

2023



Annual Research Report



Saskatchewan
Ministry of
Agriculture





MISSION STATEMENT

"We provide solutions through knowledge, helping to build a profitable and sustainable pork industry"

Table of Contents

2023 Report Highlights	3
-------------------------------	---

REPORTS & MANAGEMENT	
Chairman's Report	4
President's Report	5
Operations Manager's Report	6
Knowledge Transfer Report	8
Awards of Distinction	11

PUBLICATIONS LIST	36
--------------------------	----

FINANCIAL SUPPORT	40
--------------------------	----

RESEARCH PROGRAMS

ENGINEERING

Road and disease-challenge tests with a modified prototype livestock trailer	12
Testing of a rapid detection kit for Porcine Epidemic Diarrhea virus (PEDv)	15
Application of nanotechnology for mitigation of DON in wheat grains	17

NUTRITION

Non-essential amino acids affect nitrogen retention in pigs	19
Inclusion of non-protein nitrogen on lysine requirement for maximum nitrogen retention	21
Inclusion of non-protein nitrogen and lysine in grower pig diets on growth performance	23
Effect of feeding time on the proportion of sows farrowing during work hours	25
Response of growing pigs to the inclusion of hybrid rye in low or high energy diets	27

ETHOLOGY

Weaned piglet mortality during long transport events is affected by season	30
Weaned piglet transport practices in Canada	32
Can slat-compatible enrichment influence pigs' behaviour and response to a disease challenge?	34

2023 Report Highlights

<i>The installation of an air filtration system in a modified prototype livestock trailer was able to protect the pigs from exposure to airborne transmissible diseases such as Influenza A virus.</i>	12
<i>An existing PEDv test kit showed potential for detecting PEDv strains in Canadian swine herds, but the visual interpretation of test kit results can be further improved.</i>	15
<i>Magnetic graphene oxide (MGO) showed the greatest potential in mitigating the risk of DON contamination in wheat grains among three nanomaterials tested.</i>	17
<i>The essential amino acid (EAA) nitrogen to total nitrogen ratio should be an important consideration in formulating low-protein diets for pigs.</i>	19
<i>Ammonium phosphate is an acceptable form of nitrogen (N) for the improvement of N utilization efficiency in diets lacking non-essential amino acid-N, including low-protein diets.</i>	21
<i>Inclusion of non-protein nitrogen, as ammonium phosphate, can improve feed efficiency and increase lean depth while maintaining similar growth performance.</i>	23
<i>Feeding sows upon entry to the farrowing room in the morning instead of the evening may be beneficial for maximizing the number of farrowing events when workers are present.</i>	25
<i>Grow-finish pigs can be fed diets including 40% hybrid rye, although in younger animals the net energy level of the diet may need to be considered to avoid a reduction in growth performance.</i>	27
<i>Winter transport is a potential area of opportunity to reduce the occurrence and rate of in-transit mortality during long-duration weaned piglet transport events in Western Canada.</i>	30
<i>Western Canadian weaned piglet transport events most frequently involved events that had very short trip distances, and the average in-transit mortality rate was 0.0027%.</i>	32
<i>A rotation of enrichments increased pigs' interaction with the enrichments compared to a single chain but was not effective at influencing the response of pigs to a natural disease challenge.</i>	34

Chairman's Report

Providing Solutions to the Pork Value Chain

Don Down, Chairman of the Board



The Pork Industry has seen some major changes in the past year. As Canadian Pork producers adapt to the changes, Prairie Swine Centre has focused on providing solutions that help tackle the issues that affect the profitability and sustainability of the Pork Value Chain.

High feed and energy have pushed up the cost of production. The Prairie Swine Centre Engineering and Nutrition research teams have focused on providing solutions to these rising costs. Animal well-being continues to be an area of importance to the consumers of the pork we produce in Canada, consumed in Canada and around the world. The Prairie Swine Centre Ethology team remains focused on research into sow housing, animal handling, enrichment and transportation.

Under Murray's leadership, the Prairie Swine Centre has continued to provide research results to the industry; focusing on our changing environment, addressing the key issues we face as industry.

Communication and dissemination of key research findings as well as programs supporting biosecurity and disease management has been the focus of the Knowledge Transfer and Translation team. The increasing need of information on demand has required the team to work through different communication channels across Canada and the global pork network.

The Centre Board wants to recognize the production staff at the Centre as they continue to conduct and support world-class research while achieving sow, nursery and finisher production numbers that benchmark amongst the best in Canada.

As we move into 2024, the Board and Senior Staff will work on integrating the valuable research through collaboration with other research centres in Canada and around the world.

PSC deeply appreciates and values the financial support from the Province of Saskatchewan as well as the Pork Boards from Manitoba, Saskatchewan, Alberta, Ontario, and Quebec. PSC also wants to highlight the valuable relationship with the University of Saskatchewan and continue to help the University achieve its own research and teaching objectives.

On behalf of the board, I want to thank the Prairie Swine Centre team for their hard work and commitment, which has led to a successful research year. This annual research report is evidence of the passion and dedication of the entire team. I want to thank retiring Board members for their expertise and contributions, and welcome new Board members for 2024.

The PSC board looks forward to working with Murray Pettit and his highly skilled team during the coming year.

CEO Report

Addressing Challenges and Opportunities through Research

Murray Pettitt, Ph.D. - CEO



Prairie Swine Centre continues to remain focused on supporting the economic, environmental and social sustainability of the pork industry here in Saskatchewan and throughout the rest of Canada. Higher feed and energy prices continued to increase the cost of production during the last year, often eliminating the advantage that the relatively higher pig prices would have provided. Our information can help producers reduce their cost of production in the face of increased input costs. Prairie Swine Centre remains focused on assisting producers with this and other challenges, and the information contained in this report and on our website at www.prairieswine.com can aid with profitability, nutrition strategies, animal health and animal welfare issues. Our online searchable database, PorkInsight provides practical, production-focused information focused on enhancing the sustainability of the pork industry. PSC's research program has realized an economic return of \$4.10/pig/year and \$5.60/pig/year over the past 15 and five years respectively. The scientists and staff of PSC are always willing to provide support to producers and pork value chain; you will be able to find our contact information on the website.

This report contains articles describing the most recent work from Prairie Swine Centre. Research included improvements to a rapid PEDv test kit that could be used as a pen- or truck-side test for detecting PEDv strains present in Canadian swine herds; determining that feeding sows upon entry to the farrowing room in the morning instead of the evening may be beneficial for maximizing the number of farrowing events while staff are present; and the use of magnetic graphene oxide (MGO) to mitigate the risk of DON contamination in wheat. These and other results detailed in this report can assist producers in addressing some of the challenges and opportunities faced every day.

The ongoing, long-standing core financial support from the Saskatchewan Government's Agriculture Development Fund and the provincial Pork Boards from Saskatchewan, Alberta, Manitoba and Ontario have made this all possible. Their continued confidence in the work we do at PSC enables us to serve the Canadian pork industry in an ongoing manner and is gratefully acknowledged. Our continuing strong relationship with the University of Saskatchewan enables both the University and PSC achieve our respective research and teaching objectives and train the next generation of swine professionals. These graduates will become managers and leaders in the swine industry in the years to come.

I would like to thank the members of PSC's volunteer Board of Directors. They bring a valuable source of expertise to PSC from many perspectives: producer, government, university and related industries and their insights enable PSC to provide value to our customers. The staff and students at PSC make all this happen and their dedication to excellence and commitment to serving the swine industry is seen throughout this report.

Murray Pettitt, PhD
(306) 667-7447
murray.pettitt@usask.ca



Operations Manager's Report

Managing Productivity, Cost of Production, and Research Needs

Tatjana Ometlic, RVT. - Manager, Operations



Running research trials in all areas of the barn creates challenges of maintaining operational efficiencies and animal flow while accommodating research projects. As a research facility that promotes a robust research program and delivery of many services to our external researchers at U of S, WCV and VIDO, as well as providing the rest of the pork industry with novel science-based information, it is our first priority to accommodate the needs of research teams. In 2022, we had 21 research projects started in grow-finish, breeding, gestation, farrowing and nursery rooms. Over 4524 animals have been used for research at PSC as well as for external research. We continue the balancing act between managing high productivity and meeting research needs.

Looking at the rolling averages for this year, we can see production numbers improving across the board. We have reached almost all of our production targets and most of them are exceeded (Table 1).

Over the past 8 months, we have succeeded to reach and exceed our target for numbers of sows bred, piglets born alive, and piglets weaned. We continue to have an exceptionally high number of pigs born alive and when not in conflict with the research projects in the farrowing rooms, production staff use every opportunity to create an extra nurse sow in the room. This has certainly helped us make up for sow losses and wean more pigs this fiscal year. Staff presence has been critical for tasks as labour intensive as this. Typically, we would make a couple of nurse sows per week, one for the newborn litters and one for the smaller weaners.

Table 1. Production targets for fiscal year 2023

Category	Target/week	Rolling Average*
# Bred	14.0	14.1
# Sows farrowed	12.7	12.5
# Pigs born alive	178	187.6
Average born alive	14.0	15.0
# Piglets weaned	161	163.3
Pre-wean mortality	9.6%	12.8%
Post-wean mortality	3.0%	2.4%
Finish mortality	2.0%	1.6%
# Sold/week	156.0	147.6

*January - May, 2023

With more pigs born alive, we have seen more variations in birth weights with more low birth pig weights, which drove the Pre-Wean Mortality (PWM) rate higher. PWM is one area that is hard to manage, as we do not have a lot of control over the numbers of pigs born and the variations in the birth weights. When possible, we continue to use practical tools, such as split nursing 18+ piglets born alive and creep feeding for disadvantaged pigs in the last week of lactation.

Production's biggest challenge last year was to maintain the animal flow throughout the barn as we had lost some of the sow herd due to the nature of the sow dynamic study and increased numbers of abortions, NIP's and deaths. In the last seven months, we have seen a significant decrease in numbers of sow abortions and NIP's and our sow population is back to 300 sows again.

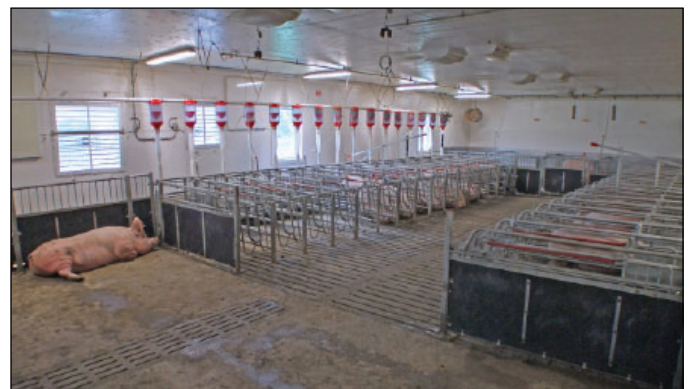


Table 2. Production parameters

	2019	2020	2021	2022	Jan-May 2023
Number of sows farrowed:	696	661	636	628	294
Conception rate %:	90.7	91.4	86.0	88.1	96.5
Farrowing rate %:	89.8	91.5	87.5	85.9	91.5
Average born alive/litter:	14.2	14.4	14.3	14.9	15.1
Farrowing index:	2.47	2.46	2.48	2.46	2.47
Number weaned/sow:	12.6	12.6	12.5	12.7	13.0
Pre-wean mortality %:	11.2	12.1	12.6	14.2	14.2
Pigs weaned/sow/year:	29.6	29.2	29.5	28.2	30.1

The production parameters for the past several years are shown in Table 2. Analysis of production performance between November 2021-November 2022 and November 2022 - May 2023 shows a big jump in our farrowing rate, from 82.5% to 91.5%. The production team focuses on improving the number of pigs weaned per sow per year and on increasing productivity of our sows by adjusting gestation feed intake and regular body scoring using calipers as a tool. We have been breeding as many animals weekly as we could, so we could catch up by the end of this fiscal year with the pig flow throughout the barn. The GDU has a continuous flow of replacement gilts and 10-14 open gilts are heat checked daily to keep up with supplies of replacement animals for our herd as well as for external researchers.

In the past year, we have been focusing on improving the body condition of our sows, having a steady pool of replacement females to replace the older sows and “opportunity” gilts, which on a long run had a negative effect on the overall herd productivity.

Our grow finish mortality continues to stay low. We have not seen many tail bites over the past several months. The grow finish staff continuously work on addressing pen densities in a timely manner as well as providing different enrichment toys through all stages of production.

We continue to sell hogs/feeders to our local abattoirs, Penner Farms and Riverview Colony, but their pickups have not been as regular this year. To manage the animal flow in grow-finish rooms and meet the space requirements from the Canadian Code of Practice we have been selling lighter hogs to Maple Leaf Foods (MLF) and have shipped additional loads of market hogs over the past few months. Shipping lighter hogs is currently helping us manage the high cost of feed and is also creating additional grow finish space, which will help us accommodate two upcoming nutritional trials.

Our MLF contract has ended in May 2023 and we have made a decision to sign a contract with Donald’s Fine Foods in Moose Jaw. We are continuing with our RWA program and as the sow plant opens soon, we will be able to ship all of our cull sows there as well. These changes are significantly going to reduce our high cost of freight.

The average cost of production keep increasing over the last two years and we continue to look for cost saving ways: days to market, throughput of pigs, delivery services, freight of shipping, herd health management, to name a few.

Over the past year, we have been collecting data on number of animals bred with semen six to eight days post collection. The data looks promising and we have not really seen a significant drop in our farrowing rate or conception and numbers born alive are still over the target. We have decided to do a trial where we will have three consecutive weeks of once a week semen delivery and three consecutive weeks of twice a week semen delivery. We will keep alternating these weeks until we have enough data to support our decision to make any changes to the frequency of semen delivery. By the end of this year, we should be able to have enough data to make a decision. This could cut down the cost of semen delivery by 50 %.



Knowledge Transfer Report

Finding New Strategies to Enhance Best Management Practices

Ken Engele, BSA. (Manager), and Miranda Smit, Ph.D. (Assistant Manager) - Knowledge Transfer



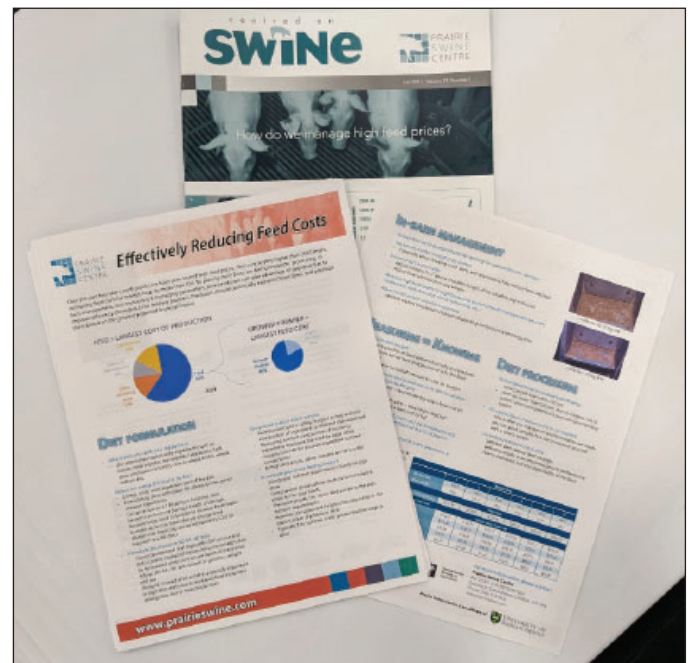
Ken Engele



Miranda Smit

Delivering timely, accurate and practical information has always been the goal of the KTT program at Prairie Swine Centre. For approximately two years, it was challenging in connecting with the pork industry in traditional ways. Over the course of 2022, we have re-engaged with producers and the industry at various meetings, conferences, trade shows and other in-person events (Alberta Pork Congress, Red Deer Swine Technology Workshop, Prairie Livestock Expo, the Sask Pork Industry Symposium and Le Porc Show) that have always been an important part of what has made the Centre successful. These events create a dynamic two-way exchange of information that is important to the industry, staff and students. We learn just as much from producers as they do from us, regarding the challenges and opportunities producers face on a daily basis in their operations. We have the opportunity to take these industry challenges, incorporate them into research programs, and find answers that will help producers achieve their goals.

Feed costs and increasing cost of production were hot topics over the past couple of years. Starting with low crop yields associated with the drought of 2021 and exacerbated by the conflict in the Ukraine, coupled by supply chain challenges resulted in record high cost of production for many producers. The news was not all bad, as 2022 also resulted in the highest average yearly hog price we have seen to date. Unfortunately, many producers experienced red ink for a majority of this period.



It is in this climate that producers are looking for information on how to reduce feed costs and their total cost of production. The KTT team continues to deliver relevant science-based information to all areas of the Canadian pork value chain through our Centred on Swine newsletter, our website, social media posts, factsheets, and one-on-one conversations with producers and other stakeholders.

Besides sharing knowledge, the KTT team has worked in conjunction with the Canadian Pork Council on training videos for swine technicians. Many of the new technicians starting their careers in hog operations come from abroad, where English is not the native language, or from different backgrounds outside of agriculture. Training these new barn workers is imperative to the success of the employee and the barn. Proper training is also an important part of employee retention. The Canadian Pork Council (CPC) started a project to create several sets of training videos that producers can use to train new barn workers. These videos do not replace in-barn learning but rather are complementary to the existing in-barn learning experience. The Centre produced two sets of training videos, focusing on general management and husbandry respectively.



The cover for the 'BARN OPERATIONS' training video features a teal background. At the top, there is a grey header with a red maple leaf logo. Below this is a dark red horizontal band with the title 'BARN OPERATIONS' in white. At the bottom, there is a small white logo of the Canadian Pork Council. The main content area is teal and contains a numbered list of 12 topics.

1. *Pre-transport planning*
2. *Ear tags and shoulder tattoos*
3. *Barn equipment checks and maintenance*
4. *Temperature and ventilation management*
5. *Farrowing room management*
6. *Weaning management*
7. *Nursery room management*
8. *Finishing room management*
9. *Sow stall barn management*
10. *Mixing pigs*
11. *Feed mill management*
12. *Feed bin management*



The cover for the 'HUSBANDRY TRAINING' training video features an orange background. At the top, there is a grey header with a red maple leaf logo. Below this is a dark red horizontal band with the title 'HUSBANDRY TRAINING' in white. At the bottom, there is a small white logo of the Canadian Pork Council. The main content area is orange and contains a numbered list of 13 topics.

1. *Body condition scoring*
2. *Farrowing midwifery*
3. *Castration and tail docking*
4. *Teeth clipping*
5. *Piglet ear identification*
6. *Breeding through artificial insemination*
7. *Preg-checking*
8. *Intramuscular injections in pigs*
9. *Handling and storage of veterinary supplies*
10. *Water medications and vaccines: usage and calibration*
11. *Cleaning and disinfecting barns*
12. *Handling mortalities in the barn*
13. *Replacement gilt management*

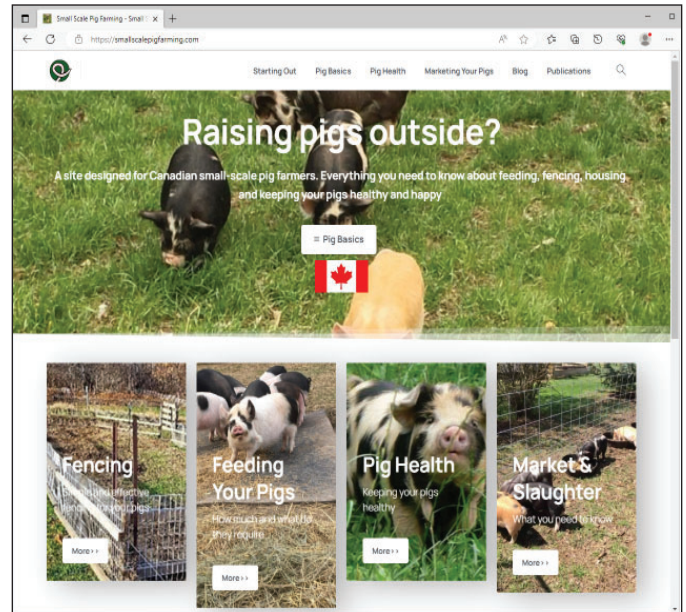
The first set of 12 videos focused on barn operations and was finalized in the Spring of 2022. The second set of 13 training videos focused on husbandry training and was finished in the Spring of 2023.

All videos are available in English and French, in addition to subtitles in several languages, including Spanish, Ukrainian, and Tagalog. All videos were available free of charge on the CPC website for a period of time, and will be part of their integrated learning system. To learn more about the videos or how to access them, you can contact CPC directly.

Reports

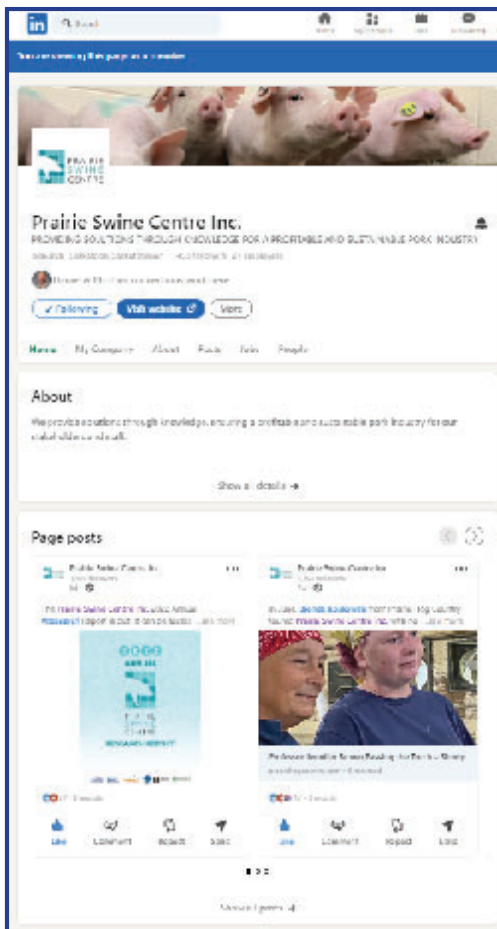
Another important initiative the KTT team is working on is the creation of communication materials for small-scale pig farmers. Keeping foreign animal diseases like ASF out of Canada's pig herd is the responsibility of the entire pork sector, including small-scale pig farmers. PSC and provincial pork agencies have been working diligently on identifying and working with this ever-growing sector. There is a need to help those producers manage their pigs and adopt best management practices that have a fit with their systems. Prairie Swine Centre has developed the website <https://smallscalepigfarming.com/> for this purpose – providing information on housing, fencing, nutrition, pig health, and marketing and slaughtering of pigs. PSC is also working on increasing engagement through social media to small producers and organizing webinars on different topics related to small-scale pig farming.

We are always assessing the most effective way in driving research results out to the industry. We welcome feedback from the industry at any time.



smallscalepigfarming.com

FOLLOW US ON LINKEDIN OR TWITTER (X)



Awards of Distinction



Jennifer Brown, PhD
Sask Pork
Lifetime Achievement Award
 Presented at the Sask Pork Industry Symposium
 November 15, 2022

Student Awards



Carley Camire

- 2nd Place R.O. Ball Young Scientist Award, Banff Pork Seminar, January 10-12, 2022



Marjorette Baguindoc

- 2nd Place CSBE Oral Contribution Award, 2022 CSBE/SCGAB Annual General Meeting and Technical Conference, July 24-27, 2022, Charlottetown, PEI



Jessica Vehof

- 1st Place Sask Pork Industry Symposium Graduate Student Competition, November 15-16, 2022, Saskatoon, SK



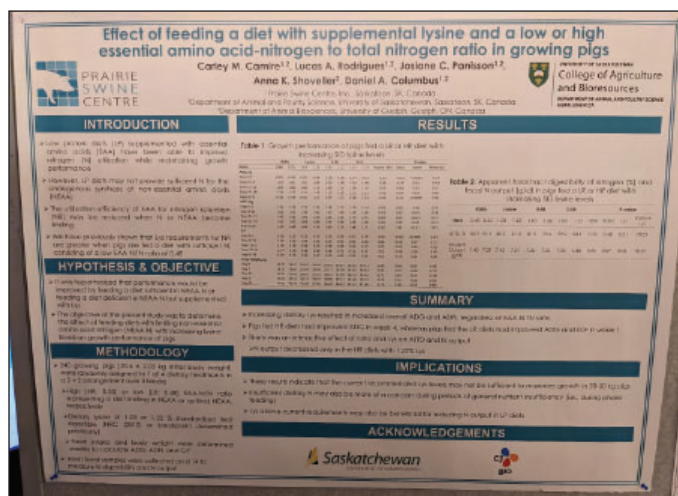
Carley Camire

- 1st Place Sask Pork Industry Symposium Poster Competition, November 15-16, 2022, Saskatoon, SK



Taiwo Erinle

- University nominee for Vanier Canada Graduate Scholarship



Road and disease-challenge tests with a modified prototype livestock trailer

B. Predicala^{1,2}, M. Sapaden^{1,2}, A. Alvarado^{1,2}, M. Baguindoc^{1,2}, and S. Kirychuk³



Bernardo Predicala



Micah Sapaden

SUMMARY

The overall goal of the work conducted was to assess the performance of an improved prototype livestock trailer with ventilation, heating, misting and air filtration systems in maintaining a welfare-friendly and pathogen-free environment during transport. The testing and evaluation comprised of road tests and disease-challenge tests. The road tests aimed to evaluate the performance of the trailer's ancillary systems (ventilation, heating, misting systems) in maintaining acceptable environmental conditions for the pigs, and assess the general welfare of the animals during transport. The disease-challenge tests, on the other hand, were carried out to assess the effectiveness of the trailer in protecting against airborne pathogens from the external environment. So far, four road tests and two disease-challenge tests have been completed. Based on the results, the trailer's ancillary system was able to maintain acceptable environmental conditions in the animal compartment during transport. In addition, results of the disease-challenge tests showed that the installation of an air filtration system in the trailer could protect the pigs from exposure to airborne transmissible diseases such as Influenza A virus. Additional road and disease-challenge tests are currently underway to provide a more definitive conclusion on the impact of the trailer equipped with an air filtration system on the environmental conditions of pigs and in preventing disease infection during transport.

"Results suggest the air filtration system in the trailer was capable of protecting the pigs from IAV infection.."

INTRODUCTION

To protect pigs against transmission of airborne diseases such as PRRS, Influenza A virus (IAV), Classical Swine Fever and PEDv, pig producers have installed air filtration systems in their swine barn facilities. However, the protection provided by the barn filtration system ends once the animals are taken out of the barn during transport, which is a routine practice in pig production. As animal transportation has proven to play a vital role in disseminating airborne viruses, a previous project developed a new prototype trailer fitted with air filtration and ventilation systems to bridge the biosecurity gap and protect the animals from airborne transmissible diseases during transport. Aside from the biosecurity concerns, the welfare of pigs during transport is also of utmost importance. The welfare of pigs depends on different factors, including the design of transport trailers, the condition of the animal at various phases of the journey (loading, time in transit, and unloading), space allowance, the environmental conditions inside the trailer such as ambient temperature and humidity, social stress, handling, unfamiliar noises, vibrations, and sudden speed changes. The primary objective of this study was to evaluate the effectiveness of the enhanced filtered trailer in maintaining a pathogen-free and welfare-friendly environment inside the trailer loaded with pigs under actual transport conditions. Once proven successful, this study will help address one critical component of preventing the spread of airborne transmissible diseases within the Canadian swineherd.

EXPERIMENTAL PROCEDURES

The prototype trailer is a dual (top and bottom) straight-deck trailer, with totally enclosed, positive-pressure fan-ventilated animal compartments. Inlet air must pass through a series of filters before entering the animal compartment. In addition, various features such as hydraulic loading platform, hinged floor and roof, a variety of sensors and electronic controllers, among others, were incorporated into the trailer design. Each deck is divided into two pens (front and rear) by a gate. Each pen has installed pig drinkers, feeders, spray misting nozzles, LED light, and sensors for temperature, relative humidity (RH), air flow, and carbon dioxide gas for environmental monitoring and control system. In front of the trailer animal compartment is a separate space which holds the ventilation fans, the bank of filters, electronic controllers, supplemental heaters, and data loggers (Figure 1).

1 Prairie Swine Centre Inc, PO Box 21057, 2105 – 8th Street East, Saskatoon, SK, S7H 5N9

2 Department of Chemical and Biological Engineering, College of Engineering, University of Saskatchewan, 57 Campus Drive, Saskatoon, SK S7N 5A9

3 Canadian Centre for Health and Safety in Agriculture, University of Saskatchewan, 104 Clinic Place, Saskatoon, SK, S7N 2Z4

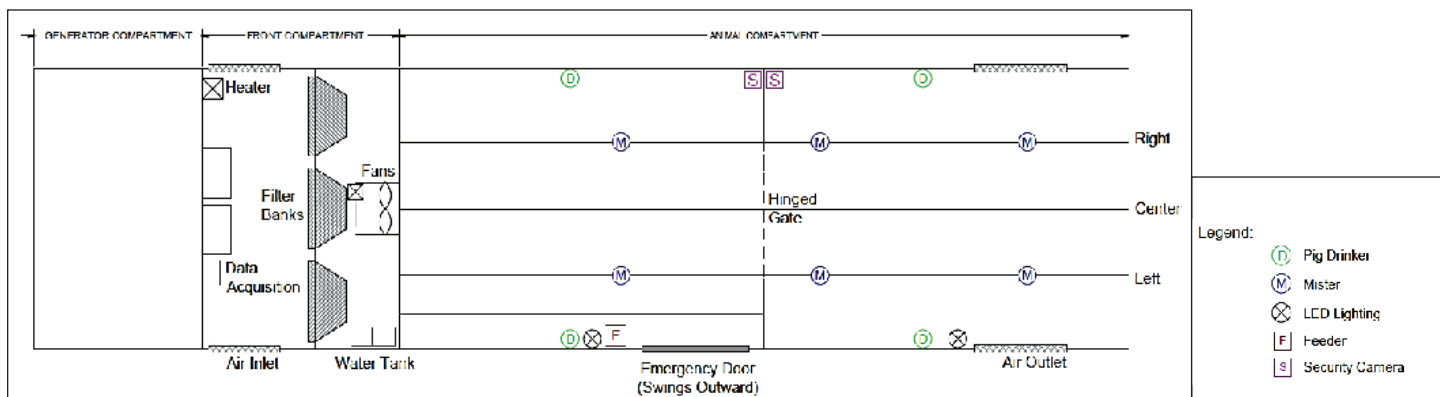


Figure 1. Schematic diagram of the additional features installed in the prototype livetsock trailer

Testing and evaluation of the prototype transport trailer comprised of road tests and disease-challenge tests. For the road tests, 40 pigs were loaded in the bottom deck of the trailer. Prior to each road test, the body weight and rectal temperature of the selected pigs were measured while in the PSC barn, and an assessment of the physical condition and behaviour was made to ensure all pigs are fit and healthy prior to loading to the trailer. All sensors and recording devices were activated prior to loading, and continued operation during the entire trip. A route was mapped to cover at least a 5-hour trip from PSC to a cooperating farm. Upon arrival at the destination, all pigs were inspected again to assess their physical condition and overall welfare. Only 10 pigs were retained in the trailer for the disease-challenge tests, while the rest were unloaded at the destination barn.

The disease-challenge tests consisted of two test conditions: 1) with the trailer filtration system in operation (Treatment), and 2) without the filtration system (Control). For each test, a group of 10 pigs were loaded in the prototype trailer, transported to an IAV-positive barn site, and then the trailer was exposed to the exhaust air from the barn for 14 hours by connecting a duct from a nursery room exhaust fan to the trailer air inlet (Figure 2). The two groups (Treatment and Control) were tested on separate trips to the site using the same prototype trailer. After exposure, the trailer was moved to a location away from the IAV-positive barn, and pigs were cared for following standard guidelines and observed for 14 days for signs of IAV infection.

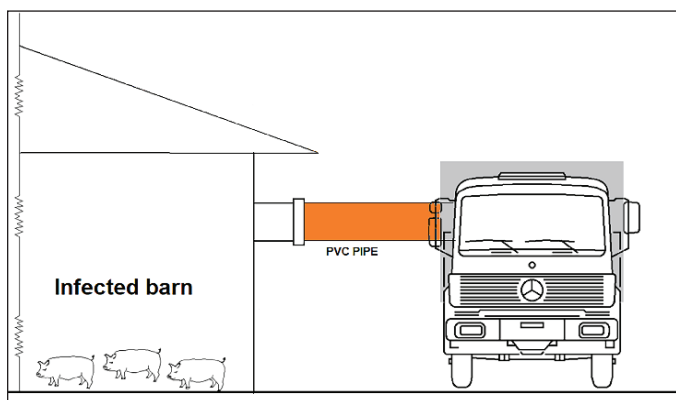


Figure 2. Experimental setup during the exposure period of the disease-challenge test.

RESULTS AND DISCUSSION

Four road tests have been completed to date. The first three road trips took about 6 hours to complete, while road test 4 took 4 hours and 50 minutes. During the four road tests, no animal-related issues were encountered. A consistent rise of temperature and humidity ratio was observed during loading and the first 30 minutes of the trips, which can be attributed to the heat production of pigs as a result of increased activities and adapting to the motion during travel. Temperature from start of loading to early period of the trips ranged from -0.5 °C to 14.1 °C and from -5.5 °C to 9 °C for the first and third monitoring trips, respectively. Temperatures inside the animal compartment for the first monitoring trip had somewhat stabilized over the main duration of the travel period until the trailer arrived at the cooperating barn. On average, temperatures ranged from 5 °C to 15 °C. However, for the third monitoring trip, a slight decrease in temperature was observed during the first 2 hours of the trip, and then, a sudden increase in temperature ranging from 12 °C to 14 °C was recorded in the last 3 hours of the travel (Figure 3). This can be attributed to the weather condition during the first 3 hours of the third monitoring trip, which was a combination of light snow, drizzle and periods of pouring rain. Interior moisture levels gradually decreased and stabilized as it reached the stable periods of both trips. Temperature ranging mainly from 0 °C to 10 °C had been measured in most trailer locations. Temperatures at locations close to the fan were relatively warmer than in areas close to the exhaust.

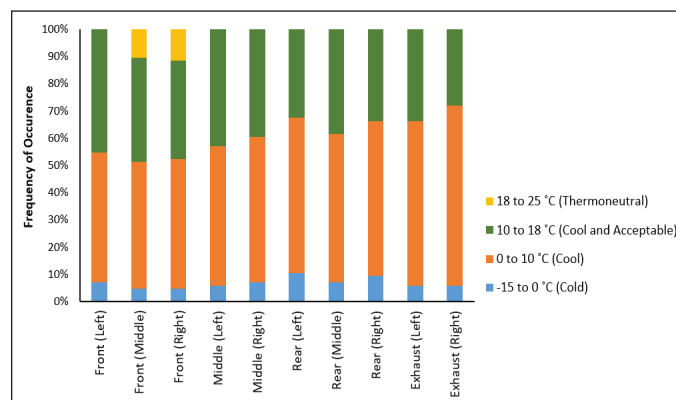


Figure 3. Thermal comfort classification of the different locations in the trailer during the third monitoring trip.

Two disease-challenge tests have been completed to date. During the first test, the air filtration system in the trailer was not installed (Control 1) while the second test had the air filtration system installed and operational (Treatment 1). For Control 1, IAV were detected in air samples collected from both upstream (before the air filtration system) and downstream (after air filter setup) locations, indicating that the pigs in the animal compartment were exposed to IAV-positive air. For Treatment 1, however, air samples collected upstream were positive for IAV, whereas air samples collected in the trailer (after the air filtration system) were negative for IAV, indicating that the air filtration system in the trailer was capable of removing IAV in the air, thereby protecting the pigs in the animal compartment from potential IAV exposure. During the 14-day observation period post-exposure, some pigs of the Control 1 group developed IAV symptoms, and one pig died on day 6, therefore the trial was terminated on day 7. Seven pigs were tested positive for IAV in their blood samples on day 7 (Table 1). On the other hand, during the Treatment 1 trial, pigs were healthy throughout the entire 14-day observation period after exposure. No clinical symptoms nor signs of IAV infection were observed. Both blood and nasal swab samples collected on days 7 and 14 were negative for IAV.

IMPLICATIONS

During the Control 1 disease-challenge test, pigs were exposed to IAV-infected air as indicated by the IAV-positive air samples collected from the animal compartment. As a result, pigs became sick starting on day 5 after the exposure. In contrast, the air samples collected in the animal compartment during the Treatment 1 test were negative for IAV. As a result, pigs remained healthy over the course of 14 days after the exposure. This result suggests that the air filtration system in the trailer was capable of protecting the pigs from IAV infection. Additional disease-challenge tests are currently underway to provide a more definitive conclusion on the impact of the air filtration system in preventing IAV infection in pigs.

ACKNOWLEDGEMENTS

Financial support for this research project was provided by the Saskatchewan Agriculture Development Fund and the Canadian Agri-Safety Applied Research Program funded by Agriculture and Agri-Food Canada. The authors would also like to acknowledge the participation of the cooperating farm in this research project, as well as the strategic program funding provided to Prairie Swine Centre by Sask Pork, Alberta Pork, Ontario Pork, the Manitoba Pork Council and the Saskatchewan Agriculture Development Fund.

Table 1. IAV tests results, weights, rectal temperature and clinical signs of IAV infection during the Control 1 disease-challenge trial.

Pig ID	Weights, kg		Rectal temperature, °C		Influenza A virus test		Clinical signs/symptoms
	Day 0	Day 7	Day 0	Day 7	Blood samples	Nasal swabs	
					Day 7	Day 7	
C1-01	27.6	32.3	40.5	40.6	Positive	Negative	Slight abdominal breathing (day 7)
C1-02	26.1	29.4	39.7	41.1	Positive	Negative	None
C1-03	26.6	30.0	40.1	40.6	Positive	Negative	None
C1-04	25.4	30.1	39.8	39.7	Positive	Negative	None
C1-05	28.0	32.8	40.7	41.2	Negative	Negative	None
C1-06	25.0	21.71	39.1	-			Coughing, weight loss (day 5); Died on day 6
C1-07	25.8	25.1	40.7	39.4	Positive	Negative	Slight abdominal breathing; weight loss (day 6)
C1-08	28.2	29.5	40.1	40.1	Positive	Negative	None
C1-09	25.0	29.1	40.5	39.9	Positive	Negative	None
C1-10	26.3	31.8	39.7	40.8	Negative	Negative	Slight coughing (day 6)

Testing of a rapid detection kit for Porcine Epidemic Diarrhea virus (PEDv)

B. Predicala^{1,2}, Y. Kryachko³, and D. Korber³



Bernardo Predicala

SUMMARY

Significant economic losses can result from outbreaks of Porcine Epidemic Diarrhea (PED), a serious disease currently circulating in North American swine herds. Accurate and rapid detection of PEDv is essential to expedite implementation of control measures for the disease. A rapid PEDv test kit is needed for this purpose. Comparison of the DNA sequence targeted by the primers included in a current PEDv test kit to the sequences of North American PEDv strains showed potential suitability of these primers for detecting PEDv strains in the Canadian swine herd. This was confirmed in laboratory testing of 20 samples collected from pigs infected with PED, although the test results showed that the visual interpretation of test kit results can be somewhat ambiguous for some types of samples and can be further improved. While definitive results were obtained from most of the test samples, in a few samples the test results showed only slight visual differences between a positive result (indicated by a sky-blue colour) and negative results (indicated by purple or lighter blue colours). To improve the current test kit and to avoid ambiguity in interpreting the results, current work in collaboration with the developer of the original test kit included modifications such as using an alternative dye which would allow better colour differentiation between positive and negative results (yellow vs. pink/red colours). Further revisions such as reformulating reagents to dry format and modifying test sample preparation procedures are also being done. The improved test kit will then be re-tested in the laboratory, where its sensitivity, specificity, and repeatability will also be assessed. Afterwards, the performance of the improved test kit will be validated by field testing in PED-positive pig farms.

"Accurate and rapid detection of PEDv is essential to expedite implementation of control measures for the disease."

INTRODUCTION

In Canada, significant economic loss attributed to Porcine Epidemic Diarrhea (PED) has been estimated at \$125,000 for a 1000-sow herd. While the initial rate of spread has slowed down due to strict biosecurity measures in the industry, new PED outbreaks are still occurring in Canada at present. Currently, real-time reverse transcription polymerase chain reaction (rRT-PCR) is the method of choice for diagnosis of PEDv infection. However, rRT-PCR testing is costly and it requires sending the samples to a central analytical laboratory, which delays the rapid response needed to limit spread and impact of an emerging disease outbreak. Availability of a rapid and economical in-barn test kit would be valuable to deploy appropriate containment actions immediately, while waiting for confirmatory results from rRT-PCR testing.



A test kit originally developed by Domingo and Paraguison-Alili (2015) is based on the Loop-Mediated Isothermal Amplification (LAMP), which can be used as an alternative to rRT-PCR. The test package is technically-simple and user-friendly to implement. More importantly, it has very minimal cost of consumables thus translating to low price point per test, with the original test kit costing only C\$10 per test. The original test kit has been developed under university laboratory settings and the developers of the test kit have already conducted extensive validation tests using samples from their local swine industry (in the Philippines). However, further refinement to ensure that the test kit can accurately detect the various PEDv strains present in North America, followed by field validation by applying the test kit on actual Canadian samples, are necessary before the test kit can be adopted as an additional biosecurity tool for the Canadian pig industry. Our current work is aimed to further improve this RT-LAMP-based kit and make it suitable for widespread use in the commercial swine industry in Saskatchewan and other Canadian provinces.

1 Prairie Swine Centre Inc, PO Box 21057, 2105 – 8th Street East, Saskatoon, SK S7H 5N9

2 Department of Chemical and Biological Engineering, College of Engineering, University of Saskatchewan, 57 Campus Drive, Saskatoon, SK S7N 5A9

3 Department of Food and Bioproduct Sciences, University of Saskatchewan, 51 Campus Drive, Saskatoon, SK, S7N 5A8

EXPERIMENTAL PROCEDURES

In silico assessment was performed to ensure that the primers in the original test kit can detect the North American PEDv strains. BLAST – Global alignment of several North American PEDv sequences against the PEDv spike protein (S) gene sequence (GenBank ID KM406181; 4126 bp), which was used by Domingo and Paraguison-Alili (2015) as the target gene sequence, was performed.

Testing and validation of the original rapid PEDv test kit: Twenty samples (5 fecal, 3 jejunal and 12 rectal swab samples) collected from PEDv-positive pigs at VIDO-Intervac and from pig barns in Saskatchewan and Manitoba, were analyzed at the VIDO-Intervac laboratory for the presence of PEDv through both RT-qPCR and LAMP analyses. RNA was extracted from the samples using QIAGEN RNeasy Plus kit. Then a reverse transcription (RT) step was performed, followed by a qPCR step. The qPCR readings were taken in triplicates and average values were calculated. The LAMP step was performed according to the instructions provided together with the original rapid PEDv test kit and as described by Domingo and Paraguison-Alili (2015).

RESULTS AND DISCUSSION

In silico analysis of the target PEDv sequence: Results of BLAST – Global alignment done against PEDv spike protein (S) gene sequence (GenBank ID KM406181; 4126 bp) indicated that it had minimum 96.8% (in most cases, 99% or higher) similarity to respective sequences of PEDv strains found in Canada. These results indicated that the North American PEDv strains will likely be easily detected using the primers included in the original test kit.

Testing and validation of the rapid PEDv test kit: Results of the testing of the 20 samples to detect PEDv using both RT-qPCR and the application of the RT-LAMP-based test kit showed that the test kit results were mostly comparable to the results from the RT-qPCR testing, indicating very good sensitivity and specificity of the test kit for detecting PEDv. However, for certain samples the interpretation of the LAMP-based kit visual results was not very definitive due to the ambiguity in the resulting color of the LAMP test results. According to the original test kit instructions (Figure 1), a sky-blue colour indicates a positive result, whereas purple or lighter blue colours indicate negative results; Figure 2 shows the actual positive and negative LAMP-PEDv “control” results, which were used as the reference against which the test results from the actual 20 samples were compared to determine whether each sample was positive or negative.

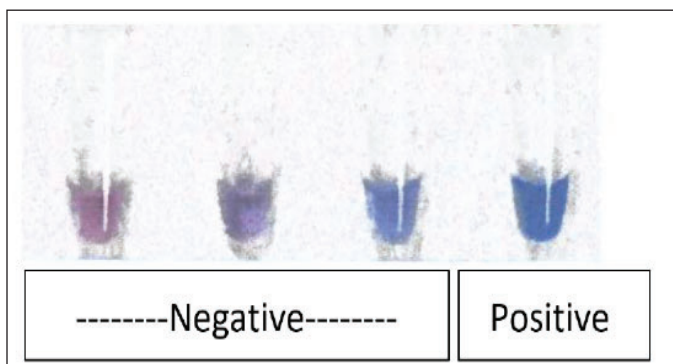


Figure 1. Interpretation of the different colors of the original RT-LAMP-based rapid PEDv detection kit results.

Some of the LAMP test results were difficult to objectively determine visually by comparing with the “positive-control” or “negative-control” tubes. Another confounding factor was the presence of fecal matter in two samples, which rendered the LAMP test tubes difficult to read properly as the resulting colour was outside the provided reference range of colours for comparison (yellow-orange instead of blue-purple). These results indicated the need for further improvement of the test kit, which are currently underway. An alternative dye that would allow better colour differentiation between positive and negative results (yellow vs. pink/red colours) has been explored and is now being used in the new version of the test kit, thereby ensuring better accuracy in objectively interpreting the test results. Additionally, modifications to the test sample preparation procedure, i.e., pre-filtration or centrifugation of certain samples with fecal material, are being investigated to ensure that the LAMP test tubes consistently show colors that can be interpreted properly against the reference color scale. Additional optimization modifications in the formulation of the reagents for better handling and storage (i.e., dry format, instead of the current liquid reagents which were found to be susceptible to leakage and evaporation) are also being done with the new version of the test kit. Once these modifications are completed, the new modified test kit will be subjected again to laboratory testing to confirm its efficacy and to assess performance parameters such as sensitivity, specificity, and repeatability. Finally, the revised test kit will be validated through field testing in actual PEDv-positive barns.

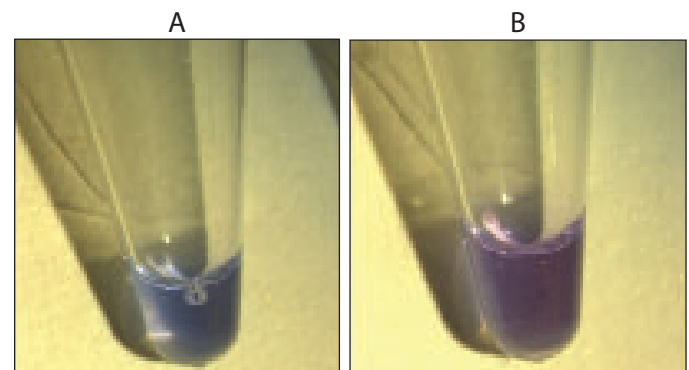


Figure 2. Visible RT-LAMP “PEDv control” results: (A) positive control and (B) negative control.

IMPLICATIONS

The primers included in the original rapid RT-LAMP-based PEDv test kit are suitable for detecting North American PEDv strains. However, modifications to the test kit are needed to allow more visual differentiation between positive and negative results, and to improve test sample preparation procedures. Once the improved test kit has been validated through field testing, it will be valuable in deploying appropriate containment actions immediately, which will help keep PEDv out of other swine production facilities.

ACKNOWLEDGEMENTS

Financial support for this research project was provided by the Saskatchewan Agriculture Development Fund. The authors would also like to acknowledge the strategic program funding to Prairie Swine Centre provided by Sask Pork, Alberta Pork, Ontario Pork, the Manitoba Pork Council and the Saskatchewan Agriculture Development Fund.

Application of nanotechnology for mitigation of DON in wheat grains

A. Alvarado¹, B. Predicala^{1,2}, and A.D. Beaulieu³



Bernardo Predicala



Alvin Alvarado

SUMMARY

A series of laboratory-scale experiments were conducted to determine the most promising nanomaterials and to optimize its operational requirements for appropriate application in mitigating mycotoxin contamination in feed grains and formulated swine diets. Three candidate nanomaterials were selected for testing based on a comprehensive literature review conducted previously: chitosan polymeric nanoparticles (CS), montmorillonite nanocomposites (MN), and magnetic graphene oxide (MGO). Based on the preliminary test results, MGO showed the greatest potential in mitigating the risk of DON contamination in wheat grains among the three nanomaterials. Additional experiments are underway to further investigate the efficacy of each nanomaterial in counteracting DON contamination in wheat grains as affected by various influencing parameters, and to establish the optimum application conditions for the most promising nanomaterial.

INTRODUCTION

Mycotoxins are secondary toxic chemicals produced by organisms of fungal origin found in contaminated grains. Mycotoxin-contaminated grains when fed to livestock result in feed refusal, affect immune and health status, and may even cause death. Nanotechnology has been used to treat contaminants in air, soil and water media. Nanomaterials are also known to have antifungal properties; several studies have shown the effective use of nanomaterials in mitigating mycotoxin contamination due to their high surface area and high reactivity and also on the fact that nanomaterials can be modified to enhance their physical and chemical properties.

Based on a set of assessment criteria which include previous similar applications, cost effectiveness, safety, and availability, three nanomaterials were selected: chitosan (CS) polymeric nanoparticles, montmorillonite nanomaterials (MN), and magnetic graphene oxide (MGO) nanostructures. While the nano-adsorbent efficiency of CS, MN and MGO against the elimination of specific mycotoxins have been demonstrated, their effectiveness against the synergistic effects of multiple mycotoxins has not been studied well.

In general, research on the potential application of nanomaterials for mycotoxin elimination in grains and in livestock feed is very limited, thus, its operational requirements such as effective dosage, binding capacity, optimum treatment application conditions, among others, are still unknown. Hence, this proposed work has been conceptualized to fill these gaps by conducting a comprehensive evaluation of the application of nanotechnology for mitigating mycotoxin risk in grain and livestock industries.

EXPERIMENTAL PROCEDURES

Some Laboratory-scale experiments of selected nanomaterials, particularly chitosan polymeric nanoparticles (CS), montmorillonite nanocomposites (MN), and magnetic graphene oxide (MGO), were conducted at a chemistry laboratory of a collaborating partner institution with previous experience in this area (Xavier University in the Philippines). Grain and feed samples from Canada and other necessary materials for the experiment (e.g., Deoxynivalenol (DON) reference standards, mycotoxin rapid test kit (Vertu reader), test nanomaterials, among others) were shipped to the partner laboratory. Each nanomaterial was subjected to a series of adsorption tests involving different ground samples of raw grains (i.e., wheat, barley, corn) and formulated swine diet (i.e., mixture of different grains and other feed ingredients).

In Activity 1, the selected nanomaterials were tested at 5 different concentrations and varying operational conditions (pH, controlled temperatures, equilibrium times, and shaking speed) to establish their efficacy in reducing the levels of DON in wheat grain. The objective of the tests was to investigate the efficacy of each commercially-available nanomaterial (adsorbent) and to determine the most effective adsorbent that will be used in subsequent tests. Additional experiments were carried out to investigate the efficacy of the selected nanomaterials at higher DON levels by spiking the naturally contaminated wheat grain with 10 ppm DON.

¹ Prairie Swine Centre Inc, PO Box 21057, 2105 – 8th Street East, Saskatoon, SK S7H 5N9

² Department of Chemical and Biological Engineering, College of Engineering, University of Saskatchewan, 57 Campus Drive, Saskatoon, SK S7N 5A9

³ Department of Animal and Poultry Science, University of Saskatchewan, 51 Campus Drive, Saskatoon, SK, S7N 5A8

In Activity 2, the most effective nanomaterials identified in the previous tests were investigated to establish the optimum application rate and operating conditions (i.e., pH, equilibrium time and temperature) for mitigating the contamination of mycotoxins in raw grains (i.e., wheat, barley and corn) and formulated swine diet. The second set of tests aimed to establish the optimum operating conditions for the most effective nanomaterial. Using the most effective nanomaterial and the corresponding application rate, the mixture of the test nanomaterial and one spiked raw grain or formulated swine diet was subjected to varying pH values, controlled temperatures, equilibrium times, and shaking speeds.

RESULTS AND DISCUSSION

Laboratory-scale experiments on the efficacy of mycotoxin nanomitigation strategies involving raw grains and formulated swine diet are still underway. Figure 1 shows the preliminary results of the adsorption efficiencies of CS, MGO and MN nanomaterials at different application rates on DON at pH 3.1 and 8.3. Among the three nanomaterials, MGO nanoparticles showed the greatest potential in reducing DON contamination in wheat grains. Adsorption efficiencies tended to increase as application rate increased but no considerable increase was observed beyond 200 mg MGO per 5 g of wheat application rate. At this rate, adsorption efficiency of MGO on DON was about 50%.

For CS nanoparticles, adsorption efficiencies were below 50% regardless of pH and application rate. The maximum adsorption efficiency was achieved at pH 3.1 for 2 mg CS per mL solution (37%). Similar to CS nanoparticles, the adsorption efficiencies of MN nanocomposites on DON were below 50% regardless of pH and application rate. However, higher adsorption efficiencies were observed for pH 3.1 than pH 8.3. The maximum adsorption efficiency was 48% and was achieved at pH 3.1 for 10 mg MN per mL solution. Overall, adsorption efficiencies of nanomaterials were significantly influenced by application rate and pH.

IMPLICATIONS

Based on the raw results from the completed trials, the application of MGO nanoparticles was the most promising strategy in counteracting the impact of DON in contaminated wheat grains. Additional experiments are currently underway to collect more data on the performance of the three nanomaterials for mitigating the contamination of DON in wheat grains. In addition, the effect of pH, temperature and contact time on the adsorption performance of the most promising nanomaterials will be assessed further in subsequent tests. Furthermore, in-barn tests are planned to test the application of the selected nanoparticles at the best application rates under real-life barn settings.

ACKNOWLEDGEMENTS

Financial support for this research project was provided by the Saskatchewan Agriculture Development Fund. The authors would also like to acknowledge the strategic program funding to Prairie Swine Centre provided by Sask Pork, Alberta Pork, Ontario Pork, the Manitoba Pork Council and the Saskatchewan Agriculture Development Fund.

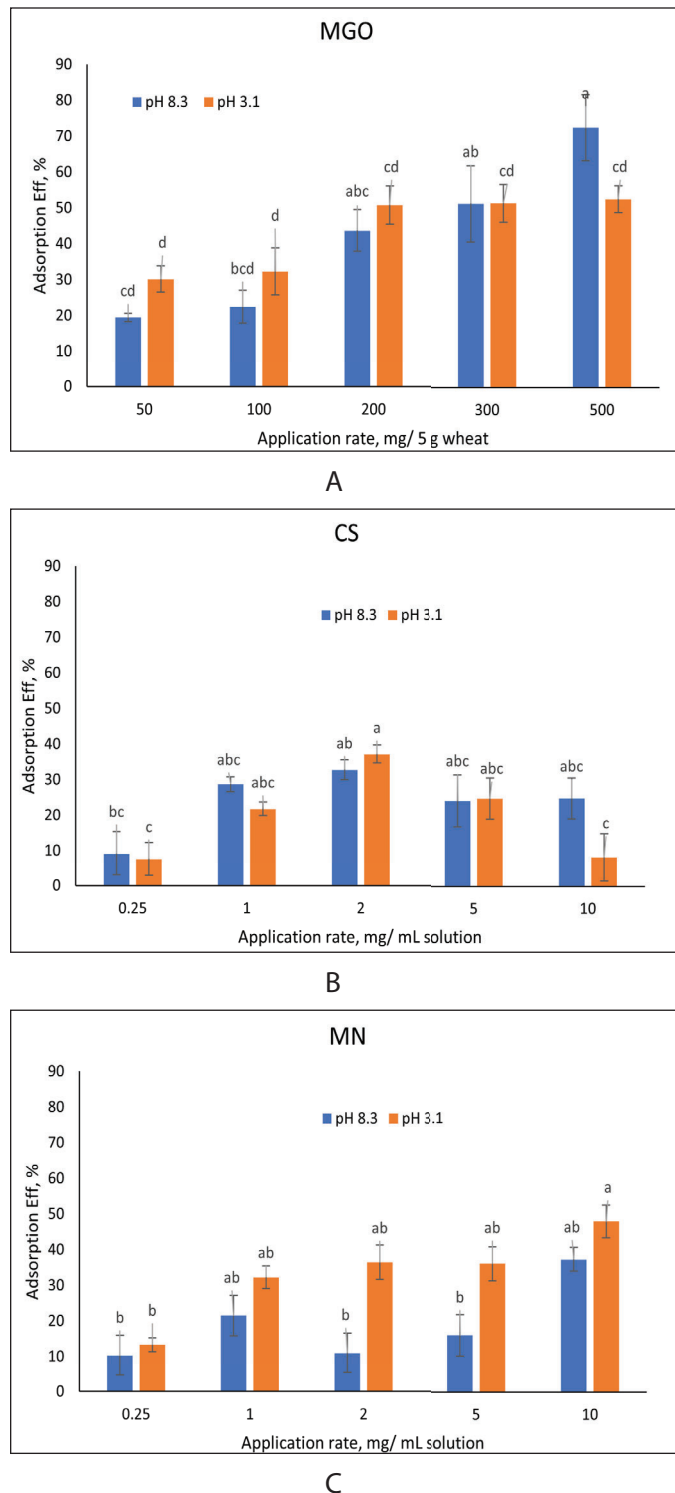


Figure 1. Adsorption efficiencies (%) of magnetic graphene oxide (A), chitosan (B) and montmorillonite (C) nanomaterials at different application rates on DON at pH 3.1 and 8.3.

Non-essential amino acids affect nitrogen retention in pigs

C.M. Camiré^{1,2}, M.O. Wellington³, J.C. Panisson¹, L.A. Rodrigues^{1,2}, A.K. Shoveller⁴, D.A. Columbus^{1,2}



Carley Camiré



Dan Columbus

NEAA, and EAA may be used to provide N in N-deficient low-protein diets. This would reduce EAA availability and utilization efficiency for N retention and may result in increased EAA requirements in low-protein diets.

"Non-essential amino acid requirements have not been considered in diet formulation as it has been assumed that pigs can synthesize enough to meet their needs."

SUMMARY

Low-protein diets supplemented with essential amino acids (EAA) can improve growth and performance. However, the dietary amount of non-essential amino acids (NEAA) may be a limiting factor in these diets. This may ultimately affect the efficient utilization of the dietary EAA for maximum nitrogen (N) retention and growth. Appropriate quantities of EAA and total N may be provided using the EAA-N to total N ratio (E:T). The present study showed that, generally, N retention increased linearly with increasing dietary lysine (Lys), but N retention was higher in the low E:T group. A higher Lys requirement was observed in the low E:T group compared to the high E:T fed group, contrary to the study hypothesis. The results from the present study indicate that NEAA or N becomes limiting in high E:T diets but not in low E:T diets, and more EAA are required in low E:T diets to maximize N retention. In conclusion, the E:T ratio should be an important consideration in formulating low-protein diets for pigs to ensure optimal and efficient utilization of the EAA provided in the diet.

INTRODUCTION

Reducing nitrogen (N) excretion in pig production is important for sustainable animal agriculture and swine production. The use of low protein diets supplemented with essential amino acids (EAA) has been used as a concept to improve feed efficiency while reducing N excretion and maintaining growth performance. However, the total amount of N in the diet is important to maintain optimal performance. Low protein diets generally have reduced amounts of non-essential amino acids (NEAA). In general, NEAA requirements have not been considered in diet formulations as it has been assumed that pigs can synthesize enough NEAA to meet their needs. However, a source of N is required for the endogenous synthesis of

The ideal protein concept focuses on meeting the EAA requirements of the pig, with little consideration given to NEAA requirements, even though they supply almost half of the total dietary N required. Consequently, the ratio between EAA-N and total N (E:T) has been suggested to depict the relationship between EAA and NEAA on an N basis. The ratio considers the appropriate amount of N coming from both EAA and NEAA sources, which may have implications on the efficiency of using EAA for N retention. It has been reported that there should be a minimum amount of NEAA supplemented in diets to improve N retention. An optimum E:T ratio of 0.48 for achieving maximum N retention was previously determined in pigs. While a number of studies have examined this ratio, there has been a lack of consistency in how this ratio has been calculated. Various factors can impact the E:T value calculation, such as total EAA, including excess above requirement, the selection of AA considered EAA and which sources of N (i.e., AA or non-protein N) are included in the NEAA-N fraction. In previous research the total N fraction only included N from NEAA and excess EAA. More recent advances in our understanding of N have shown that non-protein N can contribute to both EAA and NEAA supply in the pig and non-protein N can be used as efficiently as NEAA supplementation in NEAA-deficient diets. Thus, in the present study, we calculated the E:T ratio as the amount of EAA-N as the SID fraction up to the recommended requirement (NRC, 2012) and total dietary N as indicated by crude protein content. Consequently, our ratio represents the amount of balanced EAA (including Arg) available for protein synthesis and the total amount of N available for the synthesis of NEAA.

The objective of the present study was to determine the effect of the E:T ratio on lysine (Lys) requirement in growing pigs for maximum N retention. We hypothesized that the Lys requirement would be higher in pigs fed a diet with a high E:T ratio compared to those fed a lower ratio.

1 Prairie Swine Centre Inc, PO Box 21057, 2105 – 8th Street East, Saskatoon, SK S7H 5N9

2 Department of Animal and Poultry Science, University of Saskatchewan, 51 Campus Dr, Saskatoon, SK S7N 5A8

3 Trouw Nutrition Innovation R&D, Veerstraat 38, 5831JN, Boxmeer, Netherlands

4 Department of Animal Biosciences, University of Guelph, Guelph, ON, Canada, N1G 1Y2

EXPERIMENTAL PROCEDURES

An N-balance study was conducted at the Prairie Swine Centre to determine the lysine (Lys) requirement for maximum nitrogen retention when pigs are fed diets with a low (0.33) or high (0.36) E:T ratio. A total of 80 growing barrows (21.5 kg initial BW; SD = 0.89 kg), individually housed in metabolism crates, were randomly assigned to 1 of 10 dietary treatments (n = 8) in 8 blocks in a 2 × 5 factorial arrangement. Diets consisted of a low ratio (LR; 16.8% crude protein; E:T of 0.33) or a high ratio (HR; 15.5% crude protein; E:T of 0.36) with graded levels of Lys (0.82%, 0.92%, 1.02%, 1.12%, and 1.22% standardized ileal digestible [SID]) fed at 2.8 × maintenance metabolizable energy requirements. Ratios were formulated to be deficient in dietary N (HR) or to contain supplemental N as intact protein (LR). After a 7-d dietary adaptation, a 4-d N-balance collection was conducted. Blood samples were obtained on d2 of the collection period for plasma urea nitrogen (PUN) analysis.

RESULTS AND DISCUSSION

Nitrogen intake was greater in the LR-fed pigs than in the HR-fed pigs, whereas N intake generally increased with increasing dietary Lys content ($P < 0.05$). The apparent total tract digestibility (ATTD) of N was higher in the HR-fed pigs compared to the LR-fed pigs (83.1 vs 81.6 %; $P < 0.01$) but was not affected by dietary Lys. Fecal and urinary N output were lower in pigs fed the HR diets ($P < 0.01$), and urinary N output was decreased with increasing Lys content ($P < 0.01$).

Nitrogen retention increased linearly, and PUN decreased with increasing Lys ($P < 0.01$). A significant interaction between ratio and Lys ($P < 0.01$) was observed for N retention ($P = 0.01$). The linear broken-line breakpoint model estimated SID Lys required to maximize N retention of pigs fed HR diets at 1.08% ($R^2 = 0.61$) at maximum N retention of 17.8 g/d (Figure 1A) and LR diets at 1.21% SID Lys ($R^2 = 0.80$) at maximum N retention of 19.3 g/d (Figure 1B). We also determined Lys requirement to minimize PUN concentration. The estimated Lys requirement was 1.12% SID Lys in the HR-fed pigs ($R^2 = 0.14$) at 6.37 mg/dL PUN. In the LR-fed pigs an estimated Lys requirement was observed at 1.17% SID Lys ($R^2 = 0.23$) at 4.03 mg/dL PUN.

IMPLICATIONS

The Lys requirement was demonstrated to be higher than current NRC (2012) requirements for both LR-and-HR-fed pigs and greater in LR vs. HR diets. The results from the present study indicate that NEAA or N is limiting in HR diets and supplementation with N as intact protein (LR diets) improves N retention, resulting in greater Lys to maximize N retention. In conclusion, the E:T ratio should be considered in formulating diets for pigs to ensure optimal and efficient utilization of the EAA provided in the diet.

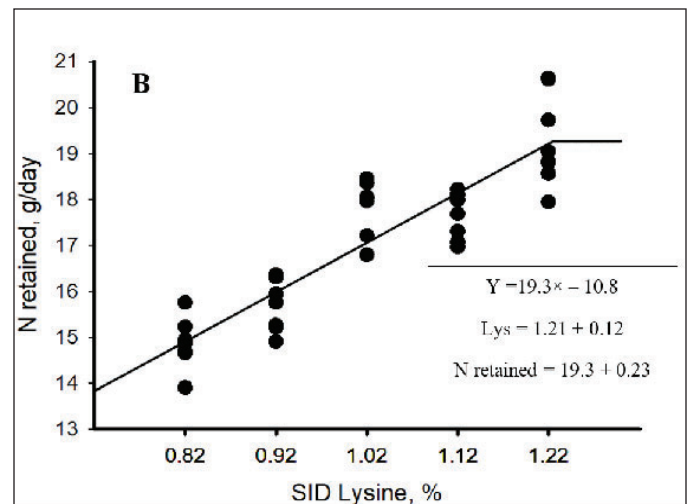
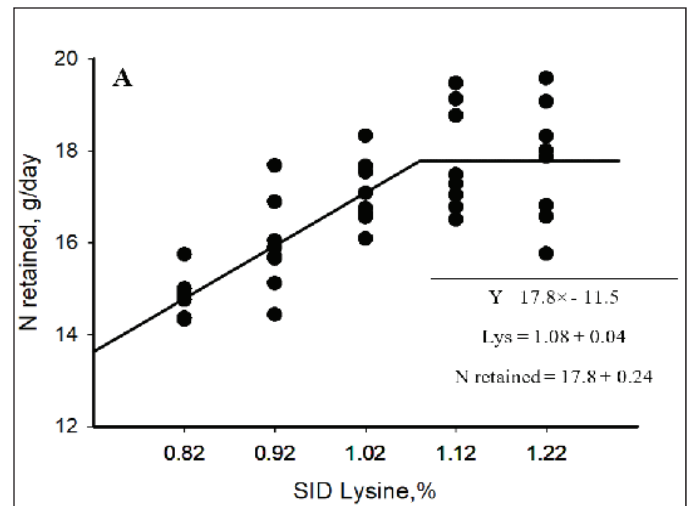


Figure 1. The linear broken-line model analyses estimate of nitrogen retention (NR; g/d) in pigs fed high essential amino acid-nitrogen: total nitrogen ratio (HR; 0.36; A) or low ratio (LR; 0.33; B) diets. The analyses indicate a breakpoint was achieved at 1.08 SID Lys, % at maximum NR at 17.8 g/d for pigs fed the HR diets (Fig 1A). The breakpoint was achieved in pigs fed the LR diet at 1.21 SID Lys, % at maximum NR 19.3 g/d (Fig.1B).

ACKNOWLEDGEMENTS

Funding for this project has been provided by the Government of Saskatchewan and Government of Saskatchewan under the Canadian Agricultural Partnership via the Agriculture Development Fund and CJ Bio. The authors would also like to acknowledge the strategic program funding provided by Sask Pork, Alberta Pork, Ontario Pork, the Manitoba Pork Council, and the Saskatchewan Agriculture Development Fund. In addition, we wish to acknowledge the support of the production and research technicians at Prairie Swine Centre that make it possible to conduct this research.

Inclusion of non-protein nitrogen on lysine requirement for maximum nitrogen retention

M.J. Buchinski^{1,2}, M.O. Wellington³, J.C. Panisson^{1,2}, L.A. Rodrigues^{1,2}, A.K. Shoveller⁴, D.A. Columbus^{1,2}



Miranda Buchinski



Dan Columbus

SUMMARY

Low protein diets have improved nutrient utilization while maintaining animal performance. However, these diets may be limiting in nitrogen (N) content to meet non-essential amino acid (NEAA) requirements, potentially altering essential amino acid (EAA) utilization and requirements. Inclusion of a source of non-protein nitrogen (NPN) may be beneficial for improving EAA utilization for lean gain. An N-balance study was conducted to determine the lysine requirement for maximum nitrogen retention (NR) when pigs are fed diets without and with the inclusion of NPN in the form of ammonium phosphate (AP). Lysine and N content had an effect ($P < 0.05$) on fecal and urinary N output, digestibility, and plasma urea nitrogen (PUN), including an increase in NR and decrease in urinary N output with inclusion of NPN and increasing Lys ($P < 0.01$). A decrease in PUN was observed with increasing Lys ($P < 0.05$). The linear breakpoint model indicated NR was maximized at 1.00% SID Lys (15.6 g/d NR; $R^2 = 0.68$) in pigs fed no AP and at 1.09% SID Lys (16.4 g/d NR; $R^2 = 0.61$) in AP-fed pigs. These results indicate that diets deficient in dietary N reduce NR and Lys requirement, which were in turn increased with NPN supplementation. Future research should continue to assess the impact NPN inclusion has on low-protein diets that are limiting in NEAA-N.

"Results indicate that diets deficient in dietary N reduce nitrogen retention and Lysine requirement, which were in turn increased with non-protein nitrogen supplementation."

INTRODUCTION

The current practice in swine production is to feed low protein (LP) diets, amino acid supplemented diets. These diets are formulated to meet essential amino acid (EAA) requirements according to the ideal protein concept, which allows for a reduction in total dietary protein. There are several benefits to this, such as lowering diet cost and reducing nitrogen (N) excretion. While these benefits are important for industry, there are issues with LP diets. For example, animals require both EAA and non-essential amino acids (NEAA) to ensure proper growth and productivity, and LP diets assume pigs can produce sufficient levels of NEAA to meet their requirements. As the endogenous synthesis of NEAA requires N, dietary N may be a limiting factor in LP diets. When there is a decrease in dietary supply of NEAA-N, the necessary N may be sourced from the catabolism of EAA, impacting efficiency of EAA utilization for lean gain. Consequently, both EAA and NEAA, or a source of N for the synthesis of NEAA, should be provided. A practical method to optimize both EAA and NEAA sources is to consider the essential amino acid-nitrogen:total nitrogen (E:T) ratio, as this ratio gives an indication of sufficiency of both EAA and NEAA. Nitrogen retention (NR) is affected by E:T, with reduced efficiency observed at extreme ratios.

It has been previously shown that non-protein nitrogen (NPN) may be used as a direct source of N in LP diets, for the endogenous synthesis of NEAA. A positive response has been observed in swine when NPN is included in diets that are deficient in NEAA-N. Previous research demonstrated feeding ammonia-N is as effective as feeding synthetic AA or intact protein to growing pigs that are undersupplied in NEAA-N, in terms of maintaining growth performance. The objective of the present study was to determine the effect of including NPN on lysine (Lys) requirement for NR in growing pigs. It was hypothesized that the Lys requirement for NR would be increased when a source of NPN was included in a diet deficient in NEAA-N compared to an unsupplemented diet.



1 Prairie Swine Centre Inc, PO Box 21057, 2105 – 8th Street East, Saskatoon, SK S7H 5N9

2 Department of Animal and Poultry Science, University of Saskatchewan, 51 Campus Dr, Saskatoon, SK S7N 5A8

3 Trouw Nutrition Innovation R&D, Veerstraat 38, 5831JN, Boxmeer, Netherlands

4 Department of Animal Biosciences, University of Guelph, Guelph, ON, Canada, N1G 1Y2

EXPERIMENTAL PROCEDURES

An N-balance study was conducted to determine the lysine requirement for maximum NR when pigs are fed diets without and with the inclusion of NPN in the form of ammonium phosphate (AP). A total of 90 growing barrows with an initial body weight of 20.4 ± 0.46 kg were individually housed in metabolism crates and randomly assigned to 1 of 10 dietary treatments ($n = 9$ pigs/treatment) in 9 blocks in a 2×5 factorial design. Diets contained no ammonium phosphate (NAP; E:T of 0.36, considered to be deficient in N) or were supplemented with 1.7% ammonium phosphate (AP; E:T of 0.33) with graded levels of dietary lysine (Lys; 0.8%, 0.9%, 1.0%, 1.1% and 1.2% standardized ileal digestible [SID]), fed at $2.8 \times$ maintenance metabolizable energy requirements in 2 equal meals each day. A 4-d N-balance collection period was conducted following a 7-d dietary adaptation period. Jugular blood samples were taken on d 2 of the collection period to measure plasma urea N (PUN).

RESULTS AND DISCUSSION

Nitrogen intake was greater in the AP-fed pigs when compared to the NAP-fed pigs and generally increased with increasing Lys content ($P < 0.01$). There was no impact of inclusion of NPN on fecal N output, but Lys content close to NRC requirements reduced fecal N output ($P < 0.05$). Urinary N output decreased and NR (g/d) increased with NPN supplementation and increasing Lys content ($P < 0.01$). Apparent total tract digestibility was greater in the pigs fed NPN ($P < 0.05$). Nitrogen retained as % of intake increased with increasing Lys content ($P < 0.01$), and was greater in NAP-fed pigs ($P < 0.05$).

Two-phase breakpoint analysis determined a Lys requirement of 1.00% SID Lys at 15.6 g/d NR in NAP-fed pigs ($R^2 = 0.68$) and 1.09% SID Lys at 16.4 g/d NR in AP-fed pigs ($R^2 = 0.61$; Figure 1). Two-phase breakpoint analysis also determined a Lys requirement of 1.00% SID Lys at 69.9% NR as % of intake in NAP-fed pigs ($R^2 = 0.64$) and 1.12% at 68.6% NR as % of intake in AP-fed pigs ($R^2 = 0.72$).

Plasma urea N tended to decrease with increasing Lys content ($P < 0.01$). The quadratic breakpoint was determined to be 1.14% SID Lys at 2.67 mg/dL in NAP-fed pigs, while the linear model analyses indicated a breakpoint of 1.12% SID Lys at 1.91 mg/dL in the AP-fed pigs.

Efficiency of Lys utilization for NR (g/d) was not impacted by NPN inclusion. Inclusion of NPN increased the marginal efficiency of utilizing SID lysine (K_{lysine} ; $P < 0.01$), whereas marginal efficiency of utilizing SID N was reduced by NPN inclusion (K_{nitrogen} ; $P < 0.0001$) for protein synthesis. These parameters were also impacted by Lys content, where K_{nitrogen} was increased with Lys content and K_{lysine} was reduced at higher Lys content ($P < 0.0001$; Table 3.3).

IMPLICATIONS

These results indicate that diets deficient in dietary N reduce NR and Lys requirement. Nitrogen retention in g/d was increased with NPN supplementation, likely a result of sufficient dietary N. The higher E:T ratio diets were shown to be limiting in NEAA or N, and indicate that the E:T ratio should be considered during diet formulation as a tool to improve N utilization. Lastly, ammonia-N in the form of AP has been shown to be an acceptable form of N for the improvement of N utilization efficiency in diets lacking NEAA-N, including low protein diets. Future research should continue to assess the impact NPN inclusion has on LP diets that are limiting in NEAA-N, while considering the E:T ratio.

ACKNOWLEDGEMENTS

Funding for this project has been provided by the Government of Saskatchewan and the Government of Canada under the Canadian Agricultural Partnership via the Agriculture Development Fund, Gowans Feed Consulting, Mitacs and CJ Bio America. The authors would also like to acknowledge the strategic program funding provided by Sask Pork, Alberta Pork, Ontario Pork, the Manitoba Pork Council, and the Saskatchewan Agriculture Development Fund. In addition, we wish to acknowledge the support of the production and research technicians at Prairie Swine Centre that make it possible to conduct this research.

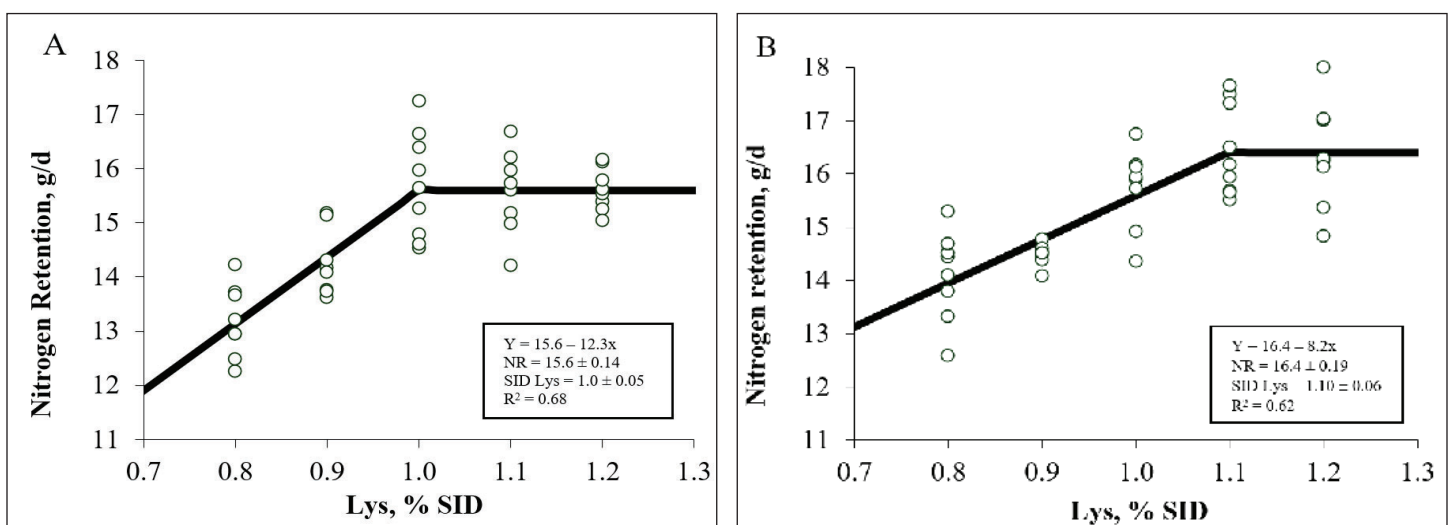
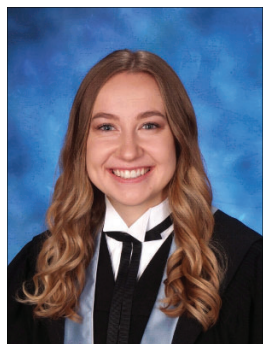


Figure 1. The two-phase breakpoint analyses estimates for nitrogen retention (NR; g/d) in pigs fed no ammonium phosphate (NAP; A) and ammonium phosphate (AP; B). The analyses indicated a breakpoint of 1.00% with maximum NR at 15.6 g/d in pigs fed the NAP diet. A breakpoint of 1.09% with maximum NR at 16.4 g/d was achieved in pigs fed the AP diet.

Inclusion of non-protein nitrogen and lysine in grower pig diets on growth performance

M.J. Buchinski^{1,2}, M.O. Wellington³, J.C. Panisson^{1,2}, L.A. Rodrigues^{1,2}, A.K. Shoveller⁴, D.A. Columbus^{1,2}



Miranda Buchinski



Dan Columbus

"Ammonium phosphate can improve feed efficiency and increase lean depth in growing pigs while maintaining similar ADG and BW."

INTRODUCTION

In recent years, the swine industry has transitioned to feeding lower total protein diets supplemented with essential amino acids (EAA). This shift has allowed for a reduction in dietary protein and subsequently nitrogen (N) content and excretion. While the introduction of these diets has enhanced aspects of the industry by improving the animal's efficiency of N utilization, they may result in reduced growth performance. Pigs require both EAA and non-essential amino acids (NEAA) to ensure proper growth, and LP diets assume pigs can produce the required levels of NEAA even with a lower dietary N content. However, reduced dietary N in low protein diets reduces the animal's ability to endogenously synthesize NEAA and utilize EAA, which may impact growth of the animal. When dietary N is insufficient, the required N for the synthesis of NEAA may be sourced from the catabolism of EAA, impacting efficiency of AA utilization for lean gain. Therefore, both EAA and NEAA, or a source of N, should be provided in the diet in order to ensure adequate N available for the endogenous synthesis of NEAA. In order to maximize growth and EAA utilization, both EAA-N and total N content of the diet should be considered. Previous studies have shown that N retention is affected by the EAA-N:total N (E:T) ratio, with reduced retention observed at extreme ratios. Therefore, the E:T ratio may be used as an indicator of N sufficiency.

It has been demonstrated that non-protein nitrogen (NPN), in the form of ammonia-N, may be used as a direct source of N for the synthesis of NEAA to maintain growth performance of pigs. Results from our previous study indicated that pigs fed high E:T ratio diet had reduced N retention and Lys requirement as a result of N deficiency, and N retention can be improved with NPN supplementation. As a result of increased N retention, the Lys requirement was also increased. The objective of the current study was to determine the effect of dietary NPN inclusion and lysine (Lys) content on growth performance, N digestibility and output, and carcass characteristics of 20-40kg growing pigs. It was hypothesized that growth performance, N digestibility and output, and carcass quality will be improved in pigs fed a diet containing a source of NPN (resulting in a low E:T ratio) and greater Lys content compared to pigs fed a diet deficient in NEAA-N (high E:T ratio).

SUMMARY

Results from our previous study demonstrated that inclusion of non-protein nitrogen (NPN) in a diet with a high essential amino acid:nitrogen:total nitrogen (E:T) ratio (i.e. limiting in total nitrogen [N]) increased the Lys requirement and maximum N retention in growing pigs. A growth performance study was conducted with grower pigs (20.2 ± 2.18 kg) fed 1 of 6 diets, with factors of NPN inclusion (no ammonium phosphate [NAP; E:T ratio of 0.35] or ammonium phosphate inclusion at 1.7% [AP; E:T ratio of 0.33]) and dietary lysine (Lys; 1.03, 1.15, or 1.27% standardized ileal digestible).

Overall average daily gain and final body weight increased with increasing Lys, but were not impacted by dietary NPN content ($P > 0.05$). Inclusion of NPN reduced feed intake and improved feed efficiency compared to pigs fed NAP diets ($P < 0.05$). Inclusion of NPN increased fecal N output ($P < 0.05$). Pigs fed AP diets had increased lean depth ($P < 0.05$). These results suggest that inclusion of NPN, as ammonium phosphate, can improve feed efficiency and increase lean depth while maintaining similar growth performance.



1 Prairie Swine Centre Inc, PO Box 21057, 2105 – 8th Street East, Saskatoon, SK S7H 5N9

2 Department of Animal and Poultry Science, University of Saskatchewan, 51 Campus Dr, Saskatoon, SK S7N 5A8

3 Trouw Nutrition Innovation R&D, Veerstraat 38, 5831JN, Boxmeer, Netherlands

4 Department of Animal Biosciences, University of Guelph, Guelph, ON, Canada, N1G 1Y2

EXPERIMENTAL PROCEDURES

Experiment A growth performance study was conducted to determine the impact of NPN inclusion on growth metrics and carcass composition. A total of 240 mixed-sex growing pigs with an initial body weight (BW) of 20.2 ± 2.18 kg were housed in groups of 5 pigs/pen. Pens were randomly assigned to 1 of 6 dietary treatments over 3 blocks ($n = 8$ pens/treatment) in a 2×3 factorial design, with factors of NPN inclusion (no ammonium phosphate [NAP] or ammonium phosphate inclusion at 1.7% [AP]) and dietary lysine (Lys; 1.03%, 1.15% or 1.27% standardized ileal digestible). The lowest Lys level was based on NRC (2012) requirement, the middle level considers the requirement determined in our previous study, and the highest level is equal distance above the middle level. The NAP and AP diets were formulated to have an E:T ratio of 0.35 (considered to be deficient in N) and 0.33, respectively. Pigs had ad libitum access to feed and water for the duration of the experiment (28 d). Individual pig body weight and feed intake were measured weekly to determine average daily gain (ADG), average daily feed intake (ADFI), and gain:feed (G:F). Fresh fecal samples were obtained on d 15 to determine apparent total tract digestibility (ATTD). On d 28, backfat and lean depth were measured on 2 pigs per pen, one male and one female.

RESULTS AND DISCUSSION

Inclusion of NPN reduced ADG from d 15 – 21 ($P < 0.05$), but did not impact daily gain in any other experimental weeks or overall ($P > 0.05$; Table 1). Average daily gain was improved with increasing dietary Lys content from d 15 – 21 and overall ($P < 0.05$). Weekly BW was not impacted by NPN inclusion, except on d 21 where it was reduced ($P < 0.05$). Body weight was increased with increasing Lys on d 14, d 21 and d 28. Average daily feed intake was impacted by NPN inclusion ($P < 0.01$), with AP-fed pigs consuming less feed over the entire experimental period (Table 1). This was reflected in G:F, which was greater in pigs fed NPN for the first 2 experimental weeks ($P < 0.05$) as well as overall ($P < 0.01$), but was not impacted by Lys content or $N \times$ Lys interaction.

The ATTD (%) of N was not impacted by NPN inclusion, Lys content or their interaction ($P > 0.05$; Table 1). Fecal N output was increased in AP-fed pigs ($P < 0.05$). Lean depth was impacted by N content, with AP-fed pigs having greater lean depth than NAP-fed pigs ($P < 0.05$; Table 1).

IMPLICATIONS

These results suggest that inclusion of NPN, as ammonium phosphate, can improve feed efficiency and increase lean depth in growing pigs while maintaining similar ADG and final BW. This indicates that NPN, in the form of ammonium phosphate, improves N utilization efficiency and can improve carcass composition in diets deficient in NEAA-N. The present study confirms our previous trial's results, and demonstrates that more research is needed to further our understanding of the impact NPN has on performance measures and carcass characteristics in growing pigs and how the E:T ratio can be used as a tool in diet formulation, particularly in diets that may be limiting in NEAA-N.

ACKNOWLEDGEMENTS

Funding for this project has been provided by the Government of Saskatchewan and the Government of Canada under the Canadian Agricultural Partnership via the Agriculture Development Fund, Gowans Feed Consulting, Mitacs and CJ Bio America. The authors would also like to acknowledge the strategic program funding provided by Sask Pork, Alberta Pork, Ontario Pork, the Manitoba Pork Council, and the Saskatchewan Agriculture Development Fund. In addition, we wish to acknowledge the support of the production and research technicians at Prairie Swine Centre that make it possible to conduct this research.

Table 1. Growth performance, carcass traits, and digestibility of nitrogen in pigs fed diets with and without ammonium phosphate at 1.7% inclusion with increasing SID Lys content¹

Lys, % SID	No ammonium phosphate			Ammonium phosphate			SEM	P-values		
	1.03	1.15	1.27	1.03	1.15	1.27		N	Lys	N × Lys
BW D 28, kg	45.3	46.7	46.5	44.9	45.1	46.9	0.65	0.19	0.01	0.10
Overall ADG, kg/d	0.90	0.93	0.94	0.88	0.90	0.94	0.02	0.24	0.02	0.73
Overall ADFI, kg/d	0.90	0.93	0.94	0.88	0.90	0.94	0.03	< 0.001	0.27	0.51
Overall G:F, kg/kg	0.58	0.59	0.59	0.59	0.61	0.61	0.01	0.002	0.08	0.51
Backfat, mm	6.6	6.7	6.8	6.4	6.4	6.5	0.32	0.15	0.80	0.89
Lean, mm	36.5	37.9	37.3	38.0	40.1	38.9	1.05	0.02	0.13	0.91
Fecal N, g/d	5.61 ^B	6.36 ^{AB}	5.97 ^{AB}	7.18 ^A	5.94 ^{AB}	6.65 ^{AB}	0.225	0.02	0.72	0.01
ATTD N, %	82.6	82.1	82.7	80.3	83.2	81.8	0.72	0.26	0.30	0.11

ADFI, average daily feed intake; ADG, average daily gain; ATTD, average total tract digestibility; BW, body weight; G:F, gain:feed; Lys, lysine; N, nitrogen; SEM, standard error of the mean; SID, standardized ileal digestible.

¹Data presented are least-square means ($n=8$ pens/treatment).

^{A,B} Values within a row without a common superscript differ significantly ($P < 0.05$).

Effect of feeding time on the proportion of sows farrowing during work hours

J. Panisson and D. Columbus



Josi Panisson



Dan Columbus

"Feeding in the morning may be beneficial for maximizing the number of farrowing events that occur and are completed when workers are present."

SUMMARY

It is sometimes necessary to provide assistance to sows and piglets during farrowing in order to improve piglet survival, resulting in increased labour costs. There is evidence in cattle and ewes that feeding at night results in an increase in the incidence of calvings during the day. In commercial farms, sows are typically fed during daytime hours, with a high percentage of farrowing events occurring unassisted overnight. The objective of this study was to determine the effect of feeding time (morning vs evening) on farrowing time in sows. A total of 278 sows were used in groups of 12 sows/block and 11 blocks/treatment. Sows were assigned to either morning (0700 h) or evening (1900 h) initiation of feeding upon entry to farrowing room (~d110 of gestation). All sows were placed on a common lactation diet and fed according to established sow feeding curves with feed intake controlled and monitored automatically (Gestal Solo, Jyga Technologies). All sows were switched to a 0700 h feeding time post-farrow. Cameras were placed in each crate to allow for recording of all farrowing events. There was no difference in born alive, stillborn and mummies ($P > 0.10$). There was an increase for total number of piglets weaned and a decrease in pre-weaning mortality in sows that received PM feeding. Initiating sow feeding in the morning increased the frequency of farrowing during the day (7:00 am to 3:00 pm) compared to evening fed sows ($P < 0.001$; 51.43% vs 21.95%, respectively). There was no difference in farrowing duration between treatments ($P > 0.10$). These results suggest that feeding in the morning may be beneficial for maximizing the number of farrowing events that occur and are completed when workers are present.

INTRODUCTION

It is sometimes necessary to provide assistance to sows and piglets during farrowing in order to improve piglet survival (e.g., drying of piglets, ensuring colostrum intake, assisting with piglet delivery), resulting in increased labour costs. Close monitoring of the farrowing process allows for more effective intervention, resulting in increased number of pigs weaned which can have a significant impact on profitability. Staff availability is a limiting factor in providing farrowing monitoring and assistance as staff must be available 24 hours per day, increasing labour costs. There is evidence in cattle and ewes that feeding at night results in an increase in the incidence of calvings during the day. In commercial farms, sows are typically fed during daytime hours, with a high percentage of farrowings occurring unassisted overnight. With the availability and adoption of automated feeding technology for sows in farrowing, it is possible to easily adjust feeding time pre-farrow. Increasing the probability and proportion of farrowing events that occur during the day will reduce labour requirements and improve productivity as well as improve pig performance.

The objective of this project was to determine the effect of feeding time (morning vs evening) of farrowing in sows. We hypothesized that when feeding time is shifted to the evening prior to farrowing that there will be an increase in the proportion of farrowing events that occur during the day.

EXPERIMENTAL PROCEDURES

A total of 278 sows were used in groups of 12 sows/block and 11 blocks/treatment. Sows were moved into farrowing rooms approximately 5 days before expected farrowing date and placed on a common lactation diet and fed according to established sow feeding curves with feed intake controlled and monitored automatically. Each room of sows were placed on either morning (0700 h) or evening (1900 h) initiation of feeding in the pre-farrowing period (~d110 of gestation). All sows were switched to a common feeding program post-farrow. Cameras were placed above each farrowing crate to allow for recording of all farrowing events. Initiation of farrowing, completion of farrowing, and farrowing duration data were collected. Total number of piglets born alive, stillborn and mummies, total number of weaned piglets, foster on, foster off and pre-weaning mortality were recorded.



RESULTS AND DISCUSSION

Of the 278 sows initially placed on test, 10 sows were removed due to low birth numbers and 30 were excluded from data calculations due to malfunctioning feeders resulting in insufficient feed intake data, 20 sows were removed due to mortality or problem with the video recording.

Sow and litter characteristics and performance: There was no difference in sow parity between treatments ($P > 0.10$). There was no difference in total number of piglets born alive, stillborn and mummies, foster on and foster off ($P > 0.10$). However, there was an increase in total number of piglets weaned and a decrease in pre-weaning mortality in sows that received PM feeding ($P < 0.05$).

Sow feed intake: Sows receiving PM feed had an increased total feed intake ($P = 0.003$) and a tendency for increased daily feed intake ($P < 0.10$). The increase in the total feed intake could be because they received the PM feed about one day extra compared to the AM fed sows ($P = 0.004$).

Frequency of start and end of farrowing: Initiating sow feeding in the morning increased the frequency of farrowing initiation during the day (7:00 am to 3:00 pm) compared to evening-fed sows (Figure 1A; $P < 0.001$; 51.43% vs 21.95%, respectively). There was no difference between morning and evening feeding time on the frequency of farrowing completion during work hours and/or after work hours (Figure 1B; $P > 0.10$). There was no difference in farrowing duration between treatments ($P > 0.10$).

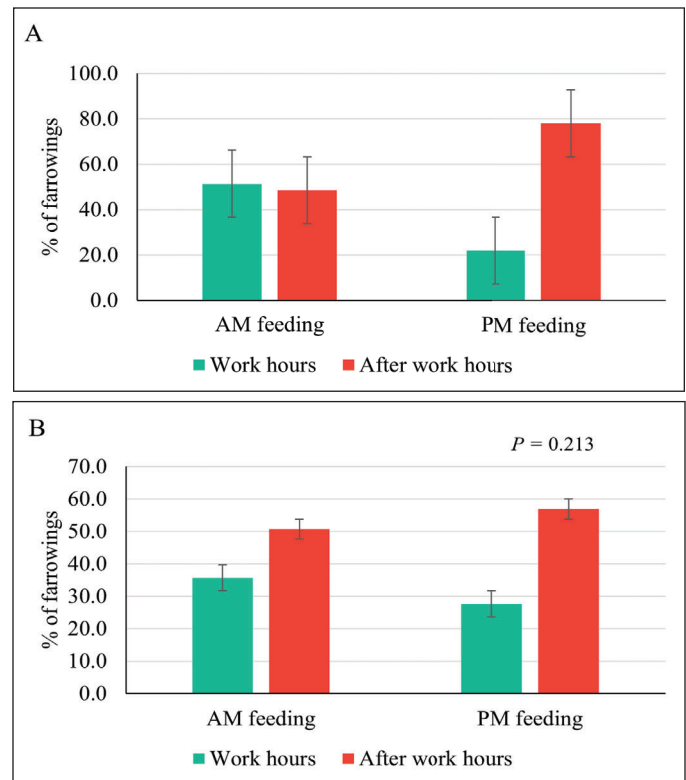


Figure 1. Effect of initiation of feeding time (AM vs. PM) on frequency of farrowing initiation (A) and farrowing completion (B) during work hours (0700 to 1500 h) or after work hours (1500 to 0700 h)

IMPLICATIONS

These results suggest that initiating feeding in the morning may be beneficial for maximizing the number of farrowing events that occur and are completed when workers are present. Further research is required to determine optimal initiation of feeding time pre-farrow to further improve farrowing outcomes.

ACKNOWLEDGEMENTS

Funding for this project was provided by the Government of Saskatchewan and the Government of Canada under the Canadian Agricultural Partnership via the Agriculture Demonstration of Practices and Technologies (ADOPT) program. The authors would also like to acknowledge the strategic program funding to Prairie Swine Centre provided by Sask Pork, Alberta Pork, Ontario Pork, the Manitoba Pork Council and the Saskatchewan Agriculture Development Fund. In addition, we wish to acknowledge the support of the production and research technicians at Prairie Swine Centre that make it possible to conduct this research.

Response of growing pigs to the inclusion of hybrid rye in low or high energy diets

M.N. Smit¹, J. Panisson¹, and A.D. Beaulieu^{1,2}



Miranda Smit



Denise Beaulieu

SUMMARY

This experiment was designed to determine if increased dietary energy content will compensate for the reduced feed intake previously shown in pigs fed diets with hybrid rye substituting for wheat. We hypothesized that pigs fed 40% hybrid rye would perform better on the high than the low energy diets. A total of 160 pigs (70.1 kg BW) housed into 32 pens, 5 pigs per pen, were fed diets with 0 or 40% hybrid rye (var. 'KWS Bono'), either with low (2350) or high (2450) kcal NE per kg of diet over two growth phases (Phase 1; 70 to 85 kg BW; Phase 2; 85 to 130 kg BW).

Overall (d 0 to 50), pigs fed the low energy rye diets gained 77 g/d less than those fed the high energy rye diet or the low energy diet without rye, which was caused by an effect observed in the first 17 days of the trial. Final BW and overall feed intake were not affected by rye inclusion or NE level. The NE intake was greater and feed efficiency (G:F) was reduced in pigs fed rye diets compared to those fed diets without rye, whereas there was no effect of NE level on NE intake or G:F. Feed cost per pig and per kg BW gain was lower for the low NE vs. the high NE diets. There was no effect of rye inclusion on feed cost per pig, but feed cost per kg BW gain tended to be 0.04 CAD higher for diets with rye compared to those without. In conclusion, pigs can be fed diets including 40% hybrid rye with only minor changes in growth performance. Increasing the NE level of the first phase diet in the grower-finisher barn may be useful to avoid a reduction in growth performance when feeding hybrid rye. Reducing the dietary NE level can be a good strategy to save money on feed costs in the grower-finisher barn.

INTRODUCTION

Long term sustainability of the livestock industries in the Canadian Prairies is dependent on increased use of alternative feeds and by-products. One such example is rye, a cereal crop comparable to wheat. New rye hybrids with improved yield potential of 25 to 30% higher than older varieties has resulted in increased acreages planted in Saskatchewan and Alberta, making it competitive as a feed grain. The new hybrid varieties (developed by KWS in Germany) not only have increased yields but have improved grain quality and are more resistant to ergot.

Rye has the potential to be a cost-effective ingredient in swine diets. Recent research demonstrated that the new hybrid rye varieties could replace wheat or corn in diets fed to growing pigs with minor effects on growth performance or carcass traits. Several studies observed slightly reduced feed intake for pigs fed increasing hybrid rye substituting for wheat or corn, which in turn resulted in lower average daily weight gain. Typically, the growing pig will eat to meet their energy requirements, meaning that for diets with a high energy value a lower daily feed intake is needed to maintain growth performance. The current experiment was designed to determine if an increased dietary energy content will compensate for reduced feed intake of pigs fed diets formulated with rye substituting for wheat. Our objective was to determine the effects of 40% hybrid rye inclusion in diets formulated to be either low or high net energy (NE) on growth, feed intake, and energy digestibility of growing pigs. We hypothesized that growing-finishing pigs fed 40% hybrid rye would perform better on the high than the low energy diets.

"Rye has the potential to be a cost-effective ingredient in swine diets."



¹ Prairie Swine Centre Inc, PO Box 21057, 2105 – 8th Street East, Saskatoon, SK S7H 5N9

² Department of Animal and Poultry Science, University of Saskatchewan, 51 Campus Dr, Saskatoon, SK S7N 5A8

EXPERIMENTAL PROCEDURES

At the Prairie Swine Centre, 80 barrows and 80 gilts (~70 kg BW) were placed in 32 pens, 5 pigs per pen, and allocated to be fed diets with either 0% or 40% hybrid rye replacing wheat, and with either low (2350 kcal) or high (2450 kcal) NE per kg of diet, resulting in 4 treatments and n = 8 pens per treatment. Hybrid rye fed in this trial was the variety 'KWS Bono' developed by KWS LOCHOW GMBH (Bergen, Germany) and obtained from FP Genetics Regina, SK. The low energy diets were formulated to have similar dietary inclusion levels of all major ingredients compared to the high energy diets, except for a decreased inclusion of canola oil. Test diets were fed to slaughter weight over 2 growth phases (Phase 1; 70 to 85 kg BW; Phase 2; 85 to 130 kg BW). Pigs had free access to water and the assigned test diet in pelleted form.

RESULTS AND DISCUSSION

The hybrid rye fed in this experiment had relatively low levels of mycotoxins, including ergot. Energy digestibility was unaffected by rye inclusion and was reduced in the low relative to the high energy diets.

For the first 8 days of the trial, pigs fed diets with hybrid rye had reduced feed intake (Figure 1). The reduction in feed intake with the hybrid rye diets was greater in the low vs. the high NE diets (reduction of 0.18 vs. 0.07 g/d, respectively). Feed efficiency (G:F) was also reduced in pigs fed the low energy rye diet, resulting in less weight gain than pigs fed one of the other three diets, and lower body weight on d 8. In the next 9 days (d 8 – 17), pigs on the low energy hybrid rye diets had numerically the lowest feed intake and feed efficiency, resulting again in lower weight gain and lower body weight on d 17. For the next growth period (d 17 to 28), the opposite happened with pigs fed the low energy rye diet gaining the most weight and having the best feed efficiency, perhaps indicating compensatory gain happened. Body weight was slightly lower for the low energy rye diets than the other diets on d 28. There was no effect of rye inclusion or NE level on weight gain after d 28, and body weight on d 43 and d 50 was no longer different among the treatments (Figure 2).

Looking at the overall results for the entire trial (d 0 to 50; Figure 3), pigs fed the low energy rye diets gained 77 g/d less than those fed the high energy rye diet or the low energy diet without rye. Overall feed intake was not affected by hybrid rye inclusion or NE level. Net energy intake was consistently greater for pigs fed diets with rye compared to those fed diets without rye. Overall feed efficiency was reduced in pigs fed rye diets compared to those fed diets without rye but was not affected by NE level.

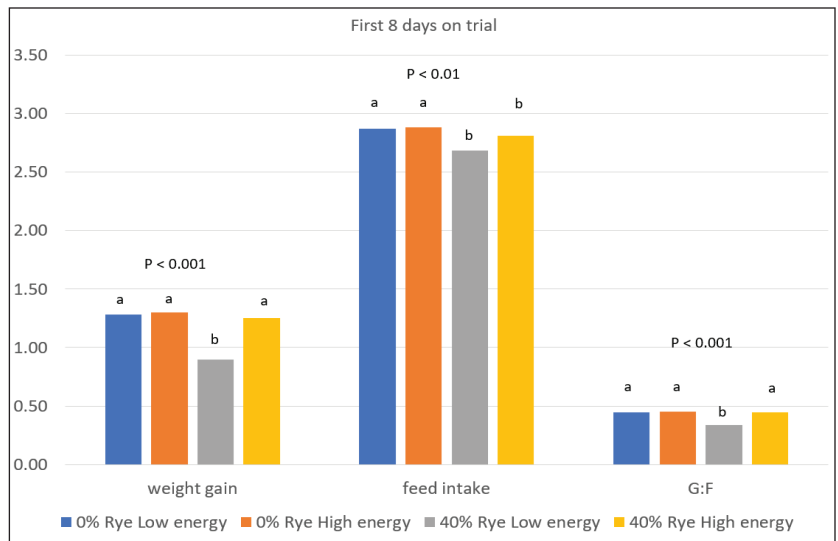


Figure 1. Growth performance in the first 8 days on trial of pigs fed 0 or 40% hybrid rye with low (2350 Mcal) or high (2450 Mcal) net energy

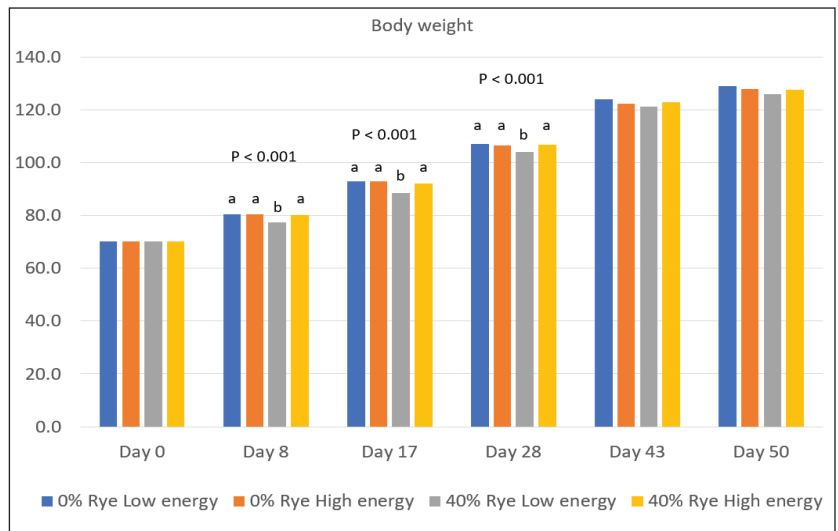


Figure 2. Body weight of pigs fed 0 or 40% hybrid rye with low (2350 Mcal) or high (2450 Mcal) net energy

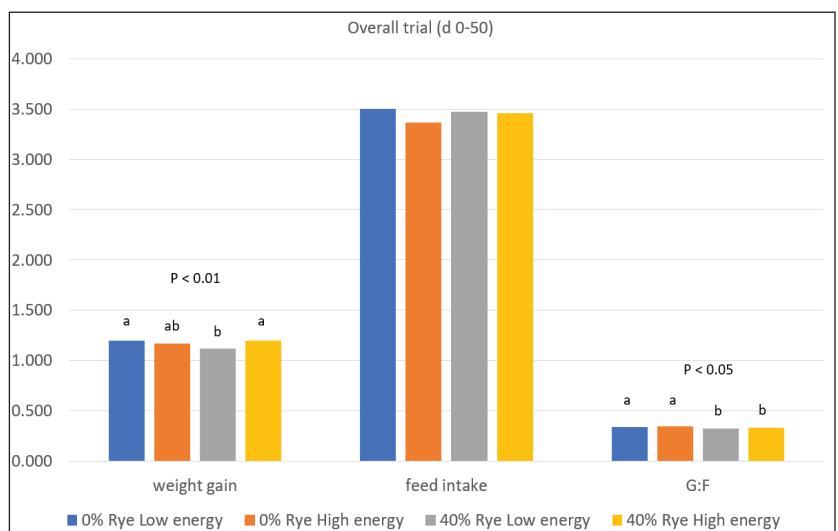


Figure 3. Overall (d 0 – 50) growth performance of pigs fed 0 or 40% hybrid rye with low (2350 Mcal) or high (2450 Mcal) net energy

We calculated the average cost of all ingredients between June and December 2022 on the Canadian Prairies. The rye diets were slightly cheaper than the wheat diets, but feed cost per pig was similar between the two grains. On the other hand, feed cost per kg BW gain tended to be \$0.04 higher for pigs fed hybrid rye vs. the wheat control diet, due to the lower overall feed efficiency for pigs fed the hybrid rye diets. The low NE diets were cheaper than the high NE diets, which translated to \$5.22 lower feed cost per pig and \$0.06 lower feed cost per kg BW gain for pigs fed low vs. high NE diets (Table 1).



"Pigs did well on the 40% hybrid rye diets regardless of the dietary NE level."

IMPLICATIONS

Altogether, our data show that in younger animals the NE level of the diet may need to be considered when formulating diets including hybrid rye to avoid a reduction in growth performance. After the first 17 days, pigs did well on the 40% hybrid rye diets regardless of the dietary NE level, resulting in similar feed intake and final body weight as pigs fed wheat diets.

A good strategy to save money on feed costs in the grower-finisher barn would be to reduce the dietary NE level, as long as pigs can increase their feed intake to make up for the reduced energy level.

Table 1. Feed cost of grower-finisher pigs fed high or low NE diets with or without 40% hybrid rye¹ inclusion²

	Rye		NE		0% Rye		40% Rye		SEM	P-values		
	0%	40%	Low	High	Low NE	High NE	Low NE	High NE		Rye	NE	Rye*NE
Feed cost/pig	89.43	89.73	86.97	92.19	87.98	90.88	85.95	93.51	1.61	0.833	0.002	0.115
Feed cost/kg BW gain	1.52	1.56	1.51	1.57	1.48	1.57	1.54	1.58	0.03	0.059	0.002	0.168

¹ KWS LOCHOW GMBH (Bergen, Germany).

² LSmeans based on 8 pens of 5 pigs each per hybrid rye level × NE level.

ACKNOWLEDGEMENTS

The authors acknowledge funding from The Government of Saskatchewan and the Government of Canada under the Canadian Agricultural partnership and from KWS Seeds, Germany. We thank FP Genetics, Regina for the contribution of the rye. The authors would also like to acknowledge the strategic program funding provided to the Prairie Swine Centre, by Sask Pork, Alberta Pork, Ontario Pork, the Manitoba Pork Council and the Saskatchewan Agriculture Development Fund. In addition, we also wish to express appreciation for the support of the production and research technicians at Prairie Swine Centre that make it possible to conduct this research, and to the Canadian Feed Research Centre, North Battleford, SK for diet preparation.

Weaned piglet mortality during long transport events is affected by season

H.R. Golightly¹, T.L. O'Sullivan¹, J.A. Brown² and Y.M. Seddon³



Hannah Golightly



Yolande Seddon

SUMMARY

Limited information is available on factors associated with piglet mortality during weaner transport events. This study aimed to identify transport characteristics associated with the occurrence of in-transit mortality or increased rates of mortality (≥ 1 piglet found dead on arrival) using records of weaned piglet transport events voluntarily provided by five Canadian swine companies. A total of 810 long duration (>8h to <28h) weaned piglet (4.2-7.7kg) transport events were analysed to investigate risk factors for the occurrence of in-transit mortality. Season of transport was the only significant independent variable in the final logistic regression model. The odds of a transport event having mortality occur was ~ 2 times greater during winter (December, January, February) compared to spring (March, April, May), summer (June, July, August) and fall (September, October, November). A separate dataset (755 long duration weaned piglet [4.2-7.9kg] transport events) was used to identify risk factors for increased rates of in-transit mortality. In-transit mortality rates ranged from 0.00-6.16%, with an average of 0.15%. Season of transport was again the only significant independent variable in the final model. The rate of piglet death in-transit was increased in all seasons compared to the summer with winter transport having the highest predicted rates of in-transit mortality (5x greater than summer and 3x greater than fall and spring). These results suggest that winter transport in Western Canada is an area of opportunity to reduce in-transit mortality during long duration weaned piglet transport events.

INTRODUCTION

In-transit mortality is an indicator of severe welfare compromise and is typically recorded in documentation accompanying commercial transport events. Despite this, previous investigations of factors associated with weaned piglet mortality during transport are limited. Previous research showed that in-transit mortality rates of weaned piglets (6.5 ± 0.7 kg) were greatest during transport events conducted in average ambient temperatures $>25^\circ\text{C}$, increasing further with farther transport distances. However, the lowest temperature category included in that study was $<15^\circ\text{C}$ and therefore likely does not represent the low temperatures encountered during winter transport in Canada (e.g., -20°C). For young piglets, cold stress is a welfare concern due to their lack of innate warming mechanisms and limited body reserves. Three-week old piglets are most comfortable when exposed to temperatures between 22 and 30°C . In addition to cold weather transport conditions, the association of trip factors including trailer type and multiple loading or unloading stops with weaned piglet mortality in-transit have yet to be evaluated. Studies investigating risk factors for in-transit mortality of piglets transported at three to four weeks of age capturing seasonal conditions experienced in Canada are needed to support the development of specific management recommendations for this unique age group. As such, the objectives of this study were to identify transport characteristics that were associated with the occurrence of in-transit mortality and/or associated with increased rates of in-transit mortality using a retrospective dataset containing records of weaned piglet transport events obtained from multiple Canadian swine companies and years of transport. Based on previous research, factors hypothesized to be associated with both the increased occurrence and rate of trip mortality were extreme temperatures (high or low) and long trip durations.



This work has been published in Preventive Veterinary Medicine 217 (2023), 105961.

¹ Department of Population Medicine, Ontario Veterinary College, University of Guelph, 50 Stone Rd E, Guelph, ON N1G 2W1

² Prairie Swine Centre Inc, PO Box 21057, 2105 – 8th Street East, Saskatoon, SK S7H 5N9

³ Department of Large Animal Clinical Sciences, Western College of Veterinary Medicine, University of Saskatchewan, 52 Campus Drive, Saskatoon, SK S7N 5B4

EXPERIMENTAL PROCEDURES

Weaned piglet transport records collected between 2013 and 2018 (n = 8891) were voluntarily provided by five Canadian companies conducting weaned piglet transport events. These five companies included three production companies (an integrator, a cooperative, and a stand-alone company) and two livestock transport companies moving piglets for private farms. The existing information provided were used to match additional information to each company's dataset (trip distance, departure and arrival temperature), calculate additional parameters (average piglet weight, estimated trip duration, in-transit mortality) and generate categorical summary variables (multiple origin barns, border crossing, multiple destination barns). As most short transport events did not provide mortality data, the decision was made to analyze data only from transport events between 8 and 28h in duration, resulting in a dataset with 810 long transport events. A mixed logistic regression model was used to look at associations of trip characteristics with a transport event having ≥ 1 piglet found dead on arrival. One company with data available from multiple years and with a range in trip durations greater than 8h was selected to study risk factors for increased rates of in-transit mortality in greater detail, resulting in a dataset with 755 long transport export events that was analysed by negative binomial regression.



RESULTS AND DISCUSSION

In total, 64% of the initial dataset included trips less than one hour in duration with 2% of trips recording a mortality, while 13% of the initial dataset included trips between eight and 28h with 30% recording mortality.

Occurrence of in-transit mortality: Longer trip durations, use of a potbelly trailer, larger load sizes, and winter transport had significantly greater odds of a trip having mortality occur, while average piglet weight and interruptions were not significantly associated. Season of transport was the only significant independent variable in the final logistic regression model. The odds of a transport event having mortality occur was approximately 2 times greater during the winter (December, January, February) compared to the spring (March, April, May), summer (June, July, August) and fall (September, October, November), with no differences observed between the other seasons.

Rates of in-transit mortality: Models of in-transit mortality rates included the factors trip duration, interruptions, season and year. The rate of in-transit mortality was greater for transport events occurring in the winter compared to the other seasons. The greatest difference was observed for trips occurring in the winter compared to those in the summer, and the least for trips occurring in the winter compared to those in the fall, with trips in the winter compared to the spring intermediate. The rate of in-transit mortality for trips conducted in the fall was 1.8 times greater than those conducted in the summer, and the rate of in-transit mortality for trips conducted in the spring was 1.6 times greater than those conducted in the summer. The rate of in-transit mortality was significantly less for transport events occurring in the summer relative to all other seasons. For every 10,000 piglets at risk (transported), the predicted rate of piglet death during transport was 27.1 piglets during winter months, 9.9 during fall months, 8.7 during spring months, and 5.5 during summer months.

"The rate of in-transit mortality was greater for transport events occurring in the winter compared to the other seasons."

IMPLICATIONS

This research identified winter transport as a potential area of opportunity to reduce the occurrence and rate of in-transit mortality during long duration weaned piglet transport events in Western Canada. Further, these findings suggest that the development of specific transport recommendations for weaned piglets may be beneficial. Investigations of management practices and factors which modulate cold weather conditions such as space allowance and bedding provision would be particularly useful in informing transport recommendations for this young age group.

ACKNOWLEDGEMENTS

This research was funded by the Saskatchewan Ministry of Agriculture, through the Agriculture Development Fund (ADF) [project #20160301], with core funding support from Alberta Pork, Manitoba Pork Council, and the Saskatchewan Pork Development Board. Funding was also provided by Swine Innovation Porc, Agriculture and Agri-Food Canada, provincial producer organizations and industry partners including Alberta Pork, Les Eleveurs de Porc du Quebec, Manitoba Pork, New Brunswick Pork, Ontario Pork, PEI Pork, and Sask Pork, within the Swine Cluster 3 research program [grant #17127]. The authors gratefully acknowledge the companies who provided the records for this research, the company representatives who assisted with the data, and those involved in record compiling, cleaning, and validation, including Hauwa Bwala, Ewen McCairns, and Enise DeCaluwe-Tulk.

Weaned piglet transport practices in Canada

H.R. Golightly¹, T.L. O'Sullivan¹, J.A. Brown² and Y.M. Seddon³



Hannah Golightly



Yolande Seddon

SUMMARY

The objective of this study was to describe characteristics of weaned piglet transport events that occurred between 2014 and 2018 using records provided by five Canadian swine companies. The dataset included records from 6203 transport events involving the transport of approximately 6.9 million piglets (4.1–7.9 kg) from 62 farm origin sites in Alberta, Ontario, or Saskatchewan, Canada. Most transport events ended at farms in Canada (71.3%), while the remaining transports delivered piglets to one of eight American states. The predominant trailer types used were Straightdeck (51.4%) and Potbelly (36.6%), but this did not reflect the number of piglets transported as Potbelly trailers have greater load capacity. Transport events most frequently involved loading piglets from one origin barn and delivering them to a single destination barn (78.1%). Only transport events involving export to the United States picked up piglets from, or delivered them to, more than one farm site. Most transport events had very short trip distances (median distance: 48.0 km; IQR: 497.0), but a large range in distances was observed (1.8–2931.2 km). Ambient temperature during these transport events ranged from -30.3–28.7 °C. Overall, less than 10% of transport events had mortality occur. The average in-transit mortality rate observed was 0.027%. However, instances of mortality over 1% did sporadically occur and could translate to considerable losses given the large load sizes common for piglets of this age (median load size: 1105 piglets; IQR: 1036 piglets). These data provide a better understanding of the interconnectedness of the Canadian swine industry as well as common transport practices which may inform future research on disease transmission in swine transport networks, and piglet welfare during transport.

INTRODUCTION

Canada's swine industry relies on transport of weaner pigs from sow herds to nursery farm sites. This practice helps to minimize disease transfer to piglets and allows for sow herds to be located in more biosecure regions, with grower pig farms located closer to feed supplies and packer facilities. Canadian transport practices for shipments of newly weaned piglets are not well-described despite documentation requirements for those transporting animals. This documentation is not available for public access. Other sources of data available on weaned piglet transport in Canada include production and export records provided by government agencies. These data are aggregated by province and pig production class and are limited in terms of the information they provide related to transport event characteristics. As such, a significant gap exists when characterizing weaned piglet transport practices in Canada. Information on weaned piglet transport practices beyond what is currently available is valuable for understanding the interconnectedness of the Canadian swine industry. Information such as frequency in which multiple barns are loaded from by one truck, trip duration, average weight of piglets at transport, etc. can help assess research findings pertaining to transport practices on piglet welfare. Documenting what trip durations, load sizes, and trailer types are commonly used would be highly valuable in informing what conditions should be captured in future experimental studies. Finally, this information can inform disease spread models. Therefore, the objective of this retrospective observational study was to describe the characteristics of transport events involving piglets at or near the time of weaning using Canadian transport record data provided by industry partners.



This work has been published in Preventive Veterinary Medicine 216 (2023), 105931.

¹ Department of Population Medicine, Ontario Veterinary College, University of Guelph, 50 Stone Rd E, Guelph, ON N1G 2W1

² Prairie Swine Centre Inc, PO Box 21057, 2105 – 8th Street East, Saskatoon, SK S7H 5N9

³ Department of Large Animal Clinical Sciences, Western College of Veterinary Medicine, University of Saskatchewan, 52 Campus Drive, Saskatoon, SK S7N 5B4

EXPERIMENTAL PROCEDURES

Weaned piglet transport records collected between 2013 and 2018 (n = 8891) were voluntarily provided in electronic or paper format by five Canadian companies conducting weaned piglet transport events. These five companies included three production companies (an integrator, a cooperative, and a stand-alone company) and two livestock transport companies moving piglets for private farms. Following data validation, 6692 records remained for analysis. The existing information provided was used to match additional information to each company's dataset (trip distance, departure temperature, arrival temperature), calculate additional parameters (average piglet weight, estimated trip duration, in-transit mortality) and generate categorical variables (multiple origin barns, border crossing, multiple destination barns). The dataset then underwent further cleaning including removal of transport records where average piglet weights were less than or greater than what would reasonably be classified as a piglet at the time of weaning (21 days of age). The final dataset contained 6203 transport events representing a total of roughly 6.9 million piglets transported between 2014 and 2018.

RESULTS AND DISCUSSION

The proportion of piglets transported in this dataset accounts for approximately 6.8%, 29.0%, and 5.9% of piglets estimated to have been weaned on Ontario, Saskatchewan, and Alberta farms, respectively, and approximately 4.7% of piglets estimated to be weaned in all of Canada between these years.

The transport events recorded during the study period involved three Canadian provinces and eight American states. The mean average weight of the transported piglets was 5.7 kg (SD: 0.5 kg, range: 4.1–7.9 kg). Most transport events (71.3%) and piglets (59.4%) were transported within Canada. The median trip distance for transports within Canada was 30 km, and the maximum trip duration was 10.4 hours.

A total of 1781 trips (28.7%) were export events to the USA. For those trips, the median trip distance was 1561.6 km and the maximum trip duration was 32.6 hours. Of the export shipments, the three states receiving the greatest number of transport events were Michigan (33.6%), Iowa (33.0%) and Indiana (12.5%), while the three states receiving the greatest number of piglets were Iowa (46.1%), Michigan (20.3%) and Minnesota (16.8%).

The median average daily temperature recorded at the departure locations was 9.1 °C (IQR: 18.5), ranging from -30.3 – 28.5 °C. The median average daily temperature recorded at the arrival locations in this dataset was 10.3 °C (IQR: 18.2), ranging from -30.3 – 28.7 °C.

Transport events with ≥ 1 piglet recorded to have been found dead on arrival represented 8.3% (n = 513) of all records in this dataset. In-transit mortality rate, defined as the percent of piglets shipped during the transport event that were recorded to have died during transport, ranged from zero to 6.16%, with a mean of 0.027%. Trip characteristics of the transport events with the ten highest recorded mortality rates are presented in Table 1.

IMPLICATIONS

This dataset provides valuable information on features of Canadian weaned piglet transport, thus offering insight on the implications of changing legislation and the relevance of conditions captured in previous experimental research. The presented data can also inform parameters used in models of disease spread in the Canadian swine industry, such as ranges of distances between origin and destination farms, numbers of piglets transported, and the frequency of multiple farm contacts in a single transport event.

ACKNOWLEDGEMENTS

This research was funded by the Saskatchewan Ministry of Agriculture, through the Agriculture Development Fund (ADF) [project #20160301], with core funding support from Alberta Pork, Manitoba Pork Council, and the Saskatchewan Pork Development Board. Funding was also provided by Swine Innovation Porc, Agriculture and Agri-Food Canada, provincial producer organizations and industry partners including Alberta Pork, Les Eleveurs de Porc du Quebec, Manitoba Pork, New Brunswick Pork, Ontario Pork, PEI Pork, and Sask Pork, within the Swine Cluster 3 research program [grant #17127]. The authors gratefully acknowledge the companies who provided the records for this research, the company representatives who assisted with the data, and those involved in record compiling, cleaning, and validation, including Hauwa Bwala, Ewen McCairns, and Enise DeCaluwe-Tulk.

Table 1. Characteristics of transport events with the ten highest mortality rates out of 6203 transport events between 2014 and 2018.

Mortality rate, %	No. piglets dead	Year	Month	Load size	Trailer type	Trip distance, km	Multiple pick-ups	Export event	Multiple drop-offs
6.16	157	2014	April	2548	Potbelly	2,043	Yes	Yes	Yes
4.73	57	2016	August	1206	Unclassified	1,650	No	Yes	No
4.04	35	2015	April	866	Straightdeck	90	No	No	No
3.82	96	2016	December	2515	Potbelly	1,787	Yes	Yes	No
3.56	89	2017	January	2500	Potbelly	1,641	No	Yes	No
3.28	82	2014	October	2500	Potbelly	1,795	Yes	Yes	No
3.04	78	2016	March	2565	Potbelly	1,688	No	Yes	No
2.79	67	2017	February	2400	Potbelly	1,929	No	Yes	No
2.76	70	2015	May	2540	Potbelly	2,166	Yes	Yes	Yes
2.52	63	2016	December	2500	Potbelly	2,412	Yes	Yes	No

Can slat-compatible enrichment influence pigs' behaviour and response to a disease challenge?

M.K. Pedersen-Macnab¹, J.C.S. Harding¹, F. Fortin², J. Dekkers³, M.K. Dyck⁴, G.S. Plastow⁴, PigGen Canada⁵, Y.M. Seddon¹



Madelena Pedersen-Macnab



Yolande Seddon

SUMMARY

Rearing pigs in highly enriched environments with a greater space allowance and provision of substrates (straw, mushroom compost, sawdust, wood branches) for rooting and chewing has been found to reduce the disease susceptibility of pigs to co-infection with PRRSV and *Actinobacillus pleuropneumoniae*, increasing the speed of viral clearance and reducing the prevalence of lung lesions. However, provision of these types of substrates is not practical in fully slatted rearing systems and may present a biosecurity risk. Scientific evidence is limited and conflicting on the efficacy of chewable, inedible enrichments to influence the productivity, behaviour, or immune function of pigs. The aim of this work was to determine if provision of a rotation of slat compatible enrichments could beneficially influence the physiological responses of pigs when exposed to a disease challenge.

The provision of a rotation of inedible point-source enrichments to pigs reared in fully slatted housing increased the interaction with enrichment compared to provision of a single chain but was not effective at beneficially influencing the response of pigs to a natural disease challenge. The results of this work can help provide information for the development of sustainable and effective environmental enrichment practices that meet animal care requirements while supporting the health and economic viability of Canadian swine production.

INTRODUCTION

Disease is a leading cause of economic loss and reduced animal welfare in the swine industry. Breeding animals for greater disease resilience is one approach to make animals less susceptible to disease. However, the rearing environment may also interact to influence disease resilience, because stress influences the

immune function. For pigs, enrichment can provide an outlet for the performance of species-specific behaviours like rooting and chewing for exploration and foraging, and in turn may reduce the likelihood of pigs redirecting nosing and biting pen-mates and pen fixtures, which could help to reduce chronic social stress within the group. Rearing pigs in highly enriched environments with a greater space allowance and provision of substrates (straw, mushroom compost, sawdust, wood branches) for rooting and chewing has been found to reduce the disease susceptibility of pigs to co-infection with Porcine Reproductive and Respiratory Syndrome Virus (PRRSV) and *Actinobacillus pleuropneumoniae*, increasing the speed of viral clearance and reducing the prevalence of lung lesions (van Dixhoorn et al., 2016). However, provision of substrate is not practical in fully slatted rearing systems and may present a biosecurity risk. Instead, slat compatible enrichment such reusable commercial chewable pig 'toys' or materials such as natural rope, flexible PVC pipe or rubber are more readily provided to pigs in fully-slatted farms. However, scientific evidence is limited and conflicting on the efficacy of chewable, inedible enrichments to influence the productivity, behaviour, or immune function of pigs. The aim of this work was to determine if provision of a rotation of slat compatible enrichments could beneficially influence the physiological responses of pigs when exposed to a disease challenge.

EXPERIMENTAL PROCEDURES

Pigs (n=1220) were transported to the Deschambault Animal Sciences Research Centre (QC) at weaning and assigned to either a treatment group (Enriched) or control group. Enriched pens were reared with a rotation of seven different inedible point-source enrichment objects (Figure 1), with control pens receiving up to two metal chains as a basic enrichment. Point-source enrichment is an item of a limited size that is typically fixed in location, such as by suspending the enrichments. Each type of enrichment was presented to pigs one at a time at a rate of one enrichment object per seven pigs. To help support novelty and retain interest, objects were rotated three times weekly (Monday, Wednesday, Friday) so that each type of object was presented for two to three days at a time and then not re-presented to the pigs for a period of nine days.

At 37-40 days of age, pigs moved into a continuous flow barn and were exposed to a polymicrobial natural disease challenge for four weeks, after which they were transferred to a finisher barn where they remained until slaughter. The disease challenge exposed pigs to 12 different pathogens. Pens of pigs remained in their respective control and treatment groups throughout each growth period, with enriched pens continuing to receive a rotation of enrichment from nursery, through the disease challenge, and to grow-finish.

¹ Prairie Swine Centre Inc, PO Box 21057, 2105 – 8th Street East, Saskatoon, SK S7H 5N9

² Department of Animal and Poultry Science, University of Saskatchewan, 51 Campus Dr, Saskatoon, SK S7N 5A8

³ Department of Large Animal Clinical Sciences, Western College of Veterinary Medicine, University of Saskatchewan, 52 Campus Drive, Saskatoon, SK S7N 5B4

⁴ Department of Agricultural, Life and Environmental Science, University of Alberta, 9011 - 116 St NW, Edmonton, AB T6G 2P5



Figure 1. Point-source enrichment objects provided to growing swine during a natural disease challenge. One type of enrichment was provided at a time and the type of object presented was rotated three times weekly. Top row (left to right): 1) Porchichew (NutraPet, East Yorkshire, UK); 2) EasyFix Luna ((EasyFix, Ballinasloe, Ireland); 3) Flexible PVC pipe, 4) jute (burlap) sack. Bottom row (left to right): 5) cotton rope; 6) tarpaulin; 7) rubber rooting mat with cotton rope treaded through.

RESULTS AND DISCUSSION

Pigs provided with a rotation of point-source enrichments were more likely to interact with the objects than control pigs provided with only chains (Figure 2), but the probability of interaction with the point-source enrichment declined over time within each growth phase. Despite frequent rotation of the items, the enrichment objects were not able to generate a benefit to pig performance or response to disease challenge. This may be because the enrichment was not rewarding enough to the pigs. On the other hand, enriched pigs were more likely to be observed lying laterally (side lying) and less time standing and lying sternally (stomach lying), which could indicate that enriched pigs were resting more comfortably and spending less time awake and inactive.

Observations of individual social and exploratory behaviour performed on 70 pigs identified that enriched pigs were more active in the nursery phase, performing a greater amount of positive and negative social behaviours and more pen rooting than control pigs ($P < 0.05$ for all). On day 13 of disease challenge, enriched pigs displayed greater levels of enrichment use ($P < 0.001$) and negative social behaviour ($P = 0.04$), but control and enriched pigs did not differ in positive social behaviour and pen rooting.

Relationships were found between the performance of specific behaviours and performance in the disease challenge in both control and enriched pigs. In both treatment groups, animals that performed a greater frequency of pen rooting during disease challenge had a greater average daily gain in the finisher phase ($P < 0.01$). Within enriched pigs only, there was a moderate, positive relationship between the performance of pen rooting and positive social behaviour and higher counts of total white blood cells, lymphocytes, total red blood cells, and hemoglobin measured at day 42 post disease exposure. This suggests that pigs that perform functional (rooting) and positive social behaviour may perform better under challenge, showing a higher growth and quicker recovery.

IMPLICATIONS

The provision of a rotation of inedible point-source enrichments to pigs reared in fully slatted housing increased the interaction with enrichment compared to provision of a single chain and influenced pig behaviour but was not effective at beneficially influencing the response of pigs to a natural disease challenge. Further research on providing enrichment that sustains pig interaction, satisfies motivational needs, and can deliver biological benefits is warranted. This will ensure investments made into enrichment to meet Code of Practice requirements can deliver good benefits for welfare and for the producer. Relationships between individual pig behaviour and performance when under challenge suggests there is value in exploring this further, and such work may lead to developments in phenotypic measures for resilient animals.

The results of this work can help provide information for the development of sustainable and effective environmental enrichment practices that meet animal care requirements while supporting the health and economic viability of Canadian swine production.

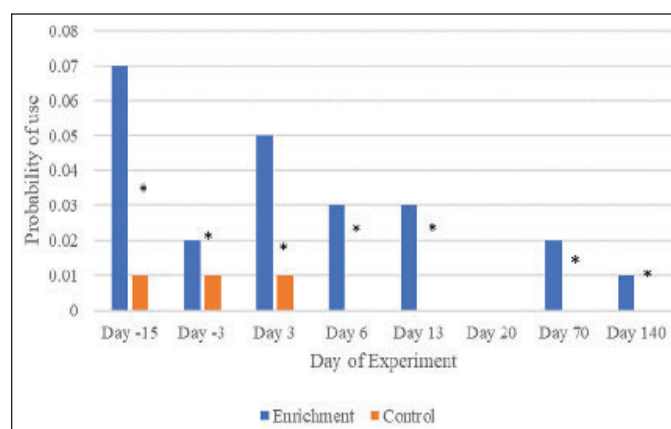


Figure 2. Probability of pigs interacting with a point-source enrichment object (Enrichment) or a metal chain (Control) during a two-hour observation period on sampling days within three experimental phases: nursery phase (Day -15, Day -3), disease challenge phase (Day 3, Day 6, Day 13, Day 20) and finisher phase (Day 70, Day 140). Statistically significant differences ($P < 0.05$) between treatment groups are denoted by an asterisk (*).

ACKNOWLEDGEMENTS

Project funding was provided by Alberta Livestock and Meat Agency (now Results Driven Agriculture Research), Genome Alberta, Genome Canada, PigGen Canada, Swine Innovation Porc and Alberta Agriculture and Forestry. Thank you for Catherine Field for her contribution to the CBC data. Thank you to CDPQ staff.

Publications List

Alvarado, A.C., S.M. Chekabab, B.Z. Predicala and D.R. Korber. 2022. Impact of Raised without Antibiotics measures on antimicrobial resistance and prevalence of pathogens in sow barns. *Antibiotics*. 11: 1221. <https://doi.org/10.3390/antibiotics11091221>

Alvarado, A., M. Baguindoc, A. Guevara and **B. Predicala**. 2022. Design criteria for enhancing cleanability and welfare characteristics of pig transport trailers. *Centred on Swine*. Prairie Swine Centre. Saskatoon, SK. Vol. 29. No. 2. pp. 1-5.

Baguindoc, M. H., Alvarado, A. C., Predicala, B. Z., Korber, D. R. 2022. Comparative study of effectiveness of alternative disinfection methods on various surfaces in different pig production rooms. Paper# 121. 2022 CSBE-SCGAB AGM and Technical Conference. Charlottetown, Prince Edward Island, Canada. 24-27 July 2022.

Baguindoc, M., A. Alvarado, D. Korber, **B. Predicala**. 2022. Investigating alternative disinfection measures applicable for antibiotic-free pig production. *PSC Research Forum*. Saskatoon, SK. 25 October 2022.

Denise Beaulieu (2021) Utilizing corn DDGS in swine diets. Presented at the Prairie Swine Centre, Virtual Town Hall. Sept., 2021.

Bolo, R., M. Martel, B. Thompson, L. Zhang, **B. Predicala**, H. Guo, S. Kirychuk. 2022. Evaluation of a pilot-scale electro-nanospray system for decontaminating pig barns. *PSC Research Forum*. Saskatoon, SK. 25 October 2022.

Bolo, R., M. Martel, B. Thompson, L. Zhang, **B. Predicala**, H. Guo, S. Kirychuk. 2022. Pilot-scale testing of electro-nanospray system for decontaminating pig barns. 2022 Saskatchewan Pork Industry Symposium. Saskatoon Inn & Convention Centre. Saskatoon, SK. 15 November 2022.

Oral presentation: **Brown, J.** (2022, June 29). Sow Mortality: Concerns, Causes and Solutions. *PSC Group Sow Housing Seminar*, Saskatoon, SK.

Oral presentation: **Brown, J.** (Oct. 11, 2022). Aggression and Lameness on group housing: Fine-tuning for success. *Gestalt Swine Summit*, Oct. 11-12, Levi, QC.

Oral presentation: **Brown, J.** (March 15, 2023). Practical options for the transition to group housing. *AASV 2023*, Denver, CO.

Jennifer Brown, "Risk factors for sow mortality in Canadian herds." *Prairie Swine Centre Producer Meetings*, Strathmore, AB, April 19, 2023; *Swift Current*, SK, May 2, 2023, and *Niverville*, MB, May 4, 2023.

J. Brown, "Effects of long distance transport on early-weaned pigs", article in *Centred on Swine*, Spring 2022, vol 9(2): 10-11. Online at <https://www.prairieswine.com/wp-content/uploads/2018/12/COS-Vol-29-No-2.pdf>

Buchinski MJ, Camire CM, Panisson JC, Shoveller AK, and **Columbus DA** (2022) Examining the impact of dietary nitrogen content and source on essential amino acid requirement in growing pigs. *Saskatchewan Pork Industry Symposium*. November 15-17, Saskatoon, SK.

Camire CM, Rodrigues LA, Panisson JC, Shoveller AK, and **Columbus DA** (2022) Effect of feeding a diet with supplemental lysine and a low or high essential amino acid-nitrogen to total nitrogen ratio on growth performance in 20-50 kg pigs. *Saskatchewan Pork Industry Symposium*. November 15-17, Saskatoon, SK.

Camire CM, Rodrigues LA, Panisson JC, Shoveller AK, and **Columbus DA** (2022) Effect of the essential amino acid-nitrogen to total nitrogen ratio on lysine requirement for nitrogen retention in growing pigs. *J. Anim. Sci.* 100(Suppl. 3):110-111.

Camire CM, Rodrigues LA, Shoveller AK, and **Columbus DA** (2022) The effect of limiting dietary non-essential amino acids on lysine requirement for protein deposition in growing pigs. *Advances in Pork Production*. 33:239.

Cargo-Froom CL, Tansil F, **Columbus DA**, Huber L, Kiarie EG, Marinangeli CPF, Levesque C, Courtney-Martin G, and Shoveller AK (2022) Comparison of ileal digestibility and indicator amino acid oxidation as methodological assessments of protein quality in growing swine. *Animal*. 13:309-311.

Cargo-Froom CL, **Columbus DA**, Kiarie EG, Marinangeli CPF, and Shoveller AK (2022) A comparison of key methodologies used to quantify protein quality in mammals: ileal digestibility, indicator amino acid oxidation, and in vitro digestibility. *J. Anim. Sci.* 100(Suppl. 3):77. Invited.

Cargo-Froom CL, Newkirk RW, Marinangeli CPF, Shoveller AK, Ai Y, Kiarie EG, and **Columbus DA** (2022) The effects of grinding and pelleting on nutrient composition of Canadian pulses. *Can. J. Anim. Sci.* 102:457-472. doi:10.1139/CJAS-2021-0111

Chastain C (Host) (2022) Episode 45: What might we be forgetting about with low-protein diets? [Audio/video podcast episode with **D. Columbus**] *The Swine Nutrition Blackbelt Podcast*, Wisenetix, Clearwater, FL.

Chastain C (Host) (2022) Episode 8: What benefits do additional functional amino acids provide to nursery pigs? [Audio/video podcast episode with **D. Columbus**] *The Swine Nutrition Blackbelt Podcast*, Wisenetix, Clearwater, FL.

Cochrane B (Host) (2022) Adding amino acids to swine rations stimulates growth but also improves health [Audio interview with **D. Columbus**] *FarmScape Online*, Wonderworks Canada Inc, Boissevain, MB.

Cochrane B (Host) (2022) Including amino acids in swine rations improves gut health, gut development, and immune function. [Audio interview with **D. Columbus**] *FarmScape Online*, Wonderworks Canada Inc, Boissevain, MB.

Cochrane B (Host) (2022) Scientist Examine Contributors to Gastric Ulcers in Pigs. [Audio interview with **A.D. Beaulieu**] *FarmScape Online*, Wonderworks Canada Inc, Boissevain, MB.

Cochrane B (Host) (2022) Rye Provides Alternative to Corn, Wheat, Barley in Swine Rations [Audio interview with **A.D. Beaulieu**] *FarmScape Online*, Wonderworks Canada Inc, Boissevain, MB.

Bruce Cochrane, "Record Keeping Key to Determining Reasons for Death Loss of Sows and Removals From the Breeding Herd", Interview with **J. Brown** and article, Farmscape Online, 2022/12/15.

Bruce Cochrane, "Researchers Compare Performance of Gestating Sows Mixed Under Static and Dynamic Mixing", Interview with **J. Brown** and article, Farmscape Online, 2022/12/20.

Bruce Cochrane, "Researchers examine risk factors for weaned piglets during transport", Interview with **J. Brown** and article, Farmscape Online, 2022/11/28.

Bruce Cochrane, "Biological Markers Offer Potential to Help Swine Producers Improve Animal Welfare", Interview with **J.M. Seddon** and article, Farmscape Online, 2022/02/04.

Bruce Cochrane, "Stress Hormones Levels Offer Potential as Indicator of Value of Animal Care Practices", Interview with **J.M. Seddon** and article, Farmscape Online, 2022/01/06.

Columbus DA. 2022. Early life nutrition in pigs in relation to immune function and disease. Midwest Swine Nutrition Conference, September 8, Danville, IN. Invited.

Columbus DA (2022) Nutrition and health. Cargill Animal Nutrition. February 25, Virtual. Invited.

Columbus DA (2022) Early life nutrition in pigs in relation to immune function and disease. Pages 7-12 In: Proceedings of the Midwest Swine Nutrition Conference. Lindeman M, editor. Danville, IN.

Columbus D (February 2022) Strategies to reduce feed costs. Pages 25-27 In: Better Pork, Guelph, ON.

Columbus DA (2022) Factors impacting effectiveness of functional amino acids for health in pigs. 7th International Animal Intestinal Ecology and Health in China Summit Forum. November 13-15, Beijing, China. Invited.

Columbus DA (2022) Nutrition for pig health. OlySky Research Update, November 3, Humboldt, SK. Invited. Ekhlasi Nia, A., K. Khaleidi, **B. Predicala**, M. Nemati. 2022. Solid-phase denitrification and denitritation of swine manure-contaminated waters: Bioreactor performance and microbial community profiles. J. Environ. Chem. Eng. <https://doi.org/10.1016/j.jece.2022.109209>

Golightly, H. R., **Brown, J.**, Bergeron, R., Poljak, Z., **Seddon, Y. M.**, & O'Sullivan, T. L. (2022). Impact of two commercial weaning and transport strategies on piglet behaviour, body weight change, lesions and lameness following transport. Applied Animal Behaviour Science, 257, 105775.

Golightly, H. R., **Brown, J.**, David-Steel, M., Bergeron, R., Poljak, Z., **Seddon, Y. M.**, & O'Sullivan, T. L. (2023) Serum concentrations of brain-derived neurotrophic factor as a potential biomarker of swine welfare. The Canadian Veterinary Journal, (in print - May 2023 issue).

Golightly, H. R., O'Sullivan, T. L., **Brown, J. A.**, & **Seddon, Y. M.** (2023). A descriptive study of weaned piglet transport practices in Canada between 2014 and 2018. Preventive Veterinary Medicine, (Accepted).

Golightly, H. R., O'Sullivan, T. L., **Brown, J. A.**, & **Seddon, Y. M.** (2023). Effect of season on weaned piglet mortality during long transport events under Canadian conditions. Preventive Veterinary Medicine, (submitted 01.19.23, under review).

Poster: Hannah R. Golightly, "Impact of weaning-related vs transport-related stress on serum cortisol levels in commercial piglets", International Symposium for Veterinary Epidemiology and Economics, Halifax, Canada, 2022/08/09.

Oral presentation: Hannah R. Golightly, "Cohort study evaluating newly weaned piglet behaviour after short or long duration transport", International Symposium for Veterinary Epidemiology and Economics, Halifax, Canada, 2022/08/11.

Poster: Hannah R. Golightly, "Risk factors for weaned piglet mortality during transport", Le Porc Show, Quebec City, Canada, 2022/12/6-7.

Golightly, H., O'Sullivan, T., **Seddon, Y.**, and **Brown, J.**, "Effects of transport duration on the health and welfare of early weaned pigs", article in PSC Annual 2022 Annual Report, Online at <https://www.prairieswine.com/portfolio-item/annual-report/>

Halm, R., R. Newkirk and **D. Beaulieu** (2022). The potential for feed processing to reduce ergot toxicity. Invited presentation. Animal Nutrition Association of Canada. May 2021.1. Saskatoon, SK.

Regina Halm, Rex Newkirk and **Denise Beaulieu** (2022). The potential for feed processing to reduce ergot toxicity. In. Feed Production and formulation Technologies: Considerations for a Sustainable Industry. Paper presented at the 2022 Animal Nutrition Conference of Canada, Saskatoon, SK.

Leong-Machielse, K., Cole, C., Miguel-Pacheco, G. and **Seddon, Y.M.** (2022) The effects of the pre-weaning environment on play behaviour and aggression of pigs in a social contest. In: Proceedings of the 14th ISAE North-American Regional Meeting. 29th – 30th April, Davis, California, USA, pp. 44.

Poster: **Karen F. Mancera, Jessica C. Vehof, Yolande M. Seddon, and Jennifer A. Brown.** Effects of sow grouping practices on reproductive performance and piglet development in relation to prenatal stress. Banff Pork Seminar, Banff, AB, Canada, January 10 – 12, 2023

Oral presentation: **Mancera, K.** (2022, June 29). Dynamic Grouping - Impact on Sow Aggression and Lameness in Sows. PSC Group Sow Housing Seminar, Saskatoon, SK.

Oral presentation: **Mancera, K.** (Sept. 28, 2022). Causes of Abnormal Behavior in Pigs. World Organization for Animal Health Workshop on Pig Welfare, Chile.

Miguel-Pacheco, G., Wang, Y. and **Seddon, Y.M.** (2022) A new approach to assessing pig welfare: A Swine Welfare Chair research update. Sask Pork Symposium, 15th & 16th November, in person.

Morton JS, Patton B, Morse CM, El'Karsh Z, **Rodrigues LA**, Mousseau DD, Ferguson DP, Ferguson DP, **Columbus DA**, Weber LP, and Olver TD (2022) Altered cerebrovascular regulation in low birth weight swine. Comp. Biochem. Physiol. A. 267:111163. doi:10.1016/j.cbpa.022.111163

C. Ochoa-Sanabria, D. Duhra, R. Newkirk, F. Buchanan, and **D. Beaulieu**. 2021. Impact of ergot-contaminated feed on yellow mealworm larvae performance, preference, and digestibility. Journal of Insects as Food and Feed 8 (6): 673 - 679. doi.org/10.3920/JIFF2021.0107

Ottemann Abbamonte CJ, Overton TR, **Beaulieu AD**, Drackley JK. 2021. Effects of in vivo phlorizin treatment and in vitro addition of carnitine, propionate, acetate, and 5-tetradecyloxy-2-furoic acid on palmitate metabolism in ovine hepatocytes. J Dairy Sci. 104(7):7749-7760. doi: 10.3168/jds.2020-20015

Panisson JC, Frobose H, **Brown J**, and **Columbus DA** (2022) Does feeding time affect farrowing time in sows? Advances in Pork Production. 33:249.

Pedersen-Macnab, M.K., Harding, J.C.S., Fortin, F., Miguel-Pacheco, G., Dekkers, J., Dyck, M.K., Plastow, G.S., PigGen Canada and **Seddon, Y.M.** (2022) Can slat-compatible enrichment influence the behaviour and disease response of pigs to a disease challenge? Centred on Swine, Fall 2022, vol 30. (1), pp. 4-7. Prairie Swine Centre Inc., Saskatoon, SK.

Penrod E (Author) (2022) Pigs fed plant-only diet struggle to recover from disease. [Text interview with **D. Columbus**] Feed Strategy, Rockford, IL.

Oral presentation: Peyer, B. and **Brown, J.** (June 30 & July 1, 2022). Eliminating discretionary deaths in the cull sow transport network. Humane Slaughter Association International Conference, Edinburgh, UK. <https://www.hsa.org.uk/downloads/hsa-conference-programme-book-fv.pdf>

Pollock, D.S., Janz, D.M., and **Seddon, Y.M.** (2022) Hair Hormones as Biomarkers of Welfare in Swine. Le Porc show, December 6th-7th, virtual.

Pollock, D.S., Janz, D.M., and **Seddon, Y.M.** (2022) The effects of rearing environment on hair and salivary cortisol and dehydroepiandrosterone concentrations as a measure of chronic stress in swine. Western Canadian Association of Swine Veterinarians Conference, 20th-21st of October, in person.

Predicala, B., A. Alvarado, M. Sapaden, S. Kirychuk. 2022. Update on Improving Biosecurity and Welfare of Animals during Transport Project. Canadian AgriSafety Applied Science Program Annual Collaborative Meeting. CCHSA Board Room, University of Saskatchewan. Saskatoon, SK. 18 October 2022.

Predicala, B., A. Alvarado, S. Chekabab and D. Korber. 2022. Impact of antibiotic-free production practices on the prevalence of pathogens and emergence of antimicrobial resistance in pig barns. The XX CIGR World Congress 2022. Kyoto International Conference Centre. Kyoto, Japan. 07 December 2022.

Predicala, B., A. Alvarado, S. Chekabab and D. Korber. 2022. Impact of antibiotic-free production practices on the prevalence of pathogens and emergence of antimicrobial resistance in pig barns. Prairie Swine Centre Research Update. OlySky, Humboldt, SK. 03 November 2022.

Predicala, B. and **K. Engele.** 2022. Pigs consume more water when stressed. Centred on Swine. Prairie Swine Centre. Saskatoon, SK. Vol. 29. No. 2. pp. 8-9.

Predicala, B., A. Alvarado, S. Chekabab and D. Korber. 2022. Impact of antibiotic-free production practices on the prevalence of pathogens and emergence of antimicrobial resistance in pig barns. 2022 Saskatchewan Pork Industry Symposium. Saskatoon Inn & Convention Centre. Saskatoon, SK. 15 November 2022.

L. Reed, "Driving closer to understanding transport distance impacts", article in Canadian Hog Journal, Aug. 8, 2022. Online at: <https://canadianhogjournal.com/2022/08/08/driving-closer-to-understanding-transport-distance-impacts/>

Rodrigues LA, Koo B, Nyachoti M, and **Columbus DA** (2022) Formulating diets for improved health status of pigs: current knowledge and perspectives. *Animals*. 12:2877. doi:10.3390/ani12202877

Rodrigues LA, Panisson JC, Van Kessel AG, and **Columbus DA** (2022) Functional amino acid supplementation attenuates the negative effects of plant-based nursery diets on the response of pigs to a subsequent Salmonella Typhimurium challenge. *J. Anim. Sci.* 100:skac267. doi:10.1093/jas/skac267

Rodrigues LA, Panisson JC, Kpogo LA, Gonzalez-Vega JC, Htoo JK, Van Kessel AG, and **Columbus DA** (2022) Functional amino acid supplementation post-weaning mitigates the response of normal birth weight more than for low birth weight pigs to a subsequent Salmonella challenge. *Animal*. 16:100566. doi:10.1016/j.animal.2022.100566

Rodrigues LA, Wellington MO, Gonzalez-Vega JC, Htoo JK, Van Kessel AG, and **Columbus DA** (2022) Rapid Communication: Ileal alkaline phosphatase is upregulated following functional amino acid supplementation in Salmonella Typhimurium-challenged pigs. *J. Anim. Sci.* 100:skab376. doi: 10.1093/jas/skab376

Rodrigues LA, Panisson JC, Kpogo LA, Htoo JK, Van Kessel AG, and **Columbus DA** (2022) Effect of functional amino acid supplementation in low and normal birth weight pigs on performance and immune status during subsequent Salmonella challenge. *J. Anim. Sci.* 100(Suppl. 3):117-118.

Rodrigues LA, Panisson JC, Van Kessel AG, and **Columbus DA** (2022) Effect of functional amino acid supplementation in Salmonella-challenged weaned pigs fed either animal- or plant-based nursery diets. *J. Anim. Sci.* 100(Suppl. 3):111.

Rodrigues LA, Panisson JC, Van Kessel AG, and **Columbus DA** (2022) Effect of nursery diet protein source and functional amino acid supplementation on the response of pigs to a subsequent Salmonella challenge. *Advances in Pork Production*. 33:243.

Rodrigues LA, Panisson JC, Kpogo LA, Gonzalez-Vega JC, Van Kessel AG, and **Columbus DA** (2022) Effect of functional amino acid supplementation in nursery diets on the response of low and normal birth weight piglets to a subsequent Salmonella challenge. *Advances in Pork Production*. 33:244.

Rodrigues LA, and Columbus DA (2022) Exploring functional amino acids: influence of birth weight on pig response. Pages 24-25 In: Better Pork, Guelph, ON.

Rodrigues LA, and Columbus DA (2022) Animal-protein based nursery diets and functional amino acids improve performance and health status of weaned pigs. Pages 1-3 In: Centred on Swine (Volume 30, Number 1), Prairie Swine Centre, Saskatoon, SK.

Rodrigues LA, and Columbus DA (2022) Effectiveness of functional amino acids in Salmonella-challenged low and normal birth weight pigs. Pages 10-11 In: Centred on Swine (Volume 30, Number 1), Prairie Swine Centre, Saskatoon, SK.

Roy, C., Kyeiwaa, V., Mancera, K.F., Seddon, Y.M., Connor, L.M., and **Brown, J.A.** Effects of Enrichment Type, Presentation and Social Status on Enrichment Use and Behavior of Sows—Part 2: Free Stall Feeding. *Animals*. 2022; 12(14):1768. <https://doi.org/10.3390/ani12141768>

Sands JM, **Rodrigues LA, Wellington MO, Panisson JC, and Columbus DA** (2022) Pre- and post-weaning performance of piglets offered different types of creep feed. *Can. J. Anim. Sci.* 102:189-193. doi:10.1139/CJAS-2021-0038.

Seddon, Y.M. (2022) Rethinking painful procedures. Invited speaker for: Pig Welfare workshop: Interpretation of the Terrestrial Code. 28th – 29th September, Valdivia, Chile.

Seddon, Y.M. (2022) Raising the bar: The future for swine welfare & drivers of change. Invited speaker for PEI Pork AGM, 24th March, virtual meeting.

Seddon, Y.M. (2022) The Code of Practice Five Year Review: Implications for Future Code revisions. Invited speaker for Banff Pork Seminar, 12th & 13th January, virtual.

Singh P, Banton S, Templeman J, Shoveller AK, Saunders-Blades J, Kostiuik D, Kelly J, Marinangeli C, **Columbus DA,** and Raheb S (2022) The pulse of it: the effects of legumes on canine cardiac function. American Feed Industry Association Pet Food Conference. January 25-27, Atlanta, GA.

Steinerova, K., **Brown, J.A.,** Parker, S.E., and **Seddon, Y.M.** (2022) Promotion of positive welfare through play behaviour in grow-finish pigs. Le Porc Show, December 6th - 7th, virtual.

Steinerova, K., **Brown, J.A.,** Parker, S.E., and **Seddon, Y.M.** (2022) Promotion of positive animal welfare through play and its physiological and psychological effects on pigs. Saskatchewan Pork Industry Symposium, November 15th – 16th.

Steinerova, K., **Brown, J.A.**, Parker, S.E., and **Seddon, Y.M.** (2022) Promotion of positive animal welfare through play and its physiological and psychological effects on pigs. The Western Canadian Association of Swine Veterinarians, October 19th – 20th.

Steinerova, K., and **Seddon, Y.M.** (2022) Play behaviour and its role to enhance pig welfare and production? Centred on Swine, Fall 2022, vol 30. (1), pp. 8-9. Prairie Swine Centre Inc., Saskatoon, SK.

Tokareva, M, Brown, J.A., MacPhee, D.J. and **Seddon, Y.M.** 2022. The effect of providing a greater freedom of movement through periodic exercise on the welfare and stress physiology of stall-housed gestating sows and on piglet behaviour. *Animal Welfare*. 31:293-308.

Tokareva, M, Brown, JA, MacPhee, DJ, and **Seddon, Y.M.** 2022. Providing periodic exercise to stall-housed gestating sows influences only the total number of live-born piglets in older parity sows. *Canadian Journal of Animal Science*. 102: 509-517. <https://doi.org/10.1139/cjas-2021-0087>

Oral presentation: **Jessica C. Vehof**. Effects of Sow Grouping Practices on Mixing Aggression and Production. Saskatchewan Pork Industry Symposium, Saskatoon, SK, Canada, November 15-16, 2022.

Poster: **Jessica C. Vehof, Karen F. Mancera, Yolande M. Seddon, Jennifer A. Brown**. Effects of Sow Grouping Practices on Mixing Aggression and Production. Banff Pork Seminar, Banff, AB, Canada, January 10 – 12, 2023.

Oral presentation: **Jessica C. Vehof**. Effects of Sow Grouping Practices on Mixing Aggression and Production. Banff Pork Seminar, Banff, AB, Canada, January 10 – 12, 2023.

Jessica Vehof, “Effects of Sow Grouping Practices on Production and Mixing Aggression.” Prairie Swine Centre Producer Meetings, Strathmore, AB, April 19, 2023; Swift Current, SK, May 2, 2023, and Niverville, MB, May 4, 2023.

Wellington MO, Rodrigues LA, Quinn MA, **Panisson JC**, Ferguson DP, and **Columbus DA** (2022) Serum metabolomics characterization of birth weight and neonatal nutrient restriction on piglet growth and development. *J. Anim. Sci.* 100(Suppl. 3):348-349.

Yang, Y., S. P. Kirychuk, Y. Si, M. C. Martel, H. Guo, **B. Z. Predicala**, L. Zhang. 2022. Reduction of airborne particulate matter from pig and poultry rearing facilities using engineered water nanostructures. *Biosystems Engineering*. 218 (2022):1-9. <https://doi.org/10.1016/j.biosystemseng.2022.03.013>

Yang, Y., M. Martel, B. Thompson, H. Guo, **B. Predicala**, L. Zhang, and S. Kirychuk. 2021. Characterisation of engineered water nanostructures (EWNS) and evaluation of their efficacy in inactivating *Escherichia coli* at conditions relevant to livestock operations. *Biosystems Engineering*. 212. <https://doi.org/10.1016/j.biosystemseng.2021.11.003>.

Financial Support

Prairie Swine Centre wants to recognize the individuals and agencies that supported the Research and Knowledge Transfer program this year. The support is essential to the ongoing developments that keep Canadian pork producers at the fore front of applied technology.

In addition to the many industry and government funding agencies, the University of Saskatchewan uses the facilities and services at Prairie Swine Centre for research and teaching.

The following organizations have provided funding or donations and in-kind to support public research at the Centre throughout the 2023 fiscal year.

PROGRAM SPONSORS

- Agricultural Development Fund (ADF)
- Alberta Pork Producers Development Corporation
- Manitoba Pork Council
- Saskatchewan Pork Development Board
- Ontario Pork Producers' Marketing Board

PROJECT SPONSORS

- Agriculture Demonstration of Practices and Technologies (ADOPT)
- Institute Research & Development for Agri-Environment (IRDA)
- National Pork Board
- Saskatchewan Barley Development Commission (SBDC)

MAJOR PROJECT SPONSORS

- Agriculture and Agri-Food Canada
- Agrivita Canada
- Canadian Swine Research & Development Cluster (SIP)
- EVONIK
- Mathematics of Information Technology & Complex Systems (MITACS)
- NSERC Discovery