PRAIRIE SWINE CENTRE

2024

PRAIRIE SWINE CENTRE

ANNUAL **RESEARCH** REPORT

PRAIRIE SWINE CENTRE

MISSION STATEMENT

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

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2025 Report Highlights

Chairman's Report

Displaying excellence in applied swine research

Mark Ferguson, Chairman of the Board

It is my pleasure to present the Annual Report for the Prairie Swine Centre for 2025. This year has been another successful one for the Centre as we continue to fulfill our mission of providing innovative solutions through knowledge, helping to build a profitable and sustainable pork industry.

Over the past year, the Centre continued to strengthen its reputation as a global leader in applied swine research. As you will read in this report, our research scientists and their teams delivered impactful work and publications in our core focus areas of nutrition, ethology, engineering. These projects will continue to address many of the challenges facing producers today and into the future.

Knowledge transfer and extension activities remained a top priority for the Centre. Through producer meetings, publications, and digital outreach, the Prairie Swine Centre continues to communicate research findings in clear, practical formats that enable producers to easily access and adopt the discoveries. The feedback we continue to receive from the industry reinforces the value of this work and highlights the critical role the Centre plays in bridging science and hog farming practices.

The Prairie Swine Centre's accomplishments each year are the direct result of the talent, passion, and dedication of our staff. Every position plays a key role in making the research and KTT programs successful. Starting with the leadership of our senior research scientists, our dedicated research technicians and production staff, and finally our administrative and knowledge transfer staff- each member contributes to the Centre's culture of innovation and excellence. Graduate students also play a key role in the projects carried out by the Centre, and training the next generation of swine specialist animal scientists is a crucial function of PSC.

On behalf of the Board, I want to thank Murray for his solid leadership and management of the centre. I also wish to also acknowledge PSC's Board of Directors, who provided strong governance and strategic guidance throughout the year. Their commitment ensures that the Centre continues to operate with integrity, accountability, and a vision for the future.

Finally, I want to recognize all organizations who financially support the Prairie Swine Centre—This support is essential to fulfilling our mission and ensuring PSC's continued success. Specifically, core funding and project specific funding provided by the Government of Saskatchewan and producers in Saskatchewan, Alberta, and Manitoba is crucial to the financial sustainability of the Centre.

Looking forward to what we can accomplish in 2026 and beyond.

CEO Report

Moving into new challenges with optimisim

Murray Pettitt, Ph.D. - CEO

While recent years have been somewhat challenging, 2025 brought a new sense of optimism to the Canadian hog industry. Record average high hog prices combined with low feed costs not seen in more than five years make reinvestment in the Centre and the industry possible. At the Centre we continue to support the industry through our core research programs in ethology, nutrition and engineering. Our current studies range from the investigation of how to utilize AI (artificial intelligence) to improve animal management, determining the best approaches to guide the transition to group housing ahead of the 2029 deadline, and how to optimize efficiencies at each stage of production through feeding programs.

PSC has welcomed a few new faces. Leading our Ethology department, we welcomed Dr. Jen-Yun Chou (March 2024), taking the torch from Jennifer Brown. Jen-Yun has wasted no time in expanding her own research program and brings a wealth of valuable insight to the Centre. This past summer we also welcomed Dr. Atta Agyekum to head our Nutrition team. Atta is no stranger at PSC – he spent time at PSC as a post-doctoral fellow working with Drs. Columbus and Beaulieu. We are excited to see where the knowledge and ideas of these two researchers will take us.

This report contains articles describing the influence of dietary nitrogen content on growth performance, the impact of indigestible protein on nursery pig performance, the use of nanotechnology to mitigate mycotoxin contamination, the influence Saskatoon berry pomace as a feed additive, the development of a rapid detection kit for PEDv, the optimization of room temperature, the use of AI to detect farrowing onset and distress, the relationship between pig thermal profile and feed efficiency, utilization of barn records to understand differences between group and stall gestation, the impact of creep pellet size and formulation on piglet health, and the influence of gestational vitamin supplementation on sow and piglet performance. These reports and the students and researchers behind them power our movement towards optimal swine production.

We also continue to highlight student awards and presentations. Our students are a driving force in all of our research, with most of the reports included within this publication being based on their projects. Students represent the future of our industry, and I encourage you to talk to them whenever possible

Prairie Swine Centre remains dedicated to identifying best practices in swine production. This report, along with our other publications and information that can be found on our website (www.prairieswine.com) contains practical, production-focused insights for the industry.

We would not be able to accomplish any of what we do without the continuous financial support of the Government of Saskatchewan Agriculture Development Fund and the provincial Pork Boards of Saskatchewan, Alberta, Manitoba, and Ontario. Their interest and confidence in the Centre allows us to complete projects important to the Canadian pork industry, and we are more than grateful for their partnership. Additionally, our ongoing relationship with the University of Saskatchewan enables public research and engages the minds of students through courses and research experience.

I would like to thank our board of directors. Our board members volunteer their time, bringing valuable experiences and perspectives from production, government, academia, and other related industries. Their insights ensure we are adding value wherever possible.

Finally, I want to acknowledge our PSC team as a whole. Researchers, students, technicians, production staff, knowledge transfer and office staff make our mission statement a reality. They embody our core values and beliefs – reliability, responsibility, reputation, and respect – and enact our mandate of producing and distributing knowledge derived through original research, scientific review, and economic analysis.

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

Bringing Value to the Industry

PRAIRIE SWINE CENTRE 35 YEARS

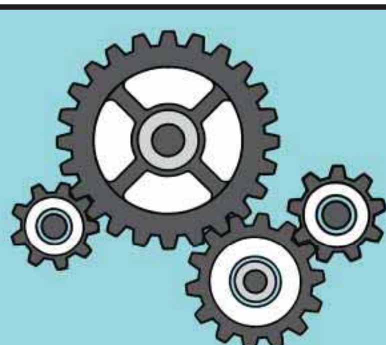
In 2026 Prairie Swine Centre will be celebrating 35 years

25 HQP

19 MSc. - 6 Ph.D. - 3 Post-Doctoral Fellows Have been supervised or co-supvised by PSC scientists and adjunct scientists

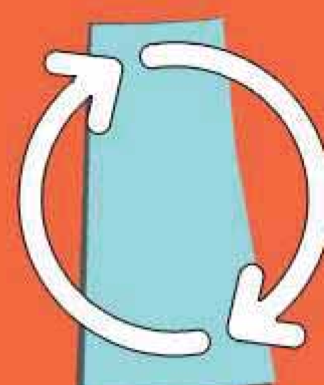
$5.31

On average, our research program has generated a $5.31/hog per year return, for the past five years



3.8

$1 of operational funding is leveraged into $3.80 of additional research funding



51%

Amount of additional outside funding secured benefiting Saskatchewan hog producers

Operations Manager's Report

Overcoming challenges in a busy research barn

Tatjana Ometlic, RVT. - Manager, Operations

Throughout the past year we reached or exceeded our new production targets. The production team-maintained efficiency and throughput even though there never seems to be a shortage of challenges or obstacles to overcome while working on continuous improvements. Specifically changes in our nutrition program for replacement gilts; once a week semen delivery; change in sire-line genetics (moved to L800-Duroc); sow research study and staff change to name a few.

Despite challenges arisng from different research projects, our production numbers met all targets except for pre-wean mortality (PWM) and number of sows bred. Pre-wean mortality has dropped from 13.8% to 12.3% over the past year. Production staff continue to use the best production practices and tools where possible, such as split-nursing 18+ piglets born alive, supplementing with electrolytes, and creep feeding for disadvantaged pigs/foster litters, while still prioritizing the needs of research teams.

Conducting research trials in the barn can create challenges with maintaining operational efficiencies and pig flow. As a research facility that promotes and maintains a robust research program and delivery of many services to our external researchers (U of S, WCVM, VIDO) and provides the pork industry with science-based information, it is our priority to accommodate the needs of research teams. The ability to adjust and adapt has always been strong suit of the Centre. In 2024, we had 17 research projects started in grow finish, breeding, gestation, farrowing, and nursery rooms. With each project, our students and staff gain unique insight into livestock research, learning valuable problem-solving skills. Any challenges faced are worth it for the development of novel science-based information for the swine industry at large.

Table 1. Production targets for fiscal year 2025

Category	Target/week	Rolling Average*
# Bred	14.0	13.8
# Sows farrowed	12.7	12.7
# Pigs born alive	190	191.8
Average born alive	15.0	15.2
# Piglets weaned	166	167.5
Pre-wean mortality	9.6%	12.3%
Post-wean mortality	3.0%	1.6%
Finish mortality	2.0%	1.6%
# Sold/week	156.0	162.9

**January - May, 2025*

Over the past year we have made several management changes to increase performance, reduce costs and improve management. Once per week semen delivery was successfully implemented as the farrowing rate for the first 5 months associated with once-a-week semen collection was 91.2%. We also updated the nutritional specifications of our gilt feeding program. Specifically, to slow down the growth rate and maximize the number of gilts bred within the right combination of weight, heat no service (HNS) and age. To date, we are not seeing any significant change in growth rate of the gilts.

Post-wean and grow finish mortality continue to be maintained at low levels when benchmarked with the swine industry. 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 put in place recording system to track cohorts (weeks of breeding to farrowing) for body condition to understand success of the feeding program and how well are sows recovering from weaning to farrowing.

"In 2024, we had 17 research projects started in grow-finish, breeding, gestation, farrowing, and nursery rooms."

Table 2. Production parameters

	2020	2021	2022	2023	2024	Jan-May 2025
Number of sows farrowed:	661	636	628	701	679	267
Conception rate %:	91.4	86.0	88.1	99.1	90.4	95.8
Farrowing rate %:	91.5	87.5	85.9	92.7	90.6	90.2
Average born alive/litter:	14.4	14.3	14.9	14.9	15.4	14.8
Farrowing index:	2.46	2.48	2.46	2.47	2.44	2.45
Number weaned/sow:	12.6	12.5	12.7	13.1	13.2	13.1
Pre-wean mortality %:	12.1	12.6	14.2	13.8	14.0	12.8
Pigs weaned/sow/year:	29.2	29.5	28.2	30.4	30.0	30.7

We have been focusing on animal flow and throughput of pigs wean to market. We have been steadily weaning over 13 pigs/sow/litter and maintaining low post-wean and grow finish mortality. For the past 12 months, total born has been at a 17.4 average. That has put us as one of the leading farms in North America for this trait. Live born is currently at 14.8, which is slightly below the target, while stillborn numbers are on the rise, 12.8%. The high stillborn numbers are driven by the older parity sows as well as sows farrowing prematurely with high numbers of stillborn piglets. The staff presence is critical, especially for higher risks sows which are flagged, making sure they are checked more frequently.

The past year has been very busy creating both challenges and successes. Production has been good, and we are ultimately on track with where we have been previous years, and we have identified the causes for measures we are falling behind in. For this past year will be close to 8,600 animals sold. This is above the target of animals to be sold for this year. Our Raised Without Antibiotics (RWA) program is going steady, as the health of the herd maintains stability. In benchmarking with other farms with PIC genetics across Canada and USA, we continue to be in the upper 10th percentile of Pig Champ Benchmarking data for 2024.

Training remains an important part of what we do at the Centre. Each year we host students from the University of Saskatchewan and Sask Polytech. In the spring of 2025, we had Sask Polytech students in our barn for their swine lab. We provided an overview of swine production and practices followed by a demonstration of all our typical procedures (litter processing, castrations, vaccinations, blood collections, restraint, etc.). Students had an opportunity, voluntarily, to do some or all the procedures. We found this approach to be much more successful as students were more open to trying things out when there were no pressure and expectations. In addition, Dr. John Harding brought the four swine residents from his Swine Medicine Advancement Recruitment and Training (SMART) program to the Centre. The objective was to teach the residents proper methods of conducting a herd health visit. As well the month of May is production's busiest time of the year: training summer students, graduate students and new staff.

I would like to acknowledge the great work of our staff, keeping up with maintenance of the facility as well as providing exceptional care for the animals. I am very grateful and commend them for their efforts and enthusiasm.

Knowledge Transfer Report

Supporting communication in the Canadian swine industry

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

Ken Engele

Miranda Smit

The following supports PSC's strategic plan objectives;

- *A highly effective KTT program that delivers relevant science-based information to all areas of the Canadian pork value chain.*
- *Enhance our ability to meet the KTT needs of the Canadian pork value chain through expansion of our extension efforts and through continued/new collaborations/ strategic alliances with Canadian and international partners.*

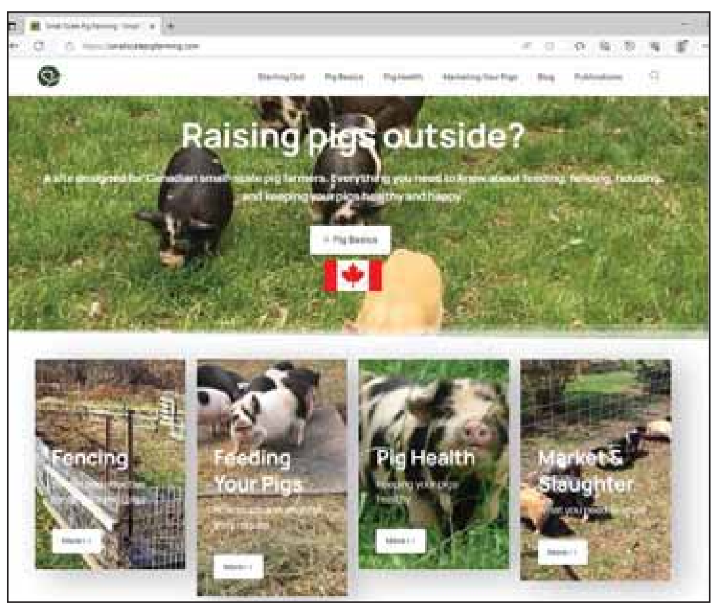
Delivering timely, relevant, and practical information is the goal of the Knowledge Transfer program at the Centre. While, over the past 35 years we have changed how we do it, fundamentally we still focus on providing information adopted on farms across Canada. The adoption of these best management practices helps create a sustainable industry, one that needs to focus on the environment, welfare and economics. Sustainability on on-farm is like a three-legged stool – missing any, one leg (environment, welfare, economics) will cause the stool to collapse. If one leg is shorter than the others it will cause it to wobble, creating uncertain times ahead, but eventually it will tip over. Creating a long-term vision for your operation and the pork industry ensures we are in the best position when times are profitable.

Knowledge Transfer is a two-way street. Not only do we work on delivering results to the industry, but we also gather input from the industry. The knowledge we gather from the industry provides input on our research programs and the types of information we need to provide that have the greatest impact to producers, at a specific point in time. We continue to engage with producers and the industry at various meetings, conferences, trade shows and other in-person events (PSC Spring Producer Meetings, Alberta Pork Congress, Red Deer Swine Technology Workshop, Prairie Livestock Expo, the Saskatchewan Pork Industry Symposium, Banff Pork Seminar, 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 industry, staff, and students.

Over the past year we have added KTT personnel to the Centre. Recently we hired a new employee, Research Assistant (Hannah Burlet), on a six-month contract to accelerate the delivery of resources from the Centre.

Core areas of focus of the KTT program include the development of CPC resources (Pig LEARN), publications (Annual Report, Centred on Swine), small-scale pig farming engagement, and the development of the Pork Research Hub. The upcoming year is one that will produce several unique and long-term resources for the Canadian hog industry.

" Sustainability on on-farm is like a three-legged stool – missing any, one leg (environment, welfare, economics) will cause the stool to collapse. "



smallscalepigfarming.com

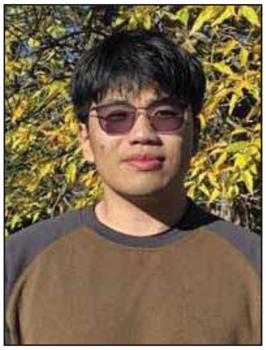
Student Awards and Presentations

- **Monica Li,** Undergraduate student, Ethology
  - Recipient of the Sebulsky Award in support of summer research internship
- **Serge Muhizi,** Ph.D. student, Ethology
  - Recipient of the Hugh Nicholson Memorial Scholarship to attend the ASAS/CSAS Annual Conference in Florida
- **Shuang Luo,** M.Sc. student, Ethology
  - Recipient of a Department of Animal & Poultry Graduate Scholarship, May 2025 – April 2026
- **Ana Paola Ubaldo,** Visiting student, Ethology
  - Recipient of a Mitacs Globalink Internship, July – October, 2025
- **Carmen Cole,** M.Sc. student, WCVM Swine Welfare Group
  - Maxwell Swine Graduate Scholarship, October 2025
  - Sharon Blok-Andersen Award in Animal Welfare, October 2025
- **Karolina Steinerova,** Ph.D. student, WCVM Swine Welfare Group
  - Maxwell Swine Graduate Scholarship, October 2024
  - Sharon Blok-Andersen Award in Animal Welfare, October 2024
- **Melvin Hagonob,** M.Sc. Student, Engineering
  - Winner - Oral Presentation, 2025 American Society of Agricultural and Biological Engineers (ASABE) Annual International Meeting, July 2025
- **Nolan Matuba,** M.Sc. Student, Engineering
  - Winner – Oral Presentation for Student Competition, 2024 Saskatchewan Pork Industry Symposium, November 2024
- **Alvin Alvarado,** Ph.D. Student, Engineering
  - 3rd Place – Oral Presentation Category, 2024 Canadian Society for Agricultural and Biosystems Engineering(CSABE/SCGAB) Annual General Meeting and Technical Conference, July 2024

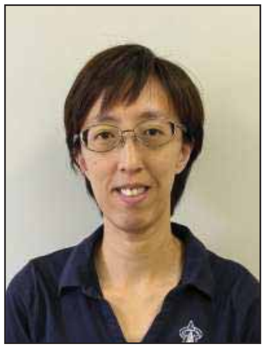
Reporting from the Prairies... and around the world!

Improving Sow Management and Performance Using Precision Feeding Records

Shuang Luo[1, 2], Kevin Brooks[3], Yolande Seddon[4], Jennifer Brown[1, 2], Jen-Yun Chou[1, 2]



Shuang Luo



Jen-Yun Chou

INSIGHT FOR PRODUCERS

Understanding how housing style influences reproductive performance is important as we approach the mandatory switch to group sow housing. By comparing the two housing styles, we can identify risk factors and best practices.

SUMMARY

In 2029, Canadian pork producers will need to make the transition to group sow housing, following the updates to the Code of Practice for the Care and Handling of Pigs. This project addresses the timely issue of assisting producers in making the transition to group housing, improving sow welfare and maintaining productivity at the same time. The first study focuses on utilizing retrospective and longitudinal data comparing sow and gilt productivity in group and stall-housed herds, under the same management, identifying production benefits and risks associated with each housing system. The second study will focus on the analysis of data collected from electronic sow feeders alongside observations recorded on dam parity, productivity, social status, and feeder behavior, In this way, we can identify sows/gilts requiring attention and design intervention strategies to improve sow welfare and productivity. The goal of the project is to identify management practices that can benefit sow health and production in Canadian sow herds. The results will ease the transition and promote success in the adoption of group housing in Canada and Saskatchewan.

INTRODUCTION

Canadian pork producers are in the process of converting to group sow housing. Group housing can provide benefits including improved sow welfare, bone strength and litter health. The transition to group housing also poses management challenges. Sows will fight at mixing as they establish their social hierarchy, in addition to potential negative effects on reproduction, which is dependent on feed system, group size, and pen design. A survey of 104 Canadian sow herds found that barns with group gestation had higher sow mortality (Prade Ramos, 2022). A review of commercial farm records indicate that first and second parity sows are at greater risk of removal in group housing due to reproductive problems; generally, sows must remain in the herd at least three parities to cover their replacement cost (Ketchem et al., 2020, and J. Brown, pers. comm.). With Canadian producers transitioning to group housing, it is important to conduct research on best practices in group housing.

Electronic sow feeding (ESF) systems record sow feed intake on daily basis, helping to guide staff by providing a daily list of animals that have not been fed. However, ESF data is largely underutilized and only a small portion of the information is used on a regular basis.

Social status within the herd influences physiological stress, reproductive performance, and access to resources within the pen. Furthermore, it has been proposed that a consistent feeding order is indicative of greater group stability. This observation could be used to predict how well the system is working or identify changes in stress levels or aggression.

Acclimation of new animals into group housing with ESF feeding can be a challenge, potentially explaining negative issues associated with group gestation. Gilts that have not been exposed to ESF systems require training on using the system. Ideally training should be completed before breeding, as missing feed around ovulation and after breeding can lower conception rates. Studies indicate that increasing the acclimation period has a positive impact, reducing the incidence of prolapse (Ross, 2019).

Based on a dataset collected from 12 individual barns managed by the same company, a retrospective analysis is being completed. With the same genetics, feed, breeding management and recording system being used, this situation provides a unique research opportunity to compare sow and gilt performance under parallel systems. Comparison of

[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 Drive, Saskatoon, SK, S7N 5AB
[3] Olymel Canada, 10333 8th Avenue Humboldt, SK, S0K 2A0
[4] Department of Large Animal Clinical Science, Western College of Veterinary Medicine, University of Saskatchewan, 52 Campus Drive, Saskatoon, SK, S7N 5B4

reproductive performance within these systems will be done using Metafarms production records. This analysis will provide clear insights into the production benefits and risks associated with each system, and aid in development of interventions to improve sow health and productivity in groups.

In the final phase of this project, three practical interventions designed to reduce stress and improve gilt acclimation will be implemented on commercial farms. The goal is to identify management practices that can benefit sow health and production in Canadian sow herds. The results will ease the transition and promote success in the adoption of group housing in Canada and Saskatchewan's swine industry.

EXPERIMENTAL METHODS

We acquired data from 12 barns, spanning 2021 to 2023. Six barns were using gestation stalls, and six barns were using group housing with electronic sow feeders.All barns use common genetics, diets, productivity measurement protocols, and general management practices. Consistent management factors provide greater experimental control and data quality than would be the case in a random sampling of sow farms. The initial dataset included sixty-nine metrics as recorded by the software Metafarms (Table 1).

Data is currently being analyzed, using sample size criteria to ensure data validity. Next steps involve using principal component analysis to explore the correlation between metrics and develop core metrics that explain variations between housing types, barns and parities. Analysis of a short survey given to the barn managers will also be completed, for identification of any micromanagement practices that may influence metrics of interest.

The results of this project will identify the relative strengths and weaknesses of each housing system in terms of breeding success, productivity, litter performance, removals, and replacements. The analysis will focus on identifying areas where performance differs between housing systems, and opportunities for improvement in group housed herds.

RESULTS

Statistical analysis of collected data and analysis of results is ongoing. Overall, more data is available from barns utilizing group housing systems. Based on the preliminary data analysis, group-housed sows tend to deliver fewer stillborn piglets, especially considering older sows. Percentage of repeat breedings tend to be higher in group-housed barns.

IMPLICATIONS

While the promise of better animal welfare is great, the transition to group sow housing can pose challenges during and after the conversion. Analysis of metrics collected from a single management system with barns using either stalls or ESF housing while maintaining similar management protocols will provide insight into the influence of housing system on productivity and help identify production risks in both systems. Understanding these factors will allow for effective development of best management practices and ease the transition to group sow housing.

ACKNOWLEDGEMENTS

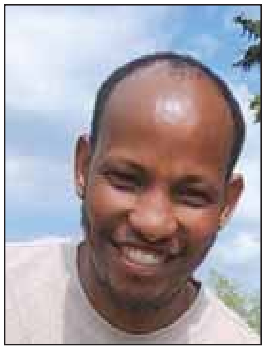
This project is supported by the Saskatchewan Agriculture Development Fund. The authors would also like to acknowledge the strategic program funding provided to Prairie Swine Centre by Sask Pork, Alberta Pork, Ontario Pork, the Manitoba Pork Council and the Saskatchewan Agriculture Development Fund.

Table 1. Some metrics collected from the barn management systems.

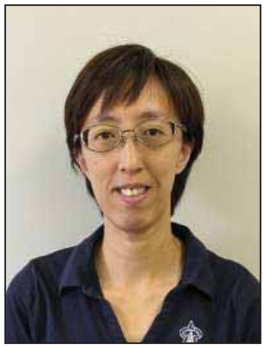
No.	Definition
2	The percentage of total services in which multiple matings occurred.
4	The percentage of sows that remain pregnant at 105 days.
6	The percentage of sows confirmed pregnant at 35 days post-service.
8	The average number of piglets weaned per sow.
9	The average number of dead piglets per litter.
11	The average number of live-born piglets per litter.
12	The average number of stillborn piglets per litter.
13	The average number of piglets (both live and dead) born per litter across the data set.
15	The overall mortality rate calculated as the percentage of farrowed sows that either died or were destroyed.
17	The average number of mummified piglets per litter.
19	The piglet death rate expressed as a percentage of live-born piglets.
20	The average age (in days) at which piglets are weaned.
22	The total number of piglets weaned in a sow's lifetime
26	The percentage of farrowed sows that were removed
28	The average number of days between weaning and the first breeding service.
30	The average total weight of a litter at weaning.
31	The average weaning weight per piglet.
32	The average weight per individual piglet at birth.
39	The percentage of services performed more than seven days after weaning.
42	The number of sows that are in a mated or breeding state at the end of the period.
44	A conversion metric showing how many services leads to a farrowing.
45	The total number of sows removed from the herd, which include culling, deaths, transfers, or transferred.
46	The number of unplanned sow deaths during the period.
47	The number of sows removed from the herd due to low performance, health issues, or age.
49	The number of sows moved from one barn or production unit to another during the period.
55	The net number of piglets fostered (moved from one sow to another) to balance litter sizes and ensure optimal survival and growth.
56	The total number of piglet deaths recorded during lactation or before weaning.
57	The number of sows that successfully weaned their litters.
58	The count of sows that weaned at least one piglet.
68	The number of sows that experienced an abortion during the gestation period.

Improving feed efficiency in pork production through individual thermal efficiency index

Serge Muhizi[1,2], Abigail Tillotson[1], Jennifer A. Brown[1,2], Allan Schaefer[3], Deborah Adewole[2] and Jen-Yun Chou[1,2]



Serge Muhizi



Jen-Yun Chou

INSIGHT FOR PRODUCERS

Feed efficiency is not equal amoung all pigs. Measuring thermal output in relation to feed efficiency may support selection practices for genetic companies, resulting in more efficient pigs, reducing feed costs and increasing profits.

SUMMARY

Feed efficiency is essential in pork production optimizing growth and maximizing nutrient use. This project will validate the use of thermal efficiency index (TEI) for evaluating feed efficiency in growing pigs. This study investigated the relationship between thermal efficiency and stress resilience. In a 2 x 2 design, weaner pigs were assessed for TEI, with high and low TEI animals selected; half of each group received a commercial supplement in water (DSS, designed to reduce stress) for 24h before and after stressful events, and half were treated as control. Pigs were challenged with a controlled handling and mixing stressor at 12 and 16 weeks respectively. Infrared temperature was evaluated before and after each stressor with additional salivary cortisol and thermal imaging measurements in the second replicate. TEI shows a consistent correlation with average daily gain, which indicates a valid metric for measuring pigs' growth. Use of DSS in water significantly reduced lesion scores at mixing compared to the control and produced a greater change in TEI in response to handling and mixing stressors.

1Prairie Swine Centre Inc., Box 21057, 2105 8th Street East, Saskatoon, SK, S7H 5N9, Canada.
2University of Saskatchewan, 52 Campus Drive, Saskatoon, SK S7N 5B5.
3Animal Inframetrics, Inc, Box 5451 Lacombe, AB T4L 1X2

INTRODUCTION

Feed efficiency is variable with 'inefficient' animals wasting more energy by giving off more heat than efficient animals, and/or absorbing less energy from feed and releasing unused nutrients to the environment. The thermal output of animals is thus a potentially useful measure for estimating feed efficiency. Infrared thermography can assess thermal output in real time and shows many other technical and practical advantages. The procedure is non-invasive and can be used to rank an animals' efficiency in approximately 20 seconds. The technology has also been patented, beta site tested, and is now entering use in commercial facilities. Further work is needed to validate TEI as a tool in swine production, including for example knowledge on relationships between TEI and stress resilience, the effects of different diet formulations on TEI, heritability of TEI, as well as relationships with susceptibility to heat stress and pig temperament.

The application of thermal profiles will be of particular benefit to genetic companies. By facilitating the early selection of pigs on the basis of efficiency, faster genetic progress can be achieved.

Because TEI can be measured in early life, the application of infrared technology and thermal profiles could also benefit pork producers. If young pigs can be sorted based on feed efficiency at the weaner or grower stage, diets can be prepared based on the different needs of each group. With thermal classification, each group of pigs would be provided a diet nutritionally tailored to better meet their needs, resulting in improved efficiency.

"By facilitating the early selection of pigs on the basis of efficiency, faster genetic progress can be achieved."

EXPERIMENTAL PROCEDURES

This study followed a 2 X 2 factorial approach with two TEI categories (HIGH and LOW) and two nutritional therapy treatments: Control (CTR) and treated (DSS). The DSS treatment utilized a nutritional therapy is a recently registered Veterinary Health Product. This product is delivered through drinking water to pigs and is demonstrated to attenuate the impacts of stress induced protein catabolism, electrolyte depletion, hyperactive HPA activity, hypoglycemia and dehydration.

The study utilized 176 pigs in two replicates (88 pigs per replicate). Pigs were enrolled one day before nursery exit (8 weeks of age) and scanned using an infrared camera to determine TEI (mean dorsal temperature/body weight×0.75). In each replicate, 44 pigs with high TEI ("HIGH": TEI 4.29 ± 0.39; body weight 15.62 ± 1.43kg) and 44 with low TEI ("LOW": TEI 3.48 ± 0.35; body weight 20.28 ±1.82kg) were selected and housed at 11 pigs/pen. Pens were randomly assigned to nutritional treatment, with four pens of 11 pigs per treatment category over two replicate studies. The study was partitioned into Grower (8-12 weeks of age), Finisher 1 (12-16 weeks) and Finisher 2 (16-20 weeks) phases, with TEI and body weight recorded at the end of each phase to determine average daily gain (ADG). Individual feed intake was recorded daily using automated feeders to determine average daily feed intake (ADFI) and Gain: Feed (G: F). Pigs were marketed at 20 weeks of age and carcass grading data was obtained.

The impact of two forms of stress were evaluated: handling stress at 12 weeks of age and mixing stress at 16 weeks. For the handling and mixing events, pigs in the DSS treatment received the nutritional therapy delivered in water for a total of 48h, from 24h before the stressor until 24h after.

Handling stressor
At 12 weeks of age, pigs underwent a controlled handling treatment, with thermal profile recorded pre and post-handling, and behavioural measures recorded during handling. Pigs were guided to the hallway and then moved along the corridor in groups of 5 or 6 animals for a total distance of approximately 90 meters, while observations of the pigs running, walking or standing, and vocalizing were recorded. In order to further understand the impact of TEI on recovery from stress, salivary cortisol samples were collected pre- and post-handling in the second replicate. Additional thermal imaging was also conducted using a handheld infrared camera, recording at 5, 10, 15 and 30 minutes post-handling.

Mixing stressor
At 16 weeks of age, pigs were mixed into pens with unfamiliar pigs. Mixing is an acute social stressor for pigs which typically results in aggression as the pigs compete to establish their social rank within the group. For each pen, 5-6 animals were moved to a pen of pigs within the same TEI and treatment category. After two hours the pigs were returned back to their original pen in order to minimize potential long-term damage due to fighting. Thermal profile was recorded before and after mixing. Behavioral measures during the mixing event and lesions were assessed as measures of aggression. Body lesions were scored before and after mixing using a four-point scale (0 =none; 3 =≥11 lesions). In the second replicate, additional measures were taken as with the "handling stressor".

RESULTS AND DISCUSSION

As the nature of TEI calculation considers body weight, we were not able to perfectly balance the body weight at entry. At weaning age, the greater feed efficiency of LOW animals resulted in higher body weights compared to HIGH animals. The average baseline weight for LOW pigs was almost 5kg heavier than the average for HIGH pigs (20.28 ±1.82 kg vs 15.61 ±1.43 kg, $P < 0.001$). Average weight at trial entry did not differ between dietary treatment groups. LOW pigs tended to have a higher ADG from 8-12 weeks. During Finisher 1, LOW pigs consumed more feed and had greater ADG with no difference in G:F. During Finisher 2, there was no difference in ADFI, ADG or G:F between TEI categories. The overall ADG throughout the grower-finisher stage was greater for LOW than HIGH pigs. LOW pigs had greater slaughter weight, and fat (mm). There was no effect of TEI on loin depth.

During handling at 12 weeks, DSS tended to affect the change of TEI (ΔTEI), with pigs given DSS showing greater change (Figure 1). In the mixing stressor at 16 weeks test, DSS pigs showed a greater ΔTEI than CTR pigs, with no effect of TEI category (Figure 2). Thermal efficiency and DSS treatment did not affect behaviour during handling. DSS treatment affected lesion scores at mixing: CTR animals received more head lesions and tended to have more mid-body lesions compared to DSS. TEI category tended to influence hind-end lesions; scores of HIGH pigs showed less change than LOW.

In terms of the relationship between thermal efficiency index and bodyweight, a linear correlation was detected. Initial TEI and bodyweight were negatively correlated, similarly at week 12, which means that pigs with lower TEI were consistently heavier. Interestingly, in week 12 after the handling stress, the correlation decreased, which suggests that pigs' body temperature was indeed disrupted by the handling stress process. Similar results were found at week 16 before the mixing stress and after.

IMPLICATIONS

The findings based on thermal efficiency alone exhibit that TEI can be used to identify pigs with better performance in terms of weight gain and carcass yield. Based on data from the beginning of the trial, at week 12, and at slaughter, there was a negative correlation between TEI and bodyweight, with LOW pigs being heavier at each point. Both handling and mixing stress decreased the extent of this negative correlation, exhibiting the physiological influence of stress.

ACKNOWLEDGEMENTS

This project is supported by the Saskatchewan Agriculture Development Fund. We would also like to acknowledge the contributions from our industry partners Animal Infometrics for providing the thermal imaging hardware and software and Country Junction for providing support with the application of the Veterinary Health Product. The authors would also like to acknowledge 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. 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, and Dr. Yolande Seddon for providing the video recording equipment.

Creep feeding and piglet development: new format and formulation approaches

Kylie Kallal[1], Abby Tillotson[1,2], Jennifer Brown[1,2], Jen-Yun Chou[1,2]


Abby Tillotson


Jen-Yun Chou

INSIGHT FOR PRODUCERS

Optimizing creep feeding may support piglets through the stressful experience of weaning, preparing them for the transition to solid feed. Creep feeding may also provide enrichment and encourage feeding behaviours.

SUMMARY

Weaning is stressful for piglets, especially for fast-growing piglets who may show signs of anemia. Providing creep diets to piglets can potentially reduce weaning stress and improve piglet health, however pellet size may affect their interactions and motivation to eat creep. This study investigated the influence of providing different forms of creep to piglets, specifically creep interaction and blood parameters. A pilot study was conducted to assess piglet preference for three different creep forms, and found that E17 horse feed (3cm pellet) and crumble starter diet maintained greater interest over a six-day observation period. The main study randomly assigned piglets to one of four diets: 1. Standard creep (SC), 2. Pellet creep (PC), 3. A mix of SC and PC (MC), and 4. No creep (NC). Overall fewer piglets interacted with the diets on day 1, with the greatest interaction on day 4. The greatest amount of interaction with the creep feed occurred in the first minute after it was placed in the feeder, with activity decreasing over time. Piglets were more likely to waste PC diets compared to MC. Creep diet had no effect on blood iron parameters, with large piglets showing greater signs of anemia. Further research is needed to develop creep diets which are nutritionally beneficial for reducing anemia and promote creep interaction and consumption to reduce stress at weaning.

INTRODUCTION

Benefits of creep feeding have not always been clear, with conflicting reports on weight gain before weaning and throughout the nursery phase. A literature review conducted by Muro et al. (2023) found creep feeding was reported to be beneficial in terms of gut development and growth performance more often than it was determined to have minimal or negative impacts. Confirming the positive impact of creep feeding indicates further research into best management practices is required to ensure optimal piglet growth and performance.

Creep intake is influenced by factors such as feed type, duration of feed availability, feeder location, and feeder design. Current creep diets tend to be formulated to contain high levels of starch, sugar, and lysine, and are generally expensive. The inclusion of sugars is meant to promote palatability and digestibility, though it has been suggested that the surge of insulin accompanying high glycaemic diets may result in fluid retention and edema, increasing body weight in a misleading fashion. This also causes an increase of red blood cells, which can mask anemia in rapidly growing weaned pigs. It has been recommended that diets for piglets should be formulated to contain fewer carbohydrates and lysine while increasing fibre content to reduce insulin spikes. High fibre ingredients typically contain more iron than high protein feeds, which may avoid or attenuate anemia. Regarding feed style, previous studies have shown that young pigs prefer larger pellets to finely textured feed.

The current study investigated if off-the-shelf, affordable large pellets meant for horses would be preferable to a standard creep diet (Phase 1 nursery diet) or influence blood iron status at weaning

[1] Department of Animal and Poultry Science, University of Saskatchewan, 51 Campus Drive, Saskatoon, SK S7N 5A8
[2] Prairie Swine Centre Inc., PO Box 21057, 2105 8th Street East, Saskatoon, SK S7H 5N9

EXPERIMENTAL PROCEDURES

1. Pilot study

The first study aimed to assess piglet preference of four different types of creep feed. Twelve litters between 2-4 weeks of age were offered two choices of feed at the same time; control and experimental. Standard creep diet was offered as a control choice. Experimental diets included:

- Hoffmans's Horse Crunchies (HHC), an approximately 1.5cm3 pellet based on soybean hulls, peas, rice bran, wheat mill run, canola meal, malt sprouts, and oat hulls
- Equest 17% Horse Crunch (E17), a pellet approximately 4 x 1.5 x 1.5cm based on alfalfa, oats, and peas
- 50% HHC/50% standard
- 50% E17/50% standard

Piglets were feed creep feed three times per week. Feed was provided in a 22.5x33 cm (approx. 9x13") steel pan attached to a 44x70 cm (approx.. 17x28") mat, accommodating multiple piglets feeding and reducing feed wastage (Figure 2). Feeders were located either at the front or the back of the pen, in order to determine optimal location. Time to piglet interaction was recorded upon feed placement, and interactions with the feed was observed at 1, 2, 3, 30, 60, 90, and 120 minutes after placement.

Figure 1. Open style creep feeder, 22.5x33 cm (approx. 9x13") steel pan attached to a 44x70 cm (approx.. 17x28") rubber mat.

2. Main study

After determining a preference for E17 pellets in the pilot study, the second study commenced. For this study, 21 litters (283 piglets) were randomly assigned to one of four diets:

- Standard creep (SC, Figure 2)
- Pellet creep (PC (E17), Figure 2)
- Mix of SC and PC (MC)
- No creep (NC)

At 10 days of age, litters were provided with 1400g of their assigned diet daily until weaning. Piglets were weighed individually at D10, D24 (weaning), D28, and D52 (nursery exit). At the beginning of the trial, average piglet weight did not differ across treatment groups.

Behavioural observation was conducted every 3 days starting at D13, with notes taken at 1, 2, 3, 30, and 60 minutes after creep was made available. The weight of leftover feed was taken before the addition of the daily ration, and the amount of waste on the feeder mat recorded.

Figure 2. Standard creep feed (SC, left) and Equest 17% Horse Crunch (E17) for pellet creep (PC, right).

Blood profile analysis
For analysis of blood profiles, samples were collected from one small and one large male piglet per litter the day before weaning. Parameters considered to be indicative of anemia included red blood cell count (RBC), hemoglobin concentration (HGB), hematocrit measure (HCT), mean corpuscular volume (MCV), red blood cell distribution width (RDW), iron concentration (iron), and total iron binding capacity (TIBC).

RESULTS AND DISCUSSION

1. Pilot study
Following observation of piglet engagement with creep feed, it was determined the E17 pellets and standard creep diets generated more interest than the HHC pellets. It was determined the best location for the creep feeder was in the middle of the pen, near the heat lamp. This location encouraged interaction while avoiding the occurrence of piglets soiling on the mat.

2. Main study
No difference in weaning weight or average daily gain (ADG) was found across different creep treatments, as welldid not influence the latency of piglet interaction, interaction over time, or the amount of feed left at the time of the next ration delivery. Creep waste (feed left on the mat but not in the bowl) tended to be lower in litters assigned the MC treatment.

Creep treatment had a significant impact on blood profile. It was determined that selected piglets from PC and MC litters had a greater variation in RDW compared to those from SC and NC litters, which is an indicator of anemia. Creep treatment and piglet size also impacted HGB and HCT, with large piglets from PC litters having the poorest measures.

Without the influence of diet, piglet size had a significant effect on all measures except RBC count; larger piglets were more likely to have a count indicative of anemia than their smaller counterparts ($P<0.001$). Large piglets also displayed an average iron concentration of less than half that of smaller piglets. This result confirms the idea that large piglets are more likely to be anemic due to faster growth but may suggest that they consume less creep than smaller littermates.

Increased exposure to creep feed decreased the time to piglet interaction; piglets took less time to approach the feed on days 14-16 than they did on D13. Piglets interacted with the creep more, and less feed was left, as the trial progressed. The most interaction with creep occurred in the 2 minutes after addition and waned over time ($P<0.001$).

"Creep may act as a form of enrichment and acts to stimulate interest in solid food in early development."

IMPLICATIONS

Though we had hypothesized that provision of a large pellet creep feed with high iron content would result in greater creep interaction and improvement of blood profiles in relation to anemia, the opposite was seen. Previous studies conducted at PSC have indicated that larger piglets tend to spend more time on the teat and less time interacting with creep feed. Observations specific to piglet size and creep interaction were not undertaken in this study, therefore the cause of the poor blood panel results cannot be clearly identified.

Regarding the style of creep feeder used, it was observed that the open style encouraged social feeding (Figure 1). The drawback of this design is the ability for piglets to push the feed out of the bowl; in this study we observed that the feed bowl was usually empty but there was clear wastage on the mat. As enrichment is generally lacking in farrowing pens, creep may act as a form of enrichment and acts to stimulate interest in solid food in early development.

While feed disappearance and wastage were estimated, actual feed consumption was not tracked. Further studies to understand creep consumption may endeavor to identify 'eaters' versus 'non-eaters' and if there is a clear connection to piglet size.

Optimization of creep diets can support piglets through a stressful period of early life. Formulating diets to include important components such as fibre and other micronutrients will support gut health and hopefully mitigate iron deficiency at weaning.

ACKNOWLEDGEMENTS

This study was completed with support from the ADOPT program (Agriculture Development of Processes and Technologies). The authors would also like to acknowledge the participation of the barn staff at Prairie Swine Centre, 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.

Impact of indigestible protein on nursery pig performance and intestinal health

T.J Erinle[1,2], O.O. Babatunde[1,2], J.K. Htoo[3], S.M. Mendoza[4], D.A. Columbus[1,2]

Taiwo Erinle

Dan Columbus

INSIGHT FOR PRODUCERS

Indigestible crude protein is available for microbial fermentation, which may lead to intestinal upset. Understanding how dietary protein content influences gut health, development, and microbial community will help to optimize diet formulation.

SUMMARY

While much work has been done on the concept of dietary protein content impact on performance and health of nursery pigs, it is unclear what factors are primarily responsible for the negative response to high protein diets. While there is a trend for reduced incidence of diarrhea with decreasing protein content, this is not consistent across studies when examining the same protein content. This suggests factors other than total dietary protein content are involved. While e presence of fermentation metabolites have been suggested as a potential mechanism for the negative effects, their actual contribution to intestinal health remains unclear. The concept of indigestible protein content is relatively new and, therefore, has not been specifically examined in past studies. Currently, diet formulations are based on meeting nutrient requirements and, in the case of nursery pig diets, to limit crude protein content. This project will be the first to characterize and validate the effect of indigestible protein on measures of animal health and performance and to examine the interaction between dietary indigestible protein, fibre content, and pathogen type. The overall goal is to provide insight into strategies to mitigate negative effects of indigestible protein and enhance the ability to utilize feedstuffs common Saskatchewan while improving sustainability of pork production.

INTRODUCTION

Stress experienced in the post-weaning period contributes to increased susceptibility of the newly weaned pig to several enteric pathogens, including enterotoxigenic Escherichia coli (ETEC) and Salmonella spp.. ETEC is the cause of approximately 25% of post-weaning diarrhea in pigs and a major contributor to post-weaning growth lag. Common Salmonella spp. serotypes produce less severe infection in the pig but induce an inflammatory response and limit pig performance, are a major cause of foodborne illness in Canada, and can be a barrier to international trade.

Dietary indigestible protein content (i.e., protein not absorbed in the small intestine) is available for microbial fermentation and may have detrimental effects on gut health. Metabolites of protein fermentation have been associated with toxic and pro-inflammatory effects on the gut epithelium. It has been suggested that high protein diets increase susceptibility to enteric pathogens and are a predisposing factor in the development of post-weaning diarrhea, with the assumption that high dietary protein equals high indigestible protein. Further, it has been suggested that feeding a low protein diet reduces the amount of substrate available for the proliferation of pathogenic bacteria, improving gut health and function in piglets.

Unlike with protein, fermentation of fibre is generally considered to produce beneficial metabolites that promote gut health and limit pathogen growth. As with protein, the impact of fibre on nursery pig performance and intestinal health has been inconsistent, likely due to differences in the physicochemical properties and fermentability of fibre sources. Inclusion of a non-structural/soluble fibre source may provide intestinal bacteria an alternative substrate for fermentation whereas inclusion of structural/insoluble source of dietary fibre may reduce the impact of indigestible protein through increased digesta flow through the gut and reduced adhesion of pathogens.

While reducing dietary crude protein has generally been shown to reduce the incidence of diarrhea, this comes at added cost through addition of supplemental crystalline amino acids and/or through reduced growth performance. The costs associated with enteric disease in the post-weaning period can be substantial. Understanding key risk factors related to dietary protein and diarrhea will support the development of mitigation strategies, helping farmers participate in raised without antibiotics programs while maintaining animal health and 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 Evonik Operations GmbH, Hanaup Wolfgang, Germany
4 Evonik Corporation, Kennesaw, GA, USA

EXPERIMENTAL PROCEDURES

1. Impact of indigestible protein on nursery pig performance and intestinal health

A total of 80 nursery pigs were randomly assigned to 1 of 2 dietary treatments over 2 blocks (n = 8 pens/treatment) for 28 days. Dietary treatments contained similar dietary crude protein (DCP) content (21 %), but different levels of IDP [low IDP, 2.74% (LIDP) or high IDP, 4.20% (HIDP)]. The IDP levels were based on the difference between DCP and SID CP and were achieved using protein sources that were digestible (soy protein concentrate) and less digestible (canola meal and corn distiller dried grain with soluble). Diets were corn-soybean-based and formulated to meet or exceed nutrient requirements according to NRC (2012) and AMINODat 6.0 requirements. Feed and water were available ad libitum. On d 0, 1, 2, 3, 4, 5, 6, 7, 14, 21, and 28, fecal samples were collected and visually scored for fecal consistency (FCS). One average weight pig per pen was humanely euthanized on d 9 for collection of blood, distal GIT content, and fecal matter.

2. Determination of effect of enteric pathogen and indigestible protein content on performance, immune status, gut health, and gut microbiome in nursery pigs

At 3 days old, tail samples were collected for the determination of ETEC F4 receptor gene following a DNA marker-based test. The collected tissues contained either resistant alleles (R) or susceptible alleles (S); pigs with allele S were selected for the ETEC F4 challenge study.

Animals, housing, diets, and experimental design

Thirty-two newly weaned pigs were randomly assigned to 1 of 2 dietary treatments in a completely randomized design (n = 8 pigs/treatment) for 14 d, comprised of 7 day adaptation and post-inoculation periods. Dietary treatments were corn-soybean-based and contained similar dietary crude protein (DCP) content (21 %), but different levels of IDP [low IDP, 2.74% (LIDP) or high IDP, 4.20% (HIDP)].The IDP levels were based on the difference between DCP and SID CP and were achieved using protein sources that were digestible (soy protein concentrate) and less digestible (canola meal and corn distiller dried grain with soluble). Feed and water were available ad libitum. Pigs and their feed intake were individually weighed at the beginning of the experiment and on weekly basis. Fecal matter was scored daily.

Pathogenic inoculation

Enterotoxigenic E. coli K88+ F4

The ETEC F4 was obtained and selected for antibiotic resistance to chloramphenicol. The ETEC F4 culture was prepared following procedure adapted from Jayaraman et al. (2017). On d 7 pre-inoculation, pigs were orally inoculated with 5 mL of 1.36 × 106 CFU/mL ETEC F4.

Salmonella Typhimurium var. Copenhagen

Salmonella Typhimurium var. Copenhagen (ST) was selected for antibiotic resistance to Nalidixic acid (Nal+) and Novobiocin (Nov+). On d 7 pre-inoculation, the pigs were orally inoculated twice within 4 h with 1 mL of 1.14 × 1010 CFU/mL ST at 0900 h in accordance with the same procedure described for ETEC F4.

RESULTS AND DISCUSSION

Results on the impact of indigestible protein on performance, intestinal health, and response to disease challenge are pending further analysis.

In previous experiments from the same study, it was found that supplementing high IDP diets with dietary fibre fractions (DFF) improved fecal consistency scores, reduced the incidence of diarrhea, and improved select aspects of gut health, though growth performance was not impacted. These results suggest that the addition of fibre in nursery diets has a beneficial impact on piglet gut health. For more information on a previous trial related to this report, please see our 2024 Annual Research Report – Impact of fibre on performance and intestinal health of pigs fed a high indigestible protein level (Erinle et al., page 15).

IMPLICATIONS

Results of a previous literature review indicate that the IDP index is a more sensitive variable compared to DP, because small changes in IDP have a greater impact on simulated weanling pig performance responses, although further validation of the model is necessary. Results show that protein source, rather than DP, is a major contributor to the negative effects of DP on simulated performance.

Furthering our understanding of how protein digestibility influences gut health in nursery pigs is paramount to ensuring good health and optimal growth throughout the production flow.

ACKNOWLEDGEMENTS

This study was completed with support from the Saskatchewan Agriculture Development Fund. 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.

Influence of dietary nitrogen content and source on growth performance in finisher pigs

Kwan Ng[1,2], Dan Columbus[1, 2]

Dan Columbus

INSIGHT FOR PRODUCERS

Producers may want to avoid ammonium phosphate in finisher pigs unless supplemental lysine is also included in the diet, as there was a decrease in average daily gain and feed efficiency with ammonium phosphate inclusion.

SUMMARY

Low-protein diets may be nitrogen-deficient for optimal growth in pigs. Previous work showed a benefit in grower pigs when dietary nitrogen, either through protein or non-protein nitrogen, was increased. The objective of this study was to determine the impact of dietary nitrogen content and source on finisher pig performance. Finisher pigs were fed a nitrogen-deficient diet or a diet containing supplemental nitrogen as protein or non-protein nitrogen. Diets included either a standard or supplemented level of lysine. There was no impact of diet on performance. This indicates that finisher pigs may not respond to additional nitrogen as was previously observed in grower pigs.

"The use of ammonium phosphate as a nitrogen source has the potential to further reduce feed costs."

INTRODUCTION

The use of reduced-protein, essential amino acid (EAA)-supplemented diets has become commonplace to reduce feed costs and mitigate nitrogen (N) excretion into the environment. While growth performance can generally be maintained on these diets, there is some indication that reduced-protein diets may become limiting in either non-essential amino acids (NEAA) or N. It has been suggested that after meeting the requirements for the EAA, protein (or N) may become limiting, reducing the production of NEAA and limiting the utilization of EAA. For instance, Rocha et al. (2022) determined a minimum crude protein level required to maintain average daily gain in pigs, with 18.4%, 16.1%, and 11.6% estimated to be required for nursery, grower, and finisher pigs, respectively.

It has been suggested that dietary N sufficiency can be estimated through calculation of the EAA-N:total N ratio (E:T), with a higher ratio indicating potential N-deficiency and lower ratio indicating sufficient N. We have previously demonstrated that when an additional source of N, either as intact protein (Camire et al., 2023) or as non-protein nitrogen (NPN; Buchinski et al., 2024a) was included in N-deficient diets (as indicated by a high E:T), that N-retention was increased, resulting in a higher lysine requirement. Plasma AA analysis demonstrated an increase in EAA utilization (decreased plasma EAA) with NPN inclusion and increased plasma content of glutamine and glutamate (Buchinski et al., 2024a), which are important NEAA for N metabolism and non-waste utilization. We also showed that addition of NPN to diets did not alter pig growth rate, but improved feed efficiency, increased lean gain, and decreased fat gain in growing pigs (Buchinski et al., 2024b). The results of these studies suggest that it may be possible to replace some dietary protein/AA with a source of NPN to maintain growth performance, however, as these studies were based on grower pigs, the impact of dietary N content and source of finisher pigs is not known.

Improved feed efficiency while maintaining similar growth performance will result in reduced feed costs. In addition, use of ammonium phosphate as a nitrogen source has the potential to further reduce feed costs as its inclusion level is lower than intact protein to achieve the same E:T ratio with the added benefit of reducing or eliminating the need for additional sources of phosphorus.

1 Prairie Swine Centre Inc., PO Box 21507, 2105 – 8th Street East, Saskatoon SK S7H 5N9
2 Department of Animal and Poultry Science, University of Saskatchewan, 51 Campus Drive, Saskatoon SK S7N 5AB

EXPERIMENTAL PROCEDURES

A total of 270 mixed-sex finisher pigs with an initial body weight (BW) of 69.8 ± 0.37 kg were housed in groups of 5 pigs/pen and pens randomly assigned to 1 of 6 dietary treatments (n=9 pens/treatment). Dietary treatments consisted of an N-deficient diet (HR; E:T ratio of 0.33) or a low E:T ratio diet (E:T ratio of 0.30) achieved by supplementing intact protein (i.e., soybean meal; LRP) or NPN (i.e., ammonium phosphate; LRA). Each diet contained either a standard amount of Lys based on the requirement as indicated by NRC (2012) or Lys at 120% of the requirement (L), as indicated by our previous studies in pigs fed diets with a low E:T ratio. All diets were formulated to meet or exceed all other nutrient requirements according to NRC (2012), with diets analyzed for dry matter, crude protein, and amino acid content.

The experimental period was 42 d in length and pigs had ad libitum access to feed and water throughout the study. Individual BW and per pen feed intake were measured on d 0, 7, 14, 21, 28, 35, and 42 of the study for determination of average daily gain, average daily feed intake, and feed efficiency (gain:feed). On d 42 of the study, ultrasound was performed on 2 pigs per pen for determination of back fat and lean depth, all pigs were then weighed and shipped to a commercial abattoir (Thunder Creek) for standard carcass measures.

RESULTS

Diets were analyzed to confirm nutrient content. Dietary protein and energy content were within the expected range of formulated values, however, amino acid content was lower than expected based on formulated values. Mixing inclusion of ingredients was confirmed to be accurate, so the lower values were either due to a systemic laboratory analysis issue or variability in ingredients. Results are discussed with the assumption that diets were made properly and contain the expected amount of nutrients, although there is a possibility that, in some cases, a lack of treatment effect may be due to lower amino acid content.

Overall dietary treatment did not influence body weight, except for a reduction in body weight of LRA-fed pigs on d 28 and 35 of the study compared to pigs fed HR, HR-L, and LRP-L ($P < 0.01$). Average daily gain between d21-28 was lower in LRA-fed pigs compared to HR-fed pigs from d 21-28 ($P < 0.05$) and compared to pigs fed HR-L over the entire experimental period (d 0-42; $P < 0.05$). There was no treatment effect on average daily feed intake. Feed efficiency (gain to feed ratio, G;F) was lower in HR-L pigs compared to LRP-fed pigs from d 0-7 ($P < 0.05$), and in LRA-fed pigs compared to HR-L, LRP-L, and LRP over the entire experimental period (d 0-42; $P < 0.01$). Gain:feed was reduced in LRA-fed pigs compared to HR-L from d 14-21 ($P < 0.05$).

There was no effect of dietary treatment on body composition, lean depth, or backfat as determined by ultrasound ($P > 0.05$). Likewise, there were no dietary effects on carcass characteristics determined in market pigs, including carcass weight, yield, backfat, or lean depth ($P > 0.05$).

IMPLICATIONS

[Note: the following conclusions assume that diets contained essential amino acids at requirements/as formulated and the low analyzed values are due to an analytical issue]

The E:T ratios of these studies does not appear to have a significant impact on growth performance of finisher pigs. Dietary lysine had limited effect on growth performance, only having a positive effect in pigs fed diets with added ammonium phosphate (LRA). As there was no impact on feed efficiency, adding ammonium phosphate appears to cause a change (i.e., reduction) in nutrient utilization and the reduced performance does not appear to be due to a decrease in palatability.

Overall, diet had no impact on final body weight or carcass composition, however, there was a decrease in average daily gain and feed efficiency with ammonium phosphate inclusion, indicating that producers may want to avoid ammonium phosphate in finisher pigs unless supplemental lysine is also included in the diet.

The differing results of E:T ratio and nitrogen supplementation in finisher pigs vs. grower pigs (Buchinski et al., 2024) may be due to a change in growth composition in finishers vs. growers, as finisher pigs have lower lean gain and reduced efficiency compared to growers.

Although not an original objective, this study also demonstrates that finisher pigs can grow well on diets containing as low as 12% protein when essential amino acids are fed at requirement. An additional potential benefit shown in this study is that ammonium phosphate can also be a source of phosphorus, with inclusion of ammonium phosphate allowing for removal of other sources of phosphorus (e.g., monocalcium phosphate) from diet formulations. Finally, the results of this study show that there is no economic advantage to providing additional nitrogen or lysine in diets for finisher pigs as formulated in the completed experiment.

ACKNOWLEDGEMENTS

This study was completed with support from the ADOPT program (Agriculture Development of Processes and Technologies). 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.

The influence of gestational vitamin supplementation on sow and piglet performance

Hannah Burlet[1], Frederic Beaudoin[2], Beatrice Sauve[3], Laetitia Cloutier[3], Matheus de Olivieria Costa[1, 4], Danyel Bueno Dalto[2]

Hannah Burlet

INSIGHT FOR PRODUCERS

Gestation is a physiologically stressful period; support of sow health through vitamin supplementation may provide a low-input and cost-effective approach to improving sow productivity and piglet health.

SUMMARY

Past research has shown that increased supplementation of certain vitamins can enhance parameters such as conception rates, litter size, and the passage of maternal immunoglobulins; these experiments generally include increased provision of one or two vitamins. To understand the impact that supplementation of all vitamins beyond industry standards would have on sow productivity, we developed two experimental diets formulated to either NRC (2012) recommendations (Control, CTR), or beyond industry standard (High Vitamin, HiVit). Utilizing the same gilts and sows, the experimental gestation diets were fed over two consecutive reproductive cycles. Factors such as litter size, weight, and survival were considered. Analysis of maternal blood serum, colostrum, and piglet serum was done to gain insight into the passage of maternal immunity. The high vitamin diet did not improve aspects of maternal performance and passage of maternal immunity over all, but interesting effects were detected. In the second reproductive cycle, second-parity HiVit gilts had significantly heavier litters than their CTR counterparts and both treatments in the first cycle, with no difference in litter size. No consistent differences were seen regarding the impact of diet on maternal antibody measures. The findings related to gilt performance in the second cycle are of great interest due to current concerns about second parity syndrome and sow lifetime performance. Further research into vitamin supplementation in gilt diets, with the possibility including precision feeding, is pertinent.

INTRODUCTION

Gestation is an undeniably important stage of swine production, generating the ultimate product of the industry. Sow mortality is currently a point of great concern, with removals at a rate higher than ever before. Support of maternal health during this period ensures that sows reach their reproductive potential and that their piglets have a healthy start to life. Larger litter sizes as a result of selection for highly prolific sows have come at the expense of individual piglet weight and survivability. Neonatal piglets also face challenge by disease, though some protection is provided through the passage of maternal antibodies via colostrum and milk.

Vitamins are known to play an important role in many physiological systems. Previous research has found that supplementation of certain vitamins beyond minimum requirement can enhance certain aspects of productivity. For example, increased supplementation of vitamins A and E are reported to improve conception rates while also enhancing antibody transfer. Though the culmination of previous research covers all vitamins individually or in subsets, none have assessed the influence of increased supplementation of all vitamins commonly included in swine premixes at once. With the relatively low cost of vitamin premix, the idea of an increase of supplementation leading to improved reproductive performance and piglet health is attractive.

The following study endeavors to determine if feeding vitamins at a rate greater than industry inclusion practices can enhance sow and piglet performance as well as passage of maternal immunity. Supplementation over two reproductive cycles with the utilization of multiple parities will hopefully reveal any additive effect that may not be seen in one cycle, especially in younger dams.

"Improving lifetime performance of sows is important... a low-cost solution such as vitamin supplementation is worth research."

1 Department of Large Animal Clinical Sciences, Western College of Veterinary Medicine, University of Saskatchewan, 52 Campus Drive, Saskatoon, SK, S7N 5B4
2 Sherbrooke Research and Development Centre, Agricuture and Agrifood Canada, 2000 College Street, Sherbrooke, QC, J1M 0C8
3 Centre de Développement du Porc du Québec inc., 450-2950 Laurier Boulevard, Québec, QC, G1V 4M6
4 Department of Population Health, Faculty of Veterinary Medicine, Utrecht University, Utrecht, Netherlands

EXPERIMENTAL METHODS

Animals used in this study were selected from the Centre de Développement du Porc du Québec inc. (CDPQ) and followed over two reproductive cycles. Gilts (n=32) and sows (n=34) were assigned to either a control (CTR) diet formulated to NRC (2012) recommendations or a high vitamin (HiVit) diet formulated beyond current industry standards (Table 1). Diets were fed from breeding (D0) to farrowing (D113-117). During gestation, sows were group housed with electronic sow feeding stations; feed distribution and intake were controlled and tracked using Gestal 3G2 feeding stations (JYGA Technologies, St-Lambert-de-Lauzon, QC). Dams were vaccinated using ProSystem RCE (Merck Animal Health, Kirkland CQ) to manufacturer instruction (D80 and 100 in gilts, D100 in sows). Cross-fostering occurred within treatment groups but between parities.

Table 1. Dietary vitamin concentrations.

Diet Component	CTR diet	HiVit diet
Vitamin A (IU/kg)	4,000	15,000
Vitamin D (IU/kg)	800	** 2,800 **
Vitamin E (mg/kg)	40	135
Vitamin K (mg/kg)	0.5	5.0
Thiamine (mg/kg)	1	2.5
Riboflavin (mg/kg)	3.75	10.0
Niacin (mg/kg)	10	45
Pantothenic acid (mg/kg)	12	40
Pyridoxine (mg/kg)	1	5.5
Biotin (mg/kg)	0.2	0.8
Folic acid (mg/kg)	1.3	5.5
Vitamin B12 (ug/kg)	15	50
Vitamin C (mg/kg)	0	300

***Note: In the HiVit diet, the 2800 IU of vitamin D will consist of 800 UI of vitamin D3 and the necessary amount of HyD to supply the equivalent of 2000 IU.*

Litter characteristics

In the farrowing room, litter characteristics were recorded. The total number of piglets born, total born alive, mummified, and stillborn were counted. On day 2 post-farrowing, litters were processed and piglets were weighed individually. Piglet removals were recorded. On day 21 post-farrowing, piglets were weighed before weaning.

Sample collection

Blood and colostrum samples were collected for analysis of total and specific IgG measures. From dams, blood was collected on days 0, 100 (prior to vaccination), and 110. Blood was also collected from two average weight piglets from each litter on days 2 and 21. Blood samples were processed to separate the serum, which was then frozen until analysis. Colostrum was collected within 12h of farrowing, utilizing the first three pairs of teats. The fat portion was separated via centrifugation then removed and the whey portion was frozen until analysis.

ELISA

To understand if there was any dietary influence on the passage of maternal immunity, ELISAs for both total IgG concentration (ELISA Flex: Porcine IgG (HRP), Mabtech Inc., Cincinnati OH) and specific IgG titres were completed. For specific IgG titres, ProSystem RCE (Merck Animal Health, Kirkland QC) was used as the coating antigen in an indirect ELISA. Serum and colostrum samples were tested in duplicate for both assays.

RESULTS

Sow and piglet performance

In the first cycle HiVit sows weaned more piglets than CTR sows (P=0.039), though this difference was not seen in the second cycle, with HiVit sows tending to wean less piglets than their CTR counterparts (Table 2., P=0.060). Gilts fed the control diet weaned fewer piglets than HiVit gilts in both cycles (P=0.014), though they also had smaller litters after cross fostering (Table 3., P=0.047). Litter sizes before cross-fostering were not statistically different. In the second cycle, HiVit gilt litters on D2 post-farrowing were significantly heavier than CTR gilt litters in the same cycle and the litters of both groups in the first cycle, though litter sizes were not significantly different (Table 4., P=0.037). This weight difference was not seen at weaning. Treatment did not alter sow litter weight at day 2 or 21.

Immunological results

Consistent differences based on treatment or treatment and cycle interaction did not influence total IgG concentrations in gilt or sow serum, colostrum, or piglet serum. The only difference related to treatment was seen in the first cycle, where CTR sows had higher total IgG concentrations in D100 serum compared to HiVit sow samples from the same day (P=0.040); this difference was also seen in CTR sow colostrum in the first cycle (P=0.012); no difference was detected on D110, in piglet serum, or in specific IgG titres. HiVit gilts had higher specific IgG titres at D100 in the first and second cycles compared to CTR gilt serum (P=0.038). This difference was not seen in D110 serum, colostrum, or associated piglet serum titres in either cycle. Diet did not influence sow specific IgG titres in serum, though HiVit sow colostrum tended to have higher titres in the second reproductive cycle compared to CTR samples where no difference was seen in the first cycle (P=0.062). This difference was not reflected in associated piglet serum samples.

IMPLICATIONS

While the findings of this study are mixed, the implication that high vitamin supplementation in gilt gestation diets over two reproductive cycles can improve second litter weights by an average of 3 kilograms is very interesting. Improving lifetime performance of sows is important, and the possibility of a low-cost solution such as vitamin supplementation is worth research. Given the influence was only seen in dams fed the diet through their first parity, there may be some link between vitamin supplementation and the physiological development of the gilt herself which allows for improved performance in the second cycle, rather than the oft expected dip.

ACKNOWLEDGEMENTS

This project was completed with support from the Saskatchewan Agriculture Development Fund, as well as with the support of DSM-Firmenich. The author would also like to acknowledge the dedication of the researchers and staff at both the CDPQ and Agriculture and Agrifood Canada (AAFC) in completing this project.

Table 2. Average litter size of sows which farrowed in both reproductive cycles, before and after cross-fostering and at weaning.

Piglets, mean (min, max)	Sows								
	Cycle 1			Cycle 2			P value		
	HiVit (n=12)	CTR (n=11)	SEM	HiVit (n=12)	CTR (n=11)	SEM	Treatment	Cycle	Interaction
Before cross-fostering	15.25 (10, 19)	15.18 (7, 18)	0.57	14.75 (12, 18)	14.55 (9, 19)	0.57	0.89	0.37	0.91
After cross-fostering	14.50 (12, 17)	13.82 (12, 15)	0.25	12.85 (11, 14)	12.91 (11, 15)	0.25	0.67	0.0001	0.10
Weaning	13.33 (11, 15)	12.73 (11, 15)	0.34	11.17 (6, 13)	12.18 (10, 15)	0.34	0.72	0.0032	0.060

Note: SEM = standard error of the mean, HiVit = high vitamin diet, CTR = control diet

Table 3. Average litter size of gilts which farrowed in both reproductive cycles, before and after cross-fostering and at weaning.

Piglets, mean (min, max)	Gilts								
	Cycle 1			Cycle 2			P value		
	HiVit (n=8)	CTR (n=10)	SEM	HiVit (n=8)	CTR (n=10)	SEM	Treatment	Cycle	Interaction
Before cross-fostering	14.13 (12, 17)	15.00 (9, 19)	0.57	13.75 (9, 18)	12.60 (6, 17)	0.83	0.912	0.074	0.18
After cross-fostering	15.00 (14, 16)	14.10 (11, 16)	0.27	13.88 (12, 15)	13.30 (12, 14)	0.21	0.047	0.014	0.65
Weaning	14.38 (13, 16)	13.30 (10, 16)	0.34	13.75 (12, 15)	12.60 (11, 14)	0.25	0.014	0.15	0.93

Note: SEM = standard error of the mean, HiVit = high vitamin diet, CTR = control diet

Table 4. Average litter weights of gilts which farrowed in both reproductive cycles, before and after cross-fostering and at weaning.

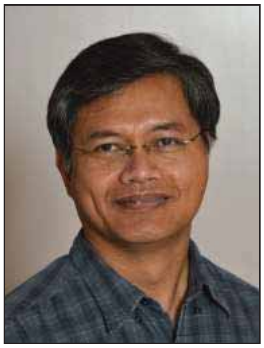
Average litter weight, kg (±SD)	Gilts						
	Cycle 1		Cycle 2		P value		
	HiVit (n=8)	CTR (n=10)	HiVit (n=8)	CTR (n=10)	Treatment	Cycle	Interaction
Before cross-fostering	19.27 (2.40)	19.90 (2.69)	23.02 (2.80)	19.68 (4.38)	0.34	0.060	0.037
After cross-fostering	20.87 (2.97)	18.70 (3.34)	23.66 (3.80)	20.99 (2.51)	0.097	0.0064	0.76
Weaning	85.81 (10.72)	77.79 (14.32)	85.33 (17.73)	82.77 (8.08)	0.37	0.49	0.40

Note: SD = standard deviation, HiVit = high vitamin diet, CTR = control diet

Investigation of Saskatoon berry pomace for mitigation of AMR in swine production

Brenna Stephens[1], Darren Korber[2], Denise Beaulieau[1], and Bernardo Predicala[3, 4]

Denise Beaulieu



Bernardo Predicala

INSIGHT FOR PRODUCERS

Fruit pomace, a byproduct of juice production, contains phytochemicals which may enhance animal health and performance. Use of byproducts from other production chains is also a cost-effective way to enrich diets.

SUMMARY

Pomace, the pressing remains of fruit, is known to be rich in phytochemicals, such as polyphenolic compounds, which possess anti-inflammatory, anti-bacterial, anti-fungal, and/or anti-oxidative properties. These characteristics may protect the gastrointestinal tract (GI) and act as an alternative to in-feed antibiotics. The aim of this project examined the effects of saskatoon berry pomace on overall pig performance and health. A pilot-scale study involved feeding pigs' diets with two levels of dried Saskatoon berry pomace to determine its appropriate inclusion rate in the diet and its impact on growth performance, nutrient digestibility, and nitrogen retention. Experimental treatments were Diet A (control, fed a basal diet), Diet B (basal diet plus 5% pomace), and Diet C (basal diet plus 10% pomace). Results indicate Diet C had an improved ($p < 0.05$) total dietary fiber and insoluble dietary fiber digestibility while Diet B had higher ($p < 0.05$) total nitrogen loss compared to Diet A. Both Diets B and C had higher ($p < 0.05$) fecal nitrogen loss compared to Diet A. Overall, a basal diet with 10% pomace (Diet C) improved total fiber and insoluble fiber digestibility and repartitioned nitrogen losses.

INTRODUCTION

Concerns about antimicrobial resistance (AMR) have led to the ban on in-feed growth-promoting antibiotics. Finding new strategies and cost-effective alternatives to antibiotics for maintaining health and achieving production goals are a significant importance to Canadian pork producers.

The gut microbial ecosystem is essential for normal nutritional, physiological, and immunological functions of the animal. Any disturbance in the microbial ecosystem also creates an opportunity for pathogenic organisms to colonize and cause disease. A number of typical barn practices such as early weaning, diet modifications, prophylactic and sub-therapeutic antibiotic use disturb the gut microbial ecosystem, predisposing pigs to disease.

Fruit processing by-products (i.e., pomace) are feed additives that have previously led to substantial improvements in pig performance (Ajila et al., 2015). Pomace, in particular, represents an excellent source of phenolic compounds. These compounds may act as growth promoters by enhancing digestive enzyme secretions and by decreasing the pathogenic microorganisms in the GI or by modulating gut morphology due to their anti-oxidant and anti-inflammatory functions. In a study by Kafantaris et al. (2018), piglets fed with a diet supplemented with grape pomace had higher average daily weight gains and greater numbers of facultative probiotic and lactic acid bacteria compared to those in a control group.

A recent research project showed that continued use of antibiotics in swine production operations increased the frequency of AMR genes, whereas the implementation of a Raised Without Antibiotics (RWA) production program resulted in lower frequency of AMR genes but higher abundance of pathogenic microorganisms. Including pomace into swine diets, while eliminating antibiotics, offers an approach to maintain or improve overall animal productivity without negatively impacting the supply of clinical drugs for human or animal therapeutic use. It can also provide a value-added stream for the fruit-processing industry by diverting waste.

The outcomes of this project are anticipated to contribute to the development of a novel effective approach to eliminating or reducing the use of antibiotics in the livestock industry without compromising productivity and welfare. The reduction of antibiotic drug use in livestock production, combined with the utilization of plant by-products, is expected to translate into decreased production costs.

1 Department of Animal and Poultry Science, University of Saskatchewan, 51 Campus Drive, Saskatoon SK S7N 5A8
2 Department of Food and Bioproduct Sciences, University of Saskatchewan, 51 Campus Drive, Saskatoon SK S7N 5A8
3 Department of Chemical and Biological Engineering, University of Saskatchewan, 57 Campus Drive, Saskatoon SK S7N 5A9
4 Prairie Swine Center Inc., PO Box 21057, 2105 – 8th Street East Saskatoon SK S7H 5N9

EXPERIMENTAL PROCEDURES

A total of 24 barrows determined to be healthy with no prior conditions or treatments and an initial BW of 35 ± 2 kg were used in this trial. The trial was conducted over two consecutive blocks, each utilizing 12 pigs for a total of 14 days. Pigs were randomly assigned to one of the three treatment groups; Diet A was a basal mash diet with 0% Saskatoon berry pomace (SBP, Control diet), Diet B was basal mash with 5% SBP inclusion and Diet C was a basal mash with 10% SBP inclusion.

Pomace and Feed

Pomace is produced by drying the mash, including the seeds and skin, remaining after juicing. The mash byproduct was dried under low heat (50-80°C) and then milled twice, first to 40 (0.042 cm) and then 80 (0.018 cm) mesh. The final product is dried SBP, not containing any other components, the nutritional content of the SBP can be found in Table 1.

The diets fed were typical Western Canadian swine diets formulated to meet nutrient requirements for pigs of the weight range used, according to the NRC (2012). Celite was used as the marker for the diets. Dietary treatment ingredients and chemical compositions can be found in Table 2.

Table 1. Dried Saskatoon berry pomace analysis and composition according to the manufacturer**.**

Composition	Amount on an as-fed basis
Moisture (g/100g)	6.80
Protein (g/100g)	7.25
Total fat (g/100g)	3.56
Saturates (g/100g)	0.63
Trans fat (g/100g)	<0.03
Cholesterol (mg/100g)	<1.02
Carbohydrate (g/100g)	79.11
Fibre (g/100g)	32.21
Sugars (g/100g)	37.31
Ash (g/100g)	3.28
Vitamin A (RE/100g)	10.35
Vitamin A (IU/100g)	103.48
Vitamin C (mg/100g)	<2.93
Calcium (mg/100g)	560.00
Iron (mg/100g)	3.35
Sodium (mg/100g)	<10.00
Calories (per 100g)	377.48
Magnesium (mg/100g)	160.00
Anthocyanins (mg/100g)	204.00
Total phenolics (mg/100g)	773.00

Note: This table was obtained from the manufacturer packaging label (Prairie Berries, unpublished data).

Table 2. Ingredient and chemical composition of the three treatment diets expressed as a percent (%) as fed basis.

Composition	**Treatment**		
Ingredients (%)	**A**	**B**	**C**
Barley 10.0% CP	46.54	46.54	46.54
Wheat 13.0% CP	15.70	15.70	15.70
Corn 8.0% CP	13.28	13.28	13.28
Soybean meal 45.0% CP	11.27	11.27	11.27
Canola meal 36.0% CP	10.00	10.00	10.00
Vegetable oil	0.30	0.30	0.30
DL-Methionine 99.0%	0.04	0.04	0.04
L-Threonine 98.5%	0.11	0.11	0.11
Coarse calcium	1.03	1.03	1.03
Potash salt bagged	0.52	0.52	0.52
Copper sulfate 25%	0.04	0.04	0.04
Vitamin and mineral premix	0.17	0.17	0.17
Calculated chemical composition (%)			
DM	95.33	95.16	95.07
OM	90.81	90.83	90.87
CP	19.32	18.51	18.53
EE	2.60	2.78	3.55
TDF	20.75	21.95	24.00
IDF	17.05	17.85	20.30
SDF	3.70	4.10	3.75
Anthocyanins (total)	0.00	0.01	0.02
Polyphenols (mg/100g)	0.00	0.04	0.07

Note: The anthocyanins and polyphenols listed in the chemical composition were taken from the manufacturer label from the SBP, the mash diet was not individually tested for either. Vitamin and mineral premix contain the following per kg of diet: 714 mg phytase, 0.30 mg selenium, 1.0 mg iodine, 8000 IU vitamin A, 1500 IU vitamin D3, 30 IU vitamin E, 2.0 mg vitamin K3, 1.0 mg vitamin B1, 4.0 mg vitamin B2, 20 mg niacin, 12 mg pantothenic acid, 2.0 mg vitamin B6, 0.10 mg biotin, 0.50 mg folic acid, 0.02 mg vitamin B12. Diets contains 0.55% BioLys 60, 0.06% Mintrex zinc, 0.02% Propath iron, 0.40% celite.

Note[2]: DM = dry matter; OM = organic matter; CP = crude protein; EE = ether extract; TDF = total dietary fiber; IDF = insoluble dietary fiber; SDF = soluble dietary fiber.

Sample Collection

The sample collection occurred during the last 4 days of each block. Urine samples were collected over days 11-12, and fecal samples were collected over days 11-14 to avoid potential day-to-day variability.

Feed samples were taken from the three treatment diets during every round of mixing feed, and each time a new feed bag was opened. Samples were pooled prior to analysis.

Laboratory Analysis

Feed, fecal, and urine samples were analyzed for crude protein (CP) using the Kjeldahl method, while fecal and urine analysis determined the overall excreted nitrogen content. Fecal and feed samples were analyzed for gross energy (GE) in cal/g. Feed samples were also analyzed for ether extract (EE) or crude fat.

RESULTS AND DISCUSSION

Growth performance

There was no significant difference between treatment groups in any of the growth performance parameters. There is a tendency for pigs fed basal diet (Diet A) to have a higher ADFI than those fed basal diet with 5% SBP inclusion (Diet B; p= 0.06). This may be due to the unfamiliarity of SBP as a feed ingredient causing a decreased initial feed intake as they became adapted to the diet. This is not seen in pigs fed diet C, with a 10% pomace inclusion which contradicts the previous assumption. An alternative rationale may be that the addition of the SBP within the diet, the nutrient content might exceed that of the control diet or allowed for a more efficient absorption of nutrients. This would allow for the pigs to consume less feed while still absorbing required amount of nutrients for growth.

Antioxidants and Polyphenolic Content

Table 3 shows the measured amount of antioxidant capacity (AC) and polyphenols contained in the feed for each treatment diet. The basal diet (Diet A) had more antioxidant capacity to mitigate oxidative stress conditions, without any pomace present in the diet, compared to diets with pomace (Diets B and C). In addition, Diet B had more antioxidant capacity to mitigate oxidative stress conditions than Diet C. Both results were unexpected due to the amount of pomace inclusions. This could be due to a sampling error as Diet C was expected to have the highest amount of AC and total phenolic content (TPC), followed by Diet B and then Diet A to contain the least amount of AC and TPC due to the rate of SBP supplementation. The TPC in all diets was too minimal to determine any differentiation between the diets with the analysis used, all containing less than 2mg/g.

Table 3. Amount of antioxidant capacity and phenolic content of each treatment on an as fed basis.

	Treatment		
Antioxidant parameter	**A**	**B**	**C**
ORAC (umol Trolox equivalent/g)	37.05	32.40	34.10
TPC (mg/g)	<2.00	<2.00	<2.00

Note: A = basal diet; B = basal+5%SBP; C = basal+10%SBP.

Digestibility and Nitrogen

The effects of SBP inclusion on nutrient digestibility and digestible energy (DE) are shown in Table 4. There were no significant differences between treatment groups in the amount of gross energy (GE), however there was a tendency for Diet A to have a higher GE digestibility than Diets B and C (P<0.1). There was a significant difference in dry matter (DM) digestibility between Diets A and B, and a tendency for Diet A to have a higher DM digestibility rate than Diet C (p= 0.07). Average total dietary fiber (TDF) and insoluble dietary fiber (IDF) digestibility was significantly higher in Diet C than in Diet B. There was no significant difference in soluble dietary fiber (SDF) digestibility between treatment groups. Average crude protein (CP) digestibility was significantly higher in Diet A than in Diets B and C. There was no significant difference in DE or DE on a DM basis between treatment groups. Overall, Diet B had the worst performance regarding digestibility. These results display potential for further investigation as Diet C, supplemented at 10% of the diet had the highest overall fiber digestibility while maintaining the growth performance when compared to basal Diet A. Though long-term effects have not been determined, supplementing 10% of grower diets with SBP may be able to improve fiber utilization and absorption while maintaining typical growth performance.

Table 4. Effect of Saskatoon berry pomace inclusion on nutrient digestibility (on a DM basis) and digestible energy in grower pigs.

	Treatment			
Calculated nutrient digestibility (%)	**A**	**B**	**C**	**SE**
GE	75.68	73.13	73.12	1.48
DM	78.66	76.29	76.66	1.27
TDF	41.63	37.85	43.16	3.37
IDF	33.71	28.82	75.09	3.63
SDF	78.85	77.60	76.76	2.51
CP	78.92	74.33	75.09	1.08
Calculated digestibility (kcal/kg)				
DE	3160.55	3111.29	3180.29	59.82
DE (DM basis)	3413.67	3345.70	3420.39	64.04

Note: A = basal diet; B = basal+5% SBP; C = basal+10% SBP; GE = gross energy; DM = dry matter; TDF = total dietary fiber; IDF = insoluble dietary fiber; SDF = soluble dietary fiber; CP = crude protein; DE = digestible energy; SE = standard error.

The effects of SBP inclusion on nitrogen losses and partitioning are shown in Table 5. There was a significant difference in total nitrogen loss between Diets B and C, with a tendency for Diet B to have a higher total nitrogen loss percentage than Diet A (p= 0.09). There was a significant difference in fecal nitrogen loss between Diets B and A, and Diets C and A. There was a significant difference in urine nitrogen loss between Diets B and C, with a tendency for Diet A to have a higher nitrogen loss percentage than Diet C (p= 0.06).

Table 5. Effect of Saskatoon berry pomace inclusion on nitrogen loss and nitrogen partitioning in grower pigs.

	Treatment			
Nitrogen losses (%)	**A**	**B**	**C**	**SE**
Total nitrogen loss	43.93	50.34	41.50	2.53
Fecal nitrogen loss	21.08	25.67	24.91	1.08
Urine nitrogen loss	22.85	24.67	16.59	2.22

Note: A = basal diet; B = basal+5% SBP; C = basal+10% SBP; SE = standard error.

Total nitrogen loss and fecal nitrogen loss was increased in SBP supplemented treatments. It is speculated that the SBP was able to pass through the intestinal tract into the hindgut and be somewhat utilized by microbial organisms, creating more bacterial nitrogen excretion and repartitioned into the feces instead of urine in the form of urea. However, total nitrogen loss was significantly higher in pigs supplemented 5% SBP than those supplemented 10% and tended to be higher than the control. Coupled with the 10% addition of nutrients added to all diets indicated that there was no reduction in dietary protein provided and the slight fiber addition from the SBP was not able to efficiently mitigate nitrogen losses in Diet B.

But the SBP addition was significantly able to increase nitrogen loss in the feces, and in Diet C, urinary nitrogen loss was significantly reduced compared to the other treatment groups. This indicates that a 10% SBP into the diet allowed for more fiber and protein utilization by microbes in the gut and did slightly reduce total nitrogen loss and was able to significantly shift nitrogen excretion from urea for bacterial protein synthesis, with excess excreted into the feces. Regarding the environmental impact of nitrogen excretion as a result of pomace inclusion, diets would need be formulated to address this issue.

IMPLICATIONS

The analysis of SBP on fiber digestibility in grower pigs demonstrated potential to be an of-value feed additive when supplemented at 10% of the diet based on body weight in terms of improving fiber utilization and nitrogen partitioning without any presumable adverse effects on health or performance.

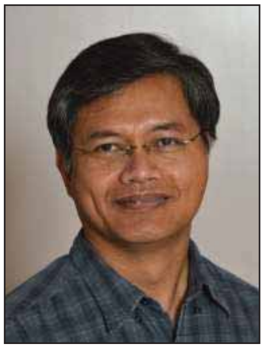
ACKNOWLEDGEMENTS

This study was completed with support from the Saskatchewan Agriculture Development Fund. 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.

Mitigating Mycotoxin Contamination from Grains used in Swine Feed Through Nanotechnology

Alvin Alvarado[1,2], A. Asok, D. Obaob, M. Mosqueda, H. Rabanes, D. Korber, D. Beaulieu, and B. Predicala[1,2]

Alvin Alvarado



Bernardo Predicala

INSIGHT FOR PRODUCERS

Mycotoxins can be detrimental to animal health, growth, and welfare. Using nanotechnology to mitigate mycotoxin contamination is a promising approach.

SUMMARY

Mycotoxin contamination can be a concern for producers resulting from adverse health issues in livestock and significant financial losses in the agriculture sector. Deoxynivalenol (DON) is a significant mycotoxin, contaminating common feed grains, such as wheat, barley and corn. Mitigation strategies for DON are limited in terms of binding efficiency, biosafety, and cost-effectiveness. This study investigated the potential application of nanotechnology to mitigate DON contamination in grains. Nanomaterials have been used to address contaminants in air, soil, and water due to their unique physical and chemical properties. Three nanomaterials were identified and selected for testing: chitosan polymeric nanoparticles (CS), montmorillonite nanocomposites (MN), and magnetic graphene oxide (MGO). It was determined that MGO had the greatest potential for mitigating DON contamination in grains (wheat).

In-barn feeding trials (nursery pigs) were conducted to determine the effectiveness of MGO nanoparticles in mitigating DON in swine diets and their effect on pig performance. Results showed that feeding pigs with MGO-treated diets had no adverse impact on their growth performance, nutrient digestibility and nitrogen retention. Economic analysis revealed using MGO to mitigate DON-contaminated feed is currently not viable due to the high cost of MGO. This could be significantly reduced by developing our own MGO materials or combining MGO nanotechnology with other environmental mitigation techniques such as photocatalytic degradation, which has been utilized to remove various environmental pollutants more effectively and at lower operational costs. Follow up research involving long-term feeding of MGO-treated diets to nursery and grower-finisher pigs with higher DON levels (more than 3 – 5 ppm) is recommended to fully assess the overall impact of this technology in mitigating mycotoxin contamination in diets as well as on the environment.

INTRODUCTION

Mycotoxins are secondary toxic chemicals produced by organisms of fungal origin found in contaminated grains. The occurrence of mycotoxin may start in the field, proliferating throughout subsequent handling, storage, and processing of the grains. The most prevalent mycotoxins identified in western Canada are deoxynivalenol (DON), HT-2 and T-2 toxins, and ergots. Use of mycotoxin-contaminated grains in livestock feed may result in feed refusal, and affect immune and health status.

Nanotechnology can be used to treat contaminants in air, soil and water. Findings from previous studies show that selected nanomaterials can effectively reduce the levels of hazardous gases (Alvarado and Predicala, 2017), growth of disease-causing microorganisms (Alvarado and Predicala, 2014), and Porcine Epidemic Diarrhea (PED) virus (Predicala et al., 2018) in swine barns. 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 the fact nanomaterials can be modified to enhance their physical and chemical properties (Tang and Kotov, 2005).

Based on assessment criteria including previous 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 is unknown. *Fusarium graminearum* and *Fusarium culmorum* are known to produce several different fusariotoxins, including DON, which interact synergistically when fed to pigs. The best way to assess the effectiveness of nanomaterials against mycotoxins is under actual production conditions using the dose of mycotoxins found in feed.

1 Prairie Swine Centre Inc, PO Box 21057, 2105 8th Street East, Saskatoon SK S7H 5N9
2 Department of Chemical and Biological Engineering, University of Saskatchewan, 57 Campus Drive, Saskatoon SK S7N 5A9

In general, research on the potential application of nanomaterials for mycotoxin decontamination 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 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

Phase 1: Laboratory-scale testing

Phase 1 aimed to determine the efficacy of selected nanomaterials, particularly chitosan polymeric nanoparticles (CS), montmorillonite nanocomposites (MN), and magnetic graphene oxide (MGO). These three nanomaterials were identified based on a comprehensive literature review.

Of the three nanomaterials tested, MGO nanoparticles had the greatest potential to reduce DON contamination. MGO nanoparticles were investigated to establish the optimum application rate and operating conditions for mitigating the mycotoxin contaminated grain (i.e., wheat, barley and corn). Dry mixing of materials was employed to simulate the mixing process during feed processing. Hence, the sorption experiments were carried out in 50-mL flasks with each flask containing a mixture of 5 g of DON-contaminated ground grain and test nanomaterial. The operating conditions investigated included MGO nanoparticle application rate (or adsorbent dose), contact time and temperature.

Phase 2: In-barn testing

Phase 2 investigated the effects of using MGO nanoparticles as a DON binder in diets related to overall pig performance. The experiment involved feeding pigs with DON-contaminated diets treated with MGO nanoparticles at an appropriate inclusion rate, as determined in phase 1. In addition to evaluating the impact of MGO nanoparticles as a DON binder on nutrient digestibility and growth performance, as well as on DON content in the diet.

A total of 12 nursery pigs (initial BW of 22 ± 2 kg) were used in the 14-day experiment and fed their assigned diets for 10 days (days 1-10). The daily feed allocation for all pigs was at 2.8x maintenance metabolizable energy requirements (197 kcal/kg $BW^{0.60}$/d; NRC, 2012) and fed in two equal meals. Water was freely available. Following the 10-day feeding period, feces (days 11-14) and urine (days 11-12) were collected.

The three dietary treatments (in mash form) were:

1. Negative Control (NC): Pigs were fed a basal wheat-barley-soybean diet that was not contaminated with DON.
2. Positive Control (PC): Pigs were fed a basal wheat-barley-soybean diet that was contaminated with DON.
3. Positive Control + 1% MGO (PC+MGO): Pigs were fed a DON-contaminated basal wheat-barley-soybean diet that was added with 1% MGO as a DON binder.

Upon completion of the experimental work, PC+MGO pigs were euthanized using captive bolt in compliance with CFIA guidelines, while the remaining NC and PC pigs were returned to the normal production herd at PSC, where they were fed conventional wheat-barley-soybean-based diets until attaining market weight and eventually sent to a commercial abattoir.

Digestibility and retention of nutrients

Digestibility and nutrient retention were measured from fecal and urine samples collected on days 11- 14 and days 11-12 of the trial, respectively, from individual pigs in each treatment group. Fecal samples were analyzed for energy, dry matter, and fiber content. Both feces and urine were analyzed for nitrogen content, allowing overall nitrogen balance to be determined to estimate protein accretion.

Growth performance

The growth performance of the nursery pigs was assessed using average daily gain (ADG), average daily feed intake (ADFI), and gain-to-feed ratio (G: F) throughout the testing period. ADG was determined by pig weight at days 0, 7, and 14.

RESULTS AND DISCUSSION

Phase 2

The growth performance of nursery pigs fed diets not contaminated with DON (NC), diets contaminated with DON (PC,) and DON-contaminated diets treated with MGO (PC+MGO) are presented in Table 1. Pigs fed PC and PC+MGO had slightly higher ADG compared to NC pigs. The difference, however, was not statistically significant ($p>0.05$). For average daily feed intake (ADFI), pigs fed PC+MGO had the highest ADFI among the three treatments, but the difference was not statistically significant ($p>0.05$). Similarly, there is no significant difference ($p>0.05$) in gain to feed ratio (G:F) between the dietary treatments. Overall, the growth performance results suggested that feeding pigs MGO had no significant impact on its ADG, ADFI and G:F.

Table 1. Growth performance of nursery pigs fed diets contaminated with DON and added with MGO as a DON binder.

Treatments	ADG1	ADFI	G:F
NC (n=4)	0.99 ± 0.2	1.37 ± 0.1	0.72 ± 0.1
PC (n=4)	1.04 ± 0.1	1.35 ± 0.1	0.77 ± 0.04
PC + MGO (n=4)	1.04 ± 0.03	1.40 ± 0.1	0.74 ± 0.04

There was no significant difference ($p>0.05$) in the levels of aflatoxin B1, fumonisins B1 and B2, HT-2, T2, nivalenol, and ochratoxin A among the three dietary treatments. However, the NC diet showed significantly lower ($p<0.05$) levels of DON, 3+15ADON and zearalenone compared to PC and PC+MGO diets. This was expected given that the NC diet is the control diet and should be free from any mycotoxin contamination. On the other hand, levels of DON, 3+15ADON and zearalenone in the PC diet were not significantly different from those in the PC+MGO diet ($p>0.05$). DON levels in the PC diet were very low (i.e., 647 ppb), making it a challenge to assess the impact of MGO on DON levels in the PC+MGO diet.

The effect of MGO inclusion on nutrient digestibility in nursery pigs is shown in Table 2. The digestibility of dry matter, gross energy, total digestible nutrients (TDN), fat and crude protein was significantly lower ($p<0.05$) in pigs fed DON-contaminated (PC) diet and PC+MGO diet than those fed the negative control (NC) diet. There was no significant difference ($p>0.05$) in dry matter, gross energy, TDN, fat and crude protein digestibility was found in piglets fed PC+MGO diet compared to those fed PC diet. The reduced digestibility of nutrients observed in pigs fed PC diet and pigs fed PC+MGO diet could be attributed to DON contamination in the diet as both diets had comparable levels of DON. The inclusion of MGO in the diet had no apparent effect on nutrient digestibility.

Table 2. Effect of MGO inclusion on nutrient digestibility in nursery pigs.

Treatments	Calculated nutrient digestibility (%)				
	GE	DM	TDN	Fat	CP
NC	86.75a	96.03a	92.76a	65.61a	86.93a
PC	83.25b	95.10b	91.11b	56.80b	82.25b
PC+MGO	82.96b	94.61b	90.44b	55.37b	82.23b

[a b]Means without a common superscript within a column are significantly different ($p<0.05$).

Phase 3: Economic analysis and recommendations

An economic analysis was conducted to determine the costs and requirements for the proper implementation of the nano-mitigation treatment in a typical pork production facility. The analysis included all costs associated with the nano-mitigation strategy, treatment cost, and labour and operating costs. The estimates were applied to a 100-head nursery room as nursery pigs are more susceptible to DON contamination compared to other stages of production. In addition, the DON-contaminated barley, which comprised 10% of the diet was treated with MGO to reduce its mycotoxin contamination.

At an application rate of 200 mg MGO per 5 g of barley, the total amount of MGO needed to treat about 4,000 kg of feed is 3.14 kg. At the current cost of the commercially-available MGO used in this experiment, this translates to a treatment cost of $62.8 per pig room turn. Furthermore, the duration of each treatment application would be about 1 hour per cycle, and the labour cost was assumed to be $15.0/hour. The operating cost to prepare the MGO-treated barley is $0.03 per pig per room turn. Summing up all these cost estimates, the total incremental cost of treating DON-contaminated feed using MGO nanoparticles is about $62.98/ pig, which is extremely high mainly due of the cost of the MGO nanoparticles.

MGO nanoparticles used in this project are research materials which are relatively costly at present because these are currently custom ordered from a commercial supplier which produced them for us in small quantities; however, similar to other nanomaterials we have used in our other previous studies, the cost for MGO nanoparticles is expected to decrease as demand for this material increases with new applications for the product. Alternatively, options for synthesizing custom batches of MGO nanoparticles that are tailor-made for this application can be explored in university laboratories as well as in small chemical companies, which can greatly reduce the cost of the nanomaterial compared to current commercial suppliers. Another potential alternative for lowering treatment cost is to integrate this nano-mitigation strategy with other environmental remediation techniques, such as photocatalytic degradation, which has been proven effective in the removal of various environmental pollutants due to its inherent properties and low cost (Wu et al., 2019).

IMPLICATIONS

This study demonstrated that nanotechnology has great potential for mitigating mycotoxin contamination in feed grains such as wheat, barley and corn, however, are not cost effective. Among the nanomaterials tested, the addition of magnetic graphene oxide (MGO) in wheat grains resulted in the highest reduction in DON levels.

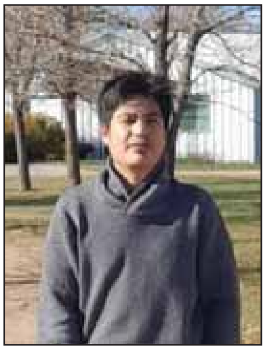
In-barn tests revealed that feeding MGO-treated diet to nursery pigs had no adverse impact on their growth performance, nutrient digestibility and nitrogen retention. The average daily gain, feed intake and gain-to-feed ratio of pigs fed MGO-treated diet were not significantly different from the control pigs. Nutrient digestibility, nitrogen retention and protein deposition were not significantly affected by MGO inclusion in the diet.

ACKNOWLEDGEMENTS

The authors acknowledge the financial support provided by the Saskatchewan Ministry of Agriculture and the Canadian Agriculture Partnership, as well as support from the Saskatchewan Development Board. 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.

Precision detection of farrowing onset and distress using advanced artificial intelligence technologies

M. Hagonob[1, 2], A. Alvarado[1, 2], and B. Predicala[1, 2]



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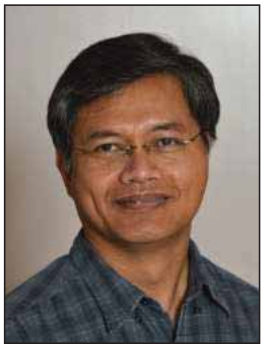


Bernardo Predicala

INSIGHT FOR PRODUCERS

Application of AI technologies can assist in the management of various stages of production. Using AI to monitor farrowing may reduce early piglet losses.

SUMMARY

Farrowing is a critical stage in pork production, however barn workers may not be present for the onset or duration. Use of detection systems may improve health and welfare in this period. Over 1,000 annotated and labelled images were collected from surveillance cameras and used as dataset for training YOLOv5 model variants (artificial intelligence technology). To train the model, three classes of posture and locomotion behavior (standing/walking, lying and sitting) were used as initial indicators of activity level of pigs in a group-housed system. Mean average precision (mAP) and number of parameters employed were used as evaluation metrics to assess the overall performance of the models. The most promising model for monitoring and detection of posture and locomotion behavior was YOLOv5S, which was capable of achieving a mAP of 83% and more efficient than the other model variants. The YOLOv5S model performed poorly in detecting sitting behavior compared to standing/walking and lying behaviors, which could be due to the large disparity in the number of images used to train the mode. Additional datasets with relatively equal proportion of standing/walking, sitting and lying behaviors are being compiled, and different hyperparameter combinations are adjusted to determine the best weights for the final object detection model. In addition, collection of farrowing videos is currently underway to detect the onset of farrowing and identify sows in distress.

INTRODUCTION

The application of AI (artificial intelligence) contributes to the application of precision livestock farming. Image processing and computer vision are examples of technologies that have been used as non-invasive methods of data collection in livestock production, including weight prediction, water usage, behaviour recognition and classification, lying patterns to evaluate the thermal environment, localization of animals, locomotion assessment, gait assessment, and animal counting. However, some accuracy, cost, and stability limitations still require further development. In swine, AI has been investigated for its potential application for prediction and identification of disease, analysis of growth performance, and monitoring of specific behaviours.

Farrowing is one of the most critical stages in pig production. Various means of predicting the onset of farrowing were investigated such as the use of detection systems such as photocell systems, force sensors, or acceleration sensors combined with different analysis algorithms. However, these sensor-based systems require specific and quite complex installations in the barn. Thus, most of these technologies are still in development stage and have not been implemented in commercial swine barns. Ths project investigates the use of AI technology to detect the onset of farrowing based on machine-vision monitoring of the increase of activity levels in sows due to nest-building behavior within hours prior to farrowing. It is hypothesized that an AI-based technology coupled with computer vision will track changes in sow activity and behavior as well as potential farrowing distress situations. Subsequently generating a warning signal that can be sent to designated barn staff to alert them of the farrowing onset or potentially distressed sows that require attention.

For this project, we have utilized a software application (OneCup AI), which has previously been used to develop AI-based applications for dairy cattle management. Ultimately, the goal of this project is to develop appropriate AI algorithms that can automate the monitoring and detection of the real-time conditions of nursery and grower-finisher pigs as well as sows. We are aiming to develop AI-based technology that can recognize patterns and behvaious such as individual pig identification, production performance, disease indicators, movement characteristics and gait abnormalities, and onset of farrowing, among others. Real-time data collection and analysis of data based on parameters routinely monitored in current barns can provide an accurate representation of the ongoing situation in the barn, hence allowing barn staff to identify priority tasks and optimize time and resource management for the workday. Application of AI technology with accessible monitoring equipment may revolutionize swine management.

1 Prairie Swine Centre Inc, PO Box 21057, 2105 8th Street East, Saskatoon SK S7H 5N9
2 Department of Chemical and Biological Engineering, University of Saskatchewan, 57 Campus Drive, Saskatoon SK S7N 5A9

Figure 1. Qualitative analysis of YOLOv5S model showing ground truths (top) vs predictions (bottom).

EXPERIMENTAL PROCEDURES

Animal Behavior Monitoring and Detection

Posture and locomotion behavior were used as indicators in determining the activity level of pigs in a group sow housing system. Three classes of posture and locomotion behaviour were investigated: standing/walking, sitting, and laying. The system model was developed and improved using pre-trained object detection to optimize its overall performance.

Model Selection

A previously developed YOLOv5-based detection model was utilized to monitor pigs' individual behavior.

Video Acquisition and pre-processing

Pig behavior monitoring was carried out where video footage was used to train, validate and test the AI models. The videos were converted to still images, then annotated and labelled based on the three classes of posture and locomotion behavior.

Datasets and Training Set-up

Annotated images were used to train the model to identify the different classes of posture and locomotion behavior. The dataset was randomly split using a 70:15:15 ratio; 70% were used for training, 15% for validation, and the remaining 15% for testing the model. The dataset used to test the models was independent of training and validation (Figure 1).

Detection of Farrowing Onset and Potential Problems

At least 100 sows in farrowing will be involved in this experiment. Data on their activity and behavior starting from 7 days prior to the anticipated farrowing date until actual farrowing were collected and analyzed to formulate the AI algorithm that marks the onset of farrowing. Additionally, indicators of farrowing distress leading to pig loss were documented and used in developing the AI algorithm to recognize such situations.

RESULTS

Model Development

Results showed that increasing the dataset size for model training improved detection performance. When using YOLOv5S with a dataset size of 100 images, detection performance was lower than that of larger dataset sizes and higher-weight variants. This outcome is expected given the smaller number of training images and hyperparameters used. On the other hand, YOLOv5L achieved higher accuracy than the other YOLOv5 variants, which could be attributed to the higher hyperparameter used. In addition, YOLOv5L outperformed other versions, indicating that it is less prone to overfitting and has a better generalization capability than other models.

YOLOv5S model performed poorly in detecting sitting behavior compared to standing/walking and lying behaviors, indicating that the model learned to detect standing/walking and lying behaviors more accurately than sitting. This could be due to the large disparity in the number of images used to train the model between different classes; the number of sitting images was substantially lower compared to standing/walking and lying images. To improve the accuracy of YOLOv5S model in detecting posture and locomotion behavior of pigs in subsequent experiments, a more balanced dataset between the different behavior classes will be used to train the model.

Detection of Farrowing Onset and Potential Problems

For this reporting period, videos are being collected continuously to detect the onset of farrowing and identify sows' distress situations. All farrowing videos were carefully analyzed based on the activity and behavior of sows from 7 days before the anticipated farrowing date until the actual farrowing. Additionally, indicators of farrowing distress leading to pig loss were also documented. The observation data and videos collected were directly sent to OneCup AI server for further analysis, which will be used to develop a model to detect the onset of farrowing and potential problems

Further development of the YOLOv5S model is ongoing. More models will be trained, validated and tested in subsequent experiments to improve accuracy and to determine the most accurate model for detecting animal behavior. Videos from the farrowing rooms continue to be collected and analyzed. Following completion of model development using the farrowing dataset, testing and validation will be done in-barn using live video feeds. Further, a cost analysis will be completed and specific recommendations for use of the technology in industry will be developed.

IMPLICATIONS

Previous studies have shown that AI-based technology through machine vision has the great potential to address current challenges in swine production (e.g., labour shortages, production inefficiencies.) however, further research is needed before they can be implemented in swine barns. Development of reliable AI detection technologies will not only increase profits but will also improve animal health and welfare. The generated data stream can also help guide new facility designs and genetic improvement.

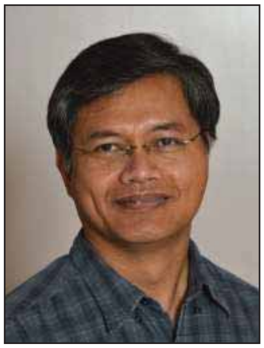
ACKNOWLEDGEMENTS

This project is supported by the Saskatchewan Agriculture Development Fund. The authors would also like to acknowledge 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. 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.

Optimizing temperature requirements of pigs to reduce energy use in swine production

N. Matuba[1, 2], A. Alvarado[1, 2], and B. Predicala[1, 2]

Nolan Matuba



Bernardo Predicala

INSIGHT FOR PRODUCERS

By understanding the minimum temperature at which animal performance in unaffected, we can provide recommendations on barn temperatures. This will reduce barn heating costs.

SUMMARY

This project set out to investigate the optimum environmental temperature requirements of sows and grower-finisher pigs, reducing energy costs and greenhouse gas emissions while maintaining long-term overall productivity and performance.

The project consists of four phases: in Phase 1, group-housed gestating sows will be kept for 6 weeks either at 16.5 °C (current recommended set-point) or 8 °C (preferred temperature determined in a previous study); in Phase 2, the preferred environmental temperature of grower-finisher pigs will be determined, using the operant mechanism and experimental protocols developed in the previous sow study; in Phase 3, grow-finish pigs will be kept for 6 weeks at either the current recommended set-point temperature or the preferred temperature determined in phase 2 to assess growth performance; and in Phase 4, an assessment of the environmental (carbon) footprint will be completed, along with cost analysis and development of recommendations for practical application of the optimized temperature management in commercial barns. Preliminary results of Phase 1 show a reduction in energy consumption of >50% in group-housed gestation rooms with a setpoint of 8 °C vs. 16.5 °C.

INTRODUCTION

Utility costs typically rank third in total cost of production, ranking only behind feed and labour. Heating costs are a substantial part of the total energy costs, therefore reducing temperature set-points on farm will reduce how often the heater is running helping reduce energy costs. A previous research project indicates that group-housed sows could tolerate temperatures up to 8 °C lower than the typical set-point (16.5 °C) currently maintained in most gestation barns, without compromising the welfare and productivity of the animals. However, the impact of raising sows at this lower temperature, on their long-term reproductive performance, still needs to be evaluated to fully assess the economic benefits of adopting this technology across the industry. Presently, no study has been conducted regarding the feasibility of a similar temperature set-point reduction for grower-finisher pigs.

EXPERIMENTAL PROCEDURES

Phase 1

The goal of this phase was to implement the tolerable set-point temperature (determined from the previous study) in actual sow (group) gestation rooms and assess its impact on energy consumption and the long-term reproductive performance of the sows under commercial barn conditions. Two rooms were used with one room designated as Control and temperature maintained at 16.5 °C (which is the typical set-point currently applied in commercial sow gestation barns) while the other room designated as Treatment had temperature maintained at the sows' preferred temperature determined from the previous study (8 °C). A total of three sow trials were conducted, with each room housing up to 45 sows per trial. Each trial lasted for 6 weeks.

Phase 2

The aim of this phase was to determine the tolerable environmental temperature for grower-finisher pigs. To train grower-finisher pigs to control their own environmental temperature, a previously developed operant mechanism was installed in each environmental chamber. A total of 5 replicate trials were carried out in the environmental chambers during winter months, with each chamber housing 5 grower-finisher pigs.

Phase 3

After the tolerable environmental temperature of the grower-finisher pigs is established from the previous phase, it will be implemented in a commercial grow-finish rooms to assess the impact on energy consumption and the pigs' performance under commercial barn conditions. Two identical grow-finish

1 Prairie Swine Centre Inc, PO Box 21057, 2105 8th Street East, Saskatoon SK S7H 5N9
2 Department of Chemical and Biological Engineering, University of Saskatchewan, 57 Campus Drive, Saskatoon SK S7N 5A9

rooms at PSC will be used, one room will be designated as "Pre-set" with temperature maintained at the typical set-point applied in grow-finish barns using a typical controller, while the other room designated as Treatment will have temperature maintained at the pigs' tolerable temperature determined from Phase 2. A total of 3 trials will be conducted, with each room housing 100 pigs per trial. Each trial will last for 6 weeks.

Phase 4
Following the in-barn experiments, an environmental footprint assessment will be performed using a sustainability assessment tool developed in a related study to determine the resulting carbon footprint from the application of the preferred temperature set-points in gestation and grow- finish barns. In addition, a feasibility analysis will be conducted to determine the costs and requirements for the proper implementation of the optimized temperature management approach in a commercial production facility. Data collected from this study, together with the information on all the expenditures and costs incurred during actual in- barn implementation including the purchase of materials and equipment, and labour and operating costs, will be used in the economic analysis. Recommendations for practical application of the optimized temperature management in commercial barns will also be developed.

RESULTS

Phase 1 trials are currently underway. Results from the first trial conducted from March 6 to April 17, 2024, are presented below.

Growth Performance
There was a slight difference in ADG between the Control room and the Treatment room (Table 1) during the first trial. In terms of ADFI, sows in the Treatment had slightly higher ADFI than those in the Control room (Table 1). This could be attributed to the difference in the initial body condition of some of the sows between the two rooms at the start of the trial; more sows in the Treatment room needed additional feed allowance to improve their initial body condition. Ultimately, G:F ratio was not significantly different between treatment groups (Table 1).

Table 1. Growth performance of sows in the Control and Treatment rooms during the first trial.

Growth performance	Control room	Treatment room
Average daily gain, ADG (kg/day)	0.43 ± 0.22	0.35 ± 0.16
Average daily feed intake, ADFI (kg/day)	2.54 ± 0.31	2.63 ± 0.41
Gain-to-feed ratio (G:F)	0.17	0.13

Note: ADG, ADFI, and G:F represent the average from 32-33 sows in each room.

Physiological responses
No substantial difference was observed in the measured rectal temperature of the sows in the two rooms. Sows in the Control room exhibited an average rectal temperature of 37.4 ± 0.4 °C, while those in the Treatment room had an average rectal temperature of 37.3 ± 0.5 °C, both measures below the expected average rectal temperature range of 38.3 – 38.8 °C. Slightly higher blood thyroxin levels were observed in the Treatment room (66.8 ± 12.1 nmol/L) compared to the Control room (63.6 ± 10.1 nmol/L). Thyroxin is a hormone produced by the thyroid gland which regulates the body's metabolic rate, with a higher concentration suggesting an increased metabolic rate (the body consumes more energy).

Room temperature
Figure 1 illustrates the average air temperature in various spatial locations within each room. In the Control room with set point maintained at 16.5 °C (which is typical for commercial gestation barns), the measured air temperature ranged between 15.8 and 17.2 °C throughout the trial. In comparison, the Treatment room (with temperature set-point maintained at 8 °C, which was determined as the sow's tolerable temperature based on previous study) exhibited air temperatures ranging from 8.3 to 11.0 °C.

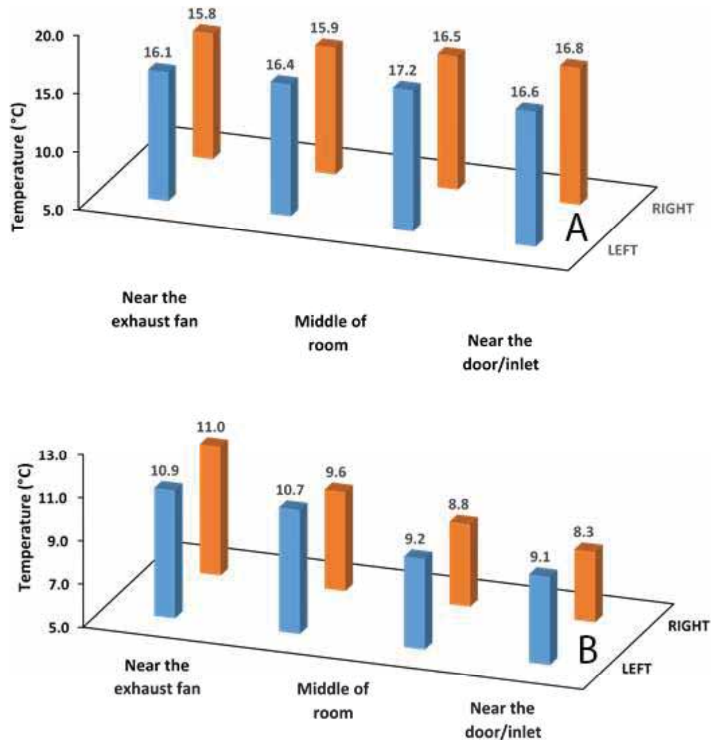


Figure 1. Average air temperature measured at various sampling locations in the Control (A) and Treatment (B) rooms

Figure 2 illustrates the temperature time series graph in each room. During the last two weeks of the trial, a temporal variation in temperature can be observed in the data. These fluctuations correlate with diurnal changes in ambient temperature, reaching a maximum of 18.8°C during the day and decreasing to as low as -4.6°C during the night (Environment Canada, 2024). The air temperatures in the rooms rely on the external ambient temperature.

"Reducing temperature set-points on farm will reduce how often the heater is running helping reduce energy costs."

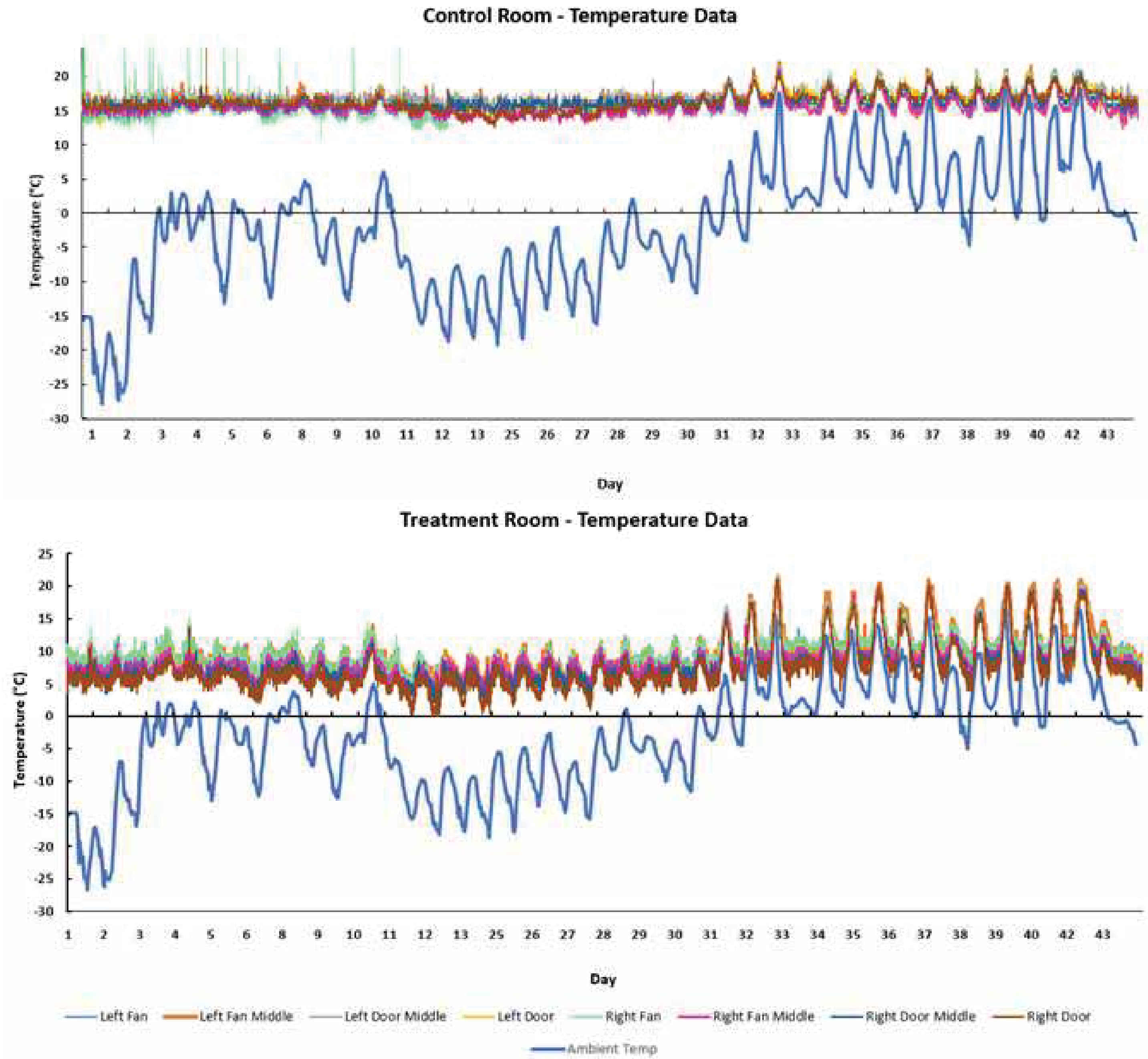


Figure 2. Air temperature profile at different sampling location in the Control (A) and Treatment (B) rooms.

Relative humidity

Figure 3 shows the average relative humidity (RH) in both rooms over the duration of the completed trial. The RH values in the Control room ranged between 57.0 to 60.7% and had an average of 58.6 ± 1.6%. On the other hand, the Treatment room had an average RH of 56.0 ± 0.3% and ranged from 55.7 to 56.4%. Both rooms showed RH levels within the recommended range for swine barns, which is between 50 to 65%.

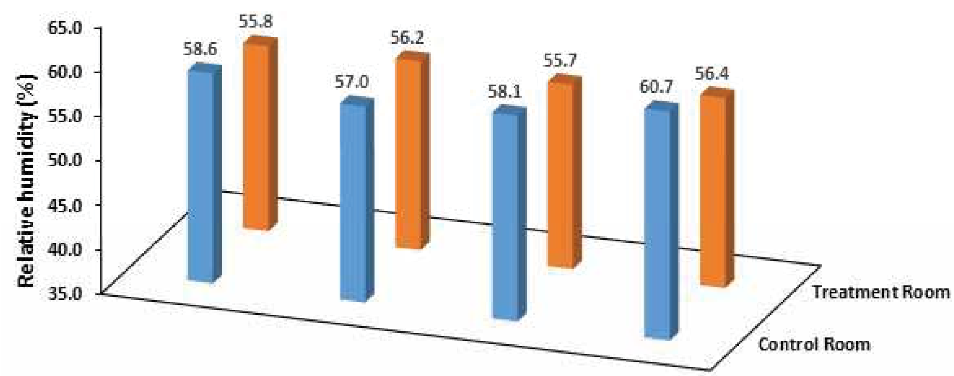


Figure 3. Average relative humidity measured in the Control and Treatment rooms over the duration of the trial.

Energy consumption (electricity and natural gas)
The electrical energy usage in each room included electricity consumption by the ventilation fans, furnace motor, and room lighting, while the natural gas utilized by the furnace for room heating during the experiment was also monitored (Table 2).

For the duration of the trial, the total electrical energy usage in the Control room was measured at 19.12 kWhr while the Treatment room recorded a total usage of 13.77 kWhr. For the total natural gas consumption, the Control room recorded usage of 3,214 BTU, which was more than double the gas consumption in the Treatment room, which totaled 1,355 BTU for the duration of the experiment.

Table 2. Total energy consumption measured from the Control and Treatment rooms during the first trial.

Energy consumption	Control room	Treatment room
Electricity, kW-hr	19.12	13.77
Natural gas, BTU	3,214	1,355

Gas concentrations (ammonia and carbon dioxide gas)
The average ammonia (NH3) level in the Control room was 15.8 ± 4.3 ppm while the Treatment room had an average NH3 level of 15.5 ± 4.2 ppm, which were below the 25 ppm level which may cause health problems for both pigs and barn staff (AASV, 2019). On the other hand, the average CO2 concentration in the Treatment room was about 987 ± 263 ppm, which was relatively lower than that in the Control room (1494 ± 387 ppm). Carbon dioxide levels are indicative of air quality, with lower concentrations indicating better quality. Barn personnel also reported perceiving more favorable air quality in the Treatment room than in the Control room.

IMPLICATIONS

This work has been conceptualized to validate and update the current industry recommendations on temperature set- points for gestating sows and to assess the impact on energy costs and overall pig production performance. The current results reflect that a lower temperature set-point reduces energy consumption and improves air quality. The impact on long-term reproductive performance is still being investigated. To date, these results imply that altering gestation room temperature is a valid approach to reducing energy use and associated costs.

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 provided to Prairie Swine Centre 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.

Evaluation, optimization, and field validation of a rapid detection kit for Porcine Epidemic Diarrhea virus (PEDv)

Bernardo Predicala[1,2] , Yuriy Kryachko[3], and D. Korber[3]

Bernardo Predicala

INSIGHT FOR PRODUCERS

Development of a rapid test kit for PEDv will help ensure that cases arre caught quickly and that measures to prevent the spread of the virus are taken as soon as possible.

SUMMARY

Significant economic loss results from outbreaks of Porcine Epidemic Diarrhea (PED). Accurate and rapid detection of PEDv is essential for the implementation of control measures. A rapid PEDv test kit is needed for this purpose. Comparison of the DNA sequence targeted by the primers included in a PEDv test kit from the Philippines to sequences of North American PEDv strains showed suitability of these primers for detecting PEDv strains in the Canadian swine herd. This was confirmed in laboratory testing of 20 samples collected from PED-infected pigs. Test results showed visual interpretation of test kit results can be somewhat ambiguous for some types of samples, therefore can be further improved. While definitive results were obtained from most of the test samples, a few 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 avoid ambiguity, current work is focusing on using an alternative dyes to generate better colour differentiation between positive and negative results (yellow vs. pink/red colours). Further revisions such as reformulating reagents to dry format and modifying 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.

INTRODUCTION

Porcine Epidemic Diarrhea virus (PEDv) is a major pig disease currently facing the Canadian swine industry. Since the first outbreak in Canada in 2014, more than 200 cases of PED have been confirmed across several provinces, causing significant economic losses estimated to be about $125,000 for a 1,000-sow herd. PED will remain a significant threat to the health and productivity of Canadian swine herds, therefore a reliable rapid diagnostic test kit will reinforce the biosecurity measures and be valuable in ensuring that herds are proactively protected against spread of this devastating disease.

Real-time reverse transcription polymerase chain reaction (rRT-PCR) is the method of choice for diagnosing PEDv infection. This testing is costly and requires sending the samples to a central analytical laboratory possessing the required equipment, delaying the rapid response needed to limit spread and impact of any emerging disease outbreak. Availability of a rapid and economical pen-side testing capability would be ideal, so that appropriate containment actions can be deployed immediately.

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

The Andali kit is based on Loop-Mediated Isothermal Amplification (LAMP), a nucleic acid amplification technique that can be used as an alternative to rRT-PCR without expensive or sophisticated equipment. The Andali test kit is a closed tube system that contains target oligonucleotides, control DNA plasmid and a LAMP reagent premix. It also involves a simple nucleic acid extraction process, with all components assembled into a kit. Using simple steps and hardware (i.e., a reusable heating block which costs about C$600), a sample swab (or a representative composite sample) collected from the suspected site can be tested to confirm the presence or absence of PEDv in 30-45 minutes. This kit costs only $10 CAD per test.

While the RT-LAMP test kit was initially validated by the original developers to detect PEDv strains endemic in their region (Philippines), further validation was needed to ensure that the test kit can accurately detect the various PEDv strains present in North America. Our current work, which builds on the findings from past and current projects is aimed at further improving the RT-LAMP-based kit to make it suitable for widespread use in the commercial swine industry Canada.

1 Prairie Swine Centre Inc., PO Box 21507, 2105 – 8th Street East, Saskatoon SK S7H 5N9
2 Department of Chemical and Biological Engineering, University of Saskatchewan, 57 Campus Drive, Saskatoon SK S7N 5A9
3 Department of Food and Bioproducts, University of Saskachewan, Saskatoon SK 51 Campus Drive, Saskatoon SK S7N 5A8

EXPERIMENTAL METHODS

Phase 1

To ensure the Andali test kit was suitable for use with Canadian strains of PEDv, an online database (BLAST – Global alignment) was used to compare several North American PEDv sequences to the PEDv spike protein used in the test (GenBank ID KM406181; 4126 bp). After suggestion of compatibility, previously collected PEDv-positive samples from Manitoba and Saskatchewan were used to ensure the test kit would generate expected results.

Tests with the original Andali kit showed in some ambiguous results; to streamline identification, phenol red (PR) and SYBR Green were tested as alternative dyes. RNA extracted from several PEDv-positive fecal samples from Canadian barns was used as a target for testing new/alternative components and procedures.

Phase 2

The overall accuracy of the modified test kit was evaluated by evaluating actual field samples collected from confirmed PEDv-positive premises in Canada. Following routine sampling and diagnostic protocols, sub-samples from a PEDv site, of the collected material were sent to a commercial laboratory for PCR testing to confirm the status of the samples. The remaining sample materials were then tested using the modified test kit. A total of 35 tests were conducted, and results validated by comparing the same samples with PCR analysis.

Phase 3

In collaboration with the developer of the original test kit, a step-by-step procedure for proper use of the modified test kit was developed in plain language intended for target users, considering the requirements of diagnostic testing and surveillance programs implemented in various provinces ensuring results from using the test kit are consistent and compatible with existing surveillance programs. This user's guide, together with a short video clip as well as images and materials generated from the project will be used as aids for training the potential target users of the test kit on its proper use.

RESULTS

In silico primer assessment

The results of BLAST – Global alignment indicated that in most cases it had 99% or higher (with a minimum of 96.8%) similarity to respective sequences of PEDv strains from cases reported in Canada. These results from the in-silico analysis thus confirmed that the primers included in the original Andali PEDv test kit are suitable for detecting North American PEDv strains.

Kit evaluation and development

Results analyzed from 20 PEDv-positive and negative samples from Canadian pigs using RT-qPCR and the original Andali rapid test kit to detect PEDv showed the original rapid test kit had 100% Positive Predictive Value (PPV) and 90% accuracy or overall agreement with PCR readings. This was considered to be adequate for quick and exploratory assessment of a potential PED disease situation. However, there were observed ambiguities in the visual outcomes of the test kit which made it difficult to interpret the test results in some cases. As shown in Figure 1, the reference color for the test kit result is 'blue' for positive (A) and 'purple' for negative tests (B) ; however, shown in Figure 2 are a few examples of the range of actual color of test kit results, some of which presented challenges when compared to the reference. Hence, some test results were misinterpreted, leading to 16.7% false-negative rate for this batch of samples.

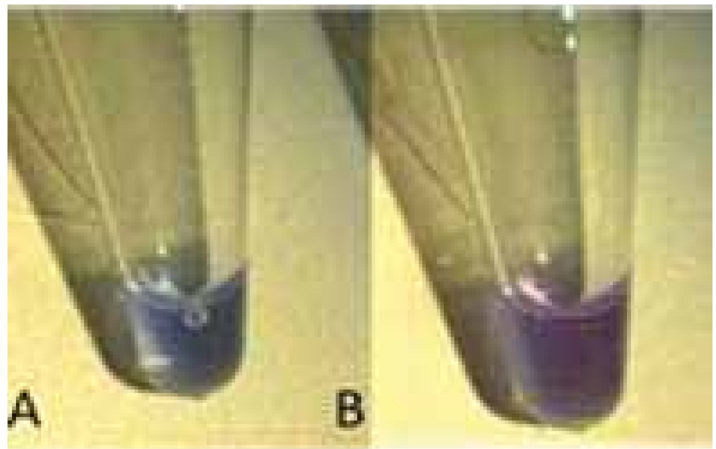


Figure 1. Positive 'blue' (A) and negative 'purple' (B) RT-LAMP results from the Andali test kit.

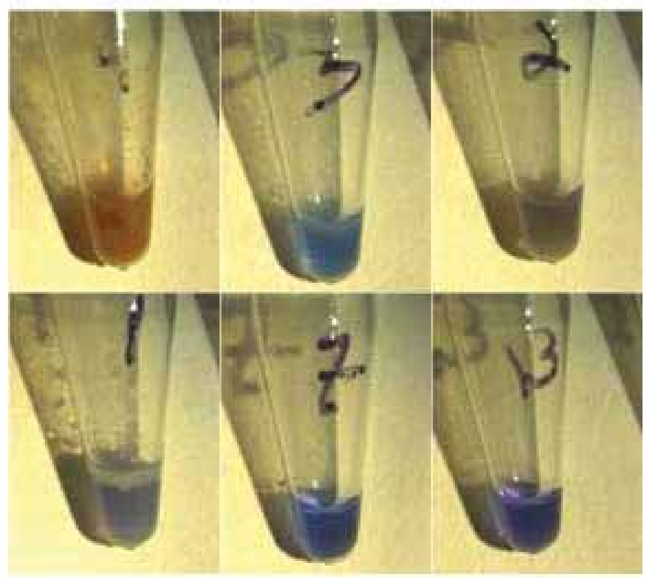


Figure 2. Colour range of results from the Andali RT-LAMP test kit.

"Using simple steps... to confirm the presence or absence of PEDv in 30-45 minutes. The kit costs only C$10 per test."

Exploring alternative dyes to reduce the chance of any ambiguity, both PR and SYBR had advantages and disadvantages. Utilizing PR ensured greater colour differentiation but insufficient samples or imperfect extraction could result in false negatives. The SYBR Green version has the added advantage of a fluorescent signal to clearly distinguish positive test results, but requires careful environmental control and handling; it should be noted that this reagent requires a UV light source, which is an additional equipment which could add to the total cost of the test kit package.

Development of kit protocol and training materials
The existing user's guide of the original Andali test kit has been revised to reflect the conditions and requirements for its use in the Canadian swine industry. Information regarding the PED surveillance program protocols applied in various Canadian provinces has been collected and integrated into the other instructional and training materials to ensure adherence to province-specific sampling and testing requirements during the use of the revised PEDv test kit in Canada.

IMPLICATIONS

The possibility of using the Andali RT-LAMP kit in Canadian swine production is clear. To make this a reality, the developing lab based in the Philippines would need to work with a suitable Canadian entity or organization gain permits from government regulatory agencies (i.e., VDD, CFIA, etc.) and commercialize this test kit.

ACKNOWLEDGEMENTS

This project was completed with the support of the Saskatchewan Pork Development Board and 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.

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Financial Support

Prairie Swine Centre wants to recognize those who have supported our Research and Knowledge Transfer programs. This support is essential to the ongoing developments that keep Canadian pork producers at the forefront of applied technology.

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