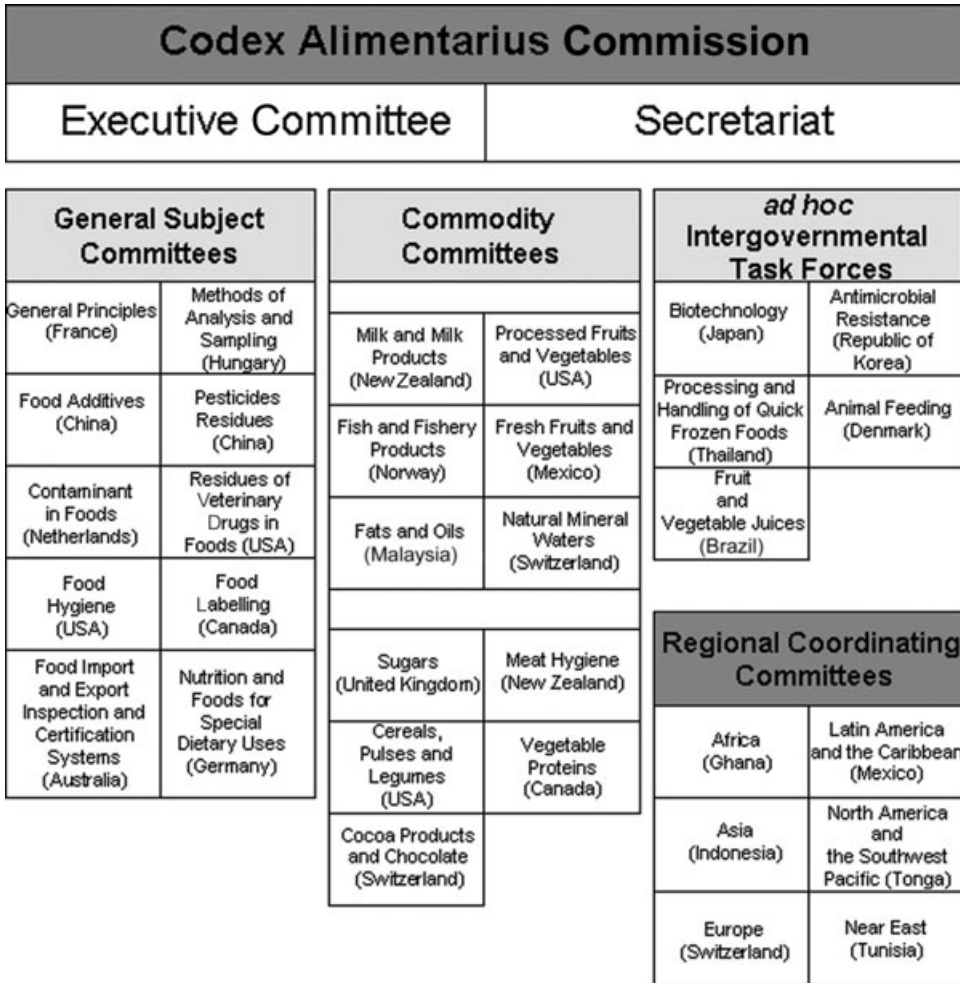


FIGURE 1. Codex organizational chart.

Codex by expert committees and consultations. These expert committees and consultations are not part of Codex, but independent bodies established by FAO and WHO to provide scientific advice to Codex and member governments. Thus, Codex elaborates food safety standards, taking into account the expert advice provided by joint expert committees, such as the Joint FAO/WHO Expert Committee on Food Additives, the Joint FAO/WHO Meetings on Pesticides Residues, the Joint FAO/WHO Expert Meetings on Microbiological Risk Assessment, and *ad hoc* expert consultations, such as with the intergovernmental tasks forces on foods derived from biotechnology (1999–2003 and 2005–2009),

antimicrobial resistance (2006–), handling and processing of quick frozen foods (2006–), fruit and vegetable juices (1999–2005), and animal feeding (1999–2004).

In the process of selecting experts for the preceding meetings, FAO and WHO follow an established procedure to ensure the transparency, excellence, and independence of the opinion delivered, including diversity of viewpoints, and balanced representation from both developing and developed countries. Moreover, all experts invited to Codex expert meetings are required to participate only in their individual scientific capacity, and are not allowed to represent the position of their national government or institution.

Codex Work Relating to Animal Feeding and Fish Products

In order to determine how to better address problems of feed ingredients and contaminated feed, FAO organized an expert consultation on animal feeding and food safety in Rome in March 1997; this consultation produced the first FAO Draft Code of Practice on Good Animal Feeding for consideration by Codex as advice to member countries.^{3,15} As a result of the recommendations of this meeting, an *ad hoc* Codex Intergovernmental Task Force on Animal Feeding was then established by the 23rd Session of the Codex Alimentarius Commission (July 1999) to address all the issues relating to animal feeding. The task force was hosted by Denmark and met five times between 2000 and 2005; the main output of the task force was the development and adoption of a Codex Code of Practice on Good Animal Feeding.¹⁶

The Code establishes a feed safety system for food-producing animals that covers the whole food chain, taking into account relevant aspects of animal health and the environment in order to minimize risks to consumers' health (the Code applies in addition to the principles of food hygiene already established by Codex).¹⁷ The objective of the Code is to help ensure the safety of food for human consumption through adherence to good animal feeding practice at the farm level and good manufacturing practices during the procurement, handling, storage, processing, and distribution of animal feed and feed ingredients for food-producing animals. The Code applies to the production and use of all materials destined for animal feed and feed ingredients at all levels, whether produced industrially or on a farm. It also includes grazing or free-range feeding, forage crop production, and aquaculture. The Code, in fulfilling the Codex mandate of consumer protection, only addresses food safety, and does not cover those issues of animal welfare, other than food safety-related animal health issues. Environmental contaminants are considered in the Code where the

level of such substances in the feed and feed ingredients could present a risk to consumers' health from the consumption of foods of animal origin.¹⁵

In the specific case of aquaculture, the Code of Practice for Good Animal Feeding notes the wide range of cultivated aquatic species, culture methods, and feeding strategies possible within the aquaculture. It follows, therefore, that to ensure food safety, necessary precautions should be taken regarding culturing methods, culturing sites, technologies, materials, and feed used to minimize contamination in order to reduce food hazards. Moreover, at the time the Code was being drafted, since Codex was already in the process of developing a separate Code of Practice for Fish and Fishery Products it was necessary for aquaculture producers to also refer to relevant sections of this Code.¹⁸

In addition, the Code of Practice for Fish and Fishery Products, and in particular Section 6 of the Code dealing with aquaculture production, states that aquaculture establishments should operate in a responsible way such that they comply with the recommendations of the Code of Conduct for Responsible Fisheries (CCRF) in order to minimize any adverse impact on human health and environment, including any potential ecological changes.^{18,19} Moreover, the Code only applies to semi-intensive and intensive industrialized and commercial aquaculture production (which generally use formulated feeds and may utilize medication and vaccines) and does not cover extensive fish-farming systems that prevail in many developing countries, or integrated livestock and fish culture systems.

With respect to feed supply, the Code states that feeds used in aquaculture production should comply with the Codex Recommended Code of Practice on Good Animal Feeding, and provides the following additional technical guidance¹⁶:

- Feed and fresh stocks should be purchased and rotated and used prior to the expiry of their shelf life.

- Dry fish feeds should be stored in cool and dry areas to prevent spoilage, mold growth, and contamination. Moist feed should be properly refrigerated according to manufacturers instructions.
- Feed ingredients should not contain unsafe levels of pesticides, chemical contaminants, microbial toxins, or other adulterating substances.
- Industrially produced complete feeds and industrially produced feed ingredients should be properly labeled. Their composition must fit the declaration on the label and they should be hygienically acceptable.
- Ingredients should meet acceptable, and if applicable, statutory standards for levels of pathogens, mycotoxins, herbicides, pesticides, and other contaminants that may give rise to human health hazards.
- Only approved colors of the correct concentration should be included in the feed.
- Moist feed or feed ingredients should be fresh and of adequate chemical and microbiological quality.
- Fresh or frozen fish should reach the fish farm in an adequate state of freshness.
- Fish silage and offal from fish, if used, should be properly cooked or treated to eliminate potential hazards to human health.
- Feed that is compounded industrially or at the fish farm, should contain only such additives, growth-promoting substances, fish-flesh coloring agents; antioxidizing agents, caking agents, or veterinary drugs that are permitted for fish by the official agency having jurisdiction.
- Products should be registered with the relevant national authority as appropriate.
- Storage and transport conditions should conform to the specifications on the label.
- Veterinary drug and other chemical treatments should be administered in accordance with recommended practices and comply with national regulations.
- Medicated feeds should be clearly identi-

fied in the package and stored separately, in order to avoid errors.

- Farmers should follow manufacturers' instructions on the use of medicated feeds.
- Product tracing of all feed ingredients should be assured by proper record keeping.

Although Codex officially dissolved the task force in 2004 (which had completed its work of producing the Code of Practice for Good Animal Feeding), a circular letter requesting proposals for future work by Codex on animal feeding was issued in July 2007 in order to allow further consideration of the issue at the 31st session of the commission in July 2008.

Codex texts relating to animal feeding that have been developed by other Codex committees have included:

- General Standard for Contaminants and Toxins in Food²⁰;
- Code of Practice for the Reduction of Aflatoxin B1 in Raw Materials and Supplemental Feedingstuffs for Milk-Producing Animals²¹;
- Code of Practice for the Prevention of Mycotoxin Contamination in Cereals²²;
- Code of Hygienic Practice for Meat²³;
- Code of Practice for Fish & Fishery Products¹⁸;
- Principles for Traceability/Product Tracing as a Tool within a Food Inspection and Certification System²⁴;
- Code of Practice to Minimise and Contain Antimicrobial Resistance²⁵;
- Code of Practice for the Prevention and Reduction of Dioxin and Dioxin-like PCB Contamination in Food and Feeds²⁶;
- Guidelines for the Establishment of a Regulatory Programme for Control of Veterinary Drug Residues in Foods²⁷;
- Guidelines for the Production, Processing, Labelling and Marketing of Organically Produced Foods²⁸;
- Methods of Sampling for Pesticide Residues for the Determination of Compliance with MRLs²⁹;

- Analysis of Pesticide Residues: Guidelines on Good Laboratory Practice in Pesticide Residue Analysis³⁰;
- Maximum Residue Limits for Veterinary Drugs in Foods³¹;
- Maximum Residue Limits (MRL) for Pesticides³²;
- Extraneous Maximum Residue Limits (EMRLs)³³;
- Classification of Food and Animal Feed³⁴
- Facilitate and promote technical, financial, and other cooperation in conservation of fisheries resources and fisheries management and development;
- Promote the contribution of fisheries to food security and food quality, giving priority to the nutritional needs of local communities;
- Promote protection of living aquatic resources and their environments and coastal areas;
- Promote the trade of fish and fishery products in conformity with relevant international rules and avoid the use of measures that constitute hidden barriers to such trade.

Food and Agriculture Organization Technical Guidelines for Responsible Fisheries

The FAO CCRF represents a series of voluntary principles and guidelines unanimously endorsed and adopted by 170 FAO member countries.¹⁹ The Code sets out principles and international standards of behavior for responsible practices with a view to ensuring the effective conservation, management, and development of living aquatic resources.

The objectives of the Code are to:

- Establish principles, in accordance with the relevant rules of international law, for responsible fishing and fisheries activities, taking into account all their relevant biological, technological, economic, social, environmental, and commercial aspects;
- Establish principles and criteria for the elaboration and implementation of national policies for responsible conservation of fisheries resources and fisheries management and development;
- Serve as an instrument of reference to help states to establish or to improve the legal and institutional framework required for the exercise of responsible fisheries, and in the formulation and implementation of appropriate measures;
- Provide guidance that may be used where appropriate in the formulation and implementation of international agreements and other legal instruments, both binding and voluntary;
- Specifically, Article 9 of the Code sets forth four basic principles: 9.1, dealing with the responsible development of aquaculture in areas under national jurisdiction; 9.2, dealing with the responsible development of aquaculture within transboundary aquatic ecosystems; 9.3, dealing with the use of aquatic genetic resources for the purposes of aquaculture, and 9.4, concerning responsible aquaculture at the production level.

Similarly, Article 11 of the Code deals with postharvest practices and trade: 11.1, dealing with responsible fish utilization, states in particular that States should:

- Adopt appropriate measures to ensure the right of consumers to safe, wholesome, and unadulterated fish and fishery products;
- Establish and maintain effective national safety and quality-assurance systems to protect consumer health and prevent commercial fraud;
- Set minimum standards for safety and quality assurance, and make sure that these standards are effectively applied throughout the industry;
- Promote implementation of quality standards agreed within the context of the FAO/WHO Codex Alimentarius Commission and other relevant organizations or arrangements.³⁵

Relevant FAO Technical Guidelines that have already been developed and published by FAO to assist member countries in support of the implementation of the CCRF, include:

- Technical Guidelines for Responsible Fish Utilization³⁶;
- Technical Guidelines for Aquaculture Development³⁷;
- Technical Guidelines for Good Aquaculture Feed Manufacturing Practice³⁸

Importance of Feed Ingredient Selection and Quality-Control Guidelines

In conclusion, and in view of the recent contaminant scares faced by the aquaculture feed and food-fish production sector,^{1,2} it may be useful here to comment on the Technical Guidelines produced by FAO for good aquaculture feed manufacturing practice.³⁸ As mentioned previously, the guidelines were compiled for FAO in support of Article 9 of the CCRF, and in particular in support of Article 9.4.3 of the CCRF, concerning the selection and use of feeds and additives. The guidelines cover a range of issues, extending from ingredient purchasing, processing, bulk storage, handling, monitoring, and documentation, to issues such as employee training and safety, customer relations, and the delivery of finished goods to the farmer. However, issues relating to the handling and management of manufactured aquaculture feeds by farmers on the farm are not covered in the guidelines.

In view of its importance to the overall theme of the current chapter, it is perhaps useful to repeat here the relevant portions of Section 6 of the guidelines, which deals with the selection and purchasing of raw ingredients, including ingredient quality control, as follows³⁸:

- [Tr1]... quality feed begins with quality ingredients and it is the manufacturer's responsibility to make sure that the ingredi-

ents used within their feeds are wholesome and safe.

- ...commodity merchants, and supplement companies from which feed ingredients are purchased, should provide the buyer with specifications of exactly what is to be bought.
- ...it is inevitable that the quality of ingredients will vary, even from the same supplier from batch to batch and/or from month to month, and so it is important that this variability be characterized and monitored.
- ...to ensure the ingredients are meeting specifications, the nutritionist/quality control staff should conduct periodic sampling to verify the ingredient specifications are being met.
- ...in addition to the nutritional and analytical characteristics of the feeding stuffs, the specifications ought to include: origins and sources; any pre-processing details; hazards or limitations; miscellaneous information including moisture content and possible non-hazardous contaminants (stones, grit, etc.).
- ... all incoming ingredients should be inspected and tags/labels should be read for medications, trace minerals and other additives.
- ... in the event the analysis indicates that an ingredient does not meet mill specifications, and the supplier continually transports substandard ingredients, that supplier should be removed from the mill's supplier list.
- ... ingredient specifications should be reviewed annually or as needed to assure that utilization in formulas is consistent with current, sound nutritional guidelines [the latest knowledge, in other words]. The production manager is responsible for monitoring the specification list in cooperation with the purchasing manager.
- ... grain or feedstuffs used in the manufacture of aquafeeds which are moldy,

treated/dyed or otherwise discolored should not be used for any feed or food.

- . . . brightly colored grain usually indicates seeds which are treated for use as rodenticides, or other pest control; these can be highly toxic to aquatic animals and man.
- . . . mycotoxins found in moldy feedstuffs may, even at very low concentrations of a few parts per billion, have detrimental effects on farmed aquatic species. There are over 100 different mycotoxins and their impact on aquaculture species is still not well understood.
- . . . similarly, low concentrations of pesticides or veterinary residues may have serious effects, not only on production of various aquaculture species, but accumulation of such residues may render aquatic species unmarketable if action levels in local regulations are exceeded.
- . . . the aquaculture feed milling company and all its facilities should be in compliance with all government regulations.
- . . . it would be wise for the aquafeed manufacturer to know their customer's receiving facilities well, to insure to the extent possible the correct care and use of feeds and ingredients.
- . . . in some regions the farmers and feed stores may be required to comply with certain standards of storage and handling to assure freshness and minimal exposure to sources of contamination due to birds, rodents and other environmental factors.
- . . . the supplier's warranty should be included in the purchase order showing suitability of an ingredient for feed use and that the ingredient is not adulterated and is in compliance with government regulations.
- . . . all suppliers should furnish some type of official document which will permit the person in the mill responsible for receiving the product(s) to correctly and positively identify the inbound product and determine that the product actually belongs to the feed mill.
- . . . suppliers, or the transportation companies used to haul commodities, are responsible for ensuring the equipment is clean before they load it and that no material was hauled previously in the trucks, containers, barges or rail cars, which could be hazardous to animals. Conveyances should be certified clean and free of materials detrimental to aquatic animals and human health.
- . . . certificates of analyses of feedstuffs (where appropriate) should be requested periodically.
- . . . when purchasing ingredients from a new supplier the following steps should be considered: perform on-site inspection of supplier's facilities, review standards of expectations (i.e., the raw materials should be clean and free from contamination), request supplier's certificates of analyses (where appropriate), request supplier's past laboratory data on ingredients to be purchased, request and review written quality assurance programs from supplier, verify supplier's reliability—check references for supplier reliability and availability of ingredients, request certificate of insurance or insurability on a routine basis from all suppliers and vendors, and request representative ingredient samples and analyse for appropriate items.
- . . . manufacturing quality control must insure that the feed produced will be consistently of a quality appropriate to the species fed. The process should include a comprehensive system of record keeping to document that the appropriate standards of a formula are being met throughout the period of manufacturing. Such records should be sufficient to make the product fully traceable.
- . . . the re-feeding of feed ingredients derived from non-processed and/or processed aquaculture products (including farmed fish and shellfish processing wastes, fish meal, shrimp meal, dead animals, etc.) should be avoided at all costs so as to

prevent the possibility for the spread of disease through feed.

It is hoped that this chapter will assist policy-makers (and in particular policymakers within developing countries) to highlight the important role and function played FAO and Codex Alimentarius Commission in the development of international standards, guidelines, and recommendations to protect the health of consumers and ensure fair practices in the food trade.

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Conflicts of Interest

The authors declare no conflicts of interest.

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