FEED SAFETY BASICS FOR VETERINARIANS

K-STATE Research and Extension

Porcine epidemic diarrhea virus (PEDV) was the first virus to suggest a possible link between contaminated feed and clinical signs in pigs (*USDA, 2015*). Though the evidence could not prove that contaminated feed was responsible for disease in pigs, veterinarians and feed mill managers began to apply biosecurity practice to feed and the delivery chain. Given U.S. trade with countries endemic for African swine fever virus (ASFV) and the potential for ingredients coming from these countries to introduce the virus into the U.S., feed safety has become central to discussions on the prevention of foreign animal diseases as well as the prevention of diseases currently present in the US. For feed to serve as a vector for disease transmission and cause infection, three events must occur:

1. The feed has to be exposed to the pathogen
2. The pathogen has to survive in the feed
3. The exposure dose of the pathogen has to be sufficient to cause infection

To ensure that animal feed will not cause infection based on these events, feed must pass through three control points which are represented as a series of stoplights in figure 1. At the first control point, the question is whether the feed has likely been exposed to a pathogen of concern. If yes, the light turns red and alternative sources of feed are explored. If no, the light turns green and the truck proceeds to the second stoplight and question, which is whether the pathogen can survive in the feed. If yes, the light turns red and the truck cannot continue. A green light suggests proceeding with the delivery. At the final critical control point the question whether the feed can cause infection. If the answer is no, the light turns green and allows the feed to progress to its final destination in the pig barn.

A red light at any of the control points should alert the veterinarian and feed mill manager to evaluate the risk associated with that particular control point. The veterinarian and feed mill manager consider the use of certain tools to address the risk and ensure feed is safe for consumption. This fact sheet defines the red or green criteria for each stoplight and presents risk mitigation techniques that may allow the shipment to proceed.

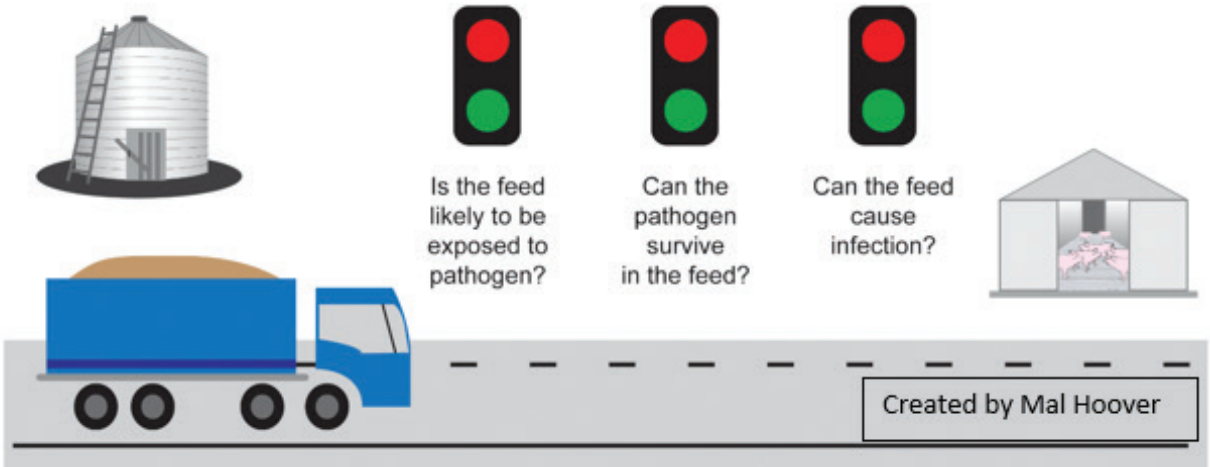

Figure 1: Control points for consumption.

Stoplight 1: Is the feed likely to be exposed to a pathogen?

The following factors all play a part in determining if this stoplight displays a red or green light:

- source of feed ingredients
- feed mill contamination
- transportation to the barn
- unloading feed into bins
- consumption by the pigs

Before feed arrives at the feed mill, it is essential to know the source of the raw ingredients. According to the OIE-WAHIS (OIE World Animal Health Information System), ASFV is present in 50 countries, while classical swine fever virus (CSFV) and foot and mouth disease (FMD) are present in Asia, Africa, and the Middle East. Ingredients arriving from these countries may have been exposed to these pathogens because of agricultural practices in those countries. After ingredients reach the U.S., storage conditions also influence disease risk.

Once ingredients arrive at the feed mill, the focus shifts to the potential for contamination from the facility. When considering a disease like PEDV, any surface contact with PEDV contaminated feces increases the risk of PEDV in the feed. PEDV can be introduced on an employee's shoes or by truck tires, but when the feed ingredient contacts a surface that may be contaminated, it increases the risk of contamination. Feed mill managers should identify points of contact, for example, spilled ingredients added back to the feed, contaminated receiving pits, and others, to reduce the risk of ingredient or complete feed contamination.

As the feed goes from the feed mill to the barn, the cleanliness of the drivers, trucks, and barn employees are the main risk factors to consider. Feed truck drivers may visit many different pig production sites per day. If the driver has PEDV on their shoes and fails to adhere to standard operating procedures (SOPS), PEDV can be tracked outside and be a risk for employees to bring it into the barn, or the driver can bring PEDV directly into the barn. When unloading the feed at a farm, if the exhaust fan blows on the feed truck or the driver, porcine reproductive and respiratory syndrome virus (PRRSV) can contaminate those items and be unintentionally brought back to the feed mill. The driver could also spill the feed, or the auger at the bottom of the bin can be loose, and again, run the risk of contaminating the feed when added back in. If barn employees failed to adhere to downtime, live with other pig industry workers, travel by barns with disease outbreaks, or travel to countries with ASFV, CSF, or FMD, the feed can become contaminated.

Ingredient sources and biosecurity failures are the main risk factors or red lights for feed contamination at stoplight one. Prevention lies in eliminating high-risk raw materials and ensuring good biosecurity through all feed manufacturing, storage, and delivery steps. It is important to note that feed is a moving portion of the biosecurity plan. Prevention for this stoplight relies on the veterinarian identifying places where biosecurity failures can occur and communicating those to the feed mill manager. A feed mill audit can facilitate communication between the veterinarian and the feed mill manager. Active surveillance is another technique to evaluate biosecurity. **Learn more about auditing and active surveillance** *(https://www.asi.k-state.edu/research-and-extension/feedsafetyresources/index.html).*

Stoplight 2: Can the pathogen survive in the feed?

The pathogen's characteristics influence whether or not it will survive whether it is a virus with an envelope or without an envelope, a bacteria, or a mycotoxin. The pathogen's natural resilience primarily determines whether it survives in the feed, but a pathogen can survive if it is in the right ingredient. For example, Jones et al. reported that high-protein, porcine based or micro-ingredients with organic carriers are more likely to promote survival (2019). In addition to natural resilience and the right ingredient, the environment is another factor that influences pathogen survival. Cold and wet environments, for example, encourage pathogen survivability. The pathogen may survive if only one of these conditions is present. **At stoplight 2, the red light is a signal to consider the type of pathogen, presence of high-risk feed ingredients, and environmental conditions.**

Stoplight 3: Does the feed have sufficient pathogen to cause infection?

The infectious dose of a pathogen is helpful when determining the risk of infection. PEDV and ASFV are the only viral pathogens with sufficient research to establish the infective dose when delivered via feed. The infectious dose of PEDV is 5.6 × 101 viral particles (*Schumacher et al., 2016*), while ASFV infectious dose is 10 viral particles (*Niederwerder et al., 2019*) for a single exposure. However, with ASFV, the infectious dose is different if introduced through the feed or the water. The infectious dose of ASFV is lower if the viral exposure is through water than feed, but pigs are continuously eating and drinking all day, resulting in multiple potential exposures by either exposure route (*Nierderwerder et al., 2019*). Bacterial infectious dose is another area of interest but, challenge doses in experiments are often based on fecal shedding and correlate weakly to an infectious dose (*Österberg et al., 2006*). The infectious dose of various pathogens is an area of feed safety that still needs a lot of work. At the third stoplight, a red light is prompted by exposure to the infectious dose and the number of exposures to the virus.

For stoplight two and three, prevention lies in incorporating specific techniques at the feed mill. The feed mill might use point-in-time mitigation or residual control techniques to reduce pathogen load in the feed. Table 1 highlights the differences between these two techniques. Some companies might also hold or quarantine ingredients from at-risk countries in facilities that have a higher temperature to minimize survivability of the pathogen and limit the introduction of a pathogen into the feed mill. The facilities for quarantining ingredients do not have to be heated, but based on the holding-time calculator (*K-State Research and Extension, 2018*) holding these ingredients before entry into the feed mill can decrease pathogen load in the feed, and higher temperatures tend to reduce the holding time to achieve pathogen reduction. Some feed mills may only use residual control techniques for genetically valuable sites like a sow farm or boar stud. It is important to note that formaldehyde is only labeled for Salmonella prevention, and uses for anything other than Salmonella are considered off-label. Another option is to use a point-in-time and residual control technique in combination to reduce the potential spread of pathogens. Using both of the methods at the same time reduces the likelihood of feed contamination.

Prevention

When considering prevention procedures, pathogens can be considered either a control-type pathogen or a prevention-type pathogen. Prevention-type pathogens are viruses like ASFV, CSFV, or FMD, which are not present in the U.S. in domesticated swine. These viruses may be introduced in feed and contribute as a fomite, an object or material likey to carry infecton. With these viruses, contamination of products or people from areas where the pathogen is present is a significant risk factor. Thus, preventing contamination is critical. Control-type pathogens are viruses such as PEDV and PRRSV, bacteria like Salmonella, or mycotoxins, which are endemic in the U.S., especially in swine-dense areas. If feed were to come in contact with fecal material with PEDV or fomites contaminated with PRRSV, the feed could serve as a vector for these diseases. The method of contamination is pathogen specific. For instance, PRRSV spreads by way of respiratory secretions and PEDV from fecal contamination. Environmental conditions play a role in contamination with

Table 1. Comparison of prevention strategies

Point-in-Time Mitigation	Residual Control
These processes eliminate the pathogen from the feed at one point in the feed process but do not guarantee prevention of recontamination	Effectively reduce pathogen throughout the feed process, theoretically from manufacture until consumption.
Examples:	**Examples:**
Thermal processing such as pelleting or extrusion	Formaldehyde
Sequencing and flushing protocols	Medium Chain Fatty Acids (MCFA)
	Others

mycotoxins and Salmonella. The specific pathogen must be considered when designing prevention techniques.

For a feed to be considered a vector for disease, it must have pathogen exposure, the pathogen must survive, and enough of the pathogen must be present in the feed to cause disease. Prevention and control methods focus on each step in the process because the techniques are based on the which phase of the production system is targeted. **Learn more about prevention and find answers to your feed safety questions** *(https://www.asi.k-state.edu/research-and-extension/feedsafetyresources/index.html)*.

References

Jones C, Woodworth J, Dritz S, Niederwerder M, Tokach M, Goodband B, and DeRouchey J. (2019) Frequently Asked Questions about ASFV and PEDV. **https://www.asi.k-state.edu/research-and-extension/swine/Frequently%20Asked%20Questions%20about%20ASFV%20and%20CSFV%20in%20Feed.pdf** Accessed March 22 2021.

Kansas State University Research and Extension (2018) Holding Time Calculation for Feed Ingredients. **https://www.asi.k-state.edu/research-and-extension/swine/Holding-Time-Calculation-for-Feed-Ingredients.pdf** Accessed March 22 2021.

Niederwerder MC, Stoian A, Rowland R, et al. (2019) Infectious Dose of African Swine Fever Virus When Consumed Naturally in Liquid or Feed. Emerging Infectious Diseases. 25(5):891-897. doi:10.3201/eid2505.181495.

OIE-WAHIS. World Organisation for Animal Health - World Animal Health Information System. **https://wahis.oie.int/#/home**. Accessed March 22 2021.

Österberg J, Vågsholm I, Boqvist S, and Sternberg Lewerin S. (2006) Feed-borne outbreak of 528 Salmonella Cubana in Swedish pig farms: risk factors and factors affecting the restriction period 529 in infected farms. Acta Veterinaria Scandinavica. 47:13–21. doi: 10.1186/1751-0147-47-13.

Schumacher LL, Woodworth JC, Jones CK, et al. (2016) Evaluation of the minimum infectious dose of porcine epidemic diarrhea virus in virus-inoculated feed. Am J Vet Res. 77(10):1108-1113. doi:10.2460/ajvr.77.10.1108

USDA-APHIS. United States Department of Agriculture Animal and Plant Health Inspection Service Veterinary Services (2015). Swine enteric coronavirus introduction to the United States: Root cause investigation report. **https://www.aphis.usda.gov/animal_health/animal_dis_spec/swine/downloads/secd_final_report.pdf**. Accessed 24 February 2021.

Cassandra Jones, Ph.D., Feed Safety Specialist, Animal Sciences and Industry
C. Grace Elijah, DVM, Graduate Student, Diagnostic Medicine/Pathobiology
Jordan Gebhardt, DVM, Ph.D., Swine Production Veterinarian, Diagnostic Medicine/Pathobiology
Jason Woodworth, Ph.D., Swine Nutritionist, Animal Sciences and Industry
Chad Paulk, Ph.D., Feed Scientist, Grain Sciences and Industry

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

K-State Research and Extension is an equal opportunity provider and employer. Issued in furtherance of Cooperative Extension Work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Director of K-State Research and Extension, Kansas State University, County Extension Councils, Extension Districts.

MF3548 June 2021