Project Number:	1830-352-0509-B
Project Title:	Soy Isoflavones and Immune Recovery Following Viral Infection in Pigs
Organization:	University of Illinois, Urbana, IL
Principal Investigator Name:	Ryan N. Dilger, Ph.D.

Growth performance:

- *Regarding the challenge model, PRRSV infection resulted in decreased average daily gain (ADG) (between 0-13 days post-inoculation, i.e., DPI) and decreased feed intake (between 6-20 DPI) during the initial stages of infection. This resulted in a divergence of growth performance between our non-infected and infected control groups of which the infected control group was unable to recover from fully through compensatory gain. This resulted in infected control animals ending the study with a 6% lighter body weight on average, which suggests significant financial repercussions for producers affected with PRRSV.*
- *Comparing non-supplemented and isoflavone (ISF) supplemented PRRSV-infected pigs, ISF intake had mild, inconsistent effects on overall growth performance, which is in agreement with previous studies. However, within our model, ISF supplementation did negatively influence final body weights, causing a 4% decrease comparted to non-supplemented PRRSV-infected pigs. However, the mechanism behind this effect and any contribution of PRRSV infection specifically to this reduction is not known.*

Immune Response – PRRSV infection establishment and clearance:

- *Comparing non-supplemented and ISF supplemented PRRSV-infected pigs, ISF intake reduced serum viral load (i.e. increased Ct values) over the post-infection period, but significantly so at 6 DPI. Potential mechanisms for lower serum antigen include ISF effects on viral replication at a cellular level or enhanced local viral clearance, though effects on viral replication may be more likely due to no differences between treatment groups for anti-PRRSV antibodies during those time periods.*
- *ISF supplementation also resulted in faster clearance of PRRSV antigen from oral fluids, with final clearance reached in 102 DPI for ISF supplemented pigs verse 123 DPI for non-ISF supplemented pigs.*

Immune Response – Clinical Pathology:

- *ISF supplementation did not impact erythrogram measurements and had only minor effects on leukogram measurements, with overall increased neutrophil proportions and decreased lymphocyte proportions on 6 DPI, but not at any other time point.*
- *Like erythrogram and leukogram results, ISF supplementation only had minor effects on serum chemistry results, with decreases in alkaline phosphatase (ALP) concentrations being the only significant effect. However, ALP is closely associated to liver function with increased concentrations indicating hepatocyte damage or decreased hepatocyte performance, suggesting that ISF may have been providing some protective functions for the liver.*

Immune Response – Characterization of the adaptive immune response:

- *ISF supplementation had no effects on peripheral T-lymphocyte effector populations, which was inconsistent with previous findings by our laboratory. Differences could be due to differing levels of infection achieved between the two studies and addition of later collection days in the current model.*
- *Regarding anti-PRRSV neutralizing antibody production, a fundamental adaptive immune response for recovery from PRRSV infection, ISF supplementation resulted in an earlier, more robust humoral response compared to non-supplemented pigs during the later stages of infection, which may explain faster*

Did this project meet the intended Key Performance Indicators (KPIs)?

- **U.S. Swine Grower/Finishers:** as a measure of product preference, average soybean meal inclusion in U.S. grower/finisher diets remains at baseline
- **Sows:** As a measure of product preference, average soybean meal inclusion in U.S. sow diets remains at baseline
    - *Results from this study suggest that soybean meal use should remain the same in order to confer the benefits of ISF intake that were demonstrated. Benefits to additional ISF content in soybean crop has yet to be elucidated.*

Expected Outputs/Deliverables - List each deliverable identified in the project, indicate whether or not it was supplied and if not supplied, please provide an explanation as to why.

- **Define an immune-related mechanism by which soy isoflavones confer specific benefits to challenged pigs over an extended period of the growth cycle, with implications to improving overall swine production efficiency.**
    - *Supplied*
    - *Findings from this project suggest that dietary ISF intake demonstrates mild to moderate influence on the immune response to PRRSV, specifically supporting development of neutralizing antibodies against PRRSV, promotion of viral clearance, and, within the limitations of this study, may have contributed to lower mortality due to infection with PRRSV and secondary opportunistic pathogens. Specific physiological mechanisms are unclear within the context of this study, but likely involve improved activation and performance of the adaptive immune system.*
    - *At this time, ISF intake alone does not confer with significant improvements on growth performance or efficiency.*
- **Coupled with recent evidence from our lab that increasing the concentration of soybean meal in weanling pig diets confers some immune protection against PRRS, results of the proposed study may encourage the swine industry to target a specific concentration of soy isoflavones in their formulations for growing pigs through market. Not only will that markedly expand the market for soy products in the swine industry, but it would also set the stage for value-added soybean lines designed to achieve isoflavone concentrations that exceed current levels. Publication of results in both peer-reviewed journals and industry-focused trade journals would further recent interest in developing soy ingredients for their immunomodulatory potential in animal agriculture.**
    - *Supplied, but additional information needed*
    - *Results from this study indicated that while effects on growth performance were mild at best, inclusion of dietary ISF resulted in protective effects against PRRSV infection through promotion of PRRSV clearance, increased production of neutralizing antibodies, and decreased infection-related mortality over the course of the study.*
    - *While we were able to demonstrate the detriment of removing isoflavones, more research is needed to determine if ISF supplemented in the diet at higher levels than currently found in standard commercial soybean products (i.e. the levels supplemented in this study) would confer stronger immunological or growth performance responses.*

Describe any unforeseen events or circumstances that may have affected project timeline, costs, or deliverables (if applicable.)

- *Due to the development of severe secondary opportunistic infections in this study, characterization of the immune response was halted prior to what was originally proposed in order to accommodate antibiotic treatment. With that said, the only time points we were unable to capture immune data on were 27 and 34 DPI, which were outside of the acute and immediate recovery period from PRRSV.*

What, if any, follow-up steps are required to capture benefits for all US soybean farmers? Describe in a few sentences how the results of this project will be or should be used.

- *Soybean meal utilization in the diets of commercial growing pigs should remain stable due to the immunological benefits of ISF, especially in regions of the country where PRRSV outbreaks are expected/experienced.*
- *Determination of ISF content in soybean crops may be a metric of interest moving forward for swine nutritionists and producers.*
- *Development of high ISF corn varieties for the development of livestock feed may be merited for future research and incorporation into swine production in the U.S.*