

The background of the entire page is a photograph of a lush green soybean field. The plants are in the foreground, filling the lower two-thirds of the frame. In the distance, a dark line of trees marks the horizon. The sky is a mix of blue and orange, indicating a sunset or sunrise. The text is overlaid on the upper half of the image.

NON-ANIMAL ORIGIN FEED INGREDIENT RISK EVALUATION FRAMEWORK: SCOPING

BACKGROUND

Recent events have heightened the concern of U.S. animal health officials and industry stakeholders regarding the potential role that imported non-animal origin feed ingredients (NOFI) may have in the introduction (entry) of high consequence viral pathogens such as African swine fever (ASF) into the United States. Concerns over the potential role of feed ingredients in the introduction and spread of viral pathogens are informed by the following:

- An APHIS Veterinary Services (VS) pathways assessment estimating the risk of entry of exotic viral pathogens of swine to the United States, determined the entry likelihood of exotic swine viruses via animal feed ingredients derived from plants or plant products was low, with a medium amount of uncertainty if the material is unprocessed;
- Epidemiologic investigations in Latvia and Lithuania that suggested feeding pigs fresh grasses and seeds harvested from areas with wild boar populations known to be infected with ASF may have been a possible source of ASF introduction to backyard farms ([Guinat et al., 2016](#); [Olsevskis et al., 2016](#); [Olesen et al., 2018](#));
- A Canadian study ([Pasick et al., 2014](#)) found feed containing spray-dried porcine plasma to be epidemiologically linked to the introduction of PEDv to Canada, and samples of feed and spray-dried porcine plasma were positive for porcine epidemic diarrhea virus (PEDv) on RRT-PCR and RT-PCR;
- The VS [Swine Enteric Coronavirus Introduction to the United States: Root Cause Investigation Report](#) implicated totes as well as NOFI such as soybeans and rice hulls as potential fomites of virus introduction;
- Recent experimental studies have shown that PEDv and foreign animal disease viruses such as ASF may be able to survive on feed ingredients during intercontinental shipping ([Dee et al., 2018a](#); [Dee et al., 2018b](#)).
- Industry stakeholders who recently visited ASF affected countries observed production practices that raised concerns over possible contamination of NOFI from the environment.

IMPORTATION OF NON-ANIMAL ORIGIN FEED INGREDIENTS

There are regulations to prevent entry of hazards on unprocessed NOFI, such as [straw, hay, or grass](#) and [rice straw and rice hulls](#). Consequently, the majority of our most frequently imported plant-origin feed ingredients are from Canada. However, other ingredients, such as corn, silage, soybeans, soybean meal, and flax are not regulated to mitigate the exclusion of foreign animal disease agents, and a portion of these ingredients are exported by countries affected by swine diseases of concern, such as ASF (). Among these products, there may be varying levels of risk among ingredient subcategories. For example, organic soybeans may represent a relatively higher risk pathway for ASF virus entry, because organic products are not treated by chemical agents used to reduce the level of bacterial and fungal pathogens as used in the storage and processing of conventional soybeans ([Dee et al., 2016](#); [Dee et al., 2018a](#)).

EXPERT ELICITATION SCOPE AND OBJECTIVE

Because of the range of potentially contaminated ingredients and source countries, the variety of feed processing and associated kill steps, and multiple pathways of introduction and exposure of swine, a single comprehensive import risk analysis is not feasible.

Therefore, our initial focus will be to identify and rank risk factors considered predictive of whether any given NOFI shipment poses substantive risk of introducing ASF to the United States.

The product of this process, a ranked list of factors, will help focus research and management on pathways and mitigations most likely to impact NOFI risk status. The complexity of the NOFI topic demands input from experts from multiple fields, each with a specific niche focus, and means that group statistics are likely of limited value. Further, the fact that there is no data on the presence of ASF viruses in NOFI shipments, or any other transboundary viral pathogen, means that experts lack field experience with which to hone their predictions. Finally, ungrounded (without field experience) hypothetical models may exaggerate risk (McBride et al., 2012). Consequently, the process described here will identify risk factors, highlight key risk management concerns and potential mitigations, but will not directly estimate disease introduction risk.



EXPERT ELICITATION METHOD

BACKGROUND

The elicitation will follow initial steps of an Integrative Group Process (IGP), often described as “estimate-talk-revise”. In an IGP, panelists are individually queried about their experience, results are summarized for panel review and discussion, and an opportunity for revision of individual responses is then provided. The process typically involves derivation of likelihood ratios from experience-based counts of the prevalence of traits (risk factors) among a hypothetical set of cases (here, contaminated shipments) and controls (here, non-contaminated shipments), and has been previously applied to animal health contexts (e.g., Gustafson et al., 2018). When the process elicits likelihood ratios, a predictive model can result. However, our elicitation process will conclude with a ranked list of factors, rather than a predictive model. The complexity of the NOFI topic demands input of experts from a wide range of fields, which means that group statistics on any particular topic may vary in their underlying level of expertise. Further, the impracticality of testing NOFI shipments for pathogen presence means that most experts will lack field experience with which to hone their predictions. Consequently, because ungrounded (without field experience) predictive models can exaggerate risk (McBride et al., 2012), our process will instead conclude with a ranked list of risk factors highlighting key concerns, and helping to direct future risk evaluations, mitigations, and research design.

STEP 1: INFORMAL PANEL SELECTION

Experts representing academic researchers, feed companies, and the American Feed Industry Association were identified through a convenience sample. This first step is simply a brainstorming process to construct a comprehensive (ideally both necessary and sufficient) set of factors facilitating contaminated NOFI introductions. Consequently, we aim to engage sufficient expertise, from a broad range of knowledge and experience, to cover each of the steps leading to (or preventing) introduction of ASF through contaminated NOFI.

STEP 2: IDENTIFICATION OF PLAUSIBLE RISK FACTORS

Informal telephone interviews with experts will generate a list of plausible factors predicting risk of disease (ASF) introduction via NOFI importation. The questioning process is informal, and simply aims to encourage consideration of the full risk pathway from seed to feed. Experts will be asked to “imagine that you were asked to predict whether a particular NOFI shipment would, or would not, pose substantive risk of introducing ASF to the United States. What would you want to know about the shipment to best inform your estimate?” To ensure that results are generalizable to a broad range of countries and NOFIs, we will ask that particular NOFIs, countries, companies or distributors are not named. The product of Step 2 will be a list of factors, and their component response levels (e.g., present yes/no, or above/below a target temperature/time, etc.), that may indicate whether a particular NOFI shipment represents a risk for pathogen introduction.

STEP 3: FORMAL PANEL SELECTION

Five to nine experts with expertise covering critical themes (per the output of the initial interviews) will be selected to rank risk factors. Selection at this stage will be based on knowledge and interest exhibited during Step 2, and aim to comprise diverse affiliations (approximately equal representation of government, industry and academia).

STEP 4: SECONDARY INTERVIEWS

The first task will be to shape the results from Step 2 into a shortened subset of key, conditionally-independent factors, each with 2-3 mutually exclusive response levels. Much of this process will take place via email, though individual phone calls with each expert may also be required. Once everyone is comfortable with the final list, experts will each independently rank the factors in order from greatest to least predictive strength. Descriptive statistics of group results will be presented to the panel during a conference call in which discussion of results and discrepancies will be encouraged. Finally, experts will be given an opportunity to clarify and revise their individual rankings, if they choose. The outcome of this step will be a ranked list of key factors considered predictive of NOFI shipment contamination with ASF.



Table 1. Ten most frequently imported non-animal origin feed ingredients to U.S., 2015-2018 by ASF country status based on data on animal feed ingredients provided by the Food and Drug Administration.

Unique product type descriptions (Lines) ^a	Top exporting countries (% of shipments imported) ^b	Percent of shipments imported		
		ASF-free Countries	ASF-affected Countries ^c	ASF-regionalized Countries
Canola Meal (137,121)	Canada (99.7%)	99.9%	0.095%	<0.01%
Corn Ground Grains (32,538)	Canada (97.4%)	99.2%	0.36%	0.49%
Alfalfa Hay (21,711)	Canada (65.8%) Mexico (33.6%)	99.8%	0.21%	<0.01%
Oats Ground Grains (17,537)	Canada (99.8%)	100%	0	0
Soybean Meal (15,383)	Canada (87.6%) India (4.7%) China (5.1%)	94.9%	5.1%	0.03%
Corn, Whole Grains (15,138)	Canada (94.9%) Romania (2.0%) Turkey (1.9%)	98%	0.01%	1.98%
Soybeans, Soybean Meal Ground Grains (14,820)	Canada (58.1%) India (26.1%) China (11.2%)	88.2%	11.7%	0.14%
Brewery/Distillery Byproduct (13,628)	Canada (78.6%) ⁵ Brazil (12.9%) Belgium (3.8%)	82.6%	4.5%	12.9%
Timothy Hay** (11,914)	Canada (99.8%)	99.9%	0	<0.01%
Corn Gluten (11,375)	Canada (99.9%)	100%	0	0

^a In the FDA database, a "line" entry designates a shipment of a unique product type. A shipment containing different products are separated into lines to that designate unique product types. The size of the shipment is not specified and varies widely.

^b Top 3 countries among those countries exporting at least 1% of total imports

^c ASF-affected countries as of December 2018. Countries exporting lines to US may have been designated free at the time of shipment.

^d Straw, hay, and grass is allowed to be imported from countries affected by pathogens of concern if processed by pelletizing or other process that effectively inactivates hazards

Table 2. The frequency of imports of non-animal origin feed ingredients originating from ASF affected countries among imports of non-animal origin feed ingredient from all countries (2015-2018), from data provided by the FDA.

(FDA data was cross-referenced to the import category code descriptors listed in the Harmonized Tariff Schedule to provide the HTS product description)

<i>HTS Product Description</i> (description of product processing)	<i>FDA Product Category</i>	<i>Number of shipments imported (by country)</i>	<i>Percentage of shipments from ASF countries among shipments from all countries</i>
High starch vegetables: cassava, arrowroot, salep, Jerusalem artichokes, sweet potatoes, and similar roots. Also sago pith. (fresh or dried)	Animal Feeds	20 (China)	100%
Ginger, saffron, turmeric, thyme, bay leaves, curry and other spices.	Animal Feeds	1 (China)	12.5%
Leguminous vegetables (dried shelled)	Animal Feeds	1 (China)	0.02%
Minimally processed vegetables (dried, whole, cut, sliced, broken, or in powder but not further prepared)	Animal Feeds	11 (China)	39%
	Sweet Corn Silage	1 (China)	100%
Corn/maize	Corn Ground Grains Animal	1 (China)	0.004%
Flaxseed/linseed (whether or not broken)	Oilseed Byproduct	2 (China)	5%
	Whole Grains Animal	3 (China) 6 (Russian Fed.)	1.2% 2.4%
Flours and meals: dried leguminous vegetables (HD. 0713), sago or roots (HD. 0714), fruit and nuts (Ch. 8) (flours and meals)	Animal Feeds	225 (China)	86%
	Potato Meal/Pulp Potato Veg Byproduct	235 (China)	99%
Flours and meals: oilseeds, oleaginous fruits other than those of mustard (flours and meals)	Soybean Meal	33 (China)	35%
	Soybeans, Soybean meal, Ground grains Animal	17 (China)	4.3%
Locust beans, seaweeds etc., sugar beet and sugar cane, fruit stones and kernels, other vegetable products used for human consumption, NESOI	Animal Feeds	29 (China)	12.3%
		1 (South Africa)	4.3%

Oil seeds and oleaginous fruits, NESOI (whether or not broken)	Animal Feeds	2 (China) 32 (Ethiopia)	0.23% 3.6%
Forage products: rutabaga, mangolds, hay, alfalfa/lucerne, clover, forage kale, lupines, and similar products (whether or not in the form of pellets)	Alfalfa Hay	38 (China)	0.18%
	Mixed Hay	1 (Gabon)	0.01%
Seeds, fruit, and spores (whole, of a kind used for sowing)	Animal Feeds	2 (China)	50%
Soybeans (whether or not broken)	Animal Feeds	5 (China) 117 (Ukraine)	2.7% 64%
	Ground Grains Animal	1 (China) 1 (Ethiopia)	0.59% 0.59%
	Soybean Meal	1 (China)	33%
	Soybeans, Soybean Meal Ground Grains Animal	87 (China) 6 (Ethiopia) 9 (Russian Fed.) 51 (Uganda) 6 (Ukraine)	1.5% 0.11% 0.16% 0.90% 0.11%
	Soybeans, Whole Grains Animal	234 (China) 7 (Ethiopia) 36 (Russian Fed.) 8 (Ukraine)	10.7% 0.32% 1.7% 0.37%
	Starches and inulin	Corn Ground Grains Animal	99 (China)
Vegetable saps and extracts: Pectic substances, pectinates, pectates, agar-agar and other mucilages and thickeners (derived from vegetable products)	Animal Feeds	1 (China)	4.52%
Wheat gluten (whether or not dried)	Mixed Feed Ration for Animals	1 (China)	100%
	Wheat Gluten	2 (China) 383 (Russian Fed.)	0.045% 8.6%
Bran, sharps, and other residues	Flour Mill Byproducts	2 (China)	100%

(in pellets or not; derived from shifting, milling, or other working of cereals or leguminous plants)	Mixed Feed Ration Used for More than One Species	5 (Nigeria)	100%
Food preparations	Brewery/Distillery Byprod	1 (China)	0.076%
	Veg Byprod	5 (China)	0.41%
Fruit, nuts, and other edible parts of plants NESOI (otherwise prepared or preserved, whether or not containing added sweetening or spirit)	Soybeans, Soybean Meal Ground Grains Animal	1 (South Africa)	4.8%
Oilcake and other solid residues, NESOI (in pellets or not; resulting from the extraction of vegetable fats or oils, except from soybean or peanuts)	Canola Meal	105 (China) 24 (Russian Fed.)	0.077% 0.018%
	Ground Grains Animal	17 (China)	7.8%
	Linseed Meal	12 (China)	2%
	Soybeans, Soybean Meal Ground Grains Animal	2 (China)	67%
Peanut oilcake and other solid residues (resulting from the extraction of peanut oil; whether or not ground or in pellets)	Peanut Meal	2 (China)	100%
Preparations of a kind used in animal feeding	Alfalfa Hay	5 (China)	50%
	Beet Molasses Veg Byproduct	5 (Russian Fed.)	100%
	Brewery/Distillery Byprod	9 (China)	29%
	Canola Meal	1 (China)	3.6%
	Corn, Whole Grains Animal	2 (China)	50%
	Rice Ground Grains Animal	2 (China)	4.8%

	Silage	1 (Ukraine)	50%
	Soybean Meal	55 (China)	98%
	Soybeans, Soybean Meal Ground Grains Animal	129 (China)	25%
	Soybeans, Whole Grains Animal	8 (China)	89%
	Wheat Gluten	10 (China)	100%
Provitaamins and vitamins (natural or synthetic; derivatives therefore used primarily as vitamins, and intermixtures of the foregoing)	Brewery/Distillery Byprod	22 (China)	100%
Residues and waste of sugar manufacture, starch manufacture, brewing, or distilling. (whether or not in pellets)	Animal Feeds	291 (China)	25%
	Brewery/Distillery Byprod	30 (China)	0.28%
	Corn Ground Grains Animal	17 (China)	4.2%
	Mixed Grains, Feeds Ground Grains Animal	9 (China)	47%
	Silage	23 (China)	100%
	Veg Byprod	1 (China)	1.8%
Soybean oilcake and other solid residues (resulting from the extraction of soy bean oil; whether or not ground or in the form of pellets)	Animal Feeds	54 (China)	16%
	Soybean Meal	688 (China)	5.3%
	Soybeans, Soybean Meal Ground Grains Animal	1425 (China) 3 (Nigeria)	18.9% 0.40%
	Soybeans, Soybean Meal Whole/Ground Grains Animal	1 (China)	100%

	Soybeans Whole Grains Animal	3 (China)	75%
Vegetable residues, waste, and by-products used in animal feeding, NESOI (in pellets or not)	Animal Feeds	493 (China)	40%
	Corn Cobs	74 (China)	99%
	Pea Vine Silage Veg Byprod	30 (China)	15.7%
Vegetables, other than tomatoes, mushrooms, and truffles (prepared or preserved otherwise than by vinegar or acetic acid, not frozen)	Sweet Corn Silage Veg Byprod	8 (China)	73%
Enzymes and prepared enzymes, NESOI	Corn Products/Byprod	4 (China)	100%
Peptones and derivatives; other proteins and derivatives NESOI; hide power (chromed or not)	Pea Vine Silage Veg Byprod	9 (China)	100%
	Rice Protein	1 (China)	100%

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