Ensuring the safety of animal feed

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Summary: A general outline is presented of measures for the production of safe animal feed. This is based on the setting of so-called 'feed safety objectives' which make use of principles that relate to animal health, animal welfare, legal aspects of farm practices and human food safety objectives for products of animal origin. Particular emphasis will be put on the types of feed used in relation to feedborne animal diseases caused by infectious and chemical agents and on the relationship between animal feed and zoonotic foodborne diseases. In addition the influence of feed on animal welfare will be discussed.

To produce safe animal feed, a pro-active control system is advocated. This approach has been very successful in relation to human food and involves the use of 'good manufacturing practices' (GMP) and the 'hazard analysis critical control point' (HACCP) concept as the main tools. However, it has been shown that the HACCP-system has certain shortcomings. To counteract these shortcomings, product traceability and hazard early-warning systems have been developed and will also be presented.

Keywords: Feed, health, welfare, environment, legislation, food safety

Introduction: Feedstuffs play an important role in maintaining the health of production animals and therefore of humans. In relation to food safety, the slogan 'healthy animals, healthy humans' is often used to demonstrate the clear relationship that exists between the health status of animals and that of human beings. Experience has shown that the transmission of diseases from domestic animals to man can only be prevented effectively by improving the health care of the animals themselves. It is even more of a challenge to prevent the transmission of zoonotic agents because, as the human population has increased, there has been a concomitant increase in the number of production animals. Factors involved in disease control include the availability of safe feedstuffs, husbandry practices, immunisation and the use of antimicrobials and other veterinary drugs. Strategies that have been explored to control foodborne human pathogens include the administration of selected microbial cultures to piglets and day-old chicks in order to establish a balanced gut microflora and increase colonisation resistance. In the case of ruminants, attempts have been made to reduce carriage of Escherichia coli O157 by using special dietary formulations. However, neither of these approaches to gut flora manipulation has been entirely successful.
In this overview, a general outline is presented of measures for the production of safe animal feed. This is based on the setting of so-called ‘feed safety objectives’ which make use of principles that relate to animal health, animal welfare, legal aspects of farm practices and human food safety objectives for products of animal origin.

1. **General outline:** A general outline of an approach to the production of safe animal feed is presented in Figure 1. The system is based on the setting of ‘feed safety objectives’, which make use of principles that relate to animal health and welfare and environmental and legal aspects, as well as the safety criteria set for human foods of animal origin, the so-called ‘food safety objectives’. To set feed safety objectives, the principles of risk analysis must be used.

![Diagram showing the general outline for the production of safe animal feed.](image)

**Figure 1. General outline for the production of safe animal feed**

To meet the feed safety objectives, a proactive control system based on scientific data is advocated. This approach has been very successful in relation to human food and involves the use of ‘good manufacturing practices’ (GMP) and the ‘hazard analysis critical control point’ (HACCP) concept as the main tools.

2. **Feed safety objectives:** The starting point is the food safety objectives for chemical and microbiological contaminants, including zoonotic disease agents, which are essential to produce acceptable, safe food products for human consumption. For both types of hazards, a ‘transfer factor’ needs to be taken into account (Figure 2). In passing through the intestinal tract, unwanted chemical substances may become diluted, decomposed, etc. In the case of infectious zoonotic agents, an increase in numbers is possible. These phenomena should be considered in setting feed safety objectives.
3. Animal diseases, welfare and other aspects: Feed should not contain infectious agents or toxic substances that can cause disease in animals. Examples include the virus responsible for Foot and Mouth disease and Bacillus anthracis, the causative agent of anthrax. As far as toxic and deleterious components are concerned, naturally occurring constituents of animal feed such as plant toxins and extraneous contaminants e.g. heavy metals and dioxins may be present from time to time. Also the suitability of the feed is an important part of animal welfare. Feed must be appropriate to the animal being fed, available in sufficient quantities to satisfy demand at all stages of animal production and be readily accessible to all individuals. Finally, animal feed needs to meet certain legal and other requirements. These relate to zoonotic diseases, trade protection, environmental aspects, etc.

4. Feedborne animal diseases: Feed ingredients are regularly subject to contamination from diverse sources, including environmental pollution and the activities of insects and micro-organisms. This is in addition to endogenous toxins associated with some of the plant materials used. Many of these contaminants cause adverse health effects such as infections and intoxications in the animals and may be transmissible to humans.

4.1 Infectious diseases. There are many infectious disease agents which are transmitted by feed to animals. Some of them are discussed briefly here as examples and an indication given of their control by the application of GMP and HACCP in the production process.

Foot and Mouth Disease (FMD). FMD is a devastating disease of livestock and is characterized by fever and blister-like lesions on the tongue and lips, in the mouth, on the teats, and among the feet. All species of cloven-hoofed animals are susceptible and the disease is extremely contagious. FMD is endemic in many areas of the world, including several countries in Africa, as well as in Asia and South America. In 2001, the disease was confirmed in the United Kingdom, France, The Netherlands, the Republic of Ireland, Argentina and Uruguay. The United Kingdom reported 2030 cases of FMD, slaughtered almost 4 million animals, and took 7 months to control the disease outbreak. Financial losses as a result of FMD can be considerable. There are direct losses due to deaths in young animals, loss of milk and meat and a decrease in growth performance. The costs associated with eradication or control can be high and, in addition, there are indirect losses due to the imposition of trade restrictions. The disease is caused by an Aphthovirus member of the family Picornaviridae and is not a threat to public health.

The virus can easily be controlled by immunisation. Due to its extremely contagious character control of the virus by other means, such as bio-security, is difficult. FMD virus can survive for long periods of time in dark and moist conditions. Therefore non-processed feed is considered to be an important route for transmission of the virus. The virus is easily killed by mild heat treatment, and is completely
inactivated during pasteurisation at 75°C for a few seconds. The FMD virus is also extremely sensitive to pH. At pH values above 9 and below 6 the virus is rapidly destroyed. For this reason, acidification of feed either by fermentation or adding e.g. citric acid, is effective.

**Trichinellosis.** Trichinellosis is caused by the nematode Trichinella spiralis which parasitises the intestinal tract of mammals, particularly pigs. The larvae encyst in the tissues, particularly the muscles which act as a source of infection for humans who consume raw or partially cooked meat. The clinical manifestations include fever, muscle pain, encephalitis and myocarditis. Death occurs only rarely. The cysts can be transmitted by non-processed feed. Treatments like freezing at -18°C for 20 days or heat treatment cause inactivation. Effective cooking of raw meat and table scraps before feeding to farm animals will eliminate transmission. This is also the case when traditional rendering temperatures are used.

**Bovine Spongiform Encephalopathy (BSE).** BSE is a disease of cattle which was first recognised in Great Britain in 1986. Cases have since occurred in many other countries. It is believed now that the disease is caused by a natural protein which folds in the wrong way and then causes other similar proteins to adopt a similar shape. The new form gradually accumulates and spreads. It can transmit disease from animal to animal at least experimentally and from contaminated animal tissue to humans (Bruce et al., 1997a; Bruce et al., 1997b). The complete exclusion of mammalian meat and bone meal (MBM) from all farm animal feed since 1988 resulted in a gradual decrease in the incidence rate of BSE. Since the disease has an incubation period of about 5 years, it was expected that action taken in 1988-90 would take some years to show through. Studies revealed that traditional rendering of animal offal contaminated with BSE prions was not sufficient to inactivate their infectivity in test animals (Fraser et al., 1988). Therefore, the European Commission decided in 1993 to use a higher standard for the treatment of animal waste (133°C, 3 bars of pressure for twenty minutes). In 1994, the EU Commission also introduced a ban on the feeding of mammalian meat and bone meal to cattle, sheep and goats.

4.2 **Mycotoxicoses.** Many mycotoxins are harmful when consumed by animals. The toxins can accumulate in maturing corn, cereals, soybeans, sorghum, peanuts, and other feed crops in the field and in grain during transportation (Christensen, 1982). The toxins may be produced during storage under conditions favourable for the growth of the toxin-producing fungus or fungi. The effects in domestic animals include allergic reactions, reproductive failure, unthriftiness, loss of appetite, feed refusal, suppression of the immune system, decreased feed efficiency, and mortality (Hesseltine and Mehlman, 1977) (Table 1).

<table>
<thead>
<tr>
<th>Mycotoxins</th>
<th>Feeds affected</th>
<th>Possible effects on animals</th>
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<tbody>
<tr>
<td>Aspergillus toxins</td>
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<tr>
<td>Aflatoxins</td>
<td>Cereal grains, peanuts, soybeans</td>
<td>Hepatoxic, carcinogenic, reduced growth rate, hemorrhagic enteritis, suppression of immunity to infection and decreased productivity</td>
</tr>
<tr>
<td>Ochratoxins</td>
<td>Cereal grains</td>
<td>Toxic to kidneys and liver, abortion, poor feed conversion, reduced growth rate and reduced immunity to infections.</td>
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<tr>
<td>Sterigmatocystin</td>
<td>Cereal grains</td>
<td>Toxemic and carcinogenic.</td>
</tr>
<tr>
<td>Tremorgenic toxin</td>
<td>Cereal grains, peanuts, soybeans</td>
<td>Tremors and convulsions.</td>
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Three genera of fungi - Aspergillus, Penicillium and Fusarium - are the ones involved most frequently in cases of mycotoxin contamination in corn, small grains, and soybeans (Table 1).

Pelletizing feeds may eliminate fungi present in the stock but will not reduce or eliminate aflatoxin present in any of the ingredients. Recently, the addition of binding agents such as hydrated sodium or calcium aluminosilicate and bentonite clays to corn has been shown to decrease the effects of aflatoxin when fed to swine. These compounds probably work by non-specific binding to the mycotoxin and reducing the rate of passage through the gut. Although not specifically approved for the purpose, various products that have this ability are approved as binding or anti-caking agents.

The diseases caused by the most relevant mycotoxins are presented in Table 38.2. Aflatoxins may cause vaccines to fail, increase the birds’ susceptibility to disease, and result in suppression of natural immunity to the infection (Elissalde et al., 1989). The animals then become susceptible to infection by bacteria such as Salmonella and to various viruses and other infectious agents commonly found around the farm, feedlot or poultry house. Normal healthy animals would ward off such agents. Zearalenone and zearalenol are produced almost exclusively by Fusarium species that contribute to the ear and stalk rot that occurs in the ears of corn and on the heads of cereal grains. When consumed by swine at more than 0.1 to 5 mg toxin per kg body weight, these compounds cause the estrogenic syndrome, which is characterized in females by a swollen and edematous vulva with enlarged mammary glands and in young males by a shrinking of the testes. Young gilts may show uterine prolapse. The financial loss to farmers comes about primarily through poor reproductive performance.

Feeds that contain 1 mg of deoxynivalenol per kg may result in significant reductions in feed consumption and weight gain by swine (Bergsjø et al., 1992). Vomiting is rather uncommon in field cases because usually pigs will not eat enough of the contaminated feed. Clinical signs and lesions in affected swine included feed refusal, a few instances of vomiting, lack of weight gain, poor feed efficiency, failure of mature sows to return to oestrus, reduced efficiency, high mortality of nursing pigs, intestinal tract inflammation, and acute diarrhoea in young pigs. Dairy cattle and poultry are relatively insensitive to the dietary concentrations of deoxynivalenol likely to be found in feeds. Apparently all
domestic animals are susceptible to injury by dietary intake of trichocenes such as T-2, HT-2, and diacetoxyscirpenol in the region of a few mg/kg. In poultry, feed contaminated with 1 to 3.5 mg/kg of T-2 and 0.7 mg/kg of HT-2 (a closely related toxicant) may produce lesions at the edges of the beaks, abnormal feathering in chicks, a sudden and drastic drop in egg production, eggs with thin shells, reduced body weight gains, and mortality. The same feed given to turkeys results in reduced growth, beak lesions, and less immunity to infection. T-2 and DAS in cattle feed results in unthriftiness, decreased feed consumption, slow growth, reduced milk production, and sterility. An outbreak of hemorrhagic bowel syndrome and death of some animals can occur in herds of cattle and swine. In swine, infertility with some lesions in the uteri and ovaries result from consumption of feed contaminated with 1 to 2 mg/kg of T-2 toxin. As with most other mycotoxins, the only control is to avoid use of contaminated feeds. Equine leucoencephalomalacia occasionally occurs in horses, mules, or donkeys foraging corn left standing in the field after harvest or when fed grain or screenings heavily infected with F. moniliforme. The toxins, fumonisin B1 and B2, are produced only by certain strains of F. moniliforme. This toxicant is also carcinogenic in laboratory tests.

Ochratoxin A, produced primarily by members of the Aspergillus ochraceus group and a number of species of Penicillium, especially P. viridicatum has been found in some samples of feed grains. Frequently, citrinin is produced simultaneously by these same fungi. In the field, however, injury from ochratoxin poisoning has occurred chiefly (or only) in poultry and swine. Listlessness, huddling, diarrhea, tremors, and other neural abnormalities are sometimes encountered in broiler flocks. Ochratoxin damage to the kidneys of swine is characteristic enough to be called “porcine nephropathy,” which is recognizable in commercial slaughtering.

4.3 Intoxications by other components. In addition to mycotoxins and naturally occurring toxic constituents in plants, there are toxic and deleterious substances that are extraneous contaminants of industrial origin. These can be increased to abnormal levels in animal feed through mishandling or other factors. The most significant hazards to human health are those chemicals that accumulate in animal tissues, are excreted in milk or become incorporated in eggs. Examples of substances that attract international attention are the polychlorinated biphenyls (PCBs), dioxins and furans and certain pesticides like DDT (Dichloro-Difenyl-Trichloorethane). Fish and fish by-products that are used to make fish meal and oil, and are ingredients in feed, may be sources of contamination in the food chain. For an overview in 1998/1999 a survey was conducted by the Canadian Food Inspection Agency. For an overview visit the internet page www.ispection.gc.ca/english/animo/feebet/dioxe.shtml. The purpose of the survey was to determine the levels of dioxins and furans, PCBs and DDT in fish meals, fish feeds and fish oils. The results indicated that dioxin-furan and PCB levels in fish feed and fish meal would not be expected to result in fish products with dioxin-furan or PCB levels above the Canadian guidelines for these chemical contaminants. These are a maximum level of 20 ng TEQ for dioxin and furan and 2.0 mg for PCBs per kg product. The same applies to fish oil. Also the levels of DDT were far below the maximum Canadian limit of 5.0 mg per kg product. Other contaminants include heavy metals such as lead, mercury and cadmium. In a Dutch survey carried out in 1998 (http://www.agralin.nl/kap/kap98/kap98_4.html) median levels were less than 1 % of the cadmium limit of 1 mg per kg product for soybeen husks, soybeen forage, maize gluten feed, palm kernel husks and citrus pulp. Cadmium levels in mineral mixes also complied with the limit set for cadmium. Another group of contaminants includes veterinary drugs that are administered via animal feeds. If the concentration used is high or withdrawal periods are not properly observed, foods of animal origin may contain residues that exceed established maximum residue limits (MRLs), such as those established by the CAC, and there may be a potential risk to human health. The problem can be avoided by applying good veterinary practices (GVP).

4.4 Zoonotic feedborne diseases. Epidemiological analysis of foodborne human diseases in The Netherlands for example, shows that the majority of cases of food-related gastro-enteritis involve
bacterial infections contracted from foods of animal origin. For the Dutch situation, the working group of experts of the Health Council of the Netherlands estimated that up to 75% of foodborne diseases are transmitted through products of animal origin (Health Council, 2000). The figure is based on the assumptions of experts. Human disease causing viruses are not believed to be of animal origin. As far as parasites are concerned, a small but unknown proportion may be caused by these organisms, although this may differ from country to country.

The most relevant organisms involved in foodborne diseases transmitted via products of animal origin include *Campylobacter* spp., *Salmonella enterica*, *Clostridium perfringens*, *Staphylococcus aureus*, *Bacillus cereus*, pathogenic *Escherichia coli* and *Yersinia enterocolitica*. All these organisms may originate from animal feed. The most two important organisms are described shortly below.

**Campylobacter spp.** The species of greatest concern is *Campylobacter jejuni* which is a Gram-negative, slender, curved, motile rod. It is a micro-aerophilic organism, which means that it has a requirement for reduced levels of oxygen. It is relatively fragile, and sensitive to environmental stresses (e.g., 21% oxygen, drying, heating, disinfectants, acid conditions). The organism is especially sensitive to drying. Its main habitat is the intestinal tract of warm-blooded animals, especially the caecum of chickens, where > 10^6/g *C. jejuni* may be present. The organism does not multiply at temperatures < 30 oC.

Surveys have shown that *C. jejuni* is the leading cause of human bacterial diarrheal illness, not only in the Netherlands but in many other countries, including the United States. There are several routes by which animals can become colonised by *C. jejuni*. Giving animals untreated water is a common source. Contamination may also occur by feeding green crops since these may become contaminated by birds that shed *C. jejuni* in their faeces. *Campylobacter* has been isolated very rarely from animal feeds like silage, cereals, or dry compound feeds. This is in accordance with the above indicated characteristics of the organism to dry conditions and susceptibility to environmental stress.

**Salmonella enterica.** The organism is a rod-shaped, motile bacterium, non-spore forming and Gram-negative. *Salmonella* is primarily present in the intestinal tract of animals. Where feed is the source, epidemiological data show clearly that the route of transmission is animal feed _ product of animal origin _ human infection (Crump et al, 2002). The organism can be present in raw meat and poultry, raw seafood, eggs, milk, dairy products, frog legs, yeast, coconut, sauces, salad dressing, cake mixes, cream-filled desserts, cream toppings, dried gelatine, peanut butter, cocoa, and chocolate. *Salmonella* is a ubiquitous organism. It survives for long periods in natural environments and is resistant to e.g. dry conditions. As a consequence it can be present in animal feed and raw materials used in animal feed.

In an epidemiological study carried out in Denmark, an assessment was made of factors that contribute to the risk of *Salmonella* contamination in poultry flocks (Angen et al., 1996). The study revealed that the following factors (in order of importance) contributed significantly to the contamination of poultry with *Salmonella*:

- Origin of the day-old chicks.
- Company delivering the feed.
- Number of flocks present on the farm.
- Season of the year (more positive flocks in autumn).
- Presence of *Salmonella* in previous flock(s).

Although several routes of transmission can be identified, animal feed is still thought to be a major source of *Salmonella* infection in poultry flocks. Therefore, efforts continue to be made to reduce the incidence of *Salmonella* in feeds, given to poultry and other animals. There is no lack of knowledge or literature on processing methods and control measures for this purpose (Beumer, 1996; Beumer and Van der Poel, 1997). In the United Kingdom, there has been some success in reducing the *Salmonella* content of feed and data for the period 1989 -1995 show a steady decrease in *Salmonella* contamination (Report of CVL, New Haw, Addlestone, Surrey, KT15 3NB. Tel. + 44 1932 341111 Fax + 44 1932 349983)
5. Animal welfare and feed. Feed plays an important part in animal welfare, as mentioned previously. Also the composition of feed is important. Feeding of pregnant sows on high-fibre diets appeared to reduce feeding motivation and thus improved the welfare of animals (Ramonet, et al., 1999). Supplying calves with straw-cecal pellets is considered beneficial for the physiological aspects of welfare in veal calves (Morisse et al., 1999), and judicious use of disease-preventing additives also contributes to animal welfare. However, unrestricted use of antimicrobials to compensate for poor husbandry is detrimental. A major obstacle to the judicious use of feed additives, is the lack of unbiased information on their efficacy and safety for farm animals in the scientific literature (Kan, et al., 1998). Welfare requirements alone make considerable demands on feed safety and feeds should not contain any infectious agents (bacteria, parasites and viruses) that could cause illness and discomfort in the animals. Toxic components such as naturally occurring plant toxins, antinutritional factors and mycotoxins should be controlled at levels that would avoid harm to the animals. Balanced formulations, well controlled production technologies and quality and safety management in the feed industry should ensure that all nutritional requirements can be satisfied. However, feeds and feeding systems may also contribute to keeping animals under conditions that allow more natural behavior and thereby reduce stress associated with high-performance animal production. Drinking systems also have clear effects on animal health and welfare. For example, it was demonstrated by Turner et al. (1999) that aggression at the drinkers was greater for large groups of growing pigs when drinker allocation was restricted. Laitat et al. (1999) compared a ‘tube-type’ feeder, by which a mixture of meal and drinking water could be given to weaned pigs, with another type of feeding system where drinking and eating were separated activities. It was observed that feeding behaviour and hence welfare were influenced by the type of feeder used, especially with large numbers of animals. The tubetype feeder resulted in a ‘more relaxed’ response. For lactating cows, it was observed that grooming, which is a behavioural need, increased significantly when feed cows were not locked up and had free access to feed (Bolinger et al., 1997).

6. Proactive control. The traditional approach to controlling the safety of animal feed safety is based largely on practical experience, education and training of personnel, inspection of production facilities and operations, and testing of the finished product. End product testing is usually an integral part of the overall control programme. However, leaving aside questions regarding the accuracy and reproducibility of the methods used, it has become clear that testing of feed is of limited value without a sound sampling plan. For the production of safe food a successful pro-active control programme is now in use. It is essentially based on the application of two basic systems: Good manufacturing Practise (GMP) and the Hazard Analysis Critical Control Point (HACCP)-concept. For the production of safe animal feed such a system needs yet to be developed.

6.1 GMP. One of the first quality assurance systems developed by the food industry was that involving the application of GMP, as a supplement to end-product testing. GMP is considered now as a prerequisite for safe food production and has been used for many years to ensure the microbiological and chemical safety and quality of food. The establishment of GMP is the outcome of long practical experience and attention to environmental conditions in the food plant, e.g. requirements for plant layout, hygienic design of equipment and control of operational procedures. GMP is now being introduced into the feed industry for the production of safe animal feed. This measure is supported by the FAO report on animal feeding and food safety (1997) which recommends that GMP is followed at all times in the production of animal feed. Thus specific control measures are given for identified hazards, which include TSEs, biological agents, veterinary drugs, agricultural chemicals and mycotoxins. However, the GMP concept is largely subjective and its benefits are only qualitative Also, it has no direct relationship to the safety status of the product. For these reasons, the concept has been extended by introducing the HACCP system, which seeks, among other things, to avoid reliance on testing of the end-product as a means of controlling food safety. As indicated previously, such testing may fail to distinguish between safe and unsafe batches of food and is both time-consuming and relatively costly.
6.2 HACCP-system. The HACCP concept is a systematic approach to the identification, assessment and control of hazards in a particular food operation. It aims to identify problems before they occur and establish measures for their control at stages in production that are critical to ensuring the safety of the food. Control is proactive, since remedial action is taken in advance of problems occurring.

The full HACCP system, as described in Alinorm 97/13, is shown in Table 2. The document also gives guidelines for practical application of the HACCP system. The system became a legal requirement for the production of all food products in the European Union (Directive 93/43).

Despite widespread usage, the present HACCP concept still has some weak points. One of them is the definition of a hazard. This is not defined as "an agent with the potential to cause an adverse health effect", as is usual in risk assessment, but as "an unacceptable contamination, growth and/or survival by micro-organisms of concern" (ICMSF, 1988), which is more restrictive and does not cover all possible hazards. Another weakness arises from the definition of a CCP. It is stated that a CCP is a location, practice or procedure where hazards can be minimised (ICMSF, 1988; IAMFES, 1991) or reduced to an acceptable level. In both cases, these are qualitative objectives and may lead to differing interpretations. It was Notermans et al. (1995) who first made a plea to use the principles of quantitative risk assessment for setting critical limits at the CCPs (process performance, product and storage criteria). It was their opinion that only when the critical limits are defined in quantitative terms can the level of control at CCPs be expressed realistically.

<table>
<thead>
<tr>
<th>Principle</th>
<th>Activity</th>
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<tbody>
<tr>
<td>1 Conduct a hazard analysis</td>
<td>List all potential hazards associated with each step, conduct a hazard analysis, and consider any measures to control identified hazards</td>
</tr>
<tr>
<td>2 Critical Control Points (CCPs)</td>
<td>Determine Critical Control Points (CCPs)</td>
</tr>
<tr>
<td>3 Critical limit(s)</td>
<td>Establish critical limits for each CCP</td>
</tr>
<tr>
<td>4 Monitoring</td>
<td>Establish a system of monitoring for each CCP</td>
</tr>
<tr>
<td>5 Corrective actions</td>
<td>Establish the corrective action to be taken when monitoring indicates that a particular CCP is not under control</td>
</tr>
<tr>
<td>6 Verification procedures</td>
<td>Establish procedures for verification to confirm that the HACCP system is working effectively</td>
</tr>
<tr>
<td>7 Documentation and record keeping</td>
<td>Establish documentation concerning all procedures and records appropriate to these principles and their application</td>
</tr>
</tbody>
</table>

Table 2. The seven principles of the HACCP-system, (CAC, Committee on Food Hygiene, 1997)

6.2.1 From feed safety objectives to HACCP-criteria. A critical control point in a feed production process can be defined as a location, practice or procedure where hazards can be minimised or reduced to an acceptable level. Therefore, the identification of CCPs in a feed production process is an important step in the control of such hazards. There are various means for controlling potentially hazardous bacteria and chemical agents in feed production processes. Suitable control of hazardous chemical agents can be achieved by setting appropriate criteria for raw materials. Hazardous microorganisms can be inactivated by e.g. heating or irradiation, while acidification of feed and use of controlled storage conditions, etc. may also be of value. In some cases stabilisation of microbial levels i.e. prevention of growth, may be sufficient. Stabilisation can be achieved by adjusting the
formulation to give a low aW, pH, etc. Such measures not only stabilize bacterial populations, but can also reduce the numbers of any pathogens present. In summary, there are several options to produce safe animal feed. They comprise:

- setting requirements (criteria) for the raw materials used
- setting criteria for processing (e.g., heat treatment)
- composition of the feed material (e.g., pH, aW)
- setting storage conditions

For the relevant possibilities, criteria need to be set in advance. For example, if a dry feed product is being produced from wet raw materials and Salmonella could be present, a drying process should be defined that effectively kills Salmonella. If an acidified feed is required a pH range should be selected that does not allow multiplication of any hazardous organisms. For feed with a limited storage life, storage conditions need to be established, including temperature and maximum storage time. If there are no CCPs in the production process, they should be introduced! GMP and HACCP are now designed to meet the criteria set. The role of GMP is to ensure that hygienic equipment is used, that well-trained personnel are involved in the production process, that re-contamination is avoided, etc. HACCP is the managerial tool in ensuring that the chosen criteria are met. Finally, verification that GMP and HACCP work as planned needs to be introduced.

6.3 Shortcomings of the control system. In the HACCP system recalls are part of the ‘corrective actions’. These actions are necessary when monitoring indicates that a particular CCP is not under control. If a failure is only apparent after the product has been sold a recall action prevents the anticipated health problem in either humans or animals. Incidentally, GMP and HACCP do not, in themselves, prevent specific health problems and corrective actions are necessary. Such situations may occur, for example, when unknown hazards appear or in the case of rare hazardous events. The same may apply where malicious practices or carelessness have occurred.

Unknown hazards. GMP and HACCP are largely based on knowledge collected in the recent past. The system may be inadequate if new, unknown hazards occur or when a hazard re-emerged. Recent examples are the internal contamination of eggs with S. Enteritidis and contamination of beef burgers with E. coli O157. Before 1980, E. coli O157 was unknown as causes of foodborne diseases and after 1980 S. Enteritidis re-emerged as disease. A newly discovered chemical hazard is acrylamide which arises from the heating of certain food products. Once these ‘new’ hazards have been characterised they will be introduced into the GMP and the HACCP concept for relevant applications.

Rare hazards. There are many types of micro-organisms and even more chemical substances that can have an adverse effect on human and animal health. Hazards that occur only very rarely are not usually included in GMP and the HACCP concept. Control of these hazards is mostly carried out at national level by general measures on the part of government. Dioxin is such an example, and the government took general measures to reduce the probability that this toxic substance would spread in the environment. One of these measures was to prohibit the production of food and feed in a given area after contamination of that area had been established.

Corrupt practices. Corrupt or malicious practices are activities which are forbidden by law. A recent example was deliberate use of sugar waste which contaminated the hormone medroxyprogesteron acetate as a raw animal feed material. Malicious practices would include terrorist activity, for example, in the case of deliberately induced food poisoning.

Carelessness. Although GMP and HACCP aim to prevent human failings they sometimes fail themselves because of carelessness. Errors or failings occur when staff are stressed by pressure of work or temporary and poorly trained people or motivated personnel are employed to do the work.

It is clear that control may be lost. The GMP and HACCP concept take this into consideration by corrective action. If a problem is recognised before distribution, the product can be retained until the corrective action has been carried out. In the case of a product that has already been sold then a recall is necessary.
For a successful recall, the product in question must be traced rapidly. Therefore an adequate system of traceability is an additional requirement in the production of safe food and feed. Since recalls may be very costly for the producer an early warning system to reduce the probability of a recall would be beneficial.

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IAMFES (International Association of Milk, Foods and Environmental Sanitarians, Inc.) (1991), Procedures to implement the hazard analysis critical control point system. IAMFES document 502.

Fermented Liquid Feed (FLF) can reduce the transfer and incidence of Salmonella in pigs.

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Summary. Surveillance studies have shown that feeding pigs liquid diets, and particularly fermented liquid diets reduces the incidence of Salmonella positive herds. Studies have shown that a concentration...