Biosecurity of the Feed Supply: Prevention and Mitigation of Risk

Abstract

Biosecurity continues to gain importance within livestock production with the continued focus on disease prevention. This continued focus includes the feed supply chain which has made significant improvements in recent years to recognize the potential risk of feed ingredients or complete feed serving as a vector for pathogen transmission. Feed biosecurity practices in the past have focused on preventing the introduction of bacterial biological hazards, such examples including the bacterium Salmonella, from entering finished feeds. Multiple points of entry of biological hazards into a feed mill exist and can include raw ingredients, transport vehicles, and people. With the widespread transmission of porcine epidemic diarrhea virus (PEDV) in the United States beginning in 2013, the focus of feed biosecurity adapted to also consider the risk of feed serving as a means by which swine viruses could infect susceptible populations of animals.
Much of the early research focused on transmission of viral pathogens focused on PEDV, but more recently has expanded into other impactful pathogens including African swine fever virus, Senecavirus A, and porcine reproductive and respiratory syndrome virus.
Through this research, it has been documented that if swine viruses contaminate a feed manufacturing facility through ingredients or other fomites such as personnel or tucks, the virus rapidly distributes within the environment and it is very challenging to fully decontaminate the facility. Thus, recent research has focused extensively on the methods to prevent the introduction of pathogens into feed mills, thereby reducing the likelihood of contamination of finished feed.

Much has been learned through industry and producer experiences related to feed biosecurity and controlled research that led to a fundamental shift in the way the swine feed manufacturing industry approaches biosecurity in recent years. An effective biosecurity plan requires the identification and evaluation of hazards, as well as procedures to control significant hazards within the facility. These control procedures can include the prevention of entry of the pathogen through sourcing safe ingredients, biosecurity during ingredient receiving, control of foot traffic by high-risk individuals, prevention of cross-contamination, and proactive mitigation using thermal processing or chemical additives.

Jordan T. Gebhardt[1]

[1] Department of Diagnostic Medicine/Pathobiology, Kansas State University, Manhattan, Kansas

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Background

Biosecurity within the feed supply chain has greatly increased importance in recent years. Feed manufacturers and livestock producers have known the importance of biological hazards such as bacteria, specifically the bacterium Salmonella, and have implemented procedures to reduce the risk of contamination in finished feeds. Multiple points of entry of biological hazards into a feed mill exist and can include raw ingredients, transport vehicles, and people which requires a broad biosecurity plan focused on multiple areas to generate successful outcomes. Prior to research conducted in the 2010's, there was little known regarding the potential for feed ingredients or complete feed in a commercial setting for transmission of swine viruses. The classical route of transmission of ASFV involves feeding food waste commonly known as "garbage feeding". This practice involves feeding wild or domesticated pigs food waste containing contaminated pork products and presents a significant opportunity for pathogen transmission. However, in modern swine production where the use of food waste products is relatively limited in scale, there historically has been little known regarding the stability of viruses in commercial ingredients or finished feed.

With the introduction of PEDV to the United States, the focus of feed biosecurity adapted to also consider the risk of feed serving as a means by which swine viruses could infect susceptible populations of animals. Much of the research focused on swine feed biosecurity in the mid-2010s focused on PEDV. Research illustrated that susceptible animals could be infected with PEDV if fed contaminated feed studies also characterized the minimum infectious dose of PEDV in feed and evaluated potential mitigation strategies using point-in-time and residual duration of activity approaches. Much of this early work with PEDV focused specifically on development and validation of techniques to inactivate or reduce the quantity of infectious virus. As this process continued and it became known that swine viruses such as PEDV rapidly distribute within feed mills and that decontamination of mills is extremely challenging, research expanded to focus on biosecurity methods to prevent the introduction into feed mills, thereby reducing the likelihood of contamination of finished feed. Much has been learned through producer experiences and controlled research that led to a fundamental shift in the way the swine feed manufacturing industry approaches biosecurity.

Feed biosecurity was further emphasized following the detection of ASFVin Asia in 2018 and subsequent distribution throughout the region. Research has documented that viruses such as ASFV can remain viable for extended periods of time in contaminated ingredients and finished feed, posing a potential hazard for transmission of this dangerous pathogen. Researchers have evaluated the distribution of ASFV within a feed mill during the manufacture of inoculated feed and have found that ASF, similar to PEDV, becomes widely distributed within the facility and that ASFV DNA can be found in multiple sub-sequent batches of feed.

Researchers also have used these diagnostic tools in field conditions in a region of ongoing ASFV circulation, demonstrating the potential value of environmental sampling with qPCR analysis for identifying potential gaps in biosecurity practices (such as the cabs of feed delivery trucks).

Collectively, feed biosecurity research has identified that under experimental conditions, viruses can rapidly distribute within a feed mill and that feed mills, vehicle interiors, and areas of high employee traffic can be challenging to disinfect. As such, feed biosecurity practices focus on the following

- **Prevention of contamination on a surface, in an ingredient, or in finished feed**
- **Intervention strategies to reduce the likelihood of infection if a surface or material comes into contact with a susceptible animal.**
  Both concepts are important to consider for a broadly applicable, effective feed biosecurity program.

Given the extended stability of swine viruses such as ASFV and SVA in feed ingredients and complete feed, biosecurity measures for ingredients being transported internationally have been meticulously evaluated and many ingredient suppliers

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have incorporated extended holding times of non-bulk ingredients sourced from regions affected by pathogens such as ASFV (holding ingredients in quarantine for set time and temperature). While there is tremendous variability in the im-
have incorporated extended holding times of non-bulk ingredients sourced from regions affected by pathogens such as ASFV (holding ingredients in quarantine for set time and temperature). While there is tremendous variability in the im-plementation of such practices within the United States and other parts of the world, there is significant interest in implementing such procedures by many swine producers to minimize the likelihood of ingredient contamination and to reduce the survival of pathogens especially in regions where important viruses such as ASFV are not present. Nonetheless, many questions remain regarding the feasibility and practicality of implementing and administering such biosecurity procedures for non-bulk and bulk ingredients originating from regions affected by foreign animal diseases such as ASF.

Once biosecurity practices have been reviewed for ingredients, transportation logistics, and personnel, feed suppliers and producers can consider implementing active mitigation steps within the feed biosecurity program.

While either prevention or mitigation alone can result in meaningful reduction in risk, it is the combination of these strategies that result in the greatest risk reduction through application of multiple “hurdles” within the biosecurity system. Two primary approaches can be taken to mitigate the hazard of swine viruses in ingredients or feed. These two approaches can be summarized the following way:

- **Point-in-time mitigation strategies**
- **Residual effect mitigation strategies. Point-in-time strategies include approaches such as extended holding time of ingredients, thermal processing, or irradiation.**

PEDV: Porcine epidemic diarrhea virus
ASFV : African swine fever virus
ASF : African swine fever
SVA : Senecavirus A

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While these strategies can be effective and result in a product that does not contain an infectious virus, these ingredients are susceptible to re-contamination. Residual strategies most commonly involve the addition of feed additives to the ingredient or diet that would be expected to retain feed mitigation properties after the initial time point in which the additive is applied. Research has documented with multiple feed additives that this residual activity does occur. There are a number of scientific publications that evaluate the efficacy of feed additive compounds reducing detection of viral genetic material as well as measures of infectivity in vitro and in vivo. With a wide variety of products available, it is challenging for feed manufacturers and swine producers to effectively compare different commercial feed additive products to select the product best suited for their particular goals.

To assist with this process, colleagues at Kansas State University have compiled and continue to update a feed additive document summarizing peer-reviewed literature that compiles relevant information to allow effective decision-making (Table 1). It is important to recognize, however, that as of spring 2023 there are no products that have been reviewed by regulatory authorities in the United States and granted permission to make any claims of anti-viral activity in ingredients or feed.

While scientific data of various forms is available for interpretation, currently no claims of efficacy can be made by feed additive suppliers. Nonetheless, many swine producers currently choose to use feed additives for other production purposes, with a potential benefit of having scientific data supporting anti-viral activity within swine feed.

Table 1. Summary of feed additives with scientific evidence evaluating efficacy against viral pathogens in swine feed.

Company	Product name	Active ingredient(s)	Inclusion, lb/ton	Pricing[1]	# of published studies documenting efficacy[2]	Total # of published studies
ADM	DaaFit & DaaFIT 5	Lauric and myristic acids and glycerol monolaurate	10 (DaaFiT s) 6 (DaaFit)	$$	1	1
ADM	DaaFit PLUS	Lauric Acid, GML-90, formic acid, short chain fatty acids	10	---	1	1
Alltech	Guardian	Lactic acid, propionic acid, essential oils	8 (dry) 5.3 (liquid)	$$$ (dry) $$ (liquid)	3	3
Anitox	Termin8	Formaldehyde, propionic acid (liquid or powder form)	6	---	0	0
Anpario	pHorce	Formic acid, propionic acid, ammonium formate	6	$$	1	1
DSM Nutritional Products	VVC Premix B	Blend of essential oil compounds and benzoic acid	7	$	2	3
Feed Energy	R2	Short, medium, long chain fatty acids and essential oils	60 (R2 active ingredients along with added fats/oils)	$ (active ingredient)	1	1
Feedworks USA	LipoVital GL-90	Glycerol monolaurate	2 to 4	$$	0	0
Form A Feed	Prohibio-R	Medium chain fatty acid and monoglyceride, organic acids	4 - 5	$$$	0	0
Furst McNess	Furst Protect	Monoglycerides, Essential oil, natural extracts	8	$$$	1	1
Kemin	FeedSURE MG	Monoglyceride blend, organic acids	3.3 to 7.7	$$	1	1
Kemin	Sal CURB	Formaldehyde, propionic acid	6.5	$	8	8
Novus	Activate DA	Organic acids, 2-Hydroxy-4-Methylthio Butanoic acid	10	$$$	2	3
PMI	Vitacy FeedLock	Blend of activated medium chain fatty acids	4	$	0	0
Provimi	Vigilex	Fatty acids	48	$	1	1
Ralco	Dual Defender	Phytonutrients	2	$$ to $$$	1	1

[1] Pricing at recommended inclusion. $ = < $10/treated ton; $$ = $10-15/treated ton; $$$ = > $15/treated ton. --- indicates that pricing estimate not available.
[2] Efficacy defined as a reduction in the infectivity of viral samples (PEDV, PRRSV, SVA, ASFV, FMDV) using either a cell culture based assay or swine bioassay.
Other non-peer reviewed data may be available to support the products such as meeting abstracts and proceedings, but not considered in this summary.

While no feed additives are currently approved by the United States Food and Drug Administration for control of swine viruses in ingredients or complete feed, multiple scientific investigations have characterized properties to reduce viral survival and thus reduce risk of infection in animals. With a variety of products currently available, our team has put together and continues to update this resource available at: www.ksufeed.org.

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Discussion

Tremendous improvements in our knowledge of prevention and intervention strategies to maintain feed biosecurity have been made possible through extensive dedication of swine producers and research funding through private industry and trade organizations. Improvement in feed biosecurity practices has been robust in recent years, but further work needs to be done to continue to refine and improve the application of these techniques to maintain the health of our united swine industry.

The implementation of biosecurity practices within the feed supply has largely been driven by the end-user, swine producers, as a risk mitigation strategy to reduce the likelihood of disease on their farms. A regulatory approach has been taken by several countries such as Canada and Australia to implement practices to reduce the risk of pathogen transmission through feed ingredients. However, in the United States, efforts focused on swine-specific viruses in common feed ingredients has been driven by swine producers working with their ingredient suppliers with little consistency across the industry. To continue to improve feed biosecurity, a program called the U.S. Swine Health Improvement Plan (US SHIP) has been established as a collaboration of state, federal, and industry partners to create a national playbook for disease preparedness, including biosecurity, traceability, and sampling and testing. This is a completely voluntary program with the goal of maintaining trade relationships in the event of a foreign animal disease incursion into the United States such as ASF. In the US SHIP program, feed biosecurity has been an area of active and productive discussions over the past 18 months. The program is currently focused on an ASF-CSF monitored program and currently is working to incorporate feed biosecurity best-practices. Current program standards require participants to use feeding practices that do not include ingredients which fall under the United States Department of Agriculture definition of “garbage”. Furthermore, in the event of an ASF or CSF incursion into the United States, participants would be required to modify feeding practices associated with porcine-origin feed ingredients including implementation of additional post-processed enhanced biosecurity practices for these ingredients prior to be included in swine diets. Furthermore, recent work is focusing on the development of a standardized program for best-practices associated with importing feed ingredients from areas where high impact diseases such as ASF are currently present. Many of these practices are already being implemented today by the request of swine producers, but the US SHIP program aims to standardize these practices for consistency in implementation. This collaboration of swine producers, state, and federal partners has served as a means of transparent, meaningful discussions about best practices associated with feed biosecurity. The US SHIP program is a viable means to create meaningful improvement in feed biosecurity within the US swine industry, and such practices can be applied globally to help maintain animal health and reduce the risk of disease transmission through the feed supply chain. More information regarding the US SHIP program can be found at: https://usswinehealthimprovementplan.com/

US SHIP: United States Swine Health Improvement Plan

Conclusion

Much has been learned through producer experiences and controlled research that led to a fundamental shift in the way the swine feed manufacturing industry approaches biosecurity. Introduction of PEDV in the United States and the subsequent research to identify and control transmission reinforce the need for continued improvement in feed biosecurity. An effective biosecurity plan requires the identification and evaluation of hazards, as well as procedures to control biological hazards within a particular facility. These control procedures can include the prevention of entry of the pathogen during ingredient receiving, monitoring and exclusion of foot traffic by high-risk individuals, prevention of cross-contamination, and proactive mitigation using thermal processing or chemical additives.

Biosecurity as a whole continues to gain importance in the global animal health industry with focus being placed on disease prevention – and feed biosecurity will continue to be an important component of a comprehensive biosecurity program.

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