Animal Feed Impact on Food Safety

Report of the FAO/WHO Expert Meeting

FAO Headquarters, Rome, 8-12 October 2007

World Health Organization

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2008

ISBN 978-92-5-105902-9

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Acknowledgments

The Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) would like to express their appreciation to all those who contributed to the preparation of this report whether by providing their time and expertise, data and other relevant information, or by reviewing and providing comments on the document.

Appreciation is also extended to all those who responded to the call for data that was issued by FAO and WHO and thereby drew our attention to information that was not readily available in the mainstream literature and official documentation.

The role of the Canadian Food Inspection Agency, the Danish Plant Directorate, the European Commission and the United States Food and Drug Administration in supporting the participation of some experts is also acknowledged.

The participation of the World Organisation for Animal Health (OIE) at the meeting is also acknowledged.

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Declaration of Interest

Of 16 experts who were invited to the meeting, 15 were able to attend. Four participants declared an interest in the topics under consideration.

Dr Keith Behnke: is Professor of Feed Science in the Department of Grain Science and Industry at Kansas State University, Manhattan, Kansas (United States of America). He is a currently providing advice and facility evaluation for a firm which produce animal health products.

Mr Sergio Carlo Franco Morgulis: is Technical Director of a company dealing with animal nutrition, animal health and pet animals. Currently, he is President of the Brazilian Association of Mineral Supplement Industries and Director of a Feed Industry Union. He is an expert on animal nutrition and collaborates with the Ministry of Agriculture in several commissions.

Dr Lea Pallaroni: is Secretary General of the National Association of Feed Producers (ASSALZOO) in Italy. She is an expert on mycotoxins and good manufacturing practices.

Mr Bill Spooncer: is the Managing Director of a consulting firm. He is an expert on rendering. He holds the honorary position of Technical Director of the Australian Renderers Association.

The above-mentioned experts were selected because their respective areas of technical expertise were very valuable to the meeting and of key importance to ensure a thorough discussion. Their declared interests were acknowledged by the participants. Their participation was considered necessary because the scope of the meeting included providing scientific advice and recommendations on management options to reduce risks to human health associated with animal feeding. It was decided that the interests declared by these experts should not prevent them from participating in the meeting and contributing to the discussions - including the formulation of conclusions and recommendations. Their activities were not considered to represent a potential conflict of interest in the meeting.

Abbreviations and acronyms

AAS	Atomic Absorption Spectrometry
ADI	Average Daily Intakes
AFRIS	Animal Feed Resources Information System
BSE	Bovine Spongiform Encephalopathy
CCMAS	Codex Committee on Methods of Analysis and Sampling
CEN	European Committee for Standardization
CRM	Certified Reference material
CV-AAS	Cold Vapour Atomic Absorption Spectrometry
DDGS	Dried Distillers' Grains with Solubles
DGS	Distillers' Grains with Solubles
ECD	Electon Capture Detection
ELISA	Enzyme-Linked ImmunoSorbent Assay
EPIC	Emergency Prevention and Intelligence Centre
EC	European Community
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GAP	Good Agriculutral Practices
GC/HR-MS	Gas Chromatography - High Resolution Mass Spectrometry
GF-AAS	Graphite Furnace Atomic Absorption Spectrometry
GMO	Genetically Modified Organism
GMP	Good Manufacturing Practice
GOARN	Global Outbreak Alert and Response Network

GPVD	Good Practices in the Use of Veterinary Drugs
HACCP	Hazard Analysis and Critical Control Point
HG-AAS	Hydride Generation Atomic Absorption Spectrometry
HPLC	High Performance Liquid Chromatography
ICP-AES	Inductively Coupled Plasma-Atomic Emission Spectrometry
IFIF	International Feed Industry Federation
INFOSAN	International Food Safety Authorities Network
ISO	International Standardization Organization
LC-DAD	Liquid Chromatography with Diode Array Detector
LC-MS	Liquid Chromatography-Mass Spectronomy
LD_{50}	Lethal Dose 50 Percent
JEFCA	Joint FAO/WHO Expert Committee on Food Additives
JEMRA	Joint Expert Meetings on Microbiological Risk Assessment
JMPR	Joint FAO/WHO Meetings on Pesticide Residues
MRL	Maximum Residue Limits
MS	Mass Spectronomy
NACA	Network of Aquaculture Centres in Asia-Pacific
OIE	World Organisation for Animal Health
PCB	Polychlorinated Biphenyl
PCR	Polymerase Chain Reaction
PT	Proficiency Testing
TDI	Tolerable Daily Intake
TEF	Toxicity Equivalence Factor
WHO	World Health Organization

Glossary

Exposure assessment: The qualitative and/or quantitative evaluation of the likely intake of biological, chemical, and physical agents via food, as well as exposures from other sources if relevant.[2]

Feed (Feedingstuff): Any single or multiple materials, whether processed, semi-processed or raw, which is intended to be fed directly to food-producing animals.[3]

Feed ingredient: A component part or constituent of any combination or mixture making up a feed, whether or not it has a nutritional value in the animal's diet, including feed additives. Ingredients are of plant, animal or aquatic origin, or other organic or inorganic substances.[3]

Feed additive: Any intentionally added ingredient not normally consumed as feed by itself, whether or not it has nutritional value, which affects the characteristics of feed or animal products.[3]
Micro-organisms, enzymes, acidity regulators, trace elements, vitamins and other products fall within the scope of this definition depending on the purpose of use and method of administration.

Hazard: A biological, chemical or physical agent in, or condition of, food with the potential to cause an adverse health effect.[2]

Hazard identification: The identification of biological, chemical, and physical agents capable of causing adverse health effects and which may be present in a particular food or group of foods.[2]

Hazard characterization: The qualitative and/or quantitative evaluation of the nature of the adverse health effects associated with biological, chemical and physical agents which may be present in food. For chemical agents, a dose-response assessment should be performed. For biological or physical agents, a dose-response assessment should be performed if the data are obtainable. [2]

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[2] **FAO/WHO.** 2007**.** *Codex Alimentarius principles for risk analysis*, (Procedural Manual of the Codex Alimentarius Commission), Seventeenth Edition. Joint FAO/WHO Food Standards Programme. Rome. (available at http://www.codexalimentarius.net/web/procedural_manual.jsp)

[3] **FAO/WHO.** 2004. *Code of practice on good animal feeding* (CAC/RCP 54-2004). Rome. (available at http://www.codexalimentarius.net/download/standards/10080/CXC_054_2004e.pdf)

Pesticide: Any substance intended for preventing, destroying, attracting, repelling, or controlling any pest including unwanted species of plants or animals during the production, storage, transport, distribution and processing of food, agricultural commodities, or animal feeds or which may be administered to animals for the control of ectoparasites. The term includes substances intended for use as a plant growth regulator, defoliant, desiccant, fruit thinning agent, or sprouting inhibitor and substances applied to crops either before or after harvest to protect the commodity from deterioration during storage and transport. The term normally excludes fertilizers, plant and animal nutrients, food additives, and animal drugs.[2]

Risk: A function of the probability of an adverse health effect and the severity of that effect, consequential to a hazard(s) in food.[2]

Risk analysis: A process consisting of three components: risk assessment, risk management and risk communication.[2]

Risk assessment: A scientifically based process consisting of the following steps: (i) hazard identification, (ii) hazard characterization, (iii) exposure assessment and (iv) risk characterization.[2]

Risk assessment policy: Documented guidelines on the choice of options and associated judgements for their application at appropriate decision points in the risk assessment, such that the scientific integrity of the process is maintained.[2]

Risk characterization: The qualitative and/or quantitative estimation, including attendant uncertainties, of the probability of occurrence and severity of known or potential adverse health effects in a given population based on hazard identification, hazard characterization and exposure assessment.[2]

Risk communication: The interactive exchange of information and opinions throughout the risk analysis process concerning risk, risk-related factors and risk perceptions, among risk assessors, risk managers, consumers, industry, the academic community and other interested parties, including the explanation of risk assessment findings and the basis of risk management decisions.[2]

Risk estimate: The quantitative estimation of risk resulting from risk characterization.[2]

Risk management: The process, distinct from risk assessment, of weighing policy alternatives, in consultation with all interested parties, considering risk assessment and other factors relevant for the health protection of consumers and for the promotion of fair trade practices, and, if needed, selecting appropriate prevention and control options.[2]

Risk profile: The description of the food safety problem and its context.[2]

Traceability/Product tracing: The ability to follow the movement of a food through specified stage(s) of production, processing and distribution.[2]

Undesirable substances: Contaminants and other substances which are present in and/or on feed and feed ingredients and which constitute a risk to consumers' health, including food safety-related animal health issues.[3]

Veterinary drug: Any substance applied or administered to any food producing animal, such as meat or milk producing animals, poultry, fish or bees, whether used for therapeutic, prophylactic or diagnostic purposes or for modification of physiological functions or behaviour.[2]

Executive Summary

The Expert Meeting was jointly organized by the Animal Production and Health Division and the Nutrition and Consumer Protection Division of the Food and Agriculture Organization of the United Nations (FAO) and the Department of Food Safety, Zoonoses and Foodborne Diseases of the World Health Organization (WHO), to review current knowledge on animal feed and its impact on food safety and international food and feed trade, and to provide orientation advice on this matter to their Members and to international organizations. The World Organisation for Animal Health (OIE) kindly joined this effort and was an important resource.

The experts discussed a diverse list of hazards that present human health risks and disrupt trade. This list is very large and constantly evolving. Consumers are increasingly aware of, and sensitive to, food safety issues and their linkage to animal production, including feeding practices. At the same time, in many countries, people are chronically short of food and there is a need to improve the efficiency of animal production to provide better access to affordable protein. Global trade in food and feed continues to expand, with countries and sectors continually emerging as new participants. Trade problems continue to arise as a result of countries establishing different national tolerances for residues, lack of harmonization with international standards, and sometimes from the lack of international standards. Differences among countries' capabilities to conduct analyses also contribute to trade problems. Economics and technological advances are driving the development of new feed products which may challenge established regulatory approaches to feed and food safety.

The meeting concluded that ensuring safe feed is an important component of efforts to reduce and prevent food safety hazards. Potential measures to ensure safe feed include:

- applying valid methods for decontamination, disinfection and cleaning;
- developing rapid and economical analytical methods for screening feed and feed ingredients;
- reporting the presence of undesirable substances to national and international authorities; to this end, minimum criteria for reporting such events to trading partners are needed;
- developing international standards for certain undesirable substances using the "Tolerable Daily Intake" (TDI) approach;
- rapidly notifying the competent authorities of feed safety incidents that could result in human food safety hazards;
- training regulators, inspectors, feed and livestock industry personnel and farmers to produce and use safe feed;
- implementing communication strategies to address consumers and the food industry, highlighting the importance of feed safety in producing safe food products; and

- assisting less-developed countries to meet international standards through the provision of technical advice and assistance.

The Expert Group made the following recommendations:

(i) The application of the Codex Code of Practice on Good Animal Feeding[4] should be promoted in order to minimize risks.

(ii) General principles and guidelines for the assessment of risk for feed ingredients or categories of ingredients should be developed.

(iii) A prioritized list of hazards of international relevance for which standards could be developed for feed and feed ingredients with respect to food safety were identified during this Expert Meeting. Countries should assess the need for further evaluation by international scientific expert committees.

(iv) The existing Codex Code of Practice for Source Directed Measures to Reduce Contamination of Food with Chemicals (CAC/RCP 49-2001)[5], which also encompasses feed, should be reviewed to include specific provisions related to feed safety.

(v) Research on the of rates of transfer and accumulation of dioxins, dibenzofurans, and dioxin-like PCBs from feed to edible tissue in animal-derived products and management measures should be continued.

(vi) Inexpensive and accurate screening methods for the detection and quantification of dioxins, dibenzofurans and dioxin-like PCBs in feed and feed ingredients should be developed.

(vii) Rapid and semi-quantitative screening methods for detection of aflatoxin B_1 in both feed and feed ingredients are needed. The methods should be simple enough for use by non-technical personnel and inexpensive so as to encourage their use.

(viii) Communication should be improved to raise the awareness among biofuel (e.g. ethanol and biodiesel) processors, livestock producers and the feed industry of the need for safety assessments prior to the use in animal feeds of by-products from the production of biofuels.

(ix) More research is needed to determine the fate and residual concentration of aflatoxin B_1, and any antibiotics used to control unwanted microbial growth during the biofuels fermentation process. Research is also needed to evaluate the risk of residual levels of methanol in glycerol from biodiesel production when it is used as a feed ingredient, particularly in dairy production.

(x) The existing Codex Codes regarding emergency situations, which also encompass feed, should be reviewed to include specific provisions on feed emergencies related to food safety.

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[4] **FAO/WHO.** 2004. *Code of practice on good animal feeding*, (CAC/RCP 54-2004). Rome. (available at www.codexalimentarius.net/download/standards/10080/CXC_054_2004e.pdf).

[5] **FAO/WHO.** 2001. *Code of practice for source directed measures to reduce contamination of food with chemicals* (CAC/RCP 49-2001). Rome. (available at www.codexalimentarius.net/download/standards/373/CXP_049e.pdf).

(xi) The international emergency notification system for food (INFOSAN) should be expanded in collaboration with the OIE to consider linkages between food and feed emergencies and to incorporate appropriate changes to include feed emergency notifications.

(xi) Emergency response systems for feed and food should be developed at the national and regional levels to contribute to food safety. FAO and WHO should assist in the development and application of such systems.

(xii) Training for regulators, inspectors, all sectors of the feed manufacturing and distribution chain, the livestock industry, farmers and other stakeholders relating to the production of safe feed should be carried out where possible using existing training materials, i.e. guidelines and manuals. FAO, WHO and other organizations should assist in the development of training methods.

(xiii) FAO and WHO should convene regular expert meetings and other fora to continue monitoring the situation, update information on the impact of feed on food safety, foster the dialogue among partners and identify areas needing attention.

1. Introduction

A Joint FAO/WHO Expert Meeting on Animal Feed Impact on Food Safety was held at FAO Headquarters in Rome from 8 to 12 October 2007 (the agenda of the meeting is provided in Appendix A). The meeting was jointly organized by the Animal Production and Health Division and the Nutrition and Consumer Protection Division of FAO and the Department of Food Safety, Zoonoses, and Foodborne Diseases of WHO. OIE kindly joined this effort and participated as an important resource. The Expert Meeting was organized according to the principles of the FAO/WHO Framework for the Provision of Scientific Advice on Food Safety and Nutrition[6].

In response to a demand from interested parties, a stakeholder meeting was held prior to the Expert Meeting, with the objective of allowing stakeholders to inform the experts on the state of the art in the field of animal feed standards, present their position on how to ensure the safety of animal feed and provide their opinions regarding relevant areas for the development of new specific standards for animal feed, and other actions required at international, regional and national levels. The position papers provided by the stakeholders[7] were made available to the experts. The meeting was opened by Samuel Jutzi, Director of FAO's Animal Production and Health Division and by Ezzeddine Boutrif, Director of the Nutrition and Consumer Protection Division, who welcomed the participants on behalf of the Directors-General of FAO and WHO. In welcoming the participants, they pointed out that the role of animal feed in the production of safe food is well recognized, and that FAO and WHO include several activities that address this matter in their programmes of work. FAO and WHO had considered it appropriate to call an Expert Meeting to review current knowledge on animal feed and its impact on food safety and international food and feed trade, and to provide orientation advice on this matter to their Members and to international organizations.

A total of sixteen experts from seven regions - Africa, Asia, Europe, the Near East, North America, South America and the Southwest Pacific, - were invited. The experts participated in their independent professional capacities and not as representatives of their governments, employers or institutions. A full list of participants is provided in Appendix B and the experts' résumés are presented in Appendix C. The meeting elected Miguel Granero Rossell as chairperson and Keith Behnke and Catherine Italiano were appointed as rapporteurs. Four working groups were established to address specific aspects of the agenda; Birgitte Broesbøl-Jensen, Jacob de Jong, Sarah Kahn and Daniel McChesney were appointed as rapporteurs of the working groups. The meeting was supported by a number of technical papers[8] prepared by some of the experts at the

[6] **FAO/WHO.** 2007. *Framework for the provision of scientific advice on food safety and nutrition.* Rome. (available at http://www.fao.org/ag/agn/agns/files/Final_Draft_EnglishFramework.pdf).

[7] See Appendix D, Part 3

[8] See list of papers in Appendix D, Part 1

request of the secretariat, which addressed the following subjects: current state of knowledge on the impact of animal feed on public health and on international trade; safety assessment of feed and feed ingredients; and the current situation of risk management addressing animal feed at international, regional and national levels, of both governmental and private sectors, including emergency situations. Other documents were submitted in response to an open call for information and data on issues related to the impact of animal feed on food safety. Finally, FAO, WHO, Codex and OIE documents and information were provided by the secretariat. These documents, as listed in Appendix D of this report, were distributed to the experts, as the need arose, prior to and during the meeting.

1.1 BACKGROUND

The role of animal feed in the production of safe food is recognized worldwide, and recent events have underlined its impacts on public health, feed and food trade, and food security. Concerns prompted by the outbreak of bovine spongiform encephalopathy (BSE) in the United Kingdom, and other more common food problems associated with *Salmonella,* enterohaemorrhagic *Escherichia coli* and other micro-organisms, have encouraged health professionals and the feed industry to scrutinize more closely the causes of these diseases and methods for their control. Some corrective measures are as basic as improving housekeeping and staff training in feed mills. Other measures are more challenging, and may require limiting the use of some ingredients or radically changing the way in which they are prepared (processed) or sourced, or restricting the locations where animals are grazed.

Development work on the application of the risk analysis framework provided by Codex in the field of animal feeding has facilitated understanding of the potential impact of animal feed safety on public health and of the implementation of risk-based measures to prevent and control hazards.

Development of improved practices in the feeding of food-producing animals, improvement of feed production systems and the development of sampling and analytical techniques suitable for animal feed have also facilitated the characterization of problems.

The scientific basis for these developments was analysed by an Expert Consultation on Animal Feeding and Food Safety organized by FAO in 1997[9]. The consultation restricted its considerations to food safety matters that pertained strictly to feeds. The consultation made the following recommendations:

(i) The feed industry and the animal production industries should recognize their important role in the production of safe food and should evaluate consequences to human health when using new feed ingredients, new suppliers or introducing new processing methods.

(ii) As quality assurance is applicable at all stages of food production to ensure the safety of the consumer, a code of practice for good animal feeding should be followed.

[9] **FAO.** 1998 *Animal feeding and food safety.* Report of an FAO Expert Consultation Rome, 10-14 March 1997. FAO Food and Nutrition Paper No. 69. Rome. (available at http://www.fao.org/docrep/w8901e/w8901e00.htm).

(iii) Manufacturers should provide adequate information to enable the quality and safety of feed to be maintained after delivery.
(iv) Known and potential risks to food safety should be re-evaluated as new information becomes available.
(v) A code of good practice for the fertilization of ponds by the addition of animal manure, agricultural by-products and other wastes should be developed by the WHO/FAO/NACA Study Group on Food Safety Issues associated with Products from Aquaculture and conveyed to the Codex Alimentarius Commission for possible inclusion in a Code of Practice for Good Animal Feeding.
(vi) The Codex Alimentarius Commission should consider for adoption the Draft Code of Practice for Good Animal Feeding.
(vii) The feed industry should assist developing countries by providing and promoting advice on good animal feeding practices.
(viii) FAO should support developing countries in the application of good animal feeding practices.

As a result of these recommendations the Codex Alimentarius Commission adopted the Code of Practice on Good Animal Feeding (CAC/RCP 54-2004)[10] in 2004[11] (hereafter referred to as "the Code"), and since then countries have advanced in the implementation of the Code through joint efforts involving national authorities and the private sector.

In recent years, the introduction of the food chain approach, which recognizes that responsibility for the supply of safe, healthy and nutritious food is shared along the entire food chain, has served to highlight the importance of feed safety. The food chain, thus, comprises every step from primary production to final consumption. Stakeholders include farmers, fishermen, slaughterhouse operators, feed producers and processors, food processors, transport operators, distributors (wholesale and retail) and consumers, as well as governments responsible for protecting public health.

Scientific developments since the FAO Expert Consultation in 1997 and the experiences of countries in the implementation of the Code since 2004, as well as advances in feed production, transport and marketing, and the development of new production methods for feed ingredients, such as the use of nanotechnology, make it clear that further work is needed to assess new hazards and their potential impact on public health and trade.

FAO and WHO therefore considered it appropriate to convene an Expert Meeting to review current knowledge on animal feed and its impact on food safety, and to provide orientation and advice on this matter to Members and to international organizations. The Expert Meeting was requested to review and analyse the experience of selected countries in modernizing and strengthening their feed safety systems and drawing lessons from their experiences.

[10] **FAO/WHO.** 2004. *Code of practice on good animal feeding*, (CAC/RCP 54-2004) Rome. (available at http://www.codexalimentarius.net/download/standards/10080/CXC_054_2004e.pdf).

[11] **FAO/WHO.** 2004. *Joint FAO/WHO Food Standards Programme. Codex Alimentarius Commission Twenty-Seventh Session, Centre International De Conférences De Genève Geneva, Switzerland, 28 June - 3 July 2004. Report.* Rome. (available at http://www.codexalimentarius.net/download/report/621/al04_41e.pdf).

1.2 SCOPE AND PURPOSE OF THE EXPERT MEETING

Within the overall role of securing food safety and ensuring fair trade practices in the food and feed trades, the objectives of the Expert Meeting were as follows:

- to review the current state of knowledge on animal feed, its impact on public health and on international trade;
- to analyse the current situation of international standards addressing animal feed;
- to identify relevant areas for the development of specific standards for animal feed, on the basis of scientific evidence relevant to ensuring the safety of foods of animal origin and fair practices in international trade; and
- to provide guidance for further action required at international level to address these issues in the most appropriate ways, and recommend specific activities needed.

The Expert Meeting focused on feed safety matters that have an impact on food safety, public health and international food and feed trade. The experts did not discuss, in any depth, issues such as the use of antimicrobials in feed, the use and labelling of genetically modified organisms (GMOs,) animal health or traceability, as these issues are under consideration in other FAO, WHO, Codex and OIE fora. The Expert Meeting did not specifically address issues related to food for companion animals, while recognizing their potential impact on public health.

2. Activities of international standard-setting organizations

FAO, WHO, Codex and OIE have been involved in many activities related to animal feeding, including risk assessment, development of international standards, capacity-building and technical assistance to their Members to promote feed safety. These organizations collaborate closely to ensure a coordinated approach along the food chain continuum. The following sections provide specific information on their activities.

2.1 FAO AND WHO WORK ON ANIMAL FEEDING

In response to its Members' request, FAO has developed a series of activities to support them in ensuring feed safety. These activities can be summarized as follows:

- development, compilation and dissemination of information;
- promotion of wide alliances and partnership with the private sector;
- technical assistance and capacity- and institutional building; and
- awareness raising and policy advice.

FAO and WHO provide the scientific basis to Codex through independent scientific expert meetings and consultations[12] and more specifically through the Joint FAO/WHO Expert Committee on Food Additives (JECFA)[13]; the Joint FAO/WHO Meetings on Pesticide Residues (JMPR)[14], the Joint Expert Meetings on Microbiological Risk Assessment (JEMRA)[15] and the Joint FAO/WHO ad hoc Expert Meetings on Safety Assessment of Food Derived from Biotechnology.

Since the Codex Alimentarius Commission approved the Code of Practice on Good Animal Feeding, in 2004, FAO has assisted its Members to: reflect the Code in national legislation; assure compliance and verification; harmonize, at country level, different standards and requirements; coordinate the different institutions and bodies responsible for ensuring feed safety; include small and medium producers and enterprises in the process; disseminate information; and raise public awareness.

More specifically, to provide a useful tool for regulators, producers and professionals at large to implement the Code, FAO in partnership with the International Feed Industry Federation (IFIF), is preparing a Manual of Good Practices for the Feed Industry. This

[12] For more information, see the Website of the FAO/WHO programme on provision of scientific advice (http://www.fao.org/ag/agn/agns/advice_en.asp).

[13] For more information, see the JECFA Website (http://www.fao.org/ag/agn/agns/jecfa_index_en.asp); and the Website of the International Programme on Chemical Safety (http://www.who.int/ipcs/en/). Note that the terms of reference of JECFA do not include direct risk assessment of animal feed.

[14] For more information, see FAO's Pesticide Management Website (http://www.fao.org/ag/agp/agpp/Pesticid/Default.htm); and the Website of the International Programme on Chemical Safety (http://www.who.int/ipcs/en/).

[15] For more information, see the JMRA Website (http://www.fao.org/ag/agn/agns/jemra_index_en.asp); and the WHO Food Safety Website (http://www.who.int/foodsafety/en/).

partnership will facilitate better access to, and communication with, the target groups. FAO also supports the prevention and control of mycotoxin contamination of animal feed through several capacity-building activities and a publication on Worldwide Regulations on Mycotoxins in Food and Feeds[16].

To disseminate relevant information, FAO, in association with the organizations responsible for international standard setting in sanitary and phytosanitary matters, has developed the International Portal on Food Safety, Animal and Plant Health[17], a facility which provides a single access point for authorized official international and national information across the sectors of food safety, and animal and plant health.

FAO has also released several publications that specifically address issues relevant to feed safety[18].

FAO has organized several international and regional training courses on Good Practices for the Animal Feed and Livestock Industries, and in partnership with IFIF, has organized two global Feed and Food Congresses in 2005 and 2007 (a third is currently being planned).[19]

2.2 CODEX WORK ON ANIMAL FEEDING

The *ad hoc* Codex Intergovernmental Task Force on Animal Feeding was established by the 23rd Session of the Codex Alimentarius Commission (July 1999) to address all issues relating to animal feeding. The main objective of the Task Force was to develop guidelines or standards, as appropriate, on Good Animal Feeding Practices with the aim of ensuring the safety and quality of foods of animal origin. The Task Force was hosted by Denmark and met five times between 2000 and 2004. Its main output was the Codex *Code of Practice on Good Animal Feeding* (CAC/RCP 54/2004)[20], which was adopted by the Codex Alimentarius Commission in 2004. The Task Force based its work on a Code of Practice for Good Animal Feeding developed by the 1997 FAO Expert Consultation on Animal Feeding and Food Safety.

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 (GMPs) 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 at farm level. It also includes grazing or free-range feeding, forage-crop production and aquaculture. The Code, in

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[16] **FAO**. 2004. *Worldwide regulations for mycotoxins in food and feed in 2003.* FAO Food and Nutrition Paper No. 81. Rome. (available at http://www.fao.org/docrep/007/y5499e/y5499e00.htm).

[17] Visit the International Portal on Food Safety, Animal and Plant Health at (http://www.ipfsaph.org).

[18] For more information, see the list of publications made available at the Expert Meeting in Appendix D, Part 3.

[19] Other information can be found on the Websites of the FAO Animal Production and Health Division (http://www.fao.org/ag/againfo/home/en/home.html); the FAO Nutrition and Consumer Protection Division (http://www.fao.org/ag/agn/index_en.stm); the FAO Fishery and Aquaculture Department Aquaculture Website (http://www.fao.org/fi/website/FIRetrieveAction.do?dom=topic&fid=16064); the Website of the FAO/IAEA Joint Division for Nuclear Techniques in Food and Agriculture (http://www-naweb.iaea.org/nafa/index.html); and the WHO's on Food Safety Website (http://www.who.int/foodsafety/en/).

[20] **FAO/WHO.** 2004. *Code of practice on good animal feeding*, (CAC/RCP 54-2004) Rome. (available at http://www.codexalimentarius.net/download/standards/10080/CXC_054_2004e.pdf).

line with Codex mandate of consumer protection, only addresses food safety and does not cover issues of animal welfare other than food safety-related animal health issues. Environmental contaminants were considered in cases where the level of such substances in feed and feed ingredients could present a risk to consumers' health via the consumption of foods of animal origin.

The Codex Alimentarius Commission dissolved the Task Force in 2004 as it had completed its work. Although the Commission recognized, in general, the value of Codex continuing to work on animal feeding because of its importance for the protection of consumers' health, it agreed to defer until 2008 its discussion of the timing and potential work of the future Task Force on Animal Feeding.

A Circular Letter (CL 2007/19-CAC)[21] requesting proposals for future work by Codex on animal feeding and information on national experiences in the implementation of the Code of Practice in Good 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.

Texts relevant to animal feeding have been developed by other Codex Committees such as those on Food Additives and Contaminants (now split into the Codex Committees on Food Additives and on Contaminants in Foods), Meat Hygiene, Residues of Veterinary Drugs in Foods, Pesticide Residues and Food Labelling.

2.3 OIE WORK ON ANIMAL FEEDING

The role of animal feed in the transmission of diseases is well known. Since its establishment, the OIE has provided standards, guidelines and recommendations on risk management, including for micro-organisms that are transmissible via feed (such as Newcastle disease virus and foot-and-mouth disease virus). The OIE provides recommendations on diseases of animals, including zoonotic diseases (diseases that can infect humans) such as BSE and salmonellae. The OIE has consistently emphasized the importance of controlling feed-borne exposure as part of the overall approach to biosecurity. Modern approaches to disease management, such as zoning and compartmentalization, require close attention to animal feed as a pathway for the introduction of unwanted micro-organisms. Disease surveillance and reporting provide the foundation for disease management and prevention.

The food safety hazards associated with animal-derived food products are well recognized. The formation in 2002 of a permanent OIE Working Group on Animal Production Food Safety marked a renewed focus by the OIE on food-borne zoonotic diseases and set the foundation for a much closer collaboration between the OIE and the Codex Alimentarius Commission. Under the auspices of the Working Group, the OIE is developing or has developed several standards relevant to food and feed safety, including on the use of antimicrobial products, identification and traceability of animals and animal products, and veterinary ante-mortem and post-mortem inspection for the control of food-borne hazards.

The development of a horizontal OIE standard on animal feeding commenced in 2006. Under the guidance of the Terrestrial Animal Health Standards Commission and the Aquatic Animal Health Standards Commission, the OIE is currently developing standards on animal feeding, for terrestrial and aquatic animals, respectively, with the prima-

[21] ftp://ftp.fao.org/codex/Circular_letters/CXCL2007/cl07_19e.pdf

ry objective of preventing disease transmission and spread via feed. Management, at the farm level, of food safety hazards (including pathogenic micro-organisms, contaminants and veterinary drugs) is within the scope of the OIE texts and is being addressed under the auspices of the Working Group. To ensure that OIE and Codex standards relevant to food safety are complementary, the two international standard-setting organizations will continue to work closely together, exchanging information and expertise as appropriate to their respective mandates.

At this time, the OIE draft standards on animal feeding primarily address disease issues. They have been circulated to OIE Members, who were broadly supportive of the approach, but requested clarification on several points. The draft standards will be republished for a further round of Member comments towards the end of 2007.

3. Current status of knowledge on the impact of animal feed on food safety and on international trade of feed and food

Food safety hazards associated with animal feed can be biological, chemical or physical (radionuclides). Each hazard is associated with particular sources and routes of contamination and exposure. Risk management must be based on a thorough understanding of these characteristics. The role of water as a potential source of hazards should not be overlooked. Hazards may be introduced with source materials or via carryover or contamination of products during handling, storage and transportation. The presence of a hazard may also result from accidental or deliberate (e.g. fraud or bioterrorism) human intervention. Risk management should be based upon preparedness and prevention rather than reaction after detection of the problem. The Code presents a preventive risk management approach.

Since the FAO Expert Consultation on Animal Feeding and Food Safety in 1997, governments have continued to manage issues associated with well-recognized hazards. The Expert Group discussed a diverse list of hazards of natural and artificial origin that present human health risks and disrupt trade. Trade problems continue to result from countries establishing different national tolerances for residues, from lack of harmonization with international standards, and from the lack of international standards.

Our understanding of issues and the regulatory approaches to risk management have evolved since 1997. Important issues that have contributed to this evolution include:

(i) BSE and other prion diseases;
(ii) impact on food safety of antimicrobial use in animals;
(iii) newly recognized undesirable substances: melamine, dioxins, dibenzofurans and dioxin-like PCBs;
(iv) the presence of genetically modified organisms, crops and enzymes in feed;
(v) by-products of new technologies (e.g. biofuel production) used in feed production;
(vi) radionuclides;
(vii) development of aquaculture industries and the search for new/better aquaculture feeds;
(viii) feed (and food) as the target of bioterrorism; and
(ix) emerging technologies, such as the use of products of nanotechnology in feed.

The Expert Group discussed the following important horizontal issues relevant to the impact of animal feed on food safety and trade.

3.1 GLOBALIZATION

Global trade in food and feed (particularly for some ingredients such as additives) continues to expand, with countries and sectors continually emerging as new participants in international trade. This highlights the importance of having national standards that are consistent with international standards and guidelines.

Zoonotic diseases, such as BSE, can have a significant bearing on international trade as a country's disease status affects its capacity to export animal products (both food and feed). It is therefore important that countries report disease events to the OIE and adopt measures to prevent the spread of micro-organisms of concern in feed and food, for example by implementing the Code and other relevant standards and recommendations of Codex and OIE.

3.2 CONSUMER AWARENESS AND RISK COMMUNICATION

Consumers are increasingly aware of, and sensitive to, food safety and its linkage with animal production, including feeding practices. Consumers are not always comfortable with new technologies and fear of the unknown must be addressed with well-structured risk communication strategies. At the same time, people in many countries are chronically short of food and there is a need to improve the efficiency of animal production to provide better access to affordable protein.

3.3 TECHNOLOGICAL DEVELOPMENT

Economics and technological advances are driving the development of new feed products, especially products of biotechnology. New products may challenge established regulatory approaches to feed and food safety risk assessment. Because of this rapid evolution, situations may arise where a specific food safety hazard has not been identified, but relevant scientific information suggests a link between consumption of a food and adverse effects on health.

Analytical methods are increasingly sensitive and this makes the work of risk assessment and management more complex. In the international context, the differences between countries in terms of their analytical capabilities can cause trade problems. International standard-setting organizations must address this issue.

There is improved capacity for rapid sharing of information on food and feed problems. This can assist countries to minimize impacts on trade.

The list of potential hazards is very large and constantly evolving. A multidisciplinary approach to risk assessment and risk management is needed. Generic approaches (such as presented in the Code) are needed, as it is beyond the resources of any country or organization to deal with every possible hazard-product combination on a case-by-case basis.

Developed countries should be prepared to help less developed countries meet international standards through the provision of technical advice and assistance. Suitable approaches include bilateral institute-to-institute or country-to-country arrangements (twinning).

4. Safety assessment and detection of hazards in animal feed and feed ingredients related to public health

As animal feed is an important route by which hazards can enter the human food chain, its safety must be assessed prior to its feeding to animals. Safety assessments are often multifaceted. They usually consider both the safety of animals as the primary consumers of the feed, and safety of humans as the indirect consumers of any residues that may remain in food of animal origin. In some cases, risk to people working with and mixing feed, and risk to the environment are assessed.

For feed safety assessments, it is important to establish guidelines that are generic enough to encompass the requirements of all ingredients and are flexible enough to allow for differences in ingredient types. Evaluations are often conducted on a case-by-case basis due to the specific characteristics and use of the ingredients which make up a complete feed. This ranges from traditional grains, oilseeds and their by-products (e.g. soybeans and soybean meal), to mineral and vitamin supplements (e.g. copper sulphate and vitamin B_{12}), by-products of food processing (e.g. dried bakery residue), viable microbial supplements and fermentation products either purified or not (e.g. *Lactobacillus acidophilus* and dried fermentation soluble), flavouring aids (e.g. aldehyde C-18), colouring agents (e.g. astaxanthin) and to other ingredients used to aid the process of manufacturing the ingredient or the mixed feed (e.g. binding or anti-caking agents).

4.1 RISK ASSESSMENT

The assessment of feed and feed ingredients should be based on the Codex Principles for Risk Analysis[22]. The risk assessment of microbiological and chemical hazards in feed and feed ingredients should be developed considering relevant Codex texts such as: the Principles and Guidelines for the Conduct of Microbiological Risk Assessment[23]; the Risk Analysis Principles applied by the Codex Committee on Pesticide Residues; the Risk Analysis Principles applied by the Codex Committee on Residues of Veterinary Drugs in Foods; and the Risk Analysis Principles applied by the Codex Committee on Food Additives and the Codex Committee on Contaminants in Foods[24].

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[22] **FAO/WHO.** 2006. *Codex Alimentarius Comission proceducral manual*, Sixteenth Edition. Rome. (available at ftp://ftp.fao.org/codex/Publications/ProcManuals/Manual_16e.pdf).

[23] **FAO/WHO.** 2001. *Principles and guidelines for the conduct of microbiological risk assessment.* Food and Nutrition/Codex Alimentarius - Joint FAO/WHO Food Standards Programme, Rome. (available at http://www.codexalimentarius.net/download/standards/357/CXG_030e.pdf).

[24] **FAO/WHO.** 2007**.** *Codex Alimentarius principles for risk analysis,* (Procedural manual of the Codex Alimentarius Commission), Seventeenth edition. Joint FAO/WHO Food Standards Programme. Rome.

The steps can be summarized as follows:

(i) **Hazard identification** - for chemicals, the hazards are identified, including components, impurities, undesirable substances, and the toxicological profile or any other relevant assessment endpoints. In the case of micro-organisms the relevant pathogens and the microbiological profile of the feed are identified.

(ii) **Hazard characterization** - for chemicals the relevant reference values, especially for an oral route exposure are identified (e.g. LD_{50}, ADI) for all species of concern, including non-target species. For microbiological hazards, the nature and the severity of the adverse health effects are characterized and where possible a dose-response relationship established.

(iii) **Exposure assessment** - the potential exposure of animals and humans to undesirable substances or micro-organisms is determined based on the prevalence and concentrations of these hazards in the daily ration of the feed or feed ingredient (when assessing an ingredient), feed and food consumption data and consideration of any processing effects.

(iv) **Risk characterization** - the risk is characterized by combining information on the nature of the adverse health effect of the hazard and the potential for exposure to the hazard, with the inclusion of uncertainty factors.

The hazard identification step identifies any undesirable substances and micro-organisms of concern that may be naturally occurring in or introduced into the ingredient during its processing, transport or storage. The frequency of their occurrence and their concentrations in the product and in the final feed should be determined. This becomes especially important in the case of some complex ingredients such as by-products produced from other industries. Examples of undesirable substances and micro-organisms of concern could include heavy metals, dioxins, dibenzofurans and PCBs, veterinary drug residues, pesticides, processing aids, mycotoxins and pathogenic bacteria.

The exposure assessment is the step in which the concentration, frequency and duration of human and animal exposure is measured or estimated. Exposures will differ as a result of the formulation of the product, the use patterns of the product, and the exposure scenarios. Whether the ingredient has the potential to enter the food chain will depend on the rate and degree of absorption and how the ingredient is distributed, metabolized, excreted or bio-accumulated in the animal. When there is an indication that bio-accumulation may result in an unacceptable residue level in foods of animal origin, direct feeding trials in livestock at appropriate levels are recommended to assess the potential transfer from feed to food of animal origin. Residue studies should be conducted for the parent compound and its possible metabolites. In the case of microbial contaminants, studies on the transfer of potential pathogens from animals to food of animal origin may be needed. However, it is often not possible to conduct direct feeding trials to account for all feeding situations (e.g., multiple species, different sexes and different stages in animals' lives). Therefore, toxico-kinetic or other models that can predict the transfer of potential residues or pathogens from feed to foods may be used.

4.2 SELECTION OF UNDESIRABLE SUBSTANCES AND MICRO-ORGANISMS OF CONCERN

The Expert Group reviewed an extensive list of hazards related to food safety that can potentially be present in feed.

The Expert Group developed the following criteria to help select hazards of current importance in feed:

(i) relevance of the hazard to public health;
(ii) extent of the occurrence of the hazard; and
(iii) impact of the hazard on international trade in food and feed.

Among others, the following feeds and feed ingredients were considered:

- compound/complete feeds;
- grains and oilseeds (whole and meals), fruit and vegetable by-products, including oils;
- forage, including grasses, hay and silage;
- directly dried products (e.g. bakery by-products);
- biofuel by-products (e.g. distillers' grains with solubles (DGS), dried distillers' grains with solubles (DDGS) and glycerol);
- food processing by-products and co-products;
- minerals, including trace elements, and binders;
- animal by-products, including meat and bone meal and fats;
- aquatic products, including fishmeal, shellfish, fish by-products, seaweed and krill;
- fermentation/biomass and dried products;
- viable microbes; and
- silage additives

The Expert Group considered the following undesirable substances and micro-organisms as being currently most important:

CHEMICAL SUBSTANCES

Dioxins, dibenzofurans, and dioxin-like PCBs (dioxins)

Because of the ubiquitous presence of dioxins in the environment, the threat of dioxin contamination posed by feed ingredients may originate from many different sources. Since the Belgian dioxin crisis in 1999, dioxins have become important considerations for feed safety. Since then, numerous cases of contamination involving dioxin from unexpected sources have been reported. This has shown that dioxins may be inherent to a product (e.g. clay minerals), can be formed during heat processing (e.g. lime in citrus pulp, directly dried bakery waste), or may arise through the use of treated wood in animal production, the grass meal or grass meal pellets produced from grass dried directly fed flue gases from (e.g. coal-fired heating plants) and pasture placed near polluting plants (e.g. coal-fired heating plants).

Dioxins and dioxin-like PCBs are two related groups of toxic compounds, both comprising a number of congeners. Each congener has its own toxicity as expressed by the toxicity equivalence factor (TEF).

It has been postulated that most human exposure to dioxins is as a result of foods of animal origin, which in turn may arise from the presence of dioxins in animal feeds. Dioxins accumulate in fat to a high degree, so even extremely low levels of dioxin in

feed can become significant over the lifetime of an animal and result in unacceptable residues in human foods such as meat, milk, and eggs. Toxicokinetic models have been developed to estimate the transfer rates of dioxins to animal tissues.[25]

As such, implementing controls for dioxins in feed represents an important step towards reducing dioxins in the food chain. In particular, screening programmes have indicated that dioxins may arise in feed via their presence in mineral sources, such as clays, recuperated copper sulphate, zinc oxide; food by-products; and fish by-products such as fish meal and fish oils.

There is a need for development/improvement of inexpensive and accurate screening methods. Feed and food exposure studies are necessary to account for all sources of dioxin entering the feed chain.

Mycotoxins: aflatoxin B_1

In the last decade, many studies have been conducted on mycotoxins. Most frequently occurring mycotoxins (aflatoxin B_1, ochratoxin A, zearalenone, fumonisin B_1, deoxinivalenol, T-2 and HT-2) are currently considered for their effects on animal health.

However, when focusing on how mycotoxins play a role in food safety, attention should be limited to mycotoxins that are known to be transferred from feed to food of animal origin, as this food represents a significant route of exposure for humans.

Although the scientific community is aware of the following transfers from feed to food: aflatoxin B_1 to liver, aflatoxin B_1 to milk as aflatoxin M_1, aflatoxin B_1 to eggs as aflatoxicol; ochratoxin A to meat; deoxynivalenol to meat as DOM_1; zearalenone to meat as zearalenol, evaluating transfer rate and route of exposure in humans is restricted to aflatoxin B_1 for animals producing milk.

Farmers should bear in mind that animals fed on aflatoxin contaminated feed do not show symptoms of aflatoxin toxicity.

Feeds most susceptible to aflatoxin are: cereals (especially maize), cottonseed, peanut and copra. Aflatoxin contamination is not homogeneous; it is therefore very important to apply an appropriate sampling method. Feeds having a significant aflatoxin contamination should not be fed to dairy cows or other animals producing milk for human consumption or to other food-producing animals.

There is some evidence to suggest that mycotoxins can concentrate in dried distillers' grains with solubles (DDGS) during the processing of grains for ethanol production.

Heavy metals

Cadmium is a ubiquitous contaminant that is present in many feed and feed ingredients, in particular minerals, and forages grown near smelting and mining areas. Arsenic and mercury are heavy metals which are widespread in the environment and which can be found in many feeds, in particular in feeds of marine origin. Lead is also a ubiquitous contaminant. Table 1 summarizes the most relevant minerals, their sources and bioaccumulation in animal tissues.

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[25] **Van Eijkeren, J.C.H., Zeilmaker, M.J., Kan, C.A., Traag, W.A. & Hoogenboom, L.A.P.** 2006, A toxicokinetic model for the carry-over of dioxins and PCBs from feed and soil to eggs *Food Additives and Contaminants*, 23(5): 509-517.

Table 1. Minerals, their sources and bioaccumulation in animal tissues

Mineral	Sources	Bioaccumulation in animal tissues:
Arsenic (inorganic)	Sea plants, fish products and supplemental minerals.	Fish
Cadmium	Mineral supplements (such as phosphate, zinc sources). Forage/grains (depending on geographical area). Manure, sewage, sludge or phosphate fertilizers can enrich soil.	Kidney and liver. Shellfish, oysters, salmon and fungi, have the highest concentrations. There are low concentrations in fruits, dairy products, legumes, meat, eggs and poultry.
Lead	Contaminated soil, lead paints, water from plumbing systems that contain lead, batteries. Mineral supplements (copper sulphate, zinc sulphate, zinc oxide).	Bone, brain and kidney
Mercury/methyl mercury	Anthropogenic contamination, fish meal.	Liver, kidney. Fish, marine mammals

Source: **NRC.** 2005. *Mineral tolerance of animals.* Washington DC, National Research Council

Veterinary Drugs

As veterinary drugs may be a potential risk for food safety, they should be used according to good practices in the use of veterinary drugs (GPVD)[26].

Residues of veterinary drugs can be present in feed when ingredients of animal origin (terrestrial and aquatic) are used, but this is not a very significant route of exposure.

Veterinary drug residues may be found in food products as a result of the carryover of veterinary drugs in feed during feed production. Therefore, it is important to follow the Code recommendations (flushing, sequencing, cleaning) when feed for food-producing animals is produced after the production of a medicated feed.

The Expert Group agreed that it is also important to take into account the illegal use of drugs in animal feed which may result in unsafe residues in meat, milk or eggs (e.g. chloramphenicol/nitrofurans in shrimps and chloramphenicol in milk powder).

There is some evidence to suggest that antibiotics used in the fermentation process to control microbiological contamination during the processing of grains for ethanol production may concentrate in DDGS.

Organochlorine pesticides

The continued presence of organochlorine pesticides in the environment, as well as their ongoing use in some countries, can cause exposure through food as a result of accumulation in the fat tissues of animals that have been fed on contaminated feed. Such animals will usually not exhibit specific clinical symptoms of the contamination. Animal products such as meat could accumulate these substances, which are extremely persistent and which decompose very slowly. Contaminated animal products can cause food safety issues for humans.

[26] **OIE.** 2007.. Appendix 3.9.3. Guidelines for the responsible and prudent use of antimicrobial agents in veterinary medicine. *Terrestrial Animal Health Code*, Sixteenth Edition, pp. 549-556.

MICROBIOLOGICAL HAZARDS

The primary sources of microbiological hazards in feed are contaminated pasture land, forages and animal and vegetable protein meals fed directly to animals. The Expert Group reviewed a number of microbiological hazards, but was unable to rank them during this meeting. Further information is needed to accurately define the importance of feed in disease transmission and food safety.

Brucella

In some countries, where *Brucella* infection occurs, infected ruminants can deliver offspring or abort in fields that are grazed or from which pasture is harvested and used for animal feed. It is well known that the placentas of infected animals contain high levels of *Brucella* micro-organisms. If contaminated forage is fed to milking animals, the micro-organisms may be excreted in their milk. If this milk is not pasteurized prior to consumption by humans, it is a risk to food safety. Suggested control measures can be found in FAO Animal Production and Health Paper No 156: Guidelines for Coordinated Human and Animal Brucellosis Surveillance[27]; in the FAO Animal Health Disease Cards on bovine brucellosis[28] and on ovine and caprine brucellosis[29]; on the WHO Web page on brucellosis[30], and in the OIE Terrestrial Animal Health Code (Chapter 2.3.1 Bovine brucellosis and Chapter 2.4.2. Caprine and ovine brucellosis)[31].

Salmonella

Salmonella is still of worldwide human health concern. It is clear that infection in animals has a direct impact on transmission to humans via food of animal origin. Contaminated feed might represent an important route of exposure to *Salmonella*. However, at the Expert Meeting there was little scientific information available about the correlation between contaminated feed and infection of livestock by the same *Salmonella* strains and the contamination of meat, milk and eggs produced from these animals.

Endoparasites

Some endoparasites of animals, such as *Echinococcus*, *Toxoplasma gondii, Cisticercus* and *Trichinella*, present a risk to human health, and ingestive stages can contaminate animal feeds. These pathogens can colonize/infect farm animals, and may pose a threat to human health if infected or contaminated products are ingested.

TOXIC PLANTS

There are many toxic plants found in grasslands around the word. Their toxic effects, and the potential presence of some toxic compounds in milk and meat, are well documented. However, there is a lack of information about metabolic fates, residues, maximum residue limits (MRL) and average daily intakes (ADI) for these different toxicants.

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[27] ftp://ftp.fao.org/docrep/fao/005/y4723e/y4723e00.pdf

[28] http://www.fao.org/ag/againfo/subjects/en/health/diseases-cards/brucellosi-bo.html

[29] http://www.fao.org/ag/againfo/subjects/en/health/diseases-cards/brucellosi-ov.html

[30] http://www.who.int/zoonoses/diseases/brucellosis/en/

[31] http://www.oie.int/eng/normes/en_mcode.htm?e1d10

This risk pathway can be controlled by following Good Agricultural Practices.[32]

4.3 METHODS OF ANALYSIS FOR THE DETECTION OF UNDESIRABLE SUBSTANCES AND MICRO-ORGANISMS

The methods of analysis that are in use for quality control, regulatory control and to facilitate trade, range from easy-to-use dipstick-type tests or plate-count methods to the use of sophisticated equipment - high performance liquid chromatography (HPLC), liquid chromatography-mass spectronomy (LC-MS), mass spectronomy (MS), polymerase chain reaction (PCR) - that requires a high level of technical expertise. Fast and inexpensive screening methods should be applied if they are available. In this way, the vast majority of samples can be classified as compliant; further analysis with confirmatory methods is needed only for suspect samples. In many cases it is advisable to use multimethods that can detect a group of compounds such as pesticides, instead of using a single analytical method.

Methods often differ with respect to their validation status, ranging from methods that have been tested in one laboratory to methods that have been validated by means of international collaborative studies.

It should be noted that feed and feed ingredients comprise a large variety of products (see above) which differ in their composition and may consist of complex matrices that can negatively impact analyte recovery. This may mean that for each specific analyte the technical procedure must be adjusted, optimized and validated for different types of feeds in order to get reliable results.

INTERNATIONAL STANDARDIZATION BODIES

Several international organizations are involved in the preparation and publication of standardized methods for chemical substances in feed.

Worldwide:

- The International Standardization Organization (ISO), Committee TC 34/SC 10 "Animal feedingstuffs" for chemical, biochemical, physical and microscopic methods; and Committee TC34/SC9 "Microbiology" for microbiological methods[33].
- AOAC International.

Regional:

- TIn Europe, until about five years ago, the European Community (EC) had standardized methods which were implemented under EC-legislation. Nowadays, the

[32] **Panter K.E. & James L.F.** 1990. Natural plant toxicants in milk: a review. *J. Anim. Sci.*, 68:892-904.
James L.F., Panter K.E., Molyneux R.J., Stegelmeier B.L. & Wagstaff D.J. 1994. Plant toxicants in milk, *In* S.M. Colegate & P.R Dorling. eds. *Plant sssociated toxins*, p.83-88. Wallingford,UK, CAB International.
Riet-Correa, F & Medeiros, R.M.T. 2001. Intoxicações por plantas em ruminantes no Brasil e no Uruguai: importância econômica, controle e riscos para a saúde pública pública, *Pesquisa Veterinária Brasileira,* 21(1).

[33] For further details, see:
http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_tc_browse.htm?commid=47920&development=true
The full list of their standards can be found at:
http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_tc_browse.htm?commid=47920&published=true.

EC has mandated this task to the CEN (European Committee for Standardization) committee TC 327 "Animal feedingstuffs - methods of sampling and analysis".

An important requirement for standardization is that methods are validated by international collaborative studies to confirm that they can successfully be performed by different laboratories.

ALTERNATIVES TO STANDARDIZED METHODS

In many cases, up-to-date standardized methods are not available. As an alternative, laboratories may subject their methods to in-house validation and subsequent accreditation according to ISO/IEC 17025[34]. To ensure traceability of the measurement, certified reference materials (CRMs) should be incorporated as part of the quality assurance protocol. Furthermore, participation in proficiency testing (PT) schemes is important. In practice, CRMs and PT-schemes are limited to a relatively small number of analyte-matrix combinations.

The Codex Committee on Methods of Analysis and Sampling (CCMAS) has elaborated the criteria approach as an alternative to method standardization. Methods may be applied if they comply with a specific set of criteria, such as accuracy, applicability (matrix and concentration range), limit of detection, limit of determination, precision, repeatability and reproducibility. Efforts to adopt this approach in the feed analytical community are still at a very early stage.

In the following paragraphs, the state of the art for selected hazards will be described, and needs for method development/validation will be indicated.

Dioxins dibenzofurans and dioxin-like PCBs

The method of choice for the combined confirmation of dioxins and dioxin-like PCBs is gas chromatography - high resolution mass spectrometry (GC/HR-MS) after extensive sample clean-up. This expensive technique is only applied by a relatively small number of laboratories. The European Committee for Standardization (CEN) has just started activities to prepare a harmonized and collaboratively studied GC/HR-MS method.

Dioxin-like PCBs can also be determined by gas chromatography with other low-resolution mass spectrometry instruments. For screening purposes, less expensive bio-assays such as the Calux-assay are applied. Although these bio-assays are successfully applied in various laboratories, there is still a need for improvement with regards to robustness and selectivity.

Aflatoxin

A variety of methods have been standardized, *viz.* a semi-quantitative ISO method based on thin-layer chromatography (ISO 6651:2001) and a methods applying HPLC with fluorimetric detection after immuno-affinity clean-up. The latter method is commonly regarded as the reference method and has been adopted by AOAC (2000.02) and ISO/CEN (ISO/EN 17375). AOAC has also granted the status of Performance Tested Method to a test kit based on single-step column clean-up followed by fluorimetric detection.

[34] **ISO/IEC**. 2005. *General requirements for the competence of testing and calibration laboratories* ISO/IEC 17025 (update) Geneva, International Organization for Standardization.

This means that this test kit has been successfully tested in one independent laboratory. For quality control of raw materials in feed mills, dipstick-like immunochemical screening methods are also applied. A list of methods of analysis for mycotoxins, including aflatoxins, is provided in Appendix D, Part 4 of this report.

Heavy metals

For lead, cadmium, arsenic and mercury, atomic absorption spectrometry (AAS) techniques are most frequently applied. CEN has published a graphite-furnace (GF)-AAS method for lead and cadmium (EN 15550:2007). CEN has also started activities for arsenic and mercury with hydride generation (HG)-AAS and cold vapour (CV)-AAS, respectively. A CEN-method (EN 155510:2007) based on inductively coupled plasma-atomic emission spectrometry (ICP-AES) may be applied for lead and cadmium, but only for higher levels in mineral products.

Veterinary drugs/feed additives

To check for carryover of antibiotic veterinary drugs and coccidiostats, at industry level, HPLC methods are frequently applied. For a number of these analytes immunochemical methods such as Enzyme-Linked ImmunoSorbent Assay (ELISA) are also available. Microbiological inhibition assays are frequently used for multiscreening for antibiotics. Suspect samples can be confirmed with LC-MS/MS or liquid chromatography with diode array detector (LC-DAD) methods. For ionophoric coccidiostats (monensin, narasin and salinomycin) a multimethod based on HPLC has been published by ISO (ISO 14183:2005) and will become an official AOAC method (AOAC 2006-01). AOAC is working on HPLC methods for oxytetracycline (OMA-2004-Oct-017) and lasalocid (OMA-2005-Jan-002). For other analytes there is a need for method validation and standardization.

For control of illegal use of chloramphenicol, immunochemical (dipstick-like and ELISA) screening methods are available. For other drugs, such as nitrofurans, HPLC can be used for screening. LC-MS methods are available for confirmation. None of these methods is extensively validated.

Organochlorine pesticides

CEN has prepared two methods for persistent organochlorine pesticides like DDT, hexachlorobenzene and aldrin. One method is based on GC-MS, the other on GC with electron-capture detection (ECD). Both methods have been collaboratively studied with successful results. Indicator PCBs can be analysed in the same run.

Micro-organisms

It should be noted that feed and feed ingredients comprise a large variety of products (see above) which differ in their composition, and may consist of complex matrices that can negatively affect microbiological analysis. This may mean that for each micro-organism the technical procedure must be adjusted, optimized and validated for different types of feeds in order to get reliable results.

ISO has published Method 6579:2002 Microbiology of Food and Animal Feeding Suffs - Horizontal Method for the Detection of *Salmonella* spp. For typing of *Salmonella* strains,

methods based on molecular biology (PCR) are frequently applied but these methods have not yet been validated through collaborative studies.

The OIE Manual of Diagnostic Tests and Vaccines for Terrestrial Animals[35] includes references for the detection of micro-organisms (including in animals and food products). The emphasis is on animals and clinical samples, but there is some information relevant to food.

A list of microbiological methods of analysis is provided in Appendix D, Part 4 of this report.

[35] **OIE**. 2004. *Manual of diagnostic tests and vaccines for terrestrial animals*, Fifth Edition. Paris. (available at http://www.oie.int/eng/normes/mmanual/A_summry.htm).

5. Prevention and control of risks in animal feed associated with public health

5.1 IMPLEMENTATION OF THE CODE

The Expert Group discussed the different ways in which the Code has been implemented by industry and governments. Some countries have implemented the Code by incorporating its provisions in national regulations. Other countries had existing legislation which incorporates the principles of the Code, while others have implemented the Code through government regulations complemented by voluntary guidelines set by the industry. Some countries have just started to implement the Code.

The Codex Secretariat indicated that it would request information on the implementation of the Code from Members. The Expert Group identified a number of international and national guidelines and manuals from industry closely related to the Code that could facilitate implementation. FAO informed the Expert Group about the draft IFIF/FAO *Manual of good practices for the feed industries*, which will be available in 2008.

It was noted that HACCP (Hazard Analysis and Critical Control Point) is an instrument to control hazards in the production process. Implementation of HACCP requires prerequisite programmes (such as good agricultural practices (GAP), GMP, hygiene systems) to be in place. In many countries there are voluntary quality assurance and certification systems initiated by the industry.

The Expert Group discussed the importance of technical standards for measuring component homogeneity of certain feed ingredients (in particular additives) in feed. Such standards could be used to validate mixer performance and establish minimum mixing times at a given facility. This point should be taken into account in the forthcoming IFIF/FAO *Manual of good practice for the feed industries*.

Some countries have a positive list of ingredients permitted for use in feed. These lists may be in legislation or be derived from industry sources. Positive lists include the names of feed ingredients that are accepted as safe because they have either been assessed or accepted as safe. Ingredients not on the list are assumed to be a safety risk until they are assessed as safe.

5.2 INFORMATION SHARING AND TRAINING

The Expert Group discussed the importance of information about feed ingredients related to safety. FAO and WHO informed the Expert Group that a lot of information is available in printed form and on the Internet - for example the Animal Feed Resources Information System (AFRIS) and the International Portal on Food Safety, Animal and Plant Health. They also invited interested parties to add new information to the data-

bases, in particular data on hazards in feed ingredients.

The Expert Group discussed the importance of training with regard to feed safety and that it should include all parts of the feed chain, in particular farmers, producers, traders and the staff of the competent authorities. Training should focus on:

- developing awareness of the impact of feed safety on food safety;
- providing knowledge about hazards in the feed chain; and
- supporting the implementation of the code, GMP, GAP, HACCP and quality assurance.

Developing countries need technical and financial support for training and implantation of the Code. Industry associations should be encouraged also to support training in developing countries.

5.3 EMERGENCY RESPONSE

The Expert Group discussed strategies for dealing with emergency situations. In Part 4.3 of the Code there are provisions for emergency situations and traceability/product tracing. The following Codex standards refer to emergency situations:

- *Principles and guidelines for the exchange of information in food safety emergency situations* (CAC/GL 19-1995)[36];
- *Guidelines for the exchange of information between countries on rejection of imported food* (CAC/GL 25-1997)[37];
- *Principles for traceability/product tracing as a tool within a food inspection a certification system* (CAC/GL 60-2006)[38].

These codes primarily relate to food. They include references to feed, but feed issues are not adequately covered or integrated in detail.

The Expert Group noted the new FAO/WHO International Food Safety Authorities Network (INFOSAN)[39]. A food safety emergency network (INFOSAN Emergency) is an integral part of INFOSAN. The food safety emergency network is intended to complement and support the existing WHO Global Outbreak Alert and Response Network (GOARN)[40] which includes a Chemical Alert and Response component. WHO indicated that it could be possible to integrate feed in these systems. FAO is establishing an Emergency Prevention and Intelligence Centre - food chain (EPIC) to assume a strategic role in the coordination of the organization's emergency prevention activities along the food chain.

The Expert Group noted that the OIE has undertaken to disseminate relevant INFOSAN advisories to OIE Delegates to help ensure that information on food safety incidents in animal products is shared at national level with official veterinary services.

The Expert Group was informed about the EU (European Union) Rapid Alert System for Food and Feed[41]. This is a network involving the competent authorities of EU Member States and those of other countries, which inform each other about serious incidents

[36] www.codexalimentarius.net/download/standards/36/CXG_019_2004e.pdf
[37] www.codexalimentarius.net/download/standards/353/CXG_025e.pdf
[38] www.codexalimentarius.net/download/standards/10603/CXG_060e.pdf
[39] http://www.who.int/foodsafety/fs_management/infosan/en/
[40] http://www.who.int/csr/outbreaknetwork/en/
[41] http://ec.europa.eu/food/food/rapidalert/index_en.htm

related to food and feed safety with respect to identified products. The EU experience has shown that information about food and feed safety emergencies must be integrated into a single system in order to ensure food safety.

The Expert Group discussed the necessity of having a system by which to exchange information on feed safety emergency situations. In such a system it is necessary to have criteria for the identification of emergency situations. In emergency situations, traceability/product tracing systems are also important, for the identification of the source of hazards. The competent authorities should identify the source of the hazard (e.g. contamination) and, once the source is identified, take appropriate measures where possible, to reduce or eliminate the source.

6. Conclusions and identification of relevant areas for further work on animal feed in relation to food safety

Ensuring safe feed in order to prevent food safety hazards is important.

The presence in feed of undesirable substances that can lead to human food safety problems needs to be reported to competent authorities and relevant international organizations. As no formal criteria for reporting such events exists at present, minimum criteria that countries should apply for reporting these events to trading partners are needed.

International standards for undesirable substances in food produced from different species/categories of animals should be developed based on the "tolerable daily intake" (TDI) approach.

Minimum safety criteria are needed for the safe use of feed ingredients. For example, in the case of distillers' grains with solubles (DGS) and dried distillers' grains with solubles (DDGS) produced as by-products of the fuel ethanol industry, there are concerns about mycotoxins and antibiotics which may remain as residues.

Criteria and methods for decontamination, disinfection and cleaning of feed should be developed to reduce or eliminate undesirable substances.

Rapid and economical analytical methods for screening feed and feed ingredients should be developed.

Rapid notification of the competent authorities about feed safety incidents resulting in human food safety hazards is important.

A Codex Code of Practice[42] exists for exchanging information in food safety situations. A similar procedure is needed for feed.

Existing notification systems should be evaluated to determine whether feed emergencies could be integrated. The evaluation should take into account that feed and food emergencies must be considered together.

Training of regulators, inspectors, feed and livestock industry personnel and farmers is required for the production of safe feed.

[42] **FAO/WHO.** 2005. Principles and guidelines for the exchange of information in food safety emergency situations (CAC/GL 19-1995, Rev 1-2004), In *Codex Alimentarius - Food import and export inspection systems, combined texts*, Second Edition. Rome. (available at www.codexalimentarius.net/download/standards/36/CXG_019_2004e.pdf).

Communication strategies for consumers and the food industry highlighting the importance of feed safety in producing safe food products are necessary. Communication mechanisms between feed and food regulatory agencies and the respective industries should be fostered wherever possible.

Because of the short duration of the Expert Meeting, many important issues that lay within its scope its could not be considered in detail. As a result, final conclusions could not be reached for all subjects. Continued discussions are required at an international level to allow further development of policy advice on feed safety.

7. Recommendations

Based on their deliberations, the experts made the following specific recommendations:

(i) The application of the Codex Code of Practice on Good Animal Feeding[43] should be promoted in order to minimize risks.

(ii) General principles and guidelines for the assessment of risk for feed ingredients or categories of ingredients should be developed.

(iii) A prioritized list of hazards of international relevance for which standards could be developed for feed and feed ingredients with respect to food safety were identified during this meeting. Countries should assess the need for further evaluation by international scientific expert committees.

(iv) The existing Codex Code of Practice for Source Directed Measures to Reduce Contamination of Food with Chemicals (CAC/RCP 49-2001)[44], which also encompasses feed, should be reviewed to include specific provisions related to feed safety.

(v) Research on rates of transfer and accumulation of dioxins, dibenzofurans, and dioxin-like PCBs from feed to edible tissue in animal-derived products and management measures should be continued.

(vi) Inexpensive and accurate screening methods for the detection and quantification of dioxins, dibenzofurans and dioxin-like PCBs in feed and feed ingredients should be developed.

(vii) Rapid and semi-quantitative screening methods for detection of aflatoxin B_1 in both feed and feed ingredients are needed. The methods should be simple enough for use by non-technical personnel and inexpensive so as to encourage their use.

(viii) Communication should be improved to raise the awareness among biofuel (e.g. ethanol and biodiesel) processors, livestock producers and the feed industry of the need for safety assessments prior to the use in animal feeds of by-products from the production of biofuels .

(ix) More research is needed to determine the fate and residual concentration of aflatoxin B_1 and any antibiotics used to control unwanted microbial growth during the biofuels fermentation process. Research is also needed to evaluate the risk of residual levels of methanol in glycerol from biodiesel production when it is used as a feed ingredient, particularly in dairy production.

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[43] **FAO/WHO**. 2004. *Code of practice on good animal feeding*, (CAC/RCP 54-2004). Rome. (available at www.codexalimentarius.net/download/standards/10080/CXC_054_2004e.pdf).

[44] **FAO/WHO**. 2001. *Code of practice for source directed measures to reduce contamination of food with chemicals* (CAC/RCP 49-2001). Rome. (available at www.codexalimentarius.net/download/standards/373/CXP_049e.pdf).

(x) The existing Codex Codes regarding emergency situations, which also encompass feed, should be reviewed to include specific provisions on feed emergencies related to food safety.

(xi) The international emergency notification system for food (INFOSAN) should be expanded in collaboration with the OIE to consider linkages between food and feed emergencies and to incorporate appropriate changes to include feed emergency notifications.

(xi) Emergency response systems for feed and food should be developed at the national and regional levels to contribute to food safety. FAO and WHO should assist in the development and application of such systems.

(xii) Training for regulators, inspectors, all sectors of the feed manufacturing and distribution chain, the livestock industry, farmers and other stakeholders relating to the production of safe feed should be carried out where possible using existing training materials, i.e. guidelines and manuals. FAO, WHO and other organizations should assist in the development of training methods.

(xiii) FAO and WHO should convene regular expert meetings and other fora to continue monitoring the situation, update information on the impact of feed on food safety, foster dialogue among partners and identify areas needing attention.

Appendix A

Agenda of the meeting

Joint FAO/WHO Expert meeting on Animal Feed Impact on Food Safety
Rome, Italy, 8-12 October 2007
FAO headquarters
AGENDA

Time	Monday 8 October 2007	Speaker
14.00 - 14.30	• Opening • Objectives and expected outputs of the meeting • Introduction of participants • Election of a chairperson and a vice-chairperson • Appointment of a rapporteur • Adoption of the agenda	FAO/WHO
	International context, ongoing activities	
14.30 - 14.45	FAO and WHO activities related to animal feeding	FAO/WHO
14.45 - 15.00	Codex activities related to animal feeding	Codex Secretariat
15.00 - 15.15	OIE activities related to animal feeding	OIE
15.15 - 15.30	Coffee break	
15.30 - 15.45	Public health problems associated with animal feed (chemical and microbiological hazards, sources and routes of contamination)	M. Bellaiche
15.45-17.30	Review the current state of knowledge on the impact of animal feed on public health and on international trade	Working group (all participants)

Time	Tuesday 9 October 2007	Speaker
9.00- 9.15	Safety assessment of new feed ingredients. Regulatory scheme for assessing novel feeds from plants derived from biotechnology	C. Italiano
9.15 -10.00	Safety assessment of feed and feed ingredients	Working Group (all participants)
10.00 - 10.30	Coffee break	
10.30 - 12.30	Safety assessment of feed and feed ingredients	Working Group (all participants)
12.30 - 14.00	Lunch	
14.00 - 15.00	Safety assessment of feed and feed ingredients	Working Group (all participants)
15.00 - 15.30	Coffee break	
15.30 - 15.45	Prevention and control of hazards associated with public health in animal feed: the EC approach	M.A. Granero Rosell
15.45 - 16.00	Prevention and control of hazards associated with public health in animal feed: the USA approach	D. McChesney
16.00 - 17.00	Analysis of the current situation of risk management addressing animal feed at international, regional and national levels, in both governmental and private sectors (including emergency situations)	Working group (all participants)

Time	Wednesday 10 October 2007	Speaker
9.00 - 10.00	Analysis of the current situation of risk management addressing animal feed at international, regional and national levels, in both governmental and private sectors (including emergency situations)	Working Group (all participants)
10.00 - 10.30	Coffee break	
10.30 - 12.30	Analysis of the current situation of risk management addressing animal feed at international, regional and national levels, in both governmental and private sectors (including emergency situations)	Working Group (all participants)
12.30 - 14.00	Lunch	
14.00 - 15.00	Identification of relevant areas for the development of specific international standards for animal feed	Working Groups (all participants)
15.00 - 15.30	Coffee break	
15.30 - 17.00	Identification of relevant areas for the development of specific international standards for animal feed	Working Groups (all participants)

Time	Thursday 11 October 2007	Speaker
9.00-10.30	Identification of requirements for further action at international, regional and national level	Working Groups (all participants)
10.30 - 11.00	Coffee break	
11.00 - 12.30	Identification of requirements for further action at international, regional and national level	Working Groups (all participants)
12.30 - 14.00	Lunch	
14.00 - 15.00	Conclusions and recommendations	Working Groups (all participants)
15.00 - 15.30	Coffee break	
15.30 - 17.00	Conclusions and recommendations	Working Groups (all participants)

Time	Friday 12 October 2007	Speaker
9.00 - 12:.30	Report : finalization and adoption of the report	
12.30 - 14:00	Lunch	
14.00 - 16:30	Report : finalization and adoption of the report	
16:30	Closure of the meeting	FAO/WHO

Appendix B

List of participants

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Appendix C

Experts' Résumés

Keith Behnke

Dr. Keith Behnke is Professor of Feed Science in the Department of Grain Science and Industry at Kansas State University, Manhattan, Kansas (United States of America). His education includes a BS degree in Feed Technology, MS in Grain Science and a PhD in Grain Science all from Kansas State University. His responsibilities at the University include teaching two feed processing related courses and a course dealing with the quality of feed ingredients. In addition to teaching, his research focuses on the effect of feed processing on animal nutrition and feed quality and safety. He is often asked to consult with companies in the livestock feed industry regarding technical issues and compliance with State and Federal regulations.

Michel Bellaiche

Has a BA in Agriculture (Animal Science) and a DVM in Veterinary Medicine from the Hebrew University of Jerusalem, and an MSc in Epidemiology and Preventive Medicine from Tel Aviv University. He has a specialization in veterinary physiology under the aegis of the Kimron Veterinary Institute and has to finalize his specialization in veterinary toxicology. Since November 1991, he is employed in the Israeli Veterinary Services and Animal Health. He started his career in the Department of Toxicology, as a veterinary toxicologist. In the framework of this function, he performed epidemiologic investigations in veterinary toxicological outbreaks dealing with public health issues, connected with toxicology and food-borne diseases. Now, he is the Head of the Epidemiology Department of the Israeli Veterinary Services. During 2003-2004, he edited a booklet about "Chemical and microbiological hazards in human food, introduced maliciously through animals in the farms". He is now also responsible for all the emergency preparations of the Israeli Veterinary Services.

Birgitte Broesbøl-Jensen

Birgitte Broesbøl-Jensen is an agronomist (MSc in Agriculture). She graduated in 1985 from the Royal Veterinary and Agricultural University (now Faculty of Life Sciences, University of Copenhagen). In 1989 she joined a permanent post in the Danish Plant Directorate (the competent authority on feed legislation in Denmark). She is involved in a project on risk assessment of by-products from the food and non-food industries used for food producing animals in relation to human and animal health. She also is dealing with questions concerning the legislation on feedingstuffs, e.g. classification of different types of feed and products lying on the borderline between feedingstuffs and medicine, and guidance of feed establishments and farmers on the legislation, e.g. on feed additives. She performs audits of feedingstuff processing units in relation to Regulation (EC)

183/2005 on Feed Hygiene. She was a member of the Danish secretariat (2002-2004) when Denmark hosted the Task Force on Animal Feeding (Copenhagen 2000-2004).

Jacob De Jong

Dr Jacob de Jong is an analytical chemist and the coordinator of the regulatory programme for feed at RIKILT - Institute of Food Safety, Wageningen, the Netherlands. He received his PhD in Analytical Chemistry at the University of Leiden. He chairs the CEN-Committee TC 327 "Animal feedingstuffs - methods of analysis and sampling" and the ISO-Committee TC 34/SC 10 "Animal feedingstuffs", aimed at standardization of methods of analysis. He is the head of the Dutch delegation in the EC-Expert Committee for methods of analysis for feed. He has coordinated two EC-supported research projects to develop and validate methods for banned antibiotics and growth promoters and registered coccidiostats in feed. He is also involved in EC-projects aimed to develop and validate methods for meat-and-bone meal and other animal proteins.

Miguel Angel Granero Rosell

Miguel Angel Granero Rosell is a Spanish agronomic engineer, specialized in food technology/food industry. From 1983-1988 he worked at a university and later in an engineering company. Working since 1988 for the European Commission, Mr Granero was involved until 1997 in the preparation, development and adoption of several pieces of EU food legislation, such as those related to contaminants in food and mineral waters. From 1997 to 2003, he worked in the risk assessment area, dedicated to the preparation of the scientific basis for a broad range of EU food safety legislation. Since 2003 he has been working on feed legislation with particular attention to feed additives.

Catherine Italiano

Catherine Italiano is the Toxicology Coordinator for the Livestock Feed Program at the Canadian Food Inspection Agency in Canada and has been with the Agency for 15 years, acting under the federal Feeds Act and Regulations. She is involved in developing and administering policy and regulations for the safety standards for feeds and contaminants in feeds including novel feeds. Catherine is also responsible for the risk assessment and management of contamination issues that arise from feed and is in the process of drafting guidelines for the mitigation of emergencies involving feeds. Catherine graduated with a BSc in Cell, Molecular and Developmental Biology from McGill University, and a Graduate Diploma in Ecotoxicology from Concordia University, both in Montreal. She worked for a number of years in research labs primarily in the field of molecular and developmental biology before moving to the regulatory world.

Alexander Komarov

Alexander Komarov is Head of the Food and Feed Safety Department at the All-Russia State Centre for Quality and Standardization of Veterinary Drugs and Feed in Moscow. The Centre has the official status as the OIE Collaborating Centre in Eastern Europe, Central Asia and Transcaucasia for Diagnosis, Control of Animal Diseases and Food Safety. He graduated from a veterinary-biological faculty of the Moscow Veterinary Academy in 1987 as a veterinary doctor and biochemist. He gained a PhD in 1991 and

a DSc in 2006. Dr. Komarov has been a supervisor of 3 PhD researchers and has had 5 PhD students. He has been working in this field for 20 years. Since 1987 he has worked on quality and safety control strategies for feed and food. His research interests lie in the development of residue analysis methodologies, particularly in the application of screening (immunochemical, GC, HPLC) and confirmatory (GC-MC/MC, LC-MC/MC) methods for detection of growth promoters, pesticides, PCB, heavy metals, mycotoxins and veterinary drugs in food and feed products. He also works as an expert in the evaluation of the safety of GM-feeds, feed additives and drugs for animals under registration procedure in the Russian Federation.

Sabine Kruse

Dr Sabine Kruse has a PhD in agricultural economics from Humbolt University Berlin. She worked as a scientist at the Institute of Agricultural Economics in Berlin from 1979 to 1990. In 1991 she moved to the Federal Ministry of Food, Agriculture and Consumer Protection, first in the business economics unit and then in the animal nutrition unit. She is responsible for all legislation relating to feed safety and animal nutrition in Germany. In particular she deals with all matters relating to undesirable substances and feed hygiene. She also coordinates feed control in Germany. She has been the Head of the German delegation to the Standing Committee for Animal Nutrition of the European Commission and head of the German delegation to the Codex Alimentarius Task Force on Animal Nutrition in Copenhagen, which developed the code of practice on good animal feeding. She has also acted as an expert consultant in the field of feed legislation, feed hygiene and feed control in different countries in Europe before their accession to the European Union. She has publications on feed legislation in the EU and in Germany, and other management measures in particular with regard to undesirable substances in feed.

Fernanda Marussi Tucci

Fernanda Marussi Tucci graduated in Animal Science in 1992 from the Universidade Estadual Paulista, Jaboticabal, São Paulo and received an MS in Animal Nutrition in 1999 from the Universidade de São Paolo and the Ph.D. in Animal Production in 2002 from the Universidade Estadual Paulista. Fernanda worked as a consultant in swine production and nutrition from 1992 to 2000. Since 2002, she is Federal Inspector at the Secretary of Animal and Plant Health, the competent authority on feed legislation of the Ministry of Agriculture, Livestock and Food Supply in Brazil.

Daniel G. McChesney

Dr Daniel G. McChesney is the Director of the Office of Surveillance and Compliance in FDA's Center for Veterinary Medicine. He has served in this position since October 2003. Prior to becoming the Director, he served as the Deputy Director for the Office of Surveillance and Compliance (1999-2003) and as the Acting Director of the Division of Compliance. His Office is responsible for developing and implementing surveillance and compliance policy concerning FDA regulatory responsibility with respect to animal drugs, feeds, food additives, veterinary medical devices, and other veterinary medical products. He joined FDA's Center for Veterinary Medicine (CVM) as a microbiologist in

1990 and served as the Center's expert on microbial contaminants of animal feed, and application of HACCP programmes to the feed industry. He received a BS in Biology from Mercer University in Macon, Georgia and his MS and PhD in Cell and Molecular Biology from the Medical College of Georgia, Augusta, Georgia. Upon completing his degree, he entered the U.S. Army and was stationed at the Walter Reed Army Institute of Research (1978-1987) where he served as a research microbiologist. After completing his active military service, he was a senior investigator at the Armed Forces Radiobiology Research Institute responsible for determining the mechanism involved in increasing survival after radiation injury.

Sergio Carlo Franco Morgulis

Sergio Carlo Franco Morgulis graduated in Veterinary Medicine from the University of São Paulo (USP) with a master's degree in animal nutrition also from USP. He gained work experience in dairy and beef cattle farms, lived and worked in the University of São Paulo's Campus of Pirassununga, working mainly with livestock production, agricultural production, slaughter houses, campus feed plant, and infrastructure assistance for teaching and research. He taught animal nutrition in veterinary school (USP). Since 1994, he has been Technical Director of Minerthal, a company with 3 divisions: animal nutrition, animal health and pet animals. Currently he is Director President of ASBRAM (Brazilian Association of Mineral Supplement Industries) and Director of Sindirações (Feed Industry Union). His technical focus is in ruminant nutrition and mineral supplements for cattle (production and use). He collaborates with the Ministry of Agriculture, participating in commissions and public inquiries about animal feed regulation.

Lea Pallaroni

Lea Pallaroni received a MS in Agriculture Science (Università Cattolica del Sacro Cuore - Italy) and graduated in Agricultural Science at the Technische Universität München (Germany), defending a thesis on a mycotoxin detection method which was developed in collaboration with the European Commission - Joint Research Centre. She developed knowledge and carried out projects on food and feed control analytical techniques, on mycotoxin detoxification and mycotoxin toxicity tests (*in vivo* and *in vitro*), and on environmental contaminants metabolism (Texas A&M - United States of America). Working for Assalzoo - Italian Feed Manufacturer Association since 2003, she is mainly dealing with legal requirements for feed production and with the development and application of a national GMP programme in the feed industries. Since 2006, Lea has been the General Secretary of Assalzoo.

Narinder Singh Sharma

Dr Narinder Singh Sharma started his career as Veterinary Officer in 1984, joined Punjab Agricultural University as Assistant Professor in the Department of Veterinary Public Health and Epidemiology in 1988, and in 1990 joined as Assistant Scientist (Bacteriology). He was selected as Bacteriologist in the Department of Veterinary Microbiology in 1998. He established a Clinical Bacteriology Laboratory, a Mycology and Mycotoxin Laboratory and a Molecular Laboratory in the department. He was instrumental in adopting and popularizing a rapid and simple test for the detection of aflatoxins in

different types of cattle and poultry feeds for the benefit of farmers. He is the Co-Principle Investigator for two research projects. Dr Sharma has been engaged in teaching and research in Veterinary Microbiology for the last 19 years. He has guided 4 MVSc. students in Veterinary Bacteriology. He has to his credit two laboratory manuals in the fields of veterinary microbiology, and chapters on veterinary mycology in a book. He has 48 research publications, 4 review papers, 13 scientific papers, 9 popular articles and has made 58 conference presentations. He remains associated with the Aflatoxin Check Sample Survey Programme of the International Agency for Research on Cancer (WHO).

Bill Spooncer

Bill Spooncer is Managing Director of consulting company Kurrajong Meat Technology. He graduated with a BSc in biochemistry from London University and had a 37 year career in the food industry, particularly the meat industry. His specialties have been in packaging, refrigeration, hygiene and meat safety. Since 1990, he has specialized in the rendering sector of the meat industry. He has developed university-based training programmes that provide accreditation for rendering plant operators and an auditing system that provides accreditation of rendering plants. He has developed codes of practice and standards for the rendering industry and has managed research programmes aimed at minimizing risks to animal and human health from the use of rendered products in animal feed. His consulting activities include advice to government departments on issues related to rendered products in animal feed, auditing of rendering plants and feed mills, training of rendering plant staff, and evaluation and development of rendering plant processes.

Liying Zhang

Dr Liying Zhang is the chief of laboratory of the Ministry of Agriculture Feed Industry Center, People's Republic of China, and also the professor of the Animal Science and Technology Department, China Agricultural University (Beijing). Since her graduation in 1985, she has been engaged in teaching and research in animal nutrition and feed analysis (1985-1998) at Laiyang Agricultural College and feed quality and safety analysis and evaluation at China Agricultural University (1999 to present). She was involved in the activities of the National Feed Industry Standardization Technology Committee, China, as a member for the last ten years. She has established eight methods for determination of antibiotics and prohibited drugs in feeds, some of which have been published as national standards or agriculture industry standards. She was also a member of the Evaluation Committee for Premix and Feed Additive Production Approval under the Ministry of Agriculture. She has been involved in the Annual Programme of Feed Quality and Safety Inspection of the Ministry of Agriculture since 2005.

Appendix D

List of documents

1. PAPERS SUBMITTED BY EXPERTS[1]

Behnke, K. 2007. *Quality and safety of feed and feed ingredients.*

Bellaiche, M. 2007. *Public health problems associated with animal feed. Chemical and microbiological hazards, sources and routes of contamination.*

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The role of animal feed in the production of safe food is recognized worldwide, and several events have underlined its impacts on public health, feed and food trade, and food security. Concerns prompted by the outbreak of bovine spongiform encephalopathy (BSE) in the United Kingdom, and other more common food problems associated with Salmonella, enterohaemorrhagic Escherichia coli and other micro-organisms, have encouraged professionals and the feed industry to scrutinize more closely the causes of these diseases and methods for their control. Some corrective measures are as basic as improving housekeeping and staff training in feed mills. Other measures are more challenging, and may require limiting the use of some ingredients or radically changing the way in which they are prepared (processed) or sourced, or restricting the locations where animals are grazed.

In recent years, the introduction of the food chain approach, which recognizes that responsibility for the supply of safe, healthy and nutritious food is shared along the entire food chain, has served to highlight the importance of feed safety. The food chain, thus, comprises every step from primary production to final consumption. Stakeholders include farmers, fishermen, slaughterhouse operators, feed producers and processors, food processors, transport operators, distributors (wholesale and retail) and consumers, as well as governments responsible for protecting public health.

FAO and WHO therefore considered it appropriate to convene an Expert Meeting to review current knowledge on animal feed and its impact on food safety, and to provide orientation and advice on this matter to their members and to international organizations. The Expert Meeting was requested to review and analyse the experience of selected countries in modernizing and strengthening their feed safety systems and drawing lessons from their experiences.

This report provides the output of that meeting with the experts' conclusions and recommendations.

ISBN 978-92-5-105902-9

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TC/M/A1507E/1/02.08/1100

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