PRAIRIE SWINE CENTRE

MISSION STATEMENT

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

Table of Contents

2014-2015 Report Highlights

Chairman's Report

What does the future hold?

RICK PREJET - Chairman of the Board

The old saying goes "Time flies when you are having fun". Well the last 8 years on the PSCI board of directors has flown by in the blink of an eye. There have been some great moments but there were difficult times when hard decision needed to be made. Seeing that this is my last year on the board I would like to again thank all board members, researchers and staff for sharing this great experience with me.

"What does the future hold?" Depending on what a person is looking for this is a difficult question to answer. In the case of the pork industry and the PSCI a few things come to mind. After a major reset in the industry the last few years I am confident we have settled into an extended period of stability and profitability. With strong global pork demand combined with several other factors such as an increasing middle class, downside in the industry will be limited. As for the PSCI, many things are in place to ensure success for years to come. Industry leading research and research staff, excellent production in the barn, a strong strategic plan, a collaborative national approach and an added emphasis on animal care and wellbeing through the National Chair on Swine Welfare will all play a role in the success of the Centre and in turn the success of the Canadian pork industry.

Although I am confident and optimistic, I have been around long enough to know that nothing can be taken for granted. We must continue to work on areas of weakness and capitalize on our strengths. One of the Centre's strengths has been the ability to stay ahead of the game and understand what is and will be important to the industry. This vision is key and the support of stakeholders, particularly pork producers, will be crucial in accomplishing this vision and the dominant factor in achieving continued success for years to come.

Within the annual report you will find an abundance of research conclusions, many of which you can take to the barn and start using immediately to enhance your operation's profitability. I encourage you to read through the document and see what the payback on your investment has been in the last year. I know you will not be disappointed.

In closing I would like to congratulate Lee and his team on another successful year. The passion they have for the Centre is evident and I wish the Center continued success in the future.

All the best, Rick

President's Report

What is Long Term Sustainable Growth?

LEE WHITTINGTON, B.Sc. (Agr.) - MBA - CEO/President

When we meet at a seminar and discuss recent research results and the economics of changing management practices, you are seeing the end product of research. Within this report there are 13 new projects to report on that adds to our knowledge in key production-limiting areas such as improving sow longevity, transportation sanitation, improved piglet growth plus others. This President's Report I want to dedicate to the researchers and technicians who pursue new ideas, many from pork producers, which seek to address our five Research Objectives (see full list of Research Objectives on page 9).

Research Objectives

1. To increase net income for pork producers by $1/pig/year
2. To improve animal wellbeing
3. To improve barn environment
4. To reduce the operating costs by $0.50/pig/year
5. To address the needs of society by leveraging our knowledge of the pig.

These Objectives are focused on benefits that will accrue to pork producers, and the pork value chain. Good ideas are plentiful; we receive insights at conferences, trade shows, our spring meetings, during tours of commercial barns, and numerous phone calls and e-mails. From the idea, there are several steps that need to be taken before it becomes a research trial. A discussion among PSC personnel and industry contacts to test is this a common need and worthwhile question, does it address one of our five objectives? If yes, then a brief literature search by a research associate can determine if anyone else is working in this area? Have solutions been identified or further challenges uncovered? This all occurs prior to deciding "yes this is worth investigating" and a proposal is prepared for one or more granting agencies. At this point the process is very time-consuming (6 months to a year) and very competitive as each agency will review many applications and only the best will be funded.

Once successfully funded, the project must be scheduled with staff (or hire new staff), students and barn access time (take a tour of PSC barns http://www.prairieswine.com/virtual-tours/. Or perhaps this project needs a partner commercial barn of the correct size or age, disease status, genetics etc. to test this particular research project on. Data collection is detailed and can include feed intake, blood sampling, manure sampling, pig weight, timing of a pig to complete a task, video monitoring interactions or the walking gait of the animal just to name a few. There is a multitude of data that then must be analyzed and interpreted. At least two articles and a research report will come out of every research project plus the various financial and results reporting required by the funding agency. A typical research project cycle will require 2 to 5 years to complete. This long cycle is why we regularly come to industry to update the research priorities. Research takes time and is expensive and we want to ensure that the efforts are being made in the right places, and well-enough in advance to provide knowledge on critical questions.

Once the analysis is complete we apply the economics, to answer the question of defining what the benefit is to the individual farm. Lastly and just as importantly we tell the story over and over again with powerpoint presentations, videos, websites, eNEWS (via email) and articles in many magazines to encourage adoption. The advantage of research to the industry can only be realized when pork producers, transporters and packer/processors embrace the new knowledge or technology and make it their own.

At Prairie Swine we are proud of our research teams, their work is making a difference everyday on commercial pork farms across Canada. We are thankful for our supporters in industry, our collaborators around the world and our many private and public funding agencies.

As always I welcome your input on our programs and invite you to contact me directly at 306-667-7447, or lee.whittington@usask.ca.

.

> *"Over the past decade it is estimated that Prairie Swine research contributes an extra $4.00 per pig improved net income each and every year from new knowledge created through research."*

Operation's Report

Achieving Record Production in a Research Environment

BRIAN ANDRIES, BSA. - Manager, Operations

This fiscal year saw a decline in pigs weaned per sow per year by about 2 pigs over the previous two years. The decision to raise the number of sows bred per week from 14 to 15 after budget was approved, went a long way to hit budgeted revenues and total numbers sold for this fiscal year. Breeding for the "mixing at weaning" trial was completed last fall and as indicated below, current conception rates have increased from 87% to close to 97% over the last 5-6 months. We should see a significant improvement in our farrowing rate starting now through the next 6 months as well. For 2012-14, gilts and first parity animals performed as follows:

Table 1. 2012-14 Sow Herd Performance

	2012-13		2013-14	
Category	Gilts	1st Parity	Gilts	1st Parity
Farrowing Rate %:	86.3	96.6	86.3	91.7
Average born alive/litter:	13.5	13.5	13.4	13.3
Number weaned/sow:	12.2	12.5	11.8	11.5
Pigs Weaned/sow/Year:	28.5	30.5	30.5	32.9

Improvement in production can also be attributed to a change in production staff that occurred around the end of September 2014. Currently both of my weekend staff are pre-veterinary medicine students which is working out very well. These two positions are very important to the Centre as 95% of our breeding takes place over the weekend.

"A total of 17 new experiments were started in 2014 involving a total of 4,971 animals on trial."

Table 2. Production Parameters

	2011-12	2012-13	2013-14	2015*
Sows farrowed, #	780	714	701	253
Conception Rate, %	93.4	90.5	87.4	96.8
Farrowing Rate, %	93.0	92.8	86.8	89.7
Avg. Born Alive/Litter	13.0	13.9	13.6	13.8
Farrowing Index	2.48	2.46	2.47	2.47
Number Weaned/Sow	11.9	12.6	12.6	12.2
Pre-wean Mortality, %:	10.7	13.2	11.0	13.6
Pigs weaned /Sow/Year	26.8	28.4	28.5	26.4
Sow Non-Prod. Days/Sow/Yr	24.3	28.0	34.8	20.3

*last 16 weeks, ending June 30, 2015

This fiscal year we will sell 7,500 animals; about 1,000 animals less than the last two fiscal years. In March and April of 2014 we shipped 575 nursery pigs to make space in grow-finish and these would have been sold as market's this year. The drop from a 92.8% to 86.8% farrowing rate accounts for the loss of about 40 sows not farrowing and 500 animal's lost in inventory. Manipulation of gestating sows for research and changing normal production procedures, can contribute significantly to losses in pigs sold per sow per year.

Markets to Maple Leaf averaged 98 kg dressed weight over the last year with an average fat (16.14), loin (64.19) and index of 109.6. H@ms Marketing Services presented us with two awards this year; one from 2013 – Independent Demerit Free-% 3rd place, and in 2014 – Top Producer Manitoba 1st place Demerit Free 96.57%. We were also presented with a Top Producer award from Pig Improvement Canada, weaning 29.1 pigs/sow/year for fiscal year 2014.

We started 17 new experiments in 2014 and put a total of 4,971 animals on trial. This total includes only animals that have been put on trial by PSC research scientists. A total of 844 animals were used by other research groups from the University of Saskatchewan. This compares to 9,717 animals used in 2013 and 5,488 used for research in 2012. Over the last year the U of S Canadian Council of Animal Care has been working with research facility managers and associated researchers to develop a protocol for animal ordering and approval. Orders for research animals is now to be placed through the Animal Order Desk and their staff are responsible for checking that approval has been granted for these animals and the appropriate number of animals are used for specific protocol numbers. Currently even PSC scientists have to place their order for research animals through the Animal Order Desk and then the request is passed on to me. This now puts the onus on the order desk to ensure in fact that experimental protocols are in place to order animals and that excess animals are not being used for trials unless modifications to the protocol are approved.

In addressing facility upgrades, the following has been completed since July 01, 2014:

1. Metal sheeting on the fan side of the roof on the grow-finish barn has been replaced along with the wood and screen ventilation inlets and eaves. The fan side of the east wing walls have also been completed. The main office metal roofing that was damaged from the wind storm in July was replaced as well as asphalt shingles on the Barn 3 roof and generator building. Metal roofing was also replaced on the roof of the link that joins the breeding barn with grow-finish. The end of this link was also sheeted which was unfinished since construction of the breeding barn.
2. The slurry transfer building has been constructed. This links to the grow-finish facility via barn 3 link. This building's exterior with metal sheeting is complete, the interior is sheeted and painted and all gas and electrical in this room is done.
3. Eaves troughs have been installed in a number of locations, mainly the storage/lab portion of the office, clean room and biosecurity room of the barn. This is a great improvement on biosecurity as this now prevents water from running into the buildings.
4. Both the men's and women's showers have been completed renovated, including new lockers in the men's and a new paint job in all 3 showers and the front foyer.
5. All bin bottoms will be repaired by the end of summer 2015

Technology Transfer Report

Ever Changing Communications for a Ever Changing Industry

KEN ENGELE, BSA. - Manager, Information Services

2016 will represent 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.

As the pork industry has changed so to has the Technology Transfer program adapted to the needs and economic pressures of the hog industry. Today approximately 40% of Canada's hog production is classified as vertically integrated, colonies still represent 30% of production with the balance of production being held in various sized operations. How we communicate with the industry is, and needs to be, different than the way we communicated with the industry in the past.

A 2014 Ipsos-Reid survey of agricultural producers provides some valuable insight on the type and how producers collect information for their operation. The two most common sources of information were print (72%) and websites (50%), while social media ranked very low comparatively (2%). Do these numbers speak to an aging producer demographic? Or are tools like Twitter and Facebook seen more a personal network rather somewhere people look for credible information?

The survey also indicates the type of information producers are looking for is information on new technologies and products. On the surface this makes sense as we are in the commodity production business. By being one of the first adopters of a new technology we inherently maintain or increase our competitive advantage against our nearest competitor.

Where and how do producers gather information? A vast majority of producers (58%) get their information from aggregate news sites like Farms.com, ThePigSite, SwineWeb, MeatFYI or PorkInsight. According to the stats they access this information from desktops (70%), laptops (49%), and mobile devices (43%).

As we continue to assess how to best communicate with the pork industry we need to ensure there is a specific communication plan for each one of our target markets. The ultimate goal of Technology Transfer, is Technology Adoption. Ensuring the industry is implementing those recommedations that have been produced by the research programs at Prairie Swine Centre that improve profitability & competitiveness or address sustainability (welfare & environmental). The real trick becomes how do we measure implementation of recommendations, technologies, and products.

We are always assessing the most effective way in driving research results out to the industry. We always welcome feedback from the industry at any time. Over the course of the next 18 months you will see several new initiatives rolled out to engage the industry on a different level.

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 - defined as all stakeholders in the pork value chain from cereal development to consumer acceptance of pork. Using an industry-oriented and multidisciplinary approach that ensures timely adoption of knowledge.

Objective #3

To leverage our strengths and capabilities as a 'knowledge-based' company.

Objective #4

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

Objective #5

To define 'Best in Class' and benchmark against critical efficiency, innovation and accountability metrics (in operations, human resource, financial, and scientific output).

Objective #6

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 #7

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. This objective applies equally to initiatives within Prairie Swine Centre as well as relationships with external institutions/agencies.

Research Objectives

Objective #1

To increase net income for pork producers through improved nutrition. This includes the development of feeding programs which emphasize economic efficiency, meat quality, and market value. Also understanding feed and fibre sources and the modifications of these to meet the needs of the pig, changing economics and opportunities to favourably impact meat quality.

Objective #2

Improve animal wellbeing by developing and modifying housing systems, animal management practices, and 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 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.

OUR COMMITMENT

To meet or exceed the research data and scientific analysis expected by our clients, and demanded by regulatory guidelines.

Weaning Sows Directly into Group Housing: Aggression, Welfare & Production

Y.M. Seddon, M.M. Bouvier, S.A. Ethier, Y.Z. Li[1] and J.A. Brown


Yolande Seddon


Jennifer Brown

SUMMARY

Social stress from mixing sows has the potential to negatively affect sow production and welfare. Housing sows in stalls from weaning until five weeks after breeding is a common strategy used to prevent aggression and ensure control over individual feeding during breeding, conception and implantation. However, alternative management options are needed as pressure to reduce stall use is likely to continue. This study compared the effects of three mixing strategies on sow performance in group sow housing. Treatments included: Early mixing (EM) - sows mixed directly at weaning; Pre-socialisation (PS) - sows mixed for two days at weaning, then stall housed for breeding and until five weeks gestation, then remixed; and Late mixing (LM) - sows stall-housed at weaning and mixed into groups at five weeks gestation. The results show no differences in the aggressive behaviour among treatments. Analysis of production showed a lower conception rate in LM groups than in EM and PS groups P<0.05. There were no differences in total born, piglets born alive or mummies among treatments, but a there were significantly fewer stillborn piglets in the EM treatment. Fewer stillborn piglets may have resulted from improved fitness and/or activity levels during early gestation. Overall, sows performed similarly in all treatments indicating that, under good management conditions, mixing sows at weaning does not impact sow performance or welfare.

"Early mixing sows performed equally to sow in other mixing treatments."

INTRODUCTION

Canadian producers are under increasing pressure to manage gestating sows in groups rather than stalls. The 2014 Canadian Code of Practice for the Care and Handling of Pigs requires that as of July 1st 2014, all newly built or renovated barns must house sows and gilts in groups. When managing groups, it is common to house sows in stalls during breeding and for a period of up to 5 weeks after breeding, however, pressure continues to reduce stall use. The effect of mixing sows at weaning is an area that has not been investigated extensively and there may be benefits to this practice that are generally overlooked. Mixing sows at weaning will give animals time to establish their social group before they cycle, avoiding any effects of mixing stress on sow conception rate. It was been suggested that mixing sows at weaning may disrupt the onset of estrus in sows. However, there is research to suggest that if mixing sows is acute it can stimulate quicker return to estrus in sows. Through allowing sows to display estrus behavior, there is also the potential to have a greater synchronization of estrus within a breeding group.

This project was designed to compare the effects of mixing sows at weaning, to minimize five weeks of gestation.

The main objectives were to:

1. Determine the effect of mixing sows at weaning vs. mixing at five weeks on reproductive performance, aggression and stress.
2. Evaluate whether pre-mixing sows for two days at weaning followed by breeding in stalls can reduce aggression or improve performance of sows that are grouped after implantation.

MATERIAL AND METHODS

A total of 252 gestating sows were studied over six replicates. Sows were group-housed in walk- in/ lock-in stalls, at 14 sows per pen, providing 2.29m^2 per sow in the group area. Each pen consisted of 16 gated free access stalls measuring 0.61m x 2.13m. with a fully slatted communal loafing area behind the stalls. Sows were fed 2.4 kg of a commercial sow ration in feeding stalls once per day. Heat detection, artificial insemination and pregnancy diagnosis took place in the free access stalls. Sows and piglets were weaned at approximately 28 days post-partum.

[1] West Central Research and Outreach Center- University of Minnesota, 46352 State Hwy 329, Morris, NM, 56267

Table 1. Means of aggressive interactions observed on days 1 and 2 after mixing in three mixing treatment (per group of 14 sows). Treatments: Early Mixing (EM); Pre-Socialization, first mixing (PS1); Pre-Socialization, second mixing (PS2); Late Mixing (LM).

	Treatment				
Behavior (totals), n = 18	EM	PS1	LM	SEM	P
Total aggressive interactions (sum of d1 and d2)	208.50	213.30	212.00	29.20	0.993
Threats per hour (day 1)	12.95	14.47	14.38	1.93	0.825
Head to head per hour (day 1)	1.87	1.77	2.13	0.65	0.918
Head to back per hour (day 1)	0.40	0.28	0.32	0.20	0.913
Percentage (%) of time spent in aggression (day 1)	3.20	2.54	3.55	0.75	0.637
Percentage (%) of time spent in aggression (days 1 and 2)	2.09	1.89	2.34	0.56	0.853
Behavior (totals)	EM	PS2	LM	SEM	P
Total aggressive interactions (sum of d1 and d2)	208.50	190.83	212.00	35.95	0.906
Threats per hour (day 1)	12.95	14.47	14.38	2.40	0.882
Head to head per hour (day 1)	1.87	1.00	2.13	0.60	0.405
Head to back per hour (day 1)	0.40	0.13	0.32	0.18	0.583
Percentage (%) of time spent in aggression (day 1)	3.20	2.21	3.55	0.79	0.477
Percentage (%) of time spent in aggression (days 1 and 2)	2.09	1.76	2.33	0.60	0.814

Table 2. Production characteristics of sows in three mixing treatments: Early Mixing (EM); Pre-Socialization (PS); and Late Mixing (LM), (total of 14 sows per pen, 6 replicates/treatment, total of 84 sows per treatment)

	Treatments			
Variable	EM	PS	LM	P
Conception rate (%)	98	94	87	<0.05
Wean to Service Interval (days)*	4.06	4.51	4.31	NS
Total born	15.16	15.63	15.47	NS
Born Alive	13.66	13.27	13.18	NS
Still born	0.95*a*	1.54*b*	1.58*b*	<0.005
Mummies	0.47	0.44	0.53	NS

NS = not significant. * Gilts excluded from analysis for wean to service interval.

Experimental treatments: The three treatments (Early Mixing [EM]; sows mixed directly into groups at weaning, Pre-socialisation [PS]; sows stall housed at weaning and mixed into groups at five weeks gestation; and Late Mixing [LM]; sows mixe for two days after weaning, then stall housed for breeding and up to five weks gestation, after which sow are remixed into the same groups) were studied over six replicates, with 14 sows per pen (84 sows per treatment). The EM and LM treatments evaluated two common management techniques, with LM acting as the control treatment to examine the interaction between mixing at critical time periods in combination with housing sows in stalls during the implantation period; it further determines if there would be any benefits, such as reduced aggression in the second mixing. The PS treatment was included as an intermediate treatment. Each group included a range of parities with parity balanced across treatments. When the treatment was required that sows be kept in stalls, the sows were locked into free access stalls. When the treatment required sows be loose in a group, sows were fed each morning in free access stalls, after which they were locked out of the stalls up to 22 hours/day.

Data collection: Sow productivity including litter characteristics, time to first service, conception rate (sows pregnant after first service), and farrowing rate were recorded. Individual body weight, back fat depth and body condition were recorded at weaning, at five weeks after breeding and again at sixteen weeks after breeding.

The behaviour of sows at the designated mixing times was recorded using video cameras suspended over the pen, and recording for two days after mixing. The number and duration of aggressive encounters was recorded. Sows in the EM treatment were observed for estrus behaviours including mounting attempts and flank nosing. Salivary cortisol was collected from four focal sows per group to assess the degree of stress induced by mixing.

Injuries resulting from aggression at mixing were assessed before and after mixing, and in weeks 5 and 16 of gestation. Sows were also scored for lameness at the same time points using the Zinpro Feet First® gait scoring system.

RESULTS AND DISCUSSION

Data collection was completed in early 2015 and an initial analysis of the sow production performance has been completed. Preliminary data on aggression at mixing from the first three replicates revealed no differences in the total time spent fighting, duration of fights, or frequency of threats.

There were no differences in aggressive interactions among any of the treatments when comparing the aggression observed in the first mixing for all treatments for the EM and LM mixing to the second PS mixing. It should also be noted levels of aggression observed in all three treatments were low. Over the two day period of observations a total of 32 minutes of aggressive behaviour were observed for 16 sows over a 17-hour observation period. This equate to eight seonds of aggression/sow/hour. The vast majority of aggressive encounters were threats (considered aggression) with relatively few physical fights (Table 2).

These behaviour results suggest that no one treatment was better at reducing aggression after mixing, and levels of aggression were generally very low. The longest total fight time for any group was 20 minutes, and this total was accumulated by 14 sows over two days of observation. There was a tendency for the frequency of head to head fights to be lower in the second PS mixing (PS2). However, with the PS group receiving two mixings and showing aggression at each, this could be considered a sub-optimal management strategy for sow welfare, as sows experienced mixing aggression twice in one gestation period.

Comparing the production results of sows, there were significant differences in conception rates across the three treatments. LM sows had the lowest conception rate at 87%, EM sows had the highest conception rate (98%), and PS sows were intermediate (Table 2). It is not clear why the LM treatment resulted in the lowest conception rate; this is the standard practice for the PSCI herd, and typically achieves a conception rate over 90%. For the current study the lower conception rate of LM sows may reflect sub-optimal stimulation of estrus expression during stall housing. In comparison, the EM and PS groups both received mixing stress immediately after weaning, which may have stimulated follicular growth and enhanced estrus expression.

The EM treatment had significantly fewer stillborns than the PS or LM group. Fewer stillborn piglets in EM sows may have resulted from improved fitness and/or activity levels during early gestation. The similar numbers of stillborn in the PS and LM treatments, and lower number in the EM group, suggests that there is an influence from not being held in the stalls during the implantation period. Whether movement of the sows during the initial weeks of gestation can reduce the number of stillborn piglets should be investigated further. There were no differences among treatments in the wean to service interval, or other litter traits including total piglets born, born alive or mummified.

CONCLUSION

Results from this study indicate that all of the mixing treatments studied had similar levels of aggression, and that overall, mixing aggression occurred at a low level. In terms of production, the EM sows performed similarly, or better, than PS and LM sows, indicating that under good management conditions (eg. no competition at feeding) mixing sows at weaning does not negatively impact sow performance. The PS treatment investigated in this study had no production benefits, and exposed sows to mixing aggression twice during gestation. As such, it can be viewed as less optimal for management and welfare.

ACKNOWLEDGEMENTS

Strategic program funding provided by Sask Pork, Alberta Pork, Manitoba Pork Council, Ontario Pork and the Saskatchewan Agricultural and Food Development Fund. The authors gratefully acknowledge specific project funding for this study provided by the National Pork Board.

National Sow Housing Conversion Project

Y.M. Seddon and J.A. Brown

Yolande Seddon

Jennifer Brown

SUMMARY

The use of stall housing for gestating sows has been criticised for being restrictive and limiting sows' ability to perform normal behaviours. As well, increasing numbers of food retailers and supermarket chains have announced plans to develop a gestation 'stall-free' pork supply chain. Consequently, the swine industry is under pressure to convert existing gestation stall housing to group systems. However, there are concerns within the industry around the costs of conversion and management of sows in groups. Within the Canadian industry there is relatively little knowledge and experience in this area. The National Sow Housing Conversion Project (NSHCP) is intended to provide the necessary information to facilitate the successful conversion of Canada's sow barns to group housing. The project brings together industry and scientific expertise to produce a comprehensive national strategy involving demonstration farms and technology transfer to support Canadian swine producers. This report describes the project, which will follow four barns through the conversion process, and collect information from an additional ten barns that are already managing sows in groups. Information collected will be in the form of questionnaires, interviews, photos, videos, and economic data. Project results will be made available to producers through presentations, newsletters, and a website offering scientific and practical information on group housing and the conversion process.

"The NSHCP is intended to provide the necessary information to facilitate the successful conversion of Canada's sow barns to group housing."

INTRODUCTION

In 2007 the largest pork producers in the USA and Canada pledged to transition their gestation sow housing to group systems over the next 10 years. In 2013, EU countries implemented a ban on the use of sow gestation stalls after 4 weeks gestation. More recently, many North American food retailers, including Tim Hortons, Burger King and McDonalds, and the supermarket chains Safeway, Costco and Walmart announced plans to develop a gestation stall-free pork supply chain. These trends and recent changes to the Code of Practice have placed Canadian producers under pressure to convert existing gestation stall systems to group housing. With over 60% of Canadian pork going to export markets, the future strength of the industry depends on maintaining and increasing access to global markets.

However, there are concerns surrounding the conversion from stalls to group housing. The process requires a large capital investment, there is a variety of systems available, and the 'right' system will vary depending on capital available, herd size, barn layout and management style. Within the Canadian industry there is relatively little knowledge or experience on the management of sows in group housing. Group housing systems are categorised primarily according the feeding system used, with 'competitive' and 'non-competitive' systems being the two main categories. Most group systems require more space and different management skills than stall housing, but overall labour inputs are reported to be similar. Without proper support and advice during this transition, there is the potential for substantial losses in herd productivity, a decline in sow welfare and an overall reduction in the Canadian breeding herd as producers make this change. The National Sow Housing Conversion Project (NSHCP) brings together industry and scientific expertise to produce a comprehensive national strategy, involving demonstration farms and technology transfer, to support and inform Canadian pork producers in this conversion.

MATERIAL AND METHODS

The NSHCP is a descriptive project with the practical aim of generating information that will increase producer's confidence when considering and implementing group sow housing. This is being achieved through five key activities:

1) Development of information resources on group sow housing
Factsheets and articles have been developed based on research and extension work describing the pros and cons of different group housing systems and principles that promote ease-of-management, sow productivity and welfare. These materials are distributed at producer meetings, through provincial pork organisations and are available at PSC's website.

2) Development of barn conversion plans
Four barn sites are being identified across the country that are in the process of converting to groups. The NSHCP will work with these producers to develop conversion plans aided by the University or Manitoba's Swine Housing Conversion Design Utility (SHCDU), a computer software program designed to model different group housing systems and estimate sow numbers and conversion costs.

Once the sites are confirmed, the conversion is documented through questionnaires, interviews, farm visits, photos, and videos taken before, during, and after the transition. In addition producers are asked to provide production and cost data. Initially, an external viewing gallery was planned for each site to allow other producers to securely view the conversion, but due to the increase in biosecurity risk from PEDv this plan been revised. Instead, videos and a dedicated project website will be used to provide barn videos and a virtual tour of each site.

In addition to the four barn conversions, up to ten other barns that are already managing sows in group housing will be documented across the country. Less intensive data will be collected from these sites, including questionnaires, interviews, photos, videos, and barn visits. These additional sites will be used to demonstrate a wider variety of system designs, and highlight the necessity of developing a system that works with the individual barn design, budget, and management style.

3) Technology transfer: disseminating barn conversion information

Communicating the results to producers interested in converting to group housing is one of the main goals of the NSHCP. Results are being presented through workshops and producer meetings, a bi-annual newsletter, and the development of a website that will contain the full documentation of the four conversions, details of the 10 additional sites, general, web links and contact information for further information and advice.

4) Refining the University of Manitoba barn conversion computer model

Two pilot sites were used as case studies for testing the Swine Housing Conversion Design Utility (SHCDU). Over the course of the project, numerous improvements have been made to the SHCDU based on limitations that were identified through the use of these case studies.

5) Development of a national working group

The National Sow Housing Working Group (NSHWG) was formed, consisting of producer groups, industry representatives and scientists from across Canada. The goal of the NSHWG is advise and coordinate the long term NSHCP. Having a national working group to coordinate future projects will ensure that producers across the country have access to similar information and the best possible advice regarding barn conversions.

RESULTS AND DISCUSSION

Funding for this four year project was secured in 2014. Currently primary and secondary sites are being identified and documented. Producers are being informed of the project through presentations at producer meetings via provincial pork board members, and through word of mouth. Currently two primary sites have been approved in Ontario, and three potential sites have been identified in Quebec and Manitoba. Five secondary sites have been approved.

Three factsheets are available discussing the pros and cons of different group housing options.

The factsheets are available on the internet at: http://www.prairieswine.com/national-sow-housing-conversion-project-2/ and cover: a) Competitive feeding Systems; b) Free Access Stalls; and c) Electronic Sow Feeders. Seven articles reviewing scientific information on group sow housing and management are also available. The articles make up PSC's 'Science of Ethology' series, and can be found by searching 'Science of Ethology' using PSC's Pork Insight search engine, located at: http://www.prairieswine.com/pork-insight/

Based on data from the University of Manitoba, CDPQ and NSHCP, cost estimates for barn renovations range from approximately $300 to over $1,000 per sow, depending on the system selected, condition of existing facilities and availability of labour on-farm. Investment in flooring, pits and penning are the most costly items. Renovation costs per sow also depend to a large extent on the number of sows that can be accommodated. On a cost per square foot basis, competitive feeding systems such as floor feeding or short stalls are the least expensive option. This is due to the ability to re-use existing feed lines and stall fronts. However, the longer term costs such as increased management inputs and potential for production losses due to competitive feeding should be considered. Transition costs, such as the transfer of sows to another site during the renovation period, are not included in most estimates, and have been estimated at an additional $75-100/sow.

Some areas for improvement and cost saving have been suggested. If existing floors and pits can be used, this can result in significant cost savings, however, flooring can also have a great impact on sow lameness and productivity in groups. Existing stall flooring is generally unsuitable for loose housing. While slat and gap widths have not been studied scientifically, the general recommendation of having gap widths no greater than 20 mm and slates no smaller than has gained wide acceptance in the EU and with ESF manufacturers.

A bi-annual newsletter and a website will be used to help communicate the results of the project to producers. Currently, the website content is being developed and the domain name www.groupsowhousing.com has been secured. The first NSHCP newsletter has been produced and was available to producers at the Saskatchewan Pork Symposium. It remains available by request or as a digital version at www.prairieswine.com, future versions will be available as a hard copy or online, and a mailing has been assembled for future editions. The newsletter also mentions the need for more participating barns, and may be able to help reach a wider audience. The working group remains active, and met most recently during the Banff Pork Seminar in January 2015.

ACKNOWLEDGEMENTS

Strategic program funding to the Prairie Swine Centre was provided by Sask Pork, Alberta Pork, Manitoba Pork, Ontario Pork, and the Saskatchewan Agricultural Development Fund. Specific project funding is providded by Swine Innovation Porc within the Swine Cluster 2. Funding is provided by Agriculture and Agri-Food Canada through the Agri-Innovation Program.

Determining the Optimum Stocking Density in Nursery Pigs

Y.M. Seddon and J.A. Brown

Yolande Seddon

Jennifer Brown

SUMMARY
Stocking density is critical for both economic and welfare reasons. The minimum space requirement in the Canadian Code of Practice for the Care and Handling of Pigs (k= 0.0335) is based on extensive research on grower-finisher pigs. However, comparatively little research has been done on nursery pigs, and there is speculation that these requirements over-estimate the space needs of nursery pigs. The aim of this research project is to determine the optimal density for nursery pigs that considers both production goals and animal welfare. The three year project will be completed in two phases. Phase 1 studies take place at Prairie Swine Centre and phase 2 take place in two commercial barns (one in SK and one in MB). Both phases will compare the effects of six different density treatments on nursery pig behaviour, welfare,a dn productivity. The studies are ongoing: data collection for phase 1 took place from June 2014 to May 2015, and phase 2 trials began in June 2015.

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 minimum space allowance for grower-finisher pigs have been used as the basis for space allowance requirements for nursery pigs. However, relatively little is known regarding the effects of stocking density on nursery pigs. Because nursery pigs are commonly observed to overlie one-another when resting, the k value which is appropriate for finishing pigs may in fact overestimate the space requirements of nursery pigs.

Although individual pig growth declines at higher densities, overall farm productivity can increase as higher numbers of pigs are produced per unit of building space. Thus, the economic optimum space allowance may be lower than that for achieving maximum growth rate. However, stocking at higher densities can also negatively affect the welfare of the pig, with risk of immune suppression and increased disease susceptibility or restriction of pigs' ability to express normal behaviour.

It has been recommended evaluation of space requirements for pigs should include changes in the behaviour of pigs, and establish the welfare relevance of such changes, to support calculation of space allowances based on what space an animal needs rather than solely on the basis of production performance. Group size and seasonal differences should also be evaluated or controlled for as these factors may also influence growth and behavior. It has been suggested that larger groups of pigs may require less space, due to the sharing of free space. However, this has also been disputed.

This study will examine measures of productivity and welfare in nursery pigs, and will include an economic analysis comparing space allowance treatments above and below the Code requirement of k= 0.0335.

MATERIAL AND METHODS

Phase 1
Animals: Density studies at PSCI were conducted using 1,200 newly-weaned pigs that were housed in the nursery for 5 weeks. Piglets were housed at one of six different densities (k= 0.023, 0.0265, 0.0300, 0.0335, 0.0370, and 0.0390) in pens of either 10 or 40 pigs/group. For four replicate trials were completed over a one year period, with one replicate per season. Pigs were weighed weekly and pen size was adjusted weekly to the prescribed density based on the predicted average body weight. Two temperature and humidity monitors (iButtons) were placed in each pen, suspended approximately 15cm above pig height to monitor conditions at pig level. An additional iButton was suspended in the center of the room to monitor room temperature and humidity throughout the trial.

Data collection: Video cameras were placed above each pen to record pig behaviour for a 24 period once per week. An infra-red setting was used during the hours of darkness. Scan sampling at 15 minute intervals was used to identify laying postures and overlying behavior. The time budgets of four focal piglets, including the amount of time spent feeding and drinking were also evaluated weekly. Standard nursery diets were provided ad libitum, and feed weigh backs were recorded weekly. Total feed consumption and animal weights were recorded on a weekly basis.

> *"Optimal density for nursery pigs is one that considers both production goals and animal welfare."*

Lesion scores were assessed weekly as pigs were weighed, and used as an estimate of aggression (Table 1). Saliva samples were collected weekly from four focal pigs for determination of cortisol as an indicator of stress. The immune response was tested in six pigs per pen (not including the focal pigs), with pigs receiving vaccines for Mycoplasma hyopneumonie. Serum samples were collected at three time points to determine M.hyo specific IgG as a measure of immune competence.

Phase 2

Animals: Two commercial operations with decent health status and levels of productivity were identified through industry contacts and provincial pork agencies. One site was selected in Manitoba and the second in Saskatchewan. The same six density treatments used in phase I will be tested. Unlike phase I, pens in phase 2 will kept at a constant size, and the number of pigs per pen will be adjusted based on the expected weight at nursery exit (approximately 25 kg). Animals are fed and cared for following the standard management practices on each farm and information on temperature and humidity within the rooms will be collected using iButton data loggers, similar to the methods used in phase I.

Table 1. Description of categories for injury scoring.

Score	Description
0	Absent of all injuries
1	Mild superficial wounds
2	Moderate superficial wounds, and/or < 2 deep wounds
3	Severe superficial wounds, and/or 2-5 deep wounds

Data collection: Pigs on trial will be weighed to determine average daily gain. At the same time skin lesions, ear tip necrosis, tail biting, scar score and general health will be assessed by a trained observer. Morbidity, mortality and any treatments will be recorded throughout the trial. At three time points, time lapse videos will collected over 7 hours. Postures and lying behaviours of the pigs will be assessed using scan sampling, as described for phase I.

RESULTS AND DISCUSSION

This project is currently in the data acquisition phase, and there are no results available at this time. A preliminary analysis of phase I results will be completed in the winter of 2015.

ACKNOWLEDGEMENTS

Strategic funding provided by Sask Pork, Alberta Pork, Manitoba Pork, Ontario Pork and Saskatchewan Agriculture and Development Fund. Specific project funding is provided by Swine Innovation Porc within the Swine Cluster 2: Driving Results Through Innovation research program. Funding is provided by Agriculture and AgriFood Canada through the AgriInnovation Program, provincial producer organizations and industry partners.

Stimulating Exploratory Behaviour in Piglets: Effects on Pre-weaning Creep Consumption

Y.M. Seddon, K.E. Davis, M.M. Bouvier, and J.A. Brown

Yolande Seddon

Jennifer Brown

SUMMARY

This study investigated whether feed consumption before and after weaning can be increased through stimulating exploratory behaviour in piglets, and whether this is best achieved through provision of enrichment (E), or through presentation of creep feed in a large tray feeder (TF) so as to facilitate synchronized feeding among littermates.

Enrichment consisted of cotton ropes hung in the farrowing pen. Piglets provided with E were observed to contact the enrichment on average 11 times per day. Feeder type, but not E, resulted in a greater frequency of piglet visits to the feeder on day 12 with more piglets the TF. On day 26 there was a tendency for a greater frequency of visits to the TF. Litters supplied with a TF also had a greater daily creep disappearance with no effect of E. However, litters provided with the Standard Feeder (SF) had a greater piglet birth to wean average daily gain. Provision of a larger feeder that encourages social feeding, appears to have a greater influence on attracting piglets to creep feed. The increased creep disappearance and more frequent feeder visits in the TF treatment indicate that this treatment may be effective at improving feed consumption and reduce weaning stress.

INTRODUCTION

Piglet weaning is a stressful experience in standard commercial practice, as shown by high levels of aggression, weight loss and increased salivary cortisol concentrations. Inadequate food intake in the first two days after weaning, in combination with the stress of weaning, has been shown to decrease piglet performance, resulting in increased disease susceptibility and mortality through changes in metabolic and immune. Promoting feed intake in piglets before weaning by provision of creep feed familiarizes the animals with solid food, and has been shown to increase feed intake and improve growth rate in the critical two days post-weaning. Pre-weaning creep feed consumption by piglets has also been shown to correlate with increased weight gain in the week prior to weaning in addition to improving post-weaning performance. However, the overall consumption of creep by a litter can be low, and varies greatly among littermates (Sulabo et. al., 2010). Considering this, the provision of creep is not generating the desired effect for producers, resulting in higher production costs without significant benefits.

It is of interest to identify convenient, effective and economical ways to increase the quantity and consistency of creep feed consumption by piglets within litters. Previous research has determined that the amount of creep consumed by piglets can be increased through provision of a specially designed feeder that encourages exploratory interaction around the feeder. It is known that piglets born outdoors are quick to consume starter feed and are often ingesting soil and plant material before weaning while exploring their environment. However, piglets born into indoor farrowing pens do not have the same opportunity for exploration in standard practice. This study builds upon current knowledge to investigate the effect of increasing the exploratory behaviour of piglets through provision of environmental enrichment in the farrowing pen and nursery. If simple enrichment can increase creep feed consumption in piglets this could transfer to piglets consuming starter feed earlier and having less of a growth check in the immediate post-weaning period.

Specific objectives of this project were to determine:

1. 1) If providing enrichment, and/or a large shallow tray feeder in the farrowing crate results in increased exploration of creep feeders or increased creep feed consumption by the piglets, and any improvements in pre-weaning growth rate.
2. 2) If the provision of enrichment in the nursery and having a larger tray feeder in the farrowing room results in increased consumption or any improvements in piglet growth during the first 2 weeks in nursery.

MATERIAL AND METHODS

Piglets from 28 litters with 11 to 14 piglets/litter were assigned to one of four treatments, (n=7 litters/treatment):

T1: Creep provided in a standard feeder (SF,see Figure 1);

T2: Creep provided in SF, with cotton rope as pen enrichment (SFE);

T3: Creep provided in a large tray feeder (9” x 13”) (TF);

T4: Creep provided in TF with E provided (TFE, see Figure 2).

Creep feed was offered to all litters from 10 days after birth until weaning at 28 days. Strips of cotton rope were attached in two locations in the farrowing crate (anterior and posterior) for the E treatment, from 5 days after birth until weaning. Piglets were weighed on days 0 (birth), 3, 7, 10 17, the day of weaning (day 26), day 35, and 42 in the nursery. Creep consumption was calculated weekly by total weight per litter. Behaviour was recorded on four litters per treatment for 8 hours (8am to 4pm), on days 12, 19, and

Table 1. Average total frequency of visits made to the creep over 8 hours (8am – 4pm) when presented in a Standard Feeder (SF) or Tray feeder (TF).

Day	Feeder type		Pooled SEM	P
	SF	TF		
12	1.3	6.0	1.2	<0.06
19	3.8	15.0	3.6	0.052
26	5.3	16.4	4.1	0.086

26. Footage was scanned at five minute intervals to determine the number of piglets interacting with the feeders, and for E and TFE , the number of piglets interacting with E. The frequency and the average number of piglets observed at the feeder or E was calculated on each observation day. Average daily gain and creep consumption were calculated. Data were analyzed using PROC MIXED (SAS 9.2) to determine the individual and interactive effects of feeder type and provision of E on visits to the creep.

RESULTS AND DISCUSSION

Piglet behaviour: Piglets interacted with E when provided, on average 11 visits per day in the farrowing crate. However, provision of a tray feeder, rather than enrichment resulted in a greater frequency of piglet visits to the creep (Table 1). This continued from day 12, with a tendency for a greater number of visits to the feeder on days 19 and 28 pre-weaning. There was a tendency for a greater number of piglets per visit at the tray feeder on day 12 pre-weaning, but no differences thereafter among the treatments.

Creep intake and growth rate: Rope enrichment had no effect on the creep disappearance or average daily gain in the pre-weaning period. Litters supplied with the TF had greater daily creep disappearance (In g/pig/day: SF: 5.4; TF: 13.2, SEM 1.33, P<0.0005), with no effect of E. No treatment differences in average daily gain values were observed between day 0 and 28, and day 28 to 42. Pre-weaning growth rate did not differ across treatments, however, piglets using a TF pre-weaning, showed no weight loss in the first days post weaning. On day 29 (day after weaning), T2 piglets had a significantly greater growth check within the first 24 hours of moving into the nursery, while the ADG of piglets in T1, T3 and T4 did not differ (Table 2).

The provision of enrichment in the farrowing pen elicited exploratory behaviour in the piglets, as demonstrated through rope interaction observations. However, provision of a larger feeder that could encourage social feeding and rooting appears to have a greater influence on attracting piglets to creep feed. This was demonstrated by the increased frequency of visits to the feeder when litters were provided with tray feeders. This feeder was a rectangular shape,

Figure 1. Standard feeder (T1 and T2) provided in farrowing crate.

Figure 2. Tray feeder (T3 and T4) and pen enrichment provided to piglets in the farrowing crate.

allowing more piglets to investigate the feeder simultaneously. Pigs are social feeders, and will synchronize feeding. The accessibility of the tray feeder may help facilitate this behaviour. The increased creep disappearance found in the tray feeder suggests piglets were interacting with the creep. However, birth to wean growth rates did not reflect any benefits of increased creep consumption suggesting that use of the tray feeder may have resulted in greater feed wastage.

In the period immediately following weaning, piglets using the tray feeder performed better, having no negative growth check, and maintained a positive average daily gain compared to piglets that had been given standard feeders. There was no effect of enrichment on the piglet performance post weaning. Piglets that received the standard feeder and rope enrichment had a significantly greater growth check at day 29 post-weaning than did piglets provided with the tray feeder, with or without enrichment.

CONCLUSION

A large tray feeder that encourages social feeding and foraging is more effective at attracting piglets to creep than a standard feeder, or the provision of rope enrichment. Providing a tray feeder before weaning also had a positive effect on piglet growth immediately after weaning. Growth benefits may have arisen from piglets more readily taking to solid feed post weaning, having had increased exploration of solid feed pre-weaning. These results are favorable for producers as a reduced growth check post weaning could also mean that piglets are better prepared for immune challenges and other stressors associated with weaning.

ACKNOWLEDGEMENTS

Strategic program funding to the Prairie Swine Centre was provided by Sask Pork, Alberta Pork, Manitoba Pork Council, and the Saskatchewan Agricultural Development Fund. The authors gratefully acknowledge specific project funding for this study provided by the Canadian Agricultural Adaptation Program.

Table 2. Growth rate (ADG, kg) per piglet across treatments.

Treatment	Standard Feeder	Standard Enrichment	Tray Feeder	Tray Feeder + Enrichment	Pooled SEM	P
Birth to Wean (Day 0 to 28)	0.26	0.23	0.21	0.22	0.014	NS
Wean to day 42	0.22	0.16	0.24	0.25	0.03	NS
ADG day 1 nursery	-0.04^{ac}	-0.22^{c}	0.16^{ab}	0.18^{ab}	0.11	0.06
ADG day 35	0.22	0.23	0.16	0.16	0.02	NS
ADG day 42	0.35	0.34	0.34	0.38	0.02	NS

Feeding Value of Cull Lentils

L. Eastwood, D.A. Gillis, M.R. Deibert and A.D, Beaulieu

Laura Eastwood

Denise Beaulieu

SUMMARY

The current study was designed to characterize the nutritive composition, including digestibility and energy concentration, of feed-grade (cull) lentils for growing pigs. We conducted two studies. The first study determined the amount and digestibility of energy and amino acids in two samples of lentils. In the second study we used these values to formulate diets for growing and finishing pigs. We assume that if the pigs grow as expected, then the nutrient values determined in the first experiment are correct for that category of pig.

INTRODUCTION

Saskatchewan is the world's leading exporter of lentils, and the second largest producer (Government of Saskatchewan, 2014). In 2014, approximately 1.64 million tonnes of lentils were produced in Saskatchewan. The production of lentils in Saskatchewan has increased by more than 100% since 2008 (Stats Canada, 2014), and the accompanying increase in marketing and the processing industry provides valuable jobs throughout the province.

Lentils, primarily grown for export (mainly to India), are often downgraded due to chipping, wrinkling or staining, which may be a result of heavy rains late in the growing season, which occurred in 2014. Approximately 40% of the 2014 Saskatchewan lentil crop (0.66 million tonnes) was graded as salvage quality. On average, if just 10% of lentil production in Canada is considered unacceptable for export, 0.19 million tonnes would be available for feed each year. If included at 10% of the diet, this would feed more than 4.5 million pigs from weaning to market.

MATERIAL AND METHODS

Experiment 1: Nutrient Digestibility

Ten barrows, weighing 35kgs were surgically fitted with T-cannulas at the terminal ileum. Two lentil samples (grade 2 (red) and 3 (feed)) were included at two inclusion levels (15 and 30%) into a wheat/barley-based control diet. The five treatment diets (2 lentil samples at 2 inclusion levels, plus 1 control diet were randomly assigned to 2 pigs in three replicates, providing 6 pigs per treatment overall. Each replicate lasted 9 days and consisted of 4 days dietary adaptation, followed by 3 days of faecal grab-sampling and 2 days of digesta collection.

Experiment 2: Growth Validation

In this experiment, 200 growing (initial weight, 35 kg) and 200 finishing (initial weight, 90 kg) pigs received a diet with feed lentils (grade 3) included at 0, 10, 20 or 30%. All diets were wheat and barley based, and formulated to be isocaloric and isonitrogenous, based on the results of the digestibility experiment (Table 1), and met all the nutrient requirements of growing and finishing pigs (NRC, 2012). Growth rate, feed intake and feed efficiency were measured throughout the trial, which lasted for 4 weeks.

"Lentils can represent up to 30% in growing - finishing pig diets without compromising performance."

RESULTS AND DISCUSSION

The chemical composition and determined DE and NE values are shown in Table 2. The crude protein content was comparable between these two samples; however the red lentils sample contained 25% more crude fibre and 45% less total fat than the sample of feed lentils. Values from the NRC (2012) are provided for reference. The lack of data on lentils is evident as the NRC (2012) bases their data on a single sample. This sample was lower in fibre, higher in fat, protein and energy relative to those tested in the current trial. The calculated DE and NE content of the feed lentils was slightly higher than the red lentils, while both are lower than the sample described in the NRC (2012), a reflection of the lower fibre content of that sample.

Table 3 shows the measured amino acid content of the red and feed lentil samples. This table also shows the amount of apparently digestible amino acids based on digestibility coefficients obtained in the first experiment. Ileal amino acid digestibility of the red lentils is 60 to 70% of the feed lentils, which is most likely due to the high fibre content of this sample of red lentils.

The results of the validation experiment are shown in Table 4. Overall, we observed no adverse effects of including up to 30% feed lentils (grade 3) into the diets of growing or finishing pigs, when the diets were balanced properly to meet the nutrient requirements of the animals. In fact, we saw an increase in ADG in finishing pigs as dietary inclusion of feed lentils increased. As expected, we did observe gender differences, with barrows having greater ADG and ADFI, but gilts and barrows responded similarly to the inclusion of lentils in the diet.

In these trials, the maximum inclusion level was 30%. We did observe an interaction between digestibility and inclusion level in the first trial. Amino acid digestibility was decreased at the 30% level relative to 15% inclusion. For this reason, we would caution the inclusion of cull lentils beyond 30% of the diet, but with properly formulated diets, 30% can be used without adversely affecting performance.

The improved growth of the finishing pigs with increased inclusion of lentils into their diets indicates the nutritive value of the lentil sample was under-estimated for this class of pig. The digestibility coefficients were obtained in younger pigs and it has been shown in other studies that these values under-estimate digestibility in older pigs.

CONCLUSION

Results from this project provide the hog industry with information needed to properly formulate diets using feed grade lentils. The full nutritive value, including DE, NE, and amino acid digestibility, of the samples used in this study allows producers to include cull lentils into rations with confidence. As evidenced in the validation study, when diets were formulated using this information, and were balanced to meet the requirements of the age of the pig, no adverse effects were observed on performance.

ACKNOWLEDGEMENTS

The authors would like to acknowledge project funding provided by the Saskatchewan Ministry of Agriculture and the Canada-Saskatchewan Growing Forward bi-lateral agreement. The authors would also like to acknowledge the strategic program funding provided to Prairie Swine Centre by the Saskatchewan Pork Development Board, Alberta Pork, Ontario Pork, the Manitoba Pork Council and the Saskatchewan Agriculture Development Fund.

Table 1. Ingredient composition of experimental diets for growth validation trial.

	Grower		Finisher	
Ingredient, % as fed	0%	30%	0%	30&
Feed lentils (grade 3)	0.00	30.00	0.00	30.00
Wheat	71.15	42.13	15.20	45.60
Barley	0.00	4.53	61.02	9.78
Soybean meal	25.00	17.90	19.00	9.60
Canola oil	1.40	3.00	3.00	3.00
Mono-dicalcium P	0.80	0.93	0.43	0.53
Limestone	0.93	0.83	0.70	0.83
Salt	0.40	0.40	0.40	0.40
Mineral and vitamin premix	0.25	0.25	0.25	0.25
L-Lysine	0.07	-	-	-
DL-methionine	-	0.03	-	-

Diets formulated with lentils included at 10 and 20% were intermediate.

Table 2. Chemical and nutritive composition of red and feed lentils (as fed).

	Red Lentils	Feed Lentils	NRC 2012 (n=1)
Composition, % as fed			
Dry matter, %	88.5	89.0	90.0
Crude protein,	21.8	23.3	26.0
Crude fibre, %	4.0	3.2	ND[2]
Fat, %	0.6	1.1	1,3
Ash, %	2.2	2.6	2.8
Starch, %	40.7	37.5	4.2
Acid detergent fibre, %	5.7	5.5	3.0
Gross energy, kcal/kg	3458	3516	4483
Digestible energy, kcal/kg[1]	2895	2990	3540
Net energy, kcal/kg[1]	2021	2086	2437

[1]Values calculated from experimental determination of digestibility.

[2]Not determined.

Table 3. Amino acid composition of Red and Feed lentils (g AA/100 g, all as fed basis)

	Red Lentils[1]		Feed Lentils[2]	
	Total	AID[3]	Total	AID[3]
Dry Matter	88.5		89.0	
Aspartic Acid	2.74	0.85	2.61	1.65
Threonine	0.85	0.35	0.80	0.61
Serine	1.05	0.56	0.93	0.77
Glutamic acid	3.68	1.98	3.55	2.54
Proline	0.87	0.39	0.86	0.56
Glycine	0.97	0.27	0.94	0.42
Alanine	0.99	0.28	0.99	0.64
Cysteine	0.23	0.06	0.22	0.15
Valine	1.14	0.28	1.14	0.52
Methionine	0.19	0.10	0.18	0.14
Isoleucine	0.98	0.26	0.99	0.46
Leucine	1.74	0.60	1.68	1.06
Tyrosine	0.70	0.23	0.67	0.42
Phenylalanine	1.15	0.31	1.14	0.68
Lysine	1.65	0.52	1.61	1.01
Histidine	0.65	0.29	0.61	0.40
Arginine	1.83	0.90	1.88	1.34
Tryptophan	0.14	0.05	0.15	0.05

[1]Red lentils were classed as feed grade 2

Feed lentils were classed as feed grade 3

[3]AID = apparent ileal digestible

Table 4. Growth (ADG), feed intake (ADFI) and feed efficiency of growing and finishing pigs fed diets with graded levels of feed lentils (feed grade 3) for a 4 week trial).

	Treatment					P Values		
	0%	10%	20%	30%	SEM	Diet	Linear	Quadratic
	Growing pigs							
Initial BW, kg	41.30	41.00	40.62	41.11	0.213			
ADG, kg/d	1.04	1.03	1.03	1.05	0.014	0.60	0.41	0.28
ADFI, kg/g	2.05	2.03	2.03	2.06	0.041	0.90	0.85	0.47
Gain:Feed,	0.51	0.51	0.51	0.51	0.011	0.99	0.92	0.93
Feed: Gain	1.96	1.96	1.96	1.96				
	Finishing pigs							
Initial BW, kg	91.17	89.99	89.52	90.98	0.550			
ADG, kg/d	1.02	1.02	1.03	1.07	0.017	0.10	0.02	0.30
ADFI, kg/d	2.83	2.82	2.84	2.92	0.069	0.22	0.09	0.22
Gain:Feed	0.36	0.36	0.37	0.37	0.007	0.80	0.33	0.96
Feed:Gain	2.78	2.78	2.70	2.70				

Can Flaxseed Replace Antibiotics in Starter Diets?

L. Eastwood, D.A. Gillis, M.R. Deibert and A.D, Beaulieu

Laura Eastwood

Denise Beaulieu

SUMMARY

We hypothesized that feeding n-3 FA's to sows in the form of flaxseed would allow for the removal of Ab's in starter feeds. Based on the findings from this trial, we can neither accept nor reject this hypothesis, as we found that in our high health herd, Ab's had no benefit when fed for the first week post-weaning.

Results from this trial have clearly shown that in a high health situation, the use of in feed Ab's post-weaning had no benefit, regardless of weaning age. This experiment has also shown that, at nursery exit (8 weeks old), piglets weaned at 3 weeks of age had heavier body weights than those weaned at 4 weeks of age, which in part may be due to the fact that piglets weaned at 3 weeks had lower WBC, CK and AST counts relative to those weaned at 4 weeks.

INTRODUCTION

In the swine industry, weaning is a stressful time in a piglets' life. During this time, they are exposed to 3 major stressors: nutritional, environmental, and social. Combined, these can activate the immune response in the piglet, which in turn can have negative impacts on animal performance immediately post weaning (low or no feed intake, reduced or negative growth rates).

In order to help combat the stress/immune response at the time of weaning, piglets are often fed a diet containing a low level of antibiotics (Ab). This helps the piglets cope with any potential secondary infections which may be contracted while their immune system is vulnerable. In many markets, the use of in-feed Ab's is banned, and in order for Canada to remain competitive in a global market, strategies must be put in place which would allow producers to remove Ab's from the feed while maintaining productivity. In April 2015, Health Canada announced that the use of in-feed antibiotics will be phased out over the next 3 years. Finding alternate strategies to help piglets cope at the time of weaning is important, and nutritional modulation for this purpose is a growing area of interest.

Flaxseed is a rich source of omega-3 (n-3) fatty acids (FA), which are known to have many different health benefits, including anti-inflammatory properties. Omega-3's can be easily transferred to piglets via the milk when sows are fed diets containing a good quality source (Eastwood, 2014). Additionally, changing the FA profile of sow diets by adding n-3's can impact the inflammatory responses of their offspring (Eastwood et al., 2012). It is possible that by improving the health of piglets prior to weaning, through nutritional modulation of the sow, we can remove Ab's in the nursery diets. This experiment was designed to test that hypothesis when piglets were weaned at 3 or 4 weeks of age.

MATERIAL AND METHODS

A total of 103 sows were used for this trial, 52 weaned at 4 weeks of age and 51 at 3 weeks of age. Within each weaning group, sows were fed one of two diets (control or n-3) throughout lactation. At the time of weaning, 10 piglets from each litter were selected, moved to the nursery and housed in 2 groups of 5 piglets each (2 nursery pens per litter). One half of the litter (1 pen) was fed a starter diet containing Ab's (LS20), and the other half received the same diet without Ab's. After one week, all piglets were switched to a common phase 2 diet for the remainder of the study. Prior to weaning, nurseries skipped a single wash cycle, to ensure that each weaning cohort was immunologically challenged. Regardless of weaning age, all piglets completed the trial at 56 days of age.

Piglet performance was determined in both the farrowing and nursery rooms. Sow milk was collected during mid-lactation to determine the FA profile consumed by piglets. Piglet health was monitored by collecting blood for CBC and chemistry blood panels 2 days post weaning. A total of 1181 piglets completed the lactation portion of the trial. Of those, 1021 piglets were used for the nursery portion.

RESULTS AND DISCUSSION

There were no dietary effects (± n-3 FA's) on sow feed intake, numbers of piglets born, piglet growth or on the number of piglets weaned per litter ($P > 0.10$). As expected, sows fed a diet with added n-3 FA's had significantly more n-3's in their milk relative to control sows (5:1 vs. 8:1 n-6:n-3 ratio).

In the nursery, there was no impact of sow diet on ADG, ADFI, G:F or final body weight for piglets weaned at 3 or 4 weeks of age ($P > 0.10$). For piglets weaned at 3 weeks of age, ADFI was 20 g/d higher during the 4th week in the nursery for piglets who received no Ab's in their phase 1 diet ($P = 0.028$); however, ADG and G:F were not affected ($P > 0.10$). Feed intake was not affected during any of the other weeks on trial for these piglets. For piglets weaned at 4 weeks of age, ADG tended to be greater in piglets fed diets with Ab's for week 1 of the trial ($P = 0.053$), which also lead to improved G:F ratios during that week (P = 0.042). Growth and G:F were unaffected by the inclusion of Ab's from weeks 2 to 4 in the nursery. Feed intake tended to be higher in Ab fed piglets during week 3 (P = 0.079), and was significantly higher in week 4 (P = 0.025) relative to piglets who received no Ab's in the first week post-weaning (930 g/d vs. 900 g/d); however this did not impact G:F. We observed no dietary effects (sow diet or nursery diet) on the final body weight of piglets at nursery exit; however, regardless of dietary treatment, piglets weaned at 3 weeks of age were ~1.5 kg heavier than those weaned at 4 weeks ($P < 0.05$).

We found no effect of sow or phase 1 diet on any of the blood measures taken when piglets were weaned at 3 weeks of age. When piglets were weaned at 4 weeks of age, piglets weaned from sows fed diets containing n-3 FA's had lower white blood cell counts relative to those weaned from sows fed the control diet ($P < 0.05$). White cell counts were unaffected by phase 1 diet, and neither sow nor phase 1 diet affected any of the other blood parameters measured. Regardless of diet, piglets weaned at 3 weeks of age had lower creatine kinase (CK), aspartate aminotransferase (AST) and white blood cell (WBC) counts relative to those weaned at 4 weeks. CK and AST are enzymes involved in muscle catabolism.

Table 1. Sow and nursery pig diet formulations

Ingredient, %	Sow Diets: Control (- n-3)	Sow Diets: + n-3	Nursery Diets: Phase 1 (+/- Ab)	Nursery Diets: Phase 2
Wheat	38.00	39.00	33.62	69.67
Barley	31.17	29.14	12.98	5.00
Soybean meal	21.00	20.20	23.50	18.00
Peas	3.00	0.00	-	-
LinPro[1]	0.00	6.00	-	-
Spray dried plasma	-	-	3.50	-
Whey powder	-	-	18.00	-
Tallow	3.65	2.50	3.50	3.50
Micronutrient Mix	3.19	3.16	4.80	3.83
Celite	-	-	0.40	-
LS 20 (antibiotic)	-	-	0 or 0.1	-
LS 20 (antibiotic)	-	-	0 or 0.1	-
Measured analysis, dry matter basis				
Dry matter, %	89.68	90.99	89.47	88.16
Moisture, %	10.32	9.01	10.53	11.84
Crude protein, %	20.47	21.33	22.07	20.51
Crude fibre, %	3.57	3.82	2.58	2.97
Fat, %	6.11	5.35	4.77	5.42
Calculated analysis, dry matter basis				
GE, Mcal/kg	4.546	4.499	4.444	4.528
DE, Mcal/kg	3.945	3.871	3.85	4.011
ME, Mcal/kg	3.788	3.265	3.683	3.851
NE, Mcal/kg	2.743	2.69	-	-
Calcium, %	0.87	0.86	1.11	0.81
Avail. P, %	0.39	0.38	0.64	0.38
SID Lysine, %	0.95	0.93	1.69	1.38
SID Threonine, %	0.60	0.59	0.98	0.83
SID Methionine, %	0.26	0.25	0.48	0.42

[1]LinPro is an extruded flaxseed:pea blend (O & T Farms, Regina, SK)

CONCLUSION

Based on the findings from this trial, when piglets are raised in a clean, high health status facility, there is no need to include Ab's into the phase 1 diets post-weaning. Additionally, weaning piglets at 3 weeks of age may be more beneficial to the producer if they are able to produce piglets with the same nursery exit weights relative to pigs weaned at 4 weeks. This may vary across facilities, and should be monitored closely to ensure final output is not compromised, but may be a strategy to help reduce the cost of raising pork, and to help improve sow longevity.

ACKNOWLEDGEMENTS

The authors acknowledge with gratitude project funding provided by the Saskatchewan Ministry of Agriculture and the Canada-Saskatchewan Growing Forward bi-lateral agreement, as well as the Western Grains Research Foundation. Additional project support has been provided by O&T Farms. 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.

Table 2. Reproductive performance of sows fed diets with or without n-3 FA's and weaned at 3 or 4 weeks of age

	Sow Lactation Diets: Control (- n-3)	Sow Lactation Diets: Omega (+ n-3)	Statistics: SEM	Statistics: P Value
3 Week Wean[1]				
Parity	2.50	2.20	0.394	0.560
Lactation length, d	19.35	19.36	0.368	0.979
ADFI, kg/d	6.01	5.81	0.262	0.589
Born alive, n	14.81	14.72	0.662	0.925
Born total, n	15.62	15.92	0.666	0.746
Weaned, n	11.15	11.24	0.310	0.844
Total litter gain, kg	54.17	52.89	2.255	0.685
Piglet ADG, kg/d	0.25	0.24	0.007	0.468
4 Week Wean[1]				
Parity	2.11	2.12	0.279	0.982
Lactation length, d	26.22	26.56	0.393	0.538
Born alive, n	14.70	14.64	0.576	0.937
Born total, n	15.96	16.12	0.670	0.867
Weaned, n	11.56	11.88	0.267	0.386
Total litter gain, kg	77.21	77.94	2.151	0.795
Piglet ADG, kg/d	0.26	0.25	0.006	0.402

[1]Litters were standardized to ~12 pigs each within the first 24 hr post-farrowing

Table 3. Performance of nursery pigs weaned at 3 or 4 weeks of age

	Sow Lactation Diet			Phase 1 Nursery Diet[1]			P Values		
	- n-3	+ n-3	SEM	+ Ab	- Ab	SEM	Sow Diet	Phase 1 Diet	S x P1
3 Week Wean									
Body Weight, kg									
Initial (weaning)	6.51	6.26	0.178	6.39	6.39	0.125	0.316	0.901	0.090
Final (56 days of age)	20.47	19.92	0.386	20.16	20.23	0.311	0.313	0.828	0.528
ADG, kg/pig/d									
Phase 1[2]	0.07	0.08	0.007	0.07	0.07	0.006	0.540	0.360	0.359
Phase 2[3]	0.46	0.45	0.011	0.46	0.46	0.009	0.471	0.720	0.604
Overall[4]	0.38	0.38	0.010	0.38	0.38	0.008	0.652	0.713	0.411
ADFI, kg/pig/d									
Phase 1[2]	0.12	0.13	0.008	0.13	0.12	0.007	0.644	0.695	0.335
Phase 2[3]	0.63	0.63	0.015	0.63	0.63	0.011	0.907	0.660	0.014
Overall[4]	0.53	0.53	0.013	0.53	0.53	0.009	0.930	0.570	0.043
G:F, kg/kg									
Phase 1[2]	0.51	0.55	0.053	0.51	0.55	0.041	0.572	0.181	0.167
Phase 2[3]	0.73	0.72	0.009	0.72	0.73	0.008	0.344	0.477	0.136
Overall[4]	0.72	0.71	0.009	0.71	0.72	0.008	0.409	0.338	0.338
4 Week Wean									
Body Weight, kg									
Initial (weaning)	8.33	8.34	0.173	8.35	8.32	0.122	0.977	0.302	0.846
Final (56 days of age)	18.64	18.77	0.328	18.92	18.48	0.256	0.787	0.034	0.997
ADG; kg/pig/d									
Phase 1[2]	0.07	0.05	0.010	0.07	0.05	0.009	0.284	0.053	0.748
Phase 2[3]	0.47	0.47	0.011	0.48	0.46	0.009	0.573	0.117	0.426
Overall[4]	0.37	0.37	0.009	0.37	0.36	0.007	0.984	0.111	0.740
ADFI, kg/pig/d									
Phase 1[2]	0.15	0.17	0.015	0.16	0.16	0.015	0.592	0.958	0.440
Phase 2[3]	0.64	0.65	0.015	0.65	0.63	0.012	0.736	0.196	0.624
Overall[4]	0.52	0.53	0.013	0.53	0.52	0.011	0.618	0.332	0.444
G:F, kg/kg									
Phase 1[2]	0.26	0.38	0.133	0.48	0.31	0.122	0.535	0.042	0.378
Phase 2[3]	0.73	0.74	0.008	0.74	0.73	0.008	0.845	0.666	0.269
Overall[4]	0.71	0.71	0.011	0.72	0.70	0.010	0.734	0.274	0.341

[1]Phase 1 diets were fed during week 1, after that all pigs went on to the same phase 2 diet
[2]Phase 1 refers to the first week post-weaning
[3]Phase 2 refers to weeks 2-5 post-weaning for 3 week weans, and 2-4 weeks post-weaning for 4 week weans
[4]Overall refers to weeks 1-5 for 3 week weans, and weeks 1-4 for 4 week weans

Effect of Dietary Calcium and Phosphorus in Sows on Bone Development in Piglets

F. Tan, A.D, Beaulieu and S. Kontulainen[1]

Felina Tan

Denise Beaulieu

SUMMARY

This study was designed to determine the influence of Ca and P intake by young, gestating sows on the growth and skeletal development of their developing piglets and if smaller birth-weight piglets are at greater risk from mineral insufficiency during gestation. A total of 30 sows were randomly assigned to 1 of 3 dietary Ca:P treatments. At birth, the smallest and a normal-sized piglet from each litter were euthanized, and the left femur extracted for peripheral quantitative computed tomography (pQCT) scanning. Number of piglets born, body weight (BW) at 3 d of age, and piglet ADG were unaffected by diet. At birth, the highest serum Ca level was seen in the small piglets from sows fed a high Ca diet however, at weaning, this value had the smallest change from the initial value. Femurs of piglets from sows fed the low Ca diet had the highest cortical density. Piglet size had no effect on cortical density. Bone ash %, ash Ca %, ash P %, and serum bone markers were unaffected by diet or piglet size.

In conclusion, moderate changes in Ca and P intake by young, gestating sows, does not negatively affect the growth or skeletal development of their piglets.

INTRODUCTION

Adequate nutrition, including minerals, is important for gestating sows, particularly gilts, as growth and development of their piglets needs to be supported while their own growth is maintained. Nutrient requirements obtained from older studies may not be applicable to the modern, highly prolific sow as they were based on sows farrowing smaller litters. Analysis of data collected from 1994 to 2004 showed that genetic improvements resulted in approximately 1 to 2 piglets more per litter in commercial sows. Larger litters however, results in decreased average birth weight.

The objective of this study was to determine the influence of Ca and P intake by young, gestating sows on the growth and skeletal development of their piglets and determine if smaller birth-weight piglets are at greater risk of mineral deficiency.

MATERIAL AND METHODS

The study was carried out at the Prairie Swine Centre Inc. (Saskatoon, SK, Canada). Sows were cared for according to the Prairie Swine Centre Inc. standard operating procedures and the experiment was approved by University of Saskatchewan's Committee on Animal Care and Supply for compliance with the Canadian Council on Animal Care guidelines.

Treatments

A total of 30 sows (gilts and parity 1) were randomly assigned to 3 treatment groups consisting of 3 dietary Ca and P levels. The control treatment for the gestation phase was based on guidelines in the National Research Council (NRC) 1998 and the National Swine Nutrition Guide (2010). The control level for the lactation phase was based on the sow model in NRC (2012). The other treatment diets were formulated with Ca and P levels 15 % lower and 15 % higher than the control, primarily by increasing limestone and monocalcium P content. The ratio of Ca and P was maintained across diets within each phase.

Table 1. Feed allotments and dietary Ca and P levels used in gestation

Nutrients	Treatment 1 (-15 % Ca:P)	Treatment 2	Treatment 3 (+15 % Ca:P)
Gestation			
Daily feed intake, kg/d	2.30	2.30	2.30
Ca, %	0.60	0.70	0.81
Total P, %	0.47	0.55	0.63

Animals and animal care

Gilts (parity 0) and parity 1 sows were randomly assigned to 1 of the 3 treatment groups at breeding. All sows were housed in individual stalls during gestation. The stalls contained partially slatted concrete flooring. Sows were moved to the farrowing room 1 wk prior to the anticipated farrowing date and maintained in farrowing crates. Piglets were cross-fostered within the first 24 h of birth but only within the dietary treatment assigned during gestation.

Gestation phase feeding began when sows were moved to the gestation room from breeding (approximately d 28 of gestation). Sows were fed 2.3 kg/d until 2 wk prior to farrowing, when this allotment was increased to 3.0 kg/d. The standard lactation diet was available ad libitum to all sows on study during lactation period.

[1] College of Kinesiology, University of Saskatchewan

Figure 1. Peripheral quantitative computed tomography (pQCT) scan in the midshaft of the femur in a newborn piglet left hind limb; (A) Norland/Stratec pQCT, (B) Limb positioned perpendicular to the laser of the gantry, (C) Scanned region of interest (ROI) at femur midshaft.

Table 2. Main effects of dietary Ca and P (15% variance from 1998 NRC recommendations) on serum Ca and P and bone markers, osteocalcin and pyridinoline, in sows[1]

Serum constituent	Diet			SEM	P-value
	-15%	Control	+15%		
Serum Ca, mmol/L					
d 100 Gestation	2.51	2.45	2.47	0.03	0.30
Wean[2]	2.66[a]	2.52[b]	2.52[b]	0.03	<0.01
Serum P, mmol/L					
d 100 Gestation	2.33	2.23	2.27	0.05	0.37
Wean[2]	2.21	2.17	2.15	0.07	0.83
Serum osteocalcin[3], ng/mL					
d 100 gestation	375.2	397.0	327.2	35.9	0.39
Wean[2]	181.2	184.8	139.9	18.9	0.19
Serum pyridinoline[4], nmol/L					
d 100 gestation	6.8	7.4	7.0	0.3	0.37
Wean[2]	7.4	6.9	7.2	0.5	0.79

[1] A total of 30 sows (gilts and parity 1) were randomly assigned to 3 dietary Ca and P treatments.
[2] Serum samples collected at lactation d 26 ± 2 from all 30 sows.
[3] Marker of bone formation.
[4]Marker of bone resorption.
[ab] Within a row, means without a common superscript differ (P < 0.05).

Data collection

Only sows farrowing 12 or more piglets remained on the experiment. Piglets were weighed on d 3 post-farrowing and prior to weaning. In each litter, the smallest or second smallest piglet (SMALL) and a piglet representing the heaviest 20 % of the piglets (NORM) were selected and birth weight recorded.

RESULTS AND DISCUSSION

Sow reproductive performance

Calcium and P content of the diet fed to the gestating sows did not influence reproductive performance. The young sows in this study were highly prolific, averaging 16 piglets per litter. The smallest piglets had an average birth weight of 0.86 kg while the normal-sized piglets averaged 1.36 kg.

Sow and piglet serum constituents

An effect of dietary Ca and P during gestation on serum total Ca of sows was observed at weaning (P < 0.01; Table 2). Sows that were fed lower Ca during the gestation period had the highest level of serum Ca prior to weaning while sows fed the high Ca:P treatment had serum Ca levels comparable to the control. There was no effect of dietary Ca on serum Ca at d 100 of gestation (P > 0.10). Dietary Ca and P had no effect on concentration of serum P, serum osteocalcium, a marker of bone formation or serum pyridinoline, a marker of bone resporpiton, at late gestation or prior to weaning (P > 0.10).

A diet by piglet size interaction was observed on serum total Ca of piglets at birth (P = 0.04; Fig. 2). The SMALL piglets from sows fed the high levels of Ca during gestation had the highest level of serum Ca at birth while those from control sows had the lowest level of serum Ca. In contrast, no differences were observed in the serum Ca concentrations of NORM piglets.

Values at weaning calculated as a change from d 0 showed a diet by size interaction where the SMALL piglets produced by sows fed the high Ca diet had the smallest increase in serum Ca prior to weaning (P = 0.02). Neither gestational diet Ca and P concentration nor piglet size affected serum P levels of the piglets at birth, but NORM piglets had higher concentrations of serum P prior to weaning (P = 0.01). NORM piglets had a greater increase in serum P from d 0 to weaning (P = 0.05) compared to SMALL piglets. Comparable to that seen with the sows, dietary Ca and P did not affect the levels of the bone biomarkers of formation (osteocalcin) or resorption (pyridinoline) of piglets either at birth or at weaning (P > 0.10).

Piglets' bone parameters

The expected differences in the fresh weight, dry weight and ash weight of femoral bones were observed between the SMALL and NORM piglets at birth; femoral bones from NORM piglets were heavier (fresh, dry or ash weights) (P < 0.01). Except that SMALL piglets had a tendency for higher ash % compared to the NORM piglets (P = 0.07), the fresh weight, dry weight and ash weight, when calculated as percentages of DM showed no differences due to dietary treatments or piglet size (P > 0.10. Femoral bone ash Ca and P were also not affected by sows' dietary Ca and P or piglet size (P > 0.10).

Femoral bone scans using pQCT revealed significant differences in bone parameters between the SMALL and NORM piglets. Based on the scans, SMALL piglets had smaller total area, cortical bone area, cortical bone content and SSI ($P < 0.01$). Femoral bones of piglets from sows fed the low Ca and P diet during gestation had the highest cortical density while the lowest cortical density was seen in piglets produced from sows fed the control diet ($P = 0.03$). Piglet size did not influence the cortical density of the femoral bone ($P > 0.10$).

CONCLUSION

Based on this study, the smaller piglets at birth do not have a higher risk of mineral deficiency. Although small piglets from sows fed the control diet had lower serum Ca at birth, serum Ca was similar regardless of the size of piglets at weaning. On the other hand, although serum P was similar between the small and normal-sized piglets at birth, small-sized piglets had lower serum P at weaning. These results combined with the lack of significance on the bone markers would suggest that apart from the mobilization of Ca and P from the bones, other adaptive mechanisms may play a role in maintaining the levels of Ca and P in the blood. The gestational diets did not negatively affect the cortical density of the newborn piglets. In fact, sows fed the low Ca diet produced piglets with the highest cortical density. The gestational diets, however, were fed for a single parity and further research is required to examine if similar results will be obtained over consecutive parities. Femoral bone analysis showed that cortical density of the small piglets were similar to the normal-sized piglets despite the size differences thus, suggesting that the smaller piglets at birth did not appear to have a higher risk of mineral deficiency.   Sketal development and serum Ca concentration will not be compromised with a moderate Calcium deficiency of the sows diet for one parity

ACKNOWLEDGEMENTS

Funding for this project has been provided by Agriculture and Agri-food Canada through the Canadian Agricultural Adaptation Program (CAAP). In Saskatchewan, this program is delivered by the Agricultural council of Saskatchewan. The authors would also like to acknowledge the strategic program funding provided by Sask Pork, Alberta 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.

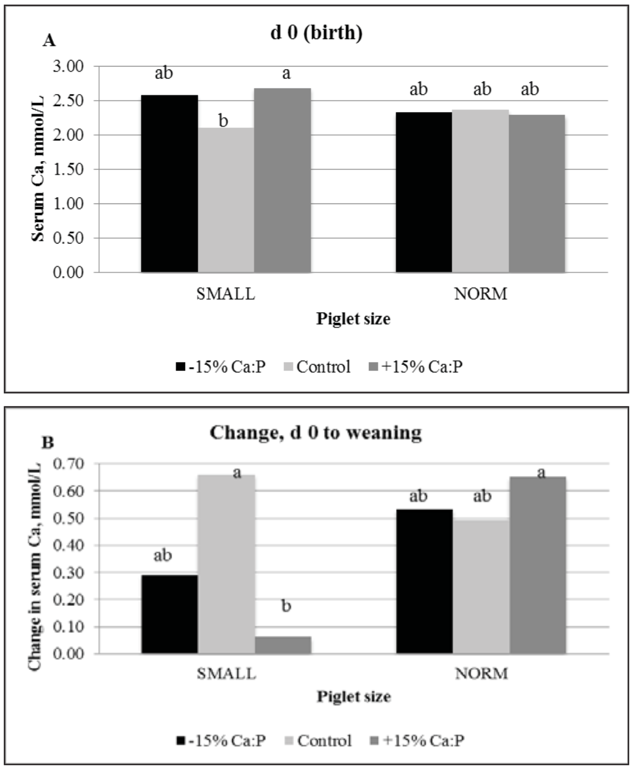

Figure 2. The effects of dietary Ca and P (15 % variance from 1998 NRC recommendations) for gestating sows and piglet size on serum Ca concentration of piglets (SMALL = smallest or second smallest piglet in each litter; NORM= heaviest 20 % of the piglets in each litter) on serum Ca of glets ($P < 0.05$); (A) d 0; SEM = 0.13, (B) Change, d 0 (birth) to weaning (d 26); SEM = 0.12. Means with the same letter are not significantly different ($P > 0.05$).

Assessing Whey to Reduce Feed Costs

D. Wrightman, M. Deibert, D.A. Gillis, L. Eastwood, D. Beaulieu

Denise Beaulieu

SUMMARY

Deproteinized whey permeate is a by-product of the cheese-making industry. Depending on the type of cheese being produced it can be categorized as “sweet whey” or “acid whey”, the latter contains about 4.7% organic acids. The objective of this experiment was to determine the response of weanling pigs to 0, 8, 12 or 16% whey in their drinking water and determine if the organic acids supplied in the acid whey provided additional benefit. Diets were formulated to account for the nutrients in the whey based on intakes from a previous experiment. Supplying up to 16% whey in the drinking water increased caloric intake and improved growth rate. Depending primarily on the cost of transporting the whey to the farm, it may be an economical supplement for weanling pigs.

INTRODUCTION

Whey, a by-product of the cheese industry has several uses, specifically due to its high content of protein. Deproteinized whey (whey permeate) however, presents the cheese industry with disposal problems. This project developed from previous work at the Prairie Swine Centre which demonstrated that growing pigs receiving liquid whey permeate in their drinking water decreased intake of dry feed. Depending on the cost of the whey permeate (primarily transportation costs), cost savings could therefore accrue.

“Supplying up to 16% whey in the drinking water increased caloric intake and improved growth rate.”

“Acid” whey is a by-product resulting from the production of soft cheeses such as cottage cheese. It contains approximately 4.7% organic acids. Several researchers have shown that weanling pigs respond to the inclusion of organic acids in their diets with improved growth, and organic acids could be a substitution for in-feed antibiotics.

The overall objective of this experiment was to determine the nutrient or “extra-nutrient” value of two types of liquid whey permeate for pigs. Specifically we wanted to determine: 1) if the weanling pig maintains overall caloric intake when the water supply is supplemented with whey permeate and if the compensation occurs regardless of the whey:water ratio, 2) if whey permeate, especially the high organic acid whey, has a positive effect on piglet health, 3) and if there are feed cost savings when the water supply contains whey permeate.

MATERIAL AND METHODS

Animals. The experiment was designed as a randomized complete block with five blocks of 16 pens of pigs, each pen housing two animals of the same sex. Pigs were assigned to treatment at weaning (26 days of age). .Each block consisted of six days of adaptation (day one to six) and 22 days used for data collection (day 7 to 28). A total of 160 animals were used, 80 barrows and 80 gilts. The smaller piglets (initial BW 7.43 ± 0.85 kg) within the litters were utilized with the assumption that weaning would present a greater challenge to them.

Housing in pairs was used to improve welfare and minimize boredom that could lead to water wastage. Additional, enrichment was provided with toys and chains in the crates which were washed and changed as needed. The crates were inoculated with manure from the existing nurseries to increase the immune challenge to the piglets.

Dietary treatments. A diet was formulated to account for nutrients expected to be consumed by pigs receiving the whey at the highest concentration. This was mixed with a control diet for treatments receiving a lower whey/water ratio. Diets contained no antibiotics. Diets were fed in two phases. The water/whey treatments, available ad libitum, were administered using a suspended bucket system over each crate that connected to the nipple drinker in each crate. Filters were removed from the nipple drinkers to prevent clogging. There was no additional source of water provided. During acclimation (day one to six) the whey concentration was gradually increased. Wasted water was caught using a bucket placed under each of the crates and this was weighed and accounted for as intake on a weekly basis. Feed was also provided ad libitum with the amount recorded as it was added. Feed weigh backs were done weekly to calculate weekly intake and waste was collected under the pen, dried, weighed and accounted for weekly.

Data collection. Piglets were weighed weekly following weaning (day one). Faecal scores were recorded daily for the trial duration (day 1 to 28) on a per pen basis, using a scoring system from zero to five with 0 being dry, hard and well-formed feces to 5 which is watery diarrhea.

RESULTS AND DISCUSSION

Although some diarrhea was observed, it was not excessive, nor associated with treatment (data not shown). There were no differences seen between the normal and the acid whey (P > 0.10), therefore table 1 presents average effects of increasing concentration of the whey in the water. The "control vs whey" comparison refers to the overall effect of whey compared to the 0 or control treatment while the linear and quadratic effects of whey refers to the effect of increasing the concentration of whey, regardless of whey type, in the drinking water.

Water and nutrient (including energy), intake, and growth rate increased with increasing whey concentration. The significant quadratic effect is due to a decrease or plateauing of nutrient intake at the highest whey concentration.

Average daily gain, followed a similar trend with the control group having the lowest gains at 0.34 kg per day followed by the sweet and acid whey treatments gaining 0.40 kg and 0.41 kg per day, respectively (P< 0.01 effect of whey, Table 1). There was no effect of the whey treatment on feed efficiency (P > 0.10).

Economic analysis

The economic analysis was conducted to determine a suitable cost of the whey. The whey is considered a waste product by the cheese industry however, a producer must consider the costs associated with transportation, storage and distribution within the barn. In this study, diets were formulated to account for the nutrients in the whey. We hypothesized that nutrient intake and thus growth would be comparable among treatments, regardless of whether the nutrients originated from the whey or the feed. In fact, caloric intake was increased with the whey treatments. Based on our results and assuming a cost of $400 and $392 per tonne for the "no-whey" and the "whey" treatment diets respectively, a producer could afford to pay approximately $400 per tonne for the liquid whey to be used in the nursery. Because of differences in diet cost, and expected differences in production responses, the economic analysis can't be extrapolated to other phases in a swine production system.

CONCLUSION

Including up to 16% whey permeate in the drinking water of nursery pigs improved gains, with no effect on feed intake, when the diets were formulated to account for the nutrients in the whey. Because of the decreased cost of the diets formulated to account for the nutrients in the whey, cost savings could accrue. There was no additional benefit seen with whey permeate which was higher in organic acids.

ACKNOWLEDGEMENTS

The authors acknowledge with gratitude project funding provided by the Saskatchewan Ministry of Agriculture and the Canada-Saskatchewan Growing Forward bi-lateral agreement, as well as the Western Grains Research Foundation. Additional project support has been provided by O&T Farms. 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.

Table 1. The effect of including whey in the drinking water of weanling pigs on feed and liquid intake and growth performance over a 22 day experimental period following a 6 day acclimation

	Whey (% in water)					Whey (% in water)		
							Whey conc.	
	0	8	12	16	SEM	Whey vs control	Linear	Quad
ADI feed (kg)	0.49	0.54	0.51	0.48	0.02	0.53	0.74	<0.01
ADI water (kg)	1.43	1.56	2.13	2.06	0.15	<0.01	<0.01	0.72
DM intake of whey	0.00	0.51	1.01	1.36	0.09	<0.01	<0.01	0.10
ADG (kg)	0.34	0.42	0.41	0.39	0.02	<0.01	<0.01	<0.01
Total nutrient intake (over 22 days, whey plus diet)								
CP (kg)	2.55	2.84	2.79	2.74	0.18	<0.01	<0.02	0.01
Sodium (kg)	0.04	0.05	0.07	0.07	0.00	<0.01	<0.01	<0.01
Calcium (kg)	0.09	0.11	0.11	0.10	0.01	<0.01	<0.01	0.02
DE (kg)	40.77	44.91	44.86	43.97	2.96	<0.01	<0.01	0.02
DM Gain:Feed	0.65	0.71	0.70	0.66	0.06	0.23	0.47	0.09

Geothermal Systems for Heating and Cooling in Swine Production

B.Z. Predicala, A.C. Alvarado, and L.T. Dominguez

Bernardo Predicala

Alvin Alvarado

SUMMARY

This study assessed the applicability of a geothermal system in swine production facilities. In-barn evaluation of the impact of the geothermal system on energy use, thermal environment, greenhouse gas emissions, and animal performance was conducted by comparing a swine grow-finish room with geothermal system to a conventional production room with a forced-convection gas-fired heater system over summer and winter seasons. Results showed that the room with the geothermal system consumed about 36% less total energy for heating and ventilation during cold season compared to the conventional room. However, during the warm season, the use of the geothermal system to cool the room resulted in larger energy use compared to the control room. Levels of greenhouse gases, namely, methane and carbon dioxide in the geothermal room when the system was in operation were significantly lower than that in the room with the conventional gas-fired heater during both heating and cooling periods.

INTRODUCTION

Previous studies showed that energy costs in swine operations range from about $7 to $12 per pig sold; this has steadily increased over recent years and now represents the third largest variable cost in hog production (after feed and labour). Maintaining the desired conditions year round in a production barn requires significant amount of energy, particularly in cold climate regions. A survey of 28 swine farms in Saskatchewan showed that heating and ventilation costs constitute almost 80% of energy used in various types of swine barns. Compared with conventional heating systems using either gas, oil or electricity, a geothermal system utilizes ground heat to provide primary heating and cooling.

RESULTS AND DISCUSSION

Computer simulation analysis was done to calculate the overall heating energy use in a production room operated under normal management practices; this served as the basis for designing the required capacity and the associated components of the geothermal system needed to meet the projected heating energy consumption in the pig room.

The geothermal system, or alternatively known as ground source heating system was composed of a heat pump and 550 m of 1.9-centimetre diameter polyethylene pipes buried in 2.6 m to 3 m deep trenches on the ground outside the PSCI barn. The buried pipes contained 20% methanol - 80% water solution for absorbing heat from the ground for heating and for using the ground as heat sink during the cooling trial. A 5-ton heat pump which used R-410a refrigerant was installed in the geothermal room and its air-handling unit was connected to the room's air recirculation duct. A 22-kW forced convection heater was also installed in the room as back-up heater.

Energy consumption for heating and ventilation

Energy consumption for heating and ventilation comprised the total energy use in each experimental room. Energy consumption for heating included both the electrical and heating fuel consumption of the geothermal heat pump and heaters while that for ventilation included the electrical consumption for both ventilation and recirculation fans. For the three heating cycles used in this analysis, the heaters needed to operate only during the first 3 to 6 weeks of the trial when the pigs were still small and the room temperature setpoint were the highest (i.e., supplemental heat from the heaters were required to maintain the setpoint temperature). On subsequent weeks of the room cycle, the heaters were only needed minimally with negligible energy usage because the heat generated by the pigs was sufficient to maintain the setpoint temperature in the room.

Figure 1. Heat pump used in the geothermal system installed in a grow-finish room.

Table 1. Energy consumption for heating and ventilation in the geothermal and control rooms over three heating trials

Trial	Heating		Ventilation	
	Geothermal, kWh electricity	Control, m3 natural gas	Geothermal, kWh	Control, kWh
1	1232	226.5	476	426
2	705	201.2	194	199
3	1682	141.6	175	181
Average	1206 ± 489	189.8 ± 43.6	282 ± 169	268 ± 136

Table 1 shows the energy consumed by the geothermal and control rooms for heating and ventilation during the period when heaters were running. On average, the room with the conventional gas-fired heater (Control) consumed a total 189.8 ± 43.6 m^3 of natural gas for heating. The room with the geothermal heating system did not use any natural gas but consumed a total of 1206 ± 489 kWh of electricity mainly to run the heat pump. On the other hand, the energy consumption for ventilation in the control room was about 268 ± 136 kWh of electricity while the geothermal room used about 282 ± 169 kWh of electricity to ventilate the room during the heating season.

Since the heating fuel consumption was expressed in terms of cubic metres (m^3) of natural gas while electrical consumption of heaters and fans was in kWh, the weekly average energy consumption data of the two rooms were converted to gigajoules (GJ) to be able to compare the two heating systems. Results showed that the weekly energy consumption for heating the geothermal room was significantly lower ($p<0.10$) than in the control room. Additionally, the two rooms did not differ significantly in average weekly energy consumption for ventilation. Thus, over one growth cycle, the geothermal heating system required less energy (5.36 GJ) to extract heat from the ground and to heat the room air compared to the conventional natural gas-fired heater (8.43 GJ); this is about 36% significant reduction ($p<0.10$) in total energy needed for heating and ventilation compared to the control room.

Temperature and relative humidity

Average air temperature at the center of the rooms as well as the temperature and relative humidity near the exhaust fans when heaters were in operation are presented in Table 2. Both rooms had almost the same room air temperature and relative humidity over the three heating trials. On average, the temperature at the center of the room with the geothermal heating system was about 21.3 ± 0.5 ^{0}C while the control room had 21.8 ± 0.6 ^{0}C. Furthermore, an average temperature of about 19.6 ± 1.0 ^{0}C and relative humidity of 60.2 ± 6.9 % were observed near the exhaust area of the geothermal room; these were about 4.8% less than the corresponding temperature and relative humidity in the control room, respectively.

CONCLUSION

Based on the findings of this study, the following conclusions can be made:

i. In-barn evaluation of the geothermal system showed about 36% reduction in energy consumption for heating and ventilation in the room with the geothermal system during the heating season relative to the room with the conventional forced-convection heater. The mean air temperature, relative humidity, and air quality within the two rooms were relatively similar during winter season.

ii. During the cooling season, the geothermal room had higher total energy for heating and ventilation (1475 kWh higher) than that in the conventional room, mainly for the operation of the heat pump. Average room air temperature was cooler in the geothermal room compared to the conventional room.

iii. Significant reduction in methane and carbon dioxide concentration during heating and cooling trials was observed in the room with the geothermal system relative to the room with the conventional gas-fired heater.

ACKNOWLEDGEMENTS

Project funding provided by Saskatchewan Agriculture Development Fund and the Saskatchewan Pork Development Board. Strategic funding provided by Sask Pork, Alberta Pork, Ontario Pork, Manitoba Pork Council and Saskatchewan Agriculture Development Fund.

Table 2. Average air temperature (^{0}C) and relative humidity (%) in the geothermal and control rooms when heaters were in operation.

Trial	Temperature at center of room, ^{0}C		Temperature near the exhaust fans, ^{0}C		Relative Humidity, %	
	Geothermal	Control	Geothermal	Control	Geothermal	Control
1	20.9	21.2	18.4	19.2	67.3	67.5
2	21.8	22.3	20.0	19.8	59.9	65.9
3	21.3	21.9	20.3	20.2	53.5	61.5
Average	21.3 ± 0.5	21.8 ± 0.6	19.6 ± 1.0	19.7 ± 0.5	60.2 ± 6.9	65.0 ± 3.1

Nanoparticles for Controlling Disease-Causing Microorganisms in Pig Barns

B.Z. Predicala, and A.C. Alvarado

Bernardo Predicala

Alvin Alvarado

SUMMARY

Laboratory-scale tests were conducted to evaluate the effectiveness of various types of commercially-available nanoparticles on the levels of microorganisms commonly encountered in swine barns. Results indicate Zinc oxide (ZnO) nanoparticles had the highest antimicrobial efficacy among all the nanoparticles tested. Further experiments carried out in the barn indicated that partial filtration of barn air with a filter loaded with ZnO nanoparticles in the ventilation recirculation system achieved reduction in bioaerosol levels at the animal- and human-occupied zones. During sanitation, 10 mg/mL of ZnO nanoparticle solution sprayed on concrete pen floor surfaces showed significant decrease in total bacterial counts on surfaces four hours after application. Microbial population, however, started to increase after new nursery pigs were brought into the room.

"Zinc oxide (ZnO) nanoparticles had the highest antimicrobial efficacy among all the nanoparticles."

INTRODUCTION

Previous research has shown that selected nanoparticles can effectively reduce the levels of specific hazardous gases (hydrogen sulphide and ammonia) in swine barns (Alvarado et al., 2014). Since nanoparticles are also known to have antimicrobial properties (Sunada et al., 1998), it is interesting to evaluate if nanoparticles can be used in controlling the growth and airborne transmission of microorganisms in swine barns. If proven effective, then with a single treatment application, this technology could simultaneously address concerns with hazardous gas emissions as well as the spread of diseases, both of which have great impact on the overall profitability and sustainability.

Control of diseases in swine production is generally conducted on two fronts: biosecurity measures are put in place to prevent entry of infectious agents into the herd, and sanitation measures are conducted to prevent exposure of pigs to high levels of potentially disease-causing microorganisms within the production facilities. Conventional sanitation procedures involve high-pressure washing of pens and room surfaces followed by application of a disinfectant to kill remaining pathogens.

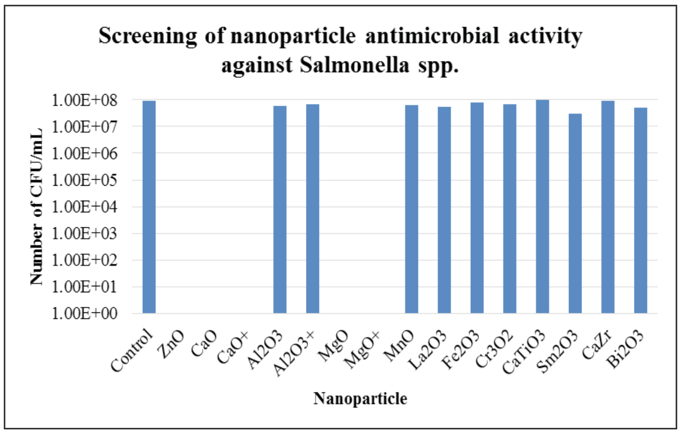

Figure 1. Results of exposing Salmonella cultures to 11 types of nanoparticles separately and then monitoring the number of colony-forming units (CFUs) after incubation for 16 hr at room temperature.

This project set out to control the growth and spread of disease-causing microorganisms in production facilities using commercially-available nanoparticles. Specifically, this study aimed to investigate application alternatives that can be implemented in barns for effective use of nanoparticles to control the spread and transmission of disease-causing microorganisms, assess the effectiveness of nanoparticles as an alternative method for sanitation, and conduct a technical and economic feasibility study of applying nanoparticle treatment technology in a commercial swine production operation.

RESULTS AND DISCUSSION

The inhibitory effect of eleven different types of nanoparticles was tested against representative Gram-positive (*Listeria monocytogenes, Streptococcus suis*) and Gram-negative organisms (*Pseudomonas fluorescence and Salmonella spp.*). As shown in Figure 1, this screening indicated that ZnO, CaO, CaO+, MgO and MgO+ had the greatest impact on the survival of microorganisms (i.e., with Zn and Mg basically completely eliminated all the surviving cells within 16 hr) whereas some of the other agents had no effect on cell number. Thus, ZnO, CaO and MgO agents were used in subsequent tests.

Barn evaluation of ZnO nanoparticles

Effect of treatment on airborne bioaerosols

The total CFU concentrations in the ventilation inlet stream as well as in the animal- and human-occupied zones of the pig-rearing chambers are shown in Figure 2.

Among the three sampling locations, the total CFU concentrations in the animal-occupied zones (about 0.5 m from pen floor) were the highest; on average, bioaerosol levels in the animal-occupied zones of the treated chamber were 3.4 times higher than the inlet concentrations, while the control chamber values were 5.1 times higher than the corresponding inlet concentrations. Additionally, while the CFU levels in the control room showed increasing trends as the trial progressed, a slight reduction (5%) was observed in the treated chamber 10 days after the filter with ZnO nanoparticles was installed. On day 10, mean CFU concentration in the animal-occupied zone of the treated chamber was 926 ± 207 CFU/m3 while the control chamber had 1583 ± 1458 CFU/m3. The control chamber, however, showed increasing trends until day 10.

Microbial loads on surfaces

Surfaces in the treated chamber exhibited a reduction in microbial levels 10 days after the filter with ZnO nanoparticles was installed. About 1.7, 1.3 and 1.4 log reduction was achieved in the concrete, metal and plastic surfaces, respectively. This reduction, however, could not be solely attributed to the application of nanoparticles in the treated chamber since the control chamber also followed the same trend. Concrete, metal and plastic surfaces in the control chamber showed about 1.5, 1.4 and 1.7 log reduction, respectively, 10 days after the filter with no nanoparticles was installed.

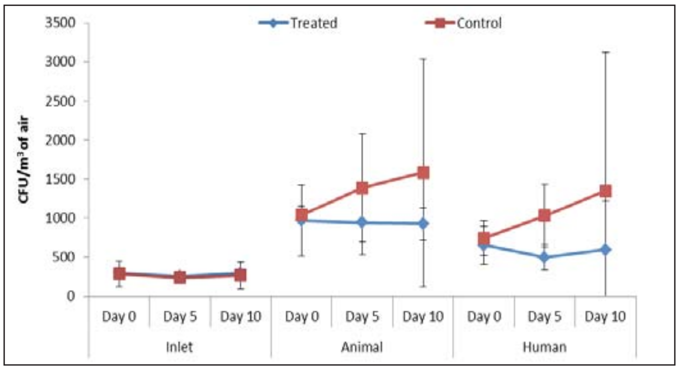

Figure 2. Mean CFU (± SD) concentration per cu. meter of air in the inlet, animal and human-occupied zones of the treated and untreated (control) chambers, n=4

Effect of treatment during sanitation

The effect of ZnO nanoparticles as a disinfectant applied as part of sanitation procedures between batches of animals in the room is shown in Figure 3. Before high-pressure washing (S1), microbial loads on surfaces were high and extremely variable, and statistical tests revealed that the total bacterial counts in all sampling locations were not significantly different ($p>0.05$) from each other. On average, CFU levels during this period ranged from 2.5×10^9 CFU/mL to 4.7×10^9 CFU/mL. These levels dropped to 6.0 $\times 10^8$ CFU/mL to 1.0×10^9 CFU/mL after high-pressure washing (S2) which could be attributed to the fact that manure and other materials deposited on the floor were removed and cleaned during the high-pressure washing. However, the trends significantly ($p<0.05$) changed 4 hours after the application of disinfectants and drying. The total bacterial counts on surfaces applied with the conventional chemical disinfectant (Control) started to increase while the surfaces applied with ZnO nanoparticles solution continued to decrease. The treatment with the higher concentration of ZnO nanoparticles (10 mg/mL) achieved about 97% significant reduction ($p<0.05$) relative to its initial concentration before high-pressure washing (S1). This reduction can be attributed to the effect of ZnO nanoparticles solution applied on those concrete floor surfaces. However, after nursery pigs were brought into the room, the total bacterial counts on all treated surfaces started to increase, with the most apparent increase observed 24 hours after pigs were moved into the room (S5).

In assessing the feasibility of the use of ZnO nanoparticles as part of sanitation procedures between batches of animals, the total cost associated with the application of ZnO nanoparticles was compared to the cost incurred when using the conventional chemical disinfectant. Using the application rate identified from the room-scale trials (10 mg/mL), the total amount of ZnO nanoparticles required to disinfect a 100-head grow-finish room at the end of each room cycle was estimated to be about 0.7 kg. The duration to prepare and apply the treatment would be about 3 hours per cycle. In addition, the total cost for the required materials included the cost of mixing containers, weighing scale and funnels. Summing up all these estimates, the total cost associated with ZnO nanoparticles as a disinfectant in a grow-finish stage of operation was around CAD$1.14 per finished pig. This was just CAD$0.12 per pig higher than the use of the conventional disinfectant (CAD$1.02 per finished pig). The unit price per kilogram of the conventional disinfectant was slightly higher than ZnO nanoparticles but because of its higher water solubility, the time to prepare and apply the treatment was lower than with ZnO nanoparticles. Nevertheless, the slim margin of the total cost associated with ZnO nanoparticle solution compared to the conventional chemical disinfectant can be compensated by its effectiveness to reduce further the levels of microorganisms on surfaces when preparing the room for next growth cycle.

CONCLUSION

1. Specific type of commercially-available nanoparticles such as Zinc Oxide (ZnO) nanoparticles were found to be effective in controlling growth of selected pathogens that can be encountered in swine production environments.
2. Deploying the nanoparticles in filter systems through which barn air is passed can effectively reduce the levels of airborne bioaerosols in a pig barn. The set-up can be made more effective with better capture of air in the room to pass through the filter system.
3. Sanitation procedures involving the application of nanoparticles in solution on pig barn surfaces can effectively inhibit the growth of microorganisms and can be an alternative to conventional chemical disinfectants.
4. Using current cost estimates and application parameters, the use of ZnO nanoparticle solution during sanitation was only about 12 cents higher than the use of the conventional disinfectant.

ACKNOWLEDGEMENTS

We would like to acknowledge the financial support for this research project from the Saskatchewan Agriculture Development Fund, the Agriculture and Food Council of Alberta, and the Saskatchewan Pork Development Board. 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.

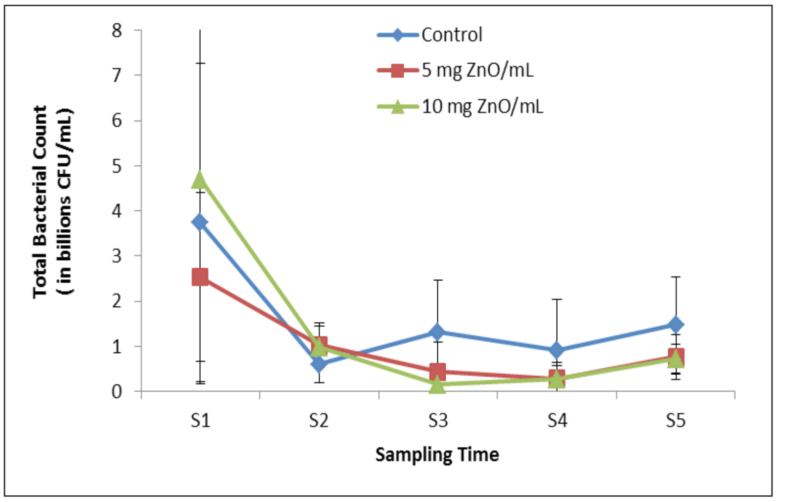

Figure 3. Mean (± SD) bacterial counts from surfaces treated with the conventional chemical disinfectant (Control) and the surface treated with ZnO nanoparticles at varying application rates, n=3. S1 = before high-pressure washing; S2 = right after washing and drying (disinfectants applied right after taking samples); S3 = 4 hr after sanitation and drying; S4 = 1 hr after pigs moved into the room; S5 = 24 hr after pigs moved into the room

Treating Swine and Municipal Wastewater with Microbial Fuel Cell Technology

B.Z. Predicala[1], M Nemati[1], L.D. Moreno[1,2]

Bernardo Predicala

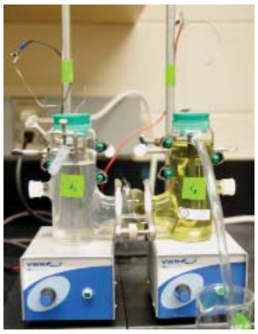

Figure 1. MFC in operation under batch conditions

SUMMARY

Wastewater generated in the agriculture sector contain organic and nitrogenous compounds which represent a valuable source of energy that could be harnessed to offset the energy required for wastewater treatment. The potential use of microbial fuel cell (MFC) technology for treatment of agricultural wastewater was evaluated. Using model compounds (i.e., lactate, acetate, phenol), it was shown that treatment of organic and nitrogenous compounds with concomitant generation of energy can be achieved successfully in microbial fuel cells, with biodegradation rates in continuous mode MFCs significantly higher than in batch systems. Biodegradability of the organic compounds influenced the open circuit potential (OCP), electrical current and power generation, which were higher in continuously operated MFCs. The possibility of biological removal of ammonia and nitrite (nitrification and nitritation processes) in the MFC systems was also demonstrated.

INTRODUCTION

Wastewater can contain organic and nitrogenous compounds (i.e. ammonia) and produced as a result of agricultural activities, including those generated in livestock operations and food processing plants. Conventional treatment processes are costly and livestock producers are increasingly facing challenges with cost of production and environmental impacts of land application of livestock wastewater. As a result there is great interest to find alternatives for the treatment and safe disposal of waste streams and if possible, offset the associated cost through generation of energy.

Treatment of wastewater requires a considerable amount of energy. Organic and nitrogenous contaminants in the wastewater represent a source of energy that if harnessed could offset the energy required for wastewater treatment and even produce a positive net energy.

This project examined the potential use of microbial fuel cell technology in treatment of agricultural wastewater containing organic and nitrogenous compounds. The long term objective was to develop a biotechnology-based treatment of agricultural wastewater to reduce or eliminate the pollutants and potentially convert the energy stored in the organic or nitrogenous compounds into electricity. Specific objectives of this project were to treat wastewater contaminated with organic compounds using microbial fuel cells (MFC) with a biological anode and a chemical cathode, and to develop a complete fuel cell with a bioanode for the removal of ammonia and organics and a biocathode for the treatment of actual wastewaters from a swine barn and municipal wastewater treatment facility.

RESULTS AND DISCUSSION

MFC configuration and operation

Experiments were conducted using H-type configuration fuel cells (Logan, 2008) shown in Figure 1. The two fuel cell chambers (anode and cathode chambers) were separated by a Nafion (NE-1035) high exchange capacity proton exchange membrane (PEM). Electrodes made of graphite rods were fixed into each chamber and chrome wires connect the chambers to complete the circuit. *Pseudomonas putida* was used as the biocatalyst for the MFC.

Two short-chain fatty acids, specifically lactate and acetate at concentrations of 1,000, 2,500 and 5,000 ppm, were tested in an H-type MFC under batch conditions. Figure 2 shows the results in terms of open circuit potential, biomass growth and substrate removal for the tests with 1,000 ppm lactate. It was observed that as the biomass concentration (represented by OD) increased, the concentration of organic substrate decreased over time. As expected, *P. putida* consumed the available organic substrate for their maintenance and growth. With the degradation of lactate, P. putida produced acetate at the same time and then consumed it as well once lactate was depleted. The removal of organic substrate and the corresponding increase in biomass was related to increase in the open circuit potential (OCP) as the bacteria started to grow and degrade the organic substrate.

[1] Prairie Swine Centre Inc, PO Box 21057, 2105 - 8th Street East, Saskatoon, SK, S7H 5N9
[2] Dept of Chemical and Biological Engineering, University of Saskatchewan, Saskatoon, SK

Potential, current and power measurements

Under batch conditions, the maximum OCP obtained with lactate ranged from 505-563 mV, while with acetate the range was 393-538 mV, and with phenol was 361-420 mV. For the continuous system, the highest OCP obtained was 705 mV, which was considerably higher compared to that in the batch system. The power and current generated per surface area of the anode electrode were measured in all the tests. In the batch systems using a single graphite rod electrode, the highest power and current densities obtained with lactate as substrate were 3.3 mW/m^2 and 48.2 mA/m^2, while with acetate the values were 1.1 mW/m^2 and 29.5 mA/m^2, and with phenol they were 2.0 mW/m^2 and 36.9 mA/m^2, respectively. In the corresponding continuous system with lactate, the highest power and current densities achieved were 8.1 mW/m^2 and 43 mA/m^2, respectively. The power and current output measured from the continuous system were generally higher compared to those obtained from the batch system.

Wastewater treatment in MFC

Batch trials using wastewater as substrate in the MFC were also conducted. The reactor was filled with 250 mL of municipal or diluted swine wastewater. Concentration of organics in the wastewater was measured in terms of chemical oxygen demand (COD) using Hach COD reactor digestion method. COD removal of municipal wastewater was 75% and physical appearance of wastewater was clearer (less turbid) after the test period of approximately 165 h. For swine wastewater, initial COD readings were significantly high (> 6000 ppm) hence, a 1:5 dilution with McKinney`s medium was done to make a less concentrated substrate of around 2200 ppm COD. As shown in Figure 3, removal of organics from swine wastewater was considerably fast (<12 h). The amount of COD removed was 73%. Swine wastewater has been chosen as substrate for subsequent MFC experiments, anticipating potentially larger range for removal of organics.

Microbial fuel cells used for ammonia and nitrite removal

Medium containing 7, 18 and 36 mM NH4+-N were tested to evaluate the effect of ammonia concentration on oxidation of ammonia (nitrification) and generation of electricity. A number of batch runs was carried out using resazurin as an electron mediator. Results clearly demonstrated the possibility of biological oxidation of ammonia and nitrite (nitrification and nitritation processes) in MFC systems. In the presence of resazurin as an electron mediator, the oxidation of ammonia was much faster, though the nitrification characteristics (oxidation of ammonia to nitrite and consequently to nitrate) did not change. Nitrite oxidation in the MFC was much more consistent and reproducible compared to ammonia. In sequential batch runs with either ammonia or nitrite, the performance of the MFC improved after consecutive trials to the point where the oxidation rate was comparable to that in an aerated conventional reactor. This highlights the importance of maintaining the microbial population in the MFC and repeated use of cells.

CONCLUSION

Results revealed that treatment of organic and nitrogenous compounds with concomitant generation of energy can be achieved successfully in microbial fuel cell type bioreactors. In continuously operated MFC system, the removal rate of lactate, phenol or combination of lactate and phenol were significantly higher than that in the batch systems regardless of type of electrode (single graphite rod vs. granular graphite), while performance of the MFCs packed with graphite granules were much better than MFCs with single rod electrode.

The biodegradation (removal) of lactate, acetate and phenol was accompanied by rise in open circuit potential (OCP) and current generation, with the extent of generated power being influenced by biodegradability of the organic compound. The OCP, power and current generation were higher in the continuously operated MFCs when compared to those obtained in the batch MFCs. Experiments with municipal and swine wastewaters were successful, indicating the potential use of MFCs for treating wastewater. Investigating the biological removal of ammonia in bioreactors provided valuable biokinetic data regarding the process of nitrification.

ACKNOWLEDGEMENTS

We would like to acknowledge the financial support for this research project from the Saskatchewan Ministry of Agriculture. 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.

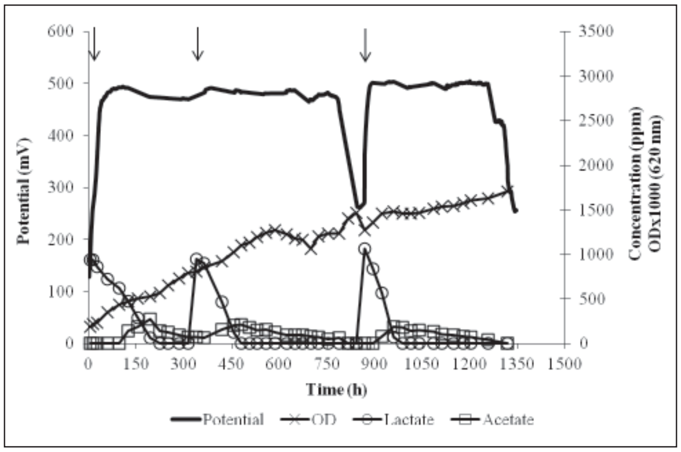

Figure 2. Open circuit potential and organic degradation in an MFC by P. putida fed with 1000 ppm lactate. Arrows indicate the time of lactate addition.

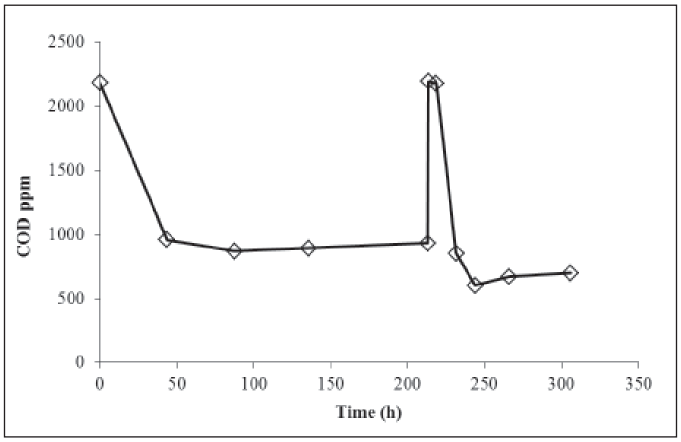

Figure 3. Removal of organic compounds in swine wastewater operated under batch conditions.

Compounding Iron Dextran with NSAIDs for Use in Piglets at Time of Processing

R.J. Johnson, T. L. O'Sullivan, R.M. Friendship

Ron Johnson

SUMMARY

The objective of this project was to evaluate whether the mixing (compounding) of NSAIDs (anti-inflammatory/analgesic agents), such as meloxicam or flunixin meglumine, with iron dextran for administration to piglets at the time of processing has any effects on the availability of the NSAID. In a series of experiments, we evaluated the stability and systemic availability of both NSAIDs when mixed with iron dextran in the same bottle for administration to piglets at the time of processing. We also evaluated the effects of this practice on iron dextran's ability to increase piglet hemoglobin concentrations. We found that the amount of NSAID recovered from the bottle was reduced beginning shortly after mixing. We also found that blood drug levels measured in piglets for each NSAID when compounded with iron dextran was significantly lower than when each NSAID was administered alone to piglets. We did not find any significant effects of mixing NSAIDs with iron dextran on iron dextran's ability to increase hemoglobin following administration to piglets. The overall conclusion from these experiments is that the mixing of NSAIDs with iron dextran in the same bottle for administration to piglets at the time of processing results in a suspected drug interaction that reduces the shelf-life of the formulation and the amount of NSAID available for therapeutic effects.

INTRODUCTION

When NSAIDs (anti-inflammatory/analgesic agents) such as meloxicam or flunixin meglumine are administered to piglets at the time of processing, it is tempting to mix or compound the NSAID with iron dextran to be delivered in a single injection, thereby reducing the number of injections to the piglet. Technically the practice of mixing two different products in the same syringe/bottle is not allowed under the Canadian Quality Assurance program, nor is the compounding of drugs for food animal use acceptable to the Canadian Global Food Animal Residue Avoidance Databank, but we are aware that this practice does occur and therefore it seems prudent to evaluate possible drug interactions that could affect the absorption and availability of either the NSAID or iron. The study was carried out using three separate experiments and performed at the University of Guelph, with the following objectives i) to evaluate the bioavailability of meloxicam (Metacam® 20 mg/mL Solution for Injection, Boehringer Ingelheim Canada LTD) and flunixin meglumine (Banamine®, Merck Animal Health) when compounded with iron dextran (Dexafer-200®, Vetoquinol) and administered to newborn piglets of approximately 5 days of age, ii) to evaluate the effect of compounding these agents on iron dextran's ability to increase piglet hemoglobin concentrations, and iii) to evaluate the storage life by measuring concentrations of the NSAIDs at various times after mixing with iron dextran.

RESULTS AND DISCUSSION

Measurement of recoverable flunixin meglumine and meloxicam when compounded in iron dextran was accomplished using high performance liquid chromatography. Our results showed that recoverable levels of either NSAID were reduced, beginning as early as 2 hours post-mixing, and with over 30% reduction in recoverable flunixin meglumine concentrations and over 10% reduction in meloxicam concentrations by 24 hours post-mixing. These findings suggested a probable drug interaction that could result in reduced NSAID being available for systemic absorption when administered to piglets. In the first of our two live animal experiments, we found no significant effects of compounding either NSAID with iron dextran on measured blood hemoglobin levels, indicating no significant effects on the iron status of the pig. The results of our bioavailability study (n= 8 piglets per group) comparing blood NSAID levels for flunixin meglumine and meloxicam when administered to piglets alone versus compounded in iron dextran did show notable findings. Piglets receiving flunixin meglumine were dosed intramuscularly at 2.2 mg/kg either as the NSAID alone or when compounded with iron dextran. Piglets receiving meloxicam were also dosed intramuscularly at 0.4 mg/kg as the NSAID alone or when compounded with iron dextran. Multiple blood samples collected shortly after dosing to 72 hours post-dosing were analyzed for meloxicam or flunixin meglumine using validated mass spectroscopy methods. Results showed significantly reduced concentrations of both NSAIDs when compounded with iron dextran compared to levels noted when NSAID was given alone rendering the compounding of NSAIDs with iron dextran not bioequivalent to NSAIDs administered alone.

CONCLUSION

The results of our study show that the mixing of meloxicam or flunixin meglumine with iron dextran likely produces a drug interaction, which does not appear to affect iron dextran's ability to maintain adequate hemoglobin concentrations, but does reduce the availability of the NSAID for absorption into the systemic circulation. The clinical ramifications of the reduced blood NSAID levels when compounding with iron dextran require additional efficacy studies to evaluate whether adequate analgesia is being provided at the current NSAID concentrations in the compounded formulation. Importantly, if flunixin meglumine or meloxicam is mixed with iron dextran for administration to piglets at the time of castration and processing the compounded product needs to be used right away.

ACKNOWLEDGEMENTS

This project was funded through the Ontario Farm Innovation Program and Ontario Pork.

Zinc Oxide and Antimicrobial Resistance in Pigs

R.J. Johnson, T. L. O'Sullivan, R.M. Friendship

Ron Johnson

SUMMARY

The objective of this research was to investigate whether therapeutic use of zinc oxide (ZnO) in swine production creates selective pressure for the emergence of methicillin-resistant Staphylococcus aureus (MRSA) due to co-location of the zinc-resistance gene (czrC) and methicillin-resistance gene (mecA) within the staphylococcal cassette chromosome mec (SCCmec). A randomized-controlled trial was completed using 110 pigs that were naturally colonized with czrC-positive MRSA. The prevalence of MRSA was significantly higher when pigs were fed a ration containing 3000 ppm of zinc oxide compared to the control group (100 ppm zinc). In an observational study of 26 farms, it was found that the use of therapeutic levels of zinc oxide (>2000 ppm) was associated with a higher likelihood of finding MRSA in nasal swabs of weanling pigs. The overall conclusion from these studies is that high levels of zinc oxide in starter rations are associated with a higher prevalence of pigs carrying MRSA.

INTRODUCTION

Zinc is an essential nutrient and needs to be provided in starter rations at around 100 ppm to meet the pig's nutritional requirements. Levels of 2000 to 3000ppm of zinc oxide are often used in early starter rations as a therapeutic agent to control post-weaning E. coli diarrhea. Bacteria can carry resistance to heavy metals such as zinc and there is concern that the use of zinc oxide as a therapeutic agent might inadvertently co-select for antibiotic resistance. Of particular public health concern is methicillin resistant Staphylococcus aureus (MRSA), an organism commonly isolated from the nasal cavities of pigs and is often found on farms where antibiotics are not used. The objectives of this research was to determine whether the herd prevalence of MRSA among nursery pigs is affected by exposure to therapeutic levels of in-feed ZnO (3,000 mg/kg) when compared to the recommended dietary levels of in-feed ZnO (100 mg/kg), and to investigate risk factors for MRSA shedding in pigs in commercial nursery herds with a particular focus on antimicrobials, heavy metals, disinfectants, biosecurity, and management practices.

RESULTS AND DISCUSSION

Trial 1

Fifty weaner pigs received feed containing therapeutic levels of ZnO (3,000 ppm) and 49 pigs received a control feed containing 100 mg/kg of zinc. Pigs receiving therapeutic levels of ZnO were significantly more likely to carry MRSA on day 28 (OR=18.1, P=0.007) and day 35 (OR=3.01, P=0.015) when compared to the control pigs (see figure 1).

Trial 2

Nasal cultures for MRSA were completed for 390 pigs from 26 farms at the end of the suckling phase and again at 3-weeks post-weaning. Herd-level information was collected and a random subset of MRSA isolates was screened for resistance to zinc. Multivariate analysis revealed that the concentration of in-feed zinc (P<0.001) and frequent disinfection of nursery pens (P<0.001) were associated with pigs carrying MRSA (see Table 1). Furthermore, 62.5% (25/40) of MRSA isolates carried the zinc-resistance gene czrC and were phenotypically resistant to zinc. The use of therapeutic levels of zinc oxide in starter feeds appeared to be an important risk factor in the persistence of MRSA in commercial swine herds.

CONCLUSION

Overall, exposure to therapeutic levels of in-feed ZnO is associated with an increase in the prevalence and persistence of MRSA among pigs, particularly during the early phase of the nursery.

ACKNOWLEDGEMENTS

Strategic funding provided by the University of Guelph and the Ontario Ministry of Agriculture and Food, and Rural Affairs Research Partnership and by Ontario Pork.

Table 1. Factors associated with methicillin-resistant Staphylococcus aureus in nursery herds.

Parameters	MRSA positive cohorts (n=8)	MRSA negative cohorts (n=14)	P-value
Herd size (sows, SD)	698 (433)	425 (427)	0.076
Continuous nursery flow (%)	25	57.1	0.204
Average weaning age (days, SD)	22.4 (2.6)	24.5 (4.8)	0.351
Nursery stocking density (pigs/m2, SD)	3.22 (1.23)	2.47 (1.17)	0.048
No outside breeding stock replacements (%)	62.5	71.4	0.999
Danish entry (%)	37.5	42.9	0.999
Shower-in/shower-out required (%)	62.5	28.6	0.187
Nursery pens disinfected for incoming pigs every time (%)	100	50	0.022
Corridors are disinfected on a weekly to monthly basis (%)	87.5	42.9	0.074
Cat(s) and/or Dog(s) on the property (%)	37.5	92.9	0.011
Live rodents observed in barn at sampling (%)	12.5	7.1	0.999
Wild birds observed in barn in past year (%)	12.5	42.9	0.193
Antibiotics administered by feed (%)	87.5	78.6	0.999
Antibiotics administered by water (%)	37.5	42.9	0.999
Antibiotics administered by injection (%)	87.5	71.4	0.613
Zinc therapyb (≥2,000 ppm in-feed) (%)	100	50	0.022

Publications List

Alvarado, A. and **B. Predicala.** 2014. Effect of nanoparticles on gas emissions and growth and transmission of microorganisms in swine production facilities. Paper No.: 1913472. 2014 ASABE and CSBE/SCGAB Annual International Meeting. Montreal, Quebec. July 13-16, 2014.

Alvarado, A. and **B. Predicala**. 2015. Control of gas and odour levels in swine facilities using filters with zinc oxide nanoparticles. Prepared for submission to Applied Engineering in Agriculture.

Beaulieu, A.D, J.A. Brown and **Y.M. Seddon**. 2015. Intensive swine production. The interaction between animal welfare, behaviour and nutrition. 4th PHode Synergetic 2015 Forum. Columbia.

Beaulieu, A.D, 2015. Getting the newly weaned pig off to a good start. Effects of diet and weaning weight. National Hog Farmer. June 20154.

Bilsborrow, K., **J.A. Brown**, **Y.M. Seddon**, C. Waldner, and J.M. Stookey,J. (2014) Validation of a behavioural test for assessing pain in piglets following castration. In: Proceedings of the 23rd International Pig Veterinary Society Congress, Cancún, Mexico, 8th – 11th June, pp. 122.

Bilsborrow, K., **Y.M. Seddon**, **J.A. Brown**, C.Waldner, J.M. Stookey, 2015. Validation of a novel behavioural test for assessing pain in piglets following castration, CJAS (submitted).

Bouvier, M. M., **S.A. Ethier**, **J.A. Brown**, Y.Z. Li, and **Y.M. Seddon** (2014) Mixing strategies for group housed sows: effects on aggression and productivity. Proceedings of the 12th ISAE North American Regional Meeting, East lansing, MI, 30-31 May, p. 39.

Brown, J.A., **Y.M. Seddon**, S.E. Edwards, **A.D. Beaulieu**, and D. Boussieres, 2015. Determining the optimum stocking density in nursery pigs, PSC Annual Report 2014-2015.

Brown, J.A., **Y.M. Seddon**, Y.Z. Li, M.M. Bouvier. (2015). Mixing strategies for group-housed gestating sows: effects on production. J Anim Sci, 93 (Suppl. 2), p. 3.

Eastwood L. and **A. D. Beaulieu**. 2014. Changing the dietary omega-6 to omega-3 fatty acid ratio impacts nursery pigs' more than omega-3 intake alone. PSCI Centred on Swine Vol. 20(1).

Eastwood L. and **A. D. Beaulieu**. Altering dietary omega-6 to omega-3 fatty acid ratios impacts the inflammatory responses of piglets challenged with lipopolysaccharide.

Eastwood L. and **A. D. Beaulieu**. Altering dietary omega-6 to omega-3 fatty acid ratios impacts protein turnover in nursery piglets.

Eastwood L. and **A. D. Beaulieu**. Changing the dietary omega-6 to omega-3 fatty acid ratio impacts nursery pig performance and health more than omega-3 intake alone.

Eastwood L. and **A. D. Beaulieu**. Changing the dietary omega-6 to omega-3 fatty acid ratio impacts nursery pig performance and health more than omega-3 intake alone.

Eastwood L. and **A. D. Beaulieu**. 2014. Changer le ratio d'acides gras alimentaires oméga-6⁄oméga-3 a plus d'impact sur la productivité des porcelets en pouponnière que la simple augmentation de la consommation d'acides gras oméga-3. Porc Québec Magazine.

Eastwood L. and **A. D. Beaulieu**. 2014. Feeding mycotoxin contaminated grain to swine. PSCI Centred on Swine Vol. 20(1).

Eastwood L., **D. A. Gillis**, **M. R. Deibert** and **A. D. Beaulieu**. 2015. Feeding value of cull lentils for growing swine. PSCI Annual Report.

Eastwood L., **D. A. Gillis**, **M. R. Deibert** and **A. D. Beaulieu**. 2015. Can sow diets enriched with extruded flaxseed replace antibiotics in starter feeds for piglets? PSCI Annual Report.

Eastwood L., **D. A. Gillis**, **M. R. Deibert** and **A. D. Beaulieu**. 2015. Feeding value of cull lentils for growing swine. PSCI Centred on Swine Vol. 20(2).

Eastwood L., **D. A. Gillis**, **M. R. Deibert** and **A. D. Beaulieu**. 2015. Feeding value of cull lentils for growing and finishing swine. Abstract and Poster Presentation, ASAS/ADSA Midwest Section Meeting, Des Moines, IA.

Eastwood L., **D. A. Gillis**, **M. R. Deibert** and **A. D. Beaulieu**. 2015. Feeding value of cull lentils for growing and finishing swine. Abstract and Poster Presentation, Banff Pork Seminar, Advances in Pork Production Vol. 25.

Eastwood L., **D. A. Gillis**, **M. R. Deibert** and **A. D. Beaulieu**. Can sow diets enriched with extruded flaxseed replace antibiotics in starter feeds for piglets?

Eastwood L., **D. A. Gillis**, **M. R. Deibert** and **A. D. Beaulieu**. Can sow diets enriched with extruded flaxseed replace antibiotics in starter feeds for piglets?

Eastwood L., **D. A. Gillis**, **M. R. Deibert** and **A. D. Beaulieu**. 2015. Can omega-3 fatty acids replace antibiotics in starter feeds? Abstract and Oral Presentation, ASAS/ADSA Midwest Section Meeting, Des Moines, IA.

Eastwood L., **D. A. Gillis**, **M. R. Deibert** and **A. D. Beaulieu**. 2015. Can sow diets enriched with extruded flaxseed replace antibiotics in starter feeds? Abstract and Poster Presentation, Banff Pork Seminar, Advances in Pork Production Vol. 25.

Eastwood L., **J.N. Shea**, **D. A. Gillis** and **A. D. Beaulieu**. Inclusion of spray-dried plasma in nursery pig diets mitigates the negative impact of deoxynivalenol (DON).

Eastwood L., **J.N. Shea**, **D. A. Gillis** and **A. D. Beaulieu**. Inclusion of spray-dried plasma in nursery pig diets mitigates the negative impact of deoxynivalenol (DON).

Eastwood L., P. Leterme and **A. D. Beaulieu**. 2014. Changing the omega-6 to omega-3 fatty acid ratio in sow diets alters serum, colostrum and milk fatty acid profiles, but has minimal impact on reproductive performance. J. Anim. Sci. 92 : 5567-5582.

Eastwood L., P. Leterme and **A. D. Beaulieu**. 2015. Body fat mobilization during lactation in high producing sows fed varied omega-6 to omega-3 fatty acid ratios. Can. J. Anim. Sci (submitted).

Eastwood, L., **M.R. Deibert**, **D.L. Wightman** and **A.D. Beaulieu**. 2015. Feeding liquid dairy derivatives (whey) to nursing pigs. Joint annual meeting of the American Society of Animal Science, Orlando, FL. . July 2015.

Fox, J, T. Widowski, S. Torrey, E. Nannoni, R. Bergeron, **H.W. Gonyou, J.A. Brown**, T. Crowe, E. Mainau, and L. Faucitano, L, 2014. Water sprinkling market pigs in a stationary trailer. 1. Effects on pig behaviour, gastrointestinal tract temperature, and trailer micro-climate. Livestock Science, 160: 113-123.

Martel, M., **B. Predicala** and **A. Alvarado**. 2014. Pilot-scale evaluation of potential measures for biocontainment of swine barns. Paper No.: 1913754. 2014 ASABE and CSBE/SCGAB Annual International Meeting. Montreal, Quebec. July 13-16, 2014.

Moreno, L., M. Nemati and **B. Predicala**. 2015. Biokinetic evaluation of fatty acids degradation in microbial fuel cell type bioreactors. Bioprocess Biosyst Eng. 38:25–38. DOI 10.1007/s00449-014-1240-3

Predicala, B. 2015. Benchmarking and standardization of swine production systems. Agriview. Saskatchewan Ministry of Agriculture. Regina, SK.

Predicala, B 2015. Evaluation of a geothermal system for swine production. Agriview. Saskatchewan Ministry of Agriculture. Regina, SK.

Predicala, B. 2015. Improving Swine Transport: Design considerations for a new and improved trailer? Presentation at the Swine Innovator's Club meeting. January 20, 2015. Banff, AB.

Predicala, B. 2015. Novel application of nanotechnology for controlling growth and transmission of disease-causing microorganisms in livestock operations. Agriview. Saskatchewan Ministry of Agriculture. Regina, SK.

Predicala, B. and **A. Alvarado.** 2014. Alternatives for animal drinking and barn cleaning to reduce water use in swine facilities. Canadian Biosystems Engineering Journal. 56:5.7-5.15. DOI 10.7451/CBE.2014.56.5.7.

Predicala, B.Z. and **A.C. Alvarado**. 2014. Development of an alternative temperature management system for group-housed sows to reduce heating costs. Poster presented at the Saskatchewan Pork Industry Symposium. November 18-19, 2014. Saskatoon, SK.

Predicala, B., **A. Alvarado** and **L. Dominguez**. 2014. Evaluation of a ground source heat pump system for heating and cooling a swine production barn. Paper No. C0674. AgEng 2014 – International Conference of Agricultural Engineering. Zurich, Switzerland. July 6-10, 2014.

Predicala, B.Z., **A.C. Alvarado, A.D. Beaulieu**, and **J.A. Brown**. 2014. Can group-housed sows be raised at lower temperatures to reduce barn heating costs? 2013 Annual Research Report. Prairie Swine Centre. Saskatoon, SK. pp. 23-24.

Predicala, B. and **A. Alvarado**. 2014. Field testing of an air filtration system for a pig transport trailer. 2013 Annual Research Report. Prairie Swine Centre. Saskatoon, SK. pp. 25-26.

Predicala, B.Z.., S. Kirychuk, T. Crowe, K. Bartlett, G. Katselis and **D.L. Whittington**. 2014. Reducing pathogen distribution from animal transportation. Invited presentation at the 7th International Symposium: Safety & Health in Agricultural & Rural Populations (SHARP). October 19-22, 2014. Delta Bessborough Hotel, Saskatoon, SK.

Predicala, B.Z. and **A.C. Alvarado**. 2015. Development of an alternative temperature management system for group-housed sows to reduce heating costs. Poster presented at the 2015 Banff Pork Seminar. January 20-22, 2015. Banff, AB.

Rioja-Lang, F.C., **Y.M. Seddon** and **J.A. Brown** (2014) Effects of mixed and uniform parity groupings on feeding behaviour, welfare and productivity of sows in ESF housing. In: Proceedings of the 23rd International Pig Veterinary Society Congress, Cancún, Mexico, 8th – 11th June, pp. 129.

Rozeboom, G.N. and **A.D. Beaulieu**. Interaction of dietary energy concentration and stocking density on economics and welfare of finishing pig performance.

Rozeboom, G.N. Maximizing net income for pork producers by determining the interaction between dietary energy concentration and stocking density on finishing pig performance, welfare, and carcass composition. 98 p.

S. Conte, R. Bergeron, **H.W. Gonyou**, **J.A. Brown**, F. C. Rioja-Lang, L. Connor, and N. Devillers, 2014. Measure and characterization of lameness in gestating sows using force plate, kinematics and accelerometers methods. J Anim Sci, 92(12): 5693-5703.

Seddon, Y.M., F. Rioja-Lang, S. Ethier and **J.A. Brown** (2014) Evaluation of lameness prevalence in a large Canadian sow herd and an intervention to reduce prevalence. In: Proceedings of the 23rd International Pig Veterinary Society Congress, Cancún, Mexico, 8th – 11th June, pp. 125.

Seddon, Y.M., **K. Davis**, **M.M. Bouvier**, and **J.A. Brown** (2014) Stimulating exploratory behaviour in piglets: effects on pre-weaning creep consumption. In: Proceedings of the 48th International Society for Applied Ethology Congress, Vitoria-Gastiez, Spain, 29th July – 2nd August, pp. 190.

Seddon, Y.M., **M.M. Bouvier, S.A. Ethier**, Y.Z. Li, and **J.A. Brown** 2015. Weaning sows directly into group housing: Effects on aggression, physiology and productivity, PSC Annual Report 2014-2015.

Seddon, Y.M., **M.M. Bouvier, K.E. Davis** and **J.A. Brown** 2015. Stimulating exploratory behavior in piglets: effects on pre-weaning creep consumption, PSC Annual Report 2014-2015.

Seddon, Y.M., **S. Fairbrother**, **K.E. Davis** and **J.A. Brown** 2014. Stimulating exploratory behaviour in piglets: Effects on pre-weaning creep consumption. Centred on Swine 20 (1); p. 8.

Seddon, Y.M., M. Fynn, C. Xiang, M. Elliott, L. Connor, **D.L. Whittington** and **J.A. Brown** 2015. National Sow Housing Conversion Project, PSC Annual Report 2014-2015.

Stevens, B., G.M. Karlen, R. Morrison, **H.W. Gonyou**, K.L. Butler, K.J. Kerswell, K.J. and P.H. Hemsworth (2015). Effects of stage of gestation at mixing on aggression, injuries and stress in sows, Applied Animal Behaviour Science, Applied Animal Behaviour Science 165, 40–46.

Strawford, M., **B.Z. Predicala**, **D.L. Whittington**, **A.C. Alvarado**, D. Korber, S. Vidovic. 2014. Nanoparticles show promise as biosecurity tool. National Hog Farmer.

Tajallipour, M., B. Awume, M. Nemati and **B.Z. Predicala**. 2015. Control of H2S emission at ambient temperatures using ZnO nanoparticles. Submitted to Journal of Hazardous Materials. January 2015.

Tan, F. Impact of dietary calcium and phosphorus on sow reproductive performance and bone development in piglets. 151 p.

Tan, F., **L. Eastwood, D.A. Gillis** and **A.D. Beaulieu**. The effects of dietary calcium and phosphorus on reproductive performance and bone turnover of sows housed in groups or stalls.

Tan, F., Kontulainen, S. and **A.D. Beaulieu**. Effects of dietary calcium and phosphorus in gestating sows on bone development in piglets.

Turner, T.D., C. Mapiye, J.L. Aalhus, **A.D. Beaulieu**, J.F. Patience, R.T. Zijlstra and M.E.R. Dugan. 2014. Flaxseed fed pork n-3 fatty acid enrichment and contribution to dietary recommendations. Meat Sci. 96: 541-547.

Vidovic, S., **B.Z. Predicala**, J. Lawrence and D. Korber. 2014. Basic facts on porcine epidemic diarrhea virus. Canadian Food Insights. Vol. 2, Issue 3. pp. 34-36.

Vidovic, S., J. Elder, P. Medihala, J.R. Lawrence, **B.Z.s Predicala**, H.Zhang and D.R. Korber. 2015. ZnO nanoparticles impose a panmetabolic toxic effect along with strong necrosis, inducing activation of the envelope stress response in Salmonella enterica serovar Enteritidis. Antimicrob Agents Chemother 59:3317–3328. doi:10.1128/AAC.00363-15.

Financial Support

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

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

The following organizations have provided funding or donations and in-kind to support public research at the Centre throughout the 2014-2015 fiscal year.

PROGRAM SPONSORS

Agricultural Development Fund (ADF)

Alberta Pork Producers Development Corporation

Manitoba Pork Council

Saskatchewan Pork Development Board

Ontario Pork Producers' Marketing Board

MAJOR PROJECT SPONSORS

Agriculture and Agri-Food Canada

Agrivita Canada

Bunge Global Innovation

Canadian Agricultural Adaptation Program

Canadian Swine Research and Development Cluster

PROJECT SPONSORS

Agriculture Demonstration of Practices and Technologies (ADOPT)

Gowans Feed Consulting

IRDA

National Pork Board

Ontario Pork