

Center for Veterinary Medicine  
Food and Drug Administration  
U.S. Department of Health and Human Services



**DRAFT Qualitative Risk Assessment  
Risk of Activity/Animal Food Combinations for  
Activities (Outside the Farm Definition) Conducted in a  
Facility Co-Located on a Farm**

**February 2013**

## EXECUTIVE SUMMARY

The Food and Drug Administration (FDA) has conducted a qualitative risk assessment (RA) related to manufacturing, processing, packing and holding activities for animal food when such activities are conducted on farms. The purpose of the RA is to provide a science-based risk analysis of those activity/animal food combinations that would be considered low risk. FDA conducted this RA to satisfy requirements of the FDA Food Safety Modernization Act (FSMA) to conduct a science-based risk analysis and to consider the results of that analysis in determining whether to exempt small or very small businesses that are engaged only in specific types of on-farm manufacturing, processing, packing, or holding activities that FDA determines to be low risk involving specific animal foods FDA determines to be low risk from the requirements of sections 418 and 421 of the Federal Food, Drug, and Cosmetic Act (FD&C Act), or whether to modify such requirements for such facilities.

The RA identified the following as low-risk activity/animal food combinations:

- Conveying, weighing, sorting, culling, or grading (incidental to storing):
  - Grain (e.g., barley, corn, rice, oat, sorghum, triticale, wheat);
  - Oilseed (e.g., cottonseed, linseed, rapeseed, soybean, sunflower);
  - Grain or oilseed byproducts;
  - Forage (hay or ensiled material);
  - Other plants or plant byproducts (e.g., such as almond, peanut or soybean hulls, citrus, other fruit including culled fruit, potatoes, or other vegetables including culled vegetables).
- Storing:
  - Dried grain;
  - Dried oilseed;
  - Byproducts of dried grain or dried oilseed;
  - Forage;
  - Other plants or plant byproducts.
- Packing:
  - Grain;
  - Oilseed;
  - Grain or oilseed byproducts;
  - Forage;
  - Other plants or plant byproducts.
- Mixing (incidental to storing or packing):
  - Grain, whole;
  - Forage.
- Cracking, crimping, flaking, or shelling:
  - Grain;
  - Oilseed;
  - Grain or oilseed byproducts.

- Crushing, grinding, milling, pulverizing, or dry rolling:
  - Grain;
  - Oilseed;
  - Grain or oilseed byproducts;
  - Forage;
  - Other plants or plant byproducts.
- Making silage.
- Chopping or shredding hay.
- Extracting (mechanical) or wet rolling:
  - Grain;
  - Oilseed.
- Labeling:
  - Grain, whole;
  - Oilseed, whole;
- Sifting, separating, or sizing:
  - Grain;
  - Oilseed;
  - Grain or oilseed byproducts;
  - Other plants or plant byproducts.

Under the statutory and regulatory framework applicable to farms and to animal food facilities co-located on farms, a specific activity (such as mixing) may have a different classification within the classes of manufacturing, processing, packing and holding (with consequences for the risk associated with the activity) depending on several factors. The determination of the classification is based on whether the food being operated upon is a raw agricultural commodity (RAC) or a processed food and whether a RAC was grown or raised on the farm performing the activity or a farm under the same ownership. An appendix to the RA arranges the results of the RA in groups shaped by these factors.

## TABLE OF CONTENTS

Executive Summary .....	2
List of Tables .....	6
I. Background and Purpose .....	7
A. Statutory and Regulatory Framework of the FDA Food Safety Modernization Act (FSMA) .....	7
B. Approach to the Qualitative Risk Assessment .....	8
C. Activities on Animal Food That Are Out of Scope of the Qualitative Risk Assessment .....	8
D. Specific Questions to be Addressed in the RA .....	9
E. Definitions of Low-Risk Activity and Low-Risk Activity/Animal Food Combination .....	10
F. Data Limitations .....	11
II. Scope .....	12
A. Activity/Animal Food Combinations within the Scope of the RA .....	12
III. Hazard Identification .....	15
IV. Hazard Characterization .....	19
A. Biological Hazards .....	19
B. Chemical Hazards .....	21
C. Nutrient Imbalances .....	23
D. Physical Hazards .....	24
E. Radiological Hazards .....	24
V. Exposure Assessment .....	25
A. Approach .....	25
B. Factors That Impact the Frequency and Levels of Contamination of the Food - Biological Hazards .....	26
1. Impact of water activity on growth of foodborne pathogens .....	27
2. Impact of pH on growth of foodborne pathogens .....	27
3. Impact of temperature on growth of foodborne pathogens .....	28
4. The impact of other factors on growth of foodborne pathogens .....	29
5. Interaction of factors that impact the growth of foodborne pathogens .....	29
6. Inherent Controls for the Biological Hazards Relevant to This Risk Assessment .....	30
7. Interventions to Control the Biological Hazards Relevant to This Risk Assessment .....	30
8. Activities That Can Introduce, or Increase the Potential for, Biological Hazards Relevant to This Risk Assessment .....	31
C. Factors That Impact the Frequency and Levels of Contamination of the Food - Chemical Hazards .....	32
D. Factors That Impact the Frequency and Levels of Contamination of the Food - Nutrient Imbalance Hazards .....	33
E. Factors That Impact the Frequency and Levels of Contamination of the Food - Physical Hazards .....	33
F. Factors That Impact the Frequency and Levels of Contamination of the Food - Radiological Hazards .....	33
G. Frequency of Consumption and Amount of Animal Food Consumed .....	34
VI. Risk Characterization .....	35

A. Approach.....	35
B. Qualitative Risk Characterization .....	35
C. Activity/Animal Food Combinations .....	37
1. Overview.....	37
2. Characterizing Activity/Food Combinations .....	37
VII. Conclusions .....	40
A. Answers to the Questions to be Addressed in This Risk Assessment .....	40
B. Summary .....	44
VIII. References .....	45
Appendix 1. Regulatory Background .....	52
A. Statutory and Regulatory Framework for the Risk Assessment .....	52
B. FDA’s Clarification of Activities Conducted on Farms .....	54
Appendix 2. Information Impacting The Risk Characterization of Activity/Animal Food Combinations .....	61
A. Regulatory Groups .....	61
B. Regulatory Group Type 1.....	61
C. Regulatory Group Type 2.....	62
D. Regulatory Group Type 3 .....	63
Appendix 3. Acronyms and Glossary .....	64

## LIST OF TABLES

TABLE 1. MANUFACTURING, PROCESSING, PACKING AND HOLDING ACTIVITY/ANIMAL FOOD COMBINATIONS THAT MAY BE CONDUCTED BY FARM MIXED-TYPE FACILITIES ON FOODS FOR ANIMAL CONSUMPTION, EXCLUDING THOSE ALWAYS WITHIN THE FARM DEFINITION*.....	13
TABLE 2. SUMMARY OF REPORTS SUBMITTED TO THE RFR, USED IN IDENTIFYING HAZARDS IN ANIMAL FOOD.....	16
TABLE 3. SUMMARY OF ANIMAL FOOD RECALLS FROM THE RES, USED IN IDENTIFYING HAZARDS.....	17
TABLE 4. HAZARDS THAT ARE REASONABLY LIKELY TO BE ASSOCIATED WITH THE ANIMAL FOOD CATEGORIES MANUFACTURED, PROCESSED, PACKED OR HELD ON A FARM MIXED-TYPE FACILITY .....	18
TABLE 5. INTERACTION OF FACTORS OPERATING AS CONTROLS FOR BIOLOGICAL HAZARDS IN THE MAKING OF SILAGE .....	30
TABLE 6. EXAMPLES OF INTERVENTIONS TO CONTROL BIOLOGICAL HAZARDS.....	31
TABLE 7. EXAMPLE OF ACTIVITY THAT CAN INTRODUCE, OR INCREASE THE POTENTIAL FOR, BIOLOGICAL HAZARDS.....	31
TABLE 8. EXAMPLES OF INTERVENTIONS AND ACTIVITIES THAT CAN AFFECT CHEMICAL HAZARDS.....	32
TABLE 9. QUALITATIVE RISK CHARACTERIZATION OF REPRESENTATIVE HAZARDS THAT MAY BE ASSOCIATED WITH ANIMAL FOODS MANUFACTURED/PROCESSED, PACKED OR HELD ON A FARM MIXED-TYPE FACILITY .....	36
TABLE 10. IS AN ACTIVITY/ANIMAL FOOD COMBINATION LOW RISK? .....	38
TABLE 11. IS AN ACTIVITY/ANIMAL FOOD COMBINATION LOW RISK? (CONTINUED) .....	39
TABLE 12. WHY CERTAIN ACTIVITY/ANIMAL FOOD COMBINATIONS ARE NOT LOW RISK .....	40
TABLE 13. KEY DEFINITIONS APPLICABLE TO THE CURRENT LEGAL AND REGULATORY FRAMEWORK UNDER SECTIONS 415 AND 418 OF THE FD&C ACT .....	54
TABLE 14. SUMMARY OF ORGANIZING PRINCIPLES REGARDING CLASSIFICATION OF ACTIVITIES ON-FARM AND OFF-FARM.....	56
TABLE 15. CLASSIFICATION OF ACTIVITIES CONDUCTED OFF-FARM AND ON-FARM (INCLUDING FARM MIXED-TYPE FACILITIES) .....	57
TABLE 16. ACRONYMS USED IN THE RA.....	64
TABLE 17. DEFINITIONS USED IN THE RA.....	64
TABLE 18. PROPOSED CHANGES TO REGULATORY DEFINITIONS RELATED TO FARM-MIXED FACILITIES .....	65

## **I. BACKGROUND AND PURPOSE**

### **A. Statutory and Regulatory Framework of the FDA Food Safety Modernization Act (FSMA)**

On January 4, 2011, the FDA Food Safety Modernization Act (FSMA) (Public Law 111–353) was signed into law. Section 103 of FSMA, Hazard Analysis and Risk-Based Preventive Controls, amends the Federal Food, Drug, and Cosmetic Act (FD&C Act) to create a new section 418 with the same name. Among other things, Section 418 requires facilities to evaluate the hazards that could affect animal food manufactured, processed, packed, or held by the facility, identify and implement preventive controls, monitor the performance of those controls, and maintain records of the monitoring. Section 418 is applicable to animal food facilities that are required to register under section 415 of the FD&C Act (Registration of Food Facilities). The registration requirement in section 415 of the FD&C Act does not apply to farms. However, it does apply to “farm mixed-type facilities”, which are establishments that grow and harvest crops or raise animals and may conduct other activities within the farm definition, but that also conduct activities that require the establishment to be registered.

Section 103(c) of FSMA directs the Secretary of the Department of Health and Human Services (HHS) to conduct a science-based risk analysis to cover “(i) specific types of on-farm packing or holding of food that is not grown, raised, or consumed on such farm or another farm under the same ownership, as such packing and holding relates to specific foods; and (ii) specific on-farm manufacturing and processing activities as such activities relate to specific foods that are not consumed on that farm or on another farm under common ownership.” The listed activities are those on-farm activities that trigger the registration requirements of section 415 of the FD&C Act and, thus, would make an establishment subject to the new requirements of section 418 of the FD&C Act and the mandatory inspection frequencies in section 421 of the FD&C Act.

Section 103(c) of FSMA also requires that the Secretary of HHS consider the results of the science-based risk analysis and exempt certain facilities from the requirements in section 418 of the FD&C Act, and the mandatory inspection frequency in section 421 of the FD&C Act, or modify the requirements, as the Secretary determines appropriate, if such facilities are engaged only in specific types of on-farm manufacturing, processing, packing, or holding activities that the Secretary determines to be low risk involving specific animal foods the Secretary determines to be low risk. The exemptions or modifications would apply only to small businesses and very small businesses (as would be defined in the regulation implementing section 418).

The purpose of this document is to satisfy these requirements of FSMA 103(c) for a science-based risk analysis covering certain manufacturing, processing, packing, and holding activities conducted on farms. Risk managers at FDA will consider the results of the risk analysis presented in this RA in determining, in part, whether to establish any exemptions from, or modifications to, requirements that would otherwise apply to small or very small farm mixed-type facilities. For more information on the regulatory

framework and its relationship to this document, see Appendix 1, Regulatory Background.

## **B. Approach to the Qualitative Risk Assessment**

We focused on activity/animal food combinations that we identified as being conducted on farms (and, thus, might be conducted by farm mixed-type facilities), but we did not consider activity/animal food combinations that would be solely within the farm definition (such as growing grains and oilseeds) and, thus, are not relevant to the requirements of section 103 of FSMA.

We considered the risk of activity/animal food combinations rather than the risk of specific animal food categories separately from the risk of specific manufacturing, processing, packing, or holding activities. Doing so enabled us to better focus on whether a specific manufacturing, processing, packing, or holding activity conducted on animal food by a farm mixed-type facility might warrant an exemption from, or modified requirements for, the provisions of section 418 of the FD&C Act. For example, although many activity/animal food combinations involving corn were determined to be low-risk by this RA, the Agency would not consider corn to be a “low-risk food” as a general matter. Illnesses in animals and humans and failure to thrive in food-producing animals have been associated with corn contaminated with aflatoxin (Caloni and Cortinovis, 2011;Merck Sharp & Dohme Corp, 2012a). Production of distillers dried grains and solubles (DDGS) from corn contaminated with aflatoxin results in product with concentrations of aflatoxin at three times the initial concentration and therefore could not be considered a low-risk activity/corn combination (Liu, 2011).

The decision before FDA was in part to determine the need for preventive controls required by section 418 of the FD&C Act for small and very small farm mixed-type facilities. Therefore, in this RA we assessed whether the types of controls that would be required by section 418 of the FD&C Act are needed to ensure the safety of the animal food manufactured, processed, packed or held by small or very small farm mixed-type facilities in light of the regulatory framework that would apply to such facilities that would become exempt from, or subject to modified requirements for, the requirements for hazard analysis and risk-based preventive controls that would be established under section 418 of the FD&C Act. Process controls (where a process is used to significantly minimize or prevent a hazard) are examples of the types of controls that facilities may implement under section 418. Any classification of an activity/animal food combination as “low risk” should not be interpreted to suggest that facilities engaged in these activities do not have an obligation to ensure the safety of the food they manufacture, process, pack, or hold and to comply with requirements of the FD&C Act and its implementing regulations.

## **C. Activities on Animal Food That Are Out of Scope of the Qualitative Risk Assessment**

Activities to produce the following animal food types are not within the scope of this RA:

- Animal tissue-derived products (such as fat; meat, fish, blood or bone meal;



- hydrolyzed feathers; calcined bones);
- Pet food, including pet treats;
- Milk products.

Activities to produce these animal food types require one or more preventive controls (e.g., heat treatment, time/temperature control for safety) to significantly minimize or prevent a hazard that is reasonably likely to cause serious adverse health consequences or death. (For additional discussion regarding foods that require time/temperature control for safety, see FDA’s Food Code (FDA, 2012a)). Additionally, we considered that when a food requires refrigeration to control pathogens, temperature control is necessary at all steps, and therefore no activity involving such food would be low risk FDA, 2012a;Institute of Food Technologists, 2009. Thus, activities to produce animal tissue-derived products, to produce pet food, including pet treats, and to produce milk products could not be considered low-risk activity/animal food combinations. We eliminated these activity/animal food combinations (e.g. rendering, churning) from the scope of the RA because they are not low-risk by virtue of requiring temperature controls.

In addition, based on the statutory framework of FSMA described in general in Appendix 1.A. of this document, activities related to low-acid canned foods are within the scope of the RA only with respect to chemical, physical, and radiological hazards These hazards related to low-acid canned foods are evaluated in the draft human food RA (FDA, 2013a). However, for animal food, we understand that low-acid canning is an activity used only in the production of pet food and is therefore out of the scope of the animal food RA.

#### **D. Specific Questions to be Addressed in the RA**

**Question 1:** What are the animal foods that would be manufactured, processed, packed or held by a farm mixed-type facility?

**Question 2:** What are the activities that might be conducted by farm mixed-type facilities on those animal foods?

**Question 3:** What are the hazards reasonably likely to occur in those animal foods?

**Question 4:** For the purpose of determining whether an activity/animal food combination is low risk, which hazards should be considered to have a reasonable probability of causing serious adverse health consequences or death to humans or animals?

**Question 5:** For the purpose of determining whether an activity/animal food combination is low risk, what animal foods have inherent controls that significantly minimize or prevent a biological hazard that is reasonably likely to occur in these animal foods and that is reasonably likely to cause serious adverse health consequences or death to humans or animals?

**Question 6:** What interventions significantly minimize or prevent a hazard that is reasonably likely to occur in these animal foods and that is reasonably likely to cause serious adverse health consequences or death to humans or animals?

**Question 7:** Which of these activities are reasonably likely to introduce into animal food, or increase the potential for occurrence of, hazards that are reasonably likely to cause serious adverse health consequences or death to humans or animals and what are these hazards?

**Question 8:** Which of these activities are interventions to significantly minimize or prevent hazards that are reasonably likely to cause serious adverse health consequences or death to humans or animals from consumption of these animal foods?

**Question 9.** Which activity/animal food combinations are low risk, i.e., what on-farm activity/animal food combinations are not reasonably likely to introduce hazards that are reasonably likely to cause serious adverse health consequences or death to humans or animals or serve as preventive controls (interventions) to significantly minimize or prevent a hazard that is reasonably likely to cause serious adverse health consequences or death to humans or animals?

## **E. Definitions of Low-Risk Activity and Low-Risk Activity/Animal Food Combination**

For the purpose of the analysis required by section 103(c)(1)(C) of FSMA, we are defining “low-risk activity” and “low-risk activity/food combinations” as follows:

- We are defining “low-risk activity” to mean an activity that:
  1. Is performed on, or during production of, an animal food that has inherent controls for foodborne pathogens, provided that the animal food does not require preventive controls to significantly minimize or prevent other types of hazards (e.g., a biological hazard such as *Clostridium botulinum*); or
  2. Satisfies both of the following criteria:
    - a) Is not reasonably likely to introduce (or increase the potential for) a hazard for which there is a reasonable probability that use of, or exposure to, the food will cause serious adverse health consequences or death to humans or animals (a SAHCODHA hazard); and
    - b) Does not significantly minimize or prevent a SAHCODHA hazard.
- We are defining “low-risk activity/animal food combination” to mean a low-risk activity that applies to a specific animal food.

For the purpose of this analysis, we:

- Refer to the above three parts of the definition of “low-risk activity” as:
  - #1 (inherent controls);
  - #2a (activity not likely to introduce, or increase the potential for, a SAHCODHA hazard; and
  - #2b (activity does not significantly minimize or prevent a SAHCODHA hazard).
- Use the term “inherent controls” to mean that in making the animal food the hazard is controlled, and it is highly unlikely that the animal food will be made in a way that the hazard is not adequately addressed.
- Use the phrase “reasonably likely to cause serious adverse health consequences or death to humans or animals” to mean that there is a reasonable probability that use of, or exposure to, an animal food containing a hazard will cause serious adverse health consequences or death to humans or animals. It is important to note that our

conclusions in this document with respect to whether there is a reasonable probability that use of, or exposure to, an animal food containing a hazard will cause serious adverse health consequences or death to humans or animals are limited to the purposes of this document. In this document, we are considering such hazards and animal foods in general terms, on a forward-looking basis, and not in reference to a particular animal food contamination incident or foodborne illness outbreak. Determinations of whether there is such a reasonable probability in specific situations may be different from the conclusions made for the limited purposes of this document.

Importantly, under the definition of low-risk activity animal food combination, to be low risk the activity/animal food combination must either:

- Satisfy part #1; or
- Satisfy both part #2a and part #2b.

## **F. Data Limitations**

There are many limitations to the data used in this analysis:

- We have limited data on the types of activity/animal food combinations associated with small and very small farm mixed-type facilities, especially for foreign facilities.
- We have limited data on the frequency and levels of contamination of animal food in general.
- We have no data on the frequency and levels of contamination of animal food manufactured, processed, packed or held by small and very small farm mixed-type facilities in particular.
- We have limited data on the occurrence of serious adverse health consequences or death from hazards associated with manufacturing, processing, packing or holding activities conducted on animal foods. Thus, we relied in large part on our existing understanding of hazards and processes in order to characterize risk.
- Information on cases of foodborne illness in animals associated with hazards in animal foods submitted to the Reportable Food Registry (RFR) by animal owners is submitted on a voluntary basis, is under-reported and is more likely to be reported for companion animals than for food animals (FDA, 2012b).
- We have no data on serious adverse health consequences or death in humans or animals from hazards associated with manufacturing, processing, packing or holding activities conducted on animal foods by small and very small farm mixed-type facilities specifically.
- We lack data to conduct a dose-response assessment for hazard characterization for animal foods for many hazards.
- Data on foodborne illness in humans associated with biological and chemical hazards is primarily linked directly to foods consumed by humans rather than indirectly to animal food. Information on the extent to which presence of a hazard in animal food influences the presence of the hazard in human food is limited to a few instances. One known example is the presence of aflatoxin in animal food for dairy cattle resulting in detectable levels of aflatoxin in milk (FDA, 2013b).

- Limited data are available on the human health impacts of direct exposure to animal food. Instances of human cases of salmonellosis associated with contact with pet food have been reported to the RFR and CDC (Centers for Disease Control and Prevention (CDC), 2008);(FDA, 2012b).
- The lack of evidence associating occurrences of serious adverse health consequences or death with biological, chemical, physical and radiological hazards associated with manufacturing, processing, packing or holding activities conducted on animal foods by small and very small farm mixed-type facilities, along with the other data limitations noted above, are significant limitations of this RA.

## **II. SCOPE**

### **A. Activity/Animal Food Combinations within the Scope of the RA**

The scope of the RA is limited to an assessment of the risk of serious adverse health consequences or death in animals or humans from hazards associated with manufacturing, processing, packing or holding activities conducted on animal foods by small and very small farm mixed-type facilities, including both domestic and foreign facilities, to determine which activity/animal food combinations conducted by such facilities are low risk.

The activity/animal food combinations considered within the scope of this RA are those that we identified that might be conducted by farm mixed-type facilities by forming a cross-tabulation with activities as rows and animal foods as columns using animal foods and activities conducted on animal foods found in animal food trade publications FDA, 2013a;FDA, 2013b. We solicited input from animal food safety and processing experts within the Center for Veterinary Medicine and from outside experts in the animal food industry and academia about whether the activity and animal food pairs represented by the cells of the table were feasible activity/animal food combinations, whether they would be considered harvesting activities (i.e., within the farm definition), and whether they were likely to be conducted by small or very small farm mixed-type facilities. We did not have data on activity/animal food combinations likely to be conducted by foreign farm mixed-type facilities, which may include activity/animal food combinations not considered here. FDA is seeking comment on other activity/animal food combinations that should be considered.

If an expert or a reference identified an activity/animal food combination that is outside the scope of this RA (i.e., activities to produce animal tissue-derived products, pet treats, and milk products), we did not include that activity/animal food combination in the list. We also did not include activity/animal food combinations or activity/animal food combinations (e.g., growing grain) that are always within the farm definition. (See Table 15 in Appendix 1 for a summary and examples of how activities would be classified as inside or outside the farm definition under the rulemaking required by section 103(c) of FSMA.)

Table 1 lists the resulting activity/animal food combinations that we identified as likely to be conducted by farm mixed-type facilities. Table 1 includes activities that would not be within the farm definition when done on others' RACs even though they would be within the farm definition when they are done on a farm's own RACs (e.g., storing grain to be entered into commerce). Table 1 also includes activities that may encompass multiple steps (e.g., ensiling or making forage may involve steps such as chopping, mixing, storing and fermenting) and groups these steps to better identify the end product. Table 1 does not include activity/animal food combinations that are always within the farm definition.

Table 1. Manufacturing, Processing, Packing and Holding Activity/Animal Food Combinations That May Be Conducted by Farm Mixed-type Facilities on Foods for Animal Consumption, Excluding Those Always Within the Farm Definition\*

<b>Activity</b>	<b>Food</b>
Aspiration, cleaning, screening	Grain, oilseed, hay
Conveying (incidental to storing)	Grain, oilseed, grain or oilseed byproducts, forage, hay, silage, other plants or plant byproducts (e.g., such as almond, peanut or soybean hulls, citrus, other fruit including culled fruit, potatoes, or other vegetables including culled vegetables), vitamins or minerals, processing aids, rendered animal or marine byproducts (e.g., bone meal, fish, shrimp, or crab meal), milk products, molasses, fats and oils
Cracking, crimping, flaking, pearling, peeling, shelling, wafering	Grain, oilseed, grain or oilseed byproducts
Crushing, grinding, milling, pulverizing, dry rolling	Grain, oilseed, grain or oilseed byproducts, hay, ensiled material, other plants or plant byproducts, vitamins or minerals, processing aids
Culling, sorting, grading (incidental to storing)	Grain, oilseed, grain or oilseed byproducts, forage, hay, silage, other plants or plant byproducts
Making silage	Forage, grain, oilseed, other plants or plant byproducts
Chopping, shredding	Hay
Post-harvest drying, dehydrating for the purpose of storage or transportation	Grain, oilseed
Extracting (mechanical), wet rolling	Grain, oilseed, brewer/distiller products
Treating against pests other than during growing (fumigation)	Grain, oilseeds, grain or oilseed byproducts, hay, silage, brewer/distiller products
Mixing (incidental to packing and storing)	Whole grain, forage
Labeling	Grain, oilseed, manufactured animal food
Mixing, blending for the purpose of making a finished animal food	Grain, oilseed, grain or oilseed byproducts, forage, hay, silage, other plants or plant byproducts, vitamins or minerals, processing aids, rendered animal or marine byproducts (e.g., bone meal, fish, shrimp, or crab meal), molasses, milk products, fats and oils
Packing	Grain, oilseed, grain or oilseed byproducts, forage, hay, other plants or plant byproducts
Sifting, separating or sizing	Grain, oilseed, grain or oilseed byproducts, other plants or plant byproducts

Activity	Food
Storing	Grain, oilseed, grain or oilseed byproducts, forage, hay, silage, other plants or plant byproducts, vitamins or minerals, processing aids, rendered animal or marine byproducts (e.g., bone meal, fish, shrimp, or crab meal), milk products, molasses, fats and oils, finished animal food
Weighing (incidental to storing)	Grain, oilseed, grain or oilseed byproducts, forage, hay, silage, other plants or plant byproducts, vitamins or minerals

\*All activities are within the farm definition when performed on a farm for consumption by animals on the farm or another farm under the same ownership. Some activities in the Table are within the farm definition when performed on a farm mixed-type facility's own RACs (see Table 15 in Appendix 1).

Solvent extraction, expanding, extruding, kibbling, pelleting, and forming or molding such as in the making of food or mineral blocks, are not included in Table 1. Both internal and external experts concluded that these activities are unlikely to be conducted by a facility co-located on a small or very small farm because they are complex operations requiring expensive equipment.

FDA believes that Table 1 includes most of the activity/animal food combinations (except for those always within the farm definition) that are potentially conducted by farm mixed-type facilities on foods that are within the scope of the RA. However, based on the Food Processing Sector Study, we acknowledge that Table 1 may not include all such activity/food combinations (Muth et al., 2011). For example, the Food Processing Sector Study classifies 175 small and very small facilities co-located on farms that produce "Food Preparations, Not Elsewhere Classified" (Muth et al., 2011). The SIC code (Standard Industrial Classification code from Dun & Bradstreet) for this category lists more than a dozen foods for which we are unable to determine the specific foods produced by the small and very small facilities co-located on farms and whether any of them were animal foods. Thus, Table 1 may not include activity/animal food combinations for these facilities.

The list of activity/animal food combinations likely to be conducted at farm mixed-type facilities contains the animal food categories that would be within the scope of the RA, including the farm's own RACs and RACs from farms under different ownership as well as animal food components purchased to make animal food. We grouped these animal food categories as follows:

- Grain (e.g., barley, corn, rice, oat, sorghum, triticale, wheat);
- Oilseed (e.g., cottonseed, linseed, rapeseed, soybean, sunflower);
- Grain or oilseed byproducts;
- Forage (e.g., milo, corn, alfalfa, grass):
  - Hay (dried alfalfa and other grasses)
  - Ensiled forage;
- Other plants or plant byproducts (e.g., almond, peanut or soybean hulls, citrus, other fruit including culled fruit, potatoes, or other vegetables including culled vegetables);

- Purchased food animal components such as vitamins or minerals, processing aids, rendered animal or marine byproducts (e.g., bone meal, fish, shrimp, or crab meal), brewer/distiller products such as dried distillers grains and solubles, milk products, molasses, fats or oils.

For the purpose of this document, a fruit is the edible reproductive body of a seed plant or tree nut (such as orange and almond) such that fruit means the harvestable or harvested part of a plant developed from a flower. For the purpose of this document, a vegetable is the edible part of an herbaceous plant (such as potato) or fleshy fruiting body of a fungus (such as white button or shiitake) grown for an edible part such that vegetable means the harvestable or harvested part of any plant or fungus whose fruit, fleshy fruiting bodies, seeds, roots, tubers, bulbs, stems, leaves, or flower parts are used as food and includes mushrooms, sprouts, and herbs (such as basil or cilantro).

For the purposes of this document, grain means the small, hard fruits or seeds of arable crops, or the crops bearing these fruits or seeds. For the purposes of this document, oilseed means the small, hard fruits or seeds of arable crops that are grown and processed mainly for the oil that is extracted from them. Examples of animal food oilseeds include soybean, cottonseed, and rapeseed. It is assumed that grain and oilseed used in animal food are field dried as part of harvesting. “Post-harvest drying, dehydrating for the purpose of storage or transportation” listed in Table 1 is an additional packing/holding step that may be performed on harvested grain or oilseed to further decrease moisture levels in preparation for storage or transportation. For the purposes of this document, the terms “grain” and “oilseed” are used in a general sense whereas the terms “dried grain” and “dried oilseed” are used in a specific sense to refer to harvested grain and oilseed that have been further dried or dehydrated in preparation for storage or transportation.

### **III. HAZARD IDENTIFICATION**

The purpose of the Hazard Identification step of a food safety risk assessment is to identify the hazards of concern. The scope of this RA requires consideration of the broad range of biological, chemical, physical, and radiological hazards in animal food that are relevant to a farm mixed-type facility under section 418 of the FD&C Act. Although there is a National Animal Health Monitoring System (NAHMS) maintained by the United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS), the animal disease cases reportable to the monitoring program are chiefly cases with communicable diseases such as tuberculosis and brucellosis in cattle rather than cases experiencing adverse health outcomes following consumption of a suspect animal food (United States Department of Agriculture and Animal and Plant Health Inspection Service, 2012). In contrast to CDC’s FoodNet data that serves to identify and estimate numbers of cases affected by microbial hazards in human food, there are no monitoring data to estimate numbers of animals affected by hazards of concern for animal food (Centers for Disease Control and Prevention (CDC), 2012). As a result, we relied more heavily upon information available from the Reportable Food Registry (RFR) and the Recall Enterprise System (RES) and identified biological, chemical, and physical hazards associated with animal food (FDA, 2013c); (FDA,

2011a). The RFR was established by section 1005 of the Food and Drug Administration Amendments Act of 2007 (Pub. L.110-085) and requires a responsible party to file a report through the RFR electronic portal when there is a reasonable probability that the use of, or exposure to, an article of food will cause serious adverse health consequences or death to humans or animals (FDA, 2013c). The RES is a component of the FDA Office of Regulatory Affairs (ORA) Mission Accomplishments and Regulatory Compliance Services (MARCS) database (FDA, 2011a).

Many of the hazards reported to the RFR and to the RES are common to food for humans and food for animals. However, nutrient imbalance is not described as a hazard for human food but is a frequently reported hazard of animal food and a very important one because often animals depend entirely on the same daily ration offered for their consumption and they consume the ration *ad libitum* (Gries and Scott, 1971);(Johnson and Storts, 1988);(National Research Council, 2000);(National Research Council, 2005). For the purposes of this RA, nutrient imbalance is considered a form of chemical hazard associated with animal food with potential to harm only animals, while chemical contamination is a form of chemical hazard associated with animal food with potential to harm both humans and animals.

The information in the RFR and in the RES is not limited to reports of serious adverse health consequences (i.e., serious illness) or death. In fact, the recalls in the RES do not consistently have observed health outcomes associated with them because the animal food contamination is usually detected by the responsible party at the animal food manufacturer facility before there are adverse health outcomes.

Table 2. Summary of Reports Submitted to the RFR, Used in Identifying Hazards in Animal Food

Hazard	Number of Reports to the RFR ( September, 2009- September, 2012)	Serious Adverse Consequences or Deaths Reported?
Biological: (Salmonella)	27	No
Chemical: contaminants (e.g.,Mycotoxins, Dioxin, Botulinum toxin)	13	No
Chemical: nutrient imbalance (e.g., excessive urea, copper; inadequate thiamine, vitamin D)	27	Yes
Physical hazards (e.g., metal, glass, plastic)	5	Yes



Table 3. Summary of Animal Food Recalls from the RES, Used in Identifying Hazards

Hazard	Number of Class I Recalls (Fiscal Years 2006-2012)	Types of Animal Food(s) Recalled
Microbiological - Total	468	Pet Food; Livestock Food
Microbiological- Salmonella	422	
Microbiological - Prohibited protein*	46	
Chemical: contaminants - Total	1371	Pet Food; Horse Food; Livestock Food
Chemical Contaminants - Melamine	1062	
Chemical Contaminants - All others (e.g., Mycotoxins, Botulinum toxin, Pesticides)	309	
Nutrient Imbalance	285	Pet Food: Livestock Food
Physical hazards (e.g., Metal, Glass, Plastic)	35	Game Bird Food; Horse Food; Livestock Food
Radiological hazards	0	

\*These recalls had to do with lack of proper labeling. Prohibited protein is used as the indicator for potential contamination by BSE prions. BSE prions are hazards outside the scope of this RA because they are found in animal tissue. Processing animal tissue is covered under BSE regulations (CFR 589.2000-589.2001).

Human cases of Salmonellosis have been linked to exposure to pet food containing *Salmonella* in the RFR reports and by the CDC (Centers for Disease Control and Prevention (CDC), 2008). Pet food production is beyond the scope of this RA on the basis of requiring temperature controls to control this hazard. Mycotoxins can adversely affect human health but exposure to human food contaminated with mycotoxins accounted for only about two percent of the mean annual illnesses from outbreaks reported by the Centers for Disease Control during the period 2003-2007 (Centers for Disease Control and Prevention (CDC), 2011a). Residue of mycotoxins in food (e.g., milk, eggs, and meat) from food producing animals that consumed animal food containing mycotoxins is a possible mechanism for mycotoxin contamination in animal food to be transferred to humans. However, most human exposure is attributed to contaminated grains and cereals (Orriss, 1997). In comparison to human diets, animal diets are much less varied and, except for companion animal foods, are comprised chiefly of grains and oilseeds so that animals have much more opportunity for exposure to

hazards such as mycotoxins (Brendemuhl and Myer, 2012);(National Research Council, 1994);(National Research Council, 2000).

No human illness cases associated with nutrient imbalance hazards, physical hazards, or radiological hazards in animal food have been reported.

Severe animal health consequences, including death, have been associated with biological, chemical (including nutrient imbalance), and physical hazards in animal food, but no animal health consequences associated with radiological hazards in animal food were found.

Table 4 provides information about the association of biological and chemical hazards that are the subject of reports of illness or injury to FDA’s RFR and RES with the animal food categories that we identified in section II.A of this document as likely to be manufactured, processed, packed or held on a farm mixed-type facility. The biological and chemical hazards identified in Table 4 as associated with specific food categories are representative of the types of biological and chemical hazards that could be associated with the manufacturing, processing, packing, or holding of animal food by a farm mixed-type facility. Table 4 is not intended to be exhaustive. We provide information about the severity of each of the hazards identified in Table 4 in the Hazard Characterization section of this document.

Table 4 does not include physical hazards, which could be a contaminant in virtually any food category. Table 4 does not include radiological hazards because they are too rare in animal food to be considered associated with any animal food category. Table 4 also does not include nutrient imbalance hazards because nutrient balance is a property of a finished animal food. There is no expectation that single animal food ingredients would be nutritionally balanced.

Table 4. Hazards That Are Reasonably Likely to Be Associated with the Animal Food Categories Manufactured, Processed, Packed or Held on a Farm Mixed-Type Facility

<b>Food Category</b>	<b>Associated Biological Hazards</b>	<b>Associated Chemical Hazards</b>	<b>References</b>
Grain	<i>Salmonella</i>	Mycotoxins (aflatoxin and deoxynivalenol); pesticide residues	(D’Mello and Macdonald, 1997);(International Commission on Microbiological Specifications for Foods, 2005a)
Oilseed	<i>Salmonella</i>	Mycotoxins (aflatoxin and deoxynivalenol); pesticide residues	(International Commission on Microbiological Specifications for Foods, 2005b);(Morita et al., 2006)

Food Category	Associated Biological Hazards	Associated Chemical Hazards	References
Grain or oilseed byproducts	<i>Salmonella</i>	Mycotoxins (aflatoxin and deoxynivalenol); pesticide residues	(D'Mello and Macdonald, 1997);(Morita et al., 2006)
Forage	<i>Salmonella</i>	Mycotoxins (e.g., aflatoxin, fumonisin)	(Cavallarin et al., 2011);(D'Mello and Macdonald, 1997)
Hay	<i>Salmonella; Clostridium botulinum</i>	Botulinum toxin; Pesticide residues	(Agriculture and Agri-Food Canada Food Production Direction Inspection Branch, 1993);(Myllykosk et al., 2009);(Whitlow and Hagler, 2005)
Ensiled material	<i>Salmonella; Clostridium botulinum</i>	Mycotoxins (e.g., aflatoxin and deoxynivalenol); botulinum toxin; pesticide residues	(Agriculture and Agri-Food Canada Food Production Direction Inspection Branch, 1993);(Myllykosk et al., 2009)
Other plants or plant byproducts	<i>Salmonella; Clostridium botulinum</i>	Mycotoxins (e.g., aflatoxin); botulinum toxin;pesticide residues	(Jones, 2011)

#### IV. HAZARD CHARACTERIZATION

The Hazard Characterization step describes the nature, severity, and duration of adverse effects that may result from ingestion of the hazard applicable to a food category. These will depend on the host, the agent and the environment, and there is generally a range of adverse effects (i.e., there is a high degree of variability) that occurs in a population ingesting a contaminated food.

##### A. Biological Hazards

In the Hazard Identification section of this RA, we identified *Salmonella*, as representative of the biological (microbial) hazards of concern for animal food categories that are likely to be manufactured, processed, packed or held on a farm mixed-type facility and within the scope of this RA. Adverse effects associated with biological hazards may occur as a result of animal consumption of or human contact with a contaminated animal food from a single exposure. Reports of *Salmonella*-contaminated animal food and illnesses associated with animal consumption of, or human contact with, a contaminated animal food are found in the RFR or RES.

*Salmonella* is a bacterium that causes the illness salmonellosis (FDA, 2012c). Symptoms of salmonellosis in people include diarrhea, fever, abdominal cramps, headache, nausea, and vomiting (FDA, 2012c). Acute symptoms may persist for 1 to 2 days or may be

prolonged, depending on host factors, ingested dose, and characteristics of the specific bacterial strain (FDA, 2012c). Most healthy people recover, but the infection can spread to the bloodstream, and then to other areas of the body, leading to severe or fatal illness, which is more likely to occur in children, the elderly, or persons with weakened immune systems (FDA, 2012c). The infective dose can be as few as 15-20 cells, depending on age and health of the victim and strain differences among the members of the genus (FDA, 2012c). *S. Typhi* and *S. Paratyphi* A, B, and C produce typhoid and typhoid-like fever in humans, infecting various organs and leading to lesions. The fatality rate for most forms of salmonellosis is less than 1 percent, although it is usually higher for typhoid fever (FDA, 2012c). However, a number of strains can cause severe disease, e.g., the fatality rate of *S. Dublin* is 15 percent when septicemic in the elderly, and the fatality rate of *S. Enteritidis* is approximately a 3.6 percent in hospital/nursing home outbreaks, with the elderly being particularly affected (FDA, 2012c). Reactive arthritis may occur in about two percent of culture-confirmed cases (FDA, 2012c). Septic arthritis, subsequent to or coincident with septicemia, also occurs and can be difficult to treat (FDA, 2012c).

Salmonellosis symptoms in animals include septicemia, acute enteritis, and chronic enteritis. Salmonellosis in cattle occurs as sporadic outbreaks while individual horses tend to contract the illness following a period of stress (Merck Sharp & Dohme Corp, 2012b). Different animal species are susceptible to different serotypes of *Salmonella*. As examples, pigs are susceptible to *S. Cholerasuis*; cattle are susceptible to *S. Newport* and *S. Dublin*; and poultry are susceptible to *S. Enteritidis* and *S. Pullorum* (Merck Sharp & Dohme Corp, 2012b);(Uzzau et al., 2000). Young livestock are more likely to develop the septicemic form of the disease with depression and fever, often culminating in death (Merck Sharp & Dohme Corp, 2012b). Adult cattle, sheep, and horses tend to develop the acute form, experiencing fever and severe watery diarrhea and often tenesmus (Merck Sharp & Dohme Corp, 2012b). Horses also become dehydrated and develop leucopenia and neutropenia, and may die within 24 hours of onset of diarrhea (Merck Sharp & Dohme Corp, 2012b). Growing pigs and some adult cattle develop the chronic enteritis form of disease with persistent diarrhea, anorexia and weight loss to the point of emaciation (Merck Sharp & Dohme Corp, 2012b). Spontaneous abortion is possible in pregnant animals with salmonellosis (Merck Sharp & Dohme Corp, 2012b). In dogs and cats, symptoms of salmonellosis are acute diarrhea with or without septicemia (Merck Sharp & Dohme Corp, 2012b).

*Clostridium botulinum* is a sporeforming anaerobic bacterium that causes botulism, a rare but serious paralytic illness caused by a nerve toxin that is produced by the bacterium (Centers for Disease Control and Prevention (CDC), 2011b). While botulinum toxin is the hazard responsible for adverse health consequences, *C. botulinum* is considered under microbial hazards because control measures to prevent the toxin from being present in animal food are exercised against the bacterium that produces the toxin. Symptoms of botulism include double vision, blurred vision, drooping eyelids, slurred speech, difficulty swallowing, dry mouth, and muscle weakness, which, if untreated, may progress to paralysis of the respiratory muscles, arms, legs, and trunk (Centers for Disease Control and Prevention (CDC), 2011b). Death due to respiratory failure can occur. A patient with severe botulism may require a breathing machine as well as

intensive medical and nursing care for several months, and some patients die from infections or other problems related to remaining paralyzed for weeks or months. Patients who survive an episode of botulism poisoning may have fatigue and shortness of breath for years and long-term therapy may be needed to aid recovery (Centers for Disease Control and Prevention (CDC), 2011b) .

Botulism incidence in animals is relatively low, with birds, including chickens, thought to be more susceptible than cattle or horses (Merck Sharp & Dohme Corp, 2012c). There are different strains of *C. botulinum* and animal species differ with respect to which strains predominantly affect them (Merck Sharp & Dohme Corp, 2012c). Clinical symptoms are similar to those in humans: disturbed vision, difficulty chewing and swallowing, progressive motor paralysis which may terminate with respiratory and cardiac paralysis. When treated early with antitoxin there is possibility of survival (Merck Sharp & Dohme Corp, 2012c). Adverse consequences in the horses exposed to *C. botulinum* reported to FDA's district offices and recorded in the RES included illness and at least one death (Table 4).

## **B. Chemical Hazards**

The Hazard Identification section of this RA identified mycotoxins (e.g., aflatoxins, ochratoxin A, deoxynivalenol, fumonisin) as representative of the chemical hazards associated with animal food categories (e.g., grain, oilseed, other plants or plant byproducts) that are likely to be manufactured, processed, packed or held on a farm mixed-type facility and within the scope of this RA. The adverse reactions due to mycotoxin hazards depend upon the type of mycotoxin and the amount to which a person or animal is exposed, and may be acute or chronic. The effects of mycotoxins on humans are still not well understood, and much information on adverse effects is based on animal models. In the past, a number of outbreaks of human illness (including some with severe illnesses and death) associated with high levels of mycotoxins have been documented. Currently, in developed countries such as the United States and those of the European Union, significant investments in production, storage and drying facilities, coupled with the country's regulatory system, now result in low concentrations of mycotoxins in foods (Williams et al., 2004). Acute adverse effects of mycotoxins currently are more common in developing countries (Pestka and Smolinski, 2005);(Williams et al., 2004). In humans, adverse effects associated with chemical hazards such as mycotoxins tend to be the result of chronic exposure rather than manifesting as an acute illness (Williams et al., 2004).

Large doses of aflatoxin can result in acute illness and death, usually through liver cirrhosis; reports of serious illness and death usually originate in the zone of risk for mycotoxin production (at latitudes between 40 degrees North and South of the equator) and occur infrequently(Williams et al., 2004). Adults usually have a high tolerance for aflatoxin, and some ingested aflatoxin is detoxified (Williams et al., 2004). Long-term, cumulative exposure to aflatoxin can result in liver cancer (Shephard, 2008);(Williams et al., 2004). Ochratoxins, which have been identified in barley, wheat, rye, corn, rice and coffee, are classified as human carcinogens and have been associated with kidney effects in animals but have not been associated with acute illnesses (Bayman and Baker, 2006).

In contrast, deoxynivalenol which may be found in wheat, corn and barley, has been associated with acute gastroenteritis similar to staphylococcal food poisoning (vomiting, abdominal pain, diarrhea, headache, dizziness and fever), although not in the United States (Pestka and Smolinski, 2005). Although mycotoxins have been associated with a number of diseases, FAO has noted that in most instances conclusive evidence for the role of mycotoxins is lacking (Bhat and Miller, 1991).

Mycotoxin effects on animals similarly vary according to the type of mycotoxin and the levels to which the animal is exposed, with acute effects being associated with high level exposures and chronic effects being associated with long-term, low-level exposure. High level exposure to aflatoxins in mammals may result in inappetance, lethargy, ataxia, rough hair coat and pale, enlarged livers. Signs of long-term low-level exposure include decreased appetite and reduced feed efficiency and milk production. Aflatoxin is also responsible for suppression of immunity and lowered resistance to disease in species such as turkeys, chickens, pigs, mice, guinea pigs, and rabbits (Whitlow and Hagler, 2005).

Fumonisin can be found mostly in corn and cause toxicity in animals primarily through disruption of lipid metabolism (Tsunoda et al., 1998). Equine leukoencephalomalacia (ELEM) has been identified as being an effect of fumonisin exposure unique to horses and it is typically secondary to cardiovascular effects (United States Department of Agriculture, 2000). Effects of lower levels of exposure to fumonisin in swine have been associated with slowly progressive hepatic necrosis while exposure to higher levels also results in pulmonary edema (Merck Sharp & Dohme Corp, 2012d). RES contains a report about horse silage feed that contained fumonisin and all 14 of the horses exposed succumbed (Table 3)

Table 4 in the Hazard Identification section of this RA identified pesticide residues as a chemical hazard that can be associated with grains, oilseeds, grain or oilseed byproducts, forage, hay, ensiled material, and other plants or plant byproducts. Whether a pesticide is safe for a particular use, in a particular food, at a particular level, depends on factors such as the amount of the food that is consumed and, if the pesticide is ingested by a living animal before slaughter, how the product is metabolized in that animal. Pesticide residues that are present in food in the absence of or in excess of a tolerance established by the EPA are deemed by the FD&C Act to be unsafe (60 FR 65096 at 65119, Federal Register of December 18, 1995). Reports from FDA's pesticide monitoring program consistently demonstrate that levels of pesticide residues in the U.S. food supply are overwhelmingly in compliance with EPA's permitted pesticide uses and tolerances (FDA, 2013d).

The most common health effect in people exposed to large amounts of dioxin is chloracne. Chloracne is a severe skin disease with acne-like lesions that occur mainly on the face and upper body. Chloracne cases have typically been the result of accidents or significant contamination events. Other effects of exposure to large amounts of dioxin include skin rashes, skin discoloration, excessive body hair, and possibly mild liver damage (Centers for Disease Control and Prevention (CDC) ATSDR, 1999);(FDA, 2011b).

Most of the population has low-level exposure to dioxins. Although dioxins are environmental contaminants, most dioxin exposure occurs through the diet, with over 95% coming through dietary intake of animal fats. Small amounts come from breathing air containing trace amounts of dioxins on particles and in vapor form, from inadvertent ingestion of soil containing dioxins, and from absorption through the skin that is in contact with air, soil, or water containing minute levels of dioxins (Centers for Disease Control and Prevention (CDC) ATSDR, 1999);(FDA, 2011b).

Effects of dioxins on animals vary considerably by animal species and by dose. In toxicological studies, death resulted from a single high dose exposure in rodents and dogs (Centers for Disease Control and Prevention (CDC) ATSDR, 1999). At low doses, as are typically seen in animal foods, chronic exposure is required to observe effects such as weight loss, liver damage, disruption of the endocrine system, weakening of the immune system, and reproductive damage and birth defects (Centers for Disease Control and Prevention (CDC) ATSDR, 1999).

### **C. Nutrient Imbalances**

The Hazard Identification section of this RA identified nutrient imbalances, too much or too little of essential nutrients, called subpotent and superpotent ratios of nutrients, as hazardous to animals. The existence and content of the National Research Council publications on nutrient requirements for all species of food animals indicates the importance of balanced nutrition for animals dependent on the rations supplied to them every day(National Research Council, 1994);(National Research Council, 2000).

More incidences of superpotent animal food are reported through the RFR or received in the RES than complaints concerning subpotent animal foods. Superpotent animal food can trigger an acute toxicity response which is likely to be pronounced and detected, whereas subpotent animal foods require more than a single exposure to elicit response. When a response to subpotent animal food occurs, it is likely to be considered unthriftiness at first. Continued exposure to subpotent animal food will eventually lead to profound effects and can result in death over time.

Nutrient imbalance hazards can result from excessive levels of a nutrient in animal food leading to toxicity (e.g., copper poisoning in sheep consuming food with excessive levels of copper), or a nutrient deficiency in the food that can compromise the health of animals (e.g., chickens fed riboflavin deficient diets experience curled toe disease)(Gries and Scott, 1971);(Johnson and Storts, 1988);(Phillips and Engel, 1938);(Wyatt et al., 1973).

Nutrient imbalance hazards can also result from diets containing inappropriate proportions of essential nutrients. For example, an animal's calcium needs cannot be considered independently of phosphorus. Calcium, an essential mineral, may be adequate in forage (especially legumes) for grazing cattle. Phosphorus, however, can be deficient in the forages, and since calcium and phosphorus work hand in hand for the animal's muscle and metabolic functions, respectively, supplemental phosphorus at an appropriate level would be needed for cattle on forage-based diets. Calcium and phosphorus are also the major mineral constituents of bone. The calcium to phosphorus ratio in the animal

food for cattle would need to be maintained in the desired range to prevent negative health effects associated with nutrient imbalance (e.g., rickets in young animals, osteomalacia in adult animals, reduced resistance to disease, overall reduced productivity including reduced food intake, reduced conception rates, or reduced milk production in cattle) (National Research Council, 2005).

Proper nutrient balance is particularly important for animal food because often one animal food type is the sole source of an animal's diet. Nutrient imbalance is therefore hazardous in a finished feed. A nutrient imbalance hazard in animal food would pose a greater risk to the health of animals fed a sole source diet than to the health of animals receiving a varied diet similar to that consumed by humans. No human health consequences as a result of nutrient imbalances in animal food were identified.

Nutrient imbalance problems reported to the RFR and RES include elevated copper, urea, zinc, and salt levels that were reported to have been associated with illness and death in ewes and goats, cows, calves, and pigs, respectively. Neurological and muscular, gastrointestinal, behavioral, and reproductive adverse health consequences were seen in pigs exposed to animal food containing high levels of selenium while weight loss and dehydration were associated with high levels of manganese sulfate in animal food fed to pigs. On the other hand, deaths were reported among pigs fed swine food or given a swine vitamin supplement found to have inadequately low levels of vitamin D.

#### **D. Physical Hazards**

The scope of this RA requires consideration of physical hazards that are relevant to a farm mixed-type facility under section 418 of the FD&C Act. Physical hazards can be contaminants in virtually any food category. Reports to the RFR included animal food exposures of horses to plastic and metal resulting in stomach ulcers and blood in the urine or injury compelling euthanasia at the extreme. There are also reports of cow deaths following consumption of animal food containing metal. Hardware disease is the common name given to this condition and death may follow puncture of the pericardium (Braun, 2009);(Ward and Ducharme, 1994).

There are not likely to be any serious injuries to humans associated with physical hazards in animal food as the physical contaminant is not assimilated into edible tissues.

#### **E. Radiological Hazards**

The scope of this RA requires consideration of radiological hazards that are relevant to a farm mixed-type facility under section 418 of the FD&C Act. Tables 2 and 3 in the Hazard Identification section of this document do not include radiological hazards because no incidents involving radiological hazards in animal food have been reported through RES or RFR. The health effect from radiological hazards depends upon the type of radionuclide and the amount to which an animal or a person is exposed. Consuming food contaminated with radioactive material will increase the amount of radioactivity a



person is exposed to and could increase the health risks (e.g., increased risk of cancer) associated with exposure to radiation (World Health Organization, 2011). For instance, exposure to certain levels of radioactive iodine is associated with increased risk of thyroid cancer (World Health Organization, 2011). However, contaminated food would have to be consumed over prolonged periods to represent a risk to human health (World Health Organization, 2011) and, therefore presumably, to animal health as well. When animals consume animal food contaminated with a radiological hazard, there is some transfer of the hazard to animal tissue and to milk. But, as was seen following release of iodine-131 from a foreign nuclear plant after a natural disaster, the amount transferred to the milk was orders of magnitude lower than levels that would trigger action to remove the milk from market (FDA and EPA, 2011).

## **V. EXPOSURE ASSESSMENT**

### **A. Approach**

Exposure assessment for foodborne hazards includes an evaluation of the actual or anticipated animal exposure to the hazards from consumption of contaminated animal foods. For animal foods, exposure assessment also includes an evaluation of the actual or anticipated human exposure to hazards either by contact with an animal food or through consumption of human food of animal origin that contains residues of a hazard that was in animal food consumed by the animal and transferred to the human food of animal origin. Factors that have a direct effect on exposure to hazards in animal food include:

- Frequency and levels of contamination of the animal food;
- Frequency of consumption of the animal food by the animals;
- Transfer potential of the animal food hazard to human food of animal origin;
- Frequency of consumption of the human food of animal origin;
- Frequency of human contact with the animal food.

For the purposes of this qualitative RA, we used the frequency of reporting, as reflected in reports to the RFR (see Table 2) and in RES data (see Table 3) as an overall indicator of exposure to hazards: biological; chemical, including nutrient imbalances; and physical hazards. We took this approach because most of the available data and information address the presence, but not the level, of these hazards. For example, RFR reports and recall reports generally would provide some information about the level of chemicals, including nutrients in foods, because the level is needed to determine whether a food meets the definition of a reportable food and to classify a recall. However, RFR reports and recall reports generally do not provide information about the level of biologic hazards because the presence of a bacterial pathogen is reportable due to the potential for bacterial growth. Levels are generally not reported for physical hazards because a single foreign object may cause injury. The use of the RFR reports as an overall indicator to exposure to hazards has limitations - e.g., the RFR reports and recall data are not limited to the animal food categories addressed by this RA. In addition, we did not attempt to include the frequency of consumption of animal foods contaminated with biologic hazards, chemical hazards, nutrient imbalances, or physical hazards, and the amount of

animal food consumed, for animal food manufactured, processed, packed, or held by farm mixed-type facilities in light of the difficulty in obtaining meaningful values for these quantities.

For the purpose of this RA, we considered exposure to radiological hazards to be low because we have received no reports to the RFR or RES concerning radiological hazards in animal foods.

For the purpose of this RA, the factors that are relevant to likelihood that hazards would contaminate the animal food when consumed include:

- Potential for growth of biological hazards in the animal food;
- Inherent controls for biological hazards (e.g., low water activity preventing growth);
- Interventions (e.g., preventive control measures applied to significantly minimize or prevent a hazard that is reasonably likely to cause serious adverse health consequences or death (e.g., drying, aspiration, cleaning, or screening ); and
- Activities that can introduce hazards into food (e.g., storing moist grain).

## **B. Factors That Impact the Frequency and Levels of Contamination of the Food - Biological Hazards**

The presence of *Salmonella* in animal food may present a significant risk to animals even when the animals are exposed to low numbers of the bacteria because the bacteria can multiply in the intestine (Merck Sharp & Dohme Corp, 2012b). In still other cases, the presence of high numbers of certain serotypes of *Salmonella* adapted to specific animal species in food may present a risk of only mild illness to the general population of those species while the presence of fewer organisms may present a risk of serious illness and death to susceptible populations, such as young animals, that have limited immunity and lack stable intestinal flora (Merck Sharp & Dohme Corp, 2012b).

Importantly, the risk of illness to animals or humans from foodborne pathogens that cause illness from consumption of only a few cells significantly increases if growth occurs. Thus, if the animal food containing a foodborne pathogen supports growth of that pathogen, and the animal food may be subject to conditions that allow growth, the risk for illness increases. The primary factors impacting the risk of illness from most foodborne pathogens in an animal food, therefore, are intrinsic factors and extrinsic factors that influence growth (Jay, 2000);(Montville and Matthews, 2007). Intrinsic factors are chemical and physical factors that are inherent to the animal food (e.g., pH and water activity (abbreviated  $a_w$ )). Extrinsic factors are those that refer to the environment surrounding the animal food (e.g., storage temperature).

Below, we discuss key intrinsic and extrinsic factors that can influence growth of bacterial pathogens. We also describe inherent controls for the representative biological hazards relevant to this RA, interventions to control these representative biological

hazards, and activities that can introduce these representative biological hazards into the food categories relevant to this RA.

### *1. Impact of water activity on growth of foodborne pathogens*

The  $a_w$  of an animal food product is a key intrinsic factor affecting the growth of foodborne pathogens. The term “water activity” relates to the amount of unbound water that a microorganism needs to grow. As moisture is removed from an animal food or bound by solutes such as salt or sugar,  $a_w$  decreases. All microorganisms require a certain  $a_w$  for growth to occur, and when  $a_w$  is reduced below that point, the organism stops growing. For example, *Salmonella* does not grow below an  $a_w$  of 0.94 (International Commission on Microbiological Specifications for Foods, 1996a), *S. aureus* does not grow below an  $a_w$  of 0.83 (International Commission on Microbiological Specifications for Foods, 1996b), and *C. botulinum* does not grow below an  $a_w$  of 0.935 (International Commission on Microbiological Specifications for Foods, 1996c).

Generally, the  $a_w$  of most raw animal food (e.g., freshly cut forage) is greater than 0.99, which supports the growth of bacterial foodborne pathogens (Jay, 2000). Foods such as dried cereal grains have very low water activities (e.g., 0.60 and below) and do not support growth of bacterial foodborne pathogens (Scott et al., 2001). Some animal foods may be dried to a moisture level at which foodborne pathogens will not grow (e.g., hay). However, many foodborne pathogens will survive for extended periods of time under dry conditions, including *Salmonella* spp. (D'Aoust and Maurer, 2007);(Scott et al., 2009). Overall, moist animal foods with  $a_w$  of 0.85 and above (e.g., chopped corn stover forage) usually require other processes (e.g., ensiling) as an intervention to control growth of foodborne pathogens for long term storage, while animal food with lower  $a_w$  (e.g., hay, dried whole cereal grains) do not necessarily require additional processing to control growth of pathogens (although in some cases the food might have limited shelf life as a result of spoilage due primarily to yeasts and molds).

Intervention measures that rely on  $a_w$  to prevent the growth of foodborne pathogens require strict control. Lack of such control can result in growth of foodborne pathogens, leading to serious adverse health consequences or death to animals or humans.

### *2. Impact of pH on growth of foodborne pathogens*

The pH of an animal food product is a key intrinsic factor affecting the growth of foodborne pathogens. Most bacterial pathogens grow best at pH values near neutral (i.e., 6.6-7.5) (Jay, 2000). Low pH inhibits the growth of bacterial foodborne pathogens and in some cases can kill such pathogens. Some animal food types are naturally acidic (i.e. have a low pH) (e.g., byproducts of many fruits, including citrus fruits, apples and grapes) and do not support growth of bacterial foodborne pathogens. Other animal food types (e.g., culled melons in other plants or plant byproducts) have pH values that support growth of bacterial foodborne pathogens. Byproducts of vegetables (e.g., vegetable trimmings) have pH values above 5.0 and support growth of bacterial foodborne pathogens when the natural protective barriers are cut. Some animal food types may be fermented by bacteria to produce products with a reduced pH (e.g., haylage). While

many strains of foodborne pathogens die off under conditions of low pH, other strains, including strains of *E. coli* O157:H7 and *Salmonella*, can survive under conditions of low pH for a long time, even though their growth might be inhibited (Conner and Kotrola, 1995);(Leyer and Johnson, 1992). Therefore, the effectiveness of pH as an intervention measure to kill, or prevent the growth of, bacterial foodborne pathogens is variable. Such intervention measures require strict control throughout manufacturing or processing. Lack of such control can result in the survival and growth of foodborne pathogens, leading to serious adverse health consequences or death in animals consuming the animal food or humans handling the animal food products.

Controls to avoid botulinum toxin in animal food involve controlling the growth of *Clostridium botulinum* bacteria in food. *C. botulinum* grows under anaerobic conditions and produces toxins while in a vegetative state; it also forms spores which are resistant to environmental extremes. Botulinum toxin contamination of animal food is a rare event usually associated with the presence of rotting animal or plant matter. For example, hay is periodically contaminated as the result of a small animal being caught up into the baling process as part of harvesting. In making silage, the fermenting forage is a good substrate for growth of bacteria including *C. botulinum* which, if present, would thrive in the anaerobic conditions if it were not for the acidification process serving as an intervention that reduces the likelihood of growth of *C. botulinum* (Leibensperger and Pitt, 1987);(Ruoho, 2007). The proper processing of animal foods such as haylage and silage requires an understanding of the principles of ensiling including, creating anaerobic conditions, chopping animal food product to the appropriate particle size, selecting raw materials of appropriate moisture content and the microbiology of ensiling, and providing appropriate containment for the ensiled animal food product. When one or more of these factors is not as it should be, the product that results may contain ammonia and be refused by the animals. High heat for over 15 minutes used as an intervention in canning processes to kill spores of *C. botulinum* is not practical for animal foods such as hay and silage.

### *3. Impact of temperature on growth of foodborne pathogens*

Temperature is a key extrinsic parameter affecting growth of foodborne pathogens. As temperature decreases, the growth of microorganisms slows; all microorganisms have a temperature below which growth cannot occur. Some foodborne pathogens do not grow, or grow very slowly, at refrigeration temperatures, e.g., most strains of *Salmonella* (International Commission on Microbiological Specifications for Foods, 1996a). Foodborne pathogens cannot grow when a food is frozen (Jay, 2000). Intervention measures that use reduced temperatures to minimize growth of foodborne pathogens require strict, ongoing control (often referred to as “maintaining the cold chain”). Lack of such control can result in the growth of foodborne pathogens, leading to serious adverse health consequences or death.

The growth of foodborne pathogens can also be controlled by maintaining the temperature of animal food products above a temperature that permits growth of those

pathogens (e.g., heated holding tanks for oils and fats used to make animal food). Increasing the temperature high enough will kill foodborne pathogens. Intervention measures that use high temperatures to kill foodborne pathogens require expert knowledge of the heat resistance of the specific pathogen in the specific animal food product, the delivery of heat via the animal food matrix to inactivate pathogens, and the parameters that impact the heat process. Improper application of such interventions can result in survival and growth of foodborne pathogens, leading to serious adverse health consequences or death in animals consuming the food or humans handling the animal food products.

#### *4. The impact of other factors on growth of foodborne pathogens*

Raw foods from plant and animal origins often have physical barriers that provide very good protection against entry and growth of foodborne pathogens. These physical barriers are biological structures that act as natural coverings for the foods. Examples of such physical barriers include the outer coverings of grains. Activities that break or remove these barriers can result in contamination of the food products by allowing invasion and growth of pathogens and molds in the tissues (Whitlow and Hagler, 2005). For example, an intact kernel of corn is unlikely to support growth of molds that produce aflatoxin. Once the grain's outer covering is broken, the protective barrier of the grain is compromised, allowing microorganisms to access parts of the grain that can support growth of microorganisms. An example is whole grain corn used to make corn silage. The intact corn kernel does not support growth of molds such as *Aspergillus* spp. However, once the grain is cracked and mixed with other portions of the corn stalk to produce silage, the cracked corn kernel may support growth of molds such as *Aspergillus* spp, unless there is an intervention such as ensiling in order to control the growth of molds (Whitlow and Hagler, 2005). Preservatives (e.g., organic acids, salts of organic acids, and formaldehyde) can minimize growth of foodborne pathogens, and in some cases aid in killing them. If preservatives that are used to control pathogens are not added properly (e.g., at the correct concentration and at the proper pH of the animal food), pathogens can survive and grow, leading to serious adverse health consequences or death. Thus, intervention measures that use preservatives to control foodborne pathogens require specialized expertise to understand the conditions under which the preservatives are effective in controlling pathogens.

#### *5. Interaction of factors that impact the growth of foodborne pathogens*

Factors such as  $a_w$ , pH, temperature, and preservatives, can interact to affect growth of foodborne pathogens (Jay, 2000). For example, as temperature decreases, the minimum  $a_w$  for growth increases (Koutsoumanis et al., 2004). For example a pathogen that would grow at room temperature if the  $a_w$  is 0.95 or above may need an  $a_w$  of 0.97 to grow under refrigeration temperatures. These interactions are complex and have been discussed in scientific reviews (Institute of Food Technologists, 2009) and in regulatory references such as FDA's Food Code (FDA, 2012a). Using combinations of factors to control foodborne pathogens requires specialized expertise. Improper application of interventions involving the interaction of intrinsic and extrinsic factors can result in the

growth of foodborne pathogens, leading to serious adverse health consequences or death to animals or humans.

Ensiling is an anaerobic fermentation process used to preserve immature green corn, legumes, grasses, and grain plants; the crop is chopped while at about 70-80% moisture and put into silos or other containers to exclude air (McGraw-Hill, 2003). Acid and heat that develop during the fermentation process act as inherent controls for bacteria. Acidification of silage significantly minimizes or prevents the hazard of toxin production by *C. botulinum* (Ito and Chen, 1978);(Townsend et al., 1954).

The product listed in Table 5 is made under conditions using interactions of factors that impact the growth of microorganisms responsible for biological and chemical hazards relevant to this RA.

Table 5. Interaction of Factors Operating as Controls for Biological Hazards in the Making of Silage

Food	Inherent Control	Comments
Silage	Acidification and heat retard growth of microorganisms	This process follows the cutting of forage and mitigates the tendency of development of bacterial growth in the cut material.

*6. Inherent Controls for the Biological Hazards Relevant to This Risk Assessment*

Processing steps involving high heat and pressure, such as those used in making pelleted animal food, hydrolyzed feathers, calcined bones, or rendered animal fats, serve as inherent controls for biological hazards. As indicated below Table 1 these activities require complex and expensive equipment and are not likely to be performed on farm.

*7. Interventions to Control the Biological Hazards Relevant to This Risk Assessment*

As discussed in sections V.B.1 through V.B.5 of this document, there are a number of interventions that may reduce the risk of the biological hazards relevant to this RA. If an intervention is not properly conducted, the applicable hazard is reasonably likely to occur. Moreover, some interventions may require special expertise to ensure they are conducted properly

Table 6 provides examples of interventions to control the representative biological hazards relevant to this RA. Other interventions could be preventive controls that

facilities may implement under section 418 of the FD&C Act, such as treatment of food to inactivate foodborne pathogens.

Table 6. Examples of Interventions to Control Biological Hazards

<b>Hazard</b>	<b>Examples of Interventions to Control Hazards</b>	<b>Comments</b>
<i>Salmonella</i> spp.; <i>Clostridium botulinum</i>	<ul style="list-style-type: none"> <li>• Killing the organism - e.g., through:               <ul style="list-style-type: none"> <li>○ Reducing the pH in combination with specific conditions (e.g., type and concentration of acid, time of exposure, and temperature).</li> </ul> </li> <li>• Preventing the growth of the organism - e.g., by:               <ul style="list-style-type: none"> <li>○ Reducing the pH or <math>a_w</math>;</li> <li>○ Adding preservatives.</li> </ul> </li> </ul>	When a kill step is applied the food must be protected from recontamination. The organisms can survive for extended periods of time under some conditions that prevent the growth but do not kill the organism (Ruoho, 2007).

*8. Activities That Can Introduce, or Increase the Potential for, Biological Hazards Relevant to This Risk Assessment*

Conducting some activities on a food may increase the risk from a biological hazard. These are often specific to the food in which the hazard occurs. For example, chopping intact corn stalks and other forage can transfer microorganisms, including pathogens, from the exterior to the interior of the plants; in many cases this allows growth, thereby increasing the risk of illness (FDA, 2012c);(Institute of Food Technologists, 2009). Table 7 provides examples of activities that can introduce, or increase the potential for, biological hazards.

Table 7. Example of Activity that Can Introduce, or Increase the Potential for, Biological Hazards

<b>Hazard</b>	<b>Examples of Activities That Are Reasonably Likely to Introduce or Increase the Potential for the Hazard</b>	<b>Comments</b>
<i>Salmonella</i> spp.	Cutting of plants can transfer the organism from the low-moisture exterior (where it cannot grow) to the high-moisture interior and release juices from tissues, providing conditions that enhance microbial growth	Mitigation step that may follow cutting is ensiling.

### C. Factors That Impact the Frequency and Levels of Contamination of the Food - Chemical Hazards

The presence and levels of mycotoxins in foods is dependent in large part on growing and harvesting activities. The type of mold, weather conditions, soil types, insect activity, and commodity type, along with timely harvest and rapid and adequate drying before storage, are important in determining the likelihood of contamination (Williams et al., 2004). Insect activity and condensation can result in pockets of moisture that can result in production of mycotoxins (Williams et al., 2004). There are no effective methods to remove mycotoxins once they have formed in animal food ingredients. Food ingredients with unsafe levels of mycotoxin contamination must be avoided in the production of finished animal food.

Pesticide residue contamination of raw agricultural commodities can be reduced by timing the application of the pesticides appropriately which is facilitated by accurate record keeping (United States Department of Agriculture and Agricultural Marketing Service, 2010). Pesticide residues are likely to be concentrated on the outer surface of the commodities so that any process that removes that outer surface serves as a means of reduction of the hazard level. Heavy metals and other chemical contaminants, on the other hand, are more likely to be incorporated into the plants from the soil. Processing steps which remove moisture will tend to concentrate the levels of these chemical contaminants in the animal food.

Table 8 provides examples of interventions to control the representative chemical hazards relevant to this RA. Other interventions could be preventive controls that facilities may implement under section 418 of the FD&C Act.

Table 8. Examples of Interventions and Activities that Can Affect Chemical Hazards

<b>Hazard</b>	<b>Examples of Interventions to Control Hazards</b>	<b>Examples of Activities That Are Reasonably Likely to Introduce or Increase the Potential for the Hazard</b>	<b>References</b>
Mycotoxins	<ul style="list-style-type: none"> <li>● Control moisture for storage</li> <li>● Pest control</li> </ul>	<ul style="list-style-type: none"> <li>● Storing incompletely dried product</li> <li>● Lack of pest control</li> </ul>	(Williams et al., 2004)
Pesticides	<ul style="list-style-type: none"> <li>● Timing application well before harvest</li> <li>● Excluding the outer layers of plant</li> </ul>	<ul style="list-style-type: none"> <li>● Applying pesticide near time of harvest</li> <li>● Using outer plant layers such as husks in animal food</li> </ul>	(Agriculture and Agri-Food Canada Food Production Direction Inspection Branch, 1993);(FDA, 2013d)



Hazard	Examples of Interventions to Control Hazards	Examples of Activities That Are Reasonably Likely to Introduce or Increase the Potential for the Hazard	References
Other chemicals	<ul style="list-style-type: none"> <li>• Test for presence of hazard and exclude contaminated product from the animal food stream</li> </ul>	<ul style="list-style-type: none"> <li>• Drying increases the concentration of chemical</li> </ul>	((FDA, 2013b))

**D. Factors That Impact the Frequency and Levels of Contamination of the Food – Nutrient Imbalance Hazards**

Manufacture of animal food with adequate nutrition requires blending of the appropriate mix of food ingredients and augmenting the mix with additional vitamins or minerals to compensate for deficiencies in the food ingredients. Knowledge of the nutritional requirements of the animals to be fed and knowledge of the composition of the food ingredients is necessary. Care in calculating the proper amount and weighing that amount of additives is of primary importance in assuring that toxic levels of nutrients are not incorporated into the animal food. Thorough mixing is necessary to ensure uniform distribution of ingredients throughout the animal food to avoid a pocket of highly concentrated additives that might be consumed by a single animal.

**E. Factors That Impact the Frequency and Levels of Contamination of the Food – Physical Hazards**

The potential presence of physical hazards depends on the activities performed on the animal food, including activities that can remove foreign objects (e.g., sorting, inline use of magnets to remove ferrous material) and those that can introduce them (e.g., shredding, raking, cutting). Adherence to general principles of good manufacturing minimizes the potential for physical hazards to be present in animal food products to which animals and humans are exposed (Jantschke and Elliott, 2006).

**F. Factors That Impact the Frequency and Levels of Contamination of the Food – Radiological Hazards**

The presence of detectable radiological hazards in animal foods is rare and derives from plants grown in certain types of mineral soil or from water in similar areas. Use of water that contains a radionuclide to manufacture an animal food is not reasonably likely when using water from a domestic municipal source subject to regulation by 40 CFR 141.66 (see 65 FR 76708, Federal Register of December 7, 2000). Exposure of humans to radionuclide hazards as a result of contact with contaminated animal food or consumption of human food of animal origin from animals that have consumed contaminated animal food as a result of naturally occurring radioactive material is very low. When events

(such as accidents or natural disasters) occur that could result in radiological contamination of water sources, there is generally much publicity that would alert a farm mixed-type facility to a risk in using a potentially contaminated water source, and we expect that government agencies, including FDA, would be likely to take specific actions based on the circumstances to prevent consumer exposure.

### **G. Frequency of Consumption and Amount of Animal Food Consumed**

For any given prevalence of contamination in animal food, the likelihood of animals becoming sick increases as the amount of food consumed increases. In 2007, of the roughly 100 million cattle in the US, 16 million were fed rations on feedlots and another nine million were fed dairy rations (United States Department of Agriculture, 2009). There were nearly 68 million hogs and pigs and close to six million sheep and lambs (United States Department of Agriculture, 2009). The poultry inventory included 350 million laying chickens; over nine billion broiler and other meat-type chickens; 100 million pullets for laying flock replacement; over 200 million turkeys; and another 25 million other poultry, including ducks, geese, pheasants, quail, squab, emus and ostriches (United States Department of Agriculture, 2009).

In total, in 2009, there were 118 million tons of animal food consumed, with nearly one third consumed by broiler chickens (Lundeen, 2010). The National Agricultural Statistics Service in its report for 2010, estimates that the annual consumption per animal on a beef feedlot is about 9,200 pounds of animal food while that of a dairy cow is around 12,600 pounds (United States Department of Agriculture, 2010). The estimates are 89 and 10.6 pounds, per turkey and per broiler chicken, respectively (United States Department of Agriculture, 2010).

Information supplied through reporting systems such as the RFR and the RES is useful in identifying the kinds of hazards being found and in what animal foods they are being found but it does not provide a means to know what fraction of the animal food supply contains hazards. First, the instances of contaminated food are likely to be under-reported because they might not all be identified. Secondly, unless the animal food is a product with lot numbers, the full extent of a contamination issue may be unknown. Information upon which to estimate the prevalence of hazards in animal food comes from surveys, studies that sample animal food and offer a snapshot in time that provides an estimate of the fraction of animal food containing the hazards under study. Results from surveys indicate considerable variability from sample to sample. One example of a survey of aflatoxin contamination in corn illustrates how difficult it is to determine either the prevalence (with a range from 2-3% in some regions to 13-32% in others) or level of contamination (with a range from no more than 20 ppb from some locations to 8% of samples with more than 100 ppb from others) (Shotwell, 1977).

Neither do we have data to determine how much of a particular animal food produced by small or very small farm mixed-type facilities is consumed in order to assess the risk of illness or death from consumption of the animal food from these facilities. We do know, based on the Food Processing Sector Study (Muth et al., 2011), that the proportion of all food, human and animal, sold from establishments co-located on farms for facilities with

fewer than 500 employees is only 1.04 percent of total sales. Thus, on a relative basis, the overall exposure of the animal population to all animal foods produced at farm mixed-type facilities is low and the exposure to such animal foods containing hazards would be even lower.

## **VI. RISK CHARACTERIZATION**

### **A. Approach**

In this section, we qualitatively characterize the risk from hazards and activity/animal food combinations based on the available information in the Hazard Identification, Hazard Characterization, and Exposure Assessment sections of this RA. There is uncertainty associated with each of these components of this RA, which leads to uncertainty in the Risk Characterization. The outcome of this risk characterization of hazards is a determination of whether, for the limited purposes of this RA, a hazard presents a reasonable probability of causing serious adverse health consequences or death in the absence of preventive controls that would be required under section 418 of the FD&C Act. In this RA, we are considering such hazards and animal foods in general terms, on a forward-looking basis, and not in reference to a particular animal food contamination incident or foodborne illness outbreak. Determinations of whether there is such a reasonable probability in specific situations may be different from the conclusions made for the limited purposes of this document. The characterization of exposure to the hazard, the severity of adverse health consequences resulting from use of, or exposure to, an animal food containing the hazard, and the conclusions with respect to “reasonable probability of serious adverse health consequences or death” are made in relative terms.

### **B. Qualitative Risk Characterization**

Table 9 presents a qualitative risk characterization of representative hazards that may be associated with animal foods manufactured, processed, packed or held on a farm mixed-type facility. Table 9 draws from information presented in Tables 2 and 3 of this RA and from discussions in the Hazard Identification, Hazard Characterization, and Exposure Assessment sections of this RA.

As discussed in the Hazard Characterization section, adverse effects associated with biological hazards and with physical hazards may occur as a result of consumption of a contaminated food during a single eating occasion.

Table 9 characterizes the relative frequency of the various hazards in terms of numbers of cases reported to the RFR as well as the relative frequency of Class I recalls of animal foods containing the various hazards in RES as follows:

Low = No reports or recalls;

Medium = Between 1 and 299 reports or recalls; and

High = Greater than 300 reports or recalls.

Table 9 characterizes the severity of the hazards in terms of whether serious health outcomes or death have been reported as follows:

Low = No serious health outcomes or deaths were reported; and  
 Medium to high = Serious health outcomes or death;

Table 9 also shows whether adverse reactions from a single eating occasion are serious and are likely to include death as follows:

Low = Cumulative exposure typically required to elicit serious health consequences or death; and  
 High = Single-Eating Occasion may elicit serious health consequences or death.

Table 9. Qualitative Risk Characterization of Representative Hazards That May Be Associated With Animal Foods Manufactured/processed, Packed or Held on a Farm Mixed-Type Facility

Hazard	Frequency	Severity	Single Eating Occasion or Cumulative Exposure?	Reasonable Probability of Causing Serious Adverse health Consequences or Death	Comments
Biological ( <i>Salmonella</i> ) Animal Effects	High	Low	Low	No	Animals are frequently carriers without symptoms depending on serotype and animal species (FDA, 2011a);(FDA, 2013c)
Biological ( <i>Salmonella</i> ) Human Effects	Medium	High	NA <sup>1</sup>	Yes	<sup>1</sup> Most human contact associated with pet food
Chemical contaminants (mycotoxins, dioxin, pesticides)	High	High	Low	Yes	Grain and oil seed comprise about 75% of animal diets (Brendemuhl and Myer, 2012);(National Reasearch Council, 1994)
Chemical (nutrient imbalance)	High	High	Low <sup>2</sup>	Yes	<sup>2</sup> Subpotent food requires multiple exposures. Superpotent food may require only a single eating occasion
Physical hazards	Medium	High	High	Yes	Typically not widely dispersed across the food supply.
Radiological hazards	Low	Low	Low	No	

## C. Activity/Animal Food Combinations

### 1. Overview

In sections VI.C.2 of this document, we characterize the risk of activity/animal food combinations without the overlay of the applicable statutory and regulatory framework. Doing so focuses the risk characterization on the risk of the activity/animal food combinations themselves. In Appendix 2 of this document, we add that regulatory overlay.

### 2. Characterizing Activity/Food Combinations

Table 10 and Table 11 present a matrix of activity/food combinations. Our use of two tables (i.e., Table 10 and Table 11) rather than a single table reflects practicalities associated with large amounts of information rather than any substantive purpose. We simply present half of the food categories in Table 10 and the remaining half of the food categories in Table 11.

As discussed in section I.E of this document, there are three parts of the definition of low-risk activity/food combination. Importantly, under the definition of low-risk activity food combination, to be low risk the activity/food combination must either:

- Satisfy part #1 (inherent controls); or
- Satisfy both part #2a (activity not likely to introduce, or increase the potential for, a SAHCODHA hazard) and part #2b (activity does not significantly minimize or prevent a SAHCODHA hazard).

Within each cell of Table 10 and Table 11, we ask whether an activity/food combination would be low risk (as defined in section I.E of this document). In answering this question, we:

- Answer the question “Yes” if the activity satisfies the definition of low-risk activity/food combination;
- Answer the question “No” if the activity does not satisfy the definition of low-risk activity/food combination; and
- Do not answer the question (i.e., leave a blank cell in the matrix) if the activity generally does not apply to the food.

Within each cell that has a “Yes” answer, we provide the part of the definition of low-risk activity governing the classification of low-risk:

- #1 (inherent controls); or
- #2 (if the activity satisfies both part #2a and part #2b of the definition of low-risk activity).

Within each cell that has a “No” answer, we provide the part of the definition of low-risk activity governing the conclusion that the activity/food combination is NOT low risk:

- #2a (if the activity introduces, or increases the potential for, a SAHCODHA hazard); or
- #2b (if the activity significantly minimizes or prevents a SAHCODHA hazard)

For those activity/food combinations that are not low risk, Table 12 explains the specific reasons why.

Table 10. Is an Activity/Animal Food Combination Low Risk?

Activity	Grains	Oilseeds	Grain or oilseed byproducts	Forage	Hay
Aspiration, cleaning, screening	No (#2b)	No (#2b)	<sup>1</sup>		No (#2b)
Conveying, weighing (incidental to storing)	Yes (#2)	Yes (#2)	Yes (#2)	Yes (#2)	Yes (#2)
Cracking, crimping, flaking, pearling, peeling, shelling, wafering	Yes (#2)	Yes (#2)	Yes (#2)		
Crushing, grinding, milling, pulverizing, dry rolling	Yes (#2)	Yes (#2)	Yes (#2)	Yes (#2)	Yes (#2)
Culling, sorting, grading (incidental to storing)	Yes (#2)	Yes (#2)	Yes (#2)	Yes (#2)	Yes (#2)
Making silage	Yes (#2)	Yes (#2)		Yes (#2)	
Chopping or shredding				<sup>2</sup>	Yes (#2)
Post-harvest drying, dehydrating for the purpose of storage or transportation	No (#2b)	No (#2b)			
Extracting (mechanical), wet rolling	Yes (#2)	Yes (#2)			
Treating against pests other than during growing (fumigation)	No (#2b)	No (#2b)	No (#2b)		No (#2b)
Mixing (incidental to packing and storing)	Yes (#2)			Yes (#2)	Yes (#2)
Labeling	Yes (#2)	Yes (#2)			
Mixing, blending for the purpose of making a complete, processed animal food	No (#2a,2b)	No (#2a,2b)	No (#2a,2b)	No (#2a,2b)	No (#2a,2b)
Packing	Yes (#2)	Yes (#2)	Yes (#2)	Yes (#2)	Yes (#2)
Sifting, separating or sizing	Yes (#2)	Yes (#2)	Yes (#2)		
Storing <sup>3</sup>	Yes (#2)	Yes (#2)	Yes (#1)	Yes (#2)	Yes (#2)

<sup>1</sup>Blank cells indicate that the activity generally does not apply to the food.

<sup>2</sup>Cutting forage is a harvesting activity within the farm definition.

<sup>3</sup>Assumes storing of dried grains, dried oilseeds, and byproducts of dried grains and dried oilseeds.

Table 11. Is an Activity/Animal Food Combination Low Risk? (Continued)

Activity	Ensiled Material	Other plants or plant byproducts	Other <sup>1</sup>
Aspiration, cleaning, screening	<sup>2</sup>		
Conveying, weighing (incidental to storing)	Yes (#2)	Yes (#2)	Yes (#2)
Cracking, crimping, flaking, pearling, peeling, shelling, wafering			
Crushing, grinding, milling, pulverizing, dry rolling	Yes (#2)	Yes (#2)	Yes (#2)
Culling, sorting, grading (incidental to storing)	Yes (#2)	Yes (#2)	
Making silage		Yes (#2)	
Chopping or shredding			
Post-harvest drying, dehydrating for the purpose of storage or transportation			
Extracting (mechanical), wet rolling			Yes (#2)
Treating against pests other than during growing (fumigation)	No (#2b)		No (#2b)
Mixing (incidental to packing or storing)			
Labeling <sup>3</sup>			
Mixing, blending for the purpose of making a complete, processed animal food	No (#2a,2b)	No (#2a,2b)	No (#2a,2b)
Packing		Yes (#2)	
Sifting, separating or sizing		Yes (#2)	
Storing <sup>4</sup>	Yes (#2)	Yes (#2)	Yes (#2)

<sup>1</sup>“Other” includes purchased animal food ingredients (FDA, 2013a) such as fish or bone meal, vitamin mixes, minerals, processing aids, etc.

<sup>2</sup>Blank cells indicate the activity generally does not apply to the food.

<sup>3</sup>Labeling of animal foods would not be low risk if the food is a mixture of ingredient foods that might be mistaken for a complete, finished animal food or a product that otherwise requires a label to be used safely.

<sup>4</sup>Assumes storing of dried grains, dried oilseeds, and byproducts of dried grains and dried oilseeds

Table 12. Why Certain Activity/Animal Food Combinations Are Not Low Risk

Activity	Food	Activity Introduces, or Increases the Potential for, a SAHCODHA Hazard (#2a)	Activity Significantly Minimizes or Prevents a SAHCODHA Hazard (#2b)
Aspiration, cleaning, screening	Grain, oilseed, hay		Activity required to significantly minimize mold and pesticide residues in outer coatings of grain or oilseed and to remove physical hazards
Post-harvest drying or dehydrating for the purpose of storage or transportation	Grain, oilseed	If done incorrectly, the activity permits molds to survive to grow and produce toxins during storage and transportation.	If done correctly, the activity kills molds or prevents them from growing and producing toxins during storage and transportation.
Treating against pests other than during growing (fumigation)	Grain, oilseed, grain or oilseed byproducts, forage, ensiled material, brewer/distiller products		Activity significantly reduces the re-introduction of molds that produce mycotoxins.
Mixing, blending for the purpose of making a complete processed animal food	All ingredients	If done incorrectly, the activity could increase the potential for nutrient imbalance which could cause SAHCOD to animals.	If done correctly, the activity prevents nutrient imbalance which could cause a SAHCOD to animals.

## VII. CONCLUSIONS

### A. Answers to the Questions to be Addressed in This Risk Assessment

**Question 1:** What are the animal foods that would be manufactured, processed, packed or held by a farm mixed-type facility?

The RA identified the following animal food categories that are within the scope of the RA and that would be manufactured, processed, packed or held by a farm mixed-type facility:

- Grain (e.g., barley, corn, rice, oat, sorghum, triticale, wheat);
- Oilseed (e.g., cottonseed, linseed, rapeseed, soybean, sunflower);
- Grain or oilseed byproducts;
- Forage (e.g., milo, corn, alfalfa, grass):
  - Hay (dried alfalfa and other grasses)
  - Ensiled forage;
- Other plants or plant byproducts (e.g., almond, peanut or soybean hulls, citrus,



other fruit including culled fruit, potatoes, or other vegetables including culled vegetables);

- Purchased food animal components such as vitamins or minerals; processing aids, rendered animal or marine byproducts (e.g., bone meal, fish, shrimp, or crab meal), brewer/distiller products such as dried distillers grains and solubles, milk products, molasses, fats or oils.

**Question 2:** What are the activities that might be conducted by farm mixed-type facilities on those animal foods [foods that would be manufactured, processed, packed or held by a farm mixed-type facility]?

Table 1 in section II.B of this document lists the activities that might be conducted by farm mixed-type facilities on those animal foods.

**Question 3:** What are the hazards reasonably likely to occur in those animal foods [that would be manufactured, processed, packed or held by a farm mixed-type facility]?

The RA identified the following hazards as representative of the hazards of concern for animal food categories that are likely to be manufactured, processed, packed or held on a farm mixed-type facility and within the scope of this RA:

- Salmonella;
- Botulinum toxin;
- Mycotoxins such as aflatoxins, fumonisins;
- Other chemical hazards such as pesticides;
- Nutrient imbalance;
- Physical hazards;
- Radiological hazards.

**Question 4:** For the purpose of determining whether an activity/animal food combination is low risk, which hazards should be considered to have a reasonable probability of causing serious adverse health consequences or death to animals or humans?

For the purpose of determining whether an activity/animal food combination is low risk, the RA identified the following hazards as having a reasonable probability of causing serious adverse health consequences or death:

- The biological hazard *Salmonella* ;
- The chemical hazards mycotoxins; and
- The chemical hazard nutrient imbalance, particularly superpotency.

**Question 5:** For the purpose of determining whether an activity/animal food combination is low risk, what animal foods have inherent controls that significantly minimize or prevent a biological hazard that is reasonably likely to occur in these animal foods and that is reasonably likely to cause serious adverse health consequences or death?

For the purpose of determining whether an activity/animal food combination is low risk, the RA identified that processing steps involving high heat and pressure, such as those

used in making pelleted animal food, hydrolyzed feathers, calcined bones, or rendered animal fats, serve as inherent controls for biological hazards. However, as indicated below Table 1 these activities require complex and expensive equipment and are not likely to be performed on farm.

**Question 6:** What interventions significantly minimize or prevent a hazard that is reasonably likely to occur in these animal foods and that is reasonably likely to cause serious adverse health consequences or death to animals or humans?

The RA identified the following examples of interventions to significantly minimize or prevent a hazard that is reasonably likely to occur in these foods and that for purposes of this RA, is considered reasonably likely to cause serious adverse health consequences or death:

- For the bacteria *Salmonella*:
  - Killing the organism - e.g., through:
    - Reducing the pH in combination with specific conditions (e.g., type and concentration of acid, time of exposure and temperature);
  - Preventing the growth of the organism - e.g., by:
    - Reducing the pH or  $a_w$ ;
    - Adding preservatives.
- For chemical contaminants, e.g., mycotoxins:
  - Ensuring that the received grain and other ingredients used in animal food products are mold free and dry;
  - Drying prior to storage to ensure storage under dry conditions that inhibit mold growth and mycotoxin production;
  - Aspiration, cleaning, and screening to remove outer coatings;
  - Treating for pests.
- For nutrient imbalances:
  - Following ration formulation and supplementation recommendations for targeted animal species;
  - Maintaining accurate scales for weighing ingredients;
  - Mixing thoroughly.

**Question 7:** Which of these activities are reasonably likely to introduce, or increase the potential for occurrence of, hazards that are reasonably likely to cause serious adverse health consequences or death and what are these hazards?

The RA identified the following examples of activities that are reasonably likely to introduce, or increase the potential for occurrence of, hazards that are reasonably likely to cause serious adverse health consequences or death:

- Mixing/blending a complete feed without proper knowledge of nutritional requirements and nutritional content of ingredients, inaccurate weighing, or incomplete mixing;

- Drying grains or oilseeds for storage or transportation that fails to achieve the appropriately low moisture content to retard mold growth;

**Question 8:** Which of these activities are interventions to significantly minimize or prevent hazards that are reasonably likely to cause serious adverse health consequences or death from consumption of these animal foods?

The RA identified the following examples of activities that are interventions to significantly minimize or prevent hazards that are reasonably likely to cause serious adverse health consequences or death from consumption of these animal foods:

- Aspiration, cleaning, screening;
- Treating against pests (fumigation).

**Question 9:** Which activity/animal food combinations are low risk, i.e., what on-farm activity/animal food combinations are not reasonably likely to introduce hazards that are reasonably likely to cause serious adverse health consequences or death or serve as preventive controls (interventions) to significantly minimize or prevent a hazard that could cause serious adverse health consequences or death?

In this section of this RA, we answer Question 9 without the overlay of the applicable statutory and regulatory framework. Doing so focuses the risk characterization on the risk of the activity/animal food combinations themselves. In Appendix 2 of this document, we add that regulatory overlay applicable to activity/animal food combinations.

Based on the information in Tables 8, 10, 11, and 12 for the purposes of the analysis required by section 103(c)(1)(C) of FSMA, the RA identified the following low-risk activity/food combinations.

- Conveying, weighing, sorting, culling, or grading (incidental to storing):
  - Grain (e.g., barley, corn, rice, oat, sorghum, triticale, wheat);
  - Oilseed (e.g., cottonseed, linseed, rapeseed, soybean, sunflower);
  - Grain or oilseed byproducts;
  - Forage (hay or ensiled material);
  - Other plants or plant byproducts (e.g., such as almond, peanut or soybean hulls, citrus, other fruit including culled fruit, potatoes, or other vegetables including culled vegetables).
- Storing:
  - Dried grain;
  - Dried oilseed;
  - Byproducts of dried grain or dried oilseed;
  - Forage;
  - Other plants or plant byproducts.
- Mixing (incidental to packing or storing):
  - Grain, whole;
  - Forage.

- Packing:
  - Grain;
  - Oilseed;
  - Grain or oilseed byproducts;
  - Forage;
  - Other plants or plant byproducts.
- Cracking, crimping, flaking, or shelling:
  - Grain;
  - Oilseed;
  - Grain or oilseed byproducts.
- Crushing, grinding, milling, pulverizing, or dry rolling:
  - Grain;
  - Oilseed;
  - Grain or oilseed byproducts;
  - Forage ;
  - Other plants or plant byproducts.
- Making silage.
- Cutting, chopping, or shredding hay.
- Extracting (mechanical) or wet rolling:
  - Grain;
  - Oilseed.
- Labeling:
  - Grain, whole;
  - Oilseed, whole;
- Sifting, separating, or sizing:
  - Grain;
  - Oilseed;
  - Grain or oilseed byproducts;
  - Other plants or plant byproducts.

## **B. Summary**

This RA assesses the risk of activities conducted on animal foods by farm mixed-type facilities to determine low-risk activity/animal food combinations. It advances our ability to describe our current state of knowledge about hazards that are reasonably likely to occur for animal foods and activities on-farm and to assess which activities are low risk. It provides a framework for integrating and evaluating the scientific knowledge related to public health as applied to on-farm activities and can be used in support of regulatory decisions in the implementation of FSMA.

## VIII. REFERENCES

Agriculture and Agri-Food Canada Food Production Direction Inspection Branch, "Regulatory Directive: Pre-Harvest Intervals for Grazing and Cutting for Hay of Immature Crops Treated With Pesticides," <http://www.hc-sc.gc.ca/cps-spc/pubs/pest/pol-guide/dir93-18/index-eng.php>, October 28, 1993. Accessed on August 24, 2013.

Bayman, P. and J. L. Baker, "Ochratoxins: a Global Perspective," *Mycopathologia*, 162:215-223, 2006.

Bhat, R. V. and J. D. Miller, "Mycotoxins and Food Supply," <http://www.fao.org/docrep/U3550t/u3550t0e.htm>, 1991. Accessed on August 24, 2013.

Braun, U., "Traumatic Pericarditis in Cattle: Clinical, Radiographic and Ultrasonographic Findings," *The Veterinary Journal*, 182:176-786, 2009.

Brendemuhl, J. and B. Myer, "Types of Swine Diets," <http://edis.ifas.ufl.edu/pdffiles/AN/AN03600.pdf>, 2012. Accessed on August 24, 2013.

Caloni, F. and C. Cortinovis, "Toxicological Effects of Aflatoxins in Horses," *The Veterinary Journal*, 188:270-273, 2011.

Cavallarin, L., E. Tabacco, S. Antoniazzi, and G. Borreani, "Aflatoxin Accumulation in Whole Cropmaize Silage As a Result of Aerobic Exposure," *Journal of the Science of Food and Agriculture*, 91:2419-2425, 2011.

Centers for Disease Control and Prevention (CDC), "Questions and Answers 2011 Preliminary FoodNet Data," <http://www.cdc.gov/foodnet/PDFs/foodnet-mmwr-2011-qa-508c.pdf>, July 12, 2012. Accessed on August 24, 2013.

Centers for Disease Control and Prevention (CDC), "Botulism General Information," <http://www.cdc.gov/nczved/divisions/dfbmd/diseases/botulism/>, July 26, 2011b. Accessed on August 24, 2013.

Centers for Disease Control and Prevention (CDC), "Surveillance for Foodborne Disease Outbreaks - United States, 2008," [http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6035a3.htm?s\\_cid=mm6035a3\\_w](http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6035a3.htm?s_cid=mm6035a3_w), September 9, 2011a.

Centers for Disease Control and Prevention (CDC), "Update: Recall of Dry Dog and Cat Food Products Associated With Human Salmonella Schwarzengrund Infections --- United States, 2008," <http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5744a2.htm>, November 7, 2008. Accessed on August 24, 2013.

Centers for Disease Control and Prevention (CDC) ATSDR, "Chlorinated Dibenzo-p-Dioxins (CDDs)," <http://www.atsdr.cdc.gov/tfacts104.pdf>, February, 1999. Accessed on August 24, 2013.

Conner, D. E. and J. S. Kotrola, "Growth and Survival of *Escherichia Coli* O157:H7 Under Acidic Conditions," Applied and Environmental Microbiology, 61:382-385, 1995.

D'Aoust, J. Y. and J. Maurer, "*Salmonella* Species," In: Food Microbiology: Fundamentals and Frontiers, edited by M. P. Doyle and L. R. Beuchat, 3rd, Washington, DC, Chapter 10, pp. 187-236, ASM Press, 2007.

D'Mello, J. P. F. and A. M. C. Macdonald, "Mycotoxins," Animal Feed Science Technology, 69:155-166, 1997.

FDA, "AAFCO Ingredient Definitions: Setting the Standards," <http://www.fda.gov/AnimalVeterinary/NewsEvents/FDAVeterinarianNewsletter/ucm109972.htm>, April 16, 2013b. Accessed on August 24, 2013.

FDA, "Bad Bug Book: Foodborne Pathogenic Microorganisms and Natural Toxins Handbook. *Salmonella* Spp.," Second 2012c.

FDA, "Dioxin," <http://www.fda.gov/AnimalVeterinary/Products/AnimalFoodFeeds/Contaminants/ucm050430.htm>, February 16, 2011b. Accessed on August 24, 2013.

FDA, "Draft Qualitative Risk Assessment Risk of Activity/Food Combinations for Activities (Outside the Farm Definition) Conducted in a Facility Co-Located on a Farm," 2013a.

FDA, "FDA Foods and Veterinary Medicine Program, The Reportable Food Registry: A New Approach to Targeting Inspection Resources and Identifying Patterns of Adulteration. Second Annual Report: September 8, 2010 - September 7, 2011," <http://www.fda.gov/downloads/Food/FoodSafety/FoodSafetyPrograms/RFR/UCM301013.pdf>, April, 2012b. Accessed August 24, 2013.

FDA, "Food Code 2009," 2009

FDA, "Guidance for Industry: Action Levels for Poisonous or Deleterious Substances in Human Food and Animal Feed," 2013b.

FDA, "Ingredients and Additives," <http://www.fda.gov/AnimalVeterinary/Products/AnimalFoodFeeds/IngredientsAdditives/default.htm>, June 27, 2013a. Accessed on August 24, 2013.

FDA, "Pesticide Monitoring Program - FY 2008," <http://www.fda.gov/downloads/Food/FoodSafety/FoodContaminantsAdulteration/Pesticides/ResidueMonitoringReports/UCM230537.pdf>, June 19, 2013d. Accessed on August 24, 2013.

FDA, "Recall Enterprise System," <http://www.fda.gov/ICECI/ComplianceManuals/RegulatoryProceduresManual/ucm177308.htm>, August 4, 2011a. Accessed on August 24, 2013.

FDA, "Reportable Food Registry (RFR) at a Glance," <http://www.fda.gov/downloads/Food/FoodSafety/FoodSafetyPrograms/RFR/UCM181885.pdf>, April, 2013c. Accessed August 24, 2013.

FDA and EPA, "Joint EPA/FDA Statement: Update on Ongoing Monitoring," <http://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm249146.htm>, March 30, 2011. Accessed August 24, 2013.

Gries, C. L. and M. L. Scott, "The Pathology of Thiamin, Riboflavin, Pantothenic Acid and Niacin Deficiencies in the Chick," The Journal of Nutrition, 102:1269-1286, 1971.

Institute of Food Technologists, "Evaluation and Definition of Potentially Hazardous Foods," (June 18, 2009).

International Commission on Microbiological Specifications for Foods, "Cereals and Cereal Products," In: Microorganisms in Foods 6. Microbial Ecology of Food Commodities, edited by T. A. Roberts, J.-L. Cordier, L. Gram, R. B. Tompkin, J. I. Pitt, L. G. M. Gorris, and K. M. J. Swanson, 2<sup>nd</sup> edition, New York, Chapter 8, pp. 392-439, Kluwer Academic / Plenum Publishers, 2005a.

International Commission on Microbiological Specifications for Foods, "Clostridium Botulinum," In: Microorganisms in Foods 5. Characteristics of Microbial Pathogens, edited by T. A. Roberts, A. C. Baird-Parker, and R. B. Tompkin, London, Chapter 5, pp. 73-333, Blackie Academic & Professional, 1996c.

International Commission on Microbiological Specifications for Foods, "Nuts, Oilseeds, and Dried Legumes," In: Microorganisms in Foods 6. Microbial Ecology of Food Commodities, edited by T. A. Roberts, J.-L. Cordier, L. Gram, R. B. Tompkin, J. I. Pitt, L. G. M. Gorris, and K. M. J. Swanson, 2<sup>nd</sup> edition, New York, Chapter 9, pp. 440-466, Kluwer Academic / Plenum Publishers, 2005b.

International Commission on Microbiological Specifications for Foods, "Salmonellae," In: Microorganisms in Foods 5. Characteristics of Microbial Pathogens, edited by T. A. Roberts, A. C. Baird-Parker, and R. B. Tompkin, London, Chapter 14, pp. 224-225, Blackie Academic & Professional, 1996a.

International Commission on Microbiological Specifications for Foods, "Staphylococcus Aureus," In: Microorganisms in Foods 5. Characteristics of Microbial Pathogens, edited by T. A. Roberts, A. C. Baird-Parker, and R. B. Tompkin, London, Chapter 17, pp. 299-333, Blackie Academic & Professional, 1996b.

Ito, K. A. and J. K. Chen, "Effect of PH on Growth of *Clostridium Botulinum* in Foods," Food Technology, 32:71-76, 1978.

Jantschke, M. and P. H. Elliott, "Physical Hazards and Controls," In: HACCP: A Systematic Approach to Food Safety, edited by V. N. Scott and K. E. Stevenson, 4<sup>th</sup> edition, Washington, D.C., Chapter 6, pp. 47-51, The Food Products Association, 2006.

Jay, J. M., "Intrinsic and Extrinsic Parameters of Foods That Affect Microbial Growth," In: Modern Food Microbiology, edited by D. R. Heldman, 6<sup>th</sup> edition, Gaithersburg, MD, Chapter 3, pp. 35-56, Aspen Publishers, Inc., 2000.

Johnson, W. D. and R. W. Storts, "Peripheral Neuropathy Associated With Dietary Riboflavin Deficiency in the Chicken I. Light Microscopic Study," Veterinary Pathology, 25:9-16, 1988.

Jones, F. T., "A Review of Practical Salmonella Control Measures in Animal Feed," The Journal of Applied Poultry Research:102-113, 2011.

Koutsoumanis, K. P., P. A. Kendall, and J. N. Sofos, "Modeling the Boundaries of Growth of *Salmonella* Typhimurium in Broth As a Function of Temperature, Water Activity and PH," Journal of Food Protection, 67:53-59, 2004.

Leibensperger, R. Y. and R. E. Pitt, "A Model of Clostridial Dominance in Ensilage," Grass and Forage Science, 42:297-317, 1987.

Leyer, G. J. and E. A. Johnson, "Acid Adaptation Promotes Survival of *Salmonella* Spp. in Cheese," Applied and Environmental Microbiology, 58:2075-2080, 1992.

Liu, K., "Chemical Composition of Distillers Grains, a Review," Journal of Agricultural and Food Chemistry, 59:1508-1526, 2011.

Lundeen, T., "Feed Marketing & Distribution," In: 2011 Feedstuffs Reference Issue & Buyer's Guide 2010.

McGraw-Hill, "McGraw-Hill Dictionary of Science and Technical Terms," <http://www.answers.com/topic/ensiling>, 2003. Accessed on August 26, 2013 and printed on November 15, 2012.

Merck Sharp & Dohme Corp, "Aflatoxicosis," <http://www.merckmanuals.com/vet/toxicology/mycotoxicoses/aflatoxicosis.html>, March, 2012a. Accessed and printed on August 23, 2013.

Merck Sharp & Dohme Corp, "Botulism," [http://www.merckmanuals.com/vet/generalized\\_conditions/clostridial\\_diseases/botulism.html?qt=Botulism](http://www.merckmanuals.com/vet/generalized_conditions/clostridial_diseases/botulism.html?qt=Botulism), March, 2012c. Accessed on August 24, 2013.

Merck Sharp & Dohme Corp, "Fumonisin Toxicosis," [http://www.merckmanuals.com/vet/toxicology/mycotoxicoses/fumonisin\\_toxicosis.html](http://www.merckmanuals.com/vet/toxicology/mycotoxicoses/fumonisin_toxicosis.html), March, 2012d. Accessed on August 24, 2013.

Merck Sharp & Dohme Corp, "Overview of Salmonellosis," [http://www.merckmanuals.com/vet/digestive\\_system/salmonellosis/overview\\_of\\_salmonellosis.html?qt=Salmonellosis&alt=sh](http://www.merckmanuals.com/vet/digestive_system/salmonellosis/overview_of_salmonellosis.html?qt=Salmonellosis&alt=sh), March, 2012b. Accessed on August 24, 2013.



Montville, T. J. and K. R. Matthews, "Growth, Survival, and Death of Microbes in Foods," In: Food Microbiology: Fundamentals and Frontiers, edited by M. P. Doyle and L. R. Beuchat, 3<sup>rd</sup> edition, pp. 3-22, ASM Press, 2007.

Morita, T., H. Kitazawa, T. Iida, and S. Kamata, "Prevention of Salmonella Cross-Contamination in an Oilmeal Manufacturing Plant," Journal of Applied Microbiology, 101:464-473, 2006.

Muth, M. K., C. Zhen, M. Coglaiti, and S. Karns, "Food Processing Sector Study, Contract HHSF 2232010745G, Task Order 13, Final Report," 2011.

Myllykoski, J., M. Lindstrom, and R. Keto-Timonen, "Type C Bovine Botulism Outbreak Due to Carcass Contaminated Non-Acidified Silage," Epidemiological Infections, 137:284-293, 2009.

National Research Council, S. o. P. N., Nutrient Requirements of Poultry, 1994.

National Research Council, Nutrient Requirements of Beef Cattle: Seventh Revised Edition, Washington, D.C., National Academy Press, 2000.

National Research Council, "Phosphorus," In: Mineral Tolerance of Animals, Second Revised Edition, pp. 290-299 2005.

Orriss, G. D., "Animal Diseases of Public Health Importance," Emerging Infectious Diseases, 3:497-502, 1997.

Pestka, J. J. and A. T. Smolinski, "Deoxynivalenol: Toxicology and Potential Effects on Humans," Journal of Toxicology and Environmental Health. Part B, Critical Reviews, 8:39-69, 2005.

Phillips, P. H. and R. W. Engel, "The Histopathology of Neuromalacia and Curled Toe Paralysis in the Chick Fed Low Riboflavin Diets," The Journal of Nutrition, 16:451-463, 1938.

Ruoho, O., "An Epidemic of Salmonellosis Caused by Silage Containing Salmonella at a Dairy Farm," In: XIII International Congress in Animal Hygiene "Animal Health, Animal Welfare and Biosecurity" Proceedings Volume 1, edited by A. Aland, pp. 882-884 2007.

Scott, V. N., R. S. Clavero, and J. A. Troller, "Measurement of Water Activity ( $A_w$ ), Acidity, and Brix," In: Compendium of Methods for the Microbiological Examination of Foods, edited by F. P. Downes and K. Ito, 4<sup>th</sup> edition, Washington, DC, Chapter 64, pp. 649-657, American Public Health Association, 2001.

Scott, V. N., C. Yuhuan, T. A. Freier, J. Kuehm, M. Moorman, J. Meyer, T. Morille-Hinds, L. Post, L. Smoot, S. Hood, J. Shebuski, and J. Banks, "Control of *Salmonella* in Low-Moisture Foods I: Minimizing Entry of *Salmonella* into a Processing Facility," Food Protection Trends, 29:342-353, 2009.

Shephard, G. S., "Risk Assessment of Aflatoxins in Food in Africa," Food Additives and Contaminants: Part A - Chemistry, Analysis, Control, Exposure and Risk Assessment, 25:1246-1256, 2008.

Shotwell, O. L., "Aflatoxin in Corn," Journal of the American Oil Chemists' Society, 54:216A-224A, 1977.

Townsend, C. T., L. Yee, and W. A. Mercer, "Inhibition of the Growth of *Clostridium Botulinum* by Acidification," Journal of Food Science, 19:536-542, 1954.

Tsunoda, M., R. P. Sharma, and R. T. Riley, "Early Fumonisin B1 Toxicity in Relation to Disrupted Sphingolipid Metabolism in Male BALB/c Mice," Journal of Biochemical and Molecular Toxicology, 12:281-289, 1998.

United States Department of Agriculture, "2007 Census of Agriculture United States Summary and State Data," [http://www.agcensus.usda.gov/Publications/2007/Full\\_Report/usv1.pdf](http://www.agcensus.usda.gov/Publications/2007/Full_Report/usv1.pdf), 2009. Accessed on August 24, 2013.

United States Department of Agriculture, APHIS, "Info Sheet: Fumonisin B1 Mycotoxin in Horse Grain/Concentrate on U.S. Horse Operations," [http://www.aphis.usda.gov/animal\\_health/nahms/equine/downloads/equine98/Equine98\\_is\\_Fumonisin.pdf](http://www.aphis.usda.gov/animal_health/nahms/equine/downloads/equine98/Equine98_is_Fumonisin.pdf), 2000. Accessed on August 24, 2013.

United States Department of Agriculture, APHIS, "National Animal Health Monitoring System: National Studies of U.S. Livestock and Poultry, 2010," [http://www.aphis.usda.gov/animal\\_health/nahms/downloads/NAHMS\\_brochure.pdf](http://www.aphis.usda.gov/animal_health/nahms/downloads/NAHMS_brochure.pdf), 2012. Accessed on August 24, 2013.

United States Department of Agriculture, AMS, "Recordkeeping Manual for Private Pesticide Applicators," <http://www.ams.usda.gov/AMSV1.0/getfile?dDocName=STELPRD3342981>, August, 2010. Accessed on August 24, 2013.

United States Department of Agriculture, NASS., "Agricultural Statistics 2010," [http://www.nass.usda.gov/Publications/Ag\\_Statistics/2010/2010.pdf](http://www.nass.usda.gov/Publications/Ag_Statistics/2010/2010.pdf), 2010. Accessed on August 24, 2013.

Uzzau, S., D. J. Brown, T. Wallis, S. Rubino, G. Leori, S. Bernard, J. Casadesus, D. J. Platt, and J. E. Olson, "Host Adapted Serotypes of *Salmonella Enterica*," Epidemiol.Infect., 125:229-255, 2000.

Ward, J. L. and N. G. Ducharme, "Traumatic Reticuloperitonitis in Dairy Cows," JAVMA, 204:874-877, 1994.

Williams, J. H., T. D. Phillips, P. E. Jolly, J. K. Stiles, C. M. Jolly, and D. Aggarwal, "Human Aflatoxicosis in Developing Countries: a Review of Toxicology, Exposure,

Potential Health Consequences, and Interventions," American Journal of Clinical Nutrition, 80:1106-1122, 2004.

Whitlow, L. W. and W. M. Hagler, "Molds and Mycotoxins in Feedstuffs - Prevention and Treatment," <http://dairy.ifas.ufl.edu/rms/2005/Whitlow.pdf>, 2005. Accessed on August 24, 2013.

World Health Organization, "FAQs: Japan Nuclear Concerns," <http://www.who.int/hac/crises/jpn/faqs/en/index.html>, September, 2011. Accessed August 26, 2013.

Wyatt, R. D., H. T. Tung, W. E. Donaldson, and P. B. Hamilton, "A New Description of Riboflavin Deficiency Syndrome in Chickens," Poultry Science, 52:237-244, 1973.

## **APPENDIX 1. REGULATORY BACKGROUND**

### **A. Statutory and Regulatory Framework for the Risk Assessment**

On January 4, 2011, the FDA Food Safety Modernization Act (FSMA) (Public Law 111–353) was signed into law. Section 103 of FSMA, Hazard Analysis and Risk-Based Preventive Controls, amends the Federal Food, Drug, and Cosmetic Act (FD&C Act) to create a new section 418 with the same name. Section 418 of the FD&C Act contains requirements applicable to food facilities that are required to register under section 415 of the FD&C Act and mandates agency rulemaking. Section 418(a) is a general provision that requires the owner, operator, or agent in charge of a facility to evaluate the hazards that could affect food manufactured, processed, packed, or held by the facility, identify and implement preventive controls, monitor the performance of those controls, and maintain records of the monitoring. Section 418(a) specifies that the purpose of the preventive controls is to prevent the occurrence of such hazards and provide assurances that such food is not adulterated under section 402 of the FD&C Act or misbranded under section 403(w) of the FD&C Act. In addition to those areas specified in section 418(a) of the FD&C Act, sections 418(b)-(i) contain more specific requirements applicable to facilities. These include corrective actions (§ 418(e)), verification (§ 418(f)), a written plan and documentation (§ 418(h)), and reanalysis of hazards (§ 418(i)). Section 418(b) of the FD&C Act requires that the hazard analysis identify and evaluate known or reasonably foreseeable hazards that may be associated with the facility, including biological, chemical, physical, and radiological hazards, natural toxins, pesticides, drug residues, decomposition, parasites, allergens, and unapproved food and color additives. Section 418(n)(1) requires rulemaking to establish science-based minimum standards for conducting a hazard analysis, documenting hazards, implementing preventive controls, and documenting the implementation of the preventive controls under section 418 and to define the terms “small business” and “very small business” for the purposes of section 418.

Section 103(c) of FSMA requires rulemaking in two areas: (1) clarification of the activities that are included as part of the definition of the term “facility” under section 415 of the FD&C Act (Registration of Food Facilities) and (2) possible exemption from or modification of requirements of section 418 and section 421 (Targeting of Inspection Resources for Domestic Facilities, Foreign Facilities, and Ports of Entry; Annual Report) of the FD&C Act for certain facilities as FDA deems appropriate. Section 415 of the FD&C Act directs FDA to require by regulation that any facility engaged in manufacturing, processing, packing, or holding food for human or animal consumption in the United States be registered with FDA. The registration requirement in section 415 of the FD&C Act does not apply to farms. Our regulations that implement section 415 and require food facilities to register with FDA are established in part 1 (21 CFR part 1), subpart H (Registration of Food Facilities) (hereinafter the section 415 registration regulations)

Section 103(c)(1)(C) of FSMA directs the Secretary [of HHS] to conduct a science-based risk analysis as part of the section 103(c) rulemaking. The science-based risk analysis is to cover “(i) specific types of on-farm packing or holding of food that is not grown,

raised, or consumed on such farm or another farm under the same ownership, as such packing and holding relates to specific foods; and (ii) specific on-farm manufacturing and processing activities as such activities relate to specific foods that are not consumed on that farm or on another farm under common ownership.”

Section 103(c)(1)(D)(i) of FSMA requires that “the Secretary [of HHS] shall consider the results of the science-based risk analysis... and shall exempt certain facilities from the requirements in section 418 of the Federal Food, Drug, and Cosmetic Act ... including hazard analysis and preventive controls, and the mandatory inspection frequency in section 421 of such Act ..., or modify the requirements in such sections 418 or 421, as the Secretary determines appropriate, if such facilities are engaged only in specific types of on-farm manufacturing, processing, packing, or holding activities that the Secretary determines to be low risk involving specific foods the Secretary determines to be low risk.” Section 103(c)(1)(D)(ii) of FSMA provides, in relevant part, that the exemptions or modifications described in section 103(c)(1)(D)(i) “shall apply only to small businesses and very small businesses, as defined in the regulation promulgated under section 418(n) of the Federal Food, Drug, and Cosmetic Act[.]”

FSMA establishes several exemptions and exceptions to the requirements specified in section 418 of the FD&C Act for hazard analysis and risk-based preventive controls. The exemptions and exceptions most relevant to the analysis required by section 103(c)(1)(C) of FSMA are:

- Section 418(j) of the FD&C Act provides an exemption for facilities that are required to comply and are in compliance with the regulations for seafood Hazard Analysis and Critical Control Point (HACCP), juice HACCP, or thermally processed low-acid foods packed in hermetically sealed containers. The exemption for thermally processed low-acid foods packed in hermetically sealed containers applies only with respect to microbiological hazards (i.e., it does not apply with respect to chemical, physical, and radiological hazards).
- Section 418(k) of the FD&C Act provides an exception for activities of a facility that are subject to section 419 of the FD&C Act (Standards for Produce Safety).
- Section 103(g) of FSMA provides an exemption for the manufacturing, processing, packing, or holding of a dietary supplement that is in compliance with sections 402(g)(2) and 761 of the FD&C Act (21 U.S.C. 342(g)(2), 379aa-1).
- Section 116(a) of FSMA (21 U.S.C 2206(a)) provides an exemption for alcoholic beverages and limited prepackaged foods other than alcoholic beverages at certain alcohol-related facilities.”

To implement sections 103(c)(1)(C)-(D) of FSMA, FDA (we) focused on activity/animal food combinations that are likely to be conducted on farms (and farm mixed-type facilities), but that are outside the definition of farm in § 1.227 in at least some circumstances. When such activities trigger the registration requirement in section 415 of the FD&C Act, they are subject to requirements under section 418 of the FD&C Act and section 421 of the FD&C Act (Targeting of Inspection Resources).

The statutory exemption in section 418(j) of the FD&C Act for thermally processed low-acid foods packed in hermetically sealed containers applies only to microbiological

hazards. We did not consider microbiological hazards that could be associated with the activity of canning low-acid foods in our analysis because the activity is performed only in the production of pet food which is not considered within the scope of the RA. Moreover, we did not consider physical, chemical, and radiological hazards associated with thermally processed low-acid foods for the same reason.

## B. FDA’s Clarification of Activities Conducted on Farms

Section 1.227 in the section 415 registration regulations includes definitions that are relevant to the scope of those regulations, including definitions for types of establishments (i.e., “facility” and “farm”) and types of activities (i.e., “holding,” “manufacturing/processing,” “packaging,” and “packing”). In relevant part, these definitions play a role in determining whether an establishment is a facility that must register with FDA and implement a provision (in section 415(b)(1) of the FD&C Act) exempting “farms” from the registration requirement in section 415. Table 13 describes key definitions applicable to the current regulatory framework that determines what establishments are required to register with FDA under section 415 of the FD&C Act and, thus, would be subject to the requirements of section 418 of the FD&C Act for hazard analysis and risk-based preventive controls.

Table 13. Key Definitions Applicable to the Current Legal and Regulatory Framework under Sections 415 and 418 of the FD&C Act

Provision of the Section 415 Registration Regulations or the FD&C Act	Definition
§ 1.227(b)(2)	For the purposes of section 415 of the FD&C Act, a facility is, in relevant part, any establishment, structure, or structures under one ownership at one general physical location, or, in the case of a mobile facility, traveling to multiple locations, that manufactures/processes, packs, or holds food for consumption in the United States.
§ 1.225	The owner, operator, or agent in charge of either a domestic or foreign facility must register in accordance with the section 415 registration regulations if the facility is engaged in the manufacturing/processing, packing, or holding of food for consumption in the United States, unless the facility qualifies for one of the exemptions in § 1.226.
§ 1.226(b)	Farms are not subject to the registration requirement in § 1.225.

Provision of the Section 415 Registration Regulations or the FD&C Act	Definition
§ 1.227(b)(3)	Farm means a facility in one general physical location devoted to the growing and harvesting of crops, the raising of animals (including seafood), or both. Washing, trimming of outer leaves of, and cooling produce are considered part of harvesting. The term “farm” includes facilities that pack or hold food, provided that all food used in such activities is grown, raised, or consumed on that farm or another farm under the same ownership; and facilities that manufacture/process food, provided that all food used in such activities is consumed on that farm or another farm under the same ownership.
§ 1.227(b)(5)	Holding means storage of food. Holding facilities include warehouses, cold storage facilities, storage silos, grain elevators, and liquid storage tanks.
§ 1.227(b)(6)	Manufacturing/processing means making food from one or more ingredients, or synthesizing, preparing, treating, modifying or manipulating food, including food crops or ingredients. Examples of manufacturing/processing activities are cutting, peeling, trimming, washing, waxing, eviscerating, rendering, cooking, baking, freezing, cooling, pasteurizing, homogenizing, mixing, formulating, bottling, milling, grinding, extracting juice, distilling, labeling, or packaging.
§ 1.227(b)(8)	Packaging (when used as a verb) means placing food into a container that directly contacts food and that the consumer receives.
§ 1.227(b)(9)	Packing means placing food into a container other than packaging the food.
Section 418(o)(2) of the FD&C Act	A facility that is subject to the requirements of section 418 of the FD&C Act is a domestic facility or a foreign facility that is required to register under section 415 of the FD&C Act.

As directed by section 103(c)(1)(B) of FSMA, FDA is initiating rulemaking to clarify what activities would be considered manufacturing, processing, packing, and holding for purposes of section 415 of the FD&C Act. As part of that rulemaking, FDA developed a definition for a “mixed-type facility” as an establishment that engages in both activities that are exempt from registration under section 415 of the FD&C Act and activities that require the establishment to be registered. An example of such a facility is a “farm mixed-type facility,” which is an establishment that grows and harvests crops or raises animals and may conduct other activities within the farm definition, but also conducts activities that require the establishment to be registered.

As part of the rulemaking required by section 103(c)(1)(C) of FSMA, FDA also is initiating rulemaking to revise definitions, in the section 415 registration regulations, that classify activities on-farm and off-farm. As part of that rulemaking, FDA developed the following organizing principles to explain and clarify the basis for these proposed revisions to the definitions. We describe those organizing principles in Table 14. A full discussion of how FDA developed these organizing principles is being published in the *Federal Register* and is outside the scope of this document.

Table 14. Summary of Organizing Principles Regarding Classification of Activities On-Farm and Off-Farm

No.	Organizing Principle
1	The basic purpose of farms is to produce RACs and RACs are the essential products of farms.
2	Activities that involve RACs and that farms traditionally do for the purposes of growing their own RACs,* removing them from the growing areas, and preparing them for use as a food RAC, and for packing, holding and transporting them, should all be within the definition of “farm” in §§ 1.227.
3	Activities should be classified based in part on whether the food operated on is a RAC or a processed food, and on whether the activity transforms a RAC into a processed food.
4	Activities farms may perform on others’ RACs should appropriately be classified as manufacturing, processing, packing, or holding in the same manner as these activities are classified off-farm when the RACs are to be distributed into commerce.
5	Manufacturing, processing, packing, or holding food-- whether RACs or processed foods, from any source-- for consumption on the farm should remain within the farm definition.

\* For the purposes of this discussion, FDA refers to RACs grown or raised on a farm or another farm under the same ownership as a farm’s “own RACs,” in contrast to RACs grown on a farm under different ownership, which FDA refers to as “others’ RACs.”

As part of the rulemaking required by section 103(c)(1)(C) of FSMA, based on these organizing principles certain definitions in the section 415 registration regulations would be revised. Appendix 3 includes a comparison of the existing definitions and the proposed revisions to those definitions. Table 15 provides examples of how activities would be classified under the proposed revisions to the definitions. Examples in the table were generated by the FDA CFSAN and therefore mainly apply to human food. Appendix 2 presents information which leads FDA CVM to conclude that activities conducted on-farm, whether performed on the farm’s own RACs or RACs from another farm, are performed to make animal food that is consumed on that farm or a farm under the same ownership. Because the animal food produced is consumed by animals on that farm or another farm under the same ownership, the activity/animal food combination



constitutes a farming activity. That is, in the case of animal food that is processed to feed animals raised on that farm, there is no distinction between activities conducted on the farm’s own RACs and those conducted on RACs from another farm with respect to invoking the need to register under section 415. Therefore, when these activity/animal food combinations are conducted to produce animal food for animals raised on the farm, they are out of the scope of the RA. If there are farm mixed facilities that are conducting activity/animal food combinations on RACs from another farm for the purposes of distribution into commerce, then they would need to comply with the requirements for registration and with the requirements of FSMA and would need to determine the applicability of the exempted low-risk activity/animal food combinations for their circumstances.

Table 15. Classification of Activities Conducted Off-Farm and On-Farm (Including Farm Mixed-Type Facilities)

Classification	Off-Farm	On-Farm (Including Farm Mixed-Type Facilities)
Harvesting	<i>Notes:</i> Not applicable. Harvesting is a classification that only applies on farms and farm mixed-type facilities.	<i>Notes:</i> Activities traditionally performed by farms for the purpose of removing RACs from growing areas and preparing them for use as food. Harvesting is limited to activities performed on RACs on the farm on which they were grown or raised, or another farm under the same ownership. Harvesting does not include activities that change a RAC into processed food. Activities that are harvesting are within the farm definition.
Harvesting	<i>Examples:</i> Not applicable.	<i>Examples:</i> Activities that fit this definition when performed on a farm’s “own RACs” (a term we use to include RACs grown or raised on that farm or another farm under the same ownership) include gathering, washing, trimming of outer leaves, removing stems and husks, sifting, filtering, threshing, shelling, and cooling. <b>These activities, performed on a farm’s own RACs, are inside the farm definition.</b>
Packing	<i>Notes:</i> Placing food in a container other than packaging the food (where packaging means placing food into a container that directly contacts the food and that the consumer receives).	<i>Notes:</i> Placing food in a container other than packaging the food (using the same definition of packaging), or activities (which may include packaging) traditionally performed by farms to prepare RACs grown or raised on that farm or another farm under the same ownership for storage or transport. Packing does not include activities that change RAC into a processed food. Activities that are packing are within the farm definition when they are performed on food grown, raised, or consumed on that farm or another farm under the same ownership; under any other circumstances they are outside the farm definition.

Classification	Off-Farm	On-Farm (Including Farm Mixed-Type Facilities)
Packing	<p><i>Examples:</i> Putting individual unit cartons into a larger box used for shipping, and putting articles of produce in non-consumer containers (such as shipping crates).</p>	<p><i>Examples:</i> Activities that fit the definition of packing when performed on a farm's own RACs include packaging, mixing, coating with wax/oil/resin for the purpose of storage or transport, stickering/labeling, drying for the purpose of storage or transport, and sorting/grading/culling. <b>These activities, performed on a farm's own RACs, are inside the farm definition.</b></p> <p>Activities that fit the definition of packing when performed on a farm on any other foods, including RACs grown or raised on a farm not under the same ownership, include putting individual unit cartons into a larger box used for shipping, and putting articles of produce in non-consumer containers (such as shipping crates) -- the same activities that fit the definition of packing off farm. <b>These activities, performed on food other than a farm's own RACs, are outside the farm definition unless done on food for consumption on the farm.</b></p>
Holding	<p><i>Notes:</i> Storage of food.</p>	<p><i>Notes:</i> Storage of food, or activities traditionally performed by farms for the safe or effective storage of RACs grown or raised on that farm or another farm under the same ownership. Holding does not include activities that change a RAC into a processed food. Activities that are holding are within the farm definition when they are performed on food grown, raised, or consumed on that farm or another farm under the same ownership; under any other circumstances they are outside the farm definition.</p>

Classification	Off-Farm	On-Farm (Including Farm Mixed-Type Facilities)
Holding	<i>Example:</i> Storing food, such as in a warehouse.	<p><i>Examples:</i> activities that fit the definition of holding when performed on a farm’s own RACs include fumigating during storage, and storing food, such as in a warehouse. <b>These activities, performed on a farm’s own RACs, are inside the farm definition.</b></p> <p>An activity that fit the definition of holding when performed on a farm on any other foods, including RACs grown or raised on a farm not under the same ownership, is storing food, such as in a warehouse -- the same activity that fits the definition of holding off farm. <b>This activity, performed on food other than a farm’s own RACs, is outside the farm definition unless done on food for consumption on the farm.</b></p>
Manufacturing/ Processing	<i>Notes:</i> Making food from one or more ingredients, or synthesizing, preparing, treating, modifying, or manipulating food. Includes packaging (putting food in a container that directly contacts food and that the consumer receives).	<i>Notes:</i> Making food from one or more ingredients, or synthesizing, preparing, treating, modifying, or manipulating food; except for things that fall into the categories of harvesting, packing, or holding (see rows above). Activities that are manufacturing/processing are outside the farm definition unless done on food for consumption on the farm.

Classification	Off-Farm	On-Farm (Including Farm Mixed-Type Facilities)
Manufacturing/Processing	<p><i>Examples:</i> Activities that fit this definition include washing, trimming of outer leaves, removing stems and husks, sifting, filtering, threshing, shelling, cooling, packaging, mixing, coating, stickering/labeling, drying, sorting/grading/culling not incidental to packing or holding, fumigating, slaughtering animals or post-slaughter operations, irradiation, cutting/coring/chopping/slicing, canning, artificial ripening, cooking, pasteurizing/homogenizing, infusing, distilling, salting, smoking, grinding/milling, and freezing.</p>	<p><i>Examples:</i> Activities that fit the definition of manufacturing/processing when performed on a farm's own RACs include slaughtering animals or post-slaughter operations, irradiation, cutting/coring/chopping/slicing, canning, coating with things other than wax/oil/resin, drying that creates a distinct commodity, artificial ripening, cooking, pasteurizing/homogenizing, infusing, distilling, salting, smoking, grinding/milling, and freezing. <b>These activities, performed on a farm's own RACs, are outside the farm definition unless done on food for consumption on the farm.</b></p> <p>Activities that fit the definition of manufacturing/processing when performed on a farm on any other foods, including RACs grown or raised on a farm not under the same ownership include washing, trimming of outer leaves, removing stems and husks, sifting, filtering, threshing, shelling, cooling, packaging, mixing, coating, stickering/labeling, drying, sorting/grading/culling not incidental to packing or holding, fumigating, slaughtering animals or post-slaughter operations, irradiation, cutting/coring/chopping/slicing, canning, artificial ripening, cooking, pasteurizing/homogenizing, infusing, distilling, salting, smoking, grinding/milling, and freezing-- the same activities that fit the definition of manufacturing/processing off farm. <b>These activities, performed on food other than a farm's own RACs, are outside the farm definition unless done on food for consumption on the farm.</b></p>

## **APPENDIX 2. INFORMATION IMPACTING THE RISK CHARACTERIZATION OF ACTIVITY/ANIMAL FOOD COMBINATIONS**

In section VI.C.2 of this document, we characterize the risk of activity/food combinations without the regulatory overlay of the definition of “farm” and the associated definitions of manufacturing, processing, packing, and holding. Doing so focused the risk characterization analysis on the risk of the activity/food combinations themselves. In Appendix 2 of this document, we add the regulatory overlay of the definition of “farm” and arrange our results in groups shaped by the applicable regulatory factors and the resulting activity classifications.

### **A. Regulatory Groups**

The groups for regulatory purposes are:

- Type 1: Packing and holding activities that might be conducted on a farm on food not grown, raised, or consumed on that farm or another farm under the same ownership;
- Type 2: Manufacturing and processing activities that might be conducted on a farm on the farm’s own RACs for distribution into commerce; and
- Type 3: Manufacturing and processing activities that might be conducted on a farm on food other than the farm’s own RACs for distribution into commerce.

### **B. Regulatory Group Type 1**

The list below presents the packing and holding activities that might be conducted on a farm on specific food categories not grown, raised, or consumed on that farm or another farm under the same ownership. Under these circumstances, packing and holding activities are outside the farm definition and, thus, trigger the section 415 registration requirement and the new requirements under section 418 of the FD&C Act for hazard analysis and risk-based preventive controls. These packing and holding activities outside the farm definition include:

- Packing or holding others’ RACs for distribution into commerce (not for consumption on the farm or another farm under the same ownership);
- Packing or holding others’ processed foods for distribution into commerce; and
- Packing or holding processed foods made on the farm for distribution into commerce.

The risk characterization of these packing and holding activity/food combinations tracks the risk characterization of the activity/food combinations presented in section VI.C.2 of this document.

- Conveying, weighing, sorting, culling, or grading (incidental to storing):
  - Grain (e.g., barley, corn, rice, oat, sorghum, triticale, wheat);
  - Oilseed (e.g., cottonseed, linseed, rapeseed, soybean, sunflower);
  - Grain or oilseed byproducts;
  - Forage (hay or ensiled material);
  - Other plants or plant byproducts (e.g., such as almond, peanut or soybean hulls, citrus, other fruit including culled fruit, potatoes, or other vegetables including culled vegetables).
- Storing:
  - Dried grain;
  - Dried oilseed;
  - Byproducts of dried grain or dried oilseed;
  - Forage;
  - Other plants or plant byproducts.
- Packing:
  - Grain;
  - Oilseed;
  - Grain or oilseed byproducts;
  - Forage;
  - Other plants or plant byproducts.
- Mixing (incidental to storing or packing):
  - Grain, whole;
  - Forage.

### **C. Regulatory Group Type 2**

The following list presents the manufacturing and processing activities that might be conducted on a farm on the farm's own RACs for distribution into commerce. The risk characterization of these manufacturing and processing activity/food combinations tracks the risk characterization of the activity/food combinations presented in section VI.C.2 of this document. However, the list of activities here is shorter than the list of activities in Table 10 and Table 11 because, as described in Appendix 1, some of the activities listed in Table 10 and Table 11 would not be manufacturing or processing activities when conducted on a farm on the farm's own RACs for distribution into commerce.

- Cracking, crimping, flaking:
  - Grain;
  - Oilseed;
  - Grain or oilseed byproducts.
- Crushing, grinding, milling, pulverizing, or dry rolling:
  - Grain;
  - Oilseed;
  - Grain or oilseed byproducts;
  - Forage;
  - Other plants or plant byproducts.

- Making silage.
- Chopping or shredding hay.
- Extracting (mechanical) or wet rolling:
  - Grain;
  - Oilseed.

### **D. Regulatory Group Type 3**

The following list shows manufacturing and processing activities that might be conducted on a farm on food other than the farm's own RACs for distribution into commerce.

These include:

- Manufacturing and processing activities on others' RACs for distribution into commerce; and
- Manufacturing and processing activities on processed foods from any source for distribution into commerce.

The risk characterization of these manufacturing and processing activity/food combinations tracks the risk characterization of the activity/food combinations presented in section VI.C.2 of this document.

- Cracking, crimping, flaking, or shelling:
  - Grain;
  - Oilseed;
  - Grain or oilseed byproducts.
- Crushing, grinding, milling, pulverizing, or dry rolling:
  - Grain;
  - Oilseed;
  - Grain or oilseed byproducts;
  - Forage;
  - Other plants or plant byproducts.
- Making silage.
- Chopping or shredding hay.
- Extracting (mechanical) or wet rolling:
  - Grain;
  - Oilseed.
- Labeling:
  - Grain, whole;
  - Oilseed, whole;
- Sifting, separating, or sizing:
  - Grain;
  - Oilseed;
  - Grain or oilseed byproducts;
  - Other plants or plant byproducts.

### APPENDIX 3. ACRONYMS AND GLOSSARY

Table 16. Acronyms Used in the RA

<b>Acronym</b>	<b>Definition</b>
CDC	Centers for Disease Control and Prevention
CFSAN	FDA Center for Food Safety and Nutrition
CGMP	Current Good Manufacturing Practice
CVM	FDA Center for Veterinary Medicine
FD&C Act	Federal Food, Drug, and Cosmetic Act
FDA	Food and Drug Administration
FSMA	FDA Food Safety Modernization Act
HACCP	Hazard Analysis and Critical Control Point
HHS	Department of Health and Human Services
RA	Risk Assessment
RFR	Reportable Food Registry
SAHCODHA	Serious Adverse Health Consequences Or Death to humans or animals

Table 17. Definitions Used in the RA

<b>Term</b>	<b>Definition for the Purpose of this Risk Assessment</b>
Inherent control	In making the food the hazard is controlled, and it is highly unlikely that the food will be made in a way that the hazard is not adequately addressed.
Reasonably likely to cause serious adverse health consequences or death	There is a reasonable probability that use of, or exposure to, a food containing a hazard will cause serious adverse health consequences or death to humans.



Table 18. Proposed Changes to Regulatory Definitions Related to Farm-Mixed Facilities

Term	Current Regulatory/Legal Definition	Proposed Revision to Regulatory Definition
Farm	A facility in one general physical location devoted to the growing and harvesting of crops, the raising of animals (including seafood), or both. Washing, trimming of outer leaves of, and cooling produce are considered part of harvesting. The term “farm” includes facilities that pack or hold food, provided that all food used in such activities is grown, raised, or consumed on that farm or another farm under the same ownership; and facilities that manufacture/process food, provided that all food used in such activities is consumed on that farm or another farm under the same ownership. (21 CFR 1.227(b)(3))	A facility in one general physical location devoted to the growing and harvesting of crops, the raising of animals (including seafood), or both. The term "farm" includes: (1) Facilities that pack or hold food, provided that all food used in such activities is grown, raised, or consumed on that farm or another farm under the same ownership; and (2) Facilities that manufacture/process food, provided that all food used in such activities is consumed on that farm or another farm under the same ownership.
Holding	Storage of food. Holding facilities include warehouses, cold storage facilities, storage silos, grain elevators, and liquid storage tanks. (21 CFR 1.227(b)(5))	Storage of food. Holding facilities include warehouses, cold storage facilities, storage silos, grain elevators, and liquid storage tanks. For farms and farm mixed-type facilities, holding also includes activities traditionally performed by farms for the safe or effective storage of raw agricultural commodities grown or raised on the same farm or another farm under the same ownership, but does not include activities that transform a raw agricultural commodity, as defined in section 201(r) of the FD&C Act, into a processed food as defined in section 201(gg) of the FD&C Act.
Major Food Allergen	Section 201(qq) of the FD&C Act defines the term “major food allergen” to mean any of the following: milk, egg, fish (e.g., bass, flounder, or cod), Crustacean shellfish (e.g., crab, lobster, or shrimp), tree nuts (e.g., almonds, pecans, or walnuts), wheat, peanuts, and soybeans, or a food ingredient that contains protein derived from one of these foods, with certain exceptions.	Not applicable

Term	Current Regulatory/Legal Definition	Proposed Revision to Regulatory Definition
Manufacturing/processing	Making food from one or more ingredients, or synthesizing, preparing, treating, modifying or manipulating food, including food crops or ingredients. Examples of manufacturing/processing activities are cutting, peeling, trimming, washing, waxing, eviscerating, rendering, cooking, baking, freezing, cooling, pasteurizing, homogenizing, mixing, formulating, bottling, milling, grinding, extracting juice, distilling, labeling, or packaging. (21 CFR 1.227(b)(6))	Making food from one or more ingredients, or synthesizing, preparing, treating, modifying or manipulating food, including food crops or ingredients. Examples of manufacturing/processing activities are: Cutting, peeling, trimming, washing, waxing, eviscerating, rendering, cooking, baking, freezing, cooling, pasteurizing, homogenizing, mixing, formulating, bottling, milling, grinding, extracting juice, distilling, labeling, or packaging. For farms and farm mixed-type facilities, manufacturing/processing does not include activities that are part of harvesting, packing, or holding.
Mixed-Type Facility	Not applicable	An establishment that engages in both activities that are exempt from registration under section 415 of the FD&C Act and activities that require the establishment to be registered. An example of such a facility is a “farm mixed-type facility,” which is an establishment that grows and harvests crops or raises animals and may conduct other activities within the farm definition, but also conducts activities that require the establishment to be registered.
Packaging	Placing food into a container that directly contacts food and that the consumer receives (when used as a verb) (21 CFR 1.227(b)(8))	No proposed revision
Packing	Placing food into a container other than packaging the food. (21 CFR 1.227(b)(9))	Placing food into a container other than packaging the food. For farms and farm mixed-type facilities, packing also includes activities (which may include packaging) traditionally performed by farms to prepare raw agricultural commodities grown or raised on the same farm or another farm under the same ownership for storage and transport, but does not include activities that transform a raw agricultural commodity, as defined in section 201(r) of the FD&C Act, into a processed food as defined in section 201(gg) of the FD&C Act.

