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Animal Feed Safety: Cases and Approaches to Identify the Contaminants and Toxins

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Abstract

Animal feed safety have come to the forefront in recent years, and the feed sector now finds that it needs to be applying food safety measures, which are common practice in human food sector. Animal feeds are routinely subject to contamination from diverse sources, including environmental pollution and activities of insects and microbes. Animal feeds may also contain endogenous toxins arising principally from specific primary and secondary substances produced by fodder plants. Thus, feed toxins include compounds of both plant and microbial origin. Although these toxins are often considered separately, because of their different origins, they share several common underlying features. Feed supply and feed safety are intimately linked due to the fact that feeding stuffs origin, processing, handling and storage, as well as many other factors related to the market, can affect at different levels both quality and safety of feed. Today, we have been witnessing a steady tendency in the increase of global demand for maize, wheat, soybeans, and their products due to the steady growth and strengthening of the livestock industry. Thus, animal feed safety has gradually become more important, with mycotoxins representing one of the most significant hazards.

Keywords: Contaminants; Feed; Safety; Toxin

Introduction

Animal feed safety have come to the forefront in recent years, and the feed sector now finds that it needs to be applying food safety measures, which are common practice in human food sector. Feed must be safe for consumption by the animal. For example, it must be free from mycotoxins and any other chemicals that would be harmful to the animal, and it must not introduce pathogenic microorganisms to the animal. The resulting meat, milk or eggs must also be safe for human consumption. Things to consider here include, for example, the accumulation of pesticides, heavy metals and other toxins with long half-lives in meat and other animal products-things that might not be of concern to the animal itself, but which might be harmful to human health when consumed over time **[4, 8]**.

Safety issues are best controlled by a hazard analysis approach-identifying the realistic potential problems and putting measures in place either to prevent their occurrence or reduce the level of a hazard or the likelihood of its occurrence to acceptable levels. Much of this can be done by standard good hygiene and good manufacturing practices. The sector is actively adapting best practices from the food and medical sectors into animal feed production, and more prescriptive standards are now being formulated and adopted. In addition, legislation surrounding feed safety is now more closely mirroring that which controls food and drink **[4]**.

A number of issues have weakened the public's confidence in the safety and wholesomeness of foods of animal origin. As a result farmers, nutritionists, industry and governments have been forced to pay serious attention to animal feedstuff production, processes, thereby acknowledging that animal feed safety is an essential prerequisite for human food safety. Concerns about these issues have produced a number of important effects including

the ban on the use of processed animal proteins, the ban on the addition of most antimicrobials to farm animal's diets for growth promotion purposes, and the implementation of feed contaminant regulations in the EU. In this context it is essential to integrate knowledge on feed safety and feed supply. Consequently, purchase of new and more economic sources of energy and protein in animal diets, which is expected to conform to adequate quality, traceability, environmental sustainability and safety standards, is an emerging issue in livestock production system **[16]**.

Animal feeds are routinely subject to contamination from diverse sources, including environmental pollution and activities of insects and microbes. Feed contaminants and toxins occur on a global scale but there are distinct geographical differences in the relative impact of individual compounds. The term "feed" is generally used in its widest context to include compound blends of straight ingredients as well as forages. With such a broad perspective, it is necessary and more instructive to introduce some focus. Consequently, this article is limited to a review of those contaminants and toxins that represent significant risks to farm livestock. Feed contamination arising from insect fragments and excreta will not be addressed, but the role of such vectors in the transmission of fungal spores and hyphae should not be ignored **[16]**. Legal control of certain feed contaminants and toxins is in place and operating within a continually evolving framework; the salient issues will be briefly reviewed here. Therefore, the main objectives of this manuscript were to review the general aspects of animal feed safety by focusing on both past and recent researches at global prospective.

What is feed safety?

Different studies stated that the terms feed safety and feed quality can sometimes be confusing. According to **[2]** feed safety refers to all those hazards, whether chronic or acute, that may make feed injurious to the health of the animals and also humans. It is not negotiable. Quality includes all other attributes that influence a product's value to the consumer. This includes negative attributes such as spoilage, contamination with filth, discoloration, off-odours and positive attributes such as the origin, colour, flavour, texture and processing method of the feed. This distinction between safety and quality has implications for public policy and influences the nature and content of the feed control system most suited to meet predetermined national objectives. Factors which contribute to potential hazards in feeds include improper agricultural practices; poor hygiene at all stages of the feed chain; lack of preventive controls in feed processing and preparation operations; misuse of chemicals; contaminated raw materials, ingredients and; inadequate or improper storage, etc. Specific concerns about feed hazards have usually focused on: Microbiological hazards, Pesticide residues, Misuse of food additives, Chemical contaminants, including biological toxins and Adulteration.

Who and what is involved in feed safety?

According to different research report, two specific groups of people are involved in maintaining feed safety and quality: the manufacturers of the individual ingredients (both the basic grain raw material and the nutritional supplements and formulation enhancers), and the compounders and feed manufacturers. In essence, they are looking to assure feed safety, including the minimization of contamination, control the cost of raw materials, and optimize their quality **[4]**.

Why is feed safety important?

The data from different studies explain that animal feed plays a leading role in the global food industry and it is the largest and most important component to ensure the sustainable production of safe and affordable animal proteins. Rapidly growing populations, along with increased urbanization and income, is expected to rise the consumption of animal products by 70% in 2050. The increase in animal production will require an additional amount of feed to be produced. The challenge is not only to meet the growing demand for feed, but to ensure its safety **[16]**. Feed safety is a prerequisite for food safety and human health, as well as a necessity for animal health and welfare. It is a component of access to trade, income generation and economic sustainability. In addition, it contributes to feed and food security and decreases feed losses. In fact, feed is an integral part of the food chain and its safety has been recognized as a shared value and a shared responsibility. Feed production must thus be subject, in a similar manner as food production, to the quality assurance of integrated food safety systems **[16]**.

According to **[26]** the role of animal feed in the production of safe food is recognized worldwide, and several critical incidents have underlined its impact on public and animal health, feed and food trade, and food security. For instance, the following are all related to animal feeding: Bovine Spongiform Encephalopathy; Foot-and-Mouth Disease; dioxin, mycotoxin, E.coli O157:H7 contaminations; and the development of antimicrobial resistance. Work on the application of the risk analysis framework provided by Codex in the field of animal feeding has facilitated the further understanding of the role of animal feed safety on public health and of the importance of risk-based measures to prevent and control hazards. Hazards may be introduced with source materials or via carryover or contamination of products during handling, storage and transportation. In many countries adequate know-how and sufficient awareness are lacking to ensure feed safety among all operators along the whole value chain. Even where more knowledge is available and control systems are in place, new and unconventional feed ingredients are 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., and with them, possibly new safety risks. Moreover, many countries still lack feed regulatory frameworks and fail to implement feed regulations harmonized with the Codex Alimentarius and other international standards.

Animal feed contaminants and toxins

Evidence from different studies provide that animal feeds contain endogenous toxins arising principally from specific primary and secondary substances produced by fodder plants. Thus, feed toxins include compounds of both plant and microbial origin. Although these toxins are often considered separately, because of their different origins, they share several common underlying features. Thus, particular compounds within both plant and microbial toxins may exert anti-nutritional effects or reduce reproductive performance in farm animals. Furthermore, the combined effects may be the result of additive or synergistic interactions between the two groups of compounds. The extent and impact of these interactions in practical livestock feeding remain to be quantified **[20]**.

According to **[31]** contaminant is a substance which not intentionally added to food / feed, but present in food as a result of production (including operations carried out in crop husbandry, animal husbandry and veterinary medicine), manufacture, processing, preparation, treatment, packaging, transport or holding of such food or as a result of environmental contamination. The term toxic or anti-nutritional factor is commonly used when referring to those substances found in foods / feeds which produce deleterious effect on ingestion by man or animals. In general, the term implies to those substances which are lethal beyond a given level of intake and on prolonged ingestion produces adverse physiological responses.

Contaminants		
Physical	**Chemical**	**Biological**
Extraneous matter (hair, husk, bolts, stones, nuts etc)	Pesticides	Mycotoxins
Insect infestation	Drugs/antibiotics	Pathogenic microorganisms
Rodent excreta	Heavy metals	Hormones
Weeds	Environmental contamination (PAH, Purnas)ioxins, Furnas	Allergen
	Radioactive contamination	

Table1. Contaminants in animal feed.

Different research done on feed safety show that animal feeds can be contaminated with a wide range of contaminants, which include:

1. Environmental contamination
2. Bacterial contaminants
3. Fungal contaminants
4. Mycotoxins
5. Plant toxins
6. Weed seeds
7. Undeclared additives

Environmental Contaminants

Van Bameveld,1999 **[33]** says that, a wide range of organic and inorganic compounds may occur in feedstuffs, including pesticides, industrial pollutants, radio nuclides and heavy metals. Pesticides that may contaminate feeds originate from most of the major groups, including organochlorine, organophosphate and pyrethroid compounds. Dioxins and polychlorinated biphenyls (PCBs) are examples of industrial pollutants that may contaminate feeds, particularly herbage. Cows grazing pastures that are close to industr-ial areas produce milk with higher dioxin content than cows from rural farms. In 1999, dioxin-contaminated animal fat was inadvertently added to animal feeds destined for Belgian, French and Netherlands farms. Unacceptable levels of dioxins were found in meat products and eggs from these farms.

The research done on environmental contamination shows that human health considerations are also paramount in the monitoring of radionuclide pollution. Following the Chernobyl accident in 1986, caesium-134 and caesium-137 were released, causing widespread contamination of pastures and conserved forages. As a consequence, milk and sheep carcasses became contaminated and restrictions were imposed on the movement and slaughter of sheep **[25]**. Contamination of feeds and herbage with cadmium may occur as a result of applying certain types of fertilizers to crops and pastures. On the other hand, lead contamination arises from industrial and urban pollution, while mercury in feeds arises from the use of fishmeal.

Bacterial Contaminants

Different researchers are done their researches on this area. According to their finding there is currently considerable interest in the occurrence of *Escherichia coli* in animal feeds following the association of the O157 type of these bacteria with human illness. In a recent United States study **[23]**, 30 percent of cattle feed samples obtained from commercial sources and farms contained *E. coli*, although none of the tests for *E. coli* O157 were positive. Replication of faecal *E. coli*, including the O157 type, was demonstrated in a variety of feeds under conditions likely to occur on cattle farms in the summer months. Since faecal contamination of feeds is widespread on farms, it is an important route for exposure of cattle to *E. coli* and other organisms.

Jeffrey JS, et al. (1998) **[19]** also shows on his research report that the potential for exposure to bacteria also exists when poultry litters are fed to cattle (in California, for example, two such poultry waste products are commercially available for use as cattle feed). However, providing the products are adequately heat processed prior to distribution, the risks of contamination with *E. coli*, *Salmonella* spp. and *Campylobacter* spp. are likely to be minimized or even eliminated. Nevertheless, it is worth noting that *S. enterica* commonly occurs in cattle feeds in the United States, Europe and South Africa, with contamination rates ranging from 5 to 19 percent.

According to **[21]** *Listeria monocytogenes* tends to occur in poor-quality silages and big-bale silage. When grass is ensiled under anaerobic conditions, the low pH regime ensures that *Listeria* is excluded from the resulting silage. However, in big-bale silage a degree of aerobic fermentation may occur, raising pH levels and allowing the growth of *Listeria*. These bacteria also survive at low temperatures and in silages with high levels of dry matter. Contamination of silage with *Listeria* is important as it causes abortion, meningitis, encephalitis and septicaemia in animals and humans. The incidence of various forms of listeriosis has been increasing in recent years.

Fungal Contaminants

Different research reports revealed that there are consistent reports of worldwide contamination of feeds with fungi and their spores. In the tropics, *Aspergillus* is the predominant genus in dairy and other feeds **[9]**. Other species include *Penicillium*, *Fusarium* and *Alternaria*, which are also important contaminants of cereal grains **[10]**. Fungal contamination is undesirable because of the potential for mycotoxin production (see next section). However, spores from mouldy hay, silage, brewers' grain and sugar-beet pulp may be inhaled or consumed by animals with deleterious effects termed "mycosis". Common examples of such conditions include ringworm and mycotic abortion. The latter may occur in cattle as a result of systemic transmission and subsequent proliferation in placental and foetal tissues.

Mycotoxins

Different research was done on mycotoxins but, according to **[11]** Mycotoxins are those secondary metabolites of fungi that have the capacity to impair animal health and productivity. The diverse effects precipitated by these compounds are conventionally considered under the generic term "mycotoxicosis", and include distinct syndromes as well as nonspecific conditions. A list of the principal mycotoxins occurring in feeds and forages is given in **(Table 2)**, which also indicates the fungal species associated with the production of these contaminants. Mycotoxin contamination of forages and cereals frequently occurs in the field following infection of plants with particular pathogenic fungi or with symbiotic endophytes. Contamination may also occur during processing and storage of harvested products and feed whenever environmental conditions are appropriate for spoilage fungi. Moisture content and ambient temperature are key determinants of fungal colonization and mycotoxin production. It is conventional to subdivide toxigenic fungi into "field" (or plantpathogenic) and "storage" (or saprophytic/spoilage) organisms. *Claviceps*, *Neotyphodium*, *Fusarium* and *Alternaria* are classical representatives of field fungi while *Aspergillus* and *Penicillium* exemplify storage organisms. Mycotoxigenic species may be further distinguished on the basis of geographical prevalence, reflecting specific environmental requirements for growth and secondary metabolism. Thus, *Aspergillus flavus*, *A. parasiticus* and *A. ochraceus* readily proliferate under warm, humid conditions, while *Penicillium expansum* and *P. verrucosum* are essentially temperate fungi. Consequently, the *Aspergillus* mycotoxins predominate in plant products emanating from the tropics and other warm regions, while the *Penicillium* mycotoxins occur widely in temperate foods, particularly cereal grains. *Fusarium* fungi are more ubiquitous, but even this genus contains toxigenic species that are almost exclusively associated with cereals from warm countries. An emerging feature is the co-production of two or more mycotoxins by the same species of fungus **(Table 2)**. This observation has enabled a fresh interpretation of the causes of well-known cases recorded in the history of mycotoxicoses.

Mycotoxins	Fungal species
Aflatoxins	Aspergillus flavus; A. parasiticus, A. flavus
Cyclopiazonic acid	Ochratoxin A A. ochraceus; Penicillium viridicatum; P.
cyclopium	Citrinin P. citrinum; P. expansum
Patulin P. expansum	Citreoviridin P. citreo-viride
Deoxynivalenol Fusarium culmorum; F. graminearum	T-2 toxin F. sporotrichioides; F. poae
Diacetoxyscirpenol F. sporotrichioides; F. graminearum; F. poae	Zearalenone F. culmorum; F. graminearum; F.
sporotrichioides	Fumonisins; moniliformin; fusaric acid F. moniliforme
Tenuazonic acid; alternariol; alternariol	methyl ether; altenuene
Alternaria alternata	Ergopeptine alkaloids Neotyphodium coenophialum
Lolitrem alkaloids N. lolii	Ergot alkaloids Claviceps purpurea
Phomopsins Phomopsis leptostromiformis	Sporidesmin A Pithomyces chartarum
Mycotoxins Fungal species	Aflatoxins Aspergillus flavus; A. parasiticus
Cyclopiazonic acid A. flavus	Ochratoxin A A. ochraceus; Penicillium viridicatum; P.

cyclopium	Citrinin P. citrinum; P. expansum
Patulin P. expansum	Citreoviridin P. citreo-viride
Deoxynivalenol Fusarium culmorum; F. graminearum	T-2 toxin F. sporotrichioides; F. poae
Diacetoxyscirpenol F. sporotrichioides; F. graminearum; F. poae	Zearalenone F. culmorum; F. graminearum; F.
sporotrichioides	Fumonisins; moniliformin; fusaric acid F. moniliforme
Tenuazonic acid; alternariol; alternariol	methyl ether; altenuene
Alternaria alternata	Ergopeptine alkaloids Neotyphodium coenophialum
Source: D'Mello and Macdonald, 1998	

Table 2. Origin of principal mycotoxins occurring in common feeds and forage.

Aflatoxins

According to different studies report this group includes aflatoxin B1, B2, G1 and G2 (AFB1, AFB2, AFG1 and AFG2, respectively). In addition, aflatoxin M1 (AFM1) has been identified in the milk of dairy cows consuming AFB1-contaminated feeds. The aflatoxigenic *Aspergilli* are generally regarded as storage fungi, proliferating under conditions of relatively high moisture/humidity and temperature. Aflatoxin contamination is, therefore, almost exclusively confined to tropical feeds such as oilseed by-products derived from groundnuts, cottonseed and palm kernel. Aflatoxin contamination of maize is also an important problem in warm humid regions where *A. flavus* may infect the crop prior to harvest and remain viable during storage. Surveillance of animal feeds for aflatoxins is an ongoing issue, owing to their diverse forms of toxicity and also because of legislation in developed countries **[11]**. In the United Kingdom, analysis conducted during the 1987-1990 period indicated that all imported feedstuffs complied with legislation in force for AFB1 levels. Elsewhere, however, aflatoxin levels in certain feeds still pose serious risks to animal health. Thus, in India total aflatoxin levels of 3 700 g/kg were detected in a sample of groundnut cake. Of potentially greater significance is the contamination of maize samples in China and northern Viet Nam with combinations of AFB1 and *Fusarium* mycotoxins. In China, 85 percent of maize samples were contaminated with both AFB1 and fumonisin B1 at levels ranging from 8 to 68_g/kg and 160 to 25 970_g/kg, respectively. Feed-grade maize in northern Viet Nam had AFB1 levels ranging from 9 to 96 _g/kg, and fumonisin B1 levels in the range of 271 to 3 447 g/kg **[30]**. Between 1988 and 1989, analyses of farmgate milk in the United Kingdom showed low levels of AFM1 contamination, but more than 50 percent of milk samples in the United Republic of Tanzania were found to contain the mycotoxin **[11]**. The importance of aflatoxins in animal health emerged in 1960, following an incident in the United Kingdom in which 100 000 turkey poults died from acute necrosis of the liver and hyperplasia of the bile duct ("turkey X disease"), attributed to the consumption of groundnuts infected with *Aspergillus flavus*. This event marked a defining point in the history of mycotoxicoses, leading to the discovery of the aflatoxins. Subsequent studies showed that aflatoxins are acutely toxic to ducklings, but ruminants are more resistant. However, the major impetus arose from epidemiological evidence linking chronic aflatoxin exposure with the incidence of cancer in humans.

Plant Toxins

The data from **[12]** study explain that many plant components have the potential to precipitate adverse effects on the productivity of farm livestock. These compounds are present in the foliage and/or seeds of virtually every plant that is used in practical feeding. Typical concentrations for selected toxins are presented in **(Table 2)**. Plant toxins may be divided into a heat-labile group, comprising lectins, proteinase inhibitors and cyanogens, which are sensitive to standard processing temperatures, and a heat-stable group including, among many others, antigenic proteins, condensed tannins, quinolizidine alkaloids, glucosinolates, gossypol, saponins, the non-protein amino acids S-methyl cysteine sulphoxide and mimosine, and phyto-oestrogens. The role of these substances as antinutritional factors has been considered at length by but the salient points are worth reiterating.

Weed Seeds

The research done on weed seed by Dozier.W.A, 2012 show that weed seeds are a common contaminant that may go unnoticed if not considered in assessing incoming feed ingredient samples. A routine feed microscopy monitoring program is an excellent way to screen for weed seeds along with more routine feed analysis. Feed manufacturers are constantly monitoring incoming feed ingredients for a wide range of contaminants and toxic substances. Established limits for a number of compounds and decades of improvements in testing methods make it easy for companies to evaluate everyday variables in buying grain and protein sources.

According to **[5]** Weed seeds are constantly found in coarse grains used in pig feed. Some weed seeds are highly poisonous and toxic, and can cause severe illness and death. Others are non-toxic but can interfere with digestion or severely lower nutrient intake, reducing growth. Many factors affect their toxicity level, including season, where they are grown, whether the seeds are ground and how they are stored. Contamination of animal feeds with weed seeds is a major problem worldwide. The impact of weed seeds arises from the toxins they contain and from their diluents effects on nutrient density of feeds. The toxins include particularly alkaloids,

saponins, amino acids and proteinase inhibitors. Examples of weed seeds that are controlled by legislation in various countries include those of *Datura* spp., common vetch, castor-oil plant and *Crotalaria* spp.

Undeclared Additives

Lynas L, 1998 **[23]** says that, animal products are frequently contaminated with drug residues administered through the feed. Such feed additives may be used for disease control and the enhancement of livestock performance. Residues may also arise through contamination of animal feeds with undeclared drugs. The occurrence of these drugs is mostly due to cross-contamination in feed mills. For example, medicated feed residues may be retained within equipment and then contaminate subsequent batches of feed. Under these conditions, levels of contamination may be low but sufficient to cause detectable residues in animal products. In addition **[24]** examined the extent of feed contamination with undeclared antimicrobial additives in Northern Ireland. Of 247 medicated feeds, 35 percent were found to contain undeclared antimicrobials; and of 161 un medicated feeds, 44 percent were shown to contain antimicrobials. The contaminants most frequently identified included chlortetracycline, sulphonamides, penicillin and ionophores. Sulphadimidine in contaminated feeds was sufficient to cause violative tissue residues if consumed by animals in the finishing stages. It is possible that feed contamination with undeclared antimicrobials is a global problem warranting further investigation. Drug residues in animal products are undesirable because of human health implications concerning allergies and the development of antibiotic resistance in disease organisms.re worth reiterating.

How and Why Feed Staffs Contaminated?

It takes several steps to get feed from farm to fork. We call these steps, "The feed production chain". Contamination can occur at any point along this chain. Production, processing, distribution and preparation. Modern feed mills produce a wide range of products on a daily basis, regardless of whether they have one or several processing lines. Formulated diets are often composed of more than 20 ingredients and each of the ingredients is carefully selected based on the nutritional quality, safety, price, and availability **[3]**.

Safe ingredients are important for the production of safe animal feed, which is in turn important for animal health, production of safe animal products for human consumption, and for the environment. To ensure security in the agro-food chain, the feed mills are obliged to control all raw materials and products for the presence of possible contaminants as well as to test numerous samples on a daily basis **[27]**. Mycotoxins are a major contaminant of feed ingredients and products. Since these secondary metabolites of molds are toxic, feed producers have to ensure that concentrations of these contaminants do not exceed maximum allowed values for a specific mycotoxin. The occurrence of mycotoxin is a significant global challenge, accompanied by rising animal and human health hazards and huge financial losses in the food and feed production industries **[14, 29]**.

According to **[15]** Contamination of feed stuffs and ingredients with different contaminants poses a major problem for animal health and the transmission of toxic substances within the animal feed chain, as these toxins ca be accumulated in to meat, egg and milk products. Mycotoxins are known worldwide as fungus-produced toxins that adulterate a wide heterogeneity of raw feed ingredients and final products. Molds are fungi that grow in multicellular colonies, as compared with yeasts that are single cellular fungi. Contaminants can be produced in feed staffs either pre-harvest or post-harvest, during storage, transport, processing, or feeding. Mold growth and mycotoxin production are related to weather extremes (causing plant stress or excess hydration of stored feedstuffs), to inadequate storage practices, to low feedstuff quality, and to faulty feeding conditions. In general, environmental conditions-heat, water, and insect damage-cause plant stress and predispose plants in the field to mycotoxin contamination. Because feedstuffs can be contaminated pre-harvest, control of additional mold growth and mycotoxin formation is dependent on storage management. After harvest, temperature, moisture content, and insect activity are the major factors influencing mycotoxin contamination of feed grains and foods **[6]**. Molds grow over a temperature range of 10-40° C (50-104° F), a pH range of 4 to 8, and above 0.7 aw (equilibrium relative humidity expressed as a decimal instead of a percentage). Mold can grow on feeds containing more than 12% to 13% moisture. In wet feeds such as silage, molds will grow if oxygen is available and the pH is suitable. Because most molds are aerobic, high moisture concentrations that exclude adequate oxygen can prevent mold growth **[22]**. A feed safety criteria based only on testing of the end product would not be an effective way to ensure absence of Salmonella contamination. Therefore, establishment of one or more process hygiene criteria at critical stages of the feed production chain, including at the end product stage, is more efficient **[7]**.

Animal Feed Safety Management

Declan.J.Bolton, 2004 **[2]** state that in the food industry in general, food safety control is achieved using prerequisite procedures and a Hazard Analysis and Critical Control Point (HACCP) plan. Prerequisites are steps or procedures followed to ensure that a food production / handling environment is favorable for the production of safe food. Prerequisites include such factors as premises and structures, services (e.g. water, waste disposal), personnel, equipment, pest control, cleaning, and supplier and delivery control. The prerequisites provide the foundation for effective HACCP implementation and should be in operation before HACCP. HACCP is a systematic approach to food safety and should be used to control hazards associated directly with food processes that are deemed to be significant by risk assessment.

Although it has been characterized in a number of publications, farm animals are typically grazed on grass, provided with feed purchased outside the farm or fed fodder produced on the farm (e.g. silage, hay). Animal feed safety has received a lot of attention in recent years. The BSE crisis led to the elimination of meat and bone meal from animal feed. Furthermore, feedstuffs have been associated with the transmission of pathogens such as *Salmonella* and *E. coli* O157. Feed manufacturers frequently subject feed to a heat treatment in order to eliminate such contaminants. Biological agents can also lead indirectly to chemical residue problems, e.g. feed contaminated with fungi which may produce mycotoxins **[18, 8]**.

Poor quality silage can also present an indirect food safety risk. It is vital that silage making and storage is optimal to prevent the growth of pathogens. **[17]** Demonstrated that *E. coli* O157, applied in slurry to grass that was subsequently made into silage and stored under conditions permitting aerobic spoilage (i.e. improperly sealed), could multiply to numbers exceeding 106 g-1 of silage.

Guidelines to prevent food safety problems due to feed include:

According to **[28]** report the following are the guide line followed to prevent the problems to be happen due to feed safety cases.

- Purchase of feed from a reputable supplier with a feed safety system in operation.
- Use of feed according to manufacturers' recommendations (e.g. feed for animal species intended).
- Particular care must be taken with medicated feed.
- Feed must never contain prohibited ingredients (e.g. meat and bone meal).
- Proper feed storage facilities (clean, dry and bird / vermin proof).
- Produce silage to the highest quality possible. Assessment of grass sugar levels can help establish if additives (i.e. acids, sugars, enzymes or bacterial inoculants) will improve silage fermentation. Wilting of grass can also help the fermentation process. Furthermore, attention to cleanliness (i.e. avoiding soil contamination), covering and sealing are important for proper fermentation.
- If cereal crops grown on the farm are fed to animals, the withdrawal dates for pesticides should be adhered to in order to prevent chemical residue contamination.

As reported by different researcher finding at present there are conflicting reports regarding the effect of food withdrawal prior to slaughter on pathogen contamination. Feed withdrawal has traditionally been advocated in order to reduce the faecal contamination at time of slaughter. However, some studies point towards increased shedding of pathogens such as *E. coli* O157 in fasting animals. There are also conflicting reports regarding the effect of diet on pathogen shedding. At present, it is impossible to recommend one diet over another. However, research is ongoing. In the future, farmers may well use animal feed supplemented with probiotics (beneficial bacteria) to help reduce animal gut colonisation by pathogens **[1]**.

Conclusion

It is clear that the basic issues surrounding feed production and formulation are similar to those facing producers of food for humans. The product has to be safe and effective (and cost-effective), and sustainable. As well as customer and business requirements acting as drivers, there is also legislation to ensure safety. Again, this is broadly similar to the situation faced by the food industry, and the steps that the feed industry must take are also similar. Many of the services that we offer to the food industry are equally applicable to the feed industry, such as analytical services, HACCP and legislation advice.

Animal feed, including herbage, may be contaminated with organic and inorganic compounds as well as with particulates. Organic chemicals comprise the largest group and include plant toxins, mycotoxins, antibiotics, prion proteins and pesticides. Inorganic compounds include heavy metals and radionuclides. Particulates such as weed seeds and certain bacterial pathogens are common contaminants of feed. The effects of feed contaminants and toxins range from reduced intake to reproductive dysfunction and increased incidence of bacterial diseases. Residues transferred to edible animal products represent another reason for concern. Comprehensive legislation is in place for the control of several of these chemical compounds and pathogens in feed. However, in many developing countries, particularly in Africa, statutory control of contaminants is at best rudimentary. The scope for decontamination of feeds is limited and generally uneconomic, and prevention is the most effective practical strategy.

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