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THE RELATIONSHIP BETWEEN FEED AND FOOD SAFETY

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Abstract

Food safety continues to be an important issue to the prevention of foodborne illness outbreaks. Animal feed is the beginning of the food safety chain. However, animal feeds can be contaminated with undesirable substances such as dioxins, mycotoxins, heavy metals, pesticides and veterinary drugs at any time during the processing, storage and dispersal. These substance can be transmitted through the food chain to humans and cause human foodborne illness. Therefore, must be paid attention to the absolute safety of feed for animals and consumer. The purpose of this paper is to review the contaminants that can be found in feeds.

Key words: *feed, contamination, food safety, undesirable substances.*

INTRODUCTION

Food safety remains a critical issue to the prevention of outbreaks of foodborne illness all around the world (Egan et al., 2007; Jia and Jukes, 2013). The first goal of the livestock production, which has an important place in terms of food safety, is delivery safe food to human consumption (Gaggía et al., 2010). Animal feed is at the beginning of the food safety chain in the "farm-to-fork" model. Safe feed products enable farms to ensure food safety, reduce production costs, maintain or increase food quality and consistency and enhance animal health and welfare by providing adequate nutrition at every stage of growth and production (Crump et al., 2002). They also can reduce the potential for pollution from animal wastes by providing only necessary amounts of highly bio-available dietary nutrients. Feedstuffs are not only a source of energy and nutrients but can also influence the quality of food in a variety of ways, through the presence of undesirable substances (dioxins, mycotoxins, heavy metals, pesticides and veterinary drugs) that they may contain (Paramithiotis et al., 2009). Feedstuffs can be contaminated with these substances at any time during growing, harvesting, processing, storage and dispersal of feed (Maciorowski et al., 2006). Therefore, must be paid attention to the absolute safety of feedstuffs for animals and consumer. After the different food crises such as BSE scandal in the 1990's, the European Union adopted a fundamental piece of legislation, namely the General Food Law which raised animal feed up to the same level as that of human food in 2002 (Mantovani et al., 2006; Kan and Meijer, 2007; Paramithiotis et al., 2009; FAO and IFIF, 2010; Bryden, 2012). The purpose of this review is explicate the contaminants and toxins in animal feeds.

CONTAMINANTS AND TOXINS IN ANIMAL FEEDS

Animal feeds are commonly subject to contamination from diverse sources, including environmental pollution, activities of insects and microbes. Animal feeds may also contain endogenous toxins arising principally from specific primary and secondary substances produced by fodder plants (FAO, 2004).

VETERINARY DRUGS AND FEED ADDITIVES

Veterinary drugs and feed additives are generally used to animals for disease control and enhancement of performance. Veterinary drugs and feed additives are generally administered on a purpose and an adequate withdrawal time is prescribed. Otherwise, residues of these additives may arise in animal feeds (Lynas et al., 1998). Lynas et al. (1998) indicated that animal feeds may be contaminated with undeclared drugs such as chlortetracycline, sulphonamides, penicillin and ionophores. As a result of this situation, animal products may be contaminated with drug residues administered through the feed and drug residues in animal products are undesirable because of human health implications concerning allergies and the development of antibiotic resistance in disease organisms (FAO, 2004; Kan, 2009).

PESTICIDES

Pesticides are major contaminants of our environment and many persist in the environment including in various feeds and foodstuffs (Garg et al., 2004). The term pesticides includes all chemical, natural or synthetic substances (insecticides, herbicides and fungicides) used to fight against diseases and pests (Cabras, 2003; Stoytcheva, 2011).

Pesticides constitute the major source of potential environmental hazards when they become part of food chain (Sodhi et al., 2006; Hussain et al., 2015). A recent survey indicated that 21 percent of feeds in the United Kingdom contain pesticide residues. Pirimiphos-methyl, an insecticide used in grain stores, was detected with the highest frequency (D'Mello, 2015). Long term exposure to these products causes many abnormalities and reduces the lifespan of organisms (Pourmirza, 2000; Gavrilescu, 2005; Sodhi et al., 2008; Hussain et al., 2011; Mahmood et al., 2012; Hussain et al., 2014).

Most insecticides are neurotoxic and affect the nervous system of the target organisms. The central nervous system of insects is highly developed and not very different to that of mammals. Therefore, chemical compounds that act on the nervous system of insects also have similar effects on man (Cabras, 2003). Also, pesticides affect different organs such as skeletal muscles, GI tract, bladder, secretory glands, and respiratory systems and create various signs and symptoms such as weakness, glandular secretion, fasciculation, acute pancreatitis, convulsion, and respiratory failure (Rahimi and Abdollahi, 2007).

Unlike insectisides, most fungicides are minimally toxic to mammals since they have an oral LD_{50} in rats ranging between 800 and > 15,000 mg kg^{-1} (Cabras, 2003; Rezg et al., 2010).

World Health Organization (WHO) intended toxicity classification based on active ingredients to show the level of danger to consumer (Table 1) (Cabras, 2003).

Table 1. Toxicity Classification

Hazardous Level		**LD_{50} * for the rat (mg kg−1 BW)**			
		Oral		Dermal	
	Class	Solid	Liquid	Solid	Liquid
Extremely	Ia	≤ 5	≤ 20	≤ 10	≤ 40
Highly	Ib	5-50	20-200	10-100	40-400
Moderately	II	50-500	200-2000	100-1000	400-4000
Slightly	III	≥501	≥2001	≥1001	≥4001

* LD_{50} Lethal dose.

Also, it has been published the toxicity levels of various pesticides for mammalian (McBean, 2012). Some of these pesticides toxicity levels are summarized in Table 2.

HEAVY METALS

Heavy metals such as arsenic (As), cadmium (Cd), lead (Pb) and mercury (Hg) are potential bioaccumulative toxicants for animal and human health. An important feature of heavy metals is that the chemical form in which they are present may change during passage of the intestine or storage in animal tissue, but that they are not metabolized (Li et al.,2005; Kan and Meijer, 2007; Bampidis et al., 2013). Earlier studies showed that liver and kidney often show a clear dose response related increase in heavy metal concentration after dietary exposure (Kan, 2009).

Animal feeds need to be assessed as potential sources of heavy metal contamination due to the feed ingredients and the compound feed for animals (especially swine and poultry) are an integral part of the consumer's food chain.

The extensive contamination of various feeds, foods and beverages with heavy metals as well as their constant and continuous use represent a serious risk to animal and human health (Alexieva et al., 2007).

European Commission reported the maximum contents of heavy metals in feeds in 2002 (Table 3) (EC, 2002).

Table 2. Toxicity Levels of Some Pesticides

	LD_{50}* (mg kg^{-1} rats)	NOAEL* (mg kg^{-1} rats)	ADI* (mg kg^{-1} BW)	Toxicity Class
Insecticides				
Organochlorine Compounds				
Aldrin	38-67	-	0.0001	-
DDT	113-118	1	0.02	II
Dieldrin	37-87	-	0.0001	-
Endosulphan	70	15	0.006	II
Organophosphorus Compounds				
Azinphos methyl	9	5	0.005	Ib
Chlorpyrifos	135-163	-	0.01	II
Methamidophos	20	2	0.004	Ib
Parathion	2	2	0.004	Ia
Malathion	1375-2800	100	0.02	III
Carbamates				
Carbofuran	8	20	0.002	Ib
Ethiofencarb	200	330	0.1	II
Methiocarb	20	67	0.001	II
Pirimicarb	147	250	0.02	II
Pyrethroids				
Deltamethrin	135-5000	1	0.01	II
Fenvalerate	451	250	0.02	II
Tau-fluvalinate	261	1	0.01	II
Cypermethrin	250-4150	7.5	0.05	II
Benzoylureas				
Diflubenzuron	> 4640	40	0.02	III
Teflubenzuron	> 5000	8	0.01	III
Triflumuron	> 5000	20	0.007	III
Fungicides				
Dithiocarbamates				
Ziram	320	-	0.02	III
Thiram	2600	1.5	0.01	III
Maneb	> 5000	250	0.03	III
Benzimidazoles				
Thiabendazole	3600	40	0.1	III
Benomyl	> 5000	> 2500	0.1	III
Carbendazim	> 15000	-	0.03	III
Dicarboxamides				
Iprodione	> 2000	150	0.06	III
Procymidone	6800	1000	0.1	III
Vinclozolin	> 15000	1.4	0.01	III
Triazoles				
Propiconazole	1517	3.6	0.02	II
Cyproconazole	1020	1	-	II
Hexaconazole	2189	2.5	0.005	III
Anilinopyrimidines				
Cyprodinil	> 2000	3	0.03	III
Mepanipyrim	> 5000	2.45	0.024	III
Pyrimethanil	> 4150	20	0.2	III
Strobilurines				
Azoxystrobin	> 5000	18	0.2	-
Kresoxin-methyl	> 5000	800	0.4	-

* LD_{50}: Lethal dose, NOAEL: No observed advers effect level, ADI: Acceptable daily intake.

The extensive contamination of various feeds, foods and beverages with heavy metals as well as their constant and continuous use represent a serious risk to animal and human health (Alexieva et al., 2007). European Commission reported the maximum contents of heavy metals in feeds in 2002 (Table 3) (EC, 2002).

Table 3. Maximum contents of heavy metals in feed*

Heavy Metals	Maximum Level (mg kg^{-1})
Arsenic	2
Lead	5
Cadmium	0.5
Mercury	0.1

* feedingstuff with mousture content of 12%

In general, clinical symptoms of heavy metals toxicity in animals and human include kidney and liver damage. Moreover, cadmium, arsenic, lead and mercury exposures have been associated with nephrotoxicity, osteoporosis, neurotoxicity, carcinogenicity and genotoxicity, teratogenicity, and endocrine and reproductive effects (Mantovani et al., 2006; Kan and Meijer, 2007; Bampidis et al., 2013).

MICROBIAL AND FUNGAL CONTAMINATION

Animal feeds can be contaminated with foodborne bacterial pathogens (*Salmonella* spp., *Listeria monocytogenes*, *E. coli*, *Clostiridum* sp.) and toxigenic fungi (genus *Aspergillus* and *Fusarium*) and mycotoxins (Aflatoxins, Ochratoxin A, T-2 toxin, etc.). This includes single feed materials but also heat-treated commercial feeds (Maciorowski et al., 2006; Carrique-Mas et al., 2007; Sapkota et al., 2007; Aury et al., 2011; Jones, 2011; Bryden, 2012; Hald et al., 2012; Cegielska-Radziejewska et al., 2013)

Contamination of feed with pathogenic microorganism or microbial toxins is an important global public health. Because, these pathogens can be transmitted through the food chain to humans and cause human foodborne illness (Crump et al., 2002; D'Mello, 2003; Walls and Bucnahan, 2005; Van Immerseel et al., 2009; Gaggia et al., 2010; Jones, 2011).

The Panel on Biological Hazards identified *Salmonella* spp. as the major hazard for microbial contamination of animal feed. *Listeria monocytogenes*, *Escherichia coli* O157: H7 and *Clostridium* sp. are other hazards for which feed is regarded a far less important source (EFSA, 2008).

In the EU, salmonellosis and campylobacteriosis are the most frequently occurring zoonotic infection in humans (Wierup and Häggblom, 2010). According to EFSA (2014), 214.268 campylobacteriosis, 91.034 salmonellosis and 1642 listeriosis cases were reported in 2012.

Animal feeds may also be contaminated with toxigenic fungi and mycotoxins produced by fungi except for bacterial pathogens (Maciorowski et al., 2007; Richard, 2007; Kumar et al., 2008; Duarte et al., 2011; Bryden, 2012; Cegielska-Radziejewska et al., 2013). Various toxigenic fungi and associated mycotoxins are given in Table 4.

Table 4. Toxigenic fungi and associated mycotoxins*

Fungi	Mycotoxin
Aspergillus flavus, A. parasiticus	Aflatoxins
A. flavus	Cyclopiazonic acid
A. ochraceus; A. carbonarius; Penicillium verrucosum	Ochratoxin A
P. citrinum; P. expansum	Citrinin
Fusarium sporotrichioides; F. poae	T-2 toxin
F. sporotrichioides; F. poae	Diacetoxyscirpenol
F. culmorum; F. graminearum	Deoxynivalenol
F. culmorum; F. graminearum	Zearalenone
F. verticillioides; F. proliferatum	Fumonisins
Alternaria alternata	Tenuazonic acid
Claviceps purpurea	Ergot alkaloids

* Bryden, 2012.

The main sources of fungal microflora in feeds originate from feed materials of plant origin, primarily cereals. Moulds developing on the surface of kernels under field and storage conditions may cause nutrient losses, organoleptic changes, potential formation of mycotoxins. Mycotoxins have been reported to be carcinogenic, teratogenic, tremorogenic, haemorrhagic and dermatitic to a wide range of organisms, and known to cause hepatic carcinoma in human (Kumar et al., 2008; Cegielska-Radziejewska et al., 2013). So, in developing countries the main concern with mycotoxin contamination is animal and human health (Shier et al., 2005).

CONCLUSIONS

Animal feeds may be contaminated with some organic and inorganic compounds and these compounds can be transferred from feed to food in some instances. Removal of contamination from contaminated feed might be technically feasible but generally uneconomic. Therefore, prevention is the most effective proctical strategy. Good Agricultural or Manufacturing Practices, comprehensive legislation and HACCP approach are in place for the control of contamination of these chemical compounds and pathogens in feed.

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