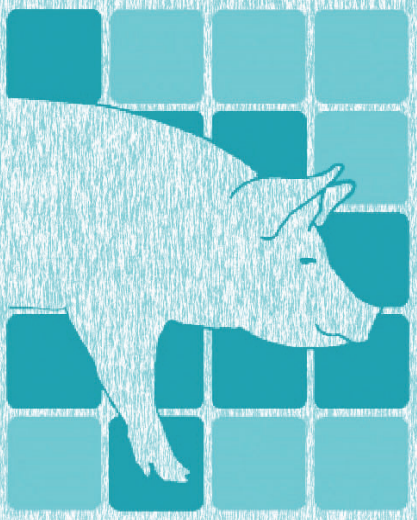
2022 ANNUAL



PRAIRIE SWINE CENTRE

RESEARCH REPORT

Sask Pork | Alberta Pork | Manitoba Pork (Locally Grown. Globally Preferred.) | Ontario Pork | Saskatchewan Ministry of Agriculture | University of Saskatchewan

PRAIRIE SWINE CENTRE | 30 YEARS

MISSION STATEMENT

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

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2022 Report Highlights

Chairman's Report

Driving Forward During Challenging Times

Don Down, Chairman of the Board

The Pork Industry has navigated through some unique challenges this past year and the Prairie Swine Centre has worked to try and provide support to the future of Swine Production in Canada.

The challenges facing the pork industry currently have never been stronger. High feed and energy costs coupled with very low market prices have forced significant change to our industry.

Under Murray's leadership the Prairie Swine Centre has continued to provide research results to the industry. The Centre's focus is to adapt to our changing environment and to address the key issues we face as industry.

Coming out of the pandemic the industry has come back together with face-to-face meetings, trade shows and industry meetings. Providing key information in-person along with the need for increased communication via a virtual and digital platform. The Knowledge Transfer and Translation Program remains very connected to the needs of the Canadian industry.

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

As me move into 2023 the Board and Senior Staff will work on integrating the valuable research by cooperating with other research centres in Canada and around the world.

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

On behalf of the board, I want to thank the Prairie Swine Centre team for their hard work and commitment which has led to a successful research year. This annual research report is evidence of the passion and dedication of the entire team. I want to thank retiring Board members for their expertise and contributions, and welcome new Board members for 2023.

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

CEO Report

Thirty Years of Practical Swine Research

Murray Pettitt, Ph.D. - CEO

It has been a very challenging year for the Canadian swine industry. Increased cost of production largely influenced by higher feed and energy prices continue to put sustained financial pressure on producers, despite having historically strong average pig prices throughout 2022. Many of the factors driving these increases in input costs are due to world events outside the influence of the Canadian swine industry, making solutions difficult to find.

Prairie Swine Centre remains committed to supporting the industry during these difficult times through our research programs. Reducing the cost of production, shifting us towards profitability is an ongoing process for all producers, including Prairie Swine Centre. The adoption of best management practices is one tool producers can use to control costs. These recommendations build on research done at Prairie Swine Centre and other organizations throughout Canada, and while some of this information is becoming older, these basic strategies are still applicable to swine production today. Our website (prairieswine.com) serves as the clearinghouse for this information that will positively affect the bottom line of your operation.

Prairie Swine Centre's most recent research is included in this report. Projects focus on supporting the health of the pig in the absence of antibiotics in the feed, understanding pathogen issues in a Raised Without Antibiotics (RWA) barn and how to manage them, and the effects of transport on the health and welfare of pigs. These results, and others included in this report can assist producers in addressing some of the challenges and opportunities pork producers experience today and tomorrow.

This research would not be possible if not for the ongoing and long-standing core financial support from the Saskatchewan Government's Agriculture Development Fund and the producers from Saskatchewan, Alberta, Manitoba and Ontario through their provincial Pork Boards. Your continued confidence in the work we do at PSC is gratefully appreciated. I also want to acknowledge our continuing strong relationship with the University of Saskatchewan that enables the University and PSC achieve our respective research and teaching objectives and train the next generation of swine professionals.

I would like to thank the members of PSC's volunteer Board of Directors. Made up of members from the swine industry and related industries they are a valuable source of experience for the staff at PSC.

Finally, I would like to thank all the PSC staff and students for their efforts and contributions to this work. Their dedication and commitment to serving the swine industry is seen throughout this report.

Murray Pettitt, PhD

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Operations Manager's Report

Balancing Optimal Production and Research

Tatjana Ometlic, RVT. - Manager, Operations

This past fiscal year had its challenges and we have seen production numbers fluctuate across the board, with the average number born alive still remaining on a rise. With more pigs born alive, we see more variations in the birth weights and more low birth pig weights that drive the PWM rate higher. As a research facility that promotes a robust research program and delivery of many services to our external researchers at U of S and VIDO, as well as providing the rest of the pork industry with novel science-based information, it is our first priority to accommodate the needs of research teams.

Production's biggest challenge was to maintain the animal flow throughout the barn as we lost about 10 % of the sow herd due to the nature of the sow dynamic study and increased numbers of abortions, NIP's and deaths on trial. Another challenge was the change in the dry sow feed formulation that was happening at the same time as the trial. Regular feed calibrations as well as body scoring of the sows were done every 3-4 weeks. We were balancing the pressures of high feed costs, adjusting sow's feed intake to address the high corn content and reducing the number of over conditioned sows while taking in consideration the trial requirements and the number of sows that need an extra top up of feed.

To maintain the number of bred animals required, we had to keep some of the older sows and "opportunity" gilts back, which on a long run will have a negative effect on the overall herd productivity. To rectify our losses, we have been breeding as many animals weekly as we could, so we could catch up by the end of this year with the pig flow throughout the barn. The GDU has a continuous flow of replacement gilts and 10-14 open gilts are heat checked daily to keep up with supplies of replacement animals.

Table 1. Production targets for fiscal year 2022

Category	Target/week	Rolling Average*
# Bred	14.0	14.8
# Sows farrowed	12.7	11.7
# Pigs born alive	178	169.2
Average born alive	14.0	14.5
# Piglets weaned	161	153.3
Pre-wean mortality	9.6%	12.8%
Post-wean mortality	3.0%	1.9%
Finish mortality	2.0%	1.0%
# Sold/week	156.0	147.3

**last 16 weeks, ending June 30, 2022*

The collaboration, planning and communication that took place between the staff and students throughout this enormous sow project has been amazing. Everyone's involvement, dedication and understanding has been greatly appreciated by the production staff. When possible, we continue to use practical tools, such as split nursing 16+ litters to manage PWM. When there are no trials in the farrowing rooms, we work on improving performance of the slowest growing/disadvantaged pigs by cross fostering the litters of small birth weights and creep feeding in the last week of lactation.

Table 2. Production parameters

	2018	2019	2020	2021	2022 (JAN-MAY)
Number of sows farrowed:	744	696	661	636	248
Conception rate %:	90.6	90.7	91.4	86.0	92.0
Farrowing rate %:	80.8	89.8	91.5	87.5	84.6
Average born alive/litter:	14.0	14.2	14.4	14.3	14.8
Farrowing index:	2.48	2.47	2.46	2.48	2.49
Number weaned/sow:	12.4	12.6	12.6	12.5	12.5
Pre-wean mortality %:	12.0	11.2	12.1	12.6	15.0
Pigs weaned/sow/year:	29.5	29.6	29.2	29.5	26.8

We hold back a nurse sow for smaller weaners when possible. The number of treated pigs in the nursery has stayed low and post-wean mortality has gone slightly up compared to the report from June 2020, due to an inability to hold back smaller pigs at weaning or adding creep feed before weaning. Our grow finish mortality continues to stay low. We have not seen many tail bites over the past several months. The grow finish staff continuously work on addressing pen densities in a timely manner as well as providing different enrichment toys through all stages of production.

Despite the challenges and obstacles we faced this year, we managed to stay competitive. In benchmarking with other farms with PIC genetics across Canada (28 farms) and USA (292 farms) we are in the upper 10th percentile of Pig Champ data for 2021. We made the 25+ League List with PIC, placing 20th out of 70 PIC farms, for 29.4 pigs weaned per sow in 2021.

In 2021, we had 19 research projects started in grow finish, breeding, gestation, farrowing and nursery rooms. Over 3,289 animals used for research at PSC as well as for external research. We continue the balancing act between managing high productivity and meeting research needs.

Looking at the Performance Trend Analysis for the past 12 months, we can see periods where there is a decline in farrowing rate. Due to the effects of the dynamic grouping and early mixing of gestating sows, we had experienced more abortions and NIP's in October and November of 2021, which brought the farrowing rate down in December 2021 (66.7%) and January/February (75.7%) of this year.

Despite the efforts made to minimize abortion rate and number of sows found NIP, we had seen the same effects in the second replica of the early group mixing. As a research facility, we are proud to contribute to the research of group housing strategies and to help pork industry and hog producers with the findings and practical solutions.

Knowledge Transfer Report

Meeting the ever-changing needs of the pork industry

Ken Engele, BSA. - Manager, Knowledge Transfer

Over the course of the upcoming year, Prairie Swine Centre will be celebrating its 30th anniversary. Through hard work of staff and students and supported by the pork industry PSC has adapted to the ever-changing needs of the pork industry over this time. Thirty years ago, the advisory board recognized the importance of delivering research results to producers; this resulted in the creation and development of the Knowledge Transfer (KTT) Program.

Delivering timely, accurate and practical information has always been the goal of the KTT program at the Centre. The past two years have been challenging in connecting with the pork industry in traditional ways. Meetings, conferences, trade shows and other in-person events have always been an important part of what has made the Centre successful. These events create a dynamic two-way exchange of information that is important to the producer and the Scientists. We learn just as much from producers as they do from us, regarding those challenges and opportunities producers face on a daily basis in their operations. We have the opportunity to take these industry challenges, incorporate them into research programs, and find answers that will help producers achieve their goals and sustainability.

Finding new ways to deliver research results to the pork industry is not something new for the Centre. Over our history, the KTT program has evolved in meeting the needs of an ever-changing pork industry. While the pillars of personal, print and electronic communication remain the same over the years, the level of influence for each pillar and the balance of push versus pull communication has changed. Thirty years ago, communication programming focused on a push strategy: printing newsletters, fact sheets, handbooks, annual reports and hosting producer meetings ensuring every producer had information readily available. This largely meant publications on their staff room table. In today's digital age, we focus largely on pull communications (website, social media) ensuring producers can access the information they are looking for when it is convenient to them.

For the past year, we added additional resources to the KT program at the Centre. Through securing additional funding, we will continue to have these resources available through the upcoming year. This will help to ensure we deliver information on a timely basis. While we continue to adapt to challenges placed in front of us, we will all be stronger in the end as we make our way through these uncharted times.

The following supports PSC's Strategic Plan Objective:

- 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.

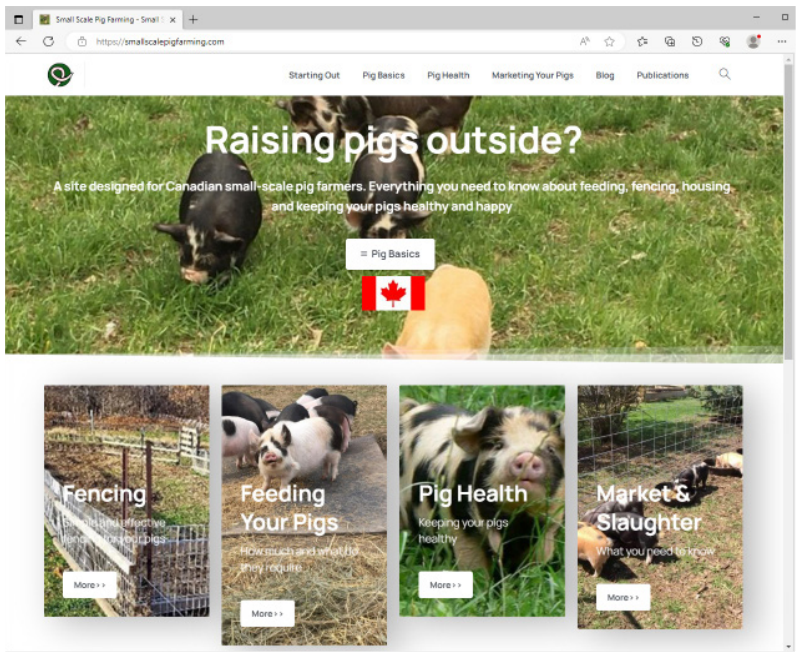
Economic Benefits to the Canadian Swine Industry

- On average, our research program returns $4.10/pig/year over the past 15 years.
- Increased to $5.60/pig/year during the last 5 years.
- Annual value of PSC's research is $42-62 million.
  - Based on 28 million Western Canada origin slaughter hogs (2022); assuming an adoption rate of 40% (results of PSC's Auditing Best Management Practices study).

Value added swine research funding

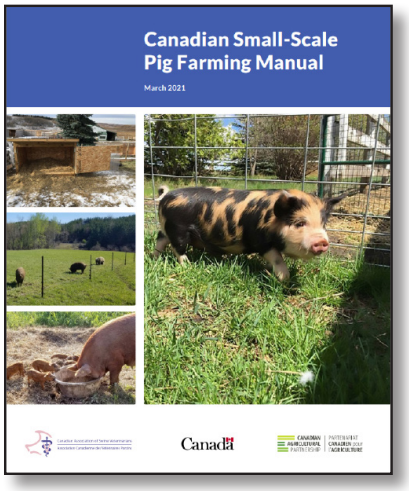
- Prairie Swine Centre generates four additional dollars for reseach projects, for each dollar it receives for base funding.
- Approximately 25% of all revenue is generated from the sales of pigs (market hogs, feeder pigs)

AFRICAN SWINE FEVER PREPAREDNESS



smallscalepigfarming.com

A collaborative effort, designed to provide outdoor pig producers essential information on biosecurity, food safety, nutrition and other topics.



New and alternative sanitization procedures for antibiotic-free swine barns

M. Baguindoc[1,2], B. Predicala[1] and D. Korber[3]

Bernardo Predicala

Mash Baguindoc

SUMMARY

Certain barns that switched to antibiotic-free production observed increased prevalence of pathogens after a few years on the program. Developing improved sanitization and disinfection procedures is an important step to reduce the pathogen load in antibiotic-free barns, which was the goal of this study.

This project identified and screened various disinfection strategies comprised of conventional and non-conventional disinfection measures. The screening phase determined calcium oxide, peracetic acid (PAA), quaternary ammonium compounds (QACs), electrolyzed water (Slightly-acidic electrolyzed water (SAEW) and Alkaline electrolyzed water (AEW)), and silver nanoparticles as the most promising alternative measures. During laboratory-scale evaluations, the application of SAEW and PAA were identified as the most promising disinfection strategies, which were investigated further in in-barn tests.

The performance of PAA and SAEW was comparable to conventional disinfectants (Virkon) and showed longer effectivity than Virkon at 4 to 24 hours after its application. Economic analysis showed that SAEW reduces the overall cost of disinfectant used per pig while PAA costs a bit more than conventional disinfectants. This study indicates that SAEW and PAA solutions could be a better alternative to conventional disinfectants.

INTRODUCTION

Restrictions on the use of antibiotics in livestock production have been implemented in response to the increasing public concern about the development and prevalence of antimicrobial resistance (AMR) to medically important drugs, particularly antibiotics. Despite various strategies developed to keep swine herds healthy with the reduced availability or total absence of antibiotics, disease outbreaks still occur caused by the gradual increase of microbial load in barns.

Currently, the most commonly used method for controlling pathogens in swine barns is the use of disinfectants such as quaternary ammonium compound (i.e. Synergize) and potassium peroxymonosulfate (i.e. Virkon). However, some pathogens develop resistance to these chemical disinfectants decreasing their biocidal capabilities. This study aimed to develop alternative disinfection measures to control the growth and transmission of disease-causing pathogens.

EXPERIMENTAL PROCEDURES

The first phase of this study consisted of a comprehensive literature review that identified 18 potential sanitation and disinfection measures, which were evaluated based on their applicability in swine barns, intrinsic properties, and safety. The six most promising measures were then subjected to laboratory-scale evaluation where polycarbonate coupons inoculated with microbial load collected from the Prairie Swine Centre barn were used as test surfaces to mimic in-barn conditions. The coupons were treated with the selected alternative disinfectants together with commonly used barn disinfectants such as Virkon as Control, and their efficacy in reducing the microbial load was assessed and compared.

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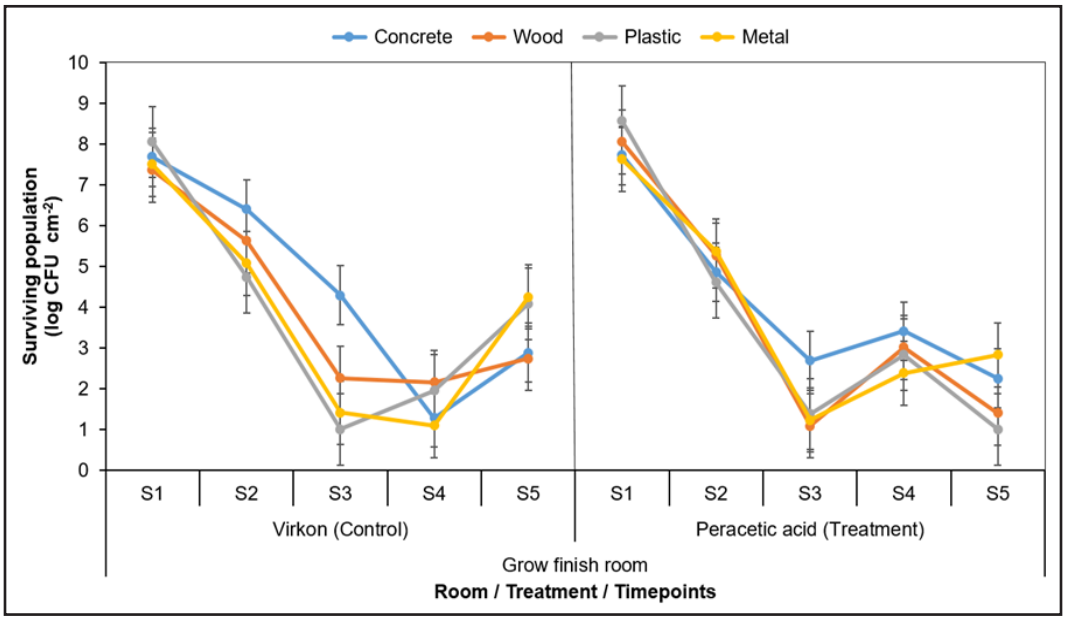
The second phase of the study investigated the two most promising disinfection strategies in in-barn tests. Rooms were pressure-washed following standard cleaning practices in commercial barns, except for the sanitizing/disinfecting step, which was part of this experiment. With Virkon as control, the selected treatments were evaluated in grow-finish, nursery and farrowing rooms and applied on various types of surfaces: concrete (flooring), metal (drinkers), plastic (penning), and wood (partitions).

The final phase of the experiment consisted of a feasibility analysis to determine the applicability of the most promising disinfection strategies in reducing microbial population levels in various production stages in a commercial pig barn. The main components of the analysis included all the costs associated with the disinfection strategies, materials and equipment required, labour, and operating costs.

RESULTS AND DISCUSSION

The screening phase yielded calcium oxide, peracetic acid (PAA), quaternary ammonium compounds (QACs), electrolyzed water (Slightly-acidic electrolyzed water (SAEW) and Alkaline electrolyzed water (AEW)), and silver nanoparticles as the most promising alternative measures. Of those, the laboratory-scale evaluation identified the application of SAEW and PAA as the most promising disinfection strategies, which were further assessed in the in-barn experiment.

High-pressure washing reduced the microbial population by approximately 99%. A further reduction in microbial population was achieved after applying the three disinfection methods (Virkon, SAEW and PAA). The performance of PAA and SAEW was comparable to conventional disinfectants (Virkon). The microbial population at 4 hrs and 24 hrs after disinfection with Virkon increased relative to the



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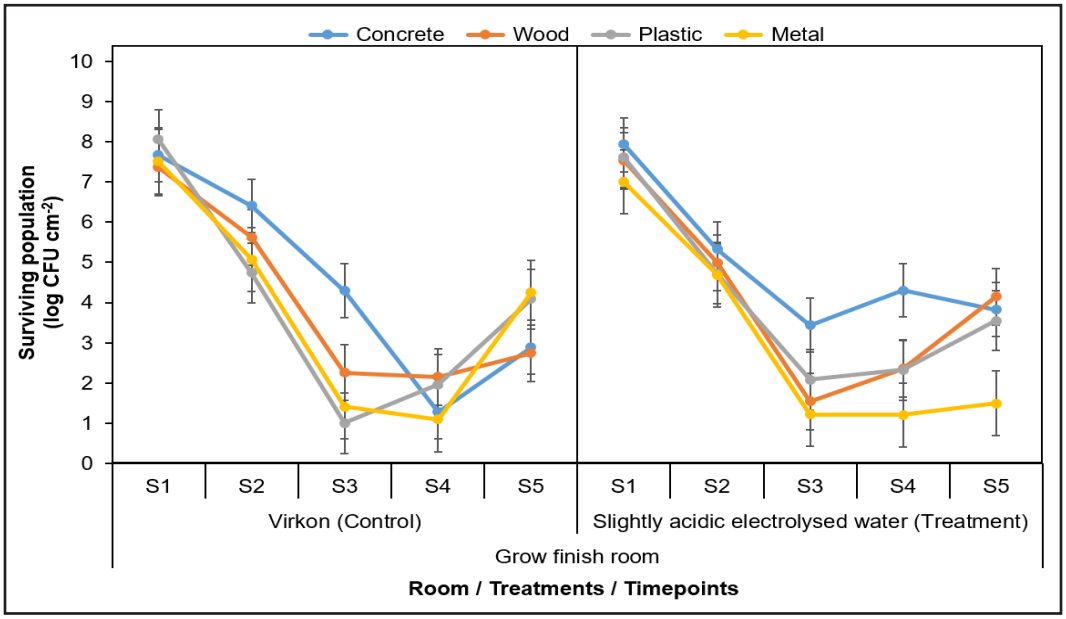

B

Figure 1. Mean (± SD) of log CFU cm^{-2} of A) Virkon (Control) and Peracetic acid (treatment) B) Virkon (Control) and Slightly acidic electrolyzed water (treatment) from different types of sampling surfaces in a grow-finish room; S1= before washing; S2 = right after washing and drying; S3 = treatments applied after washing; S4 = 4 hrs after disinfection; S5 = 24 hrs after disinfection. Performance of the control and treatment on different surfaces (from S1 to S5) are not significantly different (P>0.05).

initial concentration after pressure washing, but remained almost unchanged after disinfection with SAEW or PAA (Figure 1).

The feasibility analysis showed that relative to the cost of using current conventional disinfectants (e.g., Virkon), in the long run the application of SAEW reduces the total cost of disinfectant used per pig by about 20% for grow-finish and nursery rooms and about 26% in farrowing rooms. Compared to SAEW, peracetic acid yielded higher total cost with CAD$0.24/pig for grow-finish and nursery rooms, and CAD$1.42/pig for farrowing rooms, which are slightly higher compared to the conventional disinfectant (Virkon) with CAD$0.20/pig and CAD$1.21/pig, respectively. However, this can be compensated by its better effectiveness in reducing microbial concentration to lower levels (compared to the other treatments) and longer residual effects in keeping the microbial loads down. These results suggest that the use of SAEW and PAA solutions during sanitation could be a better alternative to conventional disinfectants. Specific recommendations and guidelines for applying these potential measures in a swine barn are summarized in Table 1.

Table 1. Specific recommendations and guidelines for the application of PAA and SAEW in commercial barns.

	Peracetic acid	Slightly acidic electrolyzed water
Preparation of the working solution	- **Concentration:** 400 mg L^{-1} - Based on the actual-in barn trials, 12 L of working solution is sufficient for a 100-head room	• **Concentration:** 50 mg L^{-1} (active chlorine concentration) • Based on the actual-in barn trials, 12 L of working solution is sufficient for a 100-head room
Additional parameters	---N/A---	**Required pH:** 5.0 - 6.5 **Input Voltage:** 20 V **Electrolyte:** 36 g of salt/4L of water
Storage of disinfectants	• Store the active ingredient in refrigerator (4˚C) when not in use • Always use freshly made working solution every disinfection process	• Always use freshly made working solution every disinfection process
Application of the working solution	• Disinfectant can be sprayed on target surfaces • Apply the disinfectant following the required dosage Apply the working solution within an hour of preparation • Longer exposure time for rough surfaces like concrete • Wear PPEs during the disinfection process	

IMPLICATIONS

This study demonstrated that slightly acidic electrolyzed water (SAEW) and peracetic acid (PAA) were the most promising alternative disinfection techniques for swine facilities. The deployment of these measures is similar to conventional disinfectants, which is convenient for pork producers.

Sufficient washing and disinfection of rooms after each growth cycle are vital in reducing microbial load levels in swine rooms. A longer exposure time should be allotted to rough surfaces (concrete) as this study revealed that disinfectants tend to have reduced efficacy when applied on rough surfaces. Thus, this serves as a reminder to pig producers to always conduct proper cleaning and disinfection procedures and avoid under-dosing of disinfectants.

ACKNOWLEDGEMENTS

We would like to acknowledge the financial support for this research project from the Saskatchewan Agriculture Development Fund. The authors would also like to acknowledge the strategic program funding provided by Sask Pork, Alberta Pork, Ontario Pork, the Manitoba Pork Council and the Saskatchewan Agriculture Development Fund. In addition, we also wish to acknowledge the support of the production and research technicians at Prairie Swine Centre that make it possible to conduct this research.

Design criteria for cleanability, worker safety and welfare characteristics of pig transport trailers

B. Predicala[1,2] , A. Alvarado[1,2], J. Domingo[1], A. Guevarra[1] and J. Brown[1]

Bernardo Predicala

Alvin Alvarado

SUMMARY

Disease transmission associated with transportation of pigs has been a long-standing issue affecting biosecurity in pig production. In addition, stress responses and welfare are greatly influenced by the trailer compartment configuration. The overall goal of this study was to develop a trailer design criteria checklist to provide the industry with an assessment tool to improve the ease of cleaning and the welfare characteristics of pig transport trailers, thereby improving the biosecurity and welfare of animals during transport. This study included a comprehensive literature review and a survey among truckers, wash bay operators and other stakeholders to develop design criteria tailored to swine transport trailers. Those design criteria were used to develop a trailer inspection checklist, made available in an app, that was field-tested on 10 different trailers, and refined throughout all trailer inspections. The checklist was re-structured so that inspections are performed by compartments (i.e., front, middle, and back) and locations in the trailer (i.e., exterior and interior). A rating scale was developed for cleanability, safety and welfare characteristics. An overall score is determined at the end of the inspection to provide a rating on each specific aspect of the trailer (i.e., cleanability, welfare, and safety). It is anticipated that wide-spread application of the inspection checklist across multiple trailers of varying types and conditions will lead to establishment of a rating database that will allow differentiation of trailers according to ease of cleaning and welfare characteristics, and consequently guide the design process to address inherent problems with biosecurity and welfare for building future trailers.

INTRODUCTION

The North American swine industry relies heavily on the transport of pigs. Disease transmission associated with transportation of pigs has been a long-standing issue affecting biosecurity in pig production. Animal transport trailers that are poorly designed in terms of cleanability are difficult to sanitize and cause significant downtime, increased costs and inconsistent cleaning results, thereby posing high biosecurity risk. In addition, recent studies on evaluation of the impact of trailer design on animal losses and welfare have found that stress responses and welfare are greatly influenced by the trailer compartment configuration. The overall goal of this study was to develop a trailer design criteria checklist to provide the industry with an assessment tool to improve the ease of cleaning and the welfare characteristics of pig transport trailers, thereby improving the biosecurity and welfare of animals during transport.

EXPERIMENTAL PROCEDURES

A comprehensive literature review was carried out to gather available information on key design components or criteria for assessing cleanability, worker safety, and animal welfare that have been developed in other similar industries. These were supplemented through surveys and interviews of various stakeholders such as truckers, wash bay operators, trailer manufacturers, veterinarians, pig producers, and other experts to develop design criteria tailored to swine transport trailers. The design criteria included things like floor plan and ramp designs, surface finish or roughness and protrusions, drainability, welding, sensors and dataloggers, and others. The design criteria were used to develop the initial draft of a trailer inspection checklist, which was made available in an app for easier use by end users. The developed checklist was then field-tested and validated by applying it on 10 different trailers in use in the Canadian swine industry, including potbelly, gooseneck straight deck, hydraulic lift, and straight deck trailers. Different components of the design criteria provided in the checklist were re-assessed and refined throughout all trailer inspections.

RESULTS AND DISCUSSION

The initial draft of a trailer inspection checklist was broken down into three categories: hygiene and cleanability (Table 1), safety (Table 2), and animal health and welfare (Table 3). Each category included recommended guidelines, with a detailed description of each guideline presented as a glossary. In addition, an electronic version of the checklist (in the form of an app) has been developed to provide end users with a more accessible interface (e.g., smartphones, tablets, laptops) for field use. The app can also provide a concise data report for easier review and interpretation, as well as to facilitate compilation of the entire dataset from inspections of multiple trailers. Different components of the design criteria provided in the checklist were re-assessed and refined throughout all trailer inspections. The checklist has gone through seven iterations and was re-structured so that inspections are performed by compartments (i.e., front, middle, and back) and locations in the

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trailer (i.e., exterior and interior), resulting in a more user-friendly checklist that can be implemented more efficiently. To enhance its overall applicability in the industry, a rating scale was developed for cleanability, safety and welfare characteristics. Each component of the design criteria can be rated as Pass, Marginal, Unacceptable, or Replace, with equivalent score of 1, 0.50, 0.25, and 0, respectively. A description of each rating scale was provided in the app to maintain consistency among multiple checklist users. An overall score is determined at the end of the inspection to provide a rating on each specific aspect of the trailer (i.e., cleanability, welfare, and safety) from 0 to 10, with 10 being the highest score.

IMPLICATIONS

It is anticipated that wide-spread application of the inspection checklist across multiple trailers of varying types and conditions will lead to establishment of a rating database that will allow differentiation of trailers according to ease of cleaning and welfare characteristics, and consequently guide the design process to address inherent problems with biosecurity and welfare for building future trailers.

ACKNOWLEDGEMENTS

Funding for this project is provided by Swine Innovation Porc through the Canadian Agricultural Partnership. The authors would also like to acknowledge the strategic program funding provided by Sask Pork, Alberta Pork, Ontario Pork, the Manitoba Pork Council and the Saskatchewan Agriculture Development Fund.

Table 1. An overview of the different components included in the trailer checklist for cleanability

Key Area	Description
C1.Surface Finish and Material of Construction	1) Interior surface materials can withstand 2,000 – 2,800 psi water pressure and heavy-duty chemical disinfectants repeatedly without being damaged. Materials used are non-absorbent of any liquids or gases.
	2) Use of aluminum alloys such as 5xxx and 6xxx series for interior surfaces is observed.
	3) There are no wooden surfaces or wooden materials used.
	4) Interior surfaces are smooth. There are no obstacles taller than 32 µ-inch or 0.8 µm, equivalent to the No.4 surface finish.
	5) There is a limited amount of double metal layers (only if necessary). Otherwise, no double layering design is present.
	6) The vehicle interior is free of any niches such as pits, cracks, corrosion, recesses, open seams, gaps, lap seams, and protruding ledges.
	7) All materials used can withstand 71°C for up to 30 minutes.
C2.Welds, Joints, Fasteners, and Contacts	1) Welding or continuous bonding with a smooth finish on exposed surfaces. If unavoidable, welded joints have a maximum weld height of 1/8" (0.3cm).
	2) Mounting plates, brackets, controller housing, junction boxes, end caps, and other items are welded continuously to the surfaces, not attached via drilled and tapped holes.
	3) There are no corners with sharp angles (≤ 90°). Instead, corners are continuous with an absolute minimum radius of 1/8" (0.3cm) and welded at flat surfaces opposite the contact side.
	4) No lap joints present. If necessary, lap joints are only acceptable if they are continuously welded with a smooth finish.
	5) If present, bolts have rubber gasket around the head which would seal the thread and keep dirt and bacteria away.
	6) Gasket insulations are used in the contact area between two metals to prevent galvanic corrosion.
	7) Hermetically sealed spacers are used to allow space between two adjoining surfaces or pieces. The gap is bigger than 1/2" (1.3cm) to allow mechanical cleaning.
C3.Fittings, Enclosures and Human-machine interfaces	1) Fittings can be removed easily for cleaning and disinfecting.
	2) Palm-nut style or "T-wing" fasteners are used instead of hex or dome nuts.
	3) Push buttons, valve handles, switches, and touchscreens are mounted and sealed properly to prevent harboring of microbes inside. The surfaces can handle harsh chemicals during cleaning process. Electronic housings are rated IP69K sealing.
C4.Hollow areas and Pockets	1) Interior structures with hollow inside are sturdy and free from holes or crevices that could trap organic matter.
	2) Hollow tube constructions such as frame members are fully sealed by continuous welding.
	3) There are no fastener penetrations into hollow tubes.
	4) There are no dead spaces, dead ends, pockets, or other framework design that can trap organic matter.
C5.Framework	1) Horizontal ledges are rounded or angled to prevent water from pooling.
	2) The roof of enclosures is inclined forward (e.g., 30° angle) to avoid water pooling and improve visibility.
C6.Drainage System	1) The vehicle has a reliable drainage system that does not leak outside.
	a. Intact sump or holding tank that contains the waste product
	2) Upper deck waste does not drop down on the animals below the deck and in their water and feed.
C7.Ventilation System	1) The materials used in the ventilation system are durable and waterproof/water-resistant to handle moisture. The ventilation system can be dismantled easily if repairs or further cleaning is required.
C8.Vehicle Exterior	1) Pressure washer can reach all the surface on the exterior of the vehicle. There are no small gaps that will prevent mechanical cleaning and disinfection.

Table 2. Overview of the different components included in the trailer checklist for safety

Key Area	Description		
S1.Interior of livestock vehicle	1) There are no sharp edges, projections, and gaps that can cause injury to animals and personnel.		
	2) Mechanical and electrical installations are inaccessible to livestock.		
	3) Lights are sealed and mounted flush with the walls/ceiling or firm at an area inaccessible to livestock.		
S2.Deck Height	1) The deck height allows the animals to stand comfortably without any part of their body touching or rubbing on the deck's ceiling.		
	2) Minimum deck height with reference to the pig's live weight (5% tolerance):		
	a. 45cm for <10kg	b. 62cm for 10-25kg	c. 70cm for 50-70kg
	d. 88cm for 100-120kg	e. 100cm for >120kg	
S3.Partitions, Barriers, and Fittings	1) Partitions and barriers are strong and sturdy enough to withstand >120kg pigs.		
	2) Partitions have solid surfaces to prevent animals from harming their neighbour.		
	3) Partitions have no gaps significant enough for animals to get their body parts stuck.		
	4) Barriers are tall enough to prevent pigs from climbing or jumping over.		
	5) Barriers are present and preventive when the load-door is open.		
	6) Fittings, such as latches, pins, slam shut mechanisms, are quick, safe, and easy to use.		
S4.Ramp Side Gates or Lateral Protections	1) Ramp side gates are tall enough to prevent pigs from falling or pigs from jumping off during loading/unloading. Side gate minimum height is 35" (90cm) for market pigs.		
	2) Ramp side gates have solid walls for preventive purposes.		
S5.Lift Platform (if present)	1) The platform has safety barriers with sufficient height and solid walls to prevent pigs from falling off and being stuck on gaps.		
S6.Emergency/ Contingency Plan	1) The transporter is well trained and educated on animal transport.		
	2) The transporter has a well-thought-out emergency plan, which includes safe evacuation of animals, procedures during a mechanical breakdown, equipment breakdown, road traffic accidents, extreme weather, road closures, etc.		
	3) Emergency contact sheets and procedure protocols are written and available.		

Table 3. An overview of the different components included in the trailer checklist for animal health and welfare

Key Area	Description		
W1.Roof	1) The vehicle's roof has proper insulation and can maintain the ambient temperature inside, even during hot summer days or freezing winter days.		
	2) The roof is painted with light colours to help with insulation during summer days.		
W2.Floors	1) The floors are strong and sturdy to support the animal's weight.		
	2) The floors are free of protrusions and gaps.		
	3) Anti-slip matting like chequer-plates, grooves, fixed or removable rubber mats, etc., are installed.		
W3.Ramps (internal and external)	1) The ramps have a maximum angle of 20° with a tolerance of +/- 5°.		
	2) Ramps with a slope steeper than 10° angle are fitted with 1" (2.5cm) or higher foot battens or secure footholds that are 8" (20cm) apart for market pigs and 4" (10cm) apart for nursery pigs.		
	3) Ramps are 35" (90cm) to 39" (100cm) wide with no gaps.		
W4.Steps	1) The fitting of the ramps from the vehicle to the ground must be continuous and flush. There is no need for animals to step onto the ramp and off the ramp. If the ramp is not flush with the platforms, steps can not exceed 8" (21cm) in height and 2" (6cm) in gaps. The steps cannot be taller than the pig's knees.		
W5.Lengths and Heights of Partitions	1) The pen's length is measured to ensure the animals do not move around too much during travel and sudden change in speed. The pen has a maximum length of 122" (310cm).		
	2) Partitions between pens are at least 30" (76cm) tall.		
	3) Partitions are present such that no more than 30 market pigs or 50 feeder pigs are in a section.		
	For long-distance transport:		
	4) Pen lengths and barrier heights are adjustable to suit the transported animals.		
W6.Floor Area and Height of Compartment	1) The pen has enough space for pigs to lie down and stand up in their natural position.		
	2) The pen has adequate headspace to allow a flow of fresh air from the ventilation system to reach all animals.		
	a. Minimum deck height with reference to the pig's live weight (5% tolerance):		
	i. 45cm for <10kg	ii. 62cm for 10-25kg	iii. 70cm for 50-70kg
	iv. 88cm for 100-120kg	v. 100cm for >120kg	

Table 3. ... continued

Key Area	Description
W7.Artificial Lighting	1) Lights must be present or available during transport to carry out tasks and allow animal inspection.
	2) Internal light fixtures are mounted flush on walls or ceilings or fixed where they are inaccessible to animals.
	3) Rear-end spotlights are available to aid loading/unloading with a minimum of 50 lux of lighting.
	4) Rear-end interior headlights point toward the front of the compartment.
W8.Access	1) There are methods for visual inspections available onboard.
	2) Equipment to access specific openings are available during transport.
	3) A person can inspect the animal compartment from outside quickly.
W9.Ventilation	1) Both passive and mechanical ventilation is variable and adjustable according to animal needs.
	2) The ventilation system is reliable and can regulate the interior climate for transport duration, and any emergency stops.
	3) The intake of the ventilation system is not directly under any exhaust of the vehicle.
	For long-distance transport:
	4) The ventilation system maintains an ambient temperature of 5°C to 30°C (+/- 5°C) inside the animal compartments.
	5) The ventilation system can operate independently of the vehicle's engine for a minimum of 4 hours.
	6) The animal compartment has enough apertures to provide ventilation in events where the fans fail or power failures.
W10.Temperature Monitoring System	**For long-distance transport:**
	1) Temperature sensors are located 32" (80cm) to 39" (100cm) above the floor of each deck. Sensors protected under an IP69K rated housing.
	2) Every 15 minutes or less, the system reads the temperature and records it.
	3) There is a minimum of four temperature probes per deck.
	4) The system has alarms that will go off when temperatures go above the threshold and alert the transporter.
W11.Cooling System	1) Misters, sprinklers, or spray systems are present to cool down animals at temperatures above 25°C.
W12.Water System	1) There is an onboard water supply of 1.5% maximum payload available for the animals.
	2) The water tank is easily refillable, accessible (water level), and easily cleanable.
	3) The water lines are secured, sealed tight, and inaccessible to animals.
	4) The transporter can water the animals during system failures.
	For long-distance transport:
	5) Animals have limited access to water supply during transport to prevent wastage, slipping, and wet standing. The transporter can easily control the water supply.
	6) Drinkers are suitable and adjustable to accommodate the transported animals.
	a. Drinkers are positioned 12" (30cm) from the floor for weaned piglets and 20" (50cm) for market pigs.
W13.Feeds and Feeding Equipment	**For long-distance transport:**
	1) The vehicle carries sufficient and appropriate feed for the transported animals.
	2) The feed storage protects the feed from weather, contaminants and inaccessible to animals.
	3) Feeders are installed correctly and secured so that animals cannot play with them during transport.
	4) The transporter can easily access and refill the feeders during stopovers if the animals need feed.
W14.Distractions	1) There are no distractions that scare the animals or cause them to stop or balk during loading/unloading. Rubber stoppers are installed to mute metal to metal contact.
	2) The floors are not shiny or reflective, even when wet.
	3) The entrance is illuminated with indirect lighting that will not shine on the animal's face.
	4) There are no loose objects in the animal compartment.
	5) The floors are even without any sudden drop or elevation. The loader can install a false solid floor to provide a continuous walking surface.
	6) Pneumatic equipment does not produce noise levels higher than 40dB. Preferably turned off during loading. Silencers are installed to reduce the noise level from equipment.
	7) Rubber stoppers are installed to silence metal on metal contacts.
	8) Fan positions are adjustable to prevent air currents from blowing on animal's faces.

Antibiotic-free production on pathogen occurrence and prevalence of antimicrobial resistance

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SUMMARY

This study assessed the impact of Raised Without Antibiotics (RWA) production practices on on-farm antibiotic use, pathogen occurrence, and the prevalence of antimicrobial resistance genes (ARGs) through the whole genome sequencing and analyzing of samples (fecal, manure, sow nasal swab, soil). Some farms that provided antibiotic use data for this study also tested an injection system that automatically records injection events in the barn and its associated meta-data. Based on the results, recommendations for best management practices for various pig production stages were formulated..

Despite encountering technical difficulties, the e-data capture technologies such as the V-ETiC injection system was demonstrated to be a good alternative to recording on paper-based treatment sheets. Compared to non-RWA barns, RWA barns had lower frequency of ARGs and higher frequency of pathogens in piglet feces and in-barn manure samples, both higher ARG and pathogen frequency in sow nasopharynx, and lower frequency of pathogens in sow feces. These results suggest the RWA program is effective in reducing the occurrence of antimicrobial resistance, but may lead to disease outbreaks due to higher pathogen loads, suggesting the need for a long-term surveillance monitoring system of pathogen loads in RWA production systems.

Some of the recommended best management practices to counter the rise of antimicrobial resistance include implementation of appropriate surveillance monitoring and antimicrobial stewardship systems, timely and effective vaccination programs, enhanced disinfection and manure management practices, and improved nutrition and feed programs.

INTRODUCTION

In order to mitigate the risks posed by the expanding antimicrobial resistance threat, more stringent rules governing the use of clinical drugs for the treatment of sick animals have been in place in Canada since December 2018. Consequently, many Canadian producers have proactively implemented procedures wherein animals are raised without the use of antibiotics (RWA) from birth to slaughter. The question is how effective are these intervention measures in actually reducing the total on-farm use of antibiotics, the occurrence of pathogens, and the prevalence of antimicrobial resistance? To answer this question, this study aimed to conduct longitudinal surveillance monitoring of conventional farms still using antibiotics as usual (except in feed) as well as farms that have entered into the RWA program.

One other gap that this study aimed to help address was the lack of a reliable national database on antibiotics use. Presently, pig farmers are required to keep detailed records of antibiotics use in their operations as part of the Canadian Quality Assurance program, but these are mainly paper-based records which are tedious and time-consuming to collect and may be potentially susceptible to errors. This study aimed to utilize available electronic data capture technologies to reduce the record-keeping burden and time-demand on barn staff, while ensuring that high-quality data is collected.

EXPERIMENTAL PROCEDURES

Activity 1: Some farms that provided antibiotic use data for this study were requested to test an injection system that includes a HSW ECO-MATIC syringe paired with the V-ETiC system and radio-frequency identification (RFID) technology. This system automatically records injection events in the barn and the associated meta-data (i.e., pig RFID tag, time, dosage, etc.) for each injection. The system provides automatic recognition of animals via RFID ear tag of the pig, treatments, the drug administered, and dosage.

Activity 2: Fecal and manure samples from 6- or 20-week-old pigs, fecal and nasal swab samples from sows, earthen manure storage samples, and soil samples from the participating farms' immediate environment were taken. Samples were sequenced, analyzed, and profiled using whole-genome sequencing to identify the prevalence of antimicrobial resistance genes (ARGs, also called resistome) and pathogens (also called pathome).

Activity 3: Following the completion of Activities 1 and 2, recommendations for best management practices for various pig production stages were formulated, including possible fine-tuning and modifications to current RWA practices to ensure that

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the intent of the program to reduce total antibiotic use, avoid the development and spread of antimicrobial resistance genes, and maintain or improve herd health, are fully realized.

RESULTS AND DISCUSSION

Activity 1: The RFID technology automatically recorded injection events in the barn as well as the associated meta-data for each injection. This data was automatically stored in the V-ETiC mobile app while inside the barn and could then be synchronized and downloaded to the V-ETiC cloud-based software via Bluetooth or WiFi anytime. Various technical issues on the system components and operating program were identified in this study, which resulted in the participating barns discontinuing the use of the device.

Activity 2: Metagenomic analyses revealed that the pathogens present in the samples belonged to five phyla: Firmicutes, Bacteriodetes, Chlamydiae, Actinobacteria and Proteobacteria. Relative to non-RWA barns, RWA barns had higher frequency of pathogens in piglet feces, in-barn manure and sow nasopharynx, and lower frequency of pathogens in sow feces. No differences were observed in the prevalence of pathogens in environment samples collected from the non-RWA and RWA farms.

The resistome profiles showed that the ARGs present in the samples were found to belong to six main classes: Aminoglycosides, β-lactams, Macrolides, Phenicol, Multi-Drug Resistance (MDR) and Tetracyclines. In RWA-piglet feces, the frequency of ARGs was significantly lower for Aminoglycosides, Macrolides, Phenicol and Tetracyclines (Figures 1A, 1C, 1E and 1F) relative to non-RWA. In RWA-barn manure, the frequency of resistance genes to β-lactams, MDR, Phenicol and Tetracyclines (Figures 1B, 1D, 1E and 1F) were also significantly lower relative to non-RWA barn manure. On the other hand, in the RWA-sow nasopharynx, the frequency of resistance genes for β-lactams, MDR and Tetracyclines were significantly higher compared to the non-RWA sow nasopharynx samples (Figures 1B, 1D and 1F). No significant difference was observed in the ARG frequency in sow feces and in barn environment samples between the two types of barns. The resistance to Tetracycline and Macrolide classes were found most frequently in fecal and manure samples. Resistance to the β-lactam class was found more frequently in nasal swabs collected from sows.

Activity 3: Some of the recommended best management practices to counter the rise of antimicrobial resistance include implementation of appropriate surveillance monitoring and antimicrobial stewardship systems, timely and effective vaccination programs, enhanced disinfection and manure management practices, and improved nutrition and feed programs (see Table 1).

Table 1. Examples of recommended best management practices according to production stage and type of operation

Production Stage	Barn Type	Recommended best management practices
Piglet	RWA	1. Continuous surveillance monitoring of antibiotic use, ARGs and prevalence of pathogens. 2. Implementation of effective vaccination program
	non-RWA	1. Antimicrobial stewardship – efficient use of antibiotics 2. Alternatives to antibiotics (e.g., probiotics, prebiotics, synbiotics)
Sow	RWA	1. Continuous surveillance monitoring of antibiotic use, ARGs and prevalence of pathogens 2. Implementation of effective vaccination program 3. Alternatives to antibiotics (e.g., probiotics, prebiotics, synbiotics)
	non-RWA	1. Antimicrobial stewardship – efficient use of antibiotics 2. Use of alternatives to antibiotics (e.g., probiotics, prebiotics)
Manure storage	RWA	1. Continuous surveillance monitoring of antibiotic use, ARGs and prevalence of pathogens 2. Implementation of effective disinfection measures
	non-RWA	1. Antimicrobial stewardship – efficient use of antibiotics 2. Manure treatments (e.g., manure separation, nanotechnology application)

IMPLICATIONS

Results from this project demonstrated that the Raised Without Antibiotics (RWA) program is an effective intervention measure to counter the occurrence of AMR in pig production operations. However, data from this study also showed that the RWA program had varying impacts on the different pig production stages. Hence, these key findings should be applied by reviewing and identifying the specific husbandry practices in each pig production stage, particularly those pertaining to maintaining animal health and administration of pharmaceutical products, that can be modified and/or optimized to further reduce or eliminate the use of antibiotics, and consequently the occurrence of ARGs.

Findings from this study showing that the elimination or reduced use of antibiotics in the production system can give rise to increasing prevalence of certain pathogens, should lead to implementation of continuous, long-term surveillance monitoring of pathogen loads in RWA production systems in order to determine the critical pathogen level before actual disease outbreaks occur. Knowing this will prevent the recurrence of catastrophic disease outbreaks experienced by early adopters of RWA practices, which ultimately led to failure (pulling out) of the program.

Despite the technical difficulties encountered (which should be within the capability of the equipment provider to resolve), the e-data capture technologies such as the V-ETiC injection system was demonstrated to be a good alternative to recording on paper-based treatment sheets. Once fully-debugged and restored to full functionality, this e-data capture technology can be utilized as an integral component of a focused surveillance monitoring system to efficiently and accurately capture, track, manage and monitor the use of any pharmaceutical products and their related meta-data in any type of production barn. In conjunction with the workflow method utilizing a health metadata-based approach for comparing and quantifying WGS data targeting the prevalence of pathogens and antimicrobial resistance developed in this study, this e-data capture technology would essentially improve the quality of the data and offer definitive insights into correlations and trends that were observed in this study.

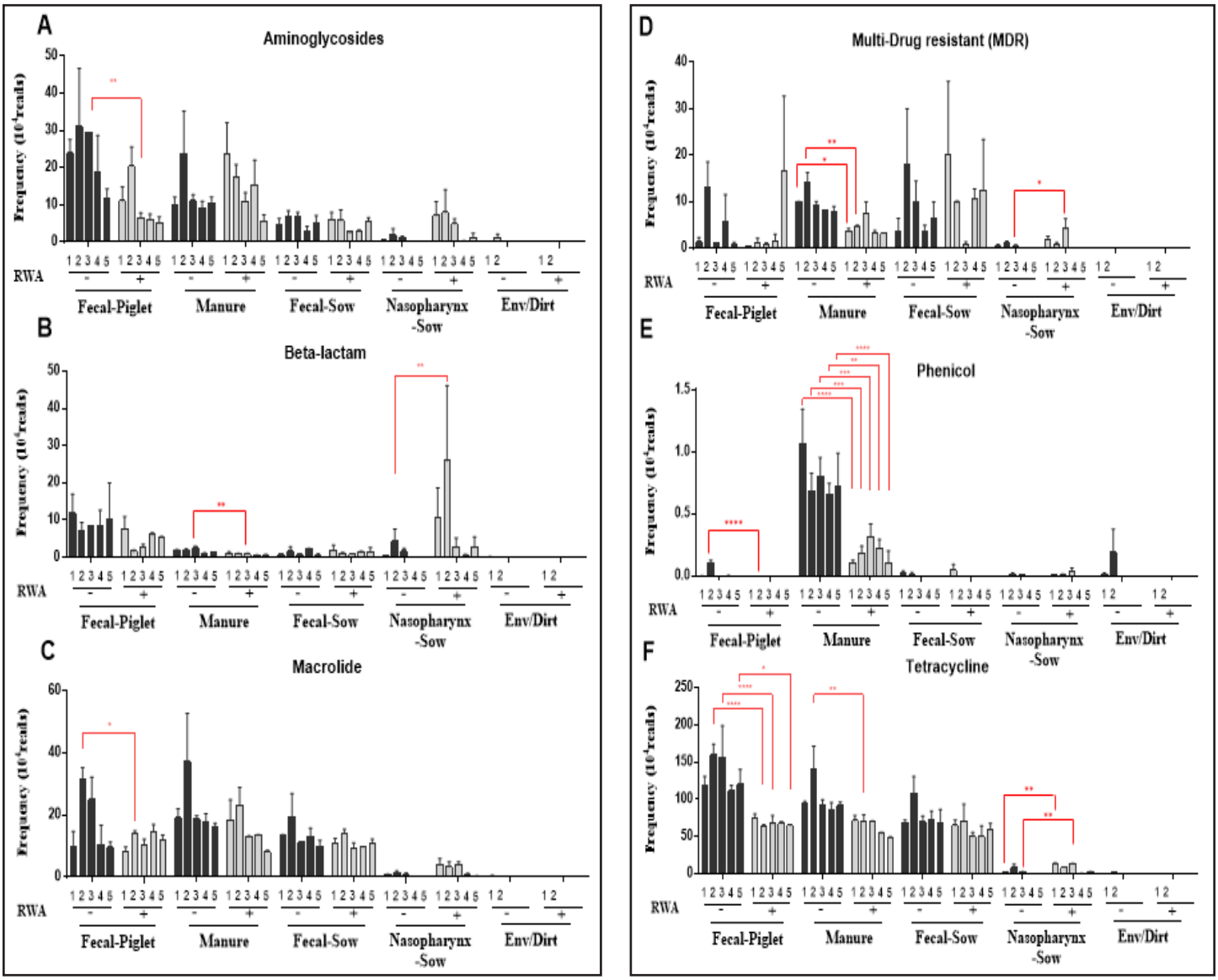

Figure 1. The frequency of ARGs in piglet feces, sow feces and nasopharynx, barn manure, and dirt/soil samples collected near the barn entrance in RWA (+ plus sign) and non-RWA (– minus sign) barns. The ARGs were clustered in six classes: Aminoglycosides (A), β-Lactams (B), Macrolides (C), MDR (D), Phenicol (E) and Tetracyclines (F). * p<0.05 ** p<0.01 *** p<0.005 **** p<0.001

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Can functional amino acids help low birth weight pigs in a Salmonella challenge?

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SUMMARY

It is not known if supplementation with functional amino acids (FAA) may mitigate the negative effects of intrauterine growth retardation seen in low birth weight (LBW) pigs. The objective was to determine the effects of birth weight category (BWC) and FAA supplementation during the postweaning period in Salmonella-challenged pigs. Thirty-two LBW (1.08 – 0.11 kg) and normal birth weight (NBW; 1.58 – 0.11 kg) pigs were assigned to a nursery feeding program at weaning (25 d) for 31 days in a 2 x 2 factorial arrangement. Factors were BWC (LBW vs. NBW) and basal (FAA–) or supplemented FAA profile (FAA+; Thr, Met, and Trp at 120% of requirements). At d 31, pigs were placed onto a common grower diet and, after a 7-d adaptation period, were inoculated with Salmonella Typhimurium (ST) and monitored for 7-d post inoculation.

Post-inoculation ADG was increased in NBW fed FAA+ compared to the other groups. There was no effect of FAA supplementation on rectal temperature or fecal shedding ($P > 0.10$). Salmonella shedding and translocation to spleen were lower in NBW-FAA+ compared to NBW-FAA- pigs ($P < 0.05$). Inoculation haptoglobin, superoxide dismutase, and colonic myeloperoxidase were increased in LBW-FAA- pigs ($P < 0.05$). Ileal alkaline phosphatase was decreased in LBW compared to NBW ($P < 0.05$).

Overall, the beneficial effects of FAA were dependent on birth weight category, with NBW pigs benefiting more from supplementation compared to LBW pigs. Therefore, functional amino acid supplementation represents a potential strategy to mitigate the effect of enteric disease challenges in normal birth weight, but not low birth weight pigs.

INTRODUCTION

The constant genetic selection for increased litter size in pigs has resulted in a higher proportion of piglets born with low birth weights (LBW). Alterations to intestinal functioning and the microbiome may impair the response to nutrient intake in LBW compared to normal birth weight pigs.

The positive effects of dietary amino acids (AA) on overall health, recently regarded as 'functional' roles, are mainly associated with improvements in intestinal mucosal barrier, antioxidant defense, and immune molecule synthesis. Previous work has shown that dietary supplementation with key functional amino acids (FAA) improves growth performance and immune status of disease-challenged normal birth weight (NBW) pigs. It is not known if supplementation with FAA may mitigate the negative effects of intrauterine growth retardation seen in LBW pigs.

The objective of the present study was to determine the effects of birth weight category (LBW vs. NBW) on the susceptibility of pigs to an enteric challenge during the grower phase and how this is influenced by the supplementation with FAA during the nursery phase. The hypothesis of this study was that supplementation with FAA would support a robust immune system, improve growth performance, and decrease disease susceptibility of LBW piglets.

EXPERIMENTAL PROCEDURES

After weaning, 32 mixed-sex piglets (LBW=16; NBW=16) were randomly assigned to 1 of 2 treatments in a randomized complete block design and individually housed for 45 days, including a 38-day adaptation period (no inoculation) and a 7-day post-inoculation period. Pigs were fed the experimental dietary treatments from d 0 to 31 post-weaning. Experimental diets were corn- wheat- barley-soybean meal-based with a basal (FAA-) or functional (FAA+) AA profile. The FAA- profile met the standardized ileal digestible (SID) AA requirements according to NRC (2012) and the FAA+ profile contained Thr, Met, and Trp at 120% of requirements for growth. At d 31, pigs were placed onto a common grower diet and, after a 7-d adaptation period, were inoculated with Salmonella Typhimurium (ST; 2.2 x 109 colony-forming units/mL) and monitored for 7-d post inoculation.

Growth performance, rectal temperature, fecal score, indicators of gut health, ST shedding score in feces, intestinal ST colonization and translocation, and blood parameters of acute-phase response and antioxidant balance were measured pre- and post inoculation.

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RESULTS AND DISCUSSION

Low BW pigs had lower BW than NBW pigs throughout the trial, and tended to have a lower ADG during the pre-inoculation period (Table 1). Pigs fed FAA+ tended to have a higher final BW than pigs fed FAA- regardless of BWC. Post-inoculation ADG was increased in NBW fed FAA+ compared to the other groups. There was no effect of FAA supplementation, BWC, or their interactions on post inoculation average daily feed intake and feed efficiency ($P > 0.10$).

Inoculation with ST increased temperature and fecal score, and the overall rectal temperature was higher in LBW compared to NBW pigs ($P < 0.05$). There was no effect of FAA supplementation on rectal temperature ($P > 0.10$). There was no effect of BWC or FAA supplementation on fecal score ($P > 0.10$).

Salmonella shedding score in feces and translocation to spleen were lower in NBW-FAA+ compared to NBW-FAA- pigs ($P < 0.05$). Post inoculation (d 7), reduced:oxidized glutathione was increased in NBW compared to LBW pigs ($P < 0.05$; Table 2). Post inoculation (d 4), serum haptoglobin and superoxide dismutase (Table 2), as well as colonic myeloperoxidase were increased in LBW-FAA- pigs ($P < 0.05$). Ileal alkaline phosphatase was decreased in LBW compared to NBW ($P < 0.05$).

Collectively, the results show that supplementation of nursery diets with FAA, specifically with Thr, Met, and Trp, above estimated requirements for growth improved growth performance, reduced pathogen shedding and suppressed bacterial translocation to lymphoid tissues when pigs were subsequently challenged with Salmonella. However, the beneficial effects of FAA were dependent on birth weight category, with normal-birth-weight pigs benefiting more from supplementation compared to low-birth-weight pigs, which were more susceptible to the gastrointestinal disturbance, oxidative stress, and systemic commitment of the immune system.

IMPLICATIONS

This study is the first to determine the effects of functional amino acid supplementation in the nursery on performance during a subsequent disease challenge in both low and normal birth weight pigs. Overall, the development of feeding strategies, such as altering dietary amino acid content, to support pig robustness will reduce reliance on antibiotics while maintaining animal performance. This study showed that functional amino acid supplementation represents a potential strategy to mitigate the effect of enteric disease challenges in normal birth weight, but not low birth weight pigs.

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Table 1. Pre- and post-inoculation growth performance of low and normal birth weight pigs inoculated with Salmonella[1]

Item	Low birth weight		Normal birth weight		SEM	P-value		
	FAA-	FAA+	FAA-	FAA+		BWC	FAA	BWC×FAA
Phase I (day 0 to 10)								
Initial body weight, kg	6.79	6.98	8.24	8.72	0.347	<0.01	0.64	0.27
Average daily gain, kg	0.246	0.249	0.287	0.313	0.044	0.45	0.22	0.16
Average daily feed intake, kg	0.386ab	0.405ab	0.361b	0.446a	0.025	0.73	0.21	0.05
Gain:Feed, kg/kg	0.64	0.62	0.79	0.70	0.093	0.28	0.86	0.89
Phase II (day 10 to 31)								
Initial body weight, kg	9.25	9.47	11.11	11.85	0.605	<0.01	0.44	0.68
Average daily gain, kg	0.382	0.400	0.360	0.403	0.036	0.80	0.41	0.72
Average daily feed intake, kg	0.699	0.721	0.780	0.773	0.050	0.20	0.88	0.79
Gain:Feed, kg/kg	0.55	0.55	0.46	0.52	0.043	0.17	0.36	0.63
Pre-inoculation (day 31 to 38)								
Initial body weight, kg	17.27	17.87	18.67	20.31	0.460	0.05	0.70	0.15
Average daily gain, kg	0.416	0.529	0.718	0.784	0.157	0.07	0.56	0.88
Average daily feed intake, kg	0.854	0.914	0.926	1.099	0.106	0.21	0.26	0.58
Gain:Feed, kg/kg	0.49	0.58	0.78	0.71	0.153	0.55	0.71	0.35
Post-inoculation (day 38 to 45)								
Initial body weight, kg	20.18	21.57	23.70	25.80	0.967	0.01	0.63	0.16
Average daily gain, kg	0.436b	0.446b	0.477b	0.565a	0.034	0.33	0.08	0.03
Average daily feed intake, kg	0.831	0.913	0.938	1.065	0.146	0.55	0.31	0.34
Gain:Feed, kg/kg	0.52	0.49	0.51	0.53	0.038	0.43	0.76	0.82
Final body weight, kg	23.23	24.69	27.04	29.76	0.841	0.03	0.07	0.48

FAA-, Basal amino acid profile; FAA+, Functional amino acid profile (Thr, Met, and Trp at 120% of requirements for growth). SEM, standard error of the mean. BWC, birth weight category. [1] Values are least squares means; n=8 pigs/treatment.
[a–b] Means within a row with different superscripts differ ($P \leq 0.05$).

Table 2a. Pre- and post-inoculation blood parameters of Salmonella-inoculated low and normal birth weight pigs[1]

Item	Low birth weight		Normal birth weight		SEM
	FAA-	FAA+	FAA-	FAA+	
Serum albumin, g/L					
Pre-inoculation (d 0)	33.75	32.75	33.37	38.29	4.064
Post-inoculation (d 4)	29.38	27.13	29.75	33.43	
Post-inoculation (d 7)	28.63	26.75	27.25	27.29	
Serum haptoglobin, g/L					
Pre-inoculation (d 0)	0.48	0.36	0.33	0.49	0.121
Post-inoculation (d 4)	1.01a	0.65b	0.73b	0.68b	
Post-inoculation (d 7)	0.54	0.54	0.53	0.55	
Serum antioxidant capacity, mM					
Pre-inoculation (d 0)	0.33	0.36	0.36	0.43	0.099
Post-inoculation (d 4)	0.19	0.31	0.23	0.34	
Post-inoculation (d 7)	0.18	0.21	0.20	0.21	
Plasma superoxide dismutase, mU/mL					
Pre-inoculation (d 0)	49.53	41.79	39.38	44.31	7.654
Post-inoculation (d 4)	93.32a	53.09b	76.58ab	67.81b	
Post-inoculation (d 7)	65.17	77.37	55.92	66.54	
Reduced glutathione (GSH), µM					
Pre-inoculation (d 0)	3.65	4.19	3.14	3.77	0.489
Post-inoculation (d 4)	2.05	1.41	1.98	1.69	
Post-inoculation (d 7)	0.89	1.04	1.62	1.21	
Oxidized glutathione (GSSG), µM					
Pre-inoculation (d 0)	0.67	0.70	0.58	0.68	0.234
Post-inoculation (d 4)	1.57	1.17	1.21	1.36	
Post-inoculation (d 7)	0.61	0.56	0.61	0.52	
GSH:GSSG					
Pre-inoculation (d 0)	5.45	5.98	5.41	5.54	0.289
Post-inoculation (d 4)	1.31	1.21	1.64	1.24	
Post-inoculation (d 7)	1.46	1.86	2.66	2.33	

FAA-, Basal amino acid profile; FAA+, Functional amino acid profile (Thr, Met, and Trp at 120% of requirements for growth). SEM, standard error of the mean. BWC, birth weight category.
[1] Values are least squares means; n=8 pigs/treatment.
[a,b] Means with a row with different superscripts differ ($P \leq 0.05$).

Table 2b. Significance of main and interactive effects of birth weight category (BWC), functional amino acid (FAA) profile, and day for pre- and post-inoculation blood parameters[1]

Item	FAA	Day	BWC × Day	FAA × Day	BWC × FAA × Day
Serum albumin	NS	0.05	NS	NS	NS
Serum haptoglobin	NS	0.02	NS	NS	0.03
Serum antioxidant capacity	0.05	0.04	NS	NS	NS
Plasma superoxide dismutase	NS	<0.01	NS	0.03	0.04
Reduced glutathione (GSH)	NS	<0.01	NS	NS	NS
Oxidized glutathione (GSSG)	NS	<0.01	NS	NS	NS
GSH:GSSG	NS	0.02	0.04	NS	NS

[1] Interactive effects not presented were not statistically significant (NS) for any of the parameters measured.

Functional amino acids in plant-based nursery diets in pigs subsequently challenged with Salmonella

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Dan Columbus

SUMMARY

Functional amino acids (FAA) attenuate the effects of Salmonella challenge in pigs. However, this may be affected by protein source (PS). The objective of the present study was to determine the effects of nursery dietary PS and FAA supplementation on growth performance and immune status of pigs subsequently challenged with Salmonella Typhimurium (ST). Thirty-two weanling pigs (8.7 ± 0.23 kg) were assigned to a feeding program for 31 d in a 2 × 2 factorial arrangement. Factors were dietary PS (plant-based [PB] vs. animal-based [AB]) and FAA profile (basal [FAA–] or supplemented [FAA+; Thr, Met, and Trp at 120% of requirements]). Pigs were subsequently placed on common grower diet and, after a 7-d adaptation, were inoculated with ST and monitored for 7 d post-inoculation. Growth performance, rectal temperature, fecal score, gut health, ST shedding score, intestinal colonization and translocation, and blood parameters of acute-phase response and antioxidant balance were measured pre- and post-inoculation.

Post-inoculation fecal score was worse, ST shedding, cecal myeloperoxidase, and cecal and colonic ST colonization were greater in PB compared to AB pigs ($P<0.05$). Translocation of ST to spleen was decreased by FAA+ ($P<0.05$), regardless of dietary protein source. Post-inoculation, AB pigs had greater average daily gain compared to PB-FAA- ($P<0.05$). Pigs fed AB-FAA- showed increased average daily feed intake compared to PB-FAA- pigs ($P < 0.05$) and feed efficiency was increased in AB-FAA+ compared to PB-FAA- pigs ($P<0.05$). Feeding PB ingredients in nursery diets seems to increase susceptibility of pigs to Salmonella. Moreover, FAA supplementation partially attenuated the negative effects of PB diets on the response of pigs to ST challenge.

INTRODUCTION

There is reduced societal acceptance of feeding livestock diets containing animal-based (AB) ingredients. Feeding plant-based (PB) protein sources (PS) during the post-weaning phase may not affect overall growth performance to market weight. However, a previous study showed reduced growth performance and increased mortality in pigs fed PB diets when an unexpected disease challenge occurred. This indicates that pigs fed a PB vs. AB diet in the nursery may be more susceptible to subsequent disease challenges.

The positive effects of dietary amino acids (AA) on overall health, recently regarded as 'functional' roles, are mainly associated with improvements in intestinal mucosal barrier, antioxidant defense, and immune molecule synthesis. Previous work has shown that dietary supplementation with key functional amino acids (FAA) improves growth performance and immune status of disease-challenged pigs. It is not known if supplementation with FAA may mitigate the negative effects of plant-based nursery diets.

The objective of the present study was to determine the effects of provision of PB or AB diets supplemented or not with FAA in the nursery period on growth performance and immune status of weaned pigs subsequently challenged with Salmonella. We hypothesized that removal of AB ingredients in nursery diets would impair gut development and decrease pig robustness, increasing susceptibility to Salmonella challenge. We further hypothesized that FAA supplementation would improve animal response to Salmonella challenge, regardless of dietary proteins source.

EXPERIMENTAL PROCEDURES

After weaning, 32 mixed-sex piglets (8.7 ± 0.2 kg initial body weight [BW]) were individually housed for 45 days, including a 38-day adaptation period (no inoculation) and a 7-day post-inoculation period. Pigs were randomly assigned to 1 of 4 treatments in a 2 × 2 factorial arrangement. Factors were dietary PS (plant-based [PB] vs. animal-based [AB]) and FAA profile (basal [FAA–] or supplemented [FAA+]). The FAA- profile met the standardized ileal digestible (SID) AA requirements according to NRC (2012) and the FAA+ profile contained Thr, Met, and Trp at 120% of requirements for growth. Pigs were fed the experimental dietary treatments from d 0 to 31 post-weaning. Experimental diets were wheat-barley based with either canola meal (PB) or meat meal-fish meal-blood meal (AB) as protein source. At d 31, pigs were placed onto a common grower diet and, after a 7-d adaptation period, were inoculated with Salmonella Typhimurium (ST; 3.05 x 109 colony-forming units/mL) and monitored for 7-d post inoculation.

Growth performance, rectal temperature, fecal score, indicators of gut health, ST shedding score in feces, intestinal ST colonization and translocation, and blood parameters of acute-phase response and antioxidant balance were measured pre- and post inoculation.

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RESULTS AND DISCUSSION

Overall rectal temperature tended to be reduced in FAA+ compared to FAA- pigs, regardless of protein source (P < 0.10; Figure 1A). Overall fecal score was negatively impacted in PB- compared to AB-fed pigs (P < 0.05; Figure 1B). Overall fecal ST shedding was reduced in AB pigs compared to PB pigs, regardless of FAA supplementation (P < 0.05). Pigs fed FAA+ tended to have reduced ST colonization in ileum (P < 0.10), regardless of protein source, and pigs fed AB had decreased ST colonization in cecum and colon (P < 0.05), regardless of FAA supplementation (Table 1). Translocation of ST to spleen was reduced by FAA+, regardless of protein source (P < 0.05).

Post-inoculation, AB pigs had greater average daily gain compared to PB-FAA- with PB-FAA+ being intermediate (P<0.05; Table 2), which indicates a clear attenuation of the negative effects of PB by FAA supplementation during a subsequent enteric infection. Pigs fed AB-FAA- showed increased average daily feed intake compared to PB-FAA- pigs (P < 0.05) and feed efficiency was increased in AB-FAA+ compared to PB-FAA- pigs (P<0.05; Table 2).

Serum albumin tended to increase in FAA+ compared to FAA- pigs, regardless of protein source (P < 0.10). There was no effect of protein source or FAA supplementation on other blood parameters (haptoglobin, SAC, SOD, GSH, GSSG or GSH:GSSG; P > 0.10). Pigs fed FAA+ diets tended to have reduced ileal myeloperoxidase (MPO) compared to pigs fed FAA- regardless of protein source (P < 0.05). Cecal MPO was reduced in AB pigs compared to PB pigs regardless of FAA supplementation (P < 0.05; Table 3).

IMPLICATIONS

Taken together, our findings show that a plant-based feeding program in the nursery period predisposed pigs to a subsequent enteric challenge, mainly through increased Salmonella intestinal colonization and fecal shedding, and deteriorated fecal score. Further, when plant-based diets were supplemented with FAA, specifically with Thr, Met, and Trp, above estimated requirements for growth, the negative effects of Salmonella on growth performance were attenuated, despite no effect on systemic markers of acute-phase response and antioxidant balance. This, combined with a lack of effect of FAA supplementation in animal-based diets during a subsequent Salmonella challenge, indicates that FAA may be a valuable strategy to mitigate the enteric disturbances caused by plant-based nursery diets.

ACKNOWLEDGEMENTS

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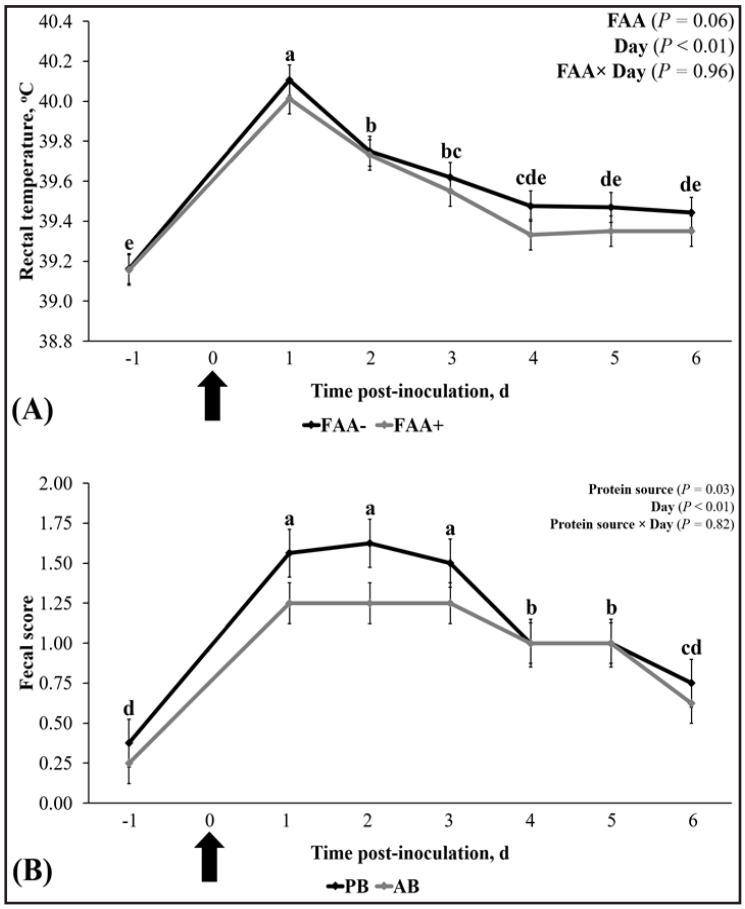

Figure 1. Rectal temperature (**A**) and fecal score (**B**) of Salmonella-inoculated pigs (indicated by arrow). Normal consistency feces were given a score of 0, semisolid feces without blood were given a score of 1, watery feces without blood were given a score of 2 and blood-tinged feces were given a score of 3. Within days, points with different superscripts differ (P < 0.05). Values are least squares means; n=16 pigs/treatment.

Table 1. Salmonella Typhimurium var. Copenhagen quantification in intestinal contents (Log10 CFU/g; d 7 post-inoculation) of Salmonella-inoculated pigs fed plant or animal-based nursery diets with or without functional amino acids supplementation[1]

Item	Plant based		Animal based		SEM	P-value		
	FAA-	FAA+	FAA-	FAA+		PS	FAA	PS×FAA
Ileum	3.49	2.87	3.36	2.13	0.625	0.41	0.09	0.56
Cecum	2.73	2.27	1.89	1.49	0.389	0.03	0.24	0.93
Colon	2.67	2.99	2.17	1.93	0.345	0.04	0.90	0.45

FAA-, Basal amino acid profile; FAA+, Functional amino acid profile (Thr, Met, and Trp at 120% of requirements for growth). SEM, standard error of the mean. PS, protein source.
1 Values are least squares means; n=8 pigs/treatment.

Table 2. Post-inoculation (day 38-45) growth performance of pigs fed plant or animal-based nursery diets with or without functional amino acids supplementation[1]

Item (kg)	Plant based		Animal based		SEM	P-value		
	FAA-	FAA+	FAA-	FAA+		PS	FAA	PS×FAA
Initial body weight	26.63	26.74	26.17	25.49	2.342	0.63	0.77	0.86
Average daily gain	0.516b	0.605ab	0.726a	0.716a	0.065	0.60	0.40	0.04
Average daily feed intake	1.173b	1.315ab	1.452a	1.325ab	0.084	0.35	0.74	0.04
Gain:Feed	0.44b	0.46ab	0.50ab	0.54a	0.047	0.49	0.59	0.05
Final body weight	30.34	30.98	31.25	30.50	1.371	0.74	0.98	0.44

FAA-, Basal amino acid profile; FAA+, Functional amino acid profile (Thr, Met, and Trp at 120% of requirements for growth). SEM, standard error of the mean. PS, protein source.
1 Values are least squares means; n=8 pigs/treatment.
a–b Means within a row with different letters differ ($P \leq 0.05$).

Table 3. Myeloperoxidase in intestinal contents (μU/mL; d 7 post-inoculation) of Salmonella-inoculated pigs fed plant or animal-based nursery diets with or without functional amino acids supplementation[1]

Item	Plant based		Animal based		SEM	P-value		
	FAA-	FAA+	FAA-	FAA+		PS	FAA	PS×FAA
Ileum	4.56	2.77	4.38	2.95	0.964	0.99	0.09	0.85
Cecum	2.64	2.65	2.00	1.83	0.372	0.05	0.82	0.80
Colon	2.24	2.41	2.51	2.63	0.225	0.27	0.51	0.90

FAA-, Basal amino acid profile; FAA+, Functional amino acid profile (Thr, Met, and Trp at 120% of requirements for growth). SEM, standard error of the mean. PS, protein source.
1Values are least squares means; n=8 pigs/treatment.
a–bMeans within a row with different letters differ ($P \leq 0.05$).

Ileal alkaline phosphatase is upregulated in Salmonella-challenged pigs fed functional AA

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SUMMARY

Functional amino acid (FAA) supplementation improves growth performance and immune status of Salmonella Typhimurium (ST)-challenged pigs, which was further improved by a longer adaptation period. It is expected that the effects are associated with increased activity of intestinal alkaline phosphatase (IAP). The objective of this study was to evaluate the effects of FAA supplementation and adaptation period on the ileal, cecal, and colonic activity of IAP in weaned pigs challenged with ST. In experiment 1, a total of 32 mixed sex weanling pigs were randomly assigned to dietary treatments in a 2 × 2 factorial arrangement with low (LP) or high protein (HP) content and basal (FAA–) or FAA profile (FAA+; Thr, Met, and Trp at 120% of requirements) as factors. In experiment 2, a total of 32 mixed-sex weanling pigs were randomly assigned to one of four dietary treatments, being FAA− fed throughout the experimental period (FAA−) or an FAA profile fed only in the post-inoculation (FAA+0), for 1 wk pre- and post-inoculation (FAA+1), or throughout the experimental period (FAA+2). In experiments 1 and 2, after a 7- and 14-d adaptation period, respectively, pigs were inoculated with saline solution containing ST (3.3 and 2.2 × 109 CFU/mL, respectively). Plasma alkaline phosphatase was measured on days 0 and 7 post-inoculation in experiment 1, and IAP (ileum, cecum, and colon) was measured in experiments 1 and 2.

In experiment 1, plasma alkaline phosphatase was decreased with ST inoculation and the overall content was increased in LP-FAA+ compared with LP-FAA− ($P < 0.05$). Moreover, ileal IAP was increased in FAA+ compared with FAA− pigs in both studies ($P < 0.05$) regardless of adaptation time ($P > 0.05$). Ileal IAP activity correlated with systemic markers of antioxidant defense, which highlights the enzyme's role in attenuating systemic infection. These results demonstrate a positive effect of FAA supplementation, but not adaptation period, on ileal alkaline phosphatase activity in Salmonella-challenged pigs, which may be associated with improvements in antioxidant balance.

INTRODUCTION

Intestinal alkaline phosphatase (IAP) is a brush border enzyme associated with positive effects on gastrointestinal health. Increased IAP activity may limit the translocation of pathogenic gut bacteria to surrounding lymphoid tissues. Amino acids have been shown to perform several functional roles, particularly in supporting gut health and development, which may be associated with improved IAP activity. We recently reported that pigs fed functional amino acids (FAAs; Thr, Met, and Trp at 120% of requirements) were better equipped to cope with a Salmonella challenge and the benefits were greater when pigs were fed FAA for a longer period pre-challenge. As the positive effects were associated with improved gut health and reduced pathogen colonization, we hypothesized that they may be mediated by or associated with increased IAP activity. The objective of this study was to determine the effects of FAA supplementation and adaptation period on IAP activity in Salmonella-challenged pigs.

EXPERIMENTAL PROCEDURES

Experiment 1: After weaning, 32 mixed-sex piglets (13.9 ± 0.8 kg initial body weight [BW]) were individually housed and randomly assigned to 1 of 4 treatments in a 2 × 2 factorial arrangement in a randomized complete block design (RCBD). Dietary treatments consisted of a low (LP) or high protein (HP) content and basal (FAA–) or functional AA profile (FAA+; Thr, Met, and Trp at 120% of requirements) as factors. After a 7-d adaptation period pigs were inoculated with solution containing Salmonella Typhimurium (ST; 3.3 × 109 CFU/ mL).

Experiment 2: A total of 32 mixed-sex weanling (weaning age: 25 d) pigs (11.6 ± 0.30 kg) were housed individually and randomly assigned to 1 of 4 treatments in an RCBD for 21 d. Treatments consisted of FAA− fed throughout the experimental period (FAA−), FAA+ fed only in the postinoculation (FAA+0), for 1 wk pre- and post-inoculation (FAA+1), or throughout the experimental period (FAA+2). After a 14-d adaptation period pigs were inoculated with ST (2.2 × 109 CFU/mL).

Plasma alkaline phosphatase was measured on days 0 and 7 post-inoculation in experiment 1, and IAP (ileum, cecum, and colon) was measured on d 7 post-inoculation in experiments 1 and 2. Correlations among ileal IAP and serum albumin and haptoglobin, plasma superoxide dismutase (SOD), malondialdehyde (MDA), and reduced:oxidized glutathione, ileal myeloperoxidase, ST shedding and ileal colonization, and post-inoculation average daily gain, feed intake (ADFI), and gain:feed were also analyzed.

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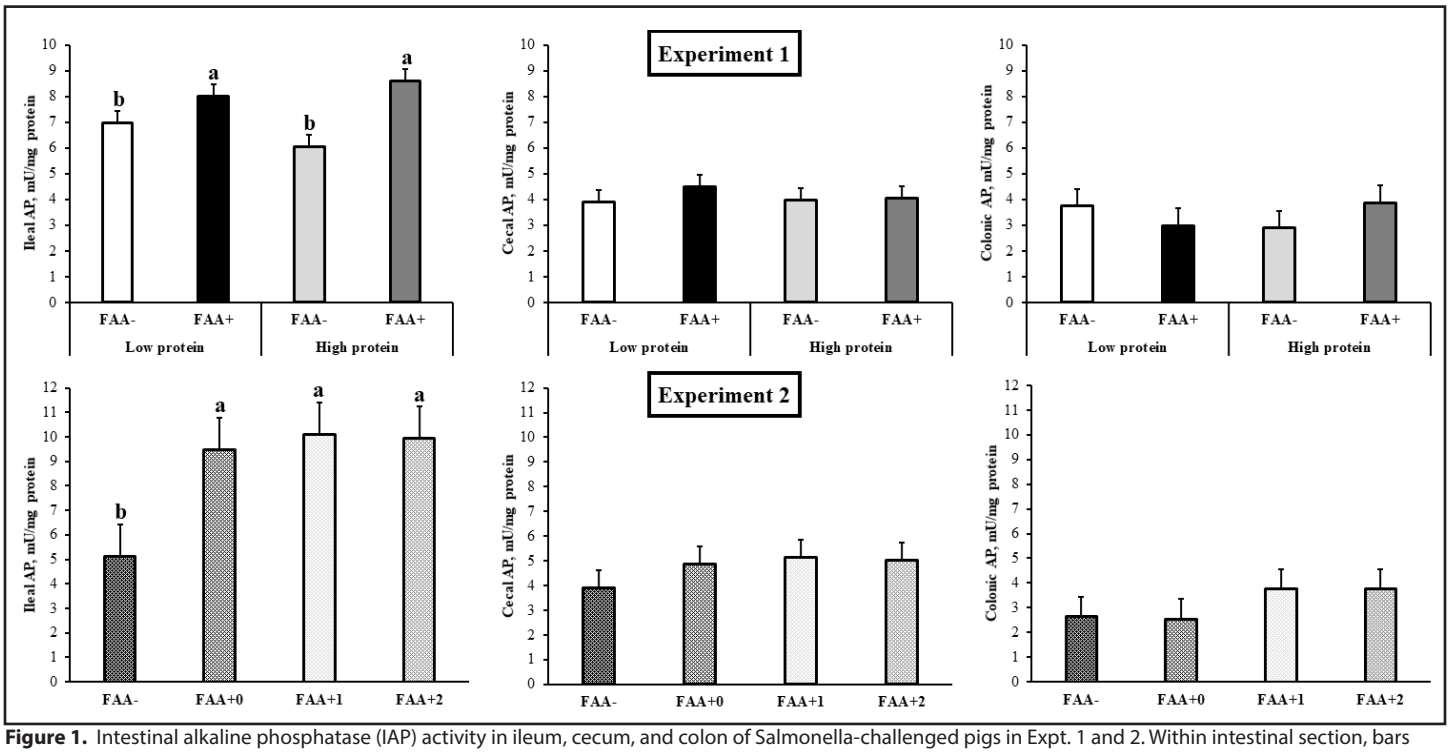

Figure 1. Intestinal alkaline phosphatase (IAP) activity in ileum, cecum, and colon of Salmonella-challenged pigs in Expt. 1 and 2. Within intestinal section, bars with different letters differ significantly (P < 0.05). Values are least squares means; n=8 pigs/treatment.

RESULTS AND DISCUSSION

Plasma alkaline phosphatase was decreased (day 0 vs. 7; 152.0 ± 9.4 vs. 67.6 ± 10.0 IU/L) post-inoculation with ST (P < 0.05). Overall, pigs fed LP-FAA+ had increased plasma alkaline phosphatase activity compared with pigs fed LP-FAA− (151.8 ± 14.4 vs. 82.2 ± 13.8 IU/L) with HP-FAA− (100.8 ± 13.4 IU/L) and HP-FAA+ (104.2 ± 13.8 IU/L) pigs being intermediate (P < 0.05).

IAP results for experiments 1 and 2 are shown in Figure 1. In experiment 1, pigs fed FAA+ had greater IAP activity in ileum tissue compared with pigs fed FAA− regardless of dietary CP content (P < 0.05). There was no effect of FAA supplementation or dietary CP content on IAP activity in cecum and colon tissues (P > 0.10). In experiment 2, FAA− pigs had lower IAP activity in ileum tissue compared with FAA + 0, FAA + 1, and FAA + 2 pigs (P < 0.05). Likewise, there was no effect of treatments on IAP activity in cecum and colon tissues (P > 0.10).

In experiment 1, IAP was positively correlated with MDA and ADFI and negatively correlated with SOD and ST shedding (Figure 2A). Other correlations among the measured parameters in both experiments can be found in Figure 2.

IMPLICATIONS

Collectively, our findings shed light on IAP modulation by diet and its relationship with systemic homeostasis. This study is the first to identify that ileal IAP activity is increased following FAA supplementation in ST-challenged pigs, regardless of adaptation period. The lack of effect of FAA adaptation period on IAP activity may be explained by antioxidant balance being more associated with AA intake than length of feeding. This study also showed that ileal IAP activity correlated with systemic markers of antioxidant defense, which highlights the enzyme's role in attenuating systemic infection. Overall, the development of feeding strategies with positive effects on IAP activity is of interest, due to the enzyme's central role on the gut and whole-body homeostasis and health.

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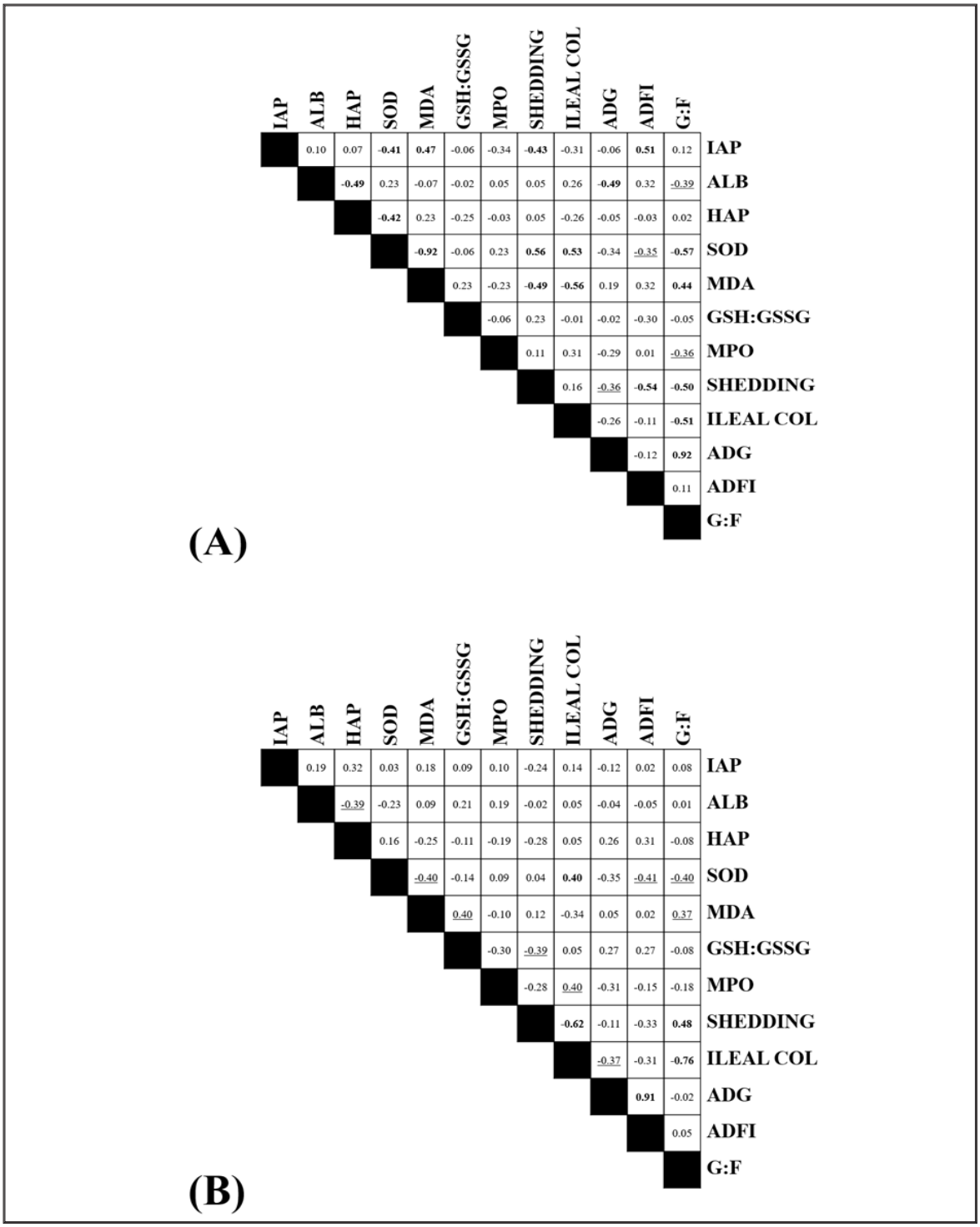

Figure 2. Correlation matrix among intestinal alkaline phosphatase (IAP), serum albumin (ALB) and haptoglobin (HAP), plasma superoxide dismutase (SOD), malondialdehyde (MDA), and reduced:oxidized glutathione (GSH:GSSG), ileal myeloperoxidase (MPO), Salmonella shedding (SHEDDING) and ileal colonization (ILEAL COL), average daily gain (ADG), average daily feed intake (ADFI), and gain:feed (G:F) in Salmonella-challenged pigs in Expt. 1 (A) and 2 (B). Values are the Pearson correlation coefficient (r value); n=32 pigs. Bold values are statistically significant ($P < 0.05$) and underlined values tend to be statistically significant ($P < 0.10$).

The use of extrusion to reduce dietary ergot toxicity in growing pigs

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SUMMARY

Ergot, produced by the fungi of the Claviceps genera, infect cereal crops such as rye and wheat when conditions are favourable. Consumption of ergot alkaloids by livestock results in reduced feed intake and growth and a dramatic reduction in the hormone prolactin, which is important for milk production. Previous research at the PSC demonstrated that extreme processing in the form of steam explosion reduced ergot toxicity, however, it is not always practical. Therefore, this trial set out to utilize extrusion as an example of a more commonly used processing technique to determine potential effects on ergot toxicity in growing pigs. A total of 160 grow-finisher pigs were fed 1 of 4 dietary treatments for 56 days in a 2 x 2 factorial design with main effects of ergot level (0 or 4000 ppb) and extruded or not.

Extrusion changed the ergot alkaloid chemistry, specifically a decrease in the R:S epimer ratio. Some reports indicate that toxicity is due primarily to the R epimer, thus a decrease in the ratio would indicate decreased toxicity of the ergot. Pigs fed ergot had decreased growth in phase 1 and overall. There was a tendency for reduced feed intake when the pigs were initially fed the ergot contaminated diets, and a significant decrease from d 29 to 42, throughout phase 2 and overall. There was no effect of ergot on feed efficiency. There were no ergot by extrusion interactions. Serum prolactin was reduced dramatically in the pigs receiving the ergot contaminated feed, however, there was no effect of extrusion, and no ergot by extrusion interaction.

The available data indicates that extrusion does not reduce ergot toxicity. The dramatic decline observed in serum prolactin observed with ergot alkaloids in the diet indicates that these diets should not be fed to sows or gilts destined for the breeding herd.

INTRODUCTION

Ergot alkaloids infect grasses and cereal crops such as rye, wheat, triticale and barley. There are "R" and "S" epimers of each alkaloid and it has been reported in the early literature that only the "R" epimer is toxic. Symptoms of toxicity range from reduced feed intake to gangrene in the extremities. Synthesis or release of the hormone, prolactin, is especially sensitive to ergot toxicity. The negative effects of ergot on prolactin are responsible for the decrease or complete cessation of milk production observed following ergot ingestion by sows.

There is some evidence suggesting that ergot toxicity can be reduced by feed processing, possibly by reducing the R:S ratio. Previously we showed that extreme processing, steam explosion, apparently reduced ergot amount and toxicity. However, steam explosion is not commonly used. Therefore, this trial set out to examine the potential of extrusion as an example of a more commonly used processing technique to determine potential effects on ergot toxicity in growing pigs. This information will be used to develop recommendations on potential processing strategies for pork producers when ergot toxicity is suspected.

Figure 1. Extruder used for this experiment, located at the Canadian Feed Research Centre

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EXPERIMENTAL PROCEDURES

Trial 1: A total of 160 grow-finisher pigs (65 ± 4 kg initial BW) were housed in groups of 5 per pen in a randomized complete block design. The pens were randomly assigned to 1 of 4 dietary treatments arranged in a 2 x 2 factorial design with main effects of ergot level (0 or 4 ppm) and extruded or not. The ergot levels were achieved by formulating a "clean" premix or a premix that contained ergot contaminated wheat screenings to achieve ergot levels of 0 and 240 ppm respectively. Premixes were either extruded at 90 ˚C with 80-100 psi pressure or not. These premixes were then included into the diets to achieve the final 0 or 4000 ppb levels. Diets were typical Western Canadian wheat-barley-soybean meal diets formulated to be isonitrogenous and isoenergetic to meet or exceed the recommended nutrient requirements for growing pigs in each phase (NRC, 2012). Diets were formulated for phase 1 to be fed to 60 to 90 kg BW pigs and phase 2 to be fed to 90 to 120 kg BW pigs.

Blood samples were collected on d7 and d56 for prolactin analyses, and pigs were weighed each week for the first 4 wks of the 56-d period and every 14 d thereafter until the heaviest pig reached market weight. Weight gain and feed disappearance were measured for each period, and feed efficiency (gain:feed) calculated.

Trial 2: A total of 32 growing pigs (75 ± 5 kg initial BW) were individually housed in metabolic crates in a randomized complete block design. Each metabolic crate had a urine collection tray underneath. Pigs were assigned to one of 4 dietary treatments in a 2 x 2 factorial design with main factors of ergot and extrusion. The diets were isonitrogenous and isoenergetic and were offered to provide 3 x maintenance energy requirement, which approximates ad libitum intake.

A 7-d adaptation to the experimental diets was followed by a 4-d collection of fecal and urine samples. These samples were analyzed for N content to allow a determination of the effect of treatment on N balance as an estimation of protein deposition.

RESULTS AND DISCUSSION

In our previous experiments, steam explosion drastically reduced total ergot content. In contrast, total ergot content in the extruded samples were reduced only by about 14%. However, the R:S ratio of the 6 measured ergot alkaloids in the non-extruded sample was 1.1, in contrast to 2.5 in the extruded sample. There was a 12% increase in the "R" epimer and a 50% decrease in the "S" epimer.

Table 1 describes the performance of growing pigs fed diets contaminated with 4 ppm ergot alkaloids, extruded or not, from 65 kg until market. Pigs fed ergot had decreased growth in phase 1 and overall. There was a tendency for reduced feed intake when the pigs were initially fed the ergot contaminated diets, and a significant decrease from d 29 to 42, throughout phase 2 and overall. There was no effect of ergot on feed efficiency, indicating that the effects of ergot were primarily due to the decrease in feed intake. Interestingly, there were no ergot by extrusion interactions for any of the performance data. An interaction would indicate a differential effect of ergot when the screenings were extruded, which would have supported our hypothesis. Thus, the lack of an interaction indicates that despite the changes observed in ergot epimer profile due to extrusion, extrusion had no effect on ergot toxicity in this experiment.

Figure 2. Room used for grow-finisher pig research at the Prairie Swine Centre

Serum prolactin was reduced dramatically in the pigs receiving the ergot contaminated feed, however, there was no effect of extrusion, and comparable to the performance data, no ergot by extrusion interaction (Table 2). The dramatic decline observed in serum prolactin observed with ergot alkaloids in the diet indicates that these diets should not be fed to gilts or sows used for reproductive purposes.

Nitrogen retention was unaffected by ergot alkaloid content of the diet, regardless of extrusion (data not shown).

IMPLICATIONS

The lack of an effect on feed efficiency indicates that ergot alkaloids exert their main effect on growth through decreases in feed intake. Extrusion had no effect on ergot toxicity in this experiment, despite changing the epimer profile. This implies either that changes in the epimer profile were not of sufficient magnitude to observe changes in performance, or that both epimers have toxic properties. Recent in vitro work by others favours the latter conclusion. Unlike what has been reported in the older literature, analysis and reporting of the ergot alkaloids should include both epimers.

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Table 1. The response of growing pigs to diets contaminated with 4 ppm ergot alkaloids, unprocessed or extruded.

Parameter	Ergot, ppm		Extrusion		Pooled SEM	P values[a]	
	0	4	No	Yes		Ergot	Extrusion
BW, kg							
Initial	65.94	65.82	65.87	65.9	1.54	0.84	0.97
d7	72.38	70.89	71.66	71.61	1.53	0.06	0.94
d14	79.5a	77.64	78.73	78.41	1.63	**0.03**	0.70
d21	88.10	85.89	87.30	86.6	1.18	**0.03**	0.55
d28	96.47	93.03	94.91	94.60	1.03	**0.002**	0.76
d42	112.56	109.55	111.33	110.77	1.15	**0.01**	0.62
ADG, kg/d							
d0-7	0.81	0.63	0.72	0.72	0.07	0.09	0.65
d8-14	1.21	1.12	1.20	1.13	0.11	0.65	0.57
d15-21	1.22	1.18	1.21	1.18	0.35	0.13	0.79
d22-28	1.18	1.02	1.08	1.12	0.28	0.35	0.81
d29-42	1.15	1.66	1.17	1.14	0.12	**0.004**	0.82
d43-56	0.92	1.00	0.98	0.93	0.07	0.14	0.17
phase 1[b]	1.07	0.95	1.02	0.99	0.02	**0.001**	0.34
phase 2[b]	0.94	0.96	0.96	0.94	0.12	0.40	0.40
Overall	**1.07**	**1.03**	**1.05**	**1.04**	**0.01**	**0.02**	**0.31**
ADFI, kg/d							
d0-7	2.1	1.92	1.98	2.03	0.07	0.09	0.65
d8-14	2.45	2.38	2.37	2.46	0.11	0.65	0.57
d15-21	3.32	3.06	3.17	3.21	0.38	0.13	0.80
d22-28	3.51	3.39	3.44	3.47	0.28	0.36	0.81
d29-42	3.23	2.92	3.06	3.09	0.12	**0.004**	0.82
d43-56	3.07	2.92	3.07	2.93	0.07	0.15	0.43
phase 1[b]	2.62	2.45	2.51	2.56	0.12	0.18	0.63
phase 2[b]	3.22	3.02	3.15	3.11	0.05	**0.01**	0.54
overall	2.97	2.78	2.88	2.89	0.05	**0.02**	0.95
G:F							
d0-7	0.40	0.33	0.36	0.36	0.02	0.08	0.66
d8-14	0.50	0.48	0.52	0.47	0.02	0.52	0.08
d15-21	0.37	0.39	0.39	0.37	0.02	0.48	0.44
d22-28	0.34	0.31	0.32	0.33	0.02	0.12	0.68
d29-42	0.36	0.40	0.39	0.37	0.01	**0.01**	0.36
d43-56	0.30	0.34	0.32	0.32	0.02	**0.02**	0.97
phase 1[b]	0.41	0.40	0.41	0.39	0.01	0.39	0.12
phase 2[b]	0.33	0.34	0.34	0.33	0.01	0.26	0.79
Overall	**0.36**	**0.37**	**0.37**	**0.36**	**0.01**	**0.19**	**0.37**

a Interaction ergot by extrusion P > 0.10. , b Phase 1, day 0-21; phase 2, day 22 to 56.

Table 2. Serum prolactin (ng, ml) of growing pigs fed diets contaminated with 4 ppm ergot alkaloids, unprocessed or extruded

Parameters	Ergot		Extrusion		Pooled SEM	P-values[a]	
	0	40	No	Yes		Ergot	Extrusion
d7	1.67	0.57	1.17	1.07	0.16	**< 0.001**	0.49
d56	0.71	0.43	0.52	0.62	0.11	**0.03**	0.38

a Interaction ergot by extrusion P > 0.10.

Out of feed events and gastric ulcers in finishing pigs fed 40% pea-starch diets

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SUMMARY

Gastric ulcers in pigs are a concern for the swine industry. To enable studies on gastric ulcer formation, an experimental model is required that will consistently result in gastric ulcers in pigs. Therefore, the objectives of this pilot study were to determine if an extra stressor in the form of an out-of-feed event was needed to create gastric ulcers in pigs fed 40% pea starch in their diets. A total of 90 finisher pigs (90.6 ± 2.2 kg initial BW) were housed in a group of 5 pigs/pen and fed 40% pea starch for 14 d before a 0, 16, or 24-hr out-of-feed event. On d 28, 3 pigs/pen were sent to a commercial abattoir and their stomach tissues harvested for lesion scoring. A control group fed a commercial diet, and no out-of-feed event was used to monitor and compare performance.

Pigs fed 40% pea starch diets had good growth performance, but lower feed efficiency than control pigs fed the commercial diet. Out of a total of 36 pig stomachs scored, 8.3 % had no ulcers (0), 47.2% had less severe ulcers (1 and 2) and 44.4% had severe to very severe ulcers (3 and 4). All 12 pigs experiencing a 24-hr out-of-feed event, 11 out of 12 pigs from the 16-h out-of-feed group, and 10 out of 12 pigs from the 0-hr out-of-feed group had some form of ulcer. It can be concluded that feeding 40% pea starch resulted in gastric ulcers in pigs, or that gastric ulcers are a common occurrence, and an out-of-feed event is not necessary for future research trials looking at gastric ulcers.

INTRODUCTION

Gastric ulcers in pigs are a concern for the industry. Pigs with ulcers may show reduced growth performance and in severe cases could even cause death. The literature points to different factors causing gastric ulcers, including small particle size of diets, out of feed events, and other stressors. However, little is known about the exact mechanisms of how gastric ulcers form and what the triggers are.

Air-classified pea starch is a by-product of the pea protein industry. Due to an increase in the pea protein industry in Canada, air-classified pea starch is an animal feed ingredient of interest. However, pea starch has a very small particle size, around 10 microns. Because a small particle size is believed to cause gastric ulcers in pigs, the question is whether a high inclusion of pea starch in grower pig diets may cause ulcers.

However, gastric ulcers are not consistently observed. Prior to initiating our research program investigating the inclusion of air-classified pea starch in swine diets we wanted to ensure a model was available that resulted in gastric ulcers in pigs. The objective of this pilot study was to see if an out-of-feed event was needed to create gastric ulcers in pigs fed diets with 40% pea starch.

EXPERIMENTAL PROCEDURES

A trial utilizing 90 pigs with an initial BW of 90.6 ± 2.2 kg housed in groups of 5 pigs/pen was used to determine if an out-of-feed event will affect growth performances and stomach health (gastric ulcers) of pigs fed pea starch diets. The pigs were provided 40% pea starch diets and water ad libitum for two weeks before the feed-out event. A control group of pigs were also fed "normal production" diets and monitored to compare growth parameters measured. There were four treatments: 1) a control group that had continuous access to feed, and a 40 % pea starch diet group exposed to 2) 0 h, 3) 16 h and 4) 24 h out-of-feed events. Pigs on the 40 % pea starch diets were acclimatized to the diet one week prior to the start of the experiment. Blood was collected at the start of the experiment and at the end to measure inflammatory bio-markers which could be indicators of stress leading to gastric ulcers. Bodyweight measurements were taken on d 0, d 7, d 17 and d 28. On d 13, feed was removed from the pigs at 7 am and 3 pm and reintroduced at 7 am for the 24 h and 16 h out-of-feed groups respectively, to mimic a feed-system breakdown. Water was available to the pigs throughout this period. Video recording of pigs after feed reintroduction will be taken to study pig reactions.

After d 28, 3 pigs per pen (n = 54) from the pigs on the 40% pea starch diets were sent to a commercial abattoir and their stomach tissues harvested. Lesions in the pars oesophagea (the non-glandular part of the stomach, just at the end of the oesophagus) which is the anatomical area that usually develops ulcer were scored on a scale of 0 to 4: 0- normal stomach; 1- parakeratosis; 2- active ulcer less than 33% of the pars oesophagea; 3- active ulcer 33 to 66% of the pars oesophagea; 4- more than 66% of the pars oesophagea.

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RESULTS AND DISCUSSION

The growth performance results are presented in Table 1. Pigs on the 40% pea starch diets tended to have a higher ADG and BW compared to the control pigs on the commercial diets by d 7. However, there was no difference on any other weigh day and the overall BW. Overall average daily feed intake (ADFI) in pigs on the 40% pea starch diet was significantly higher (about 500g averagely per day) than the control pigs. The overall G:F was reduced in the 40% pea starch-fed pigs.

Out of a total of 36 pig stomachs scored, 8.3% had no ulcers (0), 47.2% had less severe ulcers (1 and 2) and 44.4% had severe to very severe ulcers (3 and 4). All 12 pigs experiencing a 24-hr out-of-feed event, 11 out of 12 pigs from the 16-h out-of-feed group, and 10 out of 12 pigs from the 0-hr out-of-feed group had some form of ulcer (Figure 1).

IMPLICATIONS

Gastric ulcers were found in 33 out of the 36 pig stomachs scored. A total of 80% of pigs fed 40% pea starch and not experiencing an out-of-feed event had gastric ulcers. While pigs experiencing an out-of-feed event had a more severe lesion score than the ones from the 0-hr out-of-feed group, we concluded that an out-of-feed event is not necessary for future research trials examining the impact of pea starch on gastric ulcer formation in growing pigs.

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Table 1. Growth performance parameters in finishing pigs fed a commercial diet without feed out event (Control) or fed 40% pea starch diets and exposed to a feed out event of 0, 16, or 24 hours[1]

Item	Control	Out of feed event (hrs)			SEM	P-value
		0	16	24		
BW, kg						
Initial	90.08	90.11	90.59	90.19	1.00	0.95
d 7	97.85a	99.81b	100.81b	100.29b	0.56	0.09
d 14	107.98	109.45	110.46	109.82	1.74	0.31
d 28	122.8	124.57	124.17	124.52	2.18	0.46
ADG, kg d^{-1}						
d 1 to 7	1.12a	1.39b	1.39b	1.42b	0.12	**0.04**
d 8 to 14	1.43	1.38	1.46	1.38	0.21	0.85
d 15 to 28	1.00	1.08	0.99	1.05	0.07	0.77
d 0 to 28	1.14	1.23	1.20	1.23	0.05	0.20
ADFI, kg d^{-1}						
d 1 to 7	3.23a	3.63b	3.60b	3.63b	0.14	0.06
d 8 to 14	2.91a	3.65b	3.58b	3.53b	0.25	**<0.01**
d 15 to 28	2.83a	3.27b	3.27b	3.21b	0.25	0.08
d 0 to 28	2.98	3.52	3.48	3.46	0.14	**0.01**
G:F						
d 1 to 7	0.35	0.38	0.38	0.39	0.02	0.62
d 8 to 14	0.49a	0.38b	0.40b	0.40b	0.04	**0.03**
d 15 to 28	0.37	0.34	0.30	0.33	0.03	0.67
d 0 to 28	0.40a	0.37b	0.36b	0.37b	0.01	**0.03**

[1] Data are presented as least-square means of 6 replicate pens with 5 pigs per pen.
ADG = Average Daily Gain, ADFI = Average Daily Feed Intake, G:F = Gain to Feed ratio
Means without a common superscript are significantly different (P < 0.05).
P-Values in bold are significant.

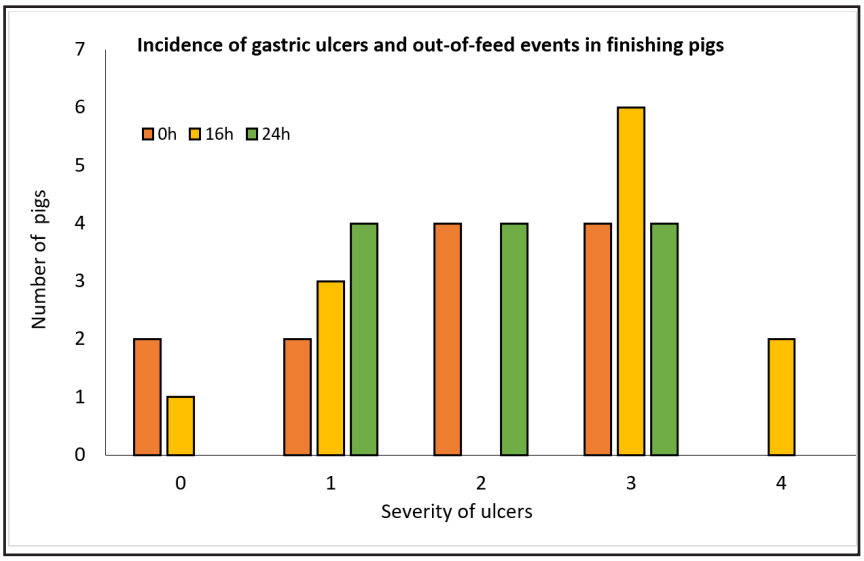

Figure 1. Incidence of gastric ulcers in finishing pigs fed 40% pea starch experiencing a 0, 16 or 24 hours long out-of-feed event

Effects of transport duration on the health and welfare of early weaned pigs

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SUMMARY

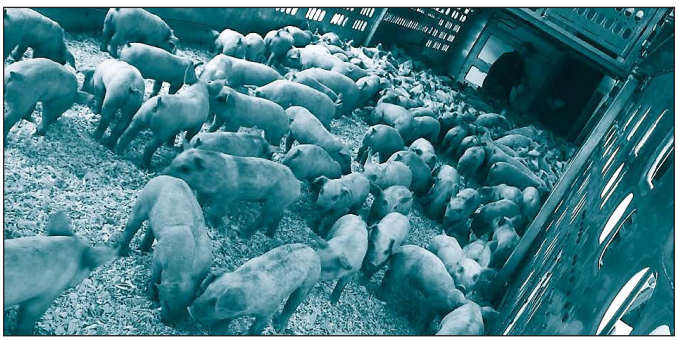
Due to the physiological differences between weaned piglets and market hogs, additional data on their response to transport are needed for age-specific evidence-based recommendations. A cohort study was conducted to observe weaned piglets undergoing short duration (SD, <3 h), or long duration (LD, >30 h) commercial summertime transport events. Piglets transported for a long duration (LD) were weaned up to six days before transport, while piglets transported for a short duration (SD) were weaned the morning of transport. Physiological changes suggesting some detrimental impact on welfare were observed in piglets exposed to both transport durations. Piglets exposed to long duration transport had greater weight loss, and had higher values of hematocrit indicating dehydration after transport, while piglets exposed to short duration transport had higher values of multiple blood indicators of muscle fatigue and stress. A greater proportion of LD piglets were observed feeding and drinking at arrival and spent more time eating at 3-4 days after transport than SD piglets. The results were also influenced by differences in weaning time, as LD piglets were weaned before transport and SD piglets were weaned at the time of loading and transport. Lesion severity increased in SD piglets compared to LD piglets in the ear, skin and tail regions assessed, likely due to weaning timeline and associated aggression.

"The differences between finished hogs and weaned piglets suggest that recommendations appropriate for one population may not benefit the other."

Changes in serum cortisol (stress hormone), lesions, and lameness were measured in piglets that either did or did not undergo weaning at 21d in a commercial facility, and compared these results to similar data collected from the aforementioned transport study. A marked increase in serum cortisol was observed in piglets that underwent weaning, compared to those that did not, lasting from 1h to 72h after weaning. In the transport study, serum cortisol measured after weaning and transport were relatively low, and most similar to non-weaned piglets, suggesting a possible moderating effect of transport on cortisol levels.

INTRODUCTION

While a considerable amount of research has been done on the effects of transport on market hogs, there is a lack of evidence available on the impact of transport on weaned piglets. The current body of weaned piglet transport research is too limited to inform transport recommendations specific to the weaned piglet age-group. The potential impact that appropriate, evidence-based recommendations could have for this younger population is significant given that millions of piglets are transported annually in Canada. Current transport regulations have been predominantly informed by investigations on the impact of transport on market hogs, with emphasis on the stress response and pork quality. The differences between finished hogs and weaned piglets, such as their physiological vulnerabilities, thermoneutral zone limits, proximity to weaning and proximity to slaughter, suggest that recommendations appropriate for one population may not benefit the other. As such, this project evaluates the impact of transport on the health and welfare of weaned piglets to provide evidence for this age group. The evaluation of transport duration using commercial farm and transport procedures including differences in the timeline of weaning and transport, as reported here, provides a valuable perspective to a research area where controlled studies (small groups of pigs under controlled/artificial transport conditions) have been traditionally employed.



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EXPERIMENTAL PROCEDURES

A cohort study was conducted to observe weaned piglets in four short-duration (SD, <3 h), and four long-duration (LD, >30 h) commercial summertime transport events. Piglets transported for a long duration were weaned up to six days before transport, while piglets transported for a short duration were weaned the morning of transport. Sixty focal piglets per LD transport event and 50 per SD transport event were chosen for data collection to measure mortality, injury, weight change, hematological or biochemical changes in hydration, muscle injury and stress response. Data collection on the 440 focal piglets out of 11,434 total transported piglets occurred the morning of the day before transport (T0), at arrival (T1) and approximately 3 to 4 d (78 to 93 h) after arrival at the nursery barn (T2). Behaviour at arrival (T1a) was collected on non-focal piglets (short transport group: n=160, long transport group: n=242), while the subset of focal piglets had weights collected, injury assessments completed, and behaviour video recorded on the day of arrival (T1b) and 3-4 days later (T2).

Next, changes in serum cortisol levels, lesions, and lameness were measured in piglets that either did or did not undergo weaning at 21d in a commercial facility, and compared these results to similar data collected from the above-mentioned transport study.

RESULTS AND DISCUSSION

The incidence of lameness between T0 and T1 was low across both short and long transport durations (1.84% of the 435 focal piglets scored) with all lameness cases identified as mild in severity. Lesions on ears and skin were more prevalent than other injury types after transport (T1) and may have been related to mixing aggression associated with weaning rather than transport alone. Hematological and biochemical differences were present between groups at T1. LD piglets had increased hematocrit levels compared with SD piglets ($P = 0.01$), suggesting increased body water losses. SD piglets showed greater levels of muscle injury compared with LD piglets including elevated aspartate aminotransferase ($P < 0.01$) and creatine kinase ($P < 0.01$). However, these parameters were within normal reference ranges for piglets of this age group. Indicators of physiological stress response including cortisol and neutrophil to lymphocyte ratios were elevated in SD piglets compared with LD piglets ($P = 0.02$ and $P < 0.01$, respectively). The results of this study demonstrate that both short and long transport durations can result in detectable physiological changes in weaned piglets.

A greater proportion of LD piglets were observed feeding at T1a (35.8% vs 0.0%; P<0.001), and piglets exposed to LD transport had greater odds of feeding compared to piglets exposed to SD transport at T1b (IRR: 9.2, 95% CI: 4.3-19.9, P<0.001) and T2 (IRR: 2.1, 95% CI: 1.8-2.4, P<0.001). Similarly, a greater proportion of LD piglets were observed drinking at T1a (13.9% vs 9.2%; P=0.005) and piglets exposed to LD transport had greater odds of drinking at T1b (IRR: 2.0, 95% CI: 1.3-2.9, P=0.001). Sitting was performed more by SD piglets at T1a (P=0.01), but piglets exposed to LD transport had greater odds of sitting at T1b (IRR: 2.5, 95% CI: 1.4-4.6, P=0.003). Short transport piglets lay down more at T1a (20.0% vs 0.0%; P<0.001) and piglets exposed to SD transport had greater odds of lying observed at T2 (IRR: 1.4, 95% CI: 1.4-1.5, P<0.001). Lesion severity increased in SD piglets compared to LD piglets in the ear, skin and tail regions assessed, likely due to weaning timeline and associated aggression.

A marked increase in serum cortisol was observed in piglets that underwent weaning, compared to those that did not, lasting from 1h to 72h after weaning. In the transport study, values collected after weaning and transport were relatively low, and most similar to non-weaned piglets, suggesting a possible moderating effect of transport on cortisol levels. The patterns of injury (lesions and lameness) observed suggest that lesion scores are more indicative of weaning, and gait scoring may be the most specific indicator of transport-related injury.

IMPLICATIONS

Transport has an impact on piglet stress whether long or short duration transport is undertaken. However, LD transport did not negatively impact piglets compared to SD under Canadian summer conditions. This study observed impacts of both transport duration and proximity to weaning on piglet welfare indicators and supports further investigation of the interaction between weaning and transport departure times. Based on increased hematocrit levels and piglet behaviour following transport, weaned piglets undergoing long transport days after weaning may benefit from having access to feed and water during transport. How to provide water and feed during transport also needs to be determined.

Cortisol levels in piglets after transport were lower than those in animals that were weaned and not transported. This indicates that the stress of transport and weaning are not additive, and suggests a possible mitigating effect of transport which merits further research.

The characterization of interior trailer conditions during the Canadian winter season and the impacts of these conditions on newly weaned piglets during and after transport will be studied in the final year of this project.

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Funding for this project is provided by Swine Innovation Porc through the Canadian Agricultural Partnership. The authors would also like to acknowledge the strategic program funding provided by Sask Pork, Alberta Pork, Ontario Pork, the Manitoba Pork Council and the Saskatchewan Agriculture Development Fund. In addition, we also wish to acknowledge the support of the production and research technicians at Prairie Swine Centre and the technicians and students at the University of Guelph that made it possible to conduct this research.

Sow mortality in Canadian Swine Herds

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SUMMARY

Sow mortality is an area of increasing concern as production records indicate a significant increase in spontaneous death losses over the past 10-20 years. This project gathered information on sow mortality through a literature review, a producer survey, visits to 13 Canadian farms for live sow measurements, and will analyze historical sow culling and mortality records from 34 Canadian farms.

Survey results from 104 herds across Canada found that the average sow replacement rate was 44% of the herd per year, with average sow mortality (sudden deaths) of 5.7%, and average parity of the sow herd was 3.5. The most common reasons for early sow removal (i.e. excluding old age) were poor reproductive performance and lameness.

Both the survey and on-farm visits showed that larger herds had a higher average sow mortality (suddden deaths) per year, higher annual sow replacement, and lower average parity. Reasons for these effects are unclear; one theory is that larger farms experience greater staff shortages, with limited time for identification and follow-up treatment of compromised sows. Farms using group housing in gestation also showed a higher average sow mortality per year when compared to farms with stall-housing, and may be associated with the increased number of aggressive interactions that result in injury and increased incidence of lameness, leading to higher removal rates.

"The most common reasons for early sow removal (i.e. excluding old age) were poor reproductive performance and lameness."

INTRODUCTION

Sow mortality is an important economic and animal welfare concern for pork producers. The average productive life of sows is decreasing. Culling and mortality numbers are often combined or not recorded consistently, making it difficult to accurately determine these numbers. Recent reports from US herds indicate average sow mortality rates of 9%, with higher levels in larger herds and more productive herds. Furthermore, almost 50% of the reported death losses occurred in young animals (gilts to parity 2), indicating a significant cost to producers, considering the revenue from young sows' piglets sold does not surpass the costs of raising replacement females until parity 3. Having comparable data for Canadian pig herds and getting an understanding of the underlying causes of sow removal will benefit sow welfare and Canadian pork producers.

EXPERIMENTAL PROCEDURES

A literature review was done to done to determine sow mortality rates based on recent research and to examine risk factors for sow mortality. A simplified sow necropsy procedure was also developed to use on-farm for assessment of causes of death.

The next phase of this study collected information regarding sow culling and mortality in Canadian swine herds from producers through an online survey. One hundred and four producers provided complete responses to 49 questions about sow management, culling and mortality factors.

Next, 13 farms were visited for sow observations on a total of 1,389 live sows and a necropsy demonstration was done on 8 sows using a developed necropsy decision tree. Live sows were evaluated based on animal-based measures (body condition score [BCS], lameness, and injury scores), and each farm's annual sow mortality (sudden deaths) and average parity of the sow herd were also recorded.

Of the surveyed farms that were not visited in-person, historical sow culling and mortality records in swine management software were obtained from 34 Canadian farms providing data on 72,700 removed sows.

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RESULTS AND DISCUSSION

No recent data has been published on the risk factors and causes of sow death in the Canadian sow herd. Previous studies have suggested that the increase in sow removal including sudden death, sow culling and involuntary removal is associated with a combination of factors, including inadequate nutrition, housing, management, genetics, environmental factors, and susceptibility to pathogens.

The survey results found that the average sow replacement per year was 44%, average sow mortality per year was 5.7%, and average parity of the herd was 3.5. The most common reason for sow removal (i.e., sum of culling, euthanasia, and death) was 'old age' (72%). The most common reasons for early sow removal were poor reproductive performance (60.6%) and lameness (28%). It was found that 65% of the survey participants did not perform necropsies on dead sows.

Average sow mortality (sudden deaths; %) per year showed a significant positive correlation with herd size and number of barn staff, with the latter accounting for 17% of the variation in average sow mortality per year ($P < 0.001$). Farms with group housing in gestation also showed a higher average sow mortality per year when compared to farms with stall-housing, and farms with mixed housing (both stalls and groups) were intermediate.

During the barn visits, the most commonly observed BCS was 3 (ideal condition). Of the 1,389 sows observed, 1,205 (88.8%) sows had no signs of lameness, and 1,003 showed no signs of injury (72.2%). Smaller herds had a higher proportion of old sows (parity >5) than large herds (>1,000 sows) and larger herds had a higher proportion of 'high' mortality levels than mid-size herds. Group gestation systems were associated with more lameness than stall gestation, however, the highest incidence of lameness was found in breeding, not in gestation. Larger farms were associated with higher average sow mortality, and sows in stall gestation showed the highest incidence of mild injury (score 1). Thus, in each type of farm different factors related to sow health and welfare were observed, and it is evident that larger farms are challenged by higher levels of injury and mortality, while farms with group gestation had higher lameness than stall gestation.

Of the eight sows necropsied, three sows were found dead, and five were euthanized. Four sows presented external and internal gross findings related to the locomotor system, and were removed from the herd by euthanasia.

The historical sow culling and mortality data have been sorted to categorize removal reasons across farms and will be analyzed along with farm information/management factors to determine risk factors related to sow death and removal. A number of recommendations will be identified related to sow longevity.

IMPLICATIONS

The average mortality rate of the Canadian herds included in the survey was moderate at 5.7%. Larger herds had a higher average sow mortality per year, higher annual sow replacement, and lower average herd parity. The association between farm size and mortality rate is a common finding but the causes are unclear. One theory is that larger farms experience greater staff shortages, with limited time for identification and treatment of compromised sows. The higher average sow mortality per year in gestating sows housed in groups may be associated with the increased number of aggressive interactions that result in injury, leading to the removal of the sow. It is anticipated that as the transition towards group gestation progresses, producer experience, management and genetics will adapt, resulting in reductions in sow death loss over time.

ACKNOWLEDGEMENTS

Funding for this project was provided by Swine Innovation Porc through the Canadian Agricultural Partnership. The authors would also like to acknowledge the strategic program funding provided by Sask Pork, Alberta Pork, Ontario Pork, the Manitoba Pork Council and the Saskatchewan Agriculture Development Fund. We are grateful for support from staff at CCSI and CDPQ who conducted farm visits in QC. In addition, we also wish to acknowledge the support of the production and research technicians at Prairie Swine Centre that made it possible to conduct this research.

Effective piglet enrichment: Development and reduction of damaging behaviours

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SUMMARY

Tail biting is a behavioural problem that impacts pig welfare and the economics of pork production. Environmental enrichment can reduce damaging behaviours, but practical information on enrichments for young pigs is lacking. The project contained two studies to evaluate enrichment at two life stages to identify whether early, late, or continuous enrichment is most effective. In Study 1 pigs at 4 to 8 weeks of age were provided one of four different enrichment treatments. Results confirmed that pigs prefer enrichment objects that are destructible, deformable, and chewable. Burlap strips produced the highest level of piglet interaction, but had to be replaced frequently, resulting in increased labour and material costs. Newsprint was consumed rapidly (usually within one hour), but provoked more play behaviour than all treatments except burlap. Study 2 will examine the long-term effect of early vs late enrichment with scented newspaper on pig growth and the development of damaging behaviour.

INTRODUCTION

Tail biting is a behavioural problem that impacts pig welfare and economics of production. Providing enrichment early in life may reduce the frequency of severe tail bites during the finishing stage. Research is needed to determine the importance of early enrichment and the type(s) of enrichment that are most effective.

Moreover, improper or inconsistent use of enrichments may have a negative impact and decrease animal welfare. For example, when pigs are moved from an enriched environment to a barren environment, they can show increased levels of problematic behaviours such as tail biting or manipulation of pen fixtures. Also, if a limited amount of enrichment is provided, it can increase competition and aggression. There is limited research looking into the effects of providing enrichments during only a portion of the pig's life, be that early (farrowing/nursery) or late (finishing).

This project aims to identify enrichments that are not only beneficial to the pigs' health and welfare but are also practical and cost-effective for producers to install and maintain.

EXPERIMENTAL PROCEDURES

Study 1. Selection and evaluation of enrichments in nursery pigs

A total of 160 weaner piglets were housed at 10 pigs/pen. The trial began when pigs were four weeks of age and finished at eight weeks of age. Each pen was assigned to one of four treatments: 1) Rope and burlap (RB); 2) PorkyPlay® and EasyFix Luna® pig toys (PL); 3) Rubber mats with dry or wet mash starter feed (M); and 4) Newsprint with and without added odour (N). The M and N enrichments were provided three days per week, whereas the RB and PL treatments were available continuously. Continuous enrichments were replaced as needed. Material and labour costs were recorded. Piglet behaviour in every pen was measured using video recordings with observations of 50 minutes per day for three days per week for two weeks. The behaviours observed included enrichment interaction (frequency and duration), object play and possessive aggression.

Study 2. Effects of environmental enrichment on behavioural development and long-term implications

A total of 240 piglets will be assigned to one of two treatments from 1 to 8 weeks of age (farrow room and nursery period): Enriched (E) pens receiving scented newsprint three days per week, or Control (C). When pigs move to the grow-finish pens at 8 weeks of age, half of the Enriched pigs will be switched to the Control treatment and vice versa to create 4 distinct treatments: Enriched early and late (EE), Enriched early/Control late (EC), Control early/Enriched late (CE), and Control early and late (CC). Enrichment use, aggression and the frequency of damaging behaviours will be recorded. A subset of

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pigs will be subjected to a series of individual behavioural tests. Tail biting scores will be taken weekly in the grow-finish phase. Post-mortem production measures such as blood glucose and cortisol, as well as carcass lesions and quality data will be taken on 20 pigs per treatment.

RESULTS AND DISCUSSION

Study 1. Selection and evaluation of enrichments in nursery pigs

The results of Study 1 indicated that the Rope and Burlap (RB) enrichment had the highest frequency and duration of piglet interaction. See Figures 1 and 2. Newsprint (N) was only available for 1/5 of the time compared to the continuous enrichments, but had the highest frequency of object play, as shown in Figure 3.

While Burlap enrichment resulted in a high level of interaction and play by piglets, it also needed to be replaced most frequently, resulting in higher labour and material costs. Based on the high levels of activity observed with scented newsprint (especially considering that it was available for a shorter time period), as well as low materials cost, lack of issues with the liquid manure system and the ability of this treatment to retain novelty over time, it was selected for use in Study 2, which will be carried out in 2023.

IMPLICATIONS

Study 1 results confirmed that pigs prefer enrichment objects that are destructible, deformable, and chewable. Burlap, while having the highest level of interaction, had to be replaced most frequently, resulting in increased labour and material costs. Newsprint was consumed rapidly, but still provoked more play behaviour than all treatments except burlap.

Study 2 will examine the long-term effect of early enrichment on development of damaging behaviour.

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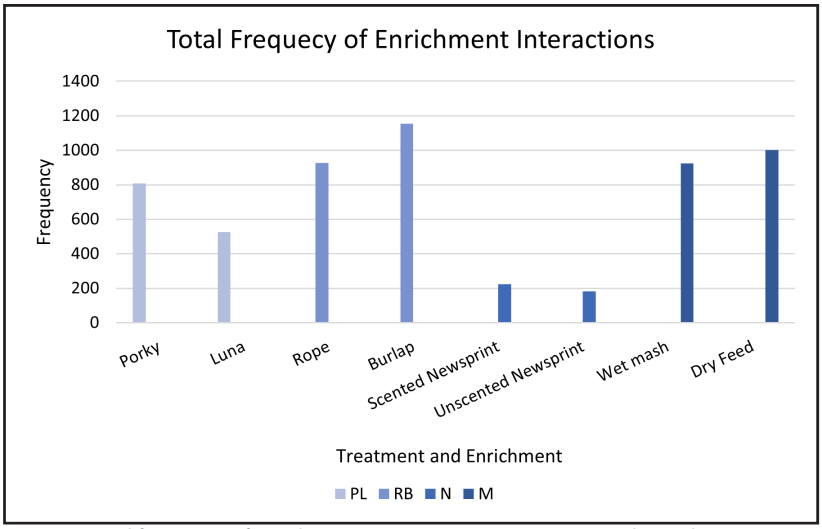

Figure 1. Total frequency of enrichment interactions per pen over a 40-hour observation period (5 hours per pen).

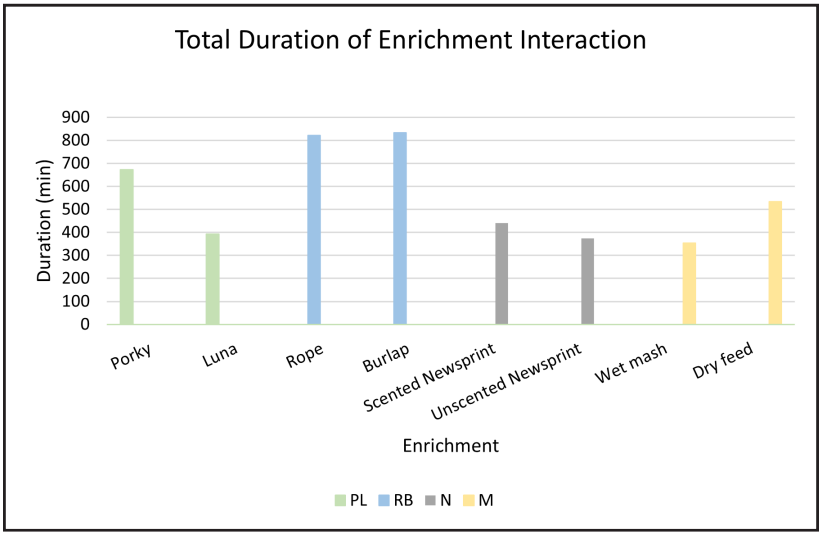

Figure 2. Total duration of enrichment interactions over a 40-hours observation period (5 hours per pen).

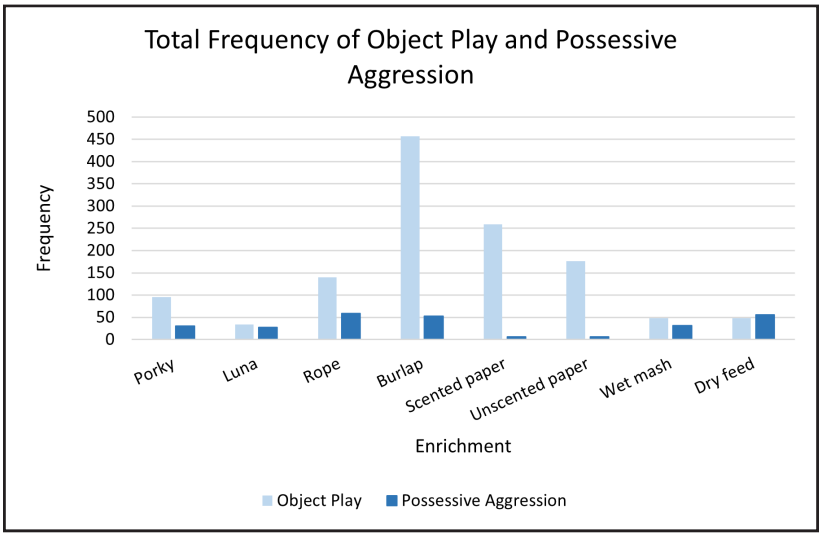

Figure 3. Total frequency of object play and possessive aggression over a 40-hour observation period (5 hours per pen). Possessive aggression is defined as the performance of forceful pushing, biting, or head knocking pen-mate(s) in order to gain or prevent access to an enrichment object. Object play is defined as the performance of playful, spontaneous head movements or locomotion involving enrichment interaction.

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