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Common Hazards to Consider during the Manufacturing of Poultry Feed[1]

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Introduction

The Food Safety Modernization Act (FSMA) was signed into law in January of 2011. The objective of this act is to shift how we approach food safety; instead of reacting to foodborne outbreaks, FSMA aims to prevent them before they occur. This law requires complying facilities that manufacture, process, pack, or hold food or food ingredients for animals to implement a Hazard Analysis and Risk-Based Preventive Controls (HARPC) food safety plan (Scheffler and Carr 2016). HARPC has many similarities to Hazard Analysis and Critical Control Points (HACCP) commonly used for human foods such as meat, seafood, and juice, but it may be unfamiliar to facilities producing poultry feed. For more information on the general structure of an animal food safety plan and compliance requirements, refer to EDIS publication AN330, *The Food Safety Modernization Act (FSMA) Preventive Controls for Animal Food* (https://edis.ifas.ufl.edu/an330).

The Food and Drug Administration is responsible for the regulation of pet food and animal feed in the United States. The Federal Food, Drug, and Cosmetic Act (FFDCA) "requires that all animal foods, like human foods, be safe to eat, produced under sanitary conditions, contain no harmful substances, and be truthfully labeled"(21 U.S.C 301 1938). The animal food industry is a multibillion-dollar industry that experiences many recalls due to food safety hazards. Costs associated with a recall vary depending on the scope and scale of the problem.Types of costs typically include litigation, government fines, lost sales, etc. According to a joint study conducted by the Food Marketing Institute and Grocery Manufacturers Association, the average cost of a recall is estimated to be 10 million dollars, plus brand damage (Grocery Manufacturers Association et al. 2010). The implications of food safety hazards go far beyond economic damage. Food safety hazards in animal feed have the potential to cause serious risk to human and animal health. For example, poultry that consume aflatoxins have the potential to carry those chemicals in their meat and eggs, which can have serious carcinogenic and hepatotoxic effects in humans (Chen et al. 2013).

The first step in developing a food safety plan is to conduct a hazard analysis. The purpose of a hazard analysis is to identify potential hazards in the process that may pose a risk to human or animal health. Hazards are separated into three categories (physical, biological, and chemical [which includes radiological]) and classified based on frequency and severity. In many cases, hazards can be controlled by written Current Good Manufacturing Practices (CGMPs) and Standard Operating Procedures (SOP), but in some

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cases, existing hazards require more robust preventive controls. Determining whether a hazard requires preventive control depends on the hazard's severity and frequency, which vary based on the facility and species being fed. This publication aims to provide a list of common hazards to consider when manufacturing poultry feeds; however, this is not a comprehensive list. A thorough hazard analysis must be conducted by a preventive controls qualified individual (PCQI) to identify hazards for each facility. For more information about PCQIs, visit https://edis.ifas.ufl.edu/an330.

Common Physical Hazards to Consider

Physical hazards are defined as any potentially harmful extraneous matter not normally found in feed that can cause illness or injury. Common examples of physical hazards include glass, metal, or wood fragments that are likely to cause choking, injury, or other adverse health effects upon consumption. In poultry feed processing, there can be a variety of physical hazards which can have serious effects on bird health. Large particle size and sharp textured objects have been common problems in the production of poultry feed. For example, an overly large feed particle can cause the animal to choke by blocking the airway, and a sharp object in the feed can damage an animal's esophagus, causing internal bleeding and potentially death. Anecdotal evidence has suggested that whole cottonseed may be a potential choking hazard for poultry, but no supporting documentation could be found to support this claim.

Processing facilities should enforce proper production procedures, maintain equipment, and ensure that employees are trained appropriately to reduce the frequency of these physical hazards. In many cases, facilities are already taking steps to reduce these hazards because various objects may also cause damage to processing equipment. For example, magnets, screens, or a feed cleaner may be utilized to prevent objects from entering a pellet mill. Standard Operating Procedures (SOPs) for handling tools and personal effects should be implemented to mitigate the risk of these objects becoming physical hazards. These risk mitigation efforts should be documented and considered in the hazard analysis. Processors should conduct a thorough hazard analysis to determine where physical hazards are more likely to be introduced into the process and implement a safety protocol, or a HARPC plan, to evaluate the frequency and severity.

Common Biological Hazards to Consider

Biological hazards include parasites, bacterial pathogens, viruses, and other agents that cause illness when ingested. The number of biological hazards of concern in poultry feed is relatively few when compared to human and pet food. The avian gut has a specialized mechanism designed to prevent bacteria from penetrating into the intestinal epithelium and causing illness (Pan and Yu 2013) that limits the number of pathogens of concern. In addition, poultry feed often comes in less direct contact with humans, posing less of a threat to human health compared to pet food.

Salmonella is a pathogen that causes gastroenteritis in humans and is often associated with the consumption of raw or undercooked poultry (Vandeplas et al. 2010). While over 2,600 serovars of *Salmonella enterica* are known to cause illness in humans, not all serovars of *Salmonella* cause infection in poultry. There are three main *Salmonella* serovars of concern in poultry feed production: *Salmonella* Pullorum, Gallinarum, and Enteriditis. All three serovars can cause illness in chickens, turkeys, and game birds (e.g., pheasants, quail, guinea fowl, partridges, peacocks) (Spickler 2019). If a house of birds becomes infected with these serovars, it can lead to major losses caused by an increased rate of mortality, morbidity, and losses in egg production (Shivaprasad 2000). In general, *Salmonella* can be found in pelleted and mash poultry feed (Bucher et al. 2008). However, it is important to note that only one of the three pathogenic serovars, Enteriditis, was found in the top 25 most common *Salmonella* serotypes found in animal feeds (Li et al. 2012).

Listeria monocytogenes is a bacterial pathogen that causes the disease Listeriosis in humans, animals, and birds. It is commonly found in moist environments, water, and soil (FDA 2019a). Although Listeriosis is rare in poultry, whenan infection does occur, it can lead to localized encephalitis or septicemia of the bird. Additionally, chickens are thought to be prime reservoirs for *Listeria*, thus contaminating litter and poultry processing environments (Rothrock et al. 2017).

Avian viruses pose a serious threat to bird health and have the potential to be transmitted through feed. Influenza A virus subtype H9N2 is categorized as a low pathogenicity virus; however, birds infected by this virus are more susceptible to highly pathogenic H5N1 viruses and other disease (Webster et al. 2006). Migratory birds are often carriers of this virus, spreading it to domestic poultry populations through direct or indirect contact with contaminated saliva, nasal secretions, and feces (Skeik and Jabr 2008). Another virus of concern in the poultry industry is infectious bronchitis virus (IBV). IBV is a highly contagious coronavirus found in chickens that can be spread directly from chicken to chicken, or indirectly through aerosols, contaminated personnel or equipment, egg packing materials, litter, and farm visits (Ignjatovic and Sapats 2000; Jackwood and de Wit 2019).

Feed ingredients that have been stored outdoors are more susceptible to biological hazards due to contamination from wild bird droppings. These bacteria and viruses then have the potential to infect domestic flocks through minimally processed feed ingredients. Processors should address these risks when evaluating starting material and process flow. It has been shown that thermal processing steps such as pelleting should reduce the prevalence of most pathogens and inactivate avian influenza viruses if present (Bucher et al. 2008; Toro et al. 2016).

Common Chemical Hazards to Consider

Chemical hazards in animal feeds can be classified into three groups: naturally occurring, unintentionally introduced, and intentionally introduced. The list of hazards associated with this section is longer and more complex than either of the previous two hazard categories. In many respects, chemical hazards are the hardest to predict, making them the most difficult to control. While not a comprehensive list, this section aims to highlight major chemical hazards associated with poultry feed. It is important to recognize that chemical hazards vary widely and must be identified through a hazard analysis.

Naturally Occurring

Mycotoxins are the most common naturally occurring chemical hazard in poultry feed. These toxins are produced by a wide variety of fungi, but primarily by molds. Although mold is considered a biological system, the mycotoxins they produce are classified as chemical hazards. There are over 200 species of molds that produce a wide range of mycotoxins. Some of the more common mycotoxins that have a significant impact on poultry health and productivity include aflatoxin, zearalenone, ochratoxin A, fumonisins, deoxynivalenol, and T-2 toxins. The consumption of these mycotoxins can result in a variety of diseases, collectively called "mycotoxicosis"; symptoms can result in reduced productivity of the birds and mortality in extreme cases (Murugesan et al. 2015).

Aflatoxin is the most common of the mycotoxins. It is produced by molds in the fungal genus *Aspergillus*. Contamination is most commonly associated with corn, cottonseed, and peanuts, but any feed products grown in tropical or subtropical regions are at risk (FAO and IFIF 2010). Aflatoxicosis can result from long-term exposure to aflatoxins, resulting in great losses due to reduced growth rate, increased susceptibility to disease, and reduced egg production to the affected poultry (Rawal et al. 2010; Peng et al. 2014; Peng et al. 2015). Due to the frequency and severity of aflatoxins in animal feed, the FDA has set action limits which are described in the FDA Compliance Policy Guide Sec. 683.100, Action Levels for Aflatoxins in Animal Feed (FDA 2019b).

To mitigate this potential risk, producers are encouraged to pay close attention to where feedstuffs are sourced. Weather can be considered to determine the relative likelihood of mycotoxins, and testing frequency of incoming feedstuffs can be adjusted accordingly. Upon receipt, feed needs to be stored in a manner to prevent contamination and mold growth at the facility. At moisture contents greater than 17.5%, and temperatures above 75F, *Aspergillus flavus* will produce aflatoxin (Trenk and Hartman1970). Inventory control depending on seasonal weather patterns may be one way to mitigate risk; maintaining lower inventory during hot and humid times of the year reduces the likelihood of mold growth and mycotoxin production. The addition of detoxification agents, such as silymarin-phospholipid complex or butylated hydroxytoluene, has been successful in reducing symptoms of aflatoxicosis in poultry (Rawal et al. 2010). However, reliance on detoxification agents is not a recommended substitute for maintaining control of mycotoxin levels.

Unintentionally Introduced

Unintentionally introduced chemical hazards in poultry feed occur at relatively low levels but can be severe in some cases. Unintentionally introduced chemical hazards include, but are not limited to, pesticides and other chemical residues. Nutrient toxicities or deficiencies are also considered chemical hazards by the FDA. Because poultry are often offered a single-source feed and have limited ability to compensate through feed selection, toxic or deficient levels of nutrients need to be prevented.

Since many crops used for animal feedstuffs are treated with pesticides and other chemicals to ensure acceptable or desired yields, they may contain chemical residues. In addition, the process of harvesting and manufacturing exposes feedstuffs to possible contamination by petroleum-based greases and other chemicals. These residues can pose risks to animal and human health due to the accumulation of these toxins in fat tissues. The FDA Pesticide Monitoring Program suggests that very few animal feeds (fewer than 3.8% of samples tested) contain levels that exceed permitted levels (FDA 2020b). More information about pesticide residues in animal feedstuffs can be found in the Compliance Policy Guide Sec. 575.100 Pesticide Residues in Food and Feed (FDA 1995). The likelihood of introduction of these chemicals to feedstuffs should be determined during a hazard analysis and appropriate prevention methods should be implemented.

Drug carryover is particularly important for facilities that manufacture feed for multiple species. Different species react to drugs very differently; a drug that may be used in a medicated feed for one species may be fatal to another. An example of this would be the use of ionophores such as monensin (Coban), narasin (Monteban), lasalocid (Avatec), or salinomycin (Sacox 60) in poultry feed. These ionophores are used as coccidiostats in poultry but are fatal to horses in very small doses. Facilities that identify drug carryover as a risk will need to develop protocols to avoid any potential risk of residue carryover. This risk will increase in facilities that manufacture feed for multiple species. Most commonly, sequencing and flushing procedures are used to address drug carryover. However, a facility needs to determine if these procedures adequately mitigate the risk for the intended species. In some cases, not producing feed for a specific species or not using a specific feed ingredient may be the desired risk-mitigation strategy.

All medicated animal feed must be manufactured and distributed according to the Current Good Manufacturing Practice for Medicated Feeds (FDA 2019c). Feed additives containing medically important antimicrobials may fall under the Veterinary Feed Directive (VFD). The VFD brings therapeutic uses of drugs under veterinary supervision and requires a prescription to use medically important drugs in feed or water of food-producing animals. For more information about which feed additives may fall under the VFD, visit the FDA website (FDA 2015).

Nutrient deficiencies and toxicities are some of the most common reasons for poultry feed recalls (FDA2020a). Poultry are extremely efficient animals, converting feed into food products quickly and with relatively low environmental impact. This high rate of productivity results in relatively high nutrient requirements, the minimum of which are described in *Nutrient Requirements of Poultry* (National Research Council 1994). Poultry have the ability to adjust their feed intake to meet individual energy requirements; if a bird consumes a diet with a high energy content, it will decrease its feed intake and vice versa. This can cause deficiencies if the diet is not balanced with a proportional amount of amino acids, vitamins, and minerals (Klasing 2015). Poultry are sensitive to nutrient toxicities from several compounds, including excess sodium, calcium, and magnesium. A more extensive list of potentially poisonous substances can be found in *Poisonings in Poultry* (Porter 2019).

Cottonseed meal (CSM) is widely used as an alternative for soybean meal in the diet of laying hens, satisfying both energy and protein requirements. During the oil extraction process, a portion of free gossypol (FG) binds to lysine, reducing the availability of lysine. Gossypol also inhibits the activity of pepsin and trypsin in the gastrointestinal tract, thereby reducing the digestibility of the protein. The reported toxic effects of gossypol are growth depression, lameness, and decreased egg size and hatchability (Nagalakshmi et al. 2006). An effective way to prevent this toxicity is to supplement CSM-containing diets with lysine.

Intentionally Introduced

Intentionally introduced chemical hazards can be any of the aforementioned hazards that are introduced into feedstuff for economic gain or sabotage. The most well-known example of a chemical hazard intentionally introduced for economic gain is melamine in pet foods. Melamine is a nitrogen-rich industrial compound that, when added to pet food or feed, artificially inflates the measured crude protein content in the product. Melamine is not an approved ingredient for animal or human food in the United States and leads to kidney failure in dogs and cats that consume the adulterated foods (FDA 2018). Intentionally introduced hazards can be difficult to predict but should be considered when developing or reviewing CGMPs and SOPs.

How to Prevent Potential Hazards

There are several ways to reduce the prevalence of hazards in poultry feed. Appropriate methods of prevention are dependent upon each individual hazard, its severity, and its frequency. Most facilities already have robust CGMPs and SOPs that are successful in reducing the likelihood of hazards. However, there are some hazards that may require more intense methods of prevention due to their severity or frequency.

Some facilities may choose to implement preventive controls, and their required components, to ensure the prevention of potential hazards (FDA 2019d). There are four forms of preventive controls: process controls, sanitation controls, supply-chain or supplier controls, and other controls. In livestock feed facilities, process controls are most commonly used; these include procedures, practices, and processes to ensure the control of parameter during operations (FDA 2019d).

The decision to use CGMPs, SOPs, or preventive controls to control a hazard depends on each facility and hazard. Be aware that decisions regarding methods of prevention require justification, which should be based on facility experience, illness data, scientific reports, and FDA resources. In addition, all justifications require a thorough and well-documented explanation.

Additional Information

FDA (key requirements for preventive controls for animal feed): https://www.fda.gov/files/food/published/FSMA-Final-Rule-for-Preventive-Controls-for-Animal-Food-%28PDF-Fact-Sheet%29.pdf

FDA (FSMA; animal feed overview): https://www.fda.gov/animal-veterinary/animal-food-feeds/food-safety-modernization-act-and-animal-food

UF/IFAS Department of Animal Sciences (FSMA): https://animal.ifas.ufl.edu/extension/courses/fsma/

Food Safety Preventive Controls Alliance (FSPCA): https://www.ifsh.iit.edu/fspca

Southern Center for FSMA Training: https://sc.ifas.ufl.edu/

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Table 1. FDA action limits for aflatoxins in poultry feeds.

Level	Ingredient	Animal
300 ppb	Cottonseed meal	Poultry of all ages and breeding status
100 ppb	Corn and peanut products	Mature poultry
20 ppb	Corn, peanut products, and other animal food and food ingredients, but excluding cottonseed meal	Immature animals and others not listed
Source: Adapted from FDA Compliance Policy Guide Sec. 683.100 Action Levels for Aflatoxins in Animal Food.		