PRAIRIE
SWINE
CENTRE
Research Profits Everyone

Annual Report

2009

PRAIRIE SWINE CENTRE

MISSION STATEMENT

We provide solutions through knowledge, ensuring a profitable and sustainable pork industry for our stakeholders and staff.

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2009 Report Highlights

Survival Strategies, Making Every Penny Count

Chairman's Report

Finding Solutions in Challenging Times

SHANNON MEYERS, Chairman of the Board

It's been a pleasure to serve the Prairie Swine Center (PSC) Board of Directors as Chairman again throughout the last year. We have a strong and diverse board that is willing to tackle the challenges the industry has faced over the last several years. Thanks to our board members who have dedicated many hours of time and thought to the PSC.

I would also like to thank President and CEO Lee Whittington and his team on their strong performance during another challenging year in the pork industry. Despite cutbacks and market challenges, the team continued to provide its stakeholders with many strong concluding statements on relevant and practical research topics. Furthermore, there are several fresh faces at the PSC which are already adding significantly to the talent pool so we look forward to even more activity and value through the coming year. Staff at the PSC have continued to show that they are willing to embrace industry challenges by becoming even more efficient at what they do.

Last year, we discussed the implementation of a new strategic plan which included moving further up and down the pork value chain. I am pleased to report that progress has been made in this area which will provide greater value to the industry as a whole and also broaden the sources of funding to the PSC. That said, I want to ensure you that the board is fully aware of the PSC mandate and that the primary stakeholders will continue to be served by the fact that the bulk of the research activity at the PSC is still directly related to primary production.

As we move into the second year of the new Sow Research Unit, we are pleased to see both the efficiencies that have been created for operations of the center itself as well as the tremendous research capability that the new unit is providing. This loose sow housing facility will provide insight into many of the questions producers have today as they contemplate the move to this type of sow housing.

Finally, we can only hope that arguably one of the worst storms the pork industry has ever seen has come to an end. All stakeholders in the industry are finally getting a reprieve, with profits finally returning to most sectors of the industry. As we sit back and take stock, its time for the industry to once again look ahead at things that will continue to make us the most competitive we can be. The last several years of turmoil has taken its toll on much of the pork industry infrastructure, particularly in Canada. As we look forward and pick up some of the pieces that have been broken, I urge all stakeholders to ensure that we maintain the vibrant infrastructure that has survived, and that we support valuable pieces of the industry like the PSC.

Regards,
Shannon

Board of Directors
Back Row L-R: Ray Price, Arlee McGrath, Dr. Jim Basinger, Dr. Hank Classen, Bob Korol, Rick Prejet
Front Row L-R: Lee Whittington, Shannon Meyers, Judy Yungwirth, Jim Babcock

President's Report

Innovative Research Addressing Industry Challenges

LEE WHITTINGTON, MBA• CEO / President

We began 2009 with optimism for a better year in the pork industry. As I review the 2008 Annual Report most of what we set out to accomplish did in fact come to fruition, but because of poor market prices it was much more difficult to begin the redefining of Prairie Swine Centre than we would have liked. Last year I included the following quotation in my report because it spoke clearly to what our best opportunity to weather the current storm was, allowing the Centre to continue providing the kind of leadership that the industry needs into the future.

"In today's marketplace it is organizational capability to adapt that is the only sustainable competitive advantage"
Willie Pietersen, in Reinventing Strategy

So Prairie Swine Centre adapted, firstly to become smaller and more efficient in line with our fiscal realities, and the expectation of our stakeholders who were going through their own changes in an effort to survive. Ultimately we emerged from arguably the worst crisis ever to grip the North American industry. We did so with most of our key capabilities intact, and a team that included some fresh faces as well as some experienced contributors. It is great to talk about new facilities, exciting research, and lower production costs. But in the end we know that it is creative, conscientious people that decide how to expend their efforts and resources that will determine our success. For that reason I want to dedicate this report to the people who have stayed with the Centre during a tough period, who watched some of their friends and co-workers move on to new careers, and who never complained about the extra responsibilities and hours required to ensure the Centre continued to meet its mandate. I also want to welcome the new people who have joined the Centre in the past year, filling positions that meet the new needs of the Centre as it evolves and looks to do our traditional tasks more efficiently, as well as seek new opportunities in new areas.

Sophisticated surgery procedures allows fundamental nutrition research and serves as a tool to evaluate changes in grain and oil seed changes from year to year.

As we seek to find new customers we have taken on the challenge to make our Centre of more value to a greater number of stakeholders. For example, we are pursuing other researchers and institutions that need our pigs and expertise. We have grown in the use of the pig not only as a model for pig nutrition and health but also seeking out collaborations with others who see the pig as a model for human health and nutrition. This serves to broaden the base of support for the Centre and provides a stable revenue stream. All of these efforts are to ensure that the research capability of the Centre remains in place to serve the commercial pork industry in the future. By seeking an alternative funding model for Prairie Swine Centre we are also recognizing that the traditional financial support from the industry, primarily Saskatchewan Pork, Alberta Pork and Manitoba Pork, is to be shared across a broader group of stakeholders in the future. This is a fundamental shift in our business model but one that is necessary given the research funding

Lee Whittington (right) receives Alberta Pork Congress 2010 Leadership Award from Elanco representative Bob Hehr

capacity of the industry at this time. Pork producers, transporters, packers, feed, animal health and equipment suppliers please note that our focus and output will still be firmly focused on practical, applied knowledge for the industry. Our vision for the pig and this facility is to simultaneously provide value to a larger segment of society and with that comes the opportunity to seek financial support from other areas as well. We view this as a win-win situation for our current stakeholders and our future clients.

Warmest Regards,
Lee Whittington

Our Mandate
To produce and distribute knowledge derived through original research, scientific review and economic analysis.

Our Vision
To be an internationally recognized source of original, practical knowledge providing value to stakeholders throughout the pork value chain.

Our Mission
We provide solutions through knowledge that ensure a profitable and sustainable pork industry and in so doing secure a prosperous future for our stakeholders and staff.

Technology Transfer Report

Providing Producers Answers at Their Fingertips

LEE WHITTINGTON, MBA • Manager, Information Services

What is more important personal contact or websites?

Our objective is to effectively communicate the knowledge generated at Prairie Swine Centre to pork producers and other key players that help support the pork industry throughout Canada. This activity supports Prairie Swine Centre's objective "To be viewed as a leader in the area of knowledge transfer within the hog industry". In light of diminishing industry resources, Prairie Swine Centre has also been curtailing expenses for the past three years – including significantly reducing the Technology Transfer program. Focusing limited resources into the pig barn and supporting our research programs has taken priority over traditional technology transfer activity. That said, although we do not have any full-time staff devoted to this part of our mandate, we have utilized summer students and partnered with other organizations to continue to deliver the details and the benefits of research to the industry.

Our focus is in making sure the most recent information from Prairie Swine Centre, as well as relevant information from other institutions, can be found on our website **www.prairieswine.ca.** We sponsored an industry meeting at three locations across western Canada to discuss the transportation study. This was so popular that we were invited to present the material in Ontario and Quebec as well. The printed materials produced this year consisted of 2 issues of Centred on Swine, a mailed piece describing the Annual Research Report, a factsheet on Closing Barns for Extended Periods of Time, and advertisements in each issue of the Western Hog Journal. Copies of all of these materials can be found on our website and downloaded at no-charge.

In trying to answer the question "What is more important personal contact or websites?" The anser is a definitive YES! Face to face contact will always be the number one way to exchange information and address industry/farm challenges through one-on-one discussion. In service to this Prairie Swine Centre was speaking at or represented at all the major pork industry events in western Canada, and many throughout the rest of Canada and the US. In addition we averaged the equivalent of 1 visitor coming to the centre per workday throughout the entire year.

To reach the bulk of the pork industry however the website contributes much more than any one person, and in much more detail as well. There are now over 5,300 articles on the website, these can be found by searching the PorkInsight database. PSC has also developed a presence on PigCareers.com and Swineweb.com websites and their regional pork industry pages. A personal contribution I started this year is a bi-weekly email which provides a regular update on pig industry technology and management to a growing list of contacts (in excess of 2,000 subscribers in North America).

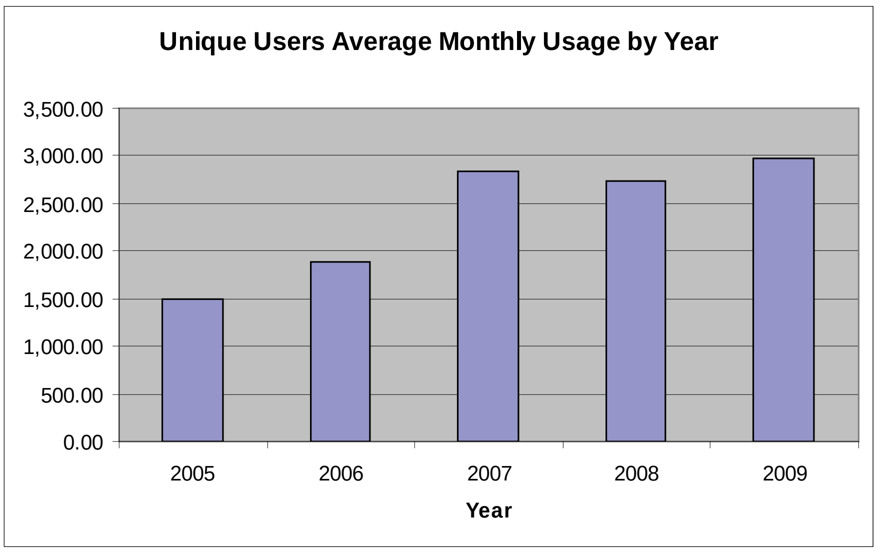
"Visit us at www.prairieswine.ca for the latest information"

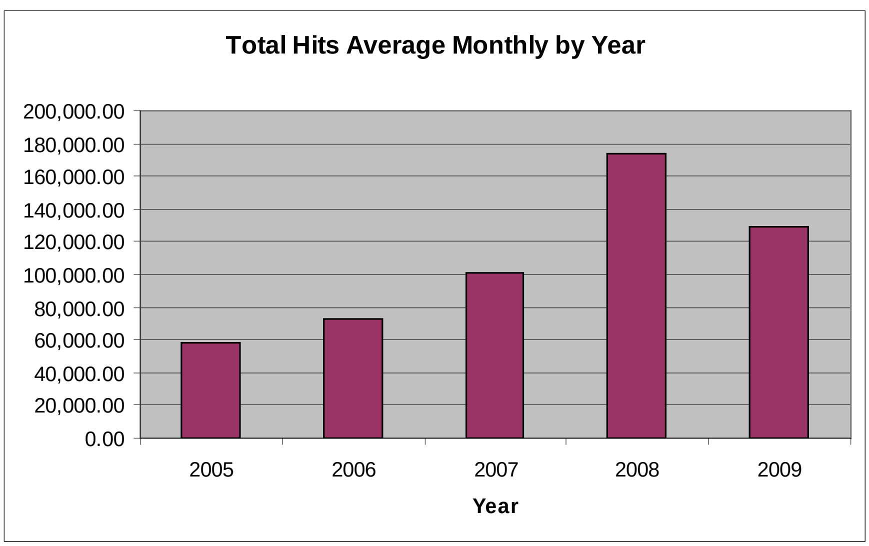
Industry seeks new information even in tough times

Emphasis has been placed on the website to ensure our work plus relevant work from other research institutions is readily available to pork producers. This is supported in our printed publications, and through advertising in the Western Hog Journal. In spite of the financial losses in pork production, and the potential to just ignore innovation, we experienced significant success in our ability to attract large and consistent volumes of visitors to the website. We measure Unique Users as this statistic tracks all visitors with a unique IP address, if they log off and then log back on in 30 minutes it is considered the same user. If they visit the site tomorrow they will be counted as a new Unique User.

Below I have shown the Unique User as well as the 'Hits' statistics for the past 5 years. Unique Users continues to grow with our best results to date; 4,500 per month in May 2010, note in 2005 this statistic was less than 1,500 per month.

Watch for our new website to be introduced in mid 2010.





Operations Manager Report

Production Improvements

BRIAN ANDRIES, BSA. • Manager, Operations

"Farrowing rate is up to 83.3%, numbers born alive 15.1 and pigs weaned/female inventory at 23.8."

Production performance is slowly growing to levels that have never been achieved at the Centre since the operation was opened by the University of Saskatchewan in 1979. Efficiencies in production were inevitable, with the breeding herd no longer split between 3 barns, even to the extent of previously having to transport nursery pigs on a weekly basis by tractor and trailer, concentrating on major production shortfalls became easier to manage.

Not only has production improved quite significantly but we have also reduced the number of production staff from 6.4 to 4.0 full time equivalents including weekend staff, driver and maintenance. Production staff is responsible for all production procedures for the sow and grow-finish herd but are also involved providing some service to research projects. The time saved by now being able to automatically feed sows in breeding and gestation allowed staff the opportunity to spend time adjusting feed levels to sow body condition. The completion of 2 specific sow trials also allowed us the opportunity over the last 4 months to develop a stringent sow culling protocol. The construction of a gilt development area in the new barn along with an emphasis on gilt management have developed a herd that is in optimum body condition and at a health status that is probably higher than it has been over the last number of years. This is evident in the lack of treatments through-out the facility and mortality rates that are lower than they have ever been: 0.70% in nurseries and 2.00% in grow/finish. Mortalities from circo-virus have virtually ceased from a rate of 8-10% in 2008-2009.

Table 1. Production parameters for the 2007-2010 fiscal years

Category	2007-2008	2008-2009	2009-2010
Sows Farrowed, #	728	797	635
Conception Rate, %	82.7	84.9	86.7
Farrowing Rate, %	83.8	82.9	83.3
Avg. Pigs Born Alive/Litter	11.1	11.9	11.9
Farrowing Index	2.55	2.48	2.46
Number Weaned	10.3	10.3	10.4
Pre-Wean Mortality, %	11.2	15.8	15.1
Pigs Weaned / sow / year	23.3	23.6	23.8

The only production parameter that has faltered since moving into the new barn has been pre-wean mortality. We have made changes in the physical environment in farrowing rooms, and we no longer use prostoglandins to induce sows to farrow in order to produce litters that are more viable. Average gestation length has increased from about 114.5 to just over 116 days. Staff come back to work in the evening, 2-3 times a week for 1-2 hours per night, depending on number of sows farrowing, to deal with transfers, fostering and teeth clipping along with weighing research piglets before moving to other sows. This attention has brought us to our current number of pigs weaned / sow / year and translates to producing from 730- 800 pigs more per year since 2007, using an average monthly inventory of 279 sows.

Over 50% of both the sow and grow-finish herd is on research trials at any one time. This has profound impact on herd operations and productivity. For examples, the first sow trial in the new barn used every possible sow in the herd from 1st to 4th parity and kept these sows on trial until they finished 3 consecutive parities. Management was not allowed to cull any of these sows, other than sick or lame animals or if they returned for a second time after being bred. Sows with low numbers born alive, low numbers weaned, savaging histories etc, had to be retained and farrow out 3 litters after being put on trial.

A second trial was completed by a researcher to determine if gestational litter size and intrauterine competition adversely affect post-natal health, performance, immune capacity and disease resistance. This required laproscopic surgery to perform unilateral oviductal cauterization on a small group of sows. After ligation, these sows were bred to produce 2 consecutive litters. Sows were selected as being highly prolific. Sows before ligation averaged 13.25 born alive. After ligation the 13 sows averaged 7.09 and 8.38 born alive for their 2 litters.

In conjunction with tightening the size of the sow herd and administering revised protocols to ensure proper feed levels are administered to sows depending on body condition, we have also looked at overall feed consumption through nursery and grow-finish. Forms are required at the time of room fills that indicate number of days that animals are on each of our 7 standard production diets through the Stage 1 Starter to the Stage 2 finisher diet. Total feed costs reflect all diets including research diets minus any extra costs associated with a research diet. The result of these changes - producing near record pig numbers, from fewer sows at lower cost.

Actual yearly animal sales in conjunction with average monthly sow inventory and total feed budget since 2006 is shown in Table 2. :

Table 2. Animal Sales, Sow Inventory and Total Feed Costs for 2006 - 2010 Fiscal Years

Year	Animal Sales	Sow Inventory	Total Feed Costs
2006-2007	7113	336	$503,000.00
2007-2008	6973	335	$668,000.00
2008-2009	6500	302	$652,000.00
2009-2010	7041	293	$473,000.00

Note: 2009-2010 projected to year end using sales and feed costs to the end of April

Friends of the Centre

LEE WHITTINGTON, MBA

Objective
To allow a broader group of pork industry individuals and corporations to lend their support to the Prairie Swine Centre.

Motivation
For the past several months and into the near-term most pork producers including the Prairie Swine Centre have faced significant financial challenges.

Concept
"Friends of the Centre" is way for for pork producers, suppliers, packers, processors and others to show their support. Benefits from having a dedicated swine research facility flows to all parts of the value chain. As a friend of the Centre you will ensure Prairie Swine Centre remains a viable part of the pork industry in the future.

Benefits to our Friends

- The opportunity to play a visible and meaninful role in the continuation of the unique industry-orientated research and technology transfer programs offered by Prairie Swine Centre.
- Friends receive advanced notice of seminars, publications and special events sponsored by the Centre.
- Friends will have their business recognized as "Friends of the Centre" on the PSC Website.
- Friends will also be provided with exclusive opportunities to provide advertorial materials for insertion in newsletters, Centred on Swine publications and the Annual Research Reports.
- Friends will also benefit by knowing that they made a difference when it really mattered.

Benefits to Prairie Swine Centre

- The Centre gains a voluntary source of funds to partially fill the gap in the business plan created by poor pig prices and the declining check-off funds available for pork associations to allocate to research.
- The Centre gains a group of motivated and interested champions that see value in maintaining a strong industry orientated research program.
- The sharing of costs incurred to generate knowledge is spread over a greater portion of the industry and better reflects the allocation of benefits to multiple members of the pork value chain. This way the number of champions that take ownership for the Centre as well as the knowledge it develops, increases.

Meet our Friends
The following individuals and companies have made financial contributions:

Maple Leaf Foods - John Carney
PIC Canada
Fast Genetics
Standard Nutrition Canada
Sunterra Farms

- Howard and Joan Fredeen
- Alwyn Woolley and Ken Woolley Memorial
- Dave Price
- Stan and Flo Price

Red Willow Pork Farm
Perkins Farm Inc.
Hutterian Brethren Church of Standoff Colony
Hutterian Brethren of Verdant Valley
Hutterian Brethren Church of Lakeside
Wild Rose Hutterian Brethren
New Rockport Hutterian Brethren
Hutterian Brethren Church of Birch Hills
Clear Lake Hutterian Brethren of Alberta
Cairlane Hutterian Brethren
Neu Muehl Hutterian Brethren of Delia
Rock Lake Hutterian Brethren
Lone Pine Hutterian Brethren
Neudorf Hutterian Brethren
Starbright Hutterian Brethren
Paradise Valley Pork Farms Inc.
Lewisville Pork Farm Limited Partnership
Poundmaker Pork Farm Limited Partnership
Hutterian Brethren Church of Veteran
Hutterian Brethren of Springview
Suncrest Hutterian Brethren
Hutterville Hutterian Brethren
Clearview Hutterian Brethren
Hutterian Brethren Church of Gadsby
Big Bend Hutterian Brethren
Hutterian Church of Wintering Hills Colony
Fairville Hutterian Brethren
Hutterian Church of Pine Haven
Hutterian Brethren of South Bend
Hutterian Brethren of Newell
Hutterian Brethren Church of Jenner
Blue Sky Colony
Hutterian Brethren Church of Plain Lake
Acadia Hutterian Brethren Ltd.
Hillsburgh Stock Farm
Neufeld Farms Ltd.
Porcherie Prejet Ltee
Porcherie Lac Du Onze Ltee

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 relationship with external institutions/agencies.

Research Objectives

Serving the Needs of the Pork Value Chain

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, for pet nutrition.

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

Evaluation of methods for controlling and monitoring occupational exposure of workers in swine facilities

Predicala, B., L. Moreno

B. Predicala

SUMMARY

This study assesses the effectiveness of selected engineering and management measures, namely, oil sprinkling, low protein diet, high level of cleaning and manure pH manipulation, in reducing ammonia (NH_3) and respirable dust concentration in swine production rooms. Six grow-finish rooms at PSCI research facility were used with two as control and four as experimental rooms each employing one of the measures being investigated. Sampling equipment was installed in each room for measurement of ammonia and respirable dust concentrations within the room airspace. Worker exposure to ammonia and dust from the rooms was also assessed by equipping workers with personal monitoring gear similar to those installed in the rooms. Ammonia levels were monitored using both the standard method and using commercial gas sensors. Results from completed trials so far showed that low-protein diet, pH manipulation of manure and employing high level of cleanliness could potentially reduce ammonia concentrations in swine production rooms. Among these measures, only spraying of canola oil reduced dust levels inside the rooms. Moreover, average daily gain of pigs was relatively similar between control and experimental rooms. A benefit-cost analysis will be conducted after all trials are completed.

INTRODUCTION

Various engineering and management measures have been shown to control air contaminant levels in swine production facilities. Additionally, barn operators have come up with innovative measures to address issues with ammonia and dust levels within their facilities. However, there is a gap in translating the results observed in previous contaminant control studies to actual reduction of personal exposure of workers to these contaminants throughout their workday. Thus, there is a need for these innovative measures to be assessed under actual swine barn conditions to determine the actual reduction of exposure of workers to air contaminants. The goal of this project is to assess the effectiveness of selected engineering and management measures (i.e. oil sprinkling, low protein diet, high level of cleaning and manure pH manipulation) in reducing ammonia (NH_3) and respirable dust concentration in a swine production room. In addition, the performance of commercial gas monitoring devices was assessed using standard gas measurement method as reference.

"Providing pigs with low protein diet, manipulation of manure pH, and employing a high level of cleanliness inside barn facilities could potentially reduce ammonia concentrations"

EXPERIMENTAL PROCEDURES

Six grow-finish rooms at the PSCI barn were used for this study. The four (4) types of engineering and management measures were applied individually in 4 of the rooms (Experimental) while the other 2 rooms were managed as conventional rooms (Control). Each 16-week grow-out period was considered as one replicate trial and a total of 5 trials will be conducted to cover each climatic season (winter and summer conditions) at least twice. Every 3 weeks, the

Figure 1. Barn worker wearing the personal sampling equipment for ammonia and respirable dust while doing pig health and room checks in their assigned rooms.

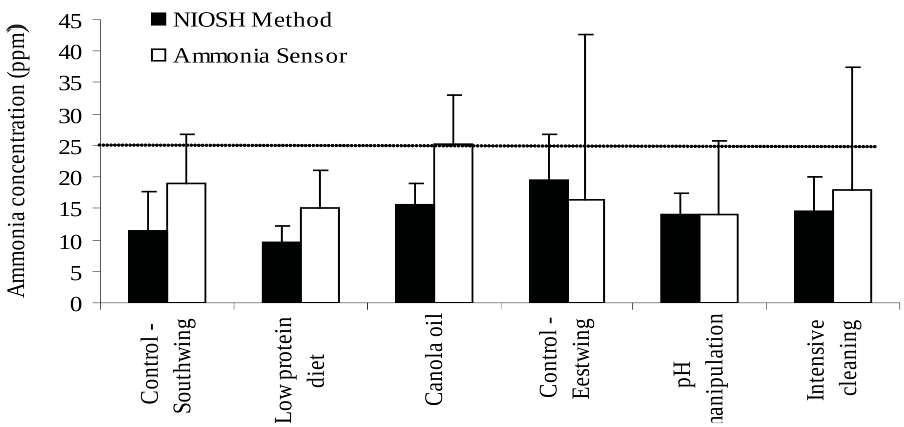


Figure 2. Ammonia concentrations measured in the control and experimental rooms using the NIOSH method and gas sensor. A line across the 25 ppm concentration indicates the ACGIH Threshold Level Value (TLV) for ammonia.

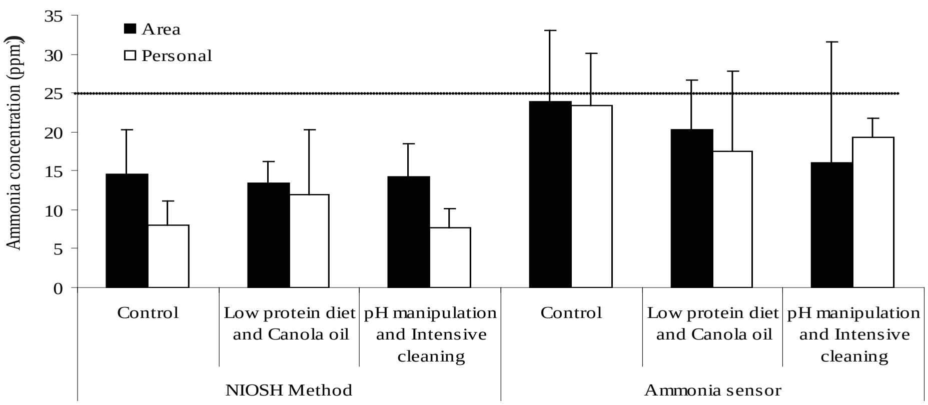


Figure 3. Ammonia concentrations measured in the control and experimental rooms by area and personal sampling using the NIOSH method and gas sensor. A line across the 25 ppm concentration indicates the ACGIH Threshold Level Value (TLV) for ammonia.

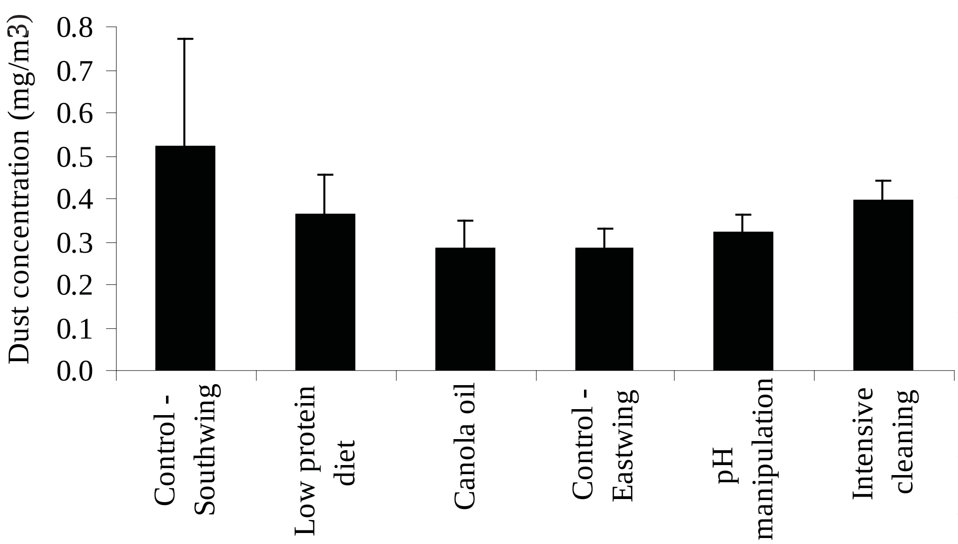


Figure 4. Respirable dust concentrations measured in the control and experimental rooms. ACGIH Threshold Level Value (TLV) for respirable nuisance dust is 3 mg/m3.

personal exposure of workers to NH_3 and dust was assessed by outfitting 3 workers with gas monitors and personal dust samplers over their work shift over a 2-day period (Figure 1). Two workers were assigned to work in the experimental rooms while the other worker was assigned in the control rooms. Each worker was assigned a logbook to document their activities during their workshift while wearing the personal monitoring gear. After each 2-day personal exposure monitoring event, area sampling within the rooms were conducted over 24 hrs to determine NH_3 levels and over 48 hrs for respirable dust concentrations.

RESULTS

The results obtained from the first two trials are summarized below. Ammonia and respirable dust levels shown are average of measurements obtained over 4 sampling events in each trial. As shown in Figure 2, ammonia concentrations in rooms with measures such as feeding low protein diet, manure pH manipulation, and high level of cleanliness were found to be substantially lower than in the control rooms. Furthermore, it was observed that the readings from the commercial gas monitoring devices were considerably higher than the concentrations determined from the standard NIOSH method (Figure 3). However, the measured values from all rooms were below the threshold limit value of 25 ppm NH_3.

For the dust levels, only spraying of canola oil showed the potential to reduce dust concentration as shown in Figure 4; this was expected since the canola oil spray helped keep dust on the surfaces from being entrained into the air. Nevertheless, it should be noted that the dust levels in all the rooms were below the threshold limit value of 3 mg/m^3. Comparison of area and personal sampling methods for monitoring dust levels showed that the concentration values obtained from personal sampling were significantly higher than the values obtained from area sampling (Figure 5).

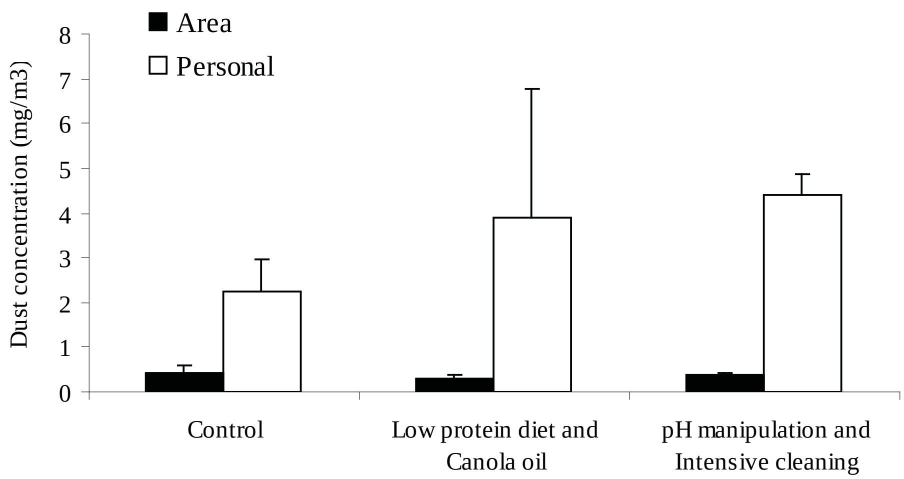


Figure 5. Respirable dust concentrations obtained in the control and experimental rooms by area and personal sampling measurements. ACGIH Threshold Level Value (TLV) for respirable nuisance dust is 3 mg/m^3.

Table 1. Average daily gain (ADG) and mortality rate of pigs in the control and experimental rooms.

	ADG (kg/day-pig)		Mortality (%)	
	Average	SD	Average	SD
Control (n=440)	0.96	0.09	3.89	5.95
Low crude protein diet (n=240)	1.03	0.23	0.42	1.31
Canola oil (n=240)	1.00	0.09	0.80	2.76
pH manipulation (n=200)	1.04	0.08	0.00	0.00
High level cleaning (n=200)	1.02	0.13	2.00	4.10

n = number of pigs specified to each treatment

This could be due to the different sampling durations; area sampling was conducted over the 48 hours while personal sampling was done in a much shorter period. Sampling duration is a significant factor in the calculation of dust concentration. Longer sampling durations would lead to larger sample volumes; since dust generation is not uniform over the sampling period this leads to lower calculated dust concentrations.

Pig performance

The average daily gain and mortality rate of pigs in the control and experimental rooms are shown in Table 3. Average daily gain of pigs in all rooms was relatively similar ranging from 0.95-1.03 kg/day-pig. However, mortality rate was higher in the control rooms with 6.94% compared to the experimental rooms (0-4.0 %). From data collected so far, the difference in pig mortalities between the treatment and control rooms could not be attributed to the levels of ammonia measured in the rooms.

IMPLICATIONS

The results from the completed trials of this study showed that providing pigs with low protein diet, manipulation of manure pH, and employing high level of cleanliness inside barn facilities could potentially reduce ammonia concentrations.

On the other hand, only the spraying of canola oil showed the potential to reduce respirable dust concentration. The different engineering measures employed in this study showed no significant impact on the animal performance. Three more trials will be implemented and a benefit-cost analysis of the various engineering measure employed in this study will be conducted.

ACKNOWLEDGEMENT

The authors would like to acknowledge the Manitoba Livestock Manure Management Initiative Inc. for financial support of this research project. Strategic program funding provided to Prairie Swine Centre Inc. by Sask Pork, Alberta Pork, the Manitoba Pork Council and the Saskatchewan Ministry of Agriculture is also acknowledged.

Application of computer simulation to evaluate potential measures for improving energy efficiency in hog production

Predicala, B., L. Dominguez

B. Predicala

SUMMARY
Results from previous work of Navia (2008) showed that many of the barns currently in use are not optimized for using energy as efficiently as possible, mainly because the cost of energy in the past has been very minimal. In view of emerging concern regarding the increasing trends in global energy prices, there is a need to re-examine existing barn building design and management to use less energy and more efficiently. As part of the on-going effort to reduce the cost of production in swine operations, this study aims to optimize energy efficiency and reduce overall energy use in swine barns. Computer simulation is being utilized to examine various energy conservation strategies that can be applied in a barn. Preliminary results show that the use of air to air heat exchangers and lighting modifications have high potential for reducing the annual energy consumption in the barn. From the simulation results, the most promising measures will be retro-fitted into the barn to enable collection of actual barn data that will serve as the basis for the development of a decision software tool.

"The model predicts savings of 1956 kWh ($200) to 12 468 kWh ($1,250) per year by switiching to compact flourescent bulbs"

INTRODUCTION
Energy prices have steadily risen in recent years and have not returned to levels seen in previous decades. Because swine production is an energy-intensive industry, this global trend resulted in a steady increase in the utility cost component of total production cost when calculated on a per pig sold basis. A survey of energy usage in 28 Saskatchewan swine barns conducted by Navia (2008) showed a wide range of variability in energy use in different types of operations, implying the potential for numerous opportunities for improving energy use practices to reduce energy cost.

The overall goal of this project is to reduce the cost of production in swine operations by optimizing energy efficiency and reducing energy use in swine barns. This particular part of the study specifically aims to use numerical computer simulation techniques to evaluate measures and strategies that can be employed in swine barns.

EXPERIMENTAL PROCEDURES
This part involves the examination of various strategies related to barn design, construction materials, equipment, and management to make a barn building more energy efficient. However, the main challenge with using a conventional research approach to evaluate various barn design strategies is the expense

Table 1. Annual heating consumption and savings (compared to base barn room) associated with increasing the wall and ceiling insulation and using air to air heat exchanger.

Applied Measures	Annual Heating (kWh)	% Decrease in Annual Heating	Annual Heating (m^3 natural gas)	Savings (m^3 natural gas)
Base barn room	12,980	-	1221	-
Wall insulation (add 90mm of R20 ins)	12,831	1.2	1207	14
Ceiling insulation (increase to R30)	12,541	3.4	1180	41
Wall + Ceiling insulation	12,429	4.2	1169	52
50% eff. Heat exchanger	5,103	60.7	480	741
60% eff. Heat exchanger	3,952	69.6	372	849
70% eff. Heat exchanger	2,976	77.1	280	941

Table 2. Electrical energy savings associated with modifications in lighting

Applied Measures	**Annual electricity savings (kWh)**					
	150 W Incandescent		**90 W Incandescent**		**23 W CFL**	
	24 h	8 h	24 h	8 h	24 h	8 h
Operate lights for 8 h instead of 24 h / day	-	8,760	-	5,256	-	1,343
Use CFL instead of incandescent	11,125	3,708	5,869	1,956	-	-
Use CFL for 8 h/day instead of 24 h/day incandescent	12,468		7,212		-	-

24 h - lights are operated 24 hours per day
8 h - lights are operated only for 8 hours per day

associated with setting up the different alternatives to be able to collect data from each option being tested. For this study, numerical computer simulation was used as a tool to examine various strategies to determine their effectiveness in improving the energy efficiency of a barn building. A computer model of a typical grow-finish room at the Prairie Swine Centre (19.75m by 7.0 m; 100-head capacity) was generated. Using numerical simulation software, the overall energy use in this baseline case (operated using conventional management practices) was calculated and served as the reference against which other alternative cases were compared. The measures being evaluated in terms of annual energy use when applied to the baseline room are categorized as follows:

a. building construction and materials

b. equipment systems - standard models vs. new high-efficiency models (e.g., heaters, fans, motors, light fixtures); use of heat exchangers

c. operational management aspects – temperature set-points, stocking density, manure management, cleaning and maintenance schedule.

The evaluation of the measures in terms of the annual energy use was done with the use of a simulation program (TRNSYS®) which is based on steady state energy conservation laws and formulated in thermodynamic quantities. Inputs into the program include building characteristics (materials, orientation, and dimensions), weather data, internal heat gains in the building, air infiltration rate, ventilation rate, and temperature set points. Using successive substitution, the program solves for the following outputs: resulting room conditions (temperature and relative humidity) and heating required to meet the room set points on an hourly basis for 8,760 hours (one year). From these outputs, the annual heating requirement of the room with the applied measure is calculated.

To evaluate the effect of different barn room designs on the resulting in-barn conditions (temperature and air distribution), a commercially-available computer simulation package ANSYS 11.0 was used. This simulation package utilizes computational fluid dynamics (CFD) principles to numerically simulate the flow of heat and air in the barn based on the physical characteristics and operational aspects of the barn, as well as on the prevailing environmental conditions. The parameters considered in the evaluation of barn room design were: room size and lay-out (large vs. small rooms); floor type (fully-slatted vs. partially-slatted); pen partition (solid vs. open partition); ventilation air inlet and outlet locations (sidewall vs. ceiling), and manure handling system (deep-pit vs. shallow-pit manure channels).

PRELIMINARY RESULTS

Preliminary results of the simulation using TRNSYS® in evaluating the impact of adding insulation and use of air to air heat exchanger are presented in Table 1. Adding insulation to the barn walls and ceiling resulted to minimal decrease in the annual heating consumption. The use of heat exchangers resulted to more than 60% decrease in the annual heating requirement.

The annual energy savings that can be realized by reducing the numbers of hours of operation and changing the type of light fixtures used are presented in Table 2. The wattage and hours of operation of the different bulbs satisfy the minimum requirement for lighting in a grow-finish room (100 lux for 8 hours per day). Shifting to compact fluorescent light (CFL) was shown to result in large annual electrical energy savings ranging from 1,956 kWh (if 8h/day 90W incandescent lighting is previously used) to 12,468 kWh (if 24 h/day 150W incandescent lighting is previously used).

Plots of the preliminary results in evaluating the effect of the position of the inlets and outlets are shown in Figures 1 and 2. These plots show that with this layout, there are areas where the air is stagnant; evaluation of other layouts will be completed to determine which layout provides the best in-barn condition.

IMPLICATION

The following preliminary conclusions can be made from the initial results of the simulation:

1. Increasing the insulation of the barn walls and ceilings results in minimal decrease in annual heating consumption.

2. Modifications in lighting and use of heat exchanger have high potential in decreasing heating energy consumption.

The simulation of other measures to determine annual energy use and resulting in-barn conditions will be completed and the most promising measures will be retrofitted into the barn for data collection which would be the basis for the development of decision support software tool.

ACKNOWLEDGEMENT

The authors would like to acknowledge the Saskatchewan Agriculture Development Fund and Advancing Canadian Agriculture and Agri-Food Saskatchewan for the financial support to this research project. The authors also acknowledge the strategic funding provided by Sask Pork, Alberta Pork, Manitoba Pork Council and the Saskatchewan Ministry of Agriculture to Prairie Swine Centre Inc.

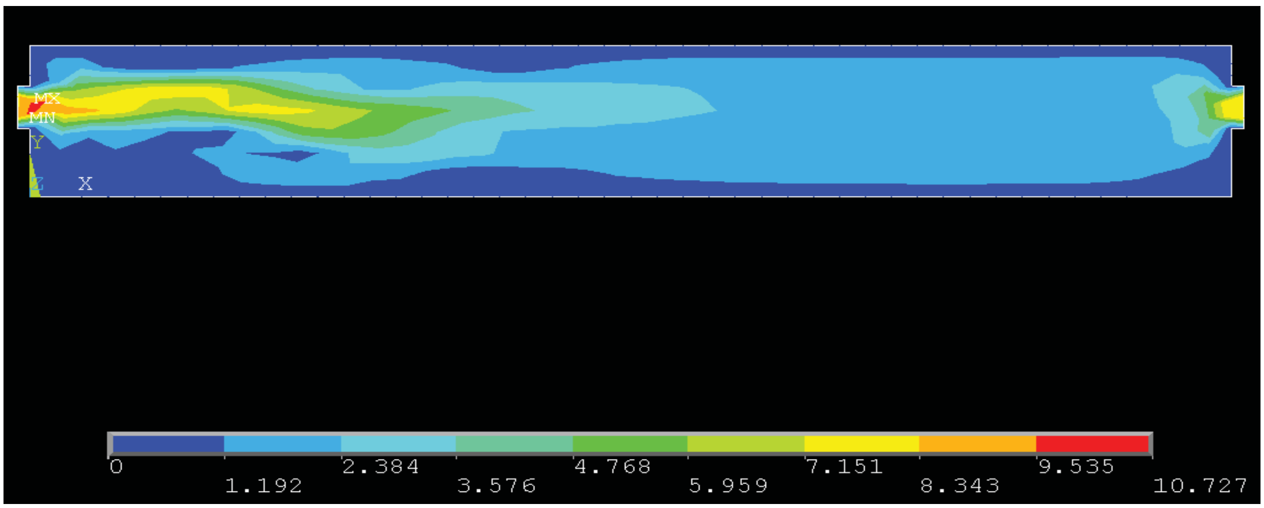


Figure 1. Side view of a 2D model of the baseline grow-finish room showing the air velocity (m/s) distribution with the inlet (left) and outlet (right) located on the side-walls.

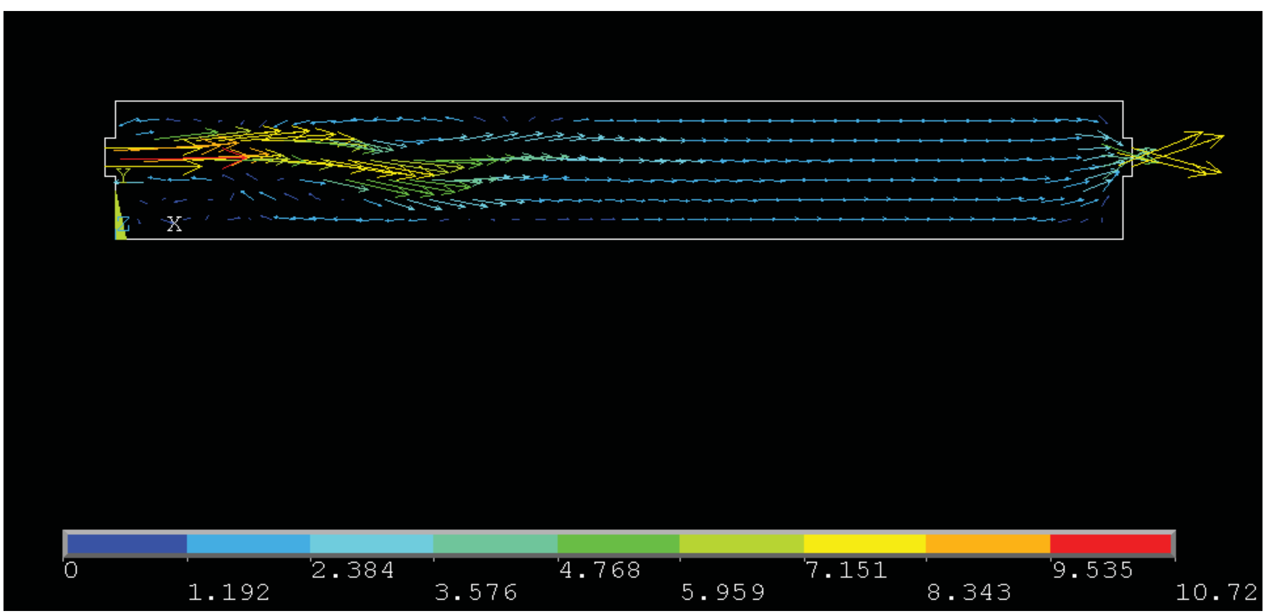


Figure 2. Contour plot of air velocity (m/s) in a 2D model of the baseline grow-finish room with the inlet (left) and outlet (right) located on the side-walls.

Comparison of performance of radiant and forced-convection heaters in swine grow-finish rooms

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B. Predicala

SUMMARY
The goal of this study was to conduct a comparative evaluation of two heating systems in terms of energy efficiency as well as effect on barn environmental conditions and hog performance. An infrared radiant heater and a forced-air convection heater were installed separately in two grow-finish rooms at Prairie Swine Centre Inc (PSCI). Consumption of natural gas and electrical energy were monitored in each room, as well as air temperature, relative humidity, and ventilation rate. Additionally, gas sensors were installed to monitor hydrogen sulfide (H_2S), ammonia (NH_3), carbon monoxide (CO) and carbon dioxide (CO^2) concentrations in the rooms. The results from three completed trials showed that the room with infrared radiant heating system consumed more natural gas but less electrical energy compared to the room with forced-air convection heater. Mean air temperature was higher in the room with forced-convection heater than in the room with radiant heater, but air temperature distribution at various locations within each room was similar. Generally, the relative humidity, ventilation rate, gas concentrations (NH_3, H_2S, CO and CO^2), and pig performance were relatively similar between the rooms, indicating no significant impact of the type of heater on these parameters.

INTRODUCTION
Swine production entails energy-intensive operations such as space and creep heating, ventilation and lighting, feed and manure handling, power washing, among other things. Due to increasing energy prices, energy cost now ranks third among the variable cost components of the total hog production. As reported by Barber et al. (1989), heating and ventilation are major contributors to energy use in different types of hog barns. With the increase in energy prices in recent years, the cost of natural gas has increased almost fourfold from $0.11/m3 in 1998 to $0.42/m3 in 2006 and electricity costs have gone from $0.08/kWh to $0.11/kWh (Huffman and MacDonald, 2006). Natural gas-fired convection heaters is widely used for space heating in hog production rooms. In this research work, a gas-fired infrared heating system was investigated as a possible measure that can be adapted for space heating in barns. Unlike the forced-air convection heater that works by heating up the air within the room and then the heated air mass needs to be physically moved to the animal occupied zones, the radiant heater transmits heat to surfaces (i.e. floor, pen wall, animals, etc) through radiation heat transfer and thus speeds up the heating process at the pig level.

The overall goal of this study was to carry out a comprehensive comparison of convection and radiant heating systems in terms of energy efficiency and their effect on environmental conditions in the barn and on hog performance.

EXPERIMENTAL PROCEDURES
Two grow-finish rooms at PSC were used in this study. Each room has inside dimensions of 66 x 24 x 10 ft and has 20 pens that could accommodate 5 pigs each. Both rooms were operated on a negative pressure ventilation system, with fresh air entering through 10 modular ceiling inlets and exiting through three sidewall fans. Both rooms were operated with identical setpoints for the heating and ventilation system and managed according to typical production practices.

"No major differences in the overall energy use (natural gas and electrical energy) was observed between rooms with infrared radiant heater and forced-air convection heater systems."

A new gas-fired infrared radiant heater was installed in the Treatment room while a new gas-fired forced-air convection heater was installed in the Control room; both types of heaters has a heating capacity of 80,000 BTUh. Thermocouples, relative humidity (RH) and fan-speed sensors were installed in each room to monitor thermal parameters while electrochemical gas sensors were used for monitoring gas levels (ammonia, hydrogen sulphide, carbon dioxide and carbon monoxide) in the room.

Weaner pigs weighing around 20-35 kg were used in the experiment. The animals were weighed, sorted by gender and distributed equally to the two rooms. Each trial is 12 weeks long with the first week allotted for animal and room preparation and the remaining eleven weeks for continuous monitoring and data collection. The average daily gain (ADG), average daily feed intake (ADFI), and mortality rate in both rooms were monitored.

RESULTS
<u>Gas and electrical energy consumption</u>
Figure 1 shows the weekly average gas consumption in both rooms during the trials. Both heaters were barely in operation after Week 7 since pigs at this growth stage were al

ready large enough to generate their own heat and sustain the required setpoint temperature, thus supplemental heat was no longer needed. For all three trials, total gas consumption over the course of a trial was higher in the radiant heater room (p=0.04) compared to the forced-air convection heater room by an average of 12.1 m^3.

Figure 2 shows the weekly average electrical energy consumption in both rooms over 3 trials. Throughout the 13-week test period, average weekly electrical consumption was relatively similar in both rooms, with the operation of the ventilation fans in response to prevailing ambient conditions mainly influencing the week to week variation in electricity consumption. Total electricity use over the course of a trial was slightly higher (p=0.86) in the forced-air convection heater room than in the infrared radiant heater room by about 1.9 kWh. This difference could be attributed to the additional electrical energy use by a recirculation fan in the forced-air convection heater room, which is an integral part of the heating and ventilation system necessary to distribute heat more uniformly throughout the room.

<u>Temperature, relative humidity and ventilation</u>

Figure 3 shows the average air temperature readings at different locations within the two rooms. Despite the same setpoints used for both rooms for all trials, the overall mean temperature from all locations in each room was higher (p<0.05) in the forced-air convection heater room (19.2 °C) than in the radiant heater room (18.4 °C). Within each room, temperatures near the middle of the room were slightly higher than those at the peripheral locations of the room, particularly near the wall with the exhaust fan (outside wall).

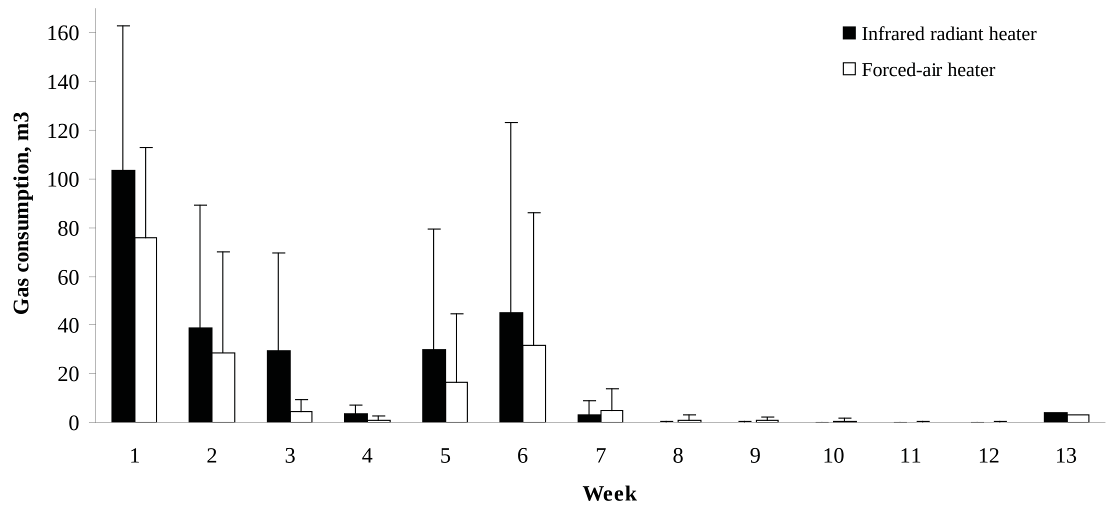


Figure 1. Average weekly gas consumption in the two rooms over 3 trials. Error bars represent standard deviation of weekly gas consumption for the 3 trials.

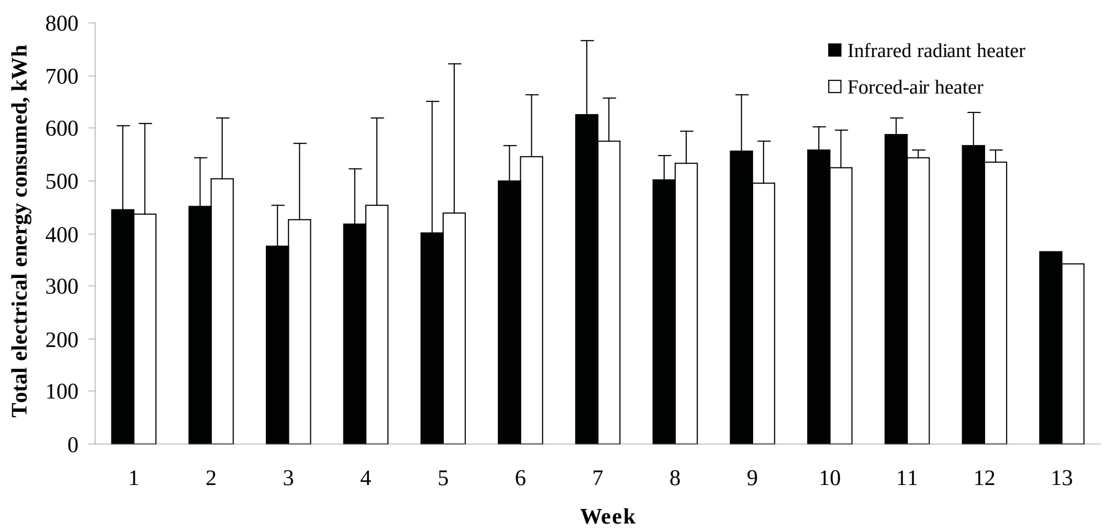
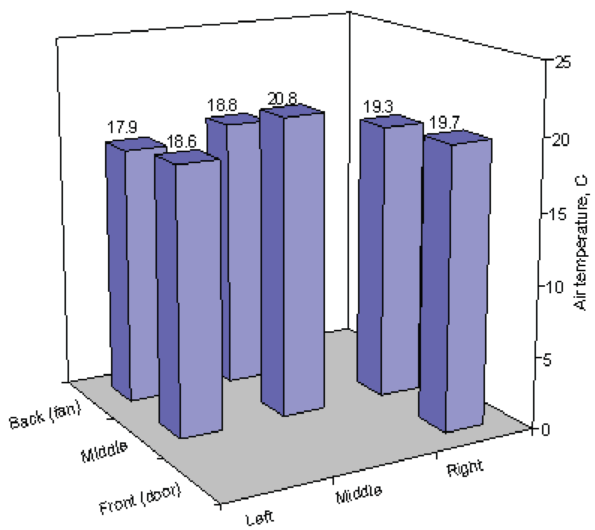


Figure 2. Average weekly electrical energy consumption in both rooms over 3 trials. Error bars represent standard deviation of electrical energy use for 3 trials.

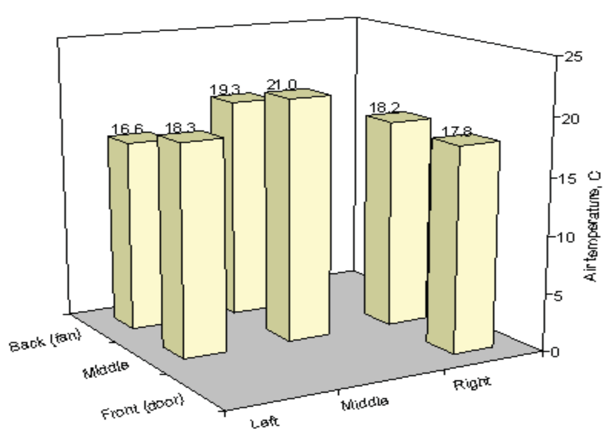
Comparison of the deviation from the mean temperature at the various locations in each room showed no significant differences (p=0.85), indicating similar uniformity in temperature distribution in both rooms.

Relative humidity readings were monitored at the middle and near the exhaust fan in both rooms. Generally, the average RH at the middle of the control room (55.5%) was higher (p<0.05) than in the trreatment room (52.3%). Near the exhaust, the average RH readings were relatively higher (58.9 - 59.2%) than at the middle of the room, but no significant difference (p=0.75) was observed between the two rooms.

The overall mean ventilation rate in the radiant heater room (2,050 L/s) was slightly higher than in the forced-air convection heater room (1,870 L/s), but due to wide variation in ventilation rate values throughout the trials, the differences between the two rooms was not significant (p=0.15).



(a)



(b)

Figure 3. Average air temperature measured at various locations in the (a) forced-convection heater room and the (b) radiant heater room.

Table 1. Weekly average concentrations (in ppm) and standard deviations (SD) of various gases monitored in the two rooms.

	Forced-air heater		Radiant heater		
Gas	**Mean**	**SD**	**Mean**	**SD**	**P-Value**
NH_3 (n=34)	6.38	4.79	5.89	3.85	0.58
CO (n=25)	0.25	0.46	0.26	0.47	0.90
H_2S (n=29)	0.46	0.82	0.29	0.68	0.09
CO_2 (n=20)	2036.97	1059.81	1298.31	498.19	0.01

Gas concentrations

Table 1 shows the mean concentrations of different gases monitored over the course of the trials. Hydrogen sulphide (H_2S) and carbon monoxide (CO) concentrations in both rooms were usually at levels barely detectable by the respective sensors with typical levels below 1 ppm. As expected, concentrations of H_2S were observed to spike to considerably high levels (>90 ppm) during pit pulling events. Ammonia (NH_3) and carbon dioxide (CO_2) levels were similar in both rooms with average concentrations below 10 and 2000 ppm, respectively. Among these various gases, only CO_2 levels were found to differ significantly (p=0.01) between the two rooms, with higher values in the control room compared to the treatment room. This can be attributed to the operation of the forced-air convection heater, which vented combustion gases into the airspace.

Pig performance

Over the course of the trials, the average daily gain (ADG) and average daily feed intake (ADFI) in both control and treatment rooms were relatively similar (p>0.05). Mean ADG values from all trials were 0.97 and 0.98 kg/pig-day while ADFI values were 2.51 and 2.60 kg/pig-day for the control and treatment rooms, respectively. Average mortality rates from all trials were 2.0% and 0.60% for the control and treatment rooms, respectively.

IMPLICATIONS

Trends observed from these trials showed no major differences in the overall energy use (natural gas and electrical energy) between the rooms with infrared radiant heater and forced-air convection heater systems. Both heater types had similar uniformity in air temperature distribution within the room. Gas concentrations (ammonia, hydrogen sulfide, carbon monoxide and carbon dioxide) and animal performance was not affected by the type of heater used.

ACKNOWLEDGEMENT

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The interaction of group size and alley width on the movement of near market pigs

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Harold Gonyou

SUMMARY

The objective of this study was to examine the interaction between group size and alley width on the ease and speed of movement of near-market pigs. Pigs were moved in different group sizes through a three-sided simulated handling course, in which alley width could be changed. Data were collected on heart rate, duration, handling and behavioural measures. Moving a group of 4 or 8 animals is preferred for minimizing stress and alley width of 0.9m appears to be most conducive to easy handling.

INTRODUCTION

Current recommendations advise that pigs should be moved on farm in small groups of 5 or 6. However packing plants routinely move groups of 25-50 pigs with ease from lairage pens to the squeeze tub. One difference is in facility design. On farms, the alley is generally limited to the width of two pigs (approx. 0.6 m), whereas in plants the alleys may be 2-3 m wide.. Therefore, handling challenges and stress related to larger group sizes on farms may be due, in part, to crowding resulting from space limitations. As farms increase the number of pigs handled and loaded each week, specialized handling and loading facilities may be warranted in order to minimize stress, speed the process and reduce labour costs. In this perspective, we examined the interaction between the group size and the alley width on the ease and speed of movement of near-market pigs.

EXPERIMENTAL PROCEDURE

This study was undertaken at the Prairie Swine Centre. Forty-four finishing pigs within three weeks of market, weighing between 100-115 kg, were used each day during this trial. A randomized block design was used with treatments in a 4 x 4 factorial arrangement: 1) alley width (0.6, 0.9, 1.2 or 2.4 m), and 2) group size (4, 8, 12 or 20 pigs). Alley width sizes were based on the shoulder widths of pigs (approx. 30 cm) and included 2, 3, 4 and 8 body widths (0.60, 0.9, 1.2 and 2.4 m). Five replicates of each alley width, group size combination was undertaken.

Pigs were moved through a three-sided simulated handling course (Figure 1). One handler was used, moving the pigs with paddle and board only. Once the animals were moved from the holding pen to the starting pen, they were left for five minutes to rest and to acclimatize to the pen and unfamiliar pigs. After the run of the course, pigs were held in the end pen for five minutes before being returned to their respective holding pens.

Heart rate data were collected from five minutes prior to running the course, while pigs where in the starting pen, and until five minutes after the end of the run while pigs waited in the end pen. Each run of the course included two pigs wearing a heart monitor. Pigs were also scored for vocalizations (squeals), turnbacks, piling, slipping and falling events. The time to complete the course was measured. The number of touches and slaps given by the handler to move pigs through the course were recorded. At the end of each run, the handler also provided a subjective rating of handling ease or difficulty using a visual analogue scale where “minimal difficulty” was labeled at one end, “average difficulty” in the centre of the scale, and “maximum difficulty” at the end of the scale.

“When handling near-market weight hogs, group sizes of 4 or 8 pigs is preferred for minimizing stress based on handling and behavioural measures“

RESULTS AND DISCUSSION

Pigs moved in groups of 12 or 20 emitted more squeals than those moved in groups of 4 or 8 (figure 2). They took significantly more time to complete the course (figure 3) than

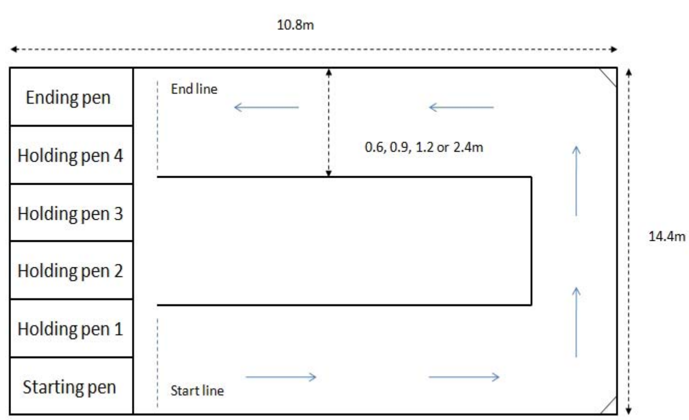

Figure 1. Handling Course

smaller groups (4 and 8 animals). In addition a significantly higher number of turn backs were also recorded when pigs were moved in groups of 12 or 20 (compared to 4 and 8), and in group size 8 compared to 4 (figure 4). This highlights the challenge of moving animals in larger group sizes, which results in a stressful situation. The handling measures (figure 5) showed that handling became more challenging as group size increased. This matches the results found for the behavioural measures in that group size 4 was rated as easier to manage by the handler than larger group sizes and group sizes of 4 and 8 required less handler intervention than group sizes 12 and 20.

Overall, the results from the behavioural and handling measures indicate that group size 4 is preferred, based on the number of turnbacks and the subjective handling scored, or that group sizes of 4 and 8 are equally superior to the larger group sizes, based on measures of vocalizations and handling (touches and slaps).

The number of touches and slaps administered by the handler (figure 5) suggest that the middle alley widths of 0.9m and 1.2m are most conducive to easy handling. However, an interaction between group size and alley width for the handling intervention measure of touches and slaps was found and suggests the alley width of 0.9m is preferable as there was no significant difference found between group sizes on this measure. In addition the number of touches and slaps given were relatively low compared to those given in group size 20 in the wider widths of 1.2m and 2.4m. The higher number of squeals emitted by pigs when moved in alley width of 0.6m (figure 2) compared to the wider widths was a reflection of the tight space causing pigs to bump into other pigs and/or bunch up. The increased difficulty in managing pigs in a wide alley width was the reason for more turnbacks in the 2.4m alley width compared to the smaller widths. Moving pigs in groups of 12 and 20 resulted in many more turnbacks (figure 4) in the alley width size 2.4m compared to 0.9m, for example, where the number of turn backs is uniformly low in group sizes 4, 8 or 12. An interaction between group size and alley width was found for turnbacks and confirms this as the difference in the number of turn backs between group sizes increased dramatically when the alley width was set at 2.4m.

A higher average heart rate was measured in group size 20 compared to group sizes 4 and 8 during the pre and post periods (table 1). This difference was likely a result of stress from mixing with unfamiliar pigs. Pigs sometimes fought during these periods. Thus, when released from the start pen to run the course, heart rates may have lessened for the pigs experiencing higher stress as a result of mixing as they were given the opportunity to escape a conflict situation. Furthermore, although we found higher maximum record heart rates in group size 20 compared to groups of 4 and 8 pigs during the run, the physical activity of the run may have confounded the accuracy of heart rate measures.

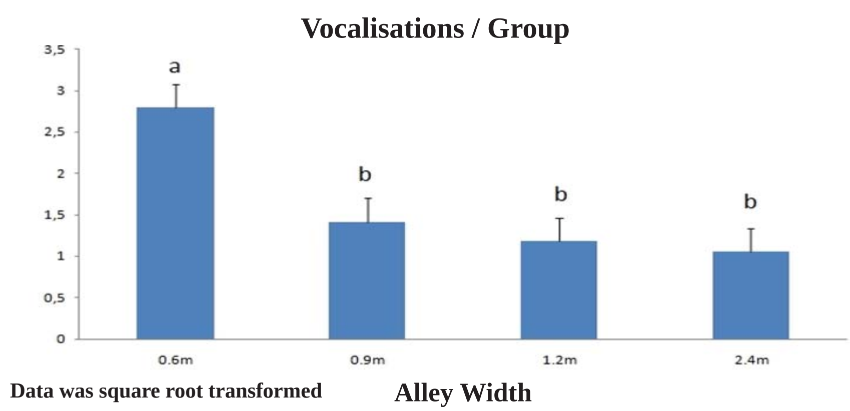

Figure 2. Number of vocalizations for each alley width

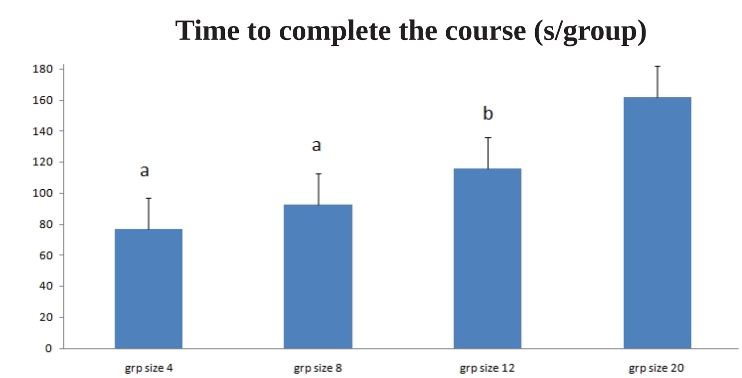

Figure 3. Time to complete the handling course for each group size

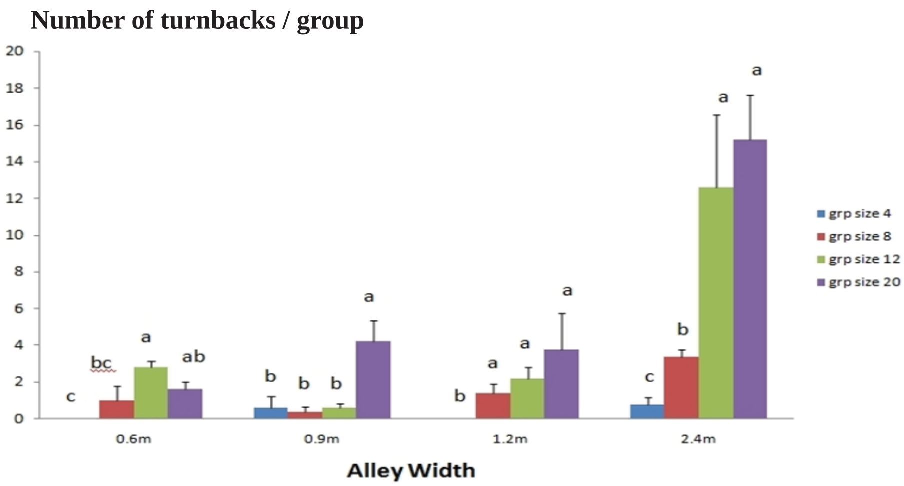

Figure 4. Interaction between group size and alley width

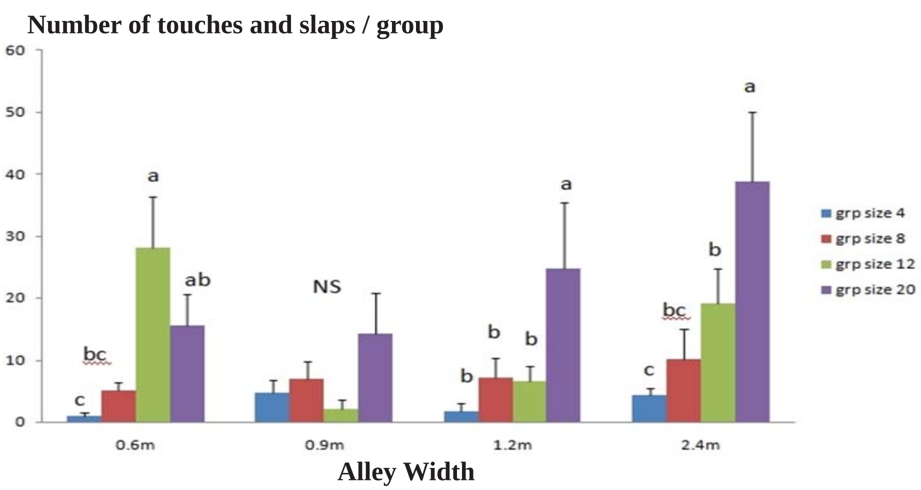

Figure 5. Interaction between group size and alley width effects on the number of touches or slaps given by the handler

IMPLICATIONS

Maximizing the ease with which animals are moved and handled requires taking into account a variety of factors. Our results support the current recommendations and suggest that moving pigs in group sizes that are appropriate for the alley width used can reduce handling time and contribute to improved welfare. This study could be extended in order to assess the effect of ramp widths on pig's movement during loading and unloading.

ACKNOWLEDGEMENTS

Strategic program funding provided by Alberta Livestock Meat Agency. Project funding provided by Sask Pork, Alberta Pork, Manitoba Pork Council & Saskatchewan Agriculture Development Fund.

Table 1. Heart rate data

	Group Size			
	4	8	12	20
Pre HR Average*	11.22[bc]	11.16[b]	11.64[ac]	11.92[a]
Run HR Maximum	175.1[b]	175.9[b]	186.6[ab]	192.5[a]
Post HR average	133.2[bc]	129.6[c]	141.1[ab]	146.8[a]

* transformed data; Means with different letters in the same row are significantly different (P<0.01).

Free space utilization of sows in free access stalls

Lang, F. C., S.M. Hayne, V. Heron, and H.W. Gonyou

Harold Gonyou

Fiona Lang

SUMMARY

With announcements by the largest producer/packers in the USA and Canada that they will transition all of their production facilities to group housing for sows over the next ten years, North American producers are anticipating change. The objectives of this study were to compare two pen configurations fitted with walk-in/lock-in stalls and determine the number, size and parity of sows that use the free space. One pen configuration, referred to as the 'I-pen', consisted of an alley with slatted flooring running between two rows of stalls. The other configuration is referred to as the 'T-pen' as it was similar to the previous configuration with an additional solid floor loafing area at one end. Pigs were individually marked and photographs taken every 2mins for 24hrs once a week, for 11 weeks through gestation. The majority of sows did use the free space although not regularly or for extended periods. Older, heavier sows used the free space area significantly more than younger, smaller sows. Although many sows did use the free space, it was at a much lower level than expected. This could be due to lower ranking animals feeling threatened by higher ranking animals.

"Sows housed in the 'T' pens used the free space area significantly more than the sows housed in the 'I' pens"

INTRODUCTION

With announcements by the largest producer/packers in both the USA and Canada that they will transition all of their production facilities to group housing for sows over the next ten years, all North American producers are anticipating a change to group housing. This can be a challenging step for producers, and it is made more difficult by the lack of scientific information currently available on the implementation and design of alternative systems. Group housing systems can be complex to initiate and require greater input from stockmen, however when done correctly, can produce sows that are able to socially interact with one another and have the freedom to move. Sows currently housed in gestation stalls have almost no opportunity to exercise and perform natural behaviours, leading to a possible decline in well-being. It has previously been suggested that exercise is required to maintain bone composition and strength, and when exercise is insufficient, calcium will be mobilized from the bone itself (Lanyon, 1984 and 1987). Exercise is important to allow the development of bone and muscle to their maximum potential. Decreased muscular strength (which is commonly observed in confined sows) can contribute towards difficulty in lying and standing, and higher susceptibility to lameness due to increased slipping. Lack of exercise in confined housing has also been shown to cause bone weakness in other species. For example, confined laying hens have significantly weaker humeri and tibiae than birds housed in non restrictive environments (Knowles and Broom, 1990). One possible alternative to gestation crates are free access or walk-in/lock-in stalls. This system provides sows with opportunities to interact as a group in a communal area, or remain alone in a free access stall. There is some concern regarding the degree to which sows use free space group areas, and how to avoid aggression, particularly when new sows are mixed into a group. This study investigates the implementation of walk-in/lock-in stalls for group housed sows. More specifically, the objectives of this study were to compare two different pen configurations by determining the proportion and type (size/parity) of sows that are using the free space areas of the walk-in/lock-in stalls, and also how sows utilize the free space areas.

EXPERIMENTAL PROCEDURES

Eight groups of 25 sows (± 3; mean ± SD) were used in the study, and were housed in walk-in/lock-in stall gestation pens at the Prairie Swine Centre, Saskatoon. Groups were selected according to how many individuals were confirmed pregnant in a batch of animals within a 2 week breeding date window, therefore group size was not always the same. Each of the groups were exposed to one of two configurations of free space areas. The first is referred to as the 'I' pen as it consisted of an alley (10ft x 35ft) with slatted flooring running between two rows of 16 stalls on each side. Any additional stalls, surplus to the group number, were locked off for the

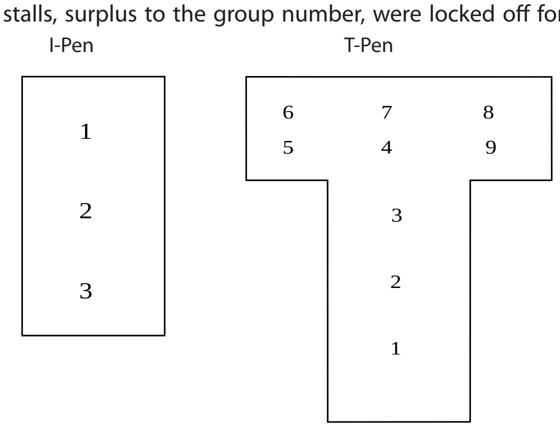

Figure 1. Location of free space areas used for space utilization

purpose of the trial. The second pen configuration is referred to as the 'T' pen as it consisted of an identical alley with an additional solid floor loafing area at one end (12ft x 23ft). Sows were weighed when moved from their breeding stall to the gestation pen, and individually marked with livestock paint.

Photographs were taken from mounted cameras at 2 minute intervals over a 24hr period, once a week, for 11 weeks throughout gestation. Two cameras were set up in the 'I' pen, one at each end of the pen. Four cameras were used in the 'T' pen in order to also observe the free space area. The pens were divided into 3 areas (I pen) and 9 areas (T pen) (see Fig. 1). The individual sow and location was recorded numerically by a trained observer. Measurements recorded from the photographs include the percentage of time spent out of the stall over 24hrs, and also the location and position of sows in the free space areas.

RESULTS AND DISCUSSION

The majority of sows did use the free space areas (> 95% of sows) although not on a regular basis or for extended periods of time. The average usage for the 'I' and 'T' pens were both relatively low, however, the sows housed in the 'T' pens used the free space area significantly more than the sows housed in the 'I' pens ($P<0.001$). More than half the animals in the study spent < 5% of their time in the free space area, however the average usage was ~18% (with considerable individual variation). Heavier sows appeared to use the free space area significantly more than lighter sows ($P<0.0001$), and older (higher parity) sows also used the free space significantly more ($P<0.001$) (Fig. 2). Figures 3 and 4 illustrate the preferred lying areas of the sows. In the 'I' pens, the far end of the pens was the most preferred place to lie, with the highest recorded usage in Area 3 with 8.9% of the average total usage. Similarly, with the 'T' pens, the most preferred place to lie was also in the corners (Areas 5, 6, 8 and 9).

Although many sows did use the free space, it was at a much lower level than expected. This could be due to several possibilities, such as lower ranking animals feeling threatened by higher ranking sows, or larger sows utilizing the free space due to crowding in the stalls. It has been suggested that due to the rigorous selection for improved meat production, the body shape of modern domestic pigs has been changed (Whittemore, 1994). Selection has resulted in larger pigs which can have difficulty lying and standing, and may not fit comfortably into conventional stalls. The areas where sows have shown a preference to lie down all have more walls than the other available areas, which can act as support. This finding is in agreement with previous studies (mostly in the farrowing environment) where sows also show preference to use support when lying down. Marchant et al., (2001) reported that 89% of lying down events were carried out using either a sloping wall, or a wall fitted with a piglet protection rail.

With the transition towards group sow housing it is important that scientific research is used to design the optimum housing system which can facilitate social interactions and minimize aggression and competition. Future research resulting from this study will focus on methods for encouraging the sows to utilize the free space areas. This will include improving the comfort of the free space area with rubber mats, providing environmental enrichment, or possibly allowing sows access to the free area in different social groups (alternate groups) i.e. gilts and sows.

IMPLICATIONS

Group housing of sows is recognised as an alternative system for improving animal comfort and well-being however, we found that not all sows used the free space areas on a regular basis, or for extended periods of time. It is apparent that the older, heavier sows are utilising the space the most, therefore further research in this area will involve reducing social stress perceived by younger animals, and making the free space area more comfortable.

ACKNOWLEDGEMENTS

Specific project funding was also provided by the Saskatchewan Department of Agriculture and Food. Strategic program funding provided by Sask Pork, Alberta Pork, Manitoba Pork Council, and the Saskatchewan Agricultural Development Fund.

Pigs using the 'T' pen free space area

Looking down onto the 'I' pen

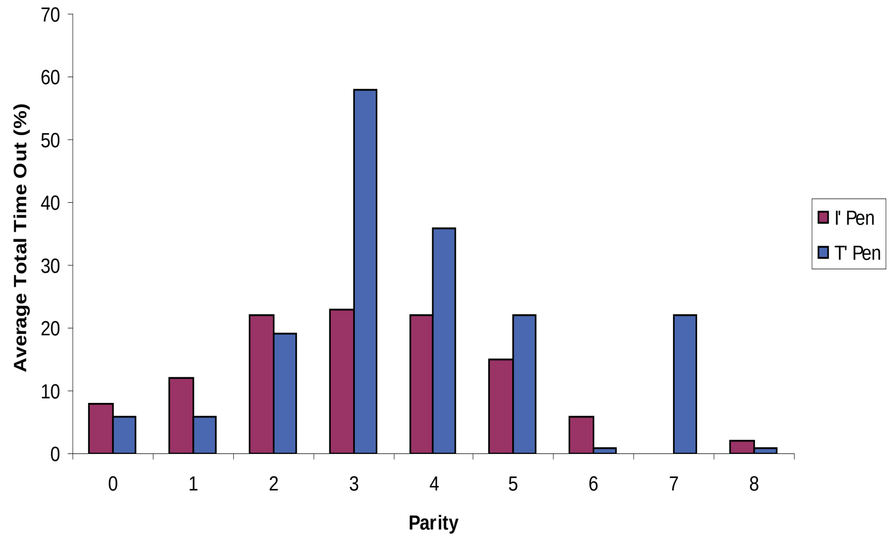

Figure 2. Average total time that sows of varying parities spend in the free access areas.

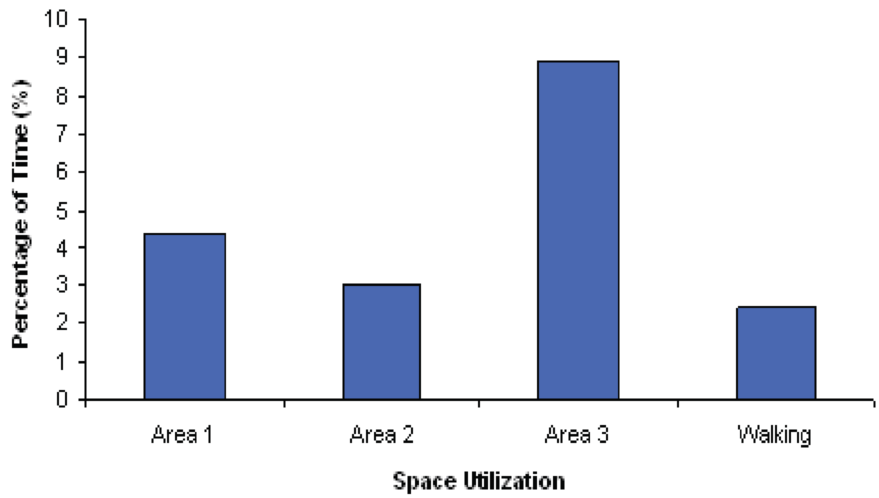

Figure 3. Percentage of time that sows spend in each location during utilization of the free space areas, I-pen data.

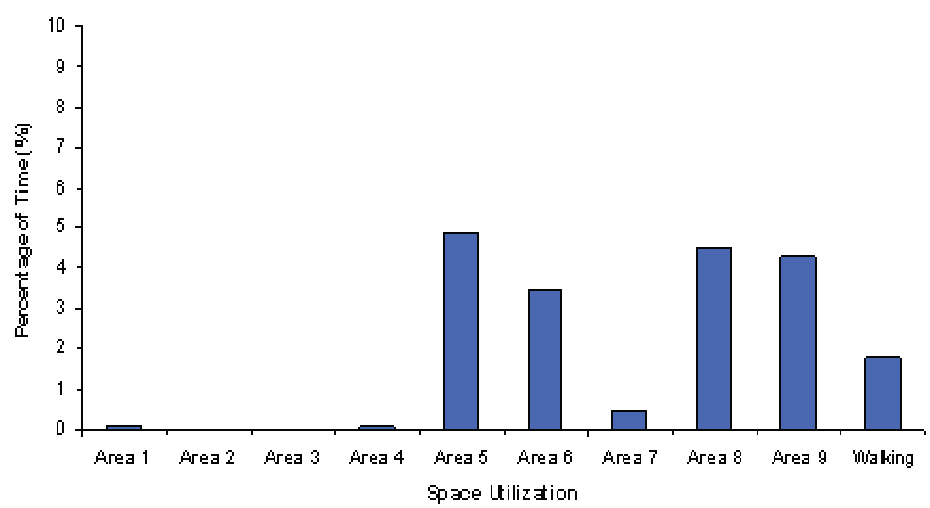

Figure 4. Percentage of time that sows spend in each location during utilization of the free space areas, T-pen data.

Effects of transport conditions and vehicle design on the welfare and meat quality of pigs in Western and Eastern Canada

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SUMMARY
This study examined transport conditions and behavioural and physiological responses of pigs transported in summer and winter, in both Eastern and Western Canada. Data were collected during all stages of transport, including loading, transport, unloading and lairage (waiting) at the abattoir. Measures included truck temperature, pig behaviour, core body temperature, heart rate, blood measures of stress and meat quality. The presence of steep internal ramps in pot belly trailers had a significant impact on the handling behaviour and heart rate of pigs at loading and unloading. Significant variation in temperatures was found between compartments within pot belly trailers during transport, both in summer and winter. The combination of handling conditions and truck temperatures had a significant impact on pork quality. In the winter trials a higher incidence of dark firm and dry (DFD) or moderate DFD pork was found, especially in the west where pigs experienced longer transport times. In the summer trials, a higher incidence of pale, soft and exudative (PSE) or moderate PSE pork was found.

INTRODUCTION
Transport conditions (including loading and unloading procedures), and the design of transport vehicles can have a significant effect on the welfare of pigs, and on the economics of pork production. A recent Ontario survey found that death losses during transport were 0.17%. The mortality rate across Canada has been estimated at 0.10%, and corresponds to approximately 1.4 million kg of pork lost per year. Most research on the effects of transport conditions on pigs has been done in European countries where moderate temperatures and shorter transport distances prevail. In comparison, swine transport in Canada is highly variable in terms of the types of vehicles used, distance of transport, and seasonal changes in temperature. The objective of this study was to examine the influence of transport conditions on the behaviour, physiology and welfare of pigs in eastern and western Canada, in both summer and winter. Our goals were to to evaluate differences between truck types, truck compartments and seasons in each region, and to use this information to identify problem areas and potential solutions.

"When transporting hogs to market, pigs in the bottom front compartment had the highest heart rate measures at unloading, and also produced the highest incidence of DFD pork"

EXPERIMENTAL PROCEDURES
Trials were conducted both in summer and winter, with 6 trials per season in the east (Quebec) and west (Saskatchewan and Manitoba). Animals transported were market weight pigs, including both males and females, averaging approximately 115 kg liveweight. A total of 24 truckloads (total of 3,756 animals) were transported in the east, and 12 truckloads (total of 2,145 animals) were transported in the west.

In western trials, a dual purpose (cattle and pig) dual-axle pot belly (PB) truck was used to transport pigs, containing 5 internal ramps to move pigs to different levels within the truck. In eastern trials, two types of trucks were used: a double deck

Testing for Meat Quality

10 wheel truck (10W) and a tri-axle potbelly trailer (PB, Figure 1). The 10W truck had no internal ramps, and the PB truck used two internal ramps to move pigs onto the upper and lower decks. Loading density on all trucks was 0.41 m^2/pig. The western pot belly truck carried 195 pigs per load, while the easter pot belly truck carried 228 and the 10W truck 85 pigs per load.

Temperatures on trucks were monitored, as was the behaviour of pigs during loading, transport, unloading, and lairage. Behaviour during transport was recorded on all trucks using still image digital cameras to determine the percentage of animals standing, sitting or lying during transit. During the lairage period, behaviour was recorded using video cameras to determine the number of pigs lying. Physiological measures, including core body temperature, heart rate, and blood indicators of stress (lactate and CPK), were collected on a total of 504 animals in the east, and 330 in the west. Carcass and meat quality data were collected on 792 pigs in the east and 495 pigs in the west. Skin damage was assessed as a measure of aggression. Pork quality was assessed in loin and ham muscles, including pH measured at 6 h and 24 h, light reflectance and drip loss.

Data from the western and eastern trials were analyzed separately. Statistcial analysis was used to determine differences between seasons and truck compartments, as well as between truck types in the eastern trails.

RESULTS AND DISCUSSION

The comparison of truck types in the eastern trials indicated that, overall, transporting pigs on the 10W truck provided superior results in terms of reduced death losses and improved welfare. Compared to the PB truck, pigs took less time to load and unload on the 10W truck, and showed fewer incidents of slipping, falling, backing and balking during loading and unloading. The 10W truck provided more consistent internal temperatures, whereas temperatures within PB trucks varied significantly. Measures of CPK and lactate were also lower in the 10W truck. Differences between HR and core body temperatures on the two trucks are less clear in terms of their effects on welfare. Pigs on the 10W truck had lower core body temperatures at the farm, but higher temperatures and HR during transport. These differences are likely due to the study protocol, as the 10W truck was always loaded last, giving pigs on the 10W less time to acclimatize before transport. Thus pigs on the 10W truck experienced the additive effects of loading and transport.

On PB trucks, significant variation was found within the truck, both in terms of truck microclimate and the response of pigs. In both eastern and western trials, compartments that required negotiation of ramps and turns had the greatest impact on physiological measures in pigs. In the western PB truck, the bottom front compartment (or 'nose') was accessed by 2 ramps, and was also the warmest area on the truck. Pigs in the bottom front compartment had the highest HR measures at unloading, and also produced the highest incidence of DFD pork. Pigs in the upper-level compartments had higher HR and core body temperatures during loading and waiting on the farm. The upper compartments were also cooler during the transport period, and this may benefit pigs in summer, but be detrimental in winter. It should be noted that pigs in this study were transported in early morning, and different results may have been found if pigs were transported in midday. Pigs loaded on the middle deck of PB trucks did not have to negotiate any internal ramps, and these animals also showed lower HR during transport, and lower CPK and lactate levels at slaughter.

The effect of season was significant, but the effects varied between eastern and western trials. In western trials, higher HR and core body temperatures were found in winter, and CPK and lactate levels were also higher in winter. Whereas in the eastern trials, HR and core body temperature were higher in summer, as were blood lactate levels. Pigs in the west experienced a much longer transport time (roughly 8 h vs. 2 h in the east) and colder winter temperatures, and thus winter transport may pose a greater challenge in these conditions. In contrast, pigs in the east had a short transport time, and experienced higher summer temperatures and increased death losses in summer (Table 1), suggesting that summer transport may be a greater challenge under these conditions

Table 1. Incidence of death losses and compromised animals at unloading in Eastern and Western trials

Region	Western trials		Eastern trials			
Truck type	Pot belly		10 Wheel		Pot belly	
Season	Summer	Winter	Summer	Winter	Summer	Winter
N	1167	953	510	512	1368	1367
NANI* (n)	0	0	1	0	7	1
NAI* (n)	0	2	0	0	2	1
Death loss (n)	1	0	1	0	6	1
Rectal prolapse (n)	4	2	1	2	2	13

* NANI: Non-ambulatory, non-injured. NAI: Non-ambulatory, injured

IMPLICATIONS

Transporting pigs on trucks such as the 10W truck, which do not require the use of internal ramps, provides benefits in terms of improved welfare and ease of loading. Unfortunately these trucks are less economical as they have much reduced capacity compared to PB trucks. In the long run, alternative designs should be sought, such as trucks including hydraulic lifts and/or minimal ramps, to minimize handling stress at loading and unloading.

On the PB trucks, compartments involving ramps and turns had the greatest impact on pig welfare in terms of HR and core body temperature. Further studies will examine the effects of ramp angle and alternative ramp configurations on the stress response of pigs. The PB trucks also showed significant variability in temperature between different compartments. Further research should be done to assess ways of controlling truck conditions to retain heat in winter, while exhausting moisture, and to increase cooling in summer. Potential solutions include adjusting panelling/vent configurations to optimize air flow, addition of insulation, use of fans, adjusting pig density, or sprinkling pigs in hot weather to increase evaporative cooling. Due to the different results observed in eastern and western trials, future studies in the east will focus on ways of cooling pigs in summer, while studies in the west will focus on the effect of transport time on the welfare and meat quality of pigs.

ACKNOWLEDGEMENTS

Specific project funding was also provided by Ontario Pork, Maple Leaf Pork, The Natural Sciences and Engineering Research Council, and Agriculture and Agri-food Canada. Strategic program funding provided by Sask Pork, Alberta Pork, Manitoba Pork Council and the Saskatchewan Agricultural Development Fund.

Figure 1. Trucks used for Eastern trials.
1a. Pot-belly truck used in Eastern trials (PB),
1b. Ten wheel truck used in Eastern trials (10W).

Impact of feeding diets containing extruded flaxseed meal and vitamin E in finishing swine

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Denise Beaulieu

SUMMARY
Previously we have shown that pork from pigs fed high flaxseed containing diets can be subject to rancidity. The objective of this experiment was to determine if added vitamin E could mitigate this problem. A total of 96 growing pigs were fed one of 3 different diets for 11 weeks prior to slaughter. The diets contained either 0 or 5 % flaxseed or 5% flaxseed plus 200 mg/kg vitamin E. As expected feeding flaxseed increased the omega-3 fatty acid content of the pork, especially high fat pork products. This was accompanied by the detection of off-flavours such as rancidity. The added vitamin E lessened these negative side-effects although this pork still did not score as high as that from animals fed no flaxseed.

"A diet containing 5% flaxseed, fed as a 50:50 co-extruded pea/flaxseed blend increased the omega-3 content of pork fat"

INTRODUCTION
Successful marketing of pork enriched with omega-3 fatty acids requires that other pork attributes are not reduced. We have conducted a series of experiments and shown that the inclusion of 5 % extruded flaxseed in the diet of finishing pigs for 11 weeks prior to marketing enriched some cuts of pork sufficiently to allow a claim of "omega-3 enriched" (300 mg omega-3 per 100 grams). At the high levels of enrichment there was some indication of "off-flavours" noted by the taste panels.

Vitamin E (DL-a-tocopherol acetate) is a natural fat-soluble vitamin which has been used in high-fat diets to prevent the oxidation of unsaturated fatty acids which can cause rancidity. The objective of this experiment was to determine the impact of added dietary vitamin E on the incidence of rancidity or off-flavours in omega-3 enriched pork products.

MATERIALS AND METHODS
The experiment required 96 pigs and was conducted utilizing a completely randomized block design with a 3 x 2 x 2 factorial arrangement of treatments: Treatments were 3 dietary treatments: a) Control, b) 5% flaxseed and c) 5% flaxseed plus 200 mg (IU)/kg diet Vit. E by 2 initial weight groups: a) 30 ± 4 kg and b) 44 ± 4 kg by 2 genders.

Diets were based on wheat, barley and soybean meal and fed for 3 phases of growth. The flaxseed was added as Linpro®, an extruded 50:50 pea/flaxseed blend using extrusion conditions optimized in a previous experiment (Htoo et al. 2008) and supplied by O & T Farms, Regina, SK. Field peas were added to the diets to compensate for the peas added in the Linpro and thus equalize pea content in all diets.

Diets a) and b) contained 11 mg (IU) /kg Vit E, , meeting the requirement (NRC 1998) for pigs of this age, but providing no "safety margin". Diets were fed for 11 weeks prior to slaughter.

Pigs were shipped to the Agriculture and Agri-Food Canada, Lacombe Research Centre, and were slaughtered in a simulated commercial manner. Sensory analysis of fresh, cooked pork and burgers was conducted by a trained taste panel.

Flax

Table 1. Omega-3 concentration (mg/100 g tissue) and fat hardness of commercial cuts.

	Treatments				
	Control	5% Flaxseed	5% Flaxseed plus Vit. E[1]	SEM	P-value
Omega-3, mg/100g					
Loin Primal[2]	127.6^{b}	887.9^{a}	870.5^{a}	28.3	<0.001
Loin Commercial[3]	343.6^{c}	2154.2^{b}	2302.8^{a}	55.7	<0.001
Burger[4]	777.9^{b}	3285.7^{a}	3252.3^{a}	96.4	<0.001
Ham Primal[2]	106.1^{b}	521.5^{a}	558.4^{a}	18.8	<0.001
Fat Hardness[5]	67.0^{a}	56.1^{a}	56.6^{b}	4.6	<0.001

[1]200 IU vitamin E (DL-α-tocopherol acetate) per kg of diet.

[2]Primal contains all muscle, plus seam fat (loin) or no seam fat (ham)

[3]Commercial cut contains loin primal plus ¼ inch of backfat. (Effect of gender (P<0.001); males 14% higher than females)

[4]Loin muscle plus 20% subcutaneous added fat.

^{a,b}. P < 0.05.

[5] Durometer units, 0-100

Table 2. Sensory analysis of fresh cork pork and burgers.

	Treatments				
	Control	5% Flaxseed	5% Flaxseed plus Vit. E.	SEM	P-Value
		.... Fresh Pork............			
Pork Flavour Intensity[1]	5.09^{a}	4.88^{b}	4.87^{b}	0.12	0.01
Stale Flavour[2]	1.67^{a}	0.00^{b}	0.00^{b}	0.49	0.02
Spongy texture[2]	2.30^{a}	0.44^{b}	0.00^{b}	0.60	0.02
Cook Time, sec/g	7.25^{a}	6.51^{b}	6.83^{ab}	0.25	0.04
		.... Burgers............			
Initial Tenderness[1]	7.65^{b}	7.73^{ab}	7.76^{a}	0.06	0.02
Initial Juiciness[1]	5.62^{b}	5.98^{a}	6.07^{a}	0.13	<0.001
Flavour desirability[1]	5.39^{a}	4.85^{c}	5.12^{b}	0.13	<0.001
Pork Flavour Intensity[1]	5.21^{a}	4.87^{b}	5.02^{b}	0.14	<0.001
Off Flavour Intensity[1]	7.83^{a}	7.08^{c}	7.44^{b}	0.10	<0.001
Sustained Juiciness[1]	5.82^{b}	6.06^{a}	6.10^{a}	0.13	0.001
Overall Palatability[1]	5.12^{a}	4.62^{c}	4.85^{b}	0.15	<0.001
Rancid Flavour[2]	0.00^{b}	6.29^{a}	1.44^{b}	1.24	<0.001
Other Flavours[2]	3.43^{b}	15.33^{a}	6.38^{b}	1.71	<0.001
Unidentified Flavours[2]	23.15^{b}	26.90^{ab}	33.39^{a}	4.29	0.01x
Typical Pork Flavour[2]	42.63^{a}	22.48^{b}	28.48^{b}	3.14	<0.001
Mushy Texture[2]	83.69^{a}	78.78^{ab}	71.81^{b}	2.82	0.008

[1] Measured on a 9-point scale where 1=extremely undesirable and 9=extremely desirable
[2] Percentage of panelists reporting the listed attribute
^{ab} P<0.05

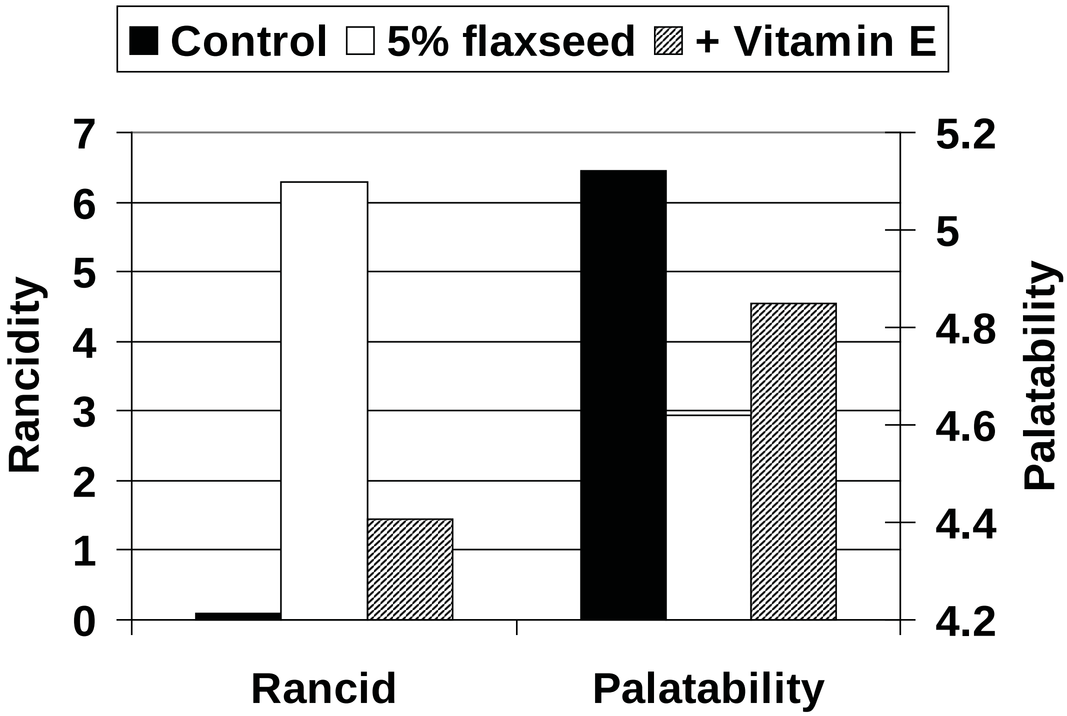

Figure 1. Sensory analysis of burgers. Rancidity is reported as the percentage of panelists reporting meat with this attribute. Palatability is measured on a 9-point scale where 1 = extremely undesirable and 9 = extremely desirable (a, b. $P < 0.05$)

RESULTS

As expected, a diet containing 5 % flaxseed, fed as a 50:50 co-extruded pea/flaxseed blend increased the omega-3 content of pork fat, and thus of pork commercial cuts containing fat regardless of the content of Vitamin E (Table 1). Omega-3 fatty acids are highly unsaturated which results in a decreased fat hardness.

Feeding 5 % flaxseed to pigs for 11 weeks had minimal or no effect on flavour, including rancidity, in low-fat cuts of pork. Ground pork, containing 20% fat, from pigs fed 5% flaxseed had slightly, but significantly, decreased pork flavour, desirability and palatability. A greater proportion of panelists reported pigs fed flaxseed have a rancid or "other flavour" (Table 2). Supplemental Vitamin E mitigated the effect of the flaxseed on rancidity, and the other negative attributes.

CONCLUSIONS

Although supplementing the diet of finishing swine with 5% flaxseed for 11 weeks will have minimal or no effects on off-flavours in low-fat cuts of pork, cuts containing a higher content of fat (ie. ground pork) will be negatively affected. Supplementing the diet with 200 IU/kg vitamin E will mitigate these negative effects (Figure 1).

IMPLICATIONS

It is well recognized that the production of pork with enchanced nutritional attributes, such as omega-3 enriched, must not compromise pork quality. The rancidity and off-flavours which may accompany increased levels of omega-3 fatty acids in pork can be mitigated by feeding high levels of vitamin E. Further research is required to determine if there are other, more efficient methods,(i.e. post-harvesting technologies) which could alleviate this problem.

ACKNOWLEDGEMENTS

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The effect on growing pig performance of changes in energy intake achieved through restriction of feed intake versus changes in dietary energy concentration

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"The utilization of net energy for body weight gain was unaffected by feeding level or by energy concentration of the diet"

SUMMARY

This study demonstrates that the energy intake of pigs can be successfully manipulated by progressive restriction of feed allowance; while changes in dietary energy may not result in changes in the pigs' energy intake. Accordingly, restriction of feed allowance was accompanied by significant changes in the performance parameters studied (ADG, ADFI, G:F, PDR); while only ADFI was significantly affected by changes in dietary energy concentration.

INTRODUCTION

The pig's energy intake can be manipulated through restriction of its feed intake or by altering the energy density of its diet. The former approach is commonly taken in a research setting while the latter is generally the more common approach in commercial pork production. Restriction of the growing pig's feed intake results in decreases in energy intake and in average daily gain. Some authors report analogous findings when dietary energy concentration is manipulated while others report that changing dietary energy concentration does not affect energy intake or growth performance. The objective of the present experiment was to compare the pig's response to changes in energy intake brought about by either a change in feed intake or altering dietary energy concentration.

MATERIALS AND METHODS

Dietary treatments were arranged in a 3 x 3 factorial design with 3 feeding levels (80, 90 and 100% of ad libitum) and 3 dietary net energy concentrations (2.18, 2.29 and 2.40 Mcal/kg). Net energy concentrations were adjusted through proportional changes in the inclusion levels of wheat (15.00, 39.55 and 64.51 % as-fed), barley (55.45, 31.33 and 6.80 % as-fed) and canola oil (1.00, 2.25 and 3.50 % as-fed) in the experimental diets.

Seventy-two individually-housed barrows (initial bodyweight 30 ± 2 kg) each received one of nine dietary treatments. On a weekly basis, the pigs were weighed, the feed allowances of the restricted-fed pigs were adjusted and the feed intake (disappearance) of the ad libitum-fed pigs recorded. Pigs were removed from the experiment at a bodyweight of 60 ± 2 kg.

Data analysis was performed using the MIXED procedure of SAS (SAS Institute, 1996) to examine the fixed effects of feeding level, energy concentration and their interaction.

RESULTS AND DISCUSSION

No interactive effects between feeding level and dietary energy concentration were found ($P > 0.10$). Average daily gain (ADG), average daily feed intake (ADFI), gain:feed (G:F) and protein deposition rate (PDR) increased with increasing feeding level (Table 1; $P < 0.05$). Increasing diet net energy concentration reduced ADFI ($P < 0.05$) but had no effect on ADG, G:F or PDR ($P>0.10$).

As feeding level increased, daily NE intake increased and a greater quantity of NE was available to the pig for bodyweight gain ($P < 0.001$); however, the efficiency with which

Weighing Feed

this portion of dietary NE was utilized for growth was unaffected by dietary treatment (Table 1; $P > 0.10$). Diet NE concentration has no effect on NE intake or NE available for body-weight gain ($P > 0.10$). The utilization of NE for gain was unaffected by feeding level or by energy concentration ($P > 0.10$).

The response of growing pigs to changes in dietary energy concentration differed from their response to changes in feed allowance. Each of the two approaches to studying the pig's response to dietary energy provides very useful information on energy metabolism, but extrapolating the findings of one to circumstances of the other must be done with great care. This is particularly noteworthy since most pigs in commercial production are fed ad libitum.

IMPLICATIONS

The present study indicates that, in terms of swine energy metabolism, it may not be universally appropriate to apply knowledge obtained using restriction of feed intake to scenarios in which dietary energy concentration is to be manipulated, and vice versa.

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Table 1. Effects of feeding level and energy concentration on the performance of growing pigs

	Feeding level, % ad lib			NE Concentration, Mcal/kg			
Item	80	90	100	2.18	2.29	2.40	SEM
N	24	23	23	24	23	23	-
Initial BW, kg	30.4	30.4	29.6	30.2	30.2	30.0	0.34
Final BW, kg	59.6	60.3	60.2	60.3	59.7	60.0	0.45
ADG, kg[1]	0.72	0.85	1.06	0.89	0.85	0.88	0.02
ADFI, kg [1, 2]	1.61	1.87	2.05	1.93	1.81	1.78	0.04
G:F, kg/kg[1]	0.45	0.46	0.52	0.46	0.47	0.50	0.02
PDR, g/d[1]	135	153	172	147	156	158	5.5
NE_{Intake}, Mcal/d[1]	3.69	4.26	4.68	4.20	4.14	4.27	0.10
$NE_{Maint.}$, Mcal/d[3]	1.36	1.37	1.36	1.37	1.36	1.36	0.01
NE_{Gain}, Mcal/d[1,4]	2.33	2.92	3.32	2.83	2.78	2.91	0.07
$NE_{Efficiency}$, Mcal/d[5]	3.30	3.43	3.19	3.24	3.31	3.36	0.12

PDR: Carcass protein deposition rate,
[1] Main effect of feeding level ($P<0.001$),
[2] Main effect of NE Concentration ($P<0.001$),
[3] $NE_{Maint} = 0.75*106*BW^{0.75}$ (NRC, 1998; Noblet, 2007),
[4] $NE_{gain} = NE_{Maint}$ [5]NE_{gain}/ADG

Enriching pork products with omega-3 fatty acids may affect pork quality

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Denise Beaulieu

SUMMARY
Carcasses from growing swine (n-96) fed diets containing either 0, 5 or 10 % flaxseed for 76 days were graded and the pork was subjected to a sensory evaluation by a trained taste panel. Feeding flaxseed enriched the omega-3 content of the high fat pork (for example ground pork with 20% added fat) sufficiently to allow a labelling-claim in Canada, however, panellists detected evidence of off-flavours and rancidity in these products. Increasing dietary flaxseed resulted in higher lean yield and reduced belly firmness and fat hardness.

INTRODUCTION
It has been shown that the consumption of omega-3 fatty acids, such as α-linolenic (C18:3) is beneficial to human health. Pork fat is representative of the fatty acids consumed by the pig, and the consumption of flaxseed, or flaxseed oil, by finishing pigs will result in a carcass enriched with omega-3 fatty acids. Several recent experiments conducted at PSCI have examined dietary regimes required to effectively increase omega-3 fatty acid concentration of pork. The flaxseed used has been co-extruded with peas giving a product (Linpro®) with improved handling properties and amino acid balance (i.e. PSCI Annual Report 2008). However, primarily because unsaturated fatty acids are susceptible to rancidity and are “oilier” in nature this experiment was designed to investigate whether increasing the omega-3 fatty acid content of the pork fat had any effect on carcass quality or sensory properties of pork chops and ground pork prepared from these carcasses.

MATERIALS AND METHODS
A total of 96 animals with an initial body weight of 48 ± 2 kg (mean ± SD) were used with 12 pens of barrows and 12 pens of gilts (4 animals per pen). Dietary treatments included 3 levels of flaxseed (0, 5 and 10 %) co-extruded 50:50 with field peas (Linpro®, supplied by O&T Farms, Regina, Saskatchewan, Canada). All diets had equal amounts of field peas and diets were formulated and adjusted every 4 weeks to meet the nutrient requirement of the pigs as they grew (NRC, 1998). After 76 days on test, animals were shipped to Lacombe Research Centre (Lacombe, AB, Canada) and slaughtered in a simulated commercial manner. A trained 8-member panel tasted fresh, frozen loin chops and hamburger and scored each for various attributes using a nine point scale.

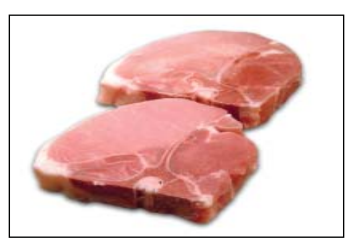
“Feeding co-extruded flaxseed to increase the alpha linoleic acid content in loin muscle did not result in levels sufficient to meet label requirements in Canada”

RESULTS
Performance
Similar to what we have observed in previous studies, feeding 10% flaxseed for 11 weeks had no effect on performance of growing pigs (data not shown).

Carcass quality
Dietary flaxseed did not affect carcass temperature or pH measured 45 min post-slaughter however there was a slight increase in pH at 48 hours post-slaughter (data not shown). Increasing dietary flaxseed also resulted in higher lean yield and reduced belly firmness and fat hardness (Table 1, $P < 0.05$).

Pork from pigs fed flaxseed was slightly darker as indicated by decreased iodine values ($P < 0.01$). No effects of diet ($P > 0.05$) were observed on tenderness of pork chops (shear force), cooking loss or cooking time (data not shown).

Sensory attributes
Panellists detected slight decreases in pork flavour and off-flavour intensity in the fresh frozen and reheated loin chops ($P < 0.05$; Table 1). Conversely in ground pork, except for juiciness, all the sensory attributes measured, including tenderness, pork flavour intensity and off-flavour intensity were negatively affected by feeding co-extruded flaxseed ($P < 0.01$). Furthermore, the percentage of panellists detecting a rancid flavour in ground pork was increased. This may be a result of increased opportunity for oxidation with processing



Raw Pork Chops

Fatty acid composition

The fatty acid composition was determined in intramuscular fat and ground pork. The trends were similar, and thus only the results for the ground pork are presented (Table 2). Dietary flaxseed increased the polyunsaturated fatty acid content of the ground pork, primarily due to a dramatic increase in C18:3 (omega-3) ($P < 0.001$). Although the content of C18:2 (n-6) was increased by feeding flaxseed, the omega-6 /omega-3 ratio was decreased ($P<0.001$), which is also beneficial to human health. The increased C18:3 levels in the ground pork (20 % added fat) seen following 10% dietary flaxseed supplementation would be sufficient to obtain a source claim of 300 mg per 100 gram serving in Canada. However, in pure muscle, with lower fat levels, the C18:3 levels would not meet this requirement.

CONCLUSIONS

Feeding co-extruded flaxseed to increase the alpha linoleic acid content in loin muscle did not result in levels sufficient to meet label requirements in Canada for a source claim if the cuts were trimmed of fat. Moreover, co-extrusion of flax not provide sufficient antioxidant capacity to alleviate texture and flavour problems in high fat products (ie. ground pork) with elevated poly-unsaturated fatty acid content. Although high fat products are required to allow labelling for an omega-3 enriched product, the added fat may result in some negative effects on palatability.

IMPLICATIONS

Although high fat products are required to allow labelling for an omega-3 enriched product, the added fat may result in some negative effects on palatability. Strategies must be investigated to mitigate these effects.

ACKNOWLEDGEMENTS

Project funding was provided by Flax Canada and the Saskatchewan Agriculture Development Fund. Strategic funding provided by Sask Pork, Alberta Pork, Manitoba Pork Council and the Saskatchewan Agriculture and Food Development Fund. We gratefully acknowledge the donation of the LinPro from O & T Farms, SK.

Table 1. Carcass traits and sensory attributes of grower pigs fed 0. 5 or 10 % co-extruded flaxseed.

	% flaxseed in diet				
	0	5	10	SEM	*P* value
Carcass traits					
Lean yield, %	57.0	58.1	58.3	0.43	0.04
Belly firmness[a]	381.8	251.9	190.2	16.0	<0.001
Fat hardness[b]	83.6	71.0	55.7	2.4	<0.001
Sensory Attributes					
Fresh frozen loin chop					
Pork flavour intensity[c]	4.79	4.47	4.40	0.09	<0.001
Off flavour intensity[c]	7.39	7.16	6.98	0.11	<0.03
Sustained juiciness[c]	5.70	5.67	5.57	0.10	0.50
Overall tenderness[c]	6.25	5.86	5.88	0.15	0.11
Overall palatability[c]	4.76	4.43	4.36	0.11	0.007
Hamburger, 20 % fat					
Pork flavour intensity[c]	4.69	4.28	3.65	0.08	<0.001
Off flavour intensity[c]	7.47	6.81	5.66	0.11	<0.001
Sustained juiciness[c]	5.62	5.94	5.94	0.09	<0.001
Overall tenderness[c]	7.88	8.05	8.09	0.07	<0.001
Overall palatability[c]	4.74	4.45	3.62	0.09	<0.001

[a]Degree of bending

[b]40-56, moderately soft, 56-66, slightly soft, 66-74, slightly hard, 74-79, moderately hard, and 79-84, very hard

[c]Pork flavour intensity, 9=extremely intense pork flavour, 1=extremely bland pork flavour); off flavour intensity (9=extremely bland, 1=extremely intense); sustained juiciness (9=extremely juicy, 1=extremely dry), overall tenderness (9=extremely tender, 1=extremely tough), overall palatability (9=extremely palatable, 1=extremely unpalatable).

Table 2. Hamburger (20%fat) fatty acid composition (mg/100 g tissue) from finishing pigs fed 0. 5 or 10% co-extruded flaxseed[a].

	Gilts			Barrows				P value[b]	
Fatty acid	0	5	10	0	5	10	SEM	Gender	Diet
C16:0	3797	3608	3168	4473	4148	3660	157	<0.001	<0.001
C18:0	2289	2222	1858	2770	2569	2235	110	<0.001	<0.001
C18:1	6253	6047	5357	6882	6402	5700	185	0.004	<0.001
C18:2	1344	1688	2016	1261	1662	1974	61	0.306	<0.001
C18:3	214	983	2236	176	1030	2326	60	0.504	<0.001
TOTAL	15702	16363	16355	7560	7015	6164	264	<0.001	<0.001
Σ SFA[c]	6360	6087	5251	7560	7015	6164	264	<0.001	<0.001
Σ PUFA[d]	1843	3135	4876	1703	3158	4937	128	0.858	<0.001
Σ omega3[e]	308	1273	2696	261	1331	2800	65	0.509	<0.001
Σ omega6[e]	1520	1847	2169	1425	1811	2124	71.2	0.264	<0.001
Omega6/ omega3	5.45	1.46	0.81	5.57	1.36	0.76	0.18	0.961	<0.001

[a] Only major fatty acids listed

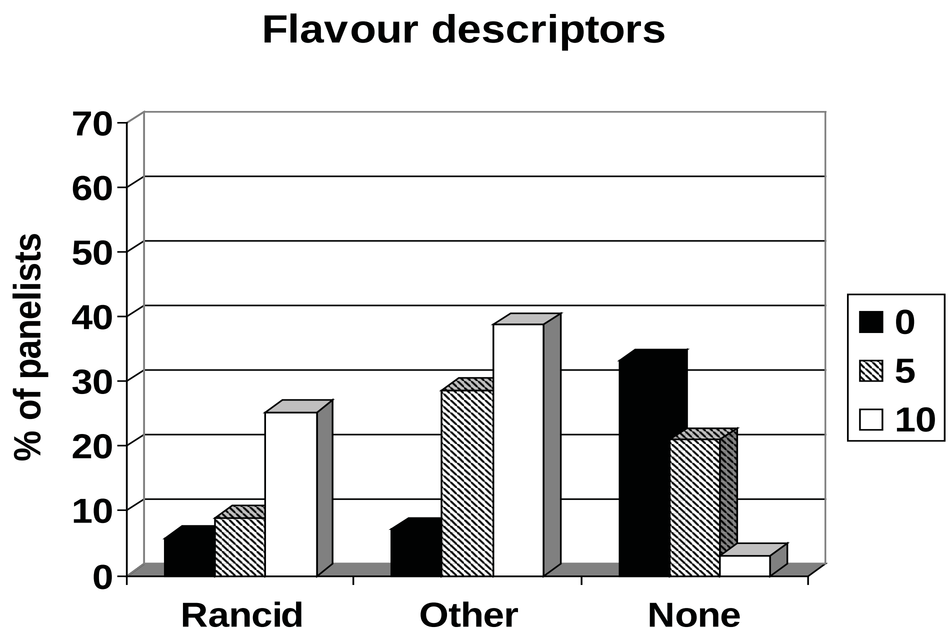
[b] Gender by diet interaction, ($P > 0.05$)

[c] Sum of saturated fatty acids

[d] Sum of polyunsaturated fatty acids

[e] Sum of omega3 or omega-6 fatty acids

[f] Ratio of omega6 to omega3 fatty acids



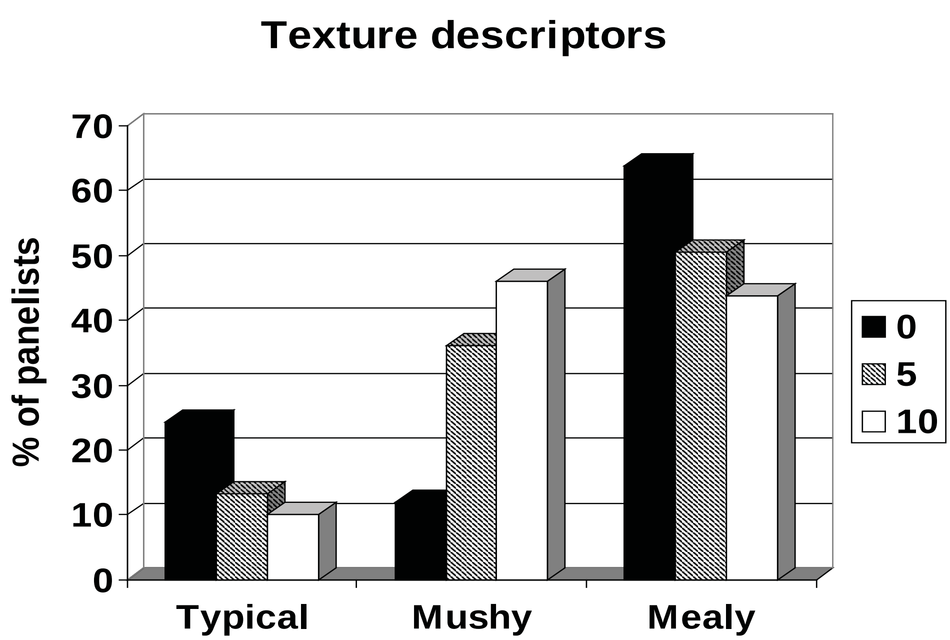


Figure 1. Percentage of panellists reporting cooked hamburger (20%fat) prepared from pigs fed 0, 5 or 10 % co-extruded flaxseed with the indicated attributes. Effect of treatment ($P < 0.05$) for all descriptors.

Effect of an NSP-hydrolysing enzyme (Rovabio Excel ®) in the diet of lactating sows on feed intake, body condition and litter performance and in vivo and in vitro nutrient digestibility

Leterme, P., S.L. Johnston, C.A. Montoya, K.V. Neufeld, J. Bindelle & R. Pieper

Pascal Leterme

SUMMARY

A non-starch polysaccharide (NSP)-hydrolyzing enzyme (Rovabio Excel®, Adisseo), was added to barley- and wheat-based diets and fed to lactating sows to determine if there would be an improvement in sow and piglet performance and feed digestibility. An in-vitro experiment was also performed to assess how the enzyme would influence fermentation of dietary fibre in the pig's large intestine. Although the enzyme improved nutrient digestibility and the energy content of the diet, there was no effect on sow or piglet performance.

"The non-starch polysaccharide (NSP)-hydrolyzing enzyme increased nutrient digestibility, both in-vitro and in-vivo"

INTRODUCTION

Starch and protein, the main nutrients in cereal grains, are surrounded by cell walls composed of indigestible carbohydrates called dietary fibre or non-starch polysaccharides (NSP). These walls must be broken down to allow for the release of nutrients such as starch, oil, and protein. However, a fraction of these carbohydrates is soluble in water and has swelling and viscous properties that can negatively affect the digestive processes by preventing the activity of the digestive enzymes. Barley and wheat contain soluble fibres which can affect the digestive processes. Some exogenous enzymes, extracted from mould or bacteria, are now added routinely in animal feeds to hydrolyse the soluble fibre fractions of barley (ß-glucans) and wheat (arabinoxylans) and improve their digestibility. We hypothesized that the addition of enzymes into the diets could also affect the amount and structure of fermentable substrate in the pig's large intestine, thereby affecting the intestinal microbial community. This is of specific interest as some studies have shown that cereal NSP may exert prebiotic properties or shift N excretion from urine to faeces. However, information on the effect of NSP hydrolyzing enzymes on intestinal microbial community composition in pigs is scarce. The objectives of these studies were to evaluate the effects of the enzyme when added to barley- and wheat-based diets for lactating sows on nutrient digestibility and animal performance. An in-vitro model was also used to study the possible effect of the enzyme on the rate of dietary fibre fermentation in the pig large intestine, metabolite production, and the hindgut microbiota.

MATERIALS AND METHODS

In-vivo (in the pig)

Five experimental diets were prepared and divided into two categories: control diets (CD) supplying all the nutritional requirements (NRC, 1998) of the lactating sows and reformulated diets (RD) supplying 1.5% less lysine and digestible energy, as compared to the CD. The latter were supplemented with 0, 50, or 500 g enzyme/tonne and the RD diets with 0 or 50 g enzyme/tonne. Different diets were also prepared for gilts (first parity) and sows (≥ 2 parities), due to the fact that the gilts require more protein for their growth. A tolerance study (10 times the recommended dose) was made comparing the diets containing 0 and 500 g/t of Rovabio enzyme. Each experimental diet was tested on 25 sows; they were fed from one week before farrowing until weaning (3 weeks). The voluntary feed intake, bodyweight, and backfat thickness of the sows were measured. In piglets, the bodyweight gain and the rate of mortality were recorded.

In-vitro (in test tube)

Seven wheat and barley samples with different carbohydrate fractions (CHO) were hydrolyzed using pepsin and pancreatin with or without the Rovabio Excel enzyme and then fermented for 72 h in a gas test with sow faeces as an innoculum. Dry matter, starch, crude protein, and β-glucan digestibilities were measured. Fermentation kinetics of the hydrolyzed ingredients were modeled, short-chain fatty acids (SCFA) production and profiles after 12, 24, and 72 h compared. Microbial communities after 72 h of fermentation were also analyzed using terminal restriction fragment length polymorphism (TRFLP).

RESULTS

In-vivo (in the pig)

We observed no effect of the enzyme on the sow's performance, possibly because of high variability. There was a tendency for increased feed intake and reduced backfat with the enzyme on the control diets. Nutrient digestibility (+ 3 to 8%) and energy content (+180 kcal/kg) increased when the enzyme was added to the diets of the gilts (Table 1). No negative effects were observed on the sow's and piglet's performances when the level of the enzyme was 10 times the recommended dose.

In-vitro (in test tube)

Besides the expected differences among cereal samples, there were significant effect of the enzyme on almost all parameters. Nutrient digestibilities were increased (Table 2) and fermentability as well as SCFA production decreased (P < 0.001). SCFA and bacterial community profiles indicated a shift from propionate to acetate production and Ruminococcus- and xylanolytic Clostridium-like bacteria increase in response to increased slow fermentable insoluble CHO and decreased fast fermentable β-glucan and starch in the hydrolyzed residues when incubated in the presence of the enzyme.

CONCLUSIONS

The NSP hydrolyzing enzyme increased nutrient digestibility, both in-vitro and in-vivo, however, there was no effect on the performance of the sows, gilts, or piglets. This may be because digestibility is a more sensitive response criteria than growth.

ACKNOWLEDGEMENTS

The authors acknowledge with gratitude the financial support provided by Adisseo. Strategic program funding provided by Sask Pork, Alberta Pork, Manitoba Pork Council and the Saskatchewan Agriculture and Food Development Fund is also acknowledged.

Filling feeders in the nursery

Table 1. Intake, total tract digestibility, and digestible energy of diets with and without non-starch polysaccharide enzyme addition in gilts.

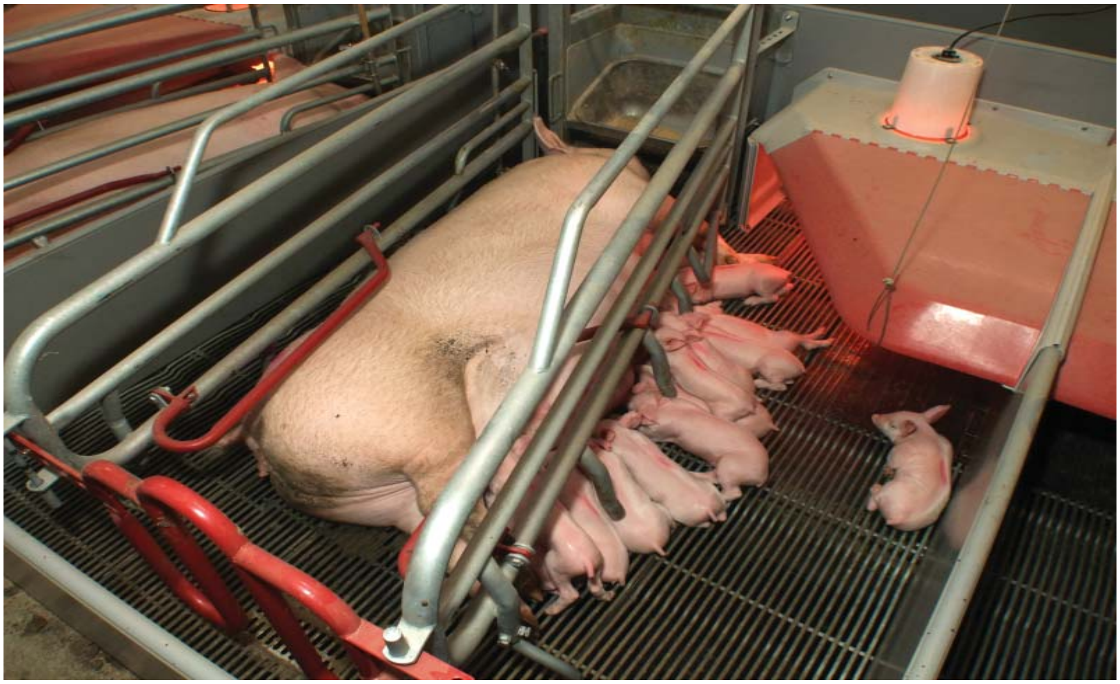
	Control diet (g/t)[1]			Ref. diet (g/t)[1]				P[2]			
	0	50	500	0	50	SEM[1]	Diet	Level	D*L	SEM	P[3]
DM Intake (kg)	125	125	119	126	126	5.4	0.845	0.976	0.940	6.3	0.492
								Digestibility (%)			
DM	52.9	59.4	58.1x	55.3	58.7	1.1	0.445	0.001	0.145	0.9	0.002
Organic matter	42.6	50.7	48.6x	46.0	49.9	1.2	0.325	0.001	0.100	1.2	0.005
Gross energy	55.2	60.7	57.6	55.6	59.8	1.0	0.793	0.001	0.526	1.9	0.393
DE[4] (Mcal/kg)	2.45y	2.65	2.61x	2.37	2.55	0.004	0.056	0.001	0.720	0.03	0.003

1 Levels of Rovabio Excel enzyme in the diets, 2 Comparisons between diet (control and reformulated) and Rovabio level (0 and 50 g/t)

3 Comparisons between diets C-0 and C-500 (tolerance study), 4 DE, digestible energy content

Table 2. In vitro dry matter, crude protein, starch, and β-glucan digestibilities with (+) and without (-) non-starch polysaccharide enzyme added during pepsin and pancreatin hydrolysis (N=8).

		Component			
Composition	Ingredient	Dry matter	Crude protein	Starch	B-Glucan
-	Positive Diet	0.825 c	0.933	0.968	0.462
+	Positive Diet	0.830 bc	0.935	0.973	0.537
-	Wheat	0.839 bc	0.916	0.944	0.095
+	Wheat	0.890 a	0.936	0.989	0.112
-	Wheat bran	0.567 j	0.784	0.985	0.112
+	Wheat bran	0.607 i	0.816	0.975	0.289
-	Common barley McLeod	0.664 h	0.795	0.820	0.242
+	Common barley McLeod	0.715 f	0.845	0.870	0.475
-	Common barley AC Metcalfe	0.697 g	0.794	0.860	0.228
+	Common barley AC Metcalfe	0.749 e	0.844	0.897	0.522
-	Hulless Barley CDC Fibar	0.770 d	0.850	0.883	0.836
+	Hulless Barley CDC Fibar	0.846 b	0.889	0.939	0.896
-	Hulless barley SB94893	0.512 k	0.673	0.567	0.064
+	Hulless barley SB94893	0.613 i	0.770	0.635	0.287
	SEM	0.0115			
	Sources of Variation	**P-values**			
	Ingregient	< 0.001	-	-	-
	Enzyme	< 0.001	-	-	-
	Ingredient x Enzyme	<0.001	-	-	-



New sow research unit features 28 day weaning, removable covered creeps and crates that adjust width from 23" - 34" (57-85 cm), trough volume of 21 L

In vitro fibre fermentation characteristics of specialty ingredients with varying non-starch polysaccharides levels

Jha, R., L. Johnston, J. Bindelle, A. Van Kessel, and P. Leterme

Pascal Leterme

LeAnn Johnston

"Fermentable fibre modulates the gut environment, extends health-promoting properties and reduces ammonia excretion"

SUMMARY

The objective of this study was to use a laboratory technique that mimics what happens in the intestimes of pigs to evaluate the fermentation characteristics of some non-conventional feed ingredients with varying fermentable fibre and their possible influence on intestinal environment and nitrogen excretion. We concluded that fibre fermentation characteristics in the pig gastrointestinal tract are extremely variable from one ingredient to another. Of the feed ingredients evaluated, peas and pea fibres had higher fermentability and bacterial protein synthesis capacity.

INTRODUCTION

The pork industry is looking for alternative feed ingredients that have functional properties to improve gut health and a positive impact on the environment. The intestinal fermentation of dietary fibre results in the formation of short-chain fatty acids (SCFA), which in turn stimulate the growth of beneficial bacteria such as lactobacilli and bifidobacteria and limits the activity of proteolytic microbes in the pig intestine. This might positively affect gut health. In addition depending on the fermentation kinetics, the nitrogen excretion pathway may be shifted from urine to faeces, reducing ammonia emission from swine facilities. However, there is limited information available on these properties of feed ingredients.

MATERIALS AND METHODS

Eight ingredients (wheat bran (WB), solka floc® (SF, wood cellulose), peas, pea hulls fibre (PHF), pea inner fibre (PIF), sugar beet pulp (SBP), flaxseed meal (FSM) and corn distiller dried grains with solubles (DDGS)) with diverse carbohydrate composition were selected for the study (Table 1).

The ingredients underwent an in-vitro pepsin-pancreatin hydrolysis. The hydrolyzed ingredients were then fermented in-vitro with minerals and buffer, using pig feces as the inoculum (Bindelle et al., 2009). The gas production kinetics during fermentation were modeled (Figure 1 and Table 2) according to France et al. (1993). Bacterial nitrogen incorporation (BNI) in fermented substrates was determined using 15N as a marker (Bindelle et al., 2009) (Table 3). Fermented residues were analyzed for SCFA content (Figure 2). There were 2 replications of 8 ingredients and 6 blanks in each of 4 batches. The influence of the ingredient on the fermentation kinetics, SCFA and BNI was compared in the statistical analyses.

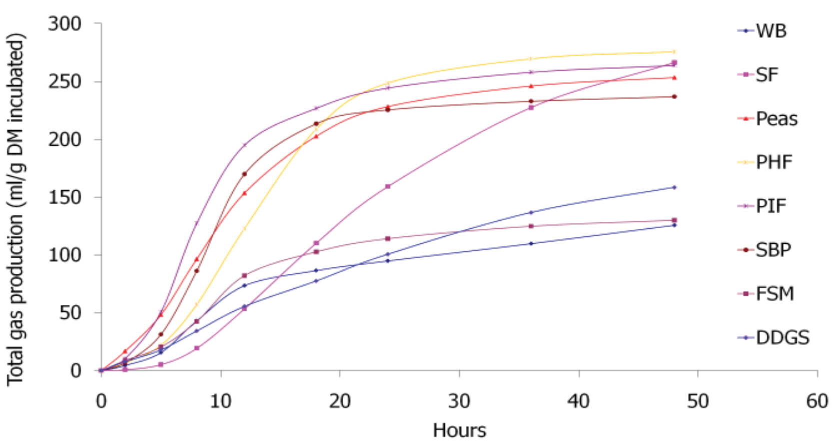


Figure 1. Gas production kinetics of different ingredients studied in vitro (in test tube)

*Representative of kinetic parameters of gas production curve (Gf, L, T/2 and μ) modeled according to France et al (1993)

RESULTS

The source of fibre affected the in-vitro dry matter degradability (IVDMD), the fermentation kinetics and the gas production profile (P<0.05). The highest (P<0.001) IVDMD values were observed for peas (0.80) and FSM (0.70), whereas SF was essentially undegraded (0.06), as would be expected. The fractional rate of degradation appeared to be lower (P<0.001) for WB and DDGS (0.07 and 0.05/h, respectively) and highest for SBP (0.20/h). Peas started to ferment rapidly (lag time 1.3 h). Half gas production (T/2) was achieved sooner for PIF (8.4 h) and was the longest for

DDGS (19.8 h). The total gas production was the highest for PH, followed by SF, PIF and peas (276, 266, 264 and 253 ml/g DM incubated, respectively) and lower for FSM and WB (130 and 124 ml/g DM incubated, respectively). There was no difference (P>0.05) in SCFA production after the fermentation of SF, P, PH, PIF and SBP (ranging from 3.8 to 4.5 mMol/g DM incubated) while WB and FSM yielded lower (P<0.05) SCFA. The bacterial nitrogen incorporation (BNI), both at T/2 and after 48 h of fermentation was the highest (P<0.001) for PIF (18.5 and 15.6 mg/g DM incubated, respectively) and the lowest for DDGS and WB.

IMPLICATIONS

peas and pea fibres had higher rates of fermentability, produced more SCFA and had high bacterial protein synthesis capacity. They thus have the potential to be included in pig diets as a source of fermentable fibre to modulate the gut environment, extend health-promoting properties and reduce ammonia excretion.

CONCLUSIONS

Fibre fermentation characteristics in the pig gastrointestinal tract are extremely variable between ingredients. Pea and pea fibres have high fermentability and bacterial protein synthesis capacity and thus have potential to be a source of fermentable fibre when included in swine diets.

ACKNOWLEDGEMENTS

Project funding was provided by the National Pork Board. Strategic Program funding from Sask Pork, Alberta Pork, the Manitoba Pork Council and the Sask. Ag. Dev. Fund is gratefully acknowledged.

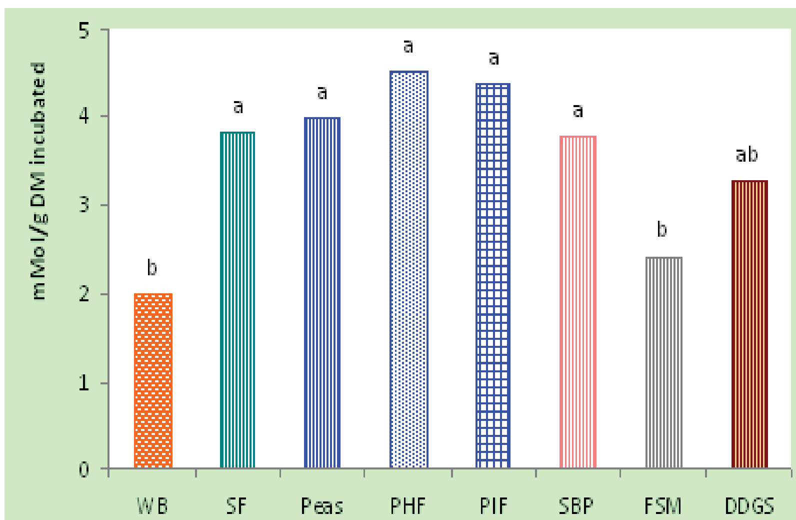


Figure 2. Short chain fatty acid production of different ingredients studied in vitro (in test tube)

Table 1. Chemical Composition of the Ingredients and the Hydrolyzed Substrates used in the Experiment

	Raw Samples						Hydrolysed samples		
Ingredients	**DM**	**CP**	**NDF**	**ADF**		**S**	**CP**	**NSP**	**S**
Wheat bran	884	221	382	125	401	186	103	347	7
Solka floc ®	953	16	995	901	989	0	0	487	0
Peas	879	257	214	81	265	441	50	254	80
Pea hull fibre	922	176	400	350	524	184	17	380	31
Pea inner fibre	890	48	213	134	449	540	12	245	71
Sugar beet pulp	913	97	425	271	563	NA	32	286	NA
Flax seed meal	906	381	245	165	394	NA	72	222	NA
Corn DDGS	883	271	366	177	365	59	147	215	21
Feed#	887	220	172	80	NA	384	NA	NA	NA

* NSP, non starch polysaccharides; S, total starch; NA, not analyzed'
# Feed sample of pig used as donor of faeces used as inoculum for in vitro fermentation

Table 2. Fitted kinetics parameters (means) on the gas accumulation recorded for different hydrolyzed substrates incubated with faecal inoculums of pig

	Per g DM					Per g CHO fermented		
Ingredients		L[2]	T/2[3]	μ[4]	G_f[5]	N[1]	μ[4]	G_f[5]
Wheat bran (WB)	8	NA	NA	NA	126[f]	8	NA	639[de]
Solka floc ® (SF)	8	NA	NA	NA	266[b]	8	NA	608[e]
Peas	8	1.33[d]		0.10[b]	253[c]	8	0.11[c]	1040[b]
Pea hull fibre (PHF)	8	3.59[a]		0.10[b]	276[a]	8	0.11[c]	713[cde]
Pea inner fibre (PIF)	8		8.38[d]	0.11[b]	264[b]	8	0.14[b]	1050[b]
Sugar beet pulp (JBP)	8	2.91[b]	9.39[c]	0.20[a]	237[d]	8	0.16[a]	834[c]
Flax seed meal (FSM)	8	1.75[c]		0.10[b]	130[f]	8	0.11[c]	753[cd]
Corn DDGS	8	NA	NA	NA	158[e]	8	NA	1199[a]
SEM					1.9			32.6
P-Value								<0.001

* N, number of observations in fermentation; L, lag time (h); T/2, half-time to asymptote (h); μ, fractional rate of degradation at t = T/2 (h^{-1}); G_f, maximum gas volume (ml per g DM incubated / CHO fermented); CHO, fermentable carbohydrate (NSP + Starch)
* NA, not available as these parameters did not fit in the model used
* Means with different superscripts within the columns are significantly different (P < 0.05)

Table 3. Bacterial Nitrogen Incorporation (BNI) of Different Fibre Sources Measured after One-Half the Final Gas Volume was Produced (T/2) and 48 h of Fermentation.

	T/2			48 h		
Ingredients	N[1]	mg/g DM incubated	mg/g CHO fermented	N[1]	mg/g DM incubated	mg/g CHO fermented
Wheat bran	8	6.5[d]	52.9[cd]	4	4.1[d]	22.2[d]
Solka floc ®	8	10.9[c]	30.6[d]	4	12.7[b]	29.1[cd]
Peas	8	11.9[c]	106.0[b]	4	9.5[c]	39.6[bc]
Pea hull fibre	8	14.4[b]	60.0[c]	4	13.6[ab]	36.0[bc]
Pea inner fibre	8	18.5[a]	133.9[a]	4	15.6[a]	62.6[a]
Sugar beet pulp	8	14.7[b]	79.3b[c]	4	12.2[b]	43.4[b]
Flax seed meal	8	7.6[d]	72.2[c]	4	6.3[d]	37.0[bc]
Corn DDGS	8	5.6[d]	78.3b[c]	4	5.2[d]	40.1[bc]
SEM		0.86	7.53		0.82	2.98
P-Value		<0.001	<0.001		<0.001	<0.001

[1] N[1]. number of observations in fermentation
* DM, dry matter; CHO, fermentable carbohydrate (NSP + starch)
* Means with different superscripts within the columns are significantly different (P < 0.05)

The effect of different feed ingredients on fermentation metabolites and nitrogen excretion in pigs

Jha, R., S.L. Johnston, and P. Leterme

Pascal Leterme

LeAnn Johnston

SUMMARY
There is growing interest for including dietary fibre (DF) in pig diets due to its potential health benefits and possible contribution to a reduction of nitrogen (N) excretion from the swine production facility. Different ingredients could be used as the source of DF in swine diets. An experiment was conducted to evaluate the influence of different DF sources with varying indigestible protein (iCP) on bacterial fermentation and associated metabolites (short-chain fatty acids, SCFA) production, and N excretion when used in swine diets. The sources of DF and its iCP content had a major effect on accumulation of ammonia in the colon and N excretion. Peas and pea-fibre based diets decreased N excretion and enhanced bacterial fermentation and SCFA production in the intestine of pigs. Thus, peas and pea-fibres could be considered for swine nutrition, in order to reduce N excretion and potentially improve gut health of pigs, compared to other ingredients studied.

"Peas and pea-fibres reduced nitrogen excretion and could possibly contribute to improving the gut health of pigs"

INTRODUCTION
Fermentation of both dietary fibre (DF) and protein in the pig intestine is a matter of interest for pig nutritionists due to their possible beneficial or harmful effect on gut health and the environment. Fermentable fibres constitute a source of energy for the pig after their fermentation and transformation to SCFA. Fibre fermentation can also lead to a decrease in ammonia concentration in the gut because of fixation of N in the bacterial proteins. Inclusion of fermentable fibre in swine diets reduces protein fermentation along the gastrointestinal tract, which can mitigate the negative impact of protein fermentation on pig health. However, most of these functional properties have been observed with isolated fibres and fermentation characteristics of fibre depend on how they are presented: in isolated form or embedded withinthe whole matrix of the feed. Moreover, adding DF just for its fermentative properties is not economically viable. A more pragmatic approach would consist in using feed ingredients that present desirable functional properties.

Many feed ingredients with high fermentable DF are also rich in iCP, which can interact with the positive effects of the fermented DF. However, there is limited information available on these possible interactions, our hypothesis is that both the non-starch polysaccharide (NSP) content and the CP:NSP ratio in the diets affects the SCFA and ammonia concentration in the pig intestine as well as N excretion.

Thus, this study was conducted with different sources of DF with varying levels of iCP to evaluate the interactions between DF and CP and their effect on N excretion and the fermentation metabolites concentration in the intestine of pigs.

MATERIALS AND METHODS
Sixty-four growing pigs were used in a completely randomized experiment where one pig was the experimental unit. They were weaned at 21 days and reared with their littermates in nursery rooms. At 6 weeks of age (average body weight 24.1 ± 3.1 kg), the pigs were moved to individual pens, with free access to water and randomly allocated to one of the 8 experimental diets with 8 piglets/diet. No antibiotics (prophylactic or therapeutic) were administered to the animals during the study. Diets were manufactured using wheat bran (WB), wood cellulose (Solka-floc®, SF), peas, pea hulls (PH), pea inner fibre (PIF), sugar beet pulp (SBP), flaxseed meal (FSM) or corn distillers dried grains with solubles (DDGS) as test ingredients. The diets were balanced in energy and amino acids with soy protein isolate, pea starch, sucrose and a vitamin-mineral premix. Faecal samples were collected for 3 consecutive days from d10 and pigs were slaughtered on d16. Digesta from ileum and colon were collected and analyzed for their SCFA and ammonia content.

RESULTS AND DISCUSSION
The coefficient of apparent total tract N digestibility (Table 1) was lower in diets based on FSM, DDGS and peas (0.72, 0.74 and 0.75, respectively), medium in diets with WB and SBP (0.76 each) and higher in those with SF, PIF and PH (0.78, 0.79 and 0.81, respectively). Expressed per kg fermented NSP, N excretion was higher with DDGS, WB and FSM diets (130, 113 and 109 g/kg NSP fermented, respectively) and lower with peas, PH, PIF and SBP diets. The pea- and pea hulls-based diets had higher ($P<0.05$) SCFA concentrations (39 and 27 mMol/kg digesta, respectively) at the ileum level, while no difference ($P>0.05$) in SCFA concentration was observed between diets in the colon.

Table 1. Apparent digestibility coefficients of nutrients and nitrogen excretion in pigs fed diets differing in fibre and protein source

Diet	CIAD		CTTAD		Nitrogen Exceretion		
	DM	N	DM	N	g/kg DM intake	g/kg N intake	g/kg NSP fer-mented
Wheat bran	0.68	0.71	0.78^{bc}	0.76^{abcd}	6.9^{b}	237^{abcd}	113^{ab}
Solka floc ®	0.67	0.77	0.77^{c}	0.78^{abc}	7.1^{ab}	217^{bcd}	102^{b}
Peas	0.77	0.71	0.88^{a}	0.75^{bcd}	7.0^{b}	251^{abc}	64^{c}
Pea Hull	0.75	0.78	0.89^{a}	0.81^{a}	6.5^{b}	191^{d}	42^{c}
Pea inner fibre	0.70	0.77	0.88^{a}	0.79^{ab}	6.5^{b}	206^{cd}	42^{c}
Sugar beet pulp	0.73	0.79	0.87^{a}	0.76^{abcd}	7.6^{ab}	236^{abcd}	55^{c}
Flax seed meal	0.65	0.65	0.82^{b}	0.72^{d}	7.4^{ab}	280^{a}	109^{ab}
Corn DDGS	0.72	0.76	0.78^{bc}	0.74^{cd}	8.3^{a}	262^{ab}	130^{a}
SEM			0.103	0.123	0.40	12.2	505
P-Value			<0.001		0.049		<0.001

Abbreviations: CIAD/CTTAD, coefficient of apparent ileal/total tract digestibility; DM, dry matter; N, nitrogen
*Mean values with different superscript within column differ ($P<0.05$)

Table 2. Fermentation metabolites in the colonic digesta of pigs fed diets differing in fibre and protein source

Diet	pH	SCFA^{+}	NH_3^{+}	% of total SCFA^{+}			
				AA	PA	BA	BCFA
Wheat bran	6.65^{a}	94.1	99.5^{abc}	63.6	19.6^{b}	12.4	2.8
Solka floc ®	6.17^{ab}	112.9	87.6^{abc}	61.8	18.0^{b}	16.3	2.1
Peas	5.97^{b}	113.9	126.5^{ab}	55.9	21.0^{ab}	16.5	2.6
Pea Hulls	6.13^{ab}	121.6	132.1^{a}	57.8	21.0^{ab}	15.3	2.6
Pea inner fibre	6.03^{b}	119.0	68.1^{c}	59.9	24.1^{a}	11.9	2.0
Sugar beet pulp	5.96^{b}	112.5	73.3^{bc}	61.1	21.8^{ab}	13.5	2.0
Flax seed meal	6.66^{a}	101.4	129.1^{a}	61.5	21.6^{ab}	11.5	2.8
Corn DDGS	6.37^{ab}	100.0	106.3^{abc}	60.5	22.1^{ab}	11.8	2.8
SEM	0.13	6.97	12.3	1.86	0.95	1.84	0.29
P-Value		0.076	<0.001	0.126	0.003	0.276	0.204

Abbreviations: AA, acetic acid; BA, butyric acid; BCFA, branched-chain fatty acids (the sume of iso-butyric and iso-valeric acids); NH_3, ammonia; PA, propionic acid; SCFA, short chain fatty acids
$^{+}$ mMol/kg digesta sample
*Mean values with different superscript within column differ ($P<0.05$)

A higher (Table 2) ammonia concentration was also found in the colon of pigs fed with PH, FSM, and peas (132, 129 and 127 mMol/kg digesta, respectively). There was lowest N excretion with peas and pea-fibre based diets when expressed per unit of NSP fermented.

The CP:NSP ratio in the diets and ammonia concentration were positively correlated here ($r=0.47$, $P<0.001$). The same was observed between the NSP level and the ammonia concentration ($r=0.46$, $P<0.001$) in the colon. This supports our hypothesis that both the NSP content and the CP:NSP ratio in the diets affect the ammonia concentration in the pig intestine. A lower ammonia concentration obtained for the PIF diet indicates a reduction in bacterial hydrolysis of nitrogenous compounds in the presence of highly fermentable fibre in the matrix.

CONCLUSION

The results of the present study show that peas and pea-fibre based diets enhanced bacterial fermentation and SCFA production in the intestine of the pig which had less N excretion as well. The fermentation process can be attributed to both source and level of fibre and indigestible protein content in the diets, in addition to DF and CP interaction. Moreover, the sources of DF and its indigestible protein content and the ratio of CP:NSP had a major effect on accumulation of ammonia in the colon and N excretion.

IMPLICATIONS

Peas and pea-fibres could be considered for swine nutrition, in order to reduce N excretion and possibly contribute in improving gut health of pigs, compared to other ingredients studied.

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Peas

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