UNIVERSITY OF MINNESOTA EXTENSION

RESEARCH REPORT

Are There Differences in Survival Among Different Swine Corona Viruses in Feed and Feed Ingredients?

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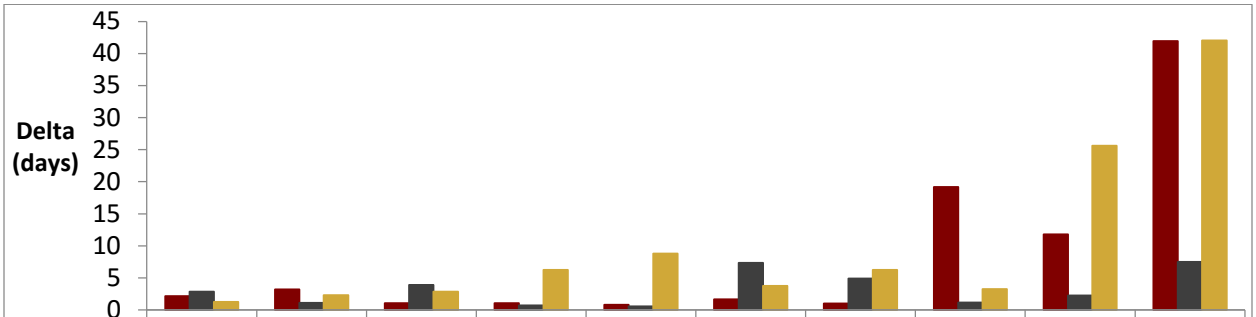
The pork industry has recently experienced the devastating effects of swine corona viruses. The three known porcine corona viruses are transmissible gastroenteritis virus (TGEV), porcine delta corona virus (PDCoV), and porcine epidemic diarrhea virus (PEDV). Each of these viruses causes severe diarrhea in young pigs and increased mortality, with subsequent reductions in growth performance and increased cost to producers. These viruses are excreted through feces and can be spread by contaminated equipment, personnel, and other fomites. After the 2013 outbreaks of PEDV in the United States, some evidence suggested that PEDV can be transmitted via contaminated feed and feed ingredients. In order to understand the role of virus-contaminated feed on its transmission, it is necessary to determine the risk of virus survival in various commonly used feed ingredients in swine diets. Our research team recently determined the survival kinetics of PEDV and PDCoV in complete feed and feed ingredients over time (Trudeau et al., 2015) and we have demonstrated that certain acidifying additives can increase inactivation of these two viruses in complete feed (Cottingim et al., 2015). However, no experiments have been conducted to compare survival kinetics of all 3 enteric swine coronaviruses simultaneously in feed and feed ingredients for swine. Therefore, the objective of this study was to measure survival time of PEDV, PDCoV, and TGEV in complete feed and feed ingredients.

Samples of common ingredient used in swine diets were collected from the feed mill at the Southern Research and Outreach Center of the University of Minnesota (Waseca, MN). In addition, a commercially available Phase 2 nursery diet was obtained from Vita Plus (Madison, WI). All feed and ingredient samples were initially analyzed by real time PCR and

shown to be negative for all corona viruses. Feed and feed ingredients were weighed and placed into separate vials in 5 g aliquots, and 1 mL of either PEDV, PDCoV, or TGEV was added to each sample. These samples were then mixed and stored at room temperature for up to 56 days. At various time points throughout the 56-day incubation, the surviving virus was eluted and inoculated into Vero-81 cells (PEDV) or Swine Testicular cells (TGEV and PDCoV). These cells were then observed daily for cytopathic effects—changes in cell morphology that indicate the cells were infected by the virus. This information was quantified as concentration value called $TCID_{50}$/mL values. These concentrations were used in a predictive model (Weibull). This model produced a delta value, which represents the amount of time necessary to produce a 90% reduction in virus concentration. Delta values were compared among ingredients and viruses to understand differences in survival of corona viruses in various feed and feed ingredient chemical and physical matrices.

Survival time of PDCoV and TGEV was greatest (delta = 41.9 and 42.0 days) in soybean meal (Table 1). This result is consistent with previous research results showing that PEDV has a very high survival in soybean meal (Dee et al., 2015), but not of the magnitude previously reported may have been a result of the lower initial PEDV titer used in our study. Interestingly, PDCoV and TGEV had dramatically greater survival time in soybean meal than PEDV. At this point, the chemical and physical factors causing high survival of these viruses in soybean meal are unknown, but should be investigated in future studies.



	Blood Meal	Complete Feed	Meat Meal	Low Oil DDGS	High Oil DDGS	Medium Oil DDGS	Meat and Bone Meal	Spray Dried Porcine Plasma	Corn	Soybean Meal
TGEV	2.2	3.2	1.0	1.0	0.8	1.7	1.0	19.2	11.8	41.9
PEDV	2.8	1.1	3.9	0.7	0.6	7.3	4.9	1.1	2.3	7.5
PDCoV	1.2	2.3	2.8	6.2	8.8	3.8	6.2	3.3	25.6	42.0

Table 1. Delta values for TGEV, PEDV, and PDCoV in feed ingredients.

In addition to soybean meal, we observed high delta values for PDCoV and TGEV (25.6 days, 11.8 days) in corn, while TGEV survived longer (19.2 days) in spray dried porcine plasma with PEDV and PDCoV survival. When comparing the survival of the 3 viruses among ingredients, PDCoV had higher delta values for high and low oil DDGS, meat and

bone meal, and corn compared with TGEV and PEDV, suggesting greater risk of transmission due to longer survival times in these ingredients. We also conducted a correlation analysis to determine if there was any association between ingredient nutrient composition and virus survival. The crude fat, moisture content, crude protein, ash, and fiber were all analyzed in each feed ingredient. Of all variables considered, greater moisture content in the feed ingredients tended to be associated with greater survival of PDCoV ($r=0.48$, $P<0.05$) and TGEV ($r=0.41$, $P<0.05$) compared with PEDV, but this association is only considered moderately correlated.

In summary, these results suggest that soybean meal has the greatest potential risk for transmitting these coronaviruses if it becomes contaminated. To minimize the risk of cornona virus transmission in feed and feed ingredients, feed mills should develop and implement a biosecurity program to minimize corona virus contamination. Pork producers should communicate with feed supplier to discuss risk and potential mitigating strategies to control virus transmission through feed delivered to their farms. This is especially true if ingredients and complete feed is obtained from locations with a high prevalence of corona viruses. Our research team at the University of Minnesota has also conducted studies and presented results that describe the potential benefits of heat processing, irradiation, and the use of organic acids to reduce virus survival (Trudeau et al., 2015), which can be applied to soybean meal to reduce its risk. Finally, control strategies for targeting PDCoV will be effective in reducing the survival of PEDV and TGEV, since PDCoV generally has a greater delta value than the other corona viruses for several ingredients.

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