PRAIRIE SWINE CENTRE 25 YEARS

Annual Report 2018

SaskPork Alberta Pork Manitoba Pork Ontario Pork Saskatchewan Ministry of Agriculture University of Saskatchewan

MISSION STATEMENT

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

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Report Higlights

Chairman's Report

James Ressor, Chairman of the Board

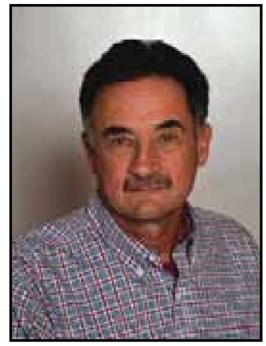
Thank You

The past year has been a very eventful time of transition for the Prairie Swine Centre. First, Lee Whittington retired after completing 25 years of dedicated and exemplary service. In 1992 Lee was among the founding staff who started and carried forward the vision for the Centre. In 2008 Lee became the President and CEO. During Lee's service as CEO, he both successfully navigated the Centre through challenging times in the Canadian swine industry and then provided leadership to the Centre and the Canadian swine industry as markets improved. Lee and his staff have provided a great presence and leadership in the Western Canadian and Canadian swine industry. This multi-million-dollar Canadian swine industry has benefited greatly from the dedicated research support and leadership provided by Lee Whittington and his fellow researchers.

On behalf of the Prairie Swine Centre Board of Directors, I want to emphasize our great appreciation for Lee Whittington's dedication and contributions. I can also add appreciation from our previous Board members and Chairs for the service and leadership Lee has provided. The Centre wishes Lee and his family all the best in their retirement.

Welcome

After a rigorous search, the Prairie Swine Centre is delighted to welcome Murray Pettitt, Ph.D., as CEO. Dr. Pettitt has been part of the Canadian swine research community for over 20 years. This includes a highly successful 10-year term with the Prairie Swine Centre as Manager of Contract Research. Dr. Pettitt then was part of the Department of Animal and Poultry Science, University of Saskatchewan for close to 10 years, before returning to the Prairie Swine Centre as CEO.



Murray was raised on a cattle and crop farm in western Manitoba. He brings both a practical perspective and an academic intensity to his role. Like John Patience and Lee Whittington, Murray is an excellent person to lead the Prairie Swine Centre in the next stage of the everchanging Canadian and world swine industry. The Prairie Swine Centre Board of Directors looks forward to working with Murray Pettitt and his team as they continue providing leadership and support to the Canadian Swine industry.

I also want to express my sincere thanks to the PSC Board Search Committee. Their professionalism and dedication to the Centre during this search was most evident.

Exciting Opportunities

In 2018, the Centre Board and Senior Staff continued examining how to sustainably operate a world class farrow-finish farm, research facility and knowledge transfer organization. The Centre continues to recognize opportunities, priorities and challenges resulting from a rapidly growing world pork industry. The Centre has the opportunity to lead and assist the pork industry integrate numerous disciplines. These disciplines include: traditional "on-farm" production measure research; environmental sustainability research that considers the wider "foot print" our industry leaves, including opportunities for integrating with crop production and livestock systems; food quality and safety research; and, social expectations regarding animal care and well-being. Overlapping all these areas are the need for designing and implementing economic systems that integrate these disciplines, enabling our industry to compete around the world.

During the coming year, the Board and Senior Staff will continue reviewing how to focus and integrate the valuable research the PSC is conducting. This includes continuing to cooperate with other swine research centres in Canada and around the world. As well, the PSC wants to reinforce the valuable relationship with the University of Saskatchewan and continue helping the University achieve its own research and teaching objectives.

The PSC deeply appreciates the very strong financial support received from the Province of Saskatchewan and the Alberta, Saskatchewan, Manitoba, Ontario and Quebec pork producer associations. The PSC is dedicated to continue earning this support and delivering valuable research and information back to the Canadian swine industry. As well, the PSC Board wishes to sincerely thank the dedicated efforts of the research farm production staff – while conducting world class research they are also are achieving world class sow, nursery and finisher production numbers, a difficult task for all research farms.

On behalf of the Board, I want to again thank the Prairie Swine Centre team on another successful swine research year. This Annual Research report clearly indicates their passion and dedication. I also want to sincerely thank retiring Board members for their dedication and talent and welcome the new Board members for 2018.

James Reesor

CEO Report

Murray Pettitt, CEO Prairie Swine Centre

"The only constant is Change" - Heraclitus

It is an old saying but is still very true. The pork industry has changed greatly since Prairie Swine Centre began some 26 years ago. Farms are larger, there are fewer of them, many are part of a vertically integrated system and the Canadian pork industry is linked to events within the global industry as never before. Pressures originating from outside of Canada, such as disease, production competition, tariffs, political agendas and crop production all affect the future of the Canadian pork producer. This constant change challenges all of us working in the pork industry to continuously adapt, improve and attempt to predict the future. At times we are successful, other times less so. As a pork producer ourselves, we fully appreciate the pressures the industry is under as we are under them as well.

I write this as the new CEO of Prairie Swine Centre – I am a change as well. I am very excited and grateful to be the new CEO of PSC, it is an amazing opportunity to continue contributing to the pork industry throughout Canada. This is my second stint at PSC, I previously led the Contract Research Program for the majority of my first 10 years at the Centre. I have been at the position since June 1 and since my return I have renewed many relationships, as well as making new ones throughout the pork industry.

PSC is coming to the end of its current 5 year plan and we are beginning to create the next one. Part of that process will be reaching out to the pork industry and pork value chain to help us identify the challenges and opportunities for both today and tomorrow. In these ever-changing times it is more important than ever that PSC maintains its close linkages with industry to ensure we can continue to provide relevant, useful and practical results to contribute to the sustainability (economic, welfare, environmental) of the Canadian Pork industry. Questions we are interested in asking include: what are the challenges? What is changing for you - biosecurity, health, digital technology, welfare technology? What research questions do you need asked? In addition to our current research pillars, are there opportunities where PSC could lead by providing practical research results in other areas that require it? I look forward to discussing these with you in the near future. As we develop our plan for the upcoming years, we anticipate further change in the industry and PSC will continue to be there to provide practical answers to practical questions for the pork industry throughout that change.

I would like to thank and acknowledge the staff of PSC for their dedication and commitment to excellence this past year. Any success PSC enjoys is entirely their fault and I know they will continue to excel at ensuring our customers receive the practical research results they need. I would also like to thank the PSC Board of Directors for trusting me to lead Prairie Swine Centre into the future.

Finally, I would like to thank my predecessor Lee Whittington for all of his years of service to PSC and the Canadian swine industry. I look forward to working with all those across Canada in laying the groundwork of the next 25 years of the Centre.

Murray Pettitt, PhD

PRAIRIE SWINE CENTRE 25 YEARS

Operation's Report

Tatjana Ometlic, Assistant Manager - Operations

This past fiscal year has been a big learning curve for new production staff and myself in the new role as the Assistant Manager. Our production goal was to sustain productivity while managing staff changes and ongoing training for new staff, volunteers, grad students and summer students. We managed to meet and exceed all the production targets for the last fiscal year. The numbers that are still a challenge and we are continuously working on improving are pre and post-wean mortality rates. We are starting to see improvements in production numbers this fiscal year, mostly due to the hiring of part time production staff during the week; this is providing stability and consistency in production practices. Currently we have two full time Animal Attendants in the grow finish area and one full time and two part time Animal Attendants in the Sow Research Unit. The workload has shifted to accommodate changes in staffing. The most important aspects of production (breeding and farrowing), are scheduled during the week when we have our permanent staff on. As of May 25th we have sold 7,795 animals and by the end of this fiscal year we should be at 8,370 animals sold. That is over 780 animals sold above the target.

Our researcher clients require consistent and large supplies of pigs of all ages to be available to meet their needs. With an eye to being a competitive pork producer, we operate our sow herd to achieve high reproductive performance, thus we focus on keeping the barn operating at capacity. To manage our high production of over 8,500 animals per year we have been selling a weekly supply of three different size animals, totaling about 40-45 animals, to an abattoir in the Osler area. Production rooms are filled to accommodate the sales and by the time pigs reach 55 kg the room is at the proper density. This still leaves additional animals to accommodate sales to the University of Saskatchewan.

Table 1. Production targets for fiscal year 2017-2018 are as follows:

Category	Target/week	Rolling Average (Jan – May, 2018)
# Bred	15.0	16.0
# Sows farrowed	13.7	14.6
# Pigs born alive	178	206.2
Average born alive	13.0	14.2
# Piglets weaned	158.5	179.3
Pre-wean mortality	10.96%	11.93%
Post-wean mortality	2.0%	2.9%
Grow-finish mortality	4.0%	2.6%
# Sold/week	158.0	162.4

Since January 2018 we had several research experiments starting in grow finish which has urged us to ship additional nursery pigs to make space allowance in grow-finish. Manipulating nursery and grow finish pigs for research and changing normal production procedures resulted in about 400 animals that would have been sold as markets in this year actually being sold at less than market weight. As a research center we continue to support and accommodate our scientist and students, assuring their requirements for projects are met while we try to sustain our production targets. It is not always an easy task to accomplish.

In grow finish we have converted two rooms, previously used for gestating sow Engineering trials, to have more capacity for market animals. Rooms can hold up to 279 animals @40 kg to 133 @ 120 kg and that will allow us to have space for extra animals not being used in research projects. Having a big flexible space that holds a lot of animals has its challenges. The tail biting has been elevated in these rooms. We looked at ways of improving conditions to reduce the tail biting incidents. More enrichment was put in place together with salt blocks and dividing panels to give animals a place to hide. Lighting was changed as well as ventilation was revisited after the training we completed in the recent months. The second load of pigs in the one room is doing a lot better with the changes we made. The second room was just marketed with average weight of 121 kg at first pull at 22 weeks of age.

This May we have welcomed four summer students, three in Ethology and one to share between Knowledge Transfer and Production. The Production summer student just completed her training in the barn and is starting her training in Knowledge Transfer. She will continue working weekends for Production. We still have a very strong pool of casual employees that are working weekends on an as needed basis when staff take vacation. Four of them just had their interview for Vet College and are awaiting results. We hope that all their hard work and commitment will pay off and that we will be looking at new future Vets. We currently have one volunteer that comes on her days off from her full time job and another volunteer that would like to start in the fall. Both of them are pre-vet students.

This past month has been eventful with welcoming new students; training in the barn on animal handling, regular production practices and a review of biosecurity. With a recent rise of PEDv in Manitoba, we want to make sure that everyone is on top of biosecurity. We also completed training for the Acushot needleless injector. Cal Funk, General Manager and Director of Marketing, was at the Centre to share his knowledge and expertise on how to properly use and take care of the device. Acushot will ensure a safer mode of application through the elimination of needles; a faster, more reliable means of application; and the reduction of labor requirements. The real benefit for a needleless injector is going to come when we start injecting nursery pigs with circovirus vaccine this summer.

Another piece of technology that we are very excited about is the Gestal Quattro, an electronic feed system that was installed last month in all farrowing rooms. It stimulates sow feed intake, reduces feed waste and makes sow management easier. With a new feature built in, it generates electricity savings. Using a customizable heat curve and temperature probe, the Gestal Quattro will reduce electricity demands while improving litter performance. In addition, it makes sow data management easier, manages reduction in weight loss and fat loss during lactation, as well as creates fast detection of sows with low feed intake. All production staff are already familiar with the system and so far we are very pleased with its performance.

Table 2. Production parameters for calendar years 2015-2017and the first 20 weeks of 2018: (Pig Champ)

	2015	2016	2017	Jan-May 2018
Number of sows farrowed:	739	750	760	331
Conception rate %:	92.8	92.5	91.8	94.1
Farrowing rate %:	93.1	92.2	92.0	91.1
Average born alive/litter:	14.0	14.2	14.2	14.3
Farrowing index:	2.46	2.49	2.48	2.50
Number weaned/sow:	12.8	12.6	12.4	12.3
Pre-wean mortality %:	11.4	11.2	12.1	12.1
Pigs weaned/sow/year:	28.7	29.5	30.1	28.8

This year's journey has not come without challenges, but also opportunities to learn, teach, support, grow and develop. Staff have been very supportive, cooperative and proud of the work they do. Together we navigated the challenges of life and career.

There has never been a dull moment and the changes in the facility and the research we do here at the Centre has made this job as rewarding as possible.

Knowledge Transfer Report

Ken Engele, Manager - Information Services

Last year we celebrated the 25th anniversary of Prairie Swine Centre being formed as a non-profit organization. A great deal of credit goes to the original advisory committee in realizing the importance of Technology Transfer in delivering a successful research program that continues to deliver practical, relevant, and timely information. As one of the original pillars of the Centre, the Technology Transfer program has seen many changes over these 25 years, while the three core areas of communication (personal, electronic, and print) remain the same, the level of importance dedicated to each method has changed significantly over time.

Delivering timely, accurate and practical information to the Canadian pork industry is the over-riding goal of the Centre's Knowledge Transfer program. It is also an essential component in building a strong brand for the Centre, which ensures long term support both from producers as well as those organizations that provide short and long term funding.

In order to achieve these objectives we must successfully integrate multiple forms of communication, repeatedly, in order to achieve the optimal outcome – technology adoption. Traditionally the three main areas of focus included: electronic, print and personal communication. Over the past 20 years these areas have remained tried and true - the importance of each component varies and will continue to shift over time. Whiles the pillars of communication remain important, the type and number of activities within each pillar changes to meet the ever-changing needs of our customers.

Knowledge Transfer is a key component in maintaining the brand of Prairie Swine Centre. Not only driving research results out to the greater pork industry, but going on-farm and measuring the impact of the research program. At the same time taking those conversations with producers and breaking them down into potential tangible research projects.

2017 was a milestone - it represented the 25 years of Centre's integration into the Canadian pork industry. We used this point in time to refresh the brand of the Centre – one that will encompass the next 25 years – and one that will ensure a high level of industry support, across all sectors of the pork industry.

Like fashion & music – what's old is new again. 25 years ago is was come to visit producers on farm – over time with larger farms and stricter biosecurity it has become increasingly difficult to schedule on-farm visits. One success story over the past year was the development, implementation and conclusion of the collaborative project (SIP, CDPQ) "From Innovation to Adoption: On-Farm Demonstration of Swine Research". This project provided us the opportunity to re-connect with producers at their operation – which is important – as it creates a different conversation that you would have meeting them at an industry event. By taking the results directly to producers we have a better understanding on finding roadblocks to implementation – which in the long run will increase the speed of technology adoption. Ultimately benefits both the Scientist and producer.

Objectives

Corporate Objectives

Objective #1

To be a profitable organization operating in a marketplace that offers growth opportunities.

Objective #2

To meet the technology needs of the pork value chain better than any competitor. Using an industry-oriented and multidisciplinary approach that ensures timely adoption of knowledge by the stakeholder.

Objective #3

To provide scientific leadership in our areas of expertise to industry, university and government.

Objective #4

To empower our people – that they should feel Valued, Challenged and Engaged in a safe work environment. Assisting them to find the breakthroughs to take us to the next level.

Objective #5

To enhance the Centre's effectiveness and sustainability, through successful collaborations, co-operative action and strategic alliances in our research, education and technology transfer roles.

Research Objectives

Objective #1

To increase net income for pork producers by $1/pig/year through improved nutrition.

a) This includes the development of feeding programs which emphasize economic efficiency, meat quality, and market value.

b) Understanding feed and fibre sources and the modifications of these to meet the needs of the pig, and changing economic conditions.

Objective #2

To improve animal wellbeing by developing and modifying housing systems, animal management practices, and improving health of the pig.

Objective #3

To improve barn environment through the development of economical and practical techniques ensuring the health and safety of barn workers and animals.

Objective #4

To reduce the operating costs by $0.50/pig/year and reduce the environmental footprint of pork production through breakthroughs in the science of odour and gas emissions, nutrient and water management, utility and resource efficiency.

Objective #5

To address the needs of society by leveraging our knowledge of the pig. This includes for example, using the pig as a model for human health and nutrition.

Finding Effective Enrichments for Group Housed Sows

R.C. Roy[1], V. Kyeiwaa[1], L. Lippens[4], Y.M. Seddon[1,3], N. Devillers[5], J.A. Brown[1,2], and L. Connor[4]

The Code of Practice for the Care and Handling of Pigs indicates that all pigs must be provided with multiple forms of enrichment to, "improve the welfare of the animals through the enhancement of their physical and social environments". This research was intended to provide pig producers evidence-based information on enrichment options which they can implement immediately. In two trials, using free-access stalls and electronic sow feeding (ESF) housing systems, the study demonstrated that wood suspended from a chain, cotton rope and straw can all be used as enrichment materials. Straw tended to be preferred by sows; straw is malleable and consumable which are known to be positive characteristics for enrichment. The straw was also provided as a diffuse enrichment on the floor, not as a single point source like the object enrichments, which allowed for more interaction. Rotating the different enrichments increased sow interactions with enrichment. This confirms that novelty and the type of material provided play a role in increasing attractiveness and sustaining sows' interest in enrichment. When free-access stalls were used, dominant sows spent more time near enrichments, while subordinate sows spent more time in the free-access stalls. In ESF housing subordinate sows interacted with enrichments more than dominants, and sows had higher skin injury scores indicating higher levels of aggression in this system compared to free-access stalls. It is possible that these differences were influenced by genetics. Further research on the effects of genetics and housing and feeding systems on enrichment use is recommended.

INTRODUCTION

Group housing for gestation sows has been adopted by approximately 25% of pork producers in Canada. Although group housing is considered a socially enriched environment, there is also an inherent risk of aggression as pigs compete for resources such as food and territory. Studies have shown that providing occupational enrichment in group housing has been associated with reduction in aggression and reductions in stereotypic behaviour. The Canadian Code of Practice for the Care and Handling of Pigs requires that all pigs be provided multiple forms of enrichment. However, what type of enrichments to provide and how enrichment should be provided is not well understood, particularly in slatted flooring systems which are widely used in North America. To address this issue, two set of studies (Phase 1 and Phase 2) where performed to examine how different types of enrichment and its presentation affects the use of enrichments by gestating sows. Both phase 1 and 2 also looked at the effect of enrichments on aggression using skin injury scores.

"Rotating enrichments increases sow interactions with the enrichment"

MATERIALS & METHODS

Phase 1

Phase 1 trials were designed to investigate suitable enrichments for sows housed on fully or partially slatted flooring systems. Studies with similar methodology were conducted at Prairie Swine Centre (PSC) and at the University of Manitoba (U of M) under different housing systems and genetics. Each treatment was studied over a 12 day period and sow groups received all four treatments in random order. Treatments consisted of:

1. Constant: constant provision of four wooden enrichments per pen;
2. Rotate: rotation of three items (rope, straw, and wood block) every three days;
3. Stimulus: rotation of the same three items, with an associated stimulus (bell);
4. Control: no enrichment provided.

Phase 2

Phase 2 compared the effects of fibre-based enrichments and object enrichments on sow behaviour. The ratio of enrichments provided per sow (one or three enrichments per group of 28 sows) was also studied. Five groups of ~ 28 sows housed in free access stalls were randomly allocated to three treatments per group, including:

1. One fibre feeder per pen (Figure 1);
2. Three fibre feeders per pen;
3. One wood enrichment per pen;
4. Three wood enrichments per pen, or
5. No enrichment (control).

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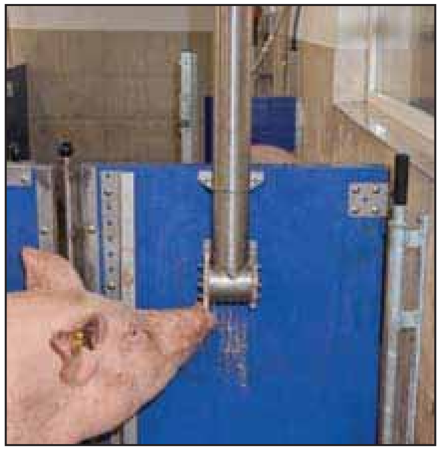
RESULTS & DISCUSSION

Enrichment Use

All types of enrichment used (straw, hanging wood, hanging rope and fibre provided in a feed hopper) elicited a response (contact with enrichment) 20 percent of sows. Enrichment contacts were three times higher in the ESF feeding system than free-access stalls. Sows preferred straw, rope and wood in decreasing order of preference. The Rotate and Stimulus treatments had a higher percentage of sows contacting enrichment compared to Constant provision of one enrichment in both study locations. Sows in the Rotate and Stimulus treatments interacted with enrichments more and spent more time in proximity to enrichment on day 10, when straw was provided in both studies. Sow activity (time standing), was greater when enrichment was provided compared to Control, indicating a higher activity level with enrichment.



Small amounts of organic material drop out of the rotor when a pig uses its snout to turn the wheel at the bottom.

Figure 1. The fibre dispenser used in this study was supplied by Big Dutchman. The original dispenser had five holes in the bottom designed to dispense pelleted feed. As finely chopped hay was used in this study, the opening in the bottom was enlarged to improve flow.

Social Status

The phase 1 study was conducted in an ESF system (University of Manitoba) and in free-access stalls (Prairie Swine Centre). Social status had a greater effect in the ESF system, with subordinate sows using the enrichment more than dominant sows. The fact that subordinate sows used the enrichments more suggests that the sows did not value the enrichments highly. This result may be due to dominant sows protecting the ESF feeder. Sows at the two sites also showed differences in stress physiology. At PSC, social status did not have a significant effect on cortisol levels, whereas at the U of MB subordinate sows had higher cortisol levels than dominant sows. There were no effects of social status and parity on sow skin lesions at either site.

When fibre enrichment was provided in the free-access stall system (Phase 2), dominant sows had greater access to enrichment than subordinates, and the prevalence of skin lesions increased, especially when only one fibre feeder was present. This indicates that sows valued the fibre enrichment, and that limiting sows to only one access point resulted in increased aggression among sows.

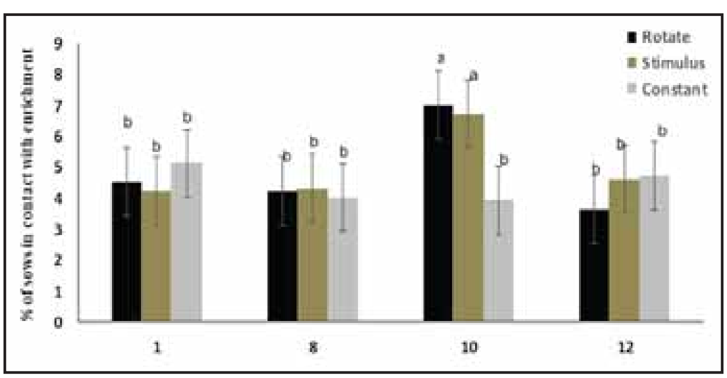


Figure 2. The percentage of sows in contact with enrichment in observations on days 1, 8, 10 and 12 in the free-access stall system. Sows were scan sampled at 15 minute intervals over 8-hours per day using time lapse digital cameras.

Aggression and Stress

In the fibre enrichment study, higher lesion scores were observed when fibre enrichment was provided than when wood enrichment was given. This result suggests that aggression may be increased when enrichments are of greater value to sows and there is limited access.

Average injury scores were higher in the ESF system than in the free-assess stall system, and subordinate sows tended to have higher injury scores than dominant sows. As previously discussed, the subordinate sows in ESF also had higher cortisol levels indicating that social competition may be higher in ESF feeding system. Alternatively, these behavioural differences may be related to differences in genetics or management between the two study sites.

CONCLUSION

Under conditions of adequate space allowance and individual feeding, wood suspended from a chain, rope and straw can all be used as enrichment materials. Straw enrichment provided on the pen floor produced the greatest response to enrichment. The rotation of enrichments tended to increase sow interaction with enrichment, indicating that maintaining novelty is an important factor to maintain sow interest.   The behaviour of sows in the two barns studied was significantly different. Sows in the ESF barn contacted the enrichments three times more frequently than those in the free-access stall barn.   Social status influenced fibre enrichment use but not use of other enrichments, with dominant sows having greater access. This suggests that when the enrichment provided is of greater perceived value and access is limited , then competition for the resource is increased.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge specific funding for this study provided by Swine Innovation Porc (SIP). 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.

Determining Optimum Space Allowance for Nursery Pigs

R.C. Roy[1], R. Kaur[1,2], Y.M. Seddon[1,3], A.D. Beaulieu[1,2], S.A. Edwards[4], D. Boussieres[5], J.A. Brown[1,2]

Studies were conducted in 2 phases to determine the effects of six different space allowances (k= 0.0230, 0.0265, 0.0300, 0.0335, 0.0370, and 0.0390) on nursery pig behavior, growth and welfare from 3 to 8 weeks of age. Phase 1 was a controlled trial conducted at Prairie Swine Centre (PSC) which explored the effects of housing piglets at the six space allowances in both large (40 pigs per pen) and small (10 pigs per pen) group sizes. Phase 2 used the same space allowances as tested in Phase 1, but studied pigs managed under commercial conditions in two production barns, one in Saskatchewan and one in Manitoba. In Phase 2, pen size remained constant throughout the trial so the targeted k value for each treatment was achieved at nursery exit.

Results from this study suggest that the minimum space requirement for nursery pigs indicated by the Canadian Code of practice for the Care and Handling of Pigs of k= 0.0335 provides a good balance between production costs and pig welfare. Housing nursery pigs at k= 0.0265 (20% below the recommended Code allowance) resulted in reductions in average daily weight gain on commercial farms, and postural changes indicating crowding (increased sitting and reduced lateral lying) in all studies.

INTRODUCTION

Floor space allowance is a complex issue in swine production, and one that is critical for both economic and welfare reasons. There is currently a significant body of research on the effects of space allowances in grow-finish pigs. The most widely accepted method to define floor space allowance (A) is to relate it to the size of pig by converting body weight (BW) with the expression of A = k * BW 0.667. The critical k value of 0.0335 established by Gonyou et al. (2006) is used to define the current minimum space allowance required for nursery pigs by the Canadian Code of Practice for the Care and Handling of pigs (NFACC, 2014). However, very little is actually known concerning effects of space allowance on nursery pigs and there is concern that the k value which is appropriate for finishing pigs may overestimate the requirements of nursery pigs. In determining the optimal space allowance in nursery, the economics of production should be considered along with the effects on piglet growth and welfare. This study set out to address concerns surrounding space allowance in nursery pigs and identify the critical cut-off at which crowding occurs.

MATERIALS & METHODS

Phase 1 Trials

Phase 1 studies took place at the Prairie Swine Centre. Pigs were housed in fully slatted pens, and fed ad-libitum via feed hoppers. The availability of feeder space and drinkers (on a per pig basis) was kept constant across all treatments. A total of 1,200 newly weaned pigs (weaning age: 4 weeks) were studied in six density treatments, tested at two group sizes (10 and 40 pigs per group), in four replicates with one replicate per season to control for seasonal variation. Space allowance was allotted to nusery pigs using the allometric equation, Area = k * BW $^{0.667}$ (where Area= space/pig in m2, k = the constant under test and BW = body weight in kg). The k values tested were: 0.0230, 0.0265, 0.0300, 0.0335, 0.0370 and 0.0390 with space allowance adjusted weekly based on pig weight. These span the range of k values commonly used in commercial barns, above and below the suggested optimum k value of 0.0335 determined by Gonyou et al. (2006). Weekly average daily gain, pen group feed intake, feeding behaviour, body postures and any incidences of morbidity and mortality were recorded per pen.

Phase 2 Trials

Phase 2 studies were conducted in two commercial barns, one in Manitoba and one in Saskatchewan. The farms had different genetics but similar group sizes (approx. 30 pigs at the lowest space allowance). Pigs were fed and cared for in accordance with standard management practices on each farm.

The same six space allowance treatments described in Phase 1 were tested using four replicates per farm in two seasons (summer and winter). Unlike Phase 1, in which pen size was adjusted to maintain a specific density relative to pig size, pens remained constant in size, and the number of pigs per pen was varied to achieve the required density based on the expected exit weight (25 kg).

"The minimum space requirement for nursery pigs provided in the 'Code' provides a balance between production cost and pig welfare."

Data Collection

Information on pig diets, management protocols, pen and barn environment were collected for each facility. Both individual pig and group weights were collected at entry and exit, and group weights were collected at mid-point in the nursery growth cycle to determine average daily gain. At weighing, skin lesions, general health, pen cleanliness, ear necrosis and tail biting scores were assessed for each pen by a trained observer. In both phases pig behaviour was studied one day week in weeks 1, 3 and 5. For Phase 1 pig behaviour was recorded for 8 hours using video cameras suspended directly above each pen. Scan sampling was

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performed at 30-minute intervals to record postures (sternal or fully recumbent), and the number of pigs overlying. Feeding and drinking behaviours were monitored continuously for 8 hours on one day in weeks 1, 3 and 5.

RESULTS AND DISCUSSION

Productivity

Average Daily Gain (ADG) was greatly influenced by the barn where the study was conducted. In the phase 1 trial at the research barn (Prairie Swine Centre), ADG was not significantly affected by the different space allowance treatments. However, for Phase 2 ADG was significantly increased with higher space allowance with differences depending upon the farm (Table 1, Figure 1) and season. ADG was significantly higher in winter than summer in the phase 2 commericial barn trial.

Table 1. Effect of six different space allowances on productivity measures in commercial farms. Average daily gain (ADG), Average daily feed intake (ADFI) and Feed efficiency (Gain:Feed- G: F).

	k =0.023	k =0.0265	k =0.03	k =0.0335	k =0.037	k =0.039	SEM	P
ADG*	0.38	0.39	0.40	0.40	0.41	0.42	0.01	0.001
ADFI	0.80	0.83	0.84	0.86	0.86	0.86	0.02	0.06
G:F	0.69	0.67	0.69	0.69	0.70	0.71	0.01	0.9

*Overall significant effect of space allowance on the production variable.
SEM= standard error of mean, P= p-value

Effect of space allowance on behaviour

Space allowance and group size had similar effects on feeding and drinking behaviour of nursery pigs. As space allowance was reduced or group size was increased (from 10 to 40 pigs), the percentage of time spent feeding or drinking decreased. However, the number of feeding bouts increased to compensate. Sitting behaviour increased significantly at lower space allowances. Sitting postures require less floor space than standing or lying, so this is interpreted as an indication of crowding. Sitting has also been associated with poor welfare in pigs. Space allowance did not have a significant effect on skin lesions on the body, ears or tail of nursery pigs in either phase 1 or phase 2.

Group size and age of the nursery pig had a strong effect on lying behaviour (sternal, recumbent and overlying). Space allowance had minimal effect on the lying behaviour. Sternal recumbency and overlying behaviour reduced with age, while lateral lying increased. Overlying behaviour reduced by 50 percent after the first week (Figure 2), therefore reducing space allowance based on the assumption that pigs will overlie is not justified and can negatively impact the productivity and welfare of nursery pigs.

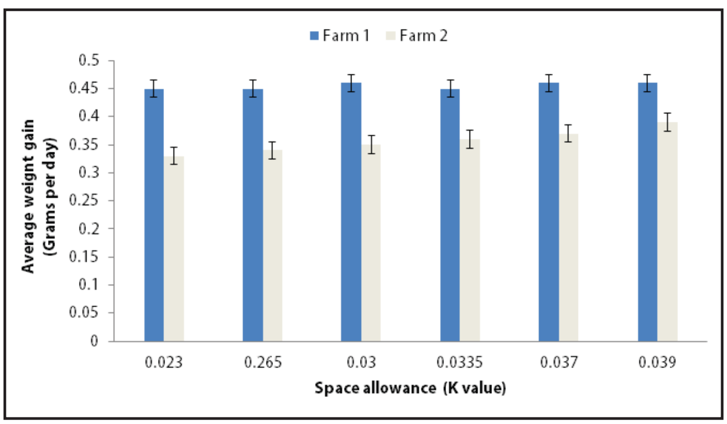

Figure 1. Average weight gain (0 to 43 days). Different space allowance (k-value) on Phase 2 commercial trials.

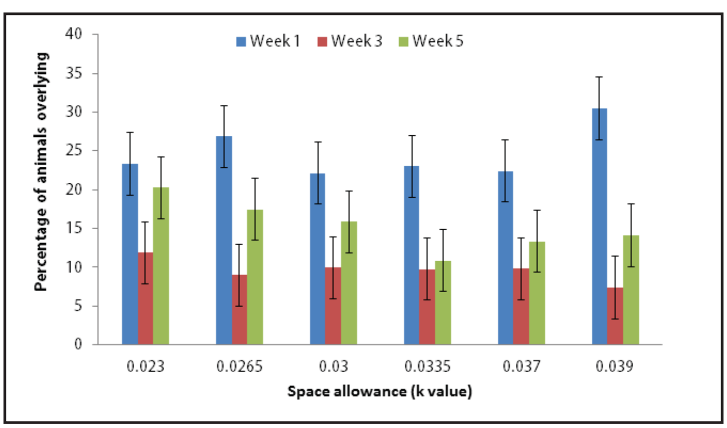

Figure 2. Predicted percentage of animals overlying in response to different space allowances in nursery weeks 1, 3 and 5.

As the temperature in the barn increased, the percentage of pigs standing decreased with a corresponding increase in the percentage of pigs in lateral recumbency. At higher ambient temperatures pigs lie on their sides more in order to increase body contact with the floor and maximize heat loss.

CONCLUSION

Results indicate that providing nursery space allowances at and above k= 0.0335 had a positive effect on the productivity and resting behaviour of nursery pigs. Although ADG reached a ceiling effect at k=0.335 in commercial studies, there was no indication that lateral lying reached a ceiling effect at this space allowance. Space allowances above k= 0.0335 may result in further changes to piglet posture and an increase in comfort behavior (e.g. increased lateral lying near the end of the Nursery phase). Higher space allowances increased resting behaviour (lateral recumbency) and reduced overlying behaviour.

Postural behaviours were significantly affected by age of the nursery pigs. Therefore overlying behaviour cannot be used as a justification to reduce space allowances as pigs are most crowded at the end of nursery phase (due to growth) and this is time that lateral lying is preferred.

No effects of group size on pig growth or behaviours related to welfare were found. Therefore, there was no evidence that larger groups require less space than small groups, however, the maximum group size studied was 40 pigs, which is smaller than is found on many commercial farms.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge specific funding for this study provided by Swine Innovation Porc (SIP). 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 Inc. that make it possible to conduct this research.

Are Sows Motivated for Movement?

M. Tokareva[1], J.A. Brown[2,3], E.A. Pajor[4], D. MacPhee[1], A.D. Beaulieu[2,3], G. Adams[1], D. Janz[1], Y.M. Seddon[1,2]

Currently, there is a lack of scientific evidence on which to base a recommendation on what constitutes 'greater freedom of movement', specifically when or how much exercise stall housed sows should receive during gestation. Additionally, whether periodically providing stall housed sows with opportunities for greater freedom of movement can benefit sow welfare is unknown. This research project addresses these questions, with the results being intended for use by stakeholders to create informed discussion when clarifying the Code of Practice requirements in July 2019.

INTRODUCTION

The Canadian Code of Practice for the Care and Handling of Pigs requires that as of July 1, 2024, all mated gilts and sows must be housed in groups, or individual pens. Mated gilts and sows may also be housed in existing stall barns if they are provided with the opportunity to turn around or exercise periodically, or other means that allow a greater freedom of movement. What constitutes 'greater freedom of movement' and the suitable options to meet this Code requirement must be clarified, by July 2019, as informed by scientific evidence, however at present there is minimal scientific evidence to address this question. The objective of study is to provide scientific information to be used as a basis for this recommendation.

MATERIALS & METHODS

A total of 24 animals (12 gilts, 12 sows) were studied regarding for their motivation to exit the gestation stall and gain access to the alleyway between stalls for a three minute period. An operant panel was constructed that contained two identical buttons (Figure 1) that were programmed to count the number of presses made to each button. One button is designated as the active button (AB), and as push counts to this button can result in a reward for the sow. The other is designated as a the dummy button (DB), acting as a control measure;, and press counts made to this button have no effect and do not contribute to the sow obtaining a reward for the sow.

Figure 1. The operant panel containing two identical buttons, a central divider, and a light to indicate when the panel is active. Image shows the operant panel hung inside a stall gate.

"Sows displayed a higher motivation to access additional food than gilts"

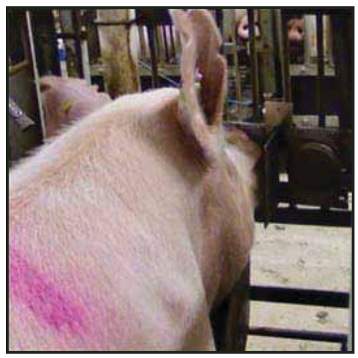

Figure 2. Sow pressing the active button.

Figure 3. Sow walking in alley between stalls.

Training and Testing Procedure

Sows were trained and tested in two phases, in one phase, the reward was the gate opening and the sow being allowed to roam the alley. In another phase, the reward was 0.2kg of feed. The order of training and testing for stall exit or extra feed was balanced, with half of the sows trained to exit first, and half trained to receive extra feed first. When training and testing animals to exit the stall, sows were rewarded for pressing the active button (Figure 2) with three minutes of time to freely move around within the alleyway between stalls (Figure 3). When sows were trained to press the operant panel for access to more feed, they were fed only 50% of their standard gestation ration in the morning in order to facilitate training. Thereafter, a handful of gestation feed (0.2kg) was the reward. The position of the AB and DB was switched between training and testing for feed and access to time out of the stall.

Once trained, sows were tested on an ascending fixed ratio (FR) schedule, where the number of AB button presses required by the sow was increased by 50% each day, starting at FR of 9, and increasing daily to a maximum FR of 365. This produced a testing schedule of FR 9, 14, 21, 32, 48, 72, 108, 162, 243, and 365.

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In each 30 minute testing session, the animal was given a maximum of three consecutive opportunities to reach the required FR and obtain their reward. If an animal failed to reach the required FR within the 30 minute period, no reward was given. The animal was given a second opportunity to reach the required FR the following day, if the animal reached the required FR, testing continued along the schedule. If the animal failed to reach the required FR for a second day, testing ended.

All sows were fitted with accelerometers to record step counts as a measure of activity when out of the stall. Additionally, a camera positioned at one end of the alleyway recorded the behaviour of sows once out of the stall. During testing for motivation to exit the stall, the frequency and duration of sows seeking social contact, or seeking food was recorded

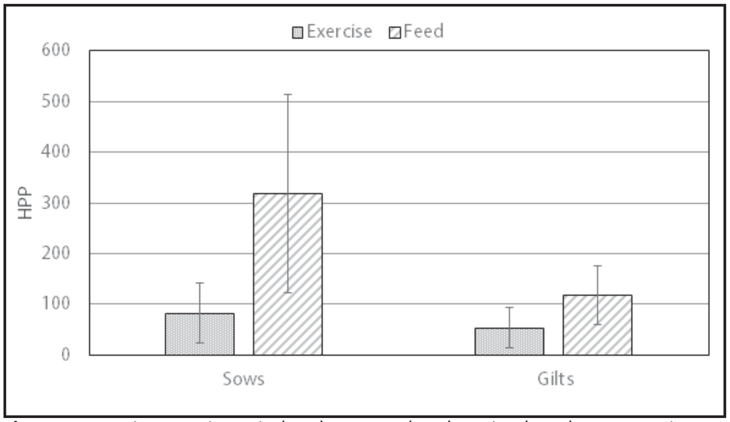

Figure 4. The highest price paid (HPP) for sows (n =4) or gilts (n = 4) to access time out of the stall (Exercise), or a feed reward (Feed) (mean ± S.D.).

RESULTS AND DISCUSSION

The motivation (as measured by the highest price paid: HPP) to exit the stall was numerically similar in sows and gilts (Figure 4). The motivation to obtain access to additional feed was greater than that for exercise in both sows and gilts, with sows showing a greater motivation for food than gilts.
However, the latency to press the active button over the whole testing period was numerically shorter for both sows and gilts when tested for access to exit the stall compared to access to feed.

Additional control sows were presented with the operant panel for 30 minutes for seven consecutive days, with no rewards. Initially they interacted with the panel, generating total push counts on day 1 within the range of the HPP by sows and gilts for access to time out of the stall. However, over the course of the seven days, interaction with the panel reduced to near zero push button counts. In contrast, sows trained that received a reward maintained levels of interaction with the panel over consecutive days, and as the FR increased (Figure 5).

CONCLUSION

Sows and gilts have a moderate level of motivation to obtain time out of the stall, as measured by the highest price paid (HPP), and in comparison to the higher level of motivation to receive a feed reward. Sows displayed a higher motivation to access additional food than gilts. To provide more substantial evidence on which to base Code recommendations, further studies will be done to examine sows' motivation to exit the stall at different feeding levels, and to compare the effects of weekly exercise versus group housing and stall housing on sow behaviour and production.

ACKNOWLEDGEMENTS

We would like to acknowledge the financial support for this research project from the Saskatchewan Agriculture Development Fund, Sask Pork the Alberta Pork. 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 staff of the University of Saskatchewan engineering department that have made it possible to conduct this research.

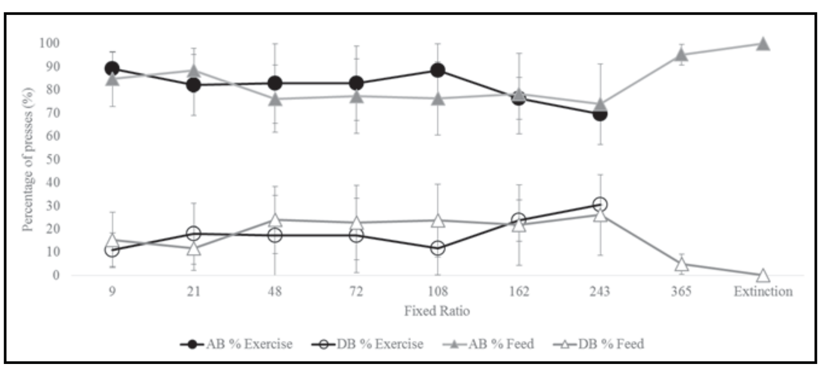

Figure 5. The mean percentage of total button presses in which the active button (AB) and dummy button (DB) was pressed when tested for access to time out of the stall (Exercise) and access to additional feed (Feed). Data from sows and gilts combined (n = 8).

Practical Alternatives for Managing Castration Pain in Piglets

E.L. Davis[1,2], Y.M. Seddon[1,2], S. Ethier[1] and J.A. Brown[1,3]

The Canadian Code of Practice requires that swine producers provide analgesics to piglets at castration to help control post-procedural pain. However, complete information on the different analgesics available to control post-procedural pain, their effectiveness and optimized procedures for delivering pain control have not been identified. This project set out to identify which analgesics provide effective pain relief to piglets, at what age castration should be performed to minimize stress and production losses, and to determine how the timing of drug administration affects piglets' pain responses following castration.

Results from two studies indicate lower cortisol concentrations are seen in sham castrates 45 minutes after treatment compared with pigs that were castrated with intermediate cortisol concentrations in piglets given an analgesic. This suggests that the analgesic, ketoprofen, has a positive influence on pain responses when given 30 minutes before castration.

INTRODUCTION

Castration is a common procedure performed on male piglets at an early age to prevent the development of boar taint. Previous research has determined that piglets experience significant pain and stress during the procedure, and the pain may last for up to five days thereafter (Marchant-Forde et al. 2014). To address this problem, the Canadian Code of Practice for the Care and Handling of Pigs now requires that castration be done with analgesics to help control post-procedural pain (NFACC 2014). However, the Code does not provide specifics regarding the appropriate analgesics or protocols for their administration. The Canadian Veterinary Medical Association (CVMA) and Canadian Pork Council have provided some guidance on the issue, however, several questions remain.

MATERIALS AND METHODS

Study 1. Comparing the effectiveness of three NSAIDs

Three NSAID analgesics were compared: meloxicam, ketoprofen, and paracetamol, with 167 male piglets from 33 litters being randomly assigned to one of five treatments:

1. castration with meloxicam (Metacam ® 0.4 mg/kg [0.3 ml/kg]) (CAM),
2. castration with ketoprofen (Anafen ® 3 mg/kg [0.3 ml/kg]) (CAA),
3. castration with acetaminophen (Pracetam ® 60 mg/kg [1.0 ml/kg]) (CAP),
4. castration control (CA), and
5. sham castration (SCA).

The analgesics were administered immediately before to castration; meloxicam and ketoprofen were given intramuscularly, while paracetamol was administered orally.

Behavioural observations and physiological measures of stress (serum cortisol) were done on separate litters to avoid the stress of blood collection influencing piglet behaviour. In total, 106 male piglets were studied for behaviour post castration, and blood samples were taken from 61 piglets.

Study 2. The effect of piglet age at castration on pain response and weight gain following castration.

117 male piglets were randomly assigned within each litter to six treatments with three castration treatments and two ages.

For piglets that received ketoprofen (Anafen ® 3 mg/kg [0.3 ml/kg]), the drug was provided intramuscularly 30 min prior to castration. Piglets were weighed and individually marked at 2-3 days of age, and trained to navigate a handling chute one day prior to treatment.

Castration treatments:

1. castration with ketoprofen (A),
2. castration control (C), and
3. sham castration control (S)

Ages:

1. 3 day old piglets (Y), and
2. 10 day old piglets (O)

Study 3. Determination of optimal timing of analgesic administration

Male piglets from 35 litters were randomly assigned to one of five treatments:

1. castration with ketoprofen, administered 1 hour before castration (HK),
2. castration with ketoprofen, administered immediately before castration (IK),
3. sham castration with saline administered 1 hour before (HS),
4. sham castration with saline administered immediately before (IS), and
5. castration control, saline administered immediately before castration (IC).

Piglets were handled twice for all treatments where the analgesic (or saline) is administered one hour prior to castration, and once where the analgesic (or saline) is administered at the time of castration. Thirty-five litters of pigs were used, with each treatment represented and randomly assigned within each litter (n=35 piglets/treatment).

Behavioral Observations

In all studies, behavioural observations were taken on piglets using a specially designed handling chute developed and validated as an objective behavioural measure of pain in castrated piglets. The duration of time piglets take to navigate the chute has been shown to take significantly longer in piglets castrated without pain control, compared to those handled but not castrated (Bilsborrow et al., 2016). Training involved four runs through the chute at intervals of 15 minutes, with the first run containing no hurdles, and the next three with increasing hurdle heights. This training was given to ensure piglets were familiar with how to transverse the chute prior to treatment application.

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On the day of treatment application, all piglets were first given a pre-treatment run at 30 min prior to the administration of treatment. Following treatment piglets were required to navigate the chute at 15, 40, 60 and 120 minutes post-treatment. Piglets were given a total of two minutes to navigate the chute unaided. If a piglet laid down in the chute it was assigned a navigation time of two minutes and was gently pushed through the chute towards the farrowing pen.

RESULTS AND DISCUSSION

Study 1. Comparing the effectiveness of three NSAIDs

In Study 1 there was a significant effect of treatment on navigation times. Comparing overall navigation times, castration control (CA) piglets had a significantly slower navigation time than castration with ketoprofen (CAA) piglets (Figure 1). CAA piglets also had a significantly faster navigation time than both castration with acetaminophen (CAP) and sham castration (SCA) piglets. There was a trend for CAA piglets to navigate the chute faster than CAM piglets. These results did not agree with our hypothesis or previous studies; sham castrates were expected to show shorted navigation times, which was not the case. This result led to questioning of the validity of the chute navigation test and a re-evaluation of chute navigation methods.

Initial results for cortisol levels showed that at 45 min post-castration, piglets castrated without analgesics had higher cortisol levels than those that were sham castrated, and piglets castrated with ketoprofen were intermediate (Castration control:194.6131.8 nmol/L; Sham handled: 81.642.8 nmol/L; Castration with ketoprofen: 142.1105.6 nmol/L, mean SD. P<0.05). No other significant differences were found among treatment groups.

Study 2: The effect of piglet age at castration on pain response and weight gain following castration

There was no significant effect of age at castration on pain responses, nor any interaction between treatment and run time (Figure 2). Preliminary results for cortisol concentrations show a significant interaction between treatment and sample (Figure 3). Piglets that were sham castrated showed no significant change in cortisol concentration across the four time-points, while those castrated showed a large increase in cortisol at 45 minutes post-treatment. Similarly, those given ketoprofen showed an intermediate rise in cortisol 45 minutes post-treatment. A significant interaction was found between treatment and age. Younger piglets had higher cortisol levels, and older pigs showed a benefit from receiving pain control while younger pigs did not (Figure 3).

CONCLUSION

Based on the cortisol levels obtained in the first two studies there appears to be a benefit of providing pain control, although significant benefits were only observed in older piglets in the second study. The results of physiological measures from these studies are preliminary, however show a promising positive influence of ketoprofen on stress levels of piglets, and confirm that castration is painful.

ACKNOWLEDGEMENTS

We would like to acknowledge the financial support for this project from the Saskatchewan Agriculture Development Fund and Sask Pork. 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.

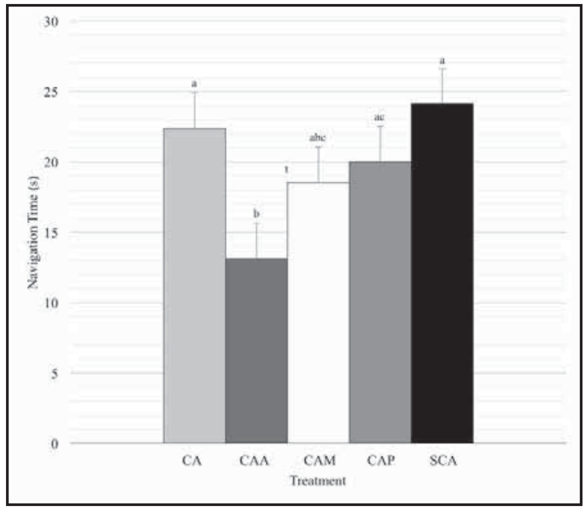

Figure 1. Overall navigation time after treatment (Four chute runs, mean and SEM in sec) for pigs given one of five treatments. Treatments: castration control (CA), castration with ketoprofen (CAA), castration with meloxicam (CAM), castration with paracetamol (CAP), and sham castration (SCA).

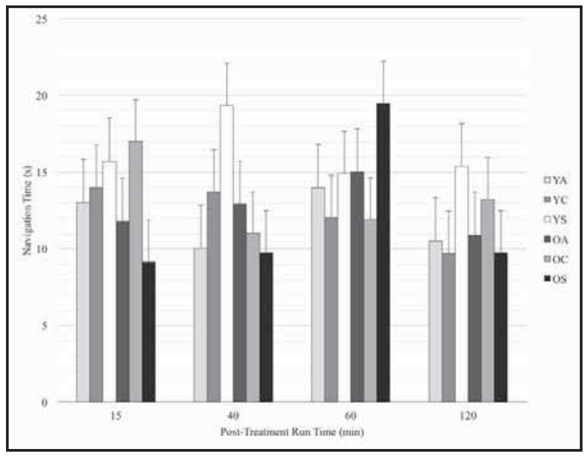

Figure 2. Mean chute navigation time (s, ±SEM) at four time points post-treatment. The six treatments included: castration at 3 days of age with ketoprofen (YA), castration at 3 days of age (YC), sham castration at 3 days of age (YS), castration at 10 days of age with ketoprofen (OA), castration at 10 days of age (OC), and sham castration at 10 days of age (OS).

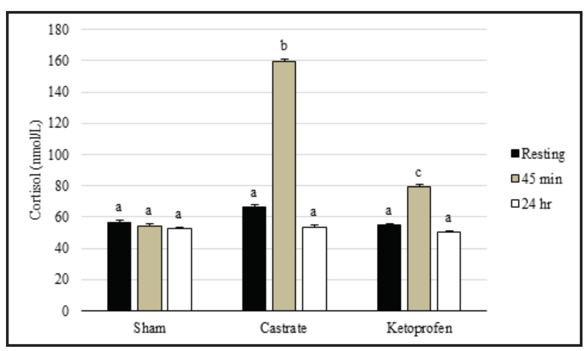

Figure 3. Study 2. Bar graph showing the interaction between analgesic treatment and sample time point for mean cortisol concentrations (nmol/L). Different superscripts indicate a significant difference (P < 0.05).

National Sow Housing Conversion Project

D. Richards[1], S. Turcotte[3], Y. Seddon[1,4], M. Fynn[5], L. Connor[6] , J. Brown[1,2]

The National Sow Housing Conversion Project (NSHCP) was conceived as a descriptive project to facilitate the successful conversion of Canada's sow barns to group housing. The project involved collaboration from industry participants and academic researchers working together on a comprehensive strategy involving demonstration farms, technology transfer materials and events to support Canadian pork producers making the transition.

Research indicates that when properly implemented and managed, group housing systems provide similar levels of production to stalls. Actual transition costs range from 250 to 750 CAD per sow place, depending on the type of design, use of existing infrastructure and producer input for labour. The majority of early adopters of group housing have implemented non-competitive feeding systems, such as electronic sow feeding, which have long term benefits in terms of ease of management and individual control of feed intake over competitive feeding systems such as floor feeding.

INTRODUCTION

In response to consumer concerns regarding the welfare of sows housed in stalls, large numbers of North American food retailers and supermarket chains have announced plans to develop 'stall-free' pork supply chains. The 2014 Canadian Code of Practice for the Care and Handling of Pigs also includes a number of requirements that limit the use of gestation stalls. Consequently, the pork industry is under pressure to implement group gestation housing for Canada's approximately 1.3 million sows. There are major concerns within the industry around the conversion process and implementation of group housing for sows. The process requires a large capital investment, and selecting the 'right' system requires knowledge that is not readily available. Within the Canadian industry there is limited knowledge and experience on the management of sows in group systems. This project set out to fill that gap by providing pork producers with scientific and practical information on barn conversion options and the management of sows in groups.

MATERIALS AND METHODS

Primary barn sites

Six barn sites were identified across Canada to document the conversion to group housing. The conversion process on these farms was documented through questionnaires, interviews, farm visits, photos, and videos taken before, during, and after the transition. As well, producers were asked to provide production data and economic data. Videos and the project website give visitors a 'virtual tour' of each facility. Producers at the primary site barns were aided by a barn evaluation by an experienced engineer and ongoing support from the NSHCP working group.

Secondary barn sites

In addition to the primary site barns, six other barns that had already implemented group housing were identified across Canada. Less intensive data was collected from these sites, including questionnaires, interviews, photos, videos, and barn visits. These additional sites are used to show producers a wider variety of feeding systems design choices, and to highlight the necessity of developing a plan that will work with their individual barn design, budget, and management style.

Communications

Communicating the results to other producers interested in converting to group housing was one of the main goals of the NSHCP. Research on group housing was compiled and summarized in multiple articles. Results have been presented through workshops and producer meetings, in an annual newsletter, and the development of the project website: www.groupsowhousing.com, which contains full documentation of the barn conversions, as well as general information on group housing options and contacts across the country for those seeking information and advice. A working group consisting of provincial pork organization representatives from across the country conducted yearly meetings throughout the project to exchange information about activities in each region and management of the project.

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RESULTS AND DISCUSSION

Design and husbandry

The project used descriptive methods to document barn renovations and producers who had already implemented group housing. A range of locations, feeding systems and farm sizes was sought so as to provide a range of examples to inform other producers considering the conversion (Table 1).

Improved knowledge by studying farm sites

Five problem areas identified while conducting this project were:

1. Producers implementing ESF systems lacked information on the importance of having a dedicated training area for training sows to use ESF feeders. This resulted in difficulties during the changeover period, as many sows did not learn the system quickly. Both producers and their animals experienced stress during the transition and only later did they install a dedicated area for training animals.
2. Electrical interference problems which caused sorting equipment to fail.
3. Staffing issues when implementing competitive feeding. All pigs should be observed at the time of feeding in these systems to identify sows that are lame or in poor health. Unlike with stall housing where sows can be checked throughout the day. This influences staff scheduling and daily feeding times.
4. Lack of suitable ear tags for sows. More information is needed on RFID ear tags to support producers using this technology. Some sows (housing systems and genotypes) are more prone to ear tag loss, so more information on this aspect of management would be helpful.
5. Enrichments for sows. The Code of Practice requires that all pigs be provided with 'multiple forms of enrichment'. This can be of particular benefit for sows as it can potentially reduce aggression and decrease stereotypic behaviour. Producers require more information on what enrichments are suitable for sows and how to provide them.

Sow production in groups

In this study, in general, producers reported no significant changes in production once group housing was established and initial management problems were addressed. One producer noted a reduction in stillborn piglets, but this was not verified. One participating farm provided detailed production data before and after conversion (Table 2), indicating comparable conception rates and litter sizes before and after the conversion.

Renovation costs

Assessing the existing barn structure is key in the decision making process. Depending on the soundness of the structure there may be additional investment required and this must be factored into cost estimates for construction and planning process. When pricing a significant renovation the cost will be approximately 50-75% of the cost of new. Most new structures, whether for farrowing, dry sows or finishing, cost around thirty two dollars a square foot structure (Ontario prices). Therefore, major renovations cost between fifteen and twenty four dollars a square foot. If estimated costs exceed these parameters, serious consideration should be given to building new. Most renovations include pit work, slats and interior walls. Exterior walls, ceiling, trusses and steel are generally not included or required.

While initial cost estimates varied greatly, ranging from under \$500/sow to over \$1,000/sow place, actual results indicate costs are generally below \$500 per sow. Detailed renovation costs for one participating farm can be seen in Table 3.. The total cost of the renovation was \$1,091,582.74 for a 3,000 sow herd (\$364/sow).

Feeding systems

Many early adopters have implemented non-competitive feeding systems including a variety of ESF and free-access ESF systems. Most non-competitive systems use radio frequency identification (RFID) ear tags to control and monitor individual feeding in sows. These systems are more expensive to install and require greater technical knowledge, but have long term benefits in terms of reducing aggression, managing feed distribution, limiting feed waste and automated data capture to facilitate sow monitoring and record keeping. The number of sows which can be accommodated and choice of feeding system is another key consideration, as some group feeding systems require more space per sow than conventional stalls. This is one reason for the popularity of large group ESF systems; they make very efficient use of floor space, resulting in similar sow numbers per square foot when converting from stalls to groups.

Competitive feeding systems, such as floor feeding or shoulder stalls, allow all animals to access feed at once. These systems are generally less expensive to install, but have higher long term costs. Management is more labour-intensive because the sows are in smaller groups and they require more frequent observation and intervention. Production levels are also generally lower and feed costs higher due to greater feed usage, with dominant sows consuming more feed than subordinates.

Sow management

Controlling aggression and managing feed intake and are two of the most challenging areas related to group gestation. However, there are many tips and techniques to address these problems. Some techniques include the use of pre-mixing pens, segregating low and high parity sows, feeding sows prior to mixing, providing enrichments at mixing, and pen designs including solid panels allowing sows to avoid bullying. Previous socialization during gilt development is also beneficial, such as providing multiple mixing events before gestation. Keeping sows in large groups also reduces social aggression as pigs adopt a more passive social response. Individual and genetic differences in aggressive behaviour have been observed, however more research is needed to identify selection criteria.

Table 1. Project Farm Sites (including 6 primary sites and 6 secondary sites)

Province	Designation*	Herd size (sow number)	Feeding system	Grouping
New Brunswick	Secondary	1200	Schauer, CanArm	Static, 16 pens of 60 sows
Quebec	Primary	600	Gestal	Static, two feeders per pen of 40 sows
Quebec	Secondary	850	Schauer	Static, two feeders per pen of 150 sows.
Ontario	Primary	220	Nedap	Dynamic, two feeders for 120 sows, one feeder for 50 gilts
Ontario	Primary	1800	CanArm	Dynamic
Ontario	Primary	100	Gestal, Organic	Static, two feeders per pen of 30 sows
Ontario	Secondary	1400	Trough	Static, pens of 18 sows
Ontario	Secondary	650	Weda	Dynamic, one pen with 5 feeders
Manitoba	Primary	3000	Gestal	Static, two feeders per pen of 40 sows
Saskatchewan	Secondary	600	Nedap	Dynamic, 5 feeders per pen, gilts and sows housed separately
Alberta	Secondary	275	Nedap	Dynamic, four feeders in one pen
Alberta	Primary	4100	Shoulder stall	Static, pens of 15-16 sows or 10 gilts

*Barn designation. Primary: The barn conversion was documented. Secondary: Barn was already converted. Barn layout and management of sows was documented.

Table 2. Herd production data before and after barn renovations for group housing.

Production variables	Stalls	Groups
Number of Serves	2008	1768
Return Serves (%)	6.9	7.0
Conception Rate (%)	91.8	93.0
Farrowing	1785	1476
Total Born/Litter	14.9	15.3
Live Born/Litter	13.6	14.0
Mummified/Litter	0.4	0.5
Born Dead/Litter	1.0	0.8
Total Weanings	1767	1355
Pigs Weaned/Litter	11.6	11.5
Total sows	2989	2586
Total gilts	330	456
Removal Rate (%/yr)	45.8	38.5
Suckling Days/Litter	21.2	24.0
Litter/Sow/Year	2.51	2.33
Pigs Weaned/Sow/Year	27.4	24.1

Note: Lower performance numbers after renovation were due mostly to smaller herd inventory, which was being rebuilt.

Table 3. Construction costs for HyLife Rosco barn renovations. The 3,000 sow farrow-to-wean facility was converted to group pens with Gestal G3 feeders.

Description	Cost
Labour	$ 289,353
Feed equipment	$ 447,130
Concrete	$ 51,127
Penning	$ 169,098
Misc	$ 134,872
TOTAL	**$ 1,091,582**

CONCLUSION

The NSHCP was designed to help Canada's swine production sector respond to the emerging issue of group sow housing. By compiling the best information available on group housing and working with early adopting producers, the extension work to spread the knowledge was done in an efficient manner.

At present, 20-25% of the Canadian sow herd is managed in groups, and this is expected to increase to over 90% by July 2024. Therefore, the information resources gathered will be even more valuable going forward to 2024. Proper planning is essential to identify the appropriate feeding system and pen layout for sows in groups. The appropriate system for each producer will vary depending on herd size, management style, technical expertise, existing structures and budget.

ACKNOWLEDGEMENTS

This project is funded by Swine Innovation Porc within the Swine Cluster 2: Driving Results through Innovation research program. Funding is provided by Agriculture and Agri-Food Canada through the AgriInnovation Program, provincial producer organizations and industry partners. 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. Most importantly, we wish to acknowledge the participation of pork producers who generously shared their time and knowledge and who made this project possible.

Mitigating Accelerated Deterioration of Pig Buildings

B. Predicala[1,2], J. Cabahug[1,2], A. Alvarado[1], R. Baah[1]

On average, Canadian swine buildings are 20 - 30 years old; over the next few years, these buildings need renovations or may be replaced with new construction. This project set out to identify potential solutions applicable to Canadian conditions to mitigate the rapid deterioration of swine buildings. A comprehensive literature search supplemented by an information survey of various stakeholder groups in the industry was carried out to compile and identify potential solutions on barn building deterioration. An information survey had a total of 46 respondents composed of producers (43%), builders (13%), materials and equipment suppliers (20%), and academic and research and development organizations (24%). Results of the literature review and survey have identified various potential solutions for farm building material degradation which were categorized based on building design, material selection and treatments, and building management and animal production practices.

INTRODUCTION

Many barns currently in use in the Canadian hog industry were built in the 1990's during the period of rapid upswing in the pig industry (Brisson, 2014); these were mainly based on the existing barn designs available at the time. Most of these barns have almost totally enclosed shell, and mechanical ventilation system composed of fans, inlets and exhaust outlets to maintain favourable conditions for the pigs year round.

During winter months, ventilation is typically turned down to a minimum level to minimize heating costs. This, however, leads to higher levels of moisture and corrosive gases, varying thermal conditions, and presence of dust and decay microorganisms. The minimum ventilation rate, combined with high prevalence of strong winds in some areas during the winter months, ultimately results in recirculation of the exhaust air back into the barn, leading to poor in-barn air quality. As a consequence, rapid deterioration of structural members (e.g. walls, eaves, ceiling, attic, plenum, etc.) is inevitable due to prolonged exposure to recirculated moisture and corrosive gases (Meyer et al., 1988). Thus, potential solutions or strategies are needed to address these issues and subsequently mitigate the accelerated degradation of swine barns.

MATERIALS AND METHODS

The overall objective of this project was to develop and evaluate measures/ strategies to mitigate accelerated deterioration of swine buildings. The main approach was to conduct a comprehensive literature review and information survey to identify potential solutions applicable to Canadian pig barns (including but not limited to alternative ventilation configurations, surface treatments, innovative building materials, etc.) to address accelerated barn deterioration.

RESULTS AND DISCUSSION

About 60% of the producers and builders had issues with rapid deterioration of barn structural components. Specifically, the structural components that they had issues with were: roofing (50% of the respondents); penning/ stalls (50%); exterior walls (40%); ceilings, trusses and/or attic, and feeding and drinking system (30%). No significant issues with accelerated deterioration have been identified in partition walls between two rooms, manure and drainage system, and barn foundations.

Table 1 summarizes the issues encountered by producers and builders related to barn deterioration and their recommendations for mitigation. The most common issue was corrosion/rusting of barn roof, penning/stalls, exterior walls, ceiling, trusses, and feeding and drinking system. Some respondents have pointed out issues related to moisture decay in trusses, and cracks in penning/stalls, and feeding and drinking system.

Mitigation Strategies

Among the solutions to improve the building life span such as surface treatments, new material, ventilation system, control and maintenance (guide information), the latest has been pointed out by the participants as the least expensive one and the easiest to adopt by producers. However, few consider maintenance improvement as the best option to improve building life span. If the cost would not be considered as a decision parameter, new building material and ventilation system improvement should be the priorities. For producers, when the cost of the technology is not considered, an adequate ventilation system, sufficient insulation and high durability wall materials are the most attractive solutions to improve building life span.

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Table 1. Summary of responses from producers, builders and their equipment suppliers on current status of pig barns in terms of barn degradation and their recommendations to mitigate them.

Structural components	Issues encountered (% reporting the issue)	Mitigation strategies
1. Roofing	• corrosion/rusting (100%)	• use of a thicker gauge of tin • better screws • application of paint on both sides of tin • modification of ventilation system so that barn air does not get in contact with the roof
2. Penning/stalls	• corrosion/rusting (86%) • cracks (29%)	• stronger support, use of heavier anchors (1/2" rather than 3/8") • use of solid rod; avoid welds in wet areas • use of stainless steel for first 6" of post or anything that has contact with manure or the floor • use of plastic (if not costly) instead of concrete or steel
3. Exterior walls	• corrosion/rusting (100%)	• plastic walls filled with concrete • thicker tin • concrete construction • better exhaust fans; proper ventilation
4. Ceiling	• corrosion/rusting (60%)	• use of screws, not nails • application of paint • use of plastic or fiberglass products
5. Trusses	• corrosion/rusting (80%) • moisture decay (60%)	• installation of ridge ventilation • use of galvanized or stainless steel, protective coatings and insulation • better ventilation to avoid back drafting
6. Feeding and drinking system	• corrosion/rusting (40%) • cracks (40%)	• thicker PVC for drinking system • use of steel feeders • use of plastics above pig level and steel at pig level • all intake hoppers and drive units should be stainless steel

CONCLUSION

Among all the potential solutions, techniques related to appropriate ventilation, environmental control and air treatments, improvement of corrosion protection efficiency of building materials, and effective building maintenance have been identified as the most promising solutions to rapid deterioration and have high adaptability to Canadian swine production conditions. Although these strategies still need to be evaluated in an actual barn prior to their full implementation for adoption in Canadian swine barns, outcomes from this current project represent significant step toward optimizing future barn renovations and constructions as well as for possibly changing the conventional swine production practices and farm building management.

ACKNOWLEDGEMENTS

We would like to acknowledge the financial support for this research project by Swine Innovation Porc. The authors would also like to acknowledge the collaboration of CDPQ and IRDA in carrying out this work. Strategic program funding provided by Saskatchewan Pork Development Board, Alberta Pork, Ontario Pork, the Manitoba Pork Council and the Saskatchewan Agriculture Development Fund is also acknowledged.

Table 2. Summary list of potential solutions to rapid barn deterioration and their applicability to Canadian swine farms based on literature review and survey.

Category/Potential Solution	Description	Applicability
A. Building Design		
1. Wood (Durable design)	• use of timber with bigger dimensions, well-seasoned and with good detailing	Applicable
2. Metal (Durable design)	• rigid or batt insulation (e.g. 4-6 mil polyethylene) plus vapour barrier especially on truss assembly • appropriate design gap between insulation and wall or ceiling for moisture drying in the event of penetration • good vapour barrier on areas in close proximity to fasteners	Applicable
3. Ventilation (in general)	• use of stacks or discharge tubes to release exhaust air away from the animal building • extension of insulation and vapour barrier from inside the building to underside of vented overhangs • chimneys installed intermittently between trusses for ridge ventilation • separate ventilation for barn interior and the attic	Applicable; extent of current application in Canadian swine/livestock buildings not confirmed

Table 2 continued on next page...

B. Building Material Selection and Treatments		
1. Wood	• use of naturally durable wood	
Chemical preservation	• oil-based preservatives (Creosote oil) • fixed water soluble preservatives • organic solvent preservatives	• Applicable
Impregnation of wood with polymers	• improve the physical and mechanical properties of low grade wood species • use of copolymer derived from allyl alcohol and methyl methacrylate (optimum compatibility and compressive strength perpendicular to fiber increased by approximately 100 times while water absorption was reduced by 50%; biodegradation did not occur)	• Applicable; Further investigation of effectiveness against deterioration needed
Bio-control	• wood treated with urea and ureolytic bacteria (*Proteus sp. and Bacillus sp.*) • combination of *Proteus sp.* and *Trichoderma viride* to inhibit growth and kill fungi	• Further investigation of effectiveness needed
Titanium dioxide nanoparticles	• used to prevent fungal *Hypocrea lixii* (white-rot) and *Mucor circinelloides* (brown-rot)) growth in wood • applied on surfaces by spraying or simple brushing	• Further investigation of applicability/ feasibility for use in livestock buildings needed
2. Metal		
Stainless steel	• known resistance to dry corrosion (oxidation) and attack of acidic condensates	• Applicable
G90 hot-dip galvanized (G90 HDG)	• treated with zinc phosphate • recommended by U.S Steel for metal connectors in animal housing, G90 zinc coating are typically used in Canada (G60 for US)	• Applicable
Duplex System	• e.g. G90 Duplex = G90 connector + paint and G185 Duplex = G185 connector + paint • G90 duplex or G185 connectors with vapour barrier and separate ventilation for attic space is recommended in animal buildings	• Applicable
Avoidance of galvanic corrosion	• e.g. using stainless steel nails for stainless steel hangers and galvanized nails for galvanized hangers	• Applicable
Use of other materials such as ceramic materials and polymers		• Applicable
Galvanizing	• zinc layer application on steel and iron structures	• Applicable
Coatings	• epoxy coating that is lead and chromate-free recommended for metal truss plates	• Applicable
Repair of corrosion-attacked metals	• cleaning as a de-rusting method remains the advised method over use of rust converters	• Applicable
3. Concrete		
Concrete mix composition	• use of sulphate-resistant binder-like type 50 Portland cement (equivalent to CEM IIIB concrete based on CSA A3000, 1998) as most effective among 8 concrete treatments • use of other supplementary cementing materials such as slag, fly ash and silica fume to minimize tricalcium aluminate (C3A) content of concrete mix • use of additives for concrete top layers (e.g. product “S” based on ground tuff) to increase life of concrete compared to regular sand-cement mix for top layer of animal housing flooring • also applies for protection of steel reinforcements	• Applicable; feasibility and cost analysis needed for application in livestock buildings

C. Building Management/Production Practices		
Interior cleanliness and maintenance	• proper cleaning and disinfection; high pressure washing and use of cleaners to effectively remove aggressive residues and manure on surfaces • periodic inspection for leaks through vapour barriers and corrosion on connectors and fasteners • removal of corrosive agents from the attic and additional protective coatings must be provided to connectors	• Applicable
Feeding method	• wet feeding method can make the degradation problem on barn floors worse • greater feeder-drinker distance to minimize lactic and acetic acid attack on concrete by the feed-water mix	• Applicable
Others	• putting concrete or brick bin underneath nipple drinkers • protection of concrete floor itself by fibre cement-board, metal plate, rubber sheet, or a top layer “product S”	• Applicable

Evaluating Novel Technologies

Engineering

B. Predicala[1,2], A. Alvarado[1], R. Baah[1]

Two novel technologies consisting of an individual water consumption system (IWCS) and infrared thermography system (ITHS) were installed in a finishing room. The individual water consumption system (installed in each pen) was composed of a nipple drinker attached to a water flow meter, and an RFID reader (and antenna) to capture individual pig data. The infrared thermography system was composed of two types of infrared cameras, one to capture images of individual pigs drinking, a second to capture an image of all the pigs in the pen. To assess whether the novel technologies were capable of detecting pigs that may be stressed due to routine practices, two stressors were introduced during the trial: (1) moving pigs to the barn hallway and handling them through a pre-defined route for 10 minutes, and (2) mixing unfamiliar groups of pigs.

Data from the IWCS system showed that grower pigs tend to consume more water when stressed, and water consumption increased as the pig grew regardless of stress induction. As captured by the infrared thermography system, aggression as a result of mixing unfamiliar pigs to the pen caused an increase in the recorded body temperature of pigs. The system also showed that the pigs' body temperature was affected by changes in room temperatures. Additionally, installing the two novel technologies and inducing stress due to moving and mixing had no considerable negative impact on the pigs' production performance.

INTRODUCTION

As part of a larger Swine Innovation Porc project (#1237) entitled 'Use of novel technologies to optimize pig performance, welfare and carcass value', various technologies were developed and pilot-tested in different universities and research centers throughout Canada (under CCSI coordination). After pilot studies were completed by the original developers of the technologies, the next step was to conduct commercial trials where selected developed technologies were applied in a production environment and evaluated under typical commercial practices. Commercial trials were a critical step after the research and development phase, providing the opportunity to make adjustments to the technologies, facilitating their adoption in commercial barns.

MATERIALS AND METHODS

Two novel technologies (IWCS and ITHS) were installed in a grow-finish room with six pens containing 14 pigs per pen (Figure 1). The IWCS was comprised of a nipple drinker attached to a water flow meter, and RFID reader and antenna together with electronic ear tag transponders. ITHS was composed of two types of infrared cameras: C3 camera (FLIR C3 Compact Thermal Imaging Camera) and A325 IRT camera (FLIR A325sc Infrared Camera). The A325 IRT cameras were used to capture the image of all the pigs in the pen while the C3 cameras were installed on top of the drinker to capture the image of an individual pig while drinking. Pigs were transferred into the room at 20-25 kg and remained in the room for 10 weeks until reaching 105-110 kg.

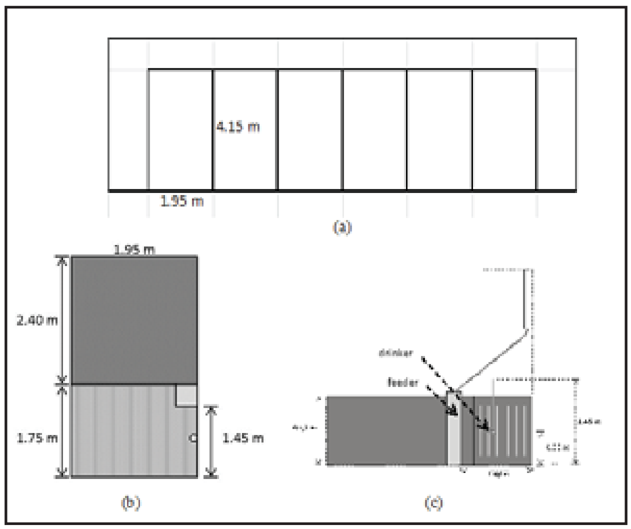

Figure 1. Floor layout (a) of the grow-finish room used in the study. Details of the pen showing the location of the feeder and drinker – top view (b) and side view (c).

RESULTS AND DISCUSSION

Water Consumption, Handling

Figure 2 shows the comparison of average water consumption before and after the moving activity. Regardless of stress induction, water consumption increased as the trial progressed. At the start of the trial, grower pigs had an average water consumption of about 4,014 mL/day; this increased to 5,876 mL/day towards the end of the trial when pigs were nearing market weight.

At the start and middle of the trial, pigs tend to consume more water after the moving activity. On average, pigs consumed about 3,890 and 5,226 mL 24 hours before stress was induced at the start of the trial and middle of the trial respectively, increasing to 4,138 and 5,878 mL after the stress was induced. These results may imply that grower pigs consumed more water when stressed. No apparent trend was observed for water consumption towards the end of the trial.

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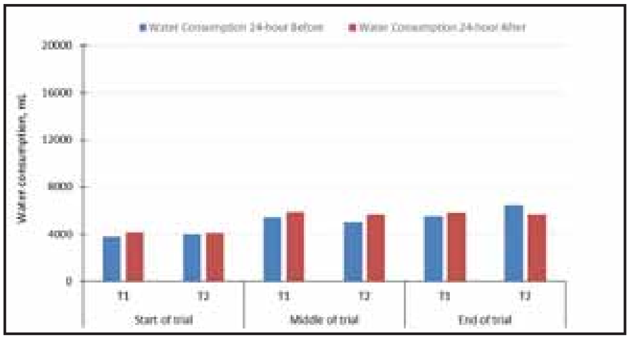

Figure 2. Average water consumption of pigs 24 hours before and 24 hours after the moving activity during the start (n=12), middle (n=12) and end (n=10) of the trial.

Water Consumption, Mixing

A comparison of average water consumption of pigs 24 hours before and 24 hours after unfamiliar pigs were introduced into the pen is shown in Figure 3. In contrast to the moving activity, water consumption generally decreased 24 hours after mixing unfamiliar pigs into the pen. Pigs consumed an average of about 5,387 mL/day of water prior to the mixing activity; this decreased to 4,738 mL/day 24 hours after mixing occurred. The decrease in water consumption might be due to aggression that occurred after mixing, which subsequently prevented some of the pigs from drinking. This observation may have also caused the no apparent increase in water consumption from the start to the end of each trial.

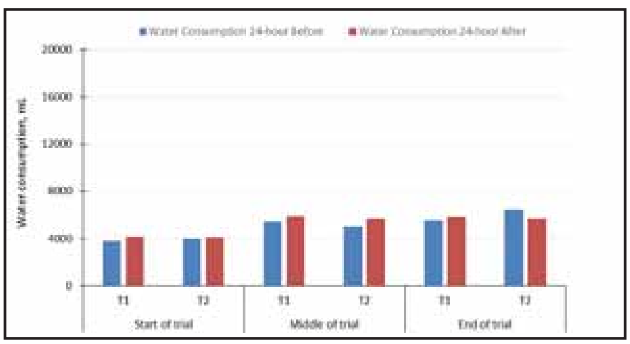

Figure 3. Average water consumption of pigs 24 hours before and 24 hours after unfamiliar pigs were introduced into the pen during the start (n=16), middle (n=16) and end (n=12) of the trial.

Infrared Thermography - Handling

During the start and middle of the trial, no considerable change in body temperatures was observed. Towards the end of the trial when pigs were close to market weight, a slight increase in body temperature was observed after the moving activity. Pig average body temperature was 36.5°C before the moving exercise; this increased to 36.8°C after the mixing activity. This minimal change in body temperature could indicate that the moving activity was not strenuous enough to cause a marked change in body temperature of pigs.

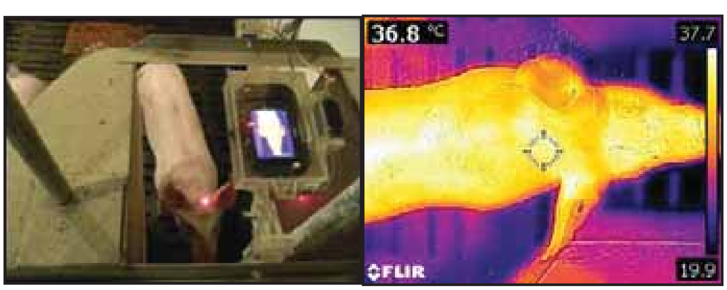

Figure 4. Photo of the C3 camera taking a snapshot of a pig while drinking (A). An IR image of the pig taken by the C3 camera (B).

Infrared Thermography - Mixing

Increase in body temperature after the mixing activity was observed at the middle and end of the trial. At the middle of the trial, the average body temperature was about 37.4°C; this increased to about 37.9°C after the introduction of new pigs into the pen. Similarly, the average body temperature increased from 35.6°C to 35.9°C after the mixing activity at the end of the trial. The increase in body temperature could be due to the level of aggression which seemed to have more impact on body temperature changes than on water consumption.

Table 1. Average daily gain and backfat depth of pigs during the trials.

Parameter	Trial 1	Trial 2	Average ± SD
Average daily gain, kg/day	1.20	1.13	1.17 ± 0.05
Average backfat depth, mm/day	0.09	0.11	0.10 ± 0.01

Pig Performance

Pigs had an average ADG of 1.17 ± 0.05 kg/day and an average backfat depth of 0.10 ± 0.01 mm/day. These values were comparable to the ADG and backfat depth of pigs in typical production barns. No considerable difference was observed in ADG and backfat depth of pigs between the two completed trials (Table 1).

CONCLUSION

1. Using the individual water consumption system, it was observed that grower pigs tend to consume more water when stressed. The system also confirmed that water consumption increased as the pig grew regardless of stress induction.
2. As captured by the infrared thermography system, aggression as a result of mixing unfamiliar pigs to the pen caused an increase in the recorded body temperature of pigs. The system also showed that the pigs' body temperature was affected by changes in room temperatures.
3. In this study, installation of the individual water consumption system and infrared thermography system and inducing stress due to moving and mixing had no considerable negative impact on pig production performance.

ACKNOWLEDGEMENTS

We would like to acknowledge the financial support for this research project provided by Swine Innovation Porc. The authors would also like to acknowledge the collaboration of researchers from CCSI, CDPQ, and Lacombe Research Centre in carrying out this study. Strategic program funding provided by Saskatchewan Pork Development Board, Alberta Pork, Ontario Pork, the Manitoba Pork Council and the Saskatchewan Agriculture Development Fund is also acknowledged. 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.

Can Nanoparticles be Used to Control PEDv?

Engineering

B. Predicala[1,3], D. Korber[2], P. Medihala[2] and A. Alvarado[1]

This project set out to evaluate the efficacy of novel metal nanoparticles (with previously demonstrated antimicrobial properties), either alone or in combination with alternative disinfecting strategies for inactivation of PED. Conducting the work under Biosafety Level 3 containment, experiments that simulated hog production environments showed that copper nanoparticles (Cu-NP) and lime treatments were effective in deactivating the PED virus. These treatments, after being fully validated in subsequent field trials, can form the basis for alternative strategies for controlling PEDv and can be used in conjunction with existing chemical disinfectants to expand biosecurity protection to gaps where current available techniques may not be effective or impractical to apply.

INTRODUCTION

Porcine epidemic diarrhea (PED) is a serious and highly contagious swine disease that is characterized by severe watery diarrhea followed by dehydration, leading to almost 100% mortality in nursing pigs. The primary strategies employed to prevent the spread of PEDv are sanitation regimes incorporating the heavy use of chemical disinfectants. While found to be adequate in critical situations and certain applications, some drawbacks of chemical disinfectants include high cost, adverse impact on certain metal structures, reduced efficacy in the presence of organic matter, and incompatibility for use in certain risk situations (e.g., large areas such as assembly yards, high-moisture or wet surfaces, non-wettable areas such as truck cabs, and heavily-soiled areas).

This project focused on finding alternative agents with proven antiviral properties that can be used against PEDv in situations where the primary chemical disinfectants being used at present cannot be applied, or have limited or unknown efficacy. The goal was to evaluate the efficacy of novel metal nanoparticles with previously demonstrated antimicrobial properties, either alone or in combination with alternative disinfecting agents for inactivation of PEDv.

MATERIALS AND METHODS

Phase I – Evaluation of various antimicrobial agents for inactivation of PED virus (in a clean environment without any organic debris)

In order to test the virucidal effect of nanoparticles (NPs) against porcine epidemic diarrhea virus (PEDv), an "infectivity assay" was conducted to determine whether the NPs treatment affected the ability of PEDv to infect a normally-susceptible host (Vero 76 cells)

Testing lethality of NPs against purified PEDv

Four 250 mL bottles, each containing 20 mL of sterile water, were inoculated with 1 mL of purified PEDv, and 1 mL of ZnO NP solution was added to each of three bottles at three different final concentrations, including: 0.27 mg/mL, 2.5 mg/mL and 5 mg/mL. The fourth bottle served as a no-NP control (just PEDv). The fourth bottle served as a no-NP control (just PEDv). Samples were taken from each treatment, including the control at 0 hr (immediately), 3 hours, 24 hours and 48 hours of NP exposure.

Phase II – Evaluation of various antimicrobial agents for inactivation of PED virus (with organic debris representative of the hog production environment)

In this part of the research, Cu-NP and Lime were evaluated for their respective effects against PEDv under simulated conditions that represent the hog production environment. Studies have shown that nanosized copper exert antiviral activity by generating hydroxyl radicals under aqueous conditions (Fujimori et al., 2011) and also by direct contact effects on dry surfaces (Warnes and Keevil, 2013). Lime has a long history of use as a high-pH disinfectant or antimicrobial agent. More recent studies have shown that lime (slaked) can also serve as an effective antiviral agent (Thammakarn et al., 2015). Accordingly, PEDv particles were mixed with sterile swine feces and then individually combined with either Cu-NP and lime under aqueous conditions.

A total of five replicates were used in this study for each treatment and for each of the three time periods (0, 3 and 6 hrs). A fresh PEDv sample was also incubated along with other treatment samples and quantified at all time periods. This control was implemented in order to monitor the natural decay of the PEDv. All tubes received a 1.3 mL aliquot of feces-PEDv suspension, 2.6 mL of each of the treatment (Lime and Cu-NP) and were then incubated for 0 (10 sec), 3 and 6 hr. After incubation, the tubes were centrifuged and the supernatant separated from the pellet. Both the pellet and the supernatant were subjected to RNA extraction and quantification. Also, the supernatant was further processed for Vero cell infection and culturing to examine the infectivity of the PEDv particles. The cell cultures were observed for 5 days for cytopathic effect and later harvested for RNA extraction. Lastly, samples from all Vero cell infection assays were transferred to fresh Vero cells and incubated to confirm the presence or absence of viable PEDv.

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RESULTS AND DISCUSSION

Infectivity assay

In this assay, the number of infectious PEDv particles in the "slurry" (host cell fragments) and the supernatant of previously-infected Vero 76 cells were determined. The results from both the slurry and supernatant infectivity assays showed similar trends. The highest number of infectious PEDv particles was detected in the control groups at 0 time. The number of PEDv able to infect after being treated with ZnO NPs progressively declined with increasing concentration of ZnO NPs, probably due to physical interference between the ZnO NPs, PEDv and Vero 76 cells. This trend could lead to the conclusion that ZnO NPs have a potency to inactivate PEDv, but not to physically destroy the viral particle.

These experiments suggest that ZnO-NPs interacted with the PEDv particles and generally tended to trap or capture them in the pelleted material. The completed tests clearly suggested the effect of ZnO-NPs in capturing the viruses, but also showed that the PEDv that remained in the supernatant were virulent and hence caused infection.

Experiments with Cu-NP and Lime under simulated field conditions

Table 1 summarizes the variation in levels of infection for the different treatments. For the first two days (48 hr), the cell cultures had no signs of infection. The PEDv in the control samples clearly showed heavy infection after day 5 but the lime and Cu-NP remained uninfected, indicating that the PEDv in these wells have been inactivated by the treatment. Also it can be seen that at T=0 hr (Table 1), the Cu-NP showed lower signs of infection as compared to the control and lime, indicating early onset of cidal effect imposed by the Cu-NP on the PEDv particles.

Table 1. Qualitative assessment of viral infection (e.g., syncytia formation) during cell culture infection.

Treatments	Samples at different incubation time		
	0 hrs	3 hrs	6 hrs
Control	+++	+++	+++
Lime	+++	0	0
Cu-NP	+	0	0

–Note: "+" sign indicates level of infection, "0" – no visible infection; "+" is 1-3 loci of infection; "++" is > 10 loci of infection; "+++" – Too many infection loci to count.

In addition, the cell culture plates when observed for the cytopathic effect, showed characteristic variations in infection between treatments and also at different incubation times (Figures 1 and 2).

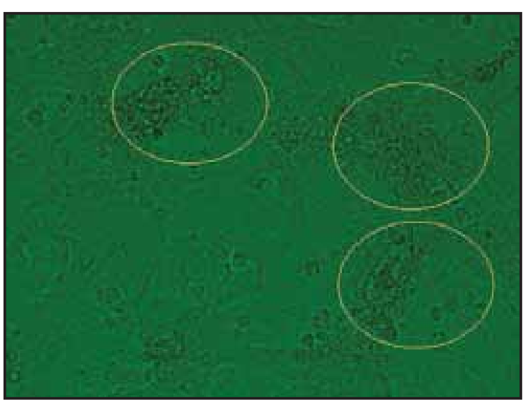

Figure 1. Image showing the sites of infection with PEDv in the Vero 76 cell culture in the 6-well plate. The circled regions show the cytopathic effect (CPE) caused by the PEDv in the control sample.

Figure 2 Image showing no infection (cytopathic effect) in the Vero 76 cell culture in the 6-well plate incubated with Cu-NP. A clear monolayer of cells is visible.

CONCLUSION

- A diagnostic methodology utilizing real time PCR techniques and modified primers was developed for reliable detection of PED virus. In addition, an infectivity assay using Vero cell cultures was also developed to accurately assess the degree of deactivation of PED virus.
- Direct evidence that both Cu nanoparticles and lime treatment exerted a significant anti-PEDv effect was measured. Although this was not shown definitively by the qPCR results, the Vero culture wells containing PEDv exposed to both Cu-NP and lime (for 3 and 6 hours) failed to show any sign of infection, thus confirming the PEDv-inactivation effect of Cu-NP and lime treatments.
- From the 0-time anti-PEDv effect observed for Cu-NPs, it seems that rapid, strong interactions occurred between PEDv and Cu-NPs, leading to an almost instant measurable decline in the number of viable virus.
- Given the results obtained from Cu-NP and lime treatment in the final set of experiments, these two agents appear to have potential to be used individually or in combination, as part of existing anti-PEDv strategies. In such an approach, these "bulk agents" can be applied on large surface areas which may or may not be contaminated with organic materials (e.g., service or assembly yards, loading docks, parking lots) that pose potential risks for PEDv contamination but to which current anti-viral disinfectants cannot or would be impractical to apply.

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We would like to acknowledge the financial support for this project provided by the Agriculture Council of Saskatchewan Inc. through the Advancing Canadian Agriculture and Agri-Food Saskatchewan (ACAAFS) program. 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.

High-Fibre Diets & Immune Stimulation Increase Threonine Requirements

D.A. Columbus[1,2], M.O. Wellington[2], A.G. Van Kessel[2], J.K. Htoo[3]

With the increased use of high-fibre co-products, such as DDGS, and other feedstuffs resulting in an increase in total dietary fibre content in swine rations, studies into the interaction between high-fibre diets and immune challenge are required. This project aims to address the need to more fully understand the interaction between dietary feedstuffs and immune status on nutrient requirements and utilization for body protein deposition and immune status. Information generated from this project will aid in the development of effective techniques and protocols that reduce the negative effects of disease/stress on pig performance as well as nutrition alternatives to antibiotics.

INTRODUCTION

Sub-clinical disease results in reduced growth and less efficient use of nutrients. With the elimination of in-feed antibiotics for growth promotion it is increasingly important to understand the interaction between nutrition and health and nutrient requirements during disease challenge events. Feeding high-fibre feedstuffs reduces the efficiency of utilization of dietary threonine for growth in pigs due to an increase in endogenous threonine loss as a result of increased mucin production. The mucus layer serves to protect the intestinal mucosal surface against threats, such as enteric pathogens, with mucin production shown to also increase with immune challenge. In addition to mucin production, threonine is an important precursor for the synthesis of many acute phase proteins involved in the immune response. While an increased threonine requirement has been shown with increased fibre (mucin production) and with immune challenge (immunoglobulin production), the interaction of these factors on threonine requirements is unknown. A nitrogen-balance study was performed in growing pigs fed high or low fibre diets and with or without immune system stimulation (ISS) to determine the optimum dietary threonine content for optimal growth and optimal immune status. An enteric pathogen challenge study will then be performed in which pigs are fed high or low fibre diets with or without increased threonine content to determine the impact of dietary threonine on pig robustness.

MATERIALS AND METHODS

A total of 90 growing barrows were used in a nitrogen (N) balance study. Pigs were individually housed in metabolism crates and adapted to the environment and experimental diets for eight days before starting the experimental protocol. The dietary treatments were arranged in a 5×2 factorial randomized complete block with 10 pigs/ block at an initial body weight (BW) of 20.47 ± 0.75 kg. The main two main factors were 1) threonine level (0.49,0.57,0.65,0.73 and 0.81% SID) and 2) fibre level (high fibre, HF; or low fibre, LF) (n=9). Pigs were fed at 2.2 times maintennce ME requirements in meals meals/day. Fecal samples and urine collection was completed daily.

Feed refusals and wastages were collected for each pig daily and weighed to determine actual daily feed intake. Water was provided ad libitum through nipple drinkers. Nitrogen balance was conducted during a pre-ISS and ISS period of 4-days each. At the start of ISS period, pigs were injected intramuscularly (I.M.) with Escherichia coli lipopolysaccharide (LPS; O55: B5) at least one hour before the morning meal to stimulate the immune system. LPS injection was repeated 48 hours after first injection to maintain ISS. The initial dosage was 30µg/kg BW, which was increased by 15% on second injection to counteract the possibility of tolerance.

RESULTS AND DISCUSSIONS

Analyzed nutrient content of experimental diets is presented in Table 1. In general the analyzed total dietary fibre (TDF) content was higher (18.5%) in the HF diets than LF (12.5%) diets. The total indispensable analyzed and calculated amino acid content of the experimental diets were similar.

During pre-ISS, PD increased linearly ($P<0.01$) as Thr concentration in the diet increased with a significant interaction ($P<0.05$) between fiber and Thr. During ISS, PD increased linearly ($P<0.05$) as Thr concentration in the diet increased. Curvilinear plateau model estimated SID Thr required to optimize PD of pigs fed LF and HF diets during pre-ISS period was 0.68% ($R2=0.88$) and 0.78% ($R2=0.99$), respectively. During ISS, SID Thr was estimated at 0.76% ($R2=0.76$) for LF diet and 0.72% ($R2=0.95$) for HF fed pigs. High fiber and ISS independently increased Thr requirement for optimal PD but these effects were not additive.

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CONCLUSIONS

Overall, both dietary fiber and immune stimulation increased the requirement for threonine for protein deposition in growing pigs, however, the interaction of the two factors did not result in a further increase. Increasing our understanding of the interaction of dietary factors and stressors on nutrient requirements will be critical for developing feeding programs that enhance both animal production and animal health while reducing the use of antibiotics.

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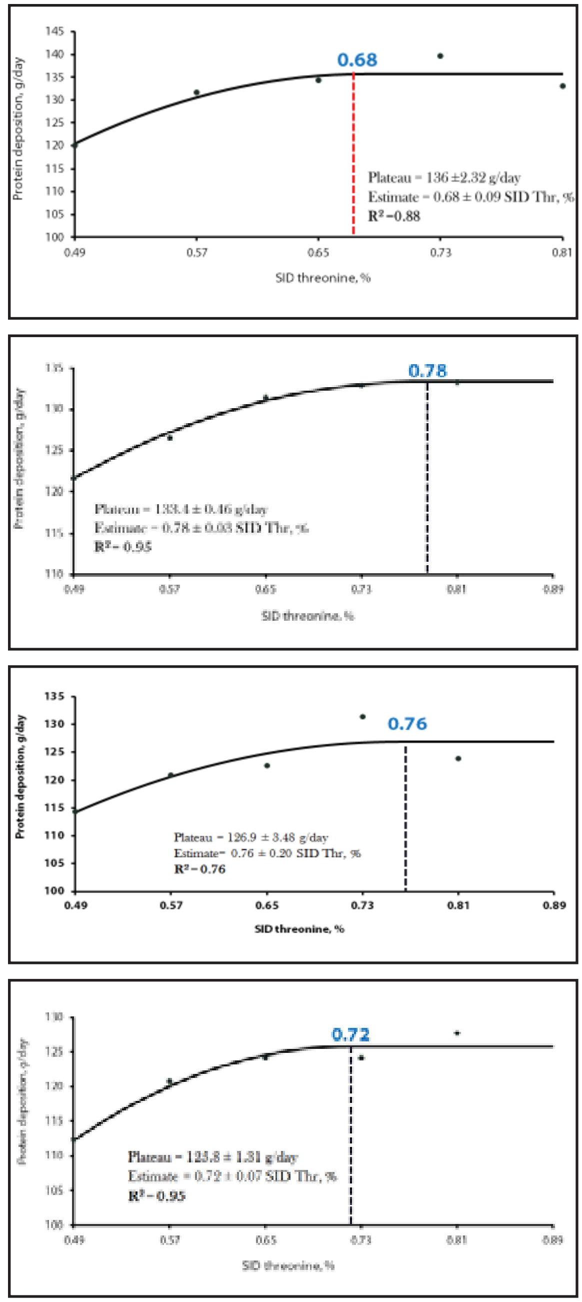

Figure 1. Estimayed threonine requirement (% SID) in pigs fed low-fibre diets (A) or high-fibre diets (B) without ISS or low-fibre diets (C) or high-fibre diets (D) with ISS.

Table 1. Composition of experimental diets with extreme SID threonine levels (as fed basis) 1, 2

	Standardized ileal digestible threonine level, %			
	Low Fiber		High Fiber	
Ingredients, %	0.49	0.81	0.49	0.81
Corn	22.00	21.70	4.30	4.00
Barley	7.00	7.00	7.00	7.00
Wheat	48.00	48.00	48.00	48.00
Soybean meal	18.20	18.20	18.50	18.50
Wheat bran	-	-	5.00	5.00
Sugar beet pulp	-	-	10.00	10.00
Canola oil	1.20	1.20	3.80	3.80
L-Lys HCl	0.58	0.58	0.56	0.56
DL-Met	0.20	0.20	0.20	0.20
L-Trp	0.04	0.04	0.03	0.03
L-Val	0.09	0.09	0.09	0.09
L-Leu	-	-	0.07	0.07
L-Thr	0.00	0.33	0.00	0.33
Limestone	1.25	1.25	1.05	1.05
Monocalcium Phosphate	0.75	0.75	0.71	0.71
Salt	0.20	0.20	0.20	0.20
Vitamin-mineral premix3	0.10	0.10	0.10	0.10
Celite	0.40	0.40	0.40	0.40
Calculated nutrient content				
ME, MJ/kg	13.9	13.9	14.0	14.0
CP, %	17.3	17.5	17.7	17.9
SID Thr, %	0.49	0.81	0.49	0.81

1 The experimental diets with the intermediate SID% Thr 0.57, 0.65 and 0.73 were prepared by blending the 0.49 and 0.81 diets in appropriate proportions.
2 SID Standardized ileal digestible.

Nutrition

Ensiled High Moisture Barley and Wheat in Nursery Pig Diets

A.K. Agyekum[1,2], K. Hutt[1,2], A.D. Beaulieu[2] and A.G. van Kessel[2]

The primary objective of this research was to investigate the nutritional value of high moisture (HM) barley and wheat ensiled with lactic acid bacteria (LAB) with or without the addition of feed enzymes for nursery pigs. Overall, the results showed that HM barley and wheat can be successfully ensiled with LAB and feed enzymes, and the resulting product was successfully incorporated into dry feed. Piglets fed diets containing ensiled HM grains had improved growth. This effect was more evident with ensiled wheat than barley.

INTRODUCTION

Harvesting grains at higher moisture increases options during harvest and is especially important when weather conditions are challenging. However, post-harvest drying or conditioning of high moisture (HM) grains before storage can be costly. An alternative method is to ferment the grains with bacteria and store them under anaerobic conditions.

The weaning period contributes to losses in profit for swine producers, as it is common for pigs to go off feed. This may lead to depressed growth, increased occurrences of enteric diseases and higher mortality. Previously, in-feed antibiotics (antibiotic growth-promotants, AGP) were used to ameliorate the post-weaning growth lag and enteric diseases. However, their use has been associated with the development of antibiotic resistance in human pathogens and environmental pollution. Thus, the use of AGP has been banned in several jurisdictions and, restrictions have been placed on AGP use in Canada and the United States.

Diets containing fermented feed ingredients could be a suitable substitute for AGP, as these feeds could provide health benefits and promote growth by improving digestibility, palatability and providing anti-microbial organic acids.

Feed or ingredients can be ensiled with lactic acid bacteria (LAB), which ultimately results in enrichment of feeds with organic acids and short chain fatty acids. Numerous studies have been reported on the ensiling of HM maize with LAB and its feeding value. However, there is limited information on the nutritional value of feeding LAB ensiled HM wheat and barley, to weanling pigs. Therefore, the overall objective of this research project was to investigate the nutritional value of ensiled HM barley and wheat for weaned piglets.

Table 1. Treatment structure for the research

Treatment	Grain	Inoculant1	Enzyme2
1	Barley	Control	No
2	Barley	Control	Yes
3	Barley	Homofermentative	No
4	Barley	Homofermentative	Yes
5	Barley	Heterofermentative	No
6	Barley	Heterofermentative	Yes
7	Wheat	Control	No
8	Wheat	Control	Yes
9	Wheat	Homofermentative	No
10	Wheat	Homofermentative	Yes
11	Wheat	Heterofermentative	No
12	Wheat	Heterofermentative	Yes

1Inoculant: control = no bacterial inoculant; HO = homofermentative lactic acid bacteria (L. plantarium; Biosil); HE = heterofermentative lactic acid bacteria (L. buchneri; Lalsil).
2 Enzyme: Yes = multi-carbohydrases and phytase inclusion (SuperzymeTM plus); No = no enzyme included.

MATERIALS AND METHODS

Ensiling protocol

The initial approach was to establish a small scale ensiling methodology using homo-fermentative (HO; ferment carbohydrates to exclusively lactic acid) or hetero-fermentative (HE; ferment carbohydrates to numerous by-products including lactic acid and ethanol) LAB inoculation. Wheat and barley were ground to pass through a 3-mm sieve and subsequently mixed with de-mineralized water for 10 min in order to achieve 27% moisture content (HM grains) before adding the LAB inoculants and enzymes. The fermentation treatment followed a $2 \times 3 \times 2$ factorial design with grain type (barley and wheat), bacteria inoculant (no addition, HO and HE) and enzyme additives (no enzyme and SuperzymeTM Plus) as main effects (Table 1). The HO inoculant was L. plantarum DSMZ 8862 and DSMZ 8866 (Bio-Sil®; Technology and Product Development GmBH, Wuthenow, Germany) and was added at 6 x 105 CFU/g of fresh grains. The HE inoculant was

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L. buchneri NCIMB 40788 (Lalsil®Fresh; Lallemand Inc., Montreal, Canada), added at 6 x 105 CFU/g fresh grain. The multi-enzyme formulation (SuperzymeTM plus, Canadian Bio-systems, Calgary, Canada) containing both carbohydrases and phytase was added at the rate of 0.5g/kg dry grain. Each treatment was prepared in 1.5 L glass jars with 4 replicates and 4 sampling time points (day 6,15, 55 and 97) for analysis of fermentation parameters (short-chain fatty acids, ethanol, and ammonia), nutrient content and microbial count.

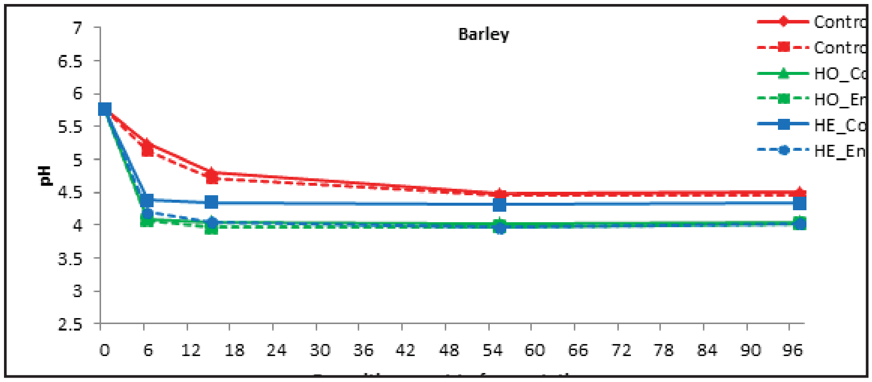

Figure 1a. pH of HM barley samples ensiled with lactic acid bacteria and without or with enzymes up to day 97 of fermentation. Inoculant: Control = no bacterial inoculant; HO = homo-fermentative lactic acid bacteria (L. plantarium; Biosil); HE = hetero-fermentative lactic acid bacteria (L. buchneri; Lalsil). Enzyme: Yes = multi-carbohydrases and phytase inclusion (Superzyme); No = no enzyme included

Growth Performance Trial

For the growth performance trial, reconstituted grains were ensiled by adding the bacterial inoculants and enzymes. The resulting mixture was tightly packed into barrels, sealed and stored for 90 days at room temperature. After 9 months of storage, the fermented grains were used to produce experimental nursery diets for the trial. This trial used the same 12 treatments described above, fed to 96 pens of 5 pigs/pen (weaned at 21 days of age, n=480) for 28 days. Pigs were allocated to pens based on body weight, regardless of sex. Each pen housed 5 pigs from day 0 to day 4. On day 4 of the trial, the average pig from each non-enzyme treatment pen (50% of treatments) was removed and euthanized to collect intestinal tissue and digesta samples to investigate parameters associated with gut health. Pigs were also removed from the other treatment pens so that from day 4 to day 28, all pigs were housed in groups of 4. Pigs and feeders were weighed weekly until day 28 to calculate average daily feed intake (ADFI), average daily gain (ADG) and gain to feed ratios (G: F) for each pen.

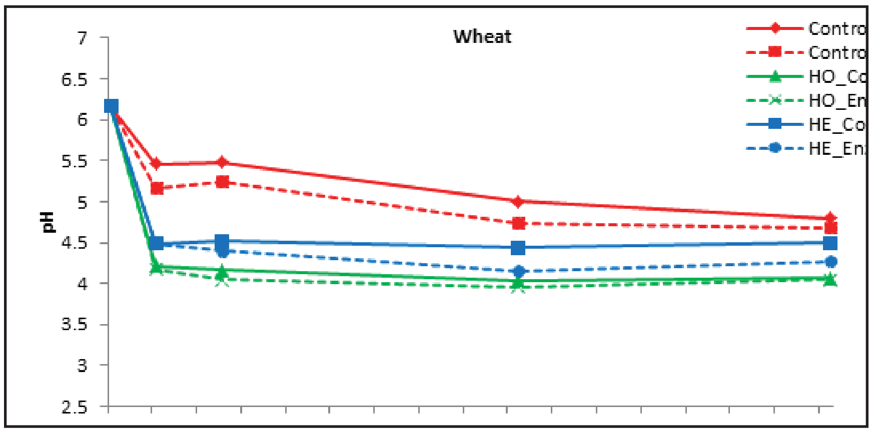

Figure 1b. pH of HM wheat samples ensiled with lactic acid bacteria and without or with enzymes up to day 97 of fermentation. Inoculant: Control = no bacterial inoculant; HO = homo-fermentative lactic acid bacteria (L. plantarium; Biosil); HE = hetero-fermentative lactic acid bacteria (L. buchneri; Lalsil). Enzyme: Yes = multi-carbohydrases and phytase inclusion (Superzyme); No = no enzyme included.

RESULTS AND DISCUSSION

The pH of the ensiled grains was measured to indicate microbial activity and preservation success during the ensiling. There was a 3-way interaction ($P < 0.05$) for grain, inoculant and enzymes on pH for the various sampling times (data not shown).The addition of LAB inoculants to the HM grains led to a pH decline below 4.5 after six days of storage (Figure 1 a and b); however, no further significant decreases were observed for the subsequent days of storage. The effect of inoculant on pH was more evident with wheat than barley ($P < 0.05$), resulting in a 2-way interaction for grain type and inoculant. Further, enzyme addition to the ensiled grains resulted in a decreased ($P < 0.05$) in pH compared to the when enzymes were not added to the mixture.

Piglets fed HM wheat had greater overall ADG and ADFI but reduced G:F than those fed HM barley (Table 2). Bacterial inoculation, regardless of type, increased final BW and overall ADG (0.22 vs 0.25 kg/d) and ADFI (0.32 vs 0.37 kg/d; $P<0.01$) but had no effect on G:F ($P=0.10$). The effect of inoculant was more evident in wheat than barley-based diets, resulting in a 2-way interaction for grain type by inoculant for final BW, day 0 to 28 ADG and ADFI. However, the addition of enzymes during the ensiling had no effect on piglet performance. Treatments had no effect on villi height, villi width or the villi: crypt ratio in the jejunum of pigs (data not shown).

CONCLUSION

The present research shows that HM grains can be successfully ensiled with LAB and enzymes and that this process had a significant effect on the concentrations of nutrients and fermentation characteristics. Further, ensiling the HM grains with LAB inoculant improved nursery pig growth performance, and the effects were more evident with wheat. However, the addition of enzymes during the ensiling process had no effect on growth performance. Finally, we have shown that ensiled HM grains can be successfully incorporated into standard dry feeding system. Therefore, producers interested in the yield and flexibility of harvesting HM grains for swine feeding may benefit from this approach. Likewise, an enterprise could produce a specialty fermented grain product and market to feed companies or swine producers.

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Table 1. Growth performance of wenaling pigs (21 2 days) fed diets containing lactic acid bacteria and ensiled wheat or barley with or without enzymes[a]

	Grain		Enzyme[1]			Inoculant[2]				P values (if no value P > 0.10)[3]	
Item	Barley	Wheat	No	Yes	SEM[4]	Control	HO	HE	SEM[5]	G	I
BW, kg											
d 0	5.98	5.97	5.98	5.96	0.190	5.97	5.97	5.97	0.190		
d 7	6.01	6.13	6.08	6.06	0.200	6.02	6.13	6.06	0.200	0.009	
d 14	7.17	7.23	7.09	7.22	0.250	7.08	7.23	7.30	0.250		0.038
d 21[6,7]	9.16	9.32	9.18	9.30	0.340	8.97	9.32	9.44	0.350		0.003
d 28[6]	12.50	12.70	12.60	12.70	0.430	12.20	12.70	12.90	0.440		0.002
ADG, kg/d											
d 0-7	0.01	0.02	0.02	0.01	0.004	0.01	0.02	0.01	0.005	0.006	0.080
d 0-28[6]	0.23	0.24	0.24	0.24	0.010	0.22	0.24	0.25	0.010		0.002
ADFI, kg/d											
d 0-78	0.08	0.09	0.08	0.07	0.010	0.07	0.08	0.09	0.010	0.025	0.054
d 0-28[6]	0.34	0.36	0.35	0.35	0.020	0.32	0.35	0.37	0.020	0.003	<.0001
G: F											
d 0-7	0.03	0.23	0.16	0.09	0.060	0.00	0.15	0.22	0.070	0.014	0.072
d 0-28[9,10]	0.70	0.67	0.69	0.68	0.010	0.69	0.69	0.67	0.010	0.007	0.096

[a] The statistical model examined the main effect of grain type (G), inoculant type (I) and enzyme type (E) and their interactions. Significance, P < 0.05; trend P < 0.10

[1] Enzyme: Yes = multi carbohydrases and phytase inclusion (Superzyme); No = no enzyme included.

[2] Inoculant: Control = no bacterial inoculant; HO = homo-fermentative lactic acid bacteria (L. plantarium; Biosil); HE = hetero-fermentative lactic acid bacteria (L. buchneri; Lalsil).

[3] Enzyme (P > 0.10)

[4] SEM, standard error of treatment means for the main effect of grain type and enzymes

[5] SEM, standard error of treatment means for the main effect of inoculant.

[6] Grain × Inoculant (P < 0.05)

[7] Grain × Enzyme (P < 0.05)

[8] Grain × Enzyme (P < 0.10)

[9] Grain × Inoculant × Enzyme (P < 0.10)

[10] Inoculant × Enzyme (P < 0.10)

[11] Grain × Inoculant (P < 0.10)

[12] Inoculant × Enzyme (P < 0.05)

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