Animal Diseases of Public Health Importance

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The Food and Agriculture Organization's (FAO) interest in emerging diseases caused by foodborne pathogens derives from its role as the leading United Nations agency with a mandate for food quality and safety matters. The Food Quality and Standards Service of FAO's Food and Nutrition Division is active in all areas related to food safety and implements the FAO/World Health Organization Food Standards Program. Its activities include providing assistance to FAO's member nations in addressing problems,strengthening infrastructure, promoting standardization as a means of facilitating trade, and safeguarding the interests of consumers. This paper considers the importance of emerging foodborne diseases from the perspectives of the consumer, international trade in food, producers and processors, and developing countries and addresses prevention and control measures.

In recent years, public concern regarding food safety has increased as a consequence of the outbreak of bovine spongiform encephalopathy (BSE) in cattle, the prevalence of *Salmonella* serotype Enteritidis illnesses (from poultry, meat, eggs), and the more localized outbreaks of illnesses associated with *Listeria monocytogenes* (from dairy products, pâté, salads) and *Escherichia coli* O157:H7 (from ground or minced beef, unpasteurized apple juice, vegetables). Emerging pathogens and the appearance of problems such as BSE have resulted in enactment of specific controls in many countries, while the general heightening of interest internationally has prompted health professionals and the food industry in many countries to scrutinize the control of emerging infectious agents.

Animal Feeding and Food Safety

The Food and Agriculture Organization (FAO) of the United Nations has had a long-standing interest in the area of food safety and food quality. Because of problems such as BSE and emerging pathogens, FAO convened an Expert Consultation on Animal Feeding and Food Safety in Rome in March 1997 to address these issues and provide the scientific basis for improving practices in the feeding of animals for the production of food.

The ultimate objective of food industry and safety regulators is to ensure that food reaching the consumer is safe and wholesome. This objective does not imply that food can ever be completely free of risk but rather that the level of risk to the consumer can be acceptable. Foods generally expected to be safe may become unsafe as a result of hazards introduced during production, processing, storage, transport, or final preparation by the consumer. For food derived from animal sources, the hazards may originate from a number of sources, including the consumption of contaminated feed.

Hazards in food that may relate to animal feed include salmonellosis, mycotoxicosis, and ingestion of unacceptable levels of veterinary drugs and agricultural and industrial chemicals. In addition, if the postulated link between BSE and new variant–Creutzfeldt-Jakob disease is established, this disease would also be an example of contamination originating from animal feed.

The FAO consultation limited its considerations to food safety matters that pertained strictly to animal feeds; it did not consider plant toxins, radionuclides, or parasites spread by human sewage. The risk to human health from other infectious agents that may

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contaminate either feed or forage appears to be negligible or nonexistent and was, therefore, not considered by the consultation. Only the standard domestic animals from which food is derived in large quantities, such as meat and meat products, milk and milk products, and eggs and egg products, as well as fish products derived from aquaculture that involves the feeding of fish, were considered. All aspects of animal feed, other than natural unrestricted grazing, were considered. The consultation concluded that emerging pathogens are generally not identified through traditional animal surveillance and epidemiology.

Hazards Associated with Animal Feed

Mycotoxins are secondary metabolites produced by fungi of various genera when fungi grow on agricultural products before or after harvest or during transportation or storage. Some fungi such as *Aspergillus* spp. and *Penicillium* spp. can invade grain after harvest and produce mycotoxins, while others, such as *Fusarium* spp., typically infest grains and produce mycotoxins before harvest. In some circumstances, Aspergilli can grow and produce mycotoxins before the crop is harvested.

Both intrinsic and extrinsic factors influence fungal growth and mycotoxin production on a substrate. Intrinsic factors include water activity, pH, and redox potential; extrinsic factors are relative humidity, temperature, and availability of oxygen.

Many mycotoxins with different chemical structures and widely differing biologic activities have been identified. Mycotoxins may be carcinogenic (e.g., aflatoxins B1, ochratoxin A, fumonisin B1), estrogenic (zearalenone and I and J zearalenols), nephrotoxic (ochratoxins, citrinin, oosporeine), dermonecrotic (trichothecenes), or immunosuppressive (aflatoxin B1, ochratoxin A, and T-2 toxin). Much of the published information on toxicity comes from studies in experimental animals, and these may not reflect the effects of mycotoxins on humans and other animals. In addition, their significance in human foods of animal origin is incompletely understood. Mycotoxins are regularly found in animal feed ingredients such as maize, sorghum grain, rice meal, cottonseed meal, groundnuts, legumes, wheat, and barley. Most are relatively stable compounds, are not destroyed by feed processing, and may even be concentrated in screenings.

Various animal species metabolize mycotoxins in different ways. In pigs, ochratoxin A can undergo enterohepatic circulation and is eliminated very slowly, whereas in poultry species it is rapidly excreted. The polar mycotoxins such as fumonisins tend to be excreted rapidly. Mycotoxins, or their metabolites, can be detected in meat, visceral organs, milk, and eggs. However, their concentration in these food products is usually considerably lower than in the feed consumed by the animals; at these levels, mycotoxins are unlikely to cause acute intoxication in humans consuming these products. Residues in animal products of carcinogenic mycotoxins, such as aflatoxin B1, M1, and ochratoxin A, pose a threat to human health, and their levels should be monitored and controlled.

In most instances, the principal source of mycotoxins for humans is contaminated grains and cereals, rather than animal products. This means that the hazard is much greater in developing countries in which maize and other grains form the staple diet and the intake of animal products, including meat, is low.

Only limited information is available regarding mycotoxin residues in animal products intended for human consumption. The metabolism of mycotoxins by animals and the residues of mycotoxins and their metabolites in animal tissues should be studied further.

Infectious Agents

Agent Causing Transmissible Spongiform Encephalopathies in Ruminants

Transmissible spongiform encephalopathies are nonfebrile neurologic diseases with a long incubation period and are fatal. These diseases are associated with incompletely defined agents termed prions, which are resistant to normal heat treatments of feed and food. Sheep scrapie has been recognized for over 250 years. BSE was first recognized in the United Kingdom during 1986. For BSE, the infectious agent enters the feed primarily through rendered infected tissues (notably the central nervous system and the reticuloendothelial system) under insufficient heat to reduce the concentration of the infectious agent to an ineffective dose. In the case of sheep scrapie, infection is naturally maintained by transmission between sheep. Humans have likely been exposed to the scrapie agent by eating brain and other tissues, although there is no evidence that Creutzfeldt-Jakob disease in humans has been associated with scrapie.

Humans can potentially be exposed to BSE through consumption of infected tissues. The occurrence of a new variant of the human transmissible spongiform encephalopathy, Creutzfeldt-Jakob disease, has raised the possibility of an association with the BSE agent. With the limited number of cases now, there is no proven link between this new variant and the possible transmission of the agent from infected bovine tissue to humans. The FAO consultation recommended risk reduction measures to address the elimination of BSE from cattle.

Salmonella enterica

The more than 2,000 *Salmonella* serotypes can be divided into three groups: species-specific, such as gallinarum (in poultry); invasive, which may cause systemic infections in their host, such as Enteritidis (in laying hens); and noninvasive, which tend to remain within the intestinal tract. Members of the first group are infrequently feedborne pathogens. Among the second group, the principal manifestation of human infection is gastroenteritis, with septicemia occurring in some patients. The third group may be associated with subclinical infections in farm livestock; it sometimes causes disease in livestock and is associated with food poisoning in humans.

Salmonellae are widely distributed, and animal feed is only one of many sources of infection for farm animals. Animal feed ingredients of both animal and plant origin are frequently contaminated with salmonellae, although the most common serotypes associated with human disease, Enteritidis and Typhimurium, are rarely isolated from animal feed. Feed can be contaminated from raw ingredients.

Toxoplasma gondii

The protozoon *T. gondii* is found in cats and, according to serologic surveys, also in birds and other domesticated species including sheep, pigs, goats, and horses. The primary source of infection for animals is feed contaminated with feces of cats and possibly with rodent tissues.

Cats are an important source of infection for humans; however, some human infections may be due to the handling or consumption of raw meat. Pregnant women may miscarry or give birth prematurely, and infants often get central nervous system disorders and ocular disease.

Trichinella spiralis

T. spiralis is a nematode that parasitizes the intestinal tract of mammals, particularly pigs. The larvae encyst in the tissues, particularly the muscles, which act as a source of infection for humans who consume raw or partially cooked meat. The clinical manifestations include fever, muscle pain, encephalitis, meningitis, myocarditis, and (rarely) death.

The cysts in infected carcasses can be killed by freezing (-18°C for 20 days) or traditional rendering temperatures. Adequate cooking of raw meat and table scraps before feeding to farm animals would eliminate this hazard.

The FAO consultation also addressed potential hazards associated with veterinary drugs and agricultural and other chemicals and recommended risk reduction measures to prevent, eliminate, or reduce the hazards to acceptable levels. The consultation participants prepared a draft Code of Practice for Good Animal Feeding to be considered by the Codex Alimentarius Commission (CAC).

Codex Alimentarius Commission

Since 1962, CAC has been responsible for implementing the Joint FAO/World Health Organization (WHO) Food Standards Program. “Codex Alimentarius,” whose name is taken from Latin and translates literally as “food code” or “food law,” was founded in response to the worldwide recognition of the importance of international trade and the need to facilitate trade while ensuring the quality and safety of food for the world consumer.

It follows, therefore, that the commission’s primary objectives are the protection of the health of consumers, the assurance of fair practices in the food trade, and the coordination of all food standards. Food standards, guidelines, and recommendations are the work of CAC. With the adoption of the World Trade Organization’s Agreement on the Application of Sanitary and Phytosanitary Measures and the Agreement on Technical Barriers to Trade, a new emphasis and dimension have been placed on Codex standards.

Codex Committee on Food Hygiene

The Codex Committee on Food Hygiene (CCFH) has overall responsibility for all provisions of food hygiene prepared by Codex commodity committees and contained in commodity standards, codes of practice, and guidelines. CCFH also develops general principles, codes of practice, guidelines for food hygiene, and microbiologic criteria for food to be applied horizontally across Codex committees. Food hygiene is defined as "all conditions and measures necessary to ensure the safety and suitability of food at all stages of the food chain."

According to the deliberations at the 29th session of CCFH, the microbiologic safety of foods is principally ensured by control at the source, product design, process control, and good hygienic practices during production, processing, handling, distribution, storage, sale, preparation, and use, preferably in conjunction with the application of the Hazard Analysis and Critical Control Points (HACCP) system. This preventive system offers more control than end-product testing because of the limited effectiveness of microbiologic examination to assess the safety of food.

When they have been established by Codex or national risk managers, objectives for food safety can be taken up by industry; by applying HACCP (or an equivalent food safety management system), industry can ensure that these objectives are met. This is the use of HACCP as a corrective risk management option: a risk is identified, and a management option is selected and implemented. HACCP is also used as a preventive risk management tool. In this case, hazard analysis identifies potential hazards in raw materials, production line, and line-environments to the consumer. Hazard analysis is defined as "The process of collecting and evaluating information on hazards and conditions leading to their presence to decide which are significant for food safety and therefore should be addressed in the HACCP plan." Input concerning the potential hazards and their control could come from risk analysis, but often such information is not available and industries need to apply their best judgment.

The Revised Principles for the Establishment and Application of Microbiological Criteria For Foods states, "Microbiological criteria should be established according to these principles, and be based on scientific analysis and advice, and where sufficient data are available, on a risk analysis appropriate to the foodstuff and its uses." These criteria may be relevant to the examination of foods, including raw materials and ingredients of unknown or uncertain origin, and may be used when no other means of verifying the efficacy of HACCP-based systems and good hygienic practices are available. Microbiologic criteria may also be used to determine that processes are consistent with the General Principles of Food Hygiene. Microbiologic criteria are not normally suitable for monitoring critical limits as defined in the HACCP system.

Establishing microbiologic criteria and food safety objectives in general is difficult because of the considerable knowledge gap relating to biologic hazards and their relationship to human illness. This has led to many evaluations by CCFH, which are based on subjective or qualitative assessments and serve as the basis for recommendations. Although aware of these limitations, CCFH is now developing a framework of principles and guidelines for the application of microbiologic risk assessment. CCFH's action was in response to the recommendation of the 1995 Joint FAO/WHO Consultation on the Application of Risk Analysis to Food Standards relating to the application of risk assessment within the Joint FAO/WHO Food Standards Program. International Commission for Microbiological Specifications for Foods and CCFH delegations are also in the process of developing background papers on a number of foodborne pathogens to better conduct quantitative risk assessments and set subsequent food safety objectives. Notwithstanding the development of risk analysis approaches by these groups, the work of CCFH and all Codex committees would benefit from advice from an expert body on foodborne biologic hazards for purposes of risk management. The committee could be modeled on the FAO/WHO Joint Expert Committee on Food Additives and Joint Meeting on Pesticide Residues, allowing for the unique consideration of epidemiologic and clinical data related to pathogens causing human illness, and of the dynamics of microbial populations in food throughout the food chain.

Control of *Listeria monocytogenes* in foods is an example of the need to consider a structured risk management approach. Listeria are frequently consumed in small amounts by the general population without apparent ill effects. Only higher levels of Listeria are thought to cause serious disease problems. It is believed that Listeria will always be present in the environment. Therefore, the critical issue may not be how to prevent Listeria in foods, but how to control its survival and growth to minimize the potential risk. In many foods, complete absence of Listeria is unrealistic and unattainable; trying to achieve this goal can limit trade without having any appreciable benefit to public health. A relevant risk management option, therefore, is to focus on foods that have historically been associated with human disease and support the growth of Listeria to high levels, rather than focusing on foods that do not support growth. Thus, establishing tolerably low levels of Listeria in specific foods may be one food safety objective achieved by risk managers after a rigorous and transparent risk analysis. Such an approach is now being considered by CCFH after an initial risk assessment by the International Commission for Microbiological Specifications for Foods and CCFH delegations.

Although Listeria presents unique challenges in terms of its widespread occurrence and the particular susceptibility of vulnerable groups, pathogens such as *E. coli* O157:H7, *Salmonella*, and *Campylobacter* are also being addressed. These microbial pathogens produce acute foodborne illnesses and can cause severe chronic sequelae, creating an important public health problem and food safety concerns.

Codex Codes of Hygienic Practice are based on good manufacturing practices, HACCP principles, and risk analysis. CCFH is responsible for coordinating and overseeing the work of specific Commodity Committees in this area. In the specific area of food hygiene, Codex has revised its main document, Recommended International Code of Practice: General Principles of Food Hygiene, to incorporate risk assessment principles and include specific references to the HACCP system.

FAO Programs on Food Quality and Safety

The Food Quality and Standards Service is a service within the Food and Nutrition Division of the FAO, located in Rome. The Secretariat of CAC is also located there. The Regular Program of the Food Quality and Standards Service provides the technical and scientific basis for FAO for all food quality matters, including food safety. This includes providing the Secretariat for the Joint Expert Committee on Food Additives and participation in both the Joint Meeting of the FAO Panel of Experts on Pesticide Residues in Food and the Environment and the WHO Expert Group on Pesticide Residues and in the Joint Expert Committee on Food Irradiation.

The Food Quality and Standards Service develops and publishes guidelines and manuals (including the FAO Food and Nutrition Paper Series and Manuals of Food Quality Control), arranges expert consultations and conferences (e.g., the Joint FAO/WHO Expert Consultation on Biotechnology and Food Safety, September 30 to October 4, 1996; the Joint FAO/WHO Expert Consultation on the Application of Risk Management to Food Safety Matters, January 27-31, 1997; the Joint FAO/WHO Consultation on Food Consumption and Exposure Assessment to Chemicals, February 10-14, 1997; and the FAO Consultation on Animal Feeding and Food Safety, March 10-14, 1997), and has a major and continuing program of providing technical assistance regarding food standards and food control to member countries, particularly developing countries and countries in transition from a centrally planned to a market economy.

The Joint Expert Committee on Food Additives, the Joint Meeting on Pesticide Residues, and the Joint Expert Committee on Food Irradiation are expert committees that provide independent scientific advice that forms the basis for the development of food safety recommendations used in international trade. These committees are forums in which independent, invited experts assess the state of scientific knowledge of food additives, pesticide and veterinary drug residues in food, mycotoxins, other chemical contaminants in food, and food irradiation treatments and make recommendations to member governments and to Codex.

FAO's Food Quality and Standards Service also develops and publishes Manuals of Food Quality Control. These manuals provide recommendations for the development and operation of food quality and safety systems. While aimed primarily at providing advice to developing countries, the manuals document modern approaches, including the development of quality control programs throughout the food chain that apply to all countries. Such an approach is instrumental in facilitating international trade in food. Key titles in the series include Food Inspection, Food for Export, Management of Food Control Programs, Imported Food Inspection, and Quality Assurance in the Food Control Laboratory.

The program of technical assistance projects undertaken by the Food Quality and Standards

Service handles assistance in food quality control, including safety; such projects have established or strengthened the food control systems in a number of developing countries. Typically, they assist in establishing the infrastructure for an enhanced food control program, assessing laboratory service requirements, providing guidance to develop legislation and procedural manuals, setting up reputable inspection and certification systems, and providing training and staff development. In these assistance projects, the standards established by the CAC are basic guides to international requirements.

Conclusion

Food will always represent some biologic risk; it is the task of the food industry to maintain the level of risk at the minimum that is practical and technologically feasible. It should be the role of regulatory bodies to use risk assessment to determine realistic and achievable risk levels for foodborne hazards and to base their risk management and food safety policies on the practical application of the results of these analyses.

Foodborne illnesses are preventable. Adherence to good manufacturing practices and good hygienic practices and application of the HACCP system can result in food safety and ensure food quality. Food safety is the shared responsibly of governments, academia, the food industry, and the consumer.

Codex standards, guidelines, and recommendations have the objective of protecting the consumer and facilitating international food trade. Adherence to Codex provides the basis for food safety and quality and meets the requirements of international trade.