Sharing of Experiences from Insights on Safety of Animal Feeds

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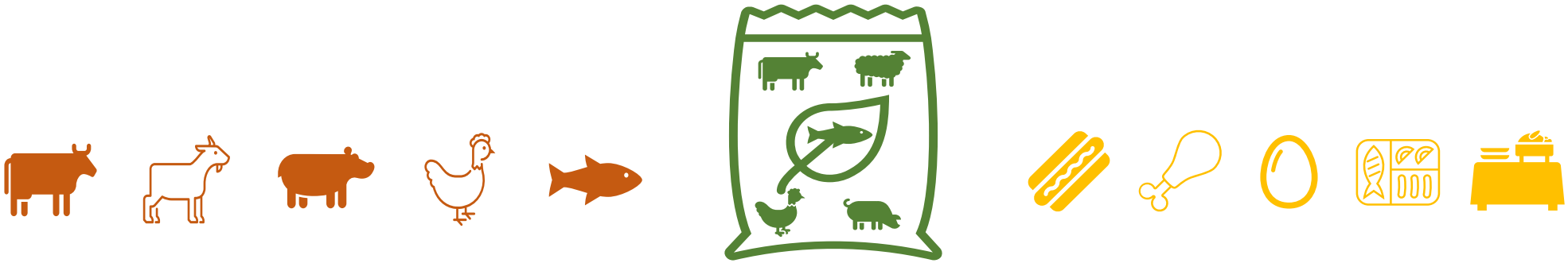
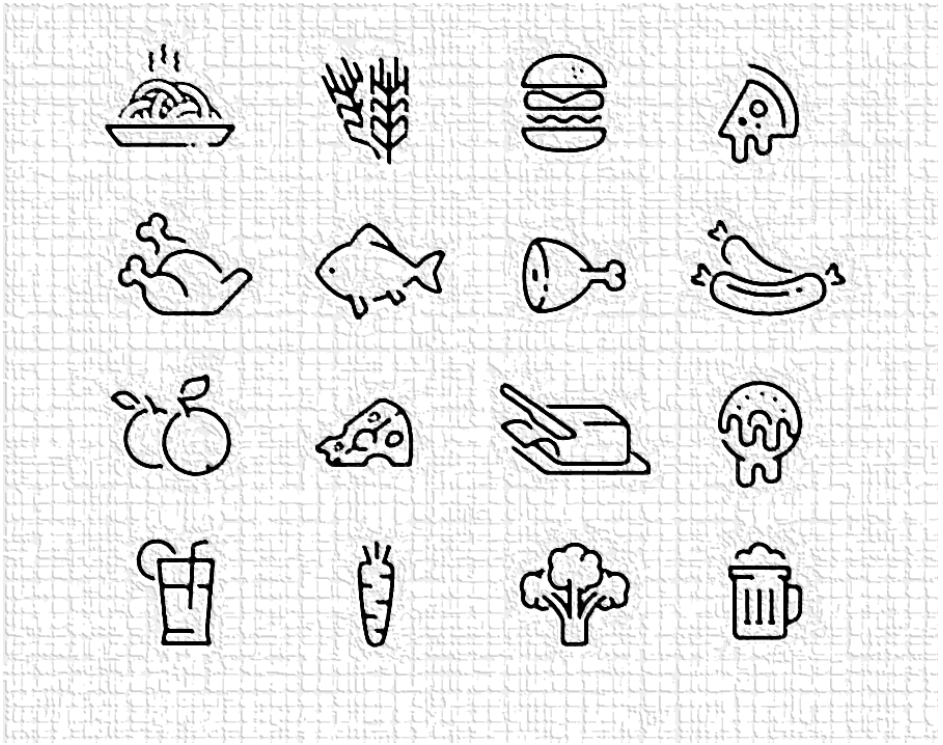
Singapore Food Agency, 1st Feb 2023



Outline of the presentation

- Why is feed safety important
- Hazards in animal feed
- Challenges to ensure feed safety
- Recommendations for sampling and analysis
- Prioritizing hazards in feed
- Singapore experiences



Why is feed safety important?

Animal feed is the largest and most important component of global food industry to ensure the sustainable production of safe and affordable animal proteins to feed the rapidly growing populations and consumption of animal products.

- Feed safety is prerequisite for food safety and human health
- Feed safety is critical for animal health and welfare
- Feed safety is a component of access to trade, income generation and economic sustainability
- Feed safety is a key contributor to feed and food security
- feed is an integral part of the food chain and its safety has been recognized as a shared value and a shared responsibility

Key facts

- World compound feed production is fast approaching ***1*** **billion** tones annually.
- Global commercial feed manufacturing generates an annual turnover of over **US *$370* billion**.
- Commercial production or use of manufactured feed takes place in over ***130*** **countries.**
- The feed sector employs over ***250 000*** skilled workers, technicians, managers and professionals.
- Around ***300*** **million tones** of feed is produced directly by on-farm mixing of feed ingredients and pre-mixes.

https://www.fao.org/feed-safety/background/why-feed-safety/en/

Hazards in Animal Feed

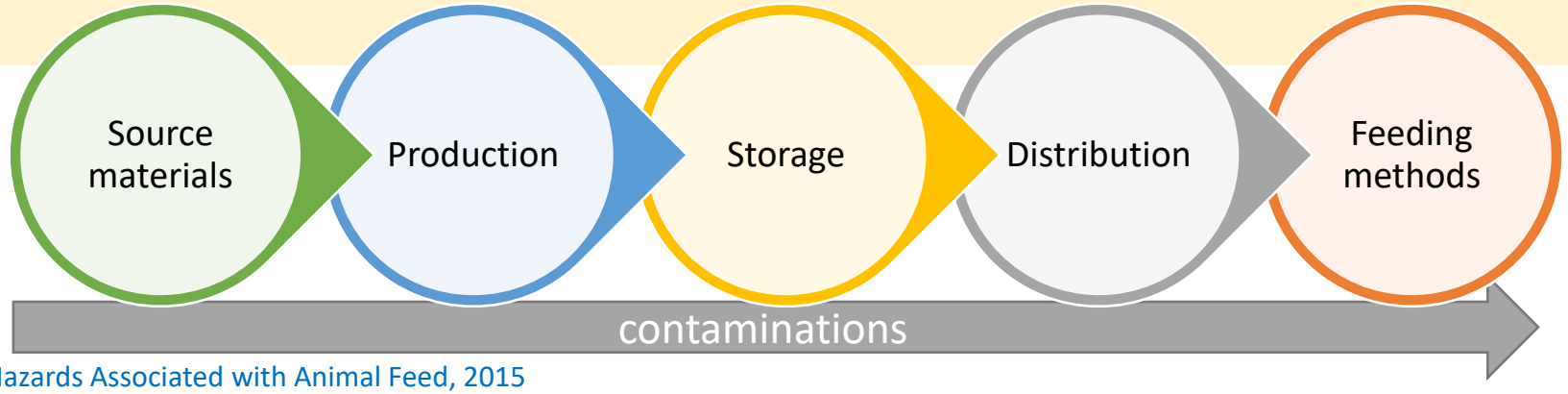
Hazards may be introduced with **source materials** or via **carryover** or **contamination** of products during **production, storage, distribution and feeding**.

Chemical hazards:

- persistent organic pollutants (POPs) such as polychlorinated dibenzo-dioxins (PCDDs) and polychlorinated dibenzo-furans (PCDFs), dioxin-like polychlorinated biphenyls (dl-PCBs) and non-dioxin-like polychlorinated biphenyls (ndl-PCBs);
- veterinary drug residues;
- organochlorine and other pesticides;
- potentially toxic elements (PTEs) (e.g. arsenic, cadmium, lead, mercury);
- Mycotoxins and plant toxins (e.g. genotoxic pyrrolizidine alkaloids and anti-nutritionals such as glucosinolates)
- other potential and emerging chemical hazards.

Biological hazards: bacteria (e.g. Salmonella and Listeria), parasites, viruses and prions

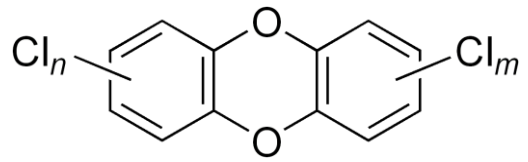
physical hazards: radionuclides, nanomaterials, micro- and nano-plastics



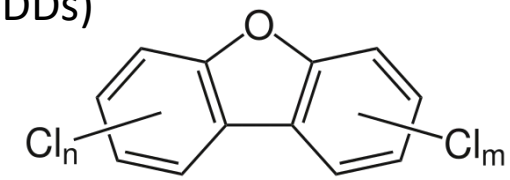
Joint FAO/WHO Expert Meeting on Hazards Associated with Animal Feed, 2015

Chemical Hazards- Persistent Organic Pollutants (POPs)

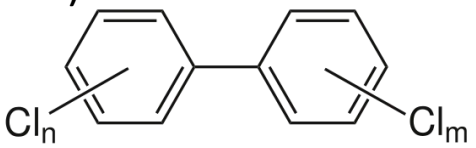
- POPs, such as polychlorinated dibenzo-dioxins, dioxin-like polychlorinated biphenyls (dl-PCBs) and non-dioxin-like polychlorinated biphenyls (ndl-PCBs), are ubiquitous and bioaccumulate in the lipid rich tissues of animals.
- Addressing the food safety risks posed by dioxin and dl-PCBs in feed, requires information on the lipid content of the feed and on the congener profile of these hazards in the feed, which impacts their transfer from feed to food.
- As Dioxin and dl-PCBs are only slowly eliminated, levels found in edible tissues, and milk and eggs, are dependent on the levels in feed and also the duration of exposure.
- More work is needed to better define the risk associated with ndl-PCBs since that are generally present at much higher levels in feed than dioxins and dl-PCBs. Ndl-PCBs accumulate in fat, liver, fillets of oily fish and are also transferred to lipid-rich products like milk and eggs.



Polychlorinated dibenzo-p-dioxins (PCDDs)



Polychlorinated dibenzofurans (PCDFs)



polychlorinated biphenyls (PCB)

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Chemical Hazards- Veterinary Drug Residues

- Feed remains a much-used vehicle for the efficient delivery of veterinary drugs to animals.
- The transfer, metabolism and toxicity of veterinary drugs in feed to animal products is fully assessed as part of the authorization process and establishment of maximum residue limits (MRLs).
- It is noted that non-target species which may be exposed via cross-contamination or carry-over of feed, and this may be an important consideration for risk management.
- There are concerns that residues of antimicrobials may be associated with the development of antimicrobial resistance.

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Chemical Hazards- Organochlorine and other Pesticides

- Organochlorines are persistent, lipophilic compounds that behave much like dioxins and PCBs and are recognized contaminants of fats (e.g. fish oils) used in feeds.
- Transfer to animal products, metabolism and toxicity of specific pesticides used in plants intended for feed production should be examined prior to pesticide authorization and the establishment of MRLs for feeds and foods of animal origin.
- Existing authorization mechanisms and established MRLs may not always reflect the extent of all plant products that may end up in feed.
- Plant products are subject to processing, residues may concentrate in by-products that are used as feeds.

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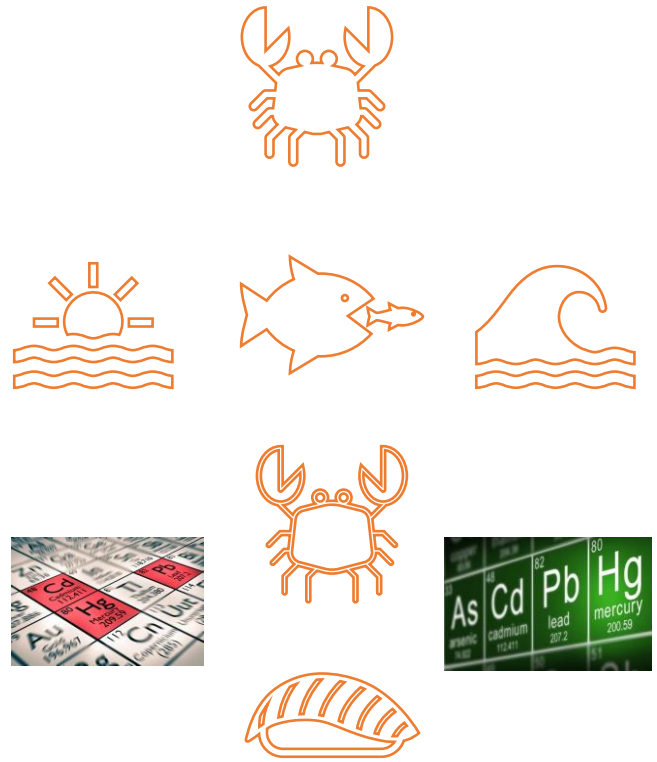
Chemical Hazards- Potentially Toxic Elements (PTEs)

- Arsenic, cadmium, lead, mercury, selenium, copper, nickel and chromium from soil and anthropogenic origin
- Toxin elements are harmful to animals and can be transferred from food to human
- Low transfer rate due to low absorption: inorganic arsenic, lead
- High transfer rate due to significant accumulation: cadmium in crustaceans, methylmercury in fish



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Chemical Hazards- Mycotoxins

- Mycotoxins contaminate farming systems globally.
- When ingested in high concentrations through feeds derived from plant materials, mycotoxins, such as aflatoxins, orchratoxin A, zearalenone, patulin and fumonisins, can seriously affect animal health and productivity.
- There are many yet-unrecognized mycotoxins that may potentially produced by thousands of fungal species and have not been assessed for toxigenicity.
- Some mycotoxins can accumulate in edible tissues and animal products. For example, Ochratoxin A have been reported in meat and milk.
- Many mycotoxins are metabolized by the animals and will not accumulate further in the food supply chain in their initial forms. The metabolites can be retained in animal tissues or excreted by the animal into milk or egg. Aflatoxin M1, a carcinogenic agent and metabolite of aflatoxin B1, has been reported in milk. Most of the mycotoxin metabolites are either not regulated, or the toxicities of them have not been well elucidated.
- Mycotoxins contaminations in animal feed may result in human exposure and health effects. Preventive measures are recommended to mitigate mycotoxin contaminations along the feed chain:
  - ✓ Crop rotation
  - ✓ Resistance breeding to inoculation with microbial antagonists
  - ✓ Storage management.
  - ✓ Continuous monitoring along the feed chain
  - ✓ Efficient detoxification strategies to deal with outbreaks and the risks posed by low level exposure

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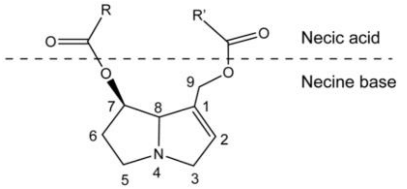
Chemical Hazards- Plant Toxins



- Toxin-producing plants may occur in grasslands used in forage and are a significant cause of livestock poisoning. Transfer of some of these toxins to edible products such as eggs, milk and meat has been demonstrated, for example in the case of genotoxic pyrrolizidine alkaloids.
- Changes in toxin occurrence in plants and concentrations of plant toxins may be caused by climate changes and worldwide an increased occurrence of some toxin producing weeds has been observed which results in a spread of the accompanying risks.
- Also changes in farming practices from migratory herds to expanded settlement and crop cultivation in dry season grazing land can mean that animals have access to a reduced variety of plants and thus potentially greater exposure to toxic plants.
- Addressing this means that efforts are needed to decrease toxicity and anti-nutritional factors in existing and newly available feeds.
- Given the variety of toxic plants, this presents extensive challenges for risk assessment and further data is needed to accurately characterize this type of hazard and the dose–effect relationship.

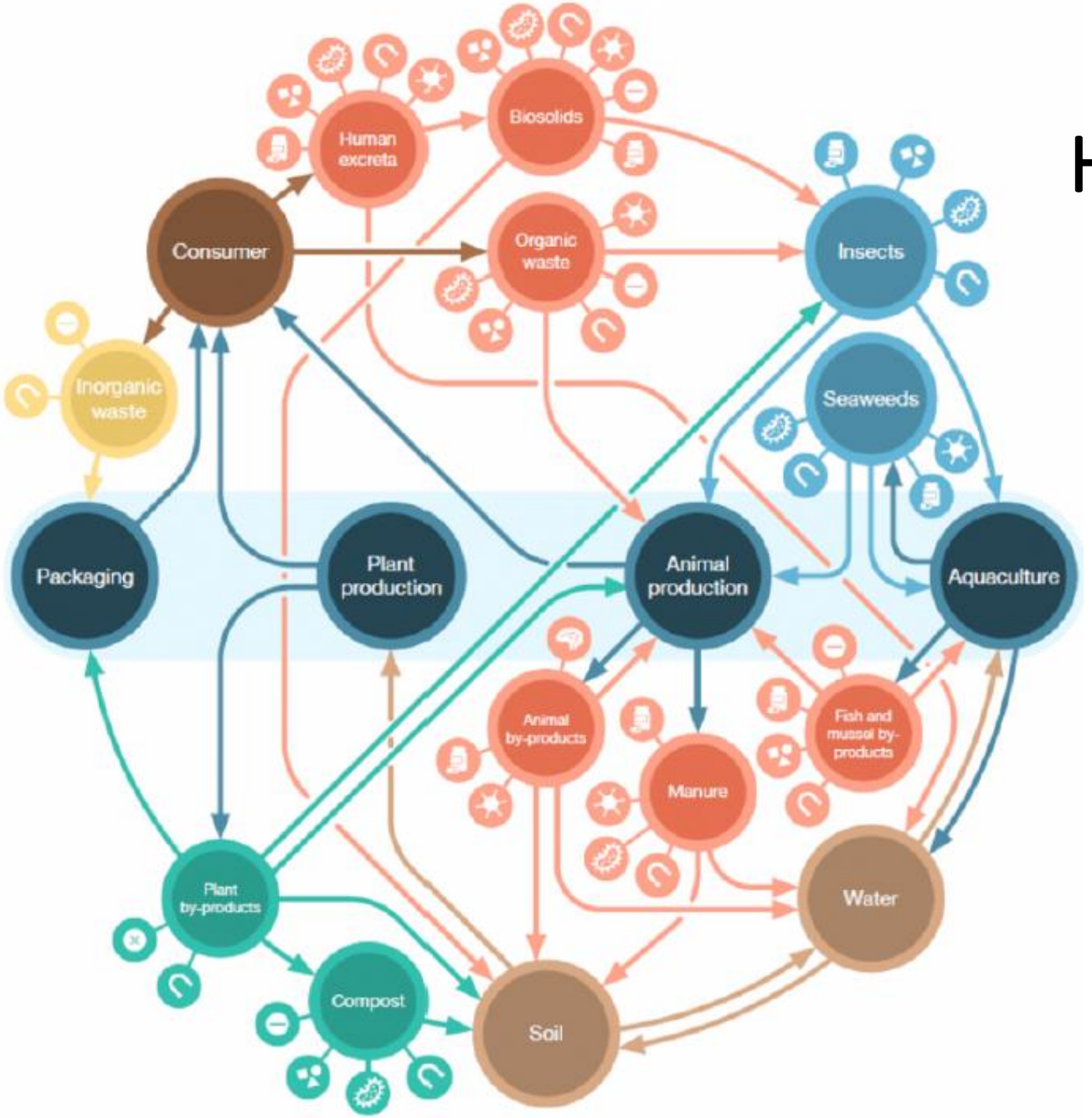
Joint FAO/WHO Expert Meeting on Hazards Associated with Animal Feed, 2015

Emerging Chemical Hazards

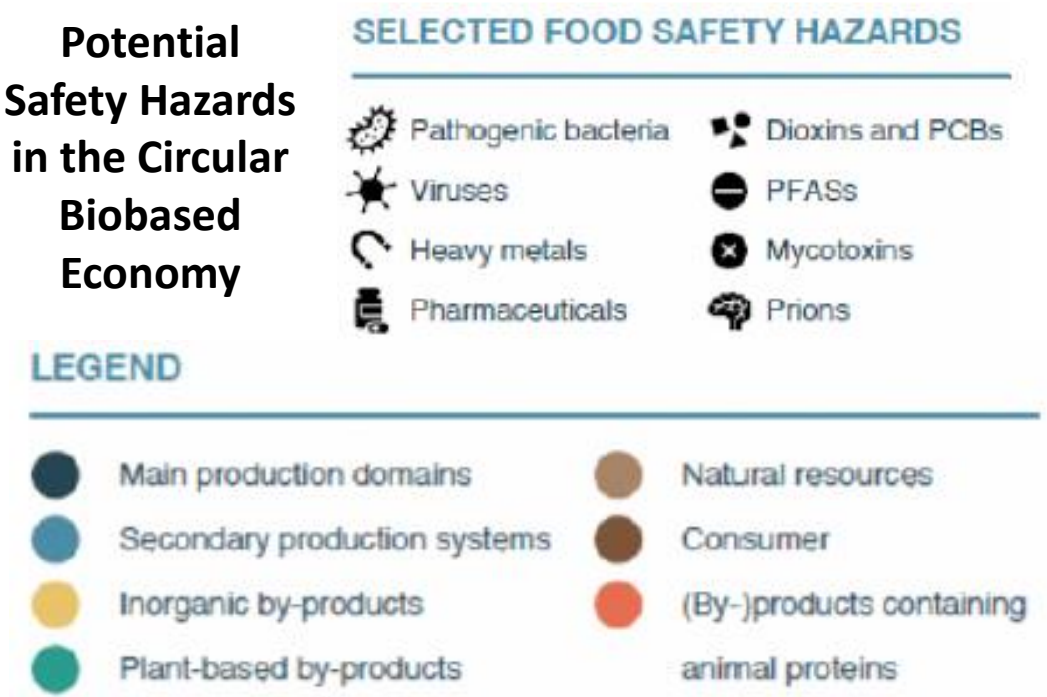
- A range of contaminants including brominated flame retardants and per- and polyfluoroalkyl substances (PFAS),have been shown to be present at low levels in animal feed.
- Insufficient information to assess whether the carry-over via feed of these compounds presents a risk to human and animal health.




Hazards from Unconventional Feed Materials and Feed Production Technologies



Potential Safety Hazards in the Circular Biobased Economy



Review of food safety hazards in circular food systems in Europe, Food Research International 158 (2022) 111505

Challenges to ensure feed safety

- Lack of know-how and awareness on feed safety among all operators along the whole value chain
- Safety risks from new and unconventional feed ingredients entering the production chain e.g. agro-industrial by-products (such as the ones of the biofuel industry), insects, food processing by-products, food wastes, etc.
- Lack of feed regulatory frameworks and fail to implement feed regulations harmonized with the Codex Alimentarius and other international standards and guidelines

Methods of sampling and analysis for monitoring hazards in animal feeds

Sampling protocols should meet scientifically recognized principles and procedures.
Laboratory methods should be developed and validated according to scientifically recognized principles.

Recommendations for sampling and analysis
When defining the sampling procedures one should consider the purpose of sampling, the laboratory analysis through which samples will undergo and the characteristic of the ingredients and finished products.
The objectives and sampling purposes to be achieved should be clear when developing the sampling procedures to be adopted.
Sampling should be done in a well defined area in order to avoid difficulties in the executing of procedures, reduce the risk of contamination and cross contamination, enable the proper execution of laboratory analysis and include all necessary safety and health precautions to the sampler and environment.
Personnel responsible for the sampling activities should be trained on the applicable procedures.
All tools and auxiliary materials should be inert, and in a clean condition before and after their use.
Portions of the material that are non homogeneous should be sampled separately and should not make a composite as it can mask quality problems.
With few exceptions, all incoming ingredients should be sampled upon arrival and inspected for identity, physical purity and compared with a reference sample and standard specifications.
International methods of sampling should be used to ensure that valid sampling procedures are applied when feed is being tested for compliance to a particular standard or objective.
A sampling procedure should stipulate the conditions based on which a lot should be inspected and classified.
Accuracy, precision, specificity, sensitivity, dependability and practicality should be considered when choosing the most appropriate method.
laboratories operating under a recognized quality standard should seek independent approval of their quality assurance arrangements preferably by accreditation which will allow them to demonstrate competency and reliability.

FAO: Good Practices for the feed Industry, 2010

Prioritizing hazards in feed

Multi-criteria Analysis Approach

Step 1- identification of the hazard, the feed and the edible product potentially associated with food safety problems.

Step 2- identification and definition of the criteria by which each selected hazard/feed/edible product combination will be quantified.

Step 3- Assignment of criterion-based values to the hazard/feed/edible product combinations

Step 4- Normalization of these values to make them comparable between criteria

Step 5- Weighing of the criteria to reflect their relative importance.

Step 6- Combining the weighed normalized values for each hazard/feed/edible product combination to produce a score, and ranking of the scores to obtain the order of priority.

Step 7- Reporting of process, method and results

Step 1: aflatoxins/ layer feed/eggs; drugs/fish feed/fish muscle; heavy metals/fish feed/fish muscles; pesticides/broiler feed/poultry meat and fat

Step 2- criterion	**Step 3, 4- normalized values (C)**			**Step5- weighing (W)**	**Step 6- scoring**
	0- low	0.5 - medium	1.0- high		C*W
C1. Occurrence level in feed (% of feed samples exceeding a defined level for the hazard)	<10%	10–25%	>25%	15%	C_1*W_1
C2. Transfer from feed to edible product (based on measurement or modeling)	<5%	5 – 50%	> 50%	40%	C_2*W_2
C3. Toxicity of chemical hazard (health-based guidance value (e.g. ADI or TDI)	> 1 mg/ kg bw/ day	1 µg- 1 mg /kg bw/ day	< 1 µg/ kg bw/ day	30%	C_3*W_3
C4. Impact on feed availability (replacement feed available)	easy	difficult	impossible	15%	C_4*W_4

Score= $C_1*W_1+C_2*W_2+C_3*W_3+C_4*W_4$

Example: mycotoxins/ layer feed/eggs

criterion	**value**	**Normalized value (C)**	**Criterion weight (W)**	**C*W**
C1. Occurrence level in feed (% of feed samples exceeding a defined level for the hazard)	<10%	0	15%	0
C2. Transfer from feed to edible product (based on measurement or modeling)	5-50%	0.5	40%	0.2
C3. Toxicity of chemical hazard (health-based guidance value (e.g. ADI or TDI)	< 1 µg/ kg bw/ day	1.0	30%	0.3
C4. Impact on feed availability s(replacement feed available)	Low	0	15%	0
			Score	**0.5**

Impact of Farming systems (i.e. organic vs conventional) and climate changes will affect mainly C1- occurrence level, which can be monitored by surveillance.

- *Hazard prioritization is part of the **risk management** process within the risk analysis framework.*
- *The **purpose of prioritizing hazards** in feed is to contribute to the safety of edible products by **optimizing allocation of the resources** required for risk assessment and risk management.*

Codex code of practice on good animal feeding (CAC/RCP 54-2004); Codex guidelines on the application of risk assessment for feed (CAC/GL 81-2013) ; Codex guidance for governments on prioritizing hazards in feed (CAC/GL 81-2013)

Singapore Experiences – Overview to SFA's Food Safety System

Vision: Safe Food for All
Mission: To ensure and secure a supply of safe food
(Aspirational Goal- Food safety from farm to fork: Zero foodborne outbreak in SG)

SFA's Food Safety System

(Food Safety is the assurance that food when produced, handled, prepared and consumed in a manner intended, will not cause adverse foodborne risks to consumers.)

Areas

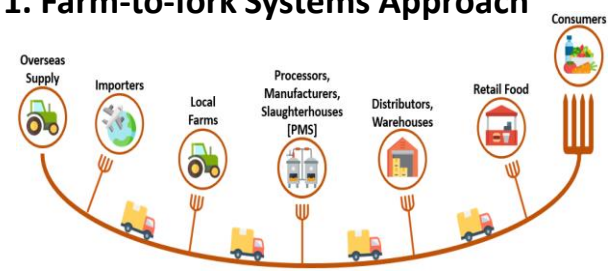
- A. Import Control
- B. Regulation of Local Food Establishments
- C. Capacity-building of Industry (e.g. training & industry standards)
- D. Consumer Education

Actions & Enablers

- Licensing & Permits
- Inspection, Sampling & Testing
- Regulatory Standards & Legislations
- Enforcement
- Incident Management

Principal Considerations

1. Farm-to-fork Systems Approach



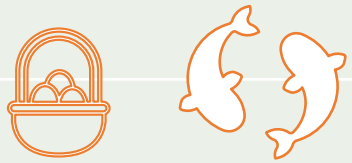
2. Science-based Risk Assessment & Management

3. Joint Food Safety Responsibility

Singapore Experiences- Feed Safety Perspectives

- **Legal power** to ensure feed safety: Feeding Stuffs Act – Regulate animal feed in Singapore; Circulars to farms on prohibited substances for food animals.
- Comprehensive **testing capabilities** by NCFS and laboratories under SFA's Laboratory recognition program (LRP): end product and feed testing for chemical hazards, biological hazards and Physical hazards
- **Research** works to address emerging risks arising from novel food and new feed materials: micro & nano- particles, emerging environmental contaminants (i.e. PFAS), industry hemp as animal feed ingredients, etc.
- **Regulatory standard setting**: e.g. setting MRLs for veterinary drugs in animal products due to carry-over issues in animal feed (e.g. coccidiostats in eggs); harmonization of MRLs for pesticides with Codex standards.
- **Surveillance** and focus studies: monitoring mycotoxins and metabolites in feed, milk and eggs; drug residue monitoring in animal feed and animal products from local farms (fish, egg and milk); dioxin testing in locally farmed fish and eggs; pesticide residues monitoring in imported and locally produced animal products; heavy metal and pathogen testing in animal feed.
- **Local farm risk management frame work**: identify hazards from farming processes, characterize the risks and identify critical control points under the guidance of Codex guidelines, GAP, GMP, GVP and HACCP, and implement risk control measures to ensure feed and food safety.

Hazards	Sample volume in 3 years	Positive detections	Positive Rate %	Details of the detections	Remarks
Veterinary drugs	900	15	1.7%	quail layer feed: 6 cases for Bacitracin with levels ranging from 0.7- 25ppm; fish feed: 4 cases for enrofloxacin with levels ranging from 0.2- 4ppm; fish feed: 2 cases for lincomycin with levels ranging from 0.1-0.2ppm; fish feed: 1 case for amoxicillin at 4.9ppm fish feed: 1 case for florfenicol at 0.1ppm	no residues detected in final animal products, e.g. fish and eggs
Mycotoxins	900	40	4.4%	In both fish and layer feed; 34 samples with levels < 5ppb; 6 samples with levels within the range of 5 - 40ppb	no residues detected in final animal products, e.g. fish and eggs
Pathogens	450	-	-	-	-

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