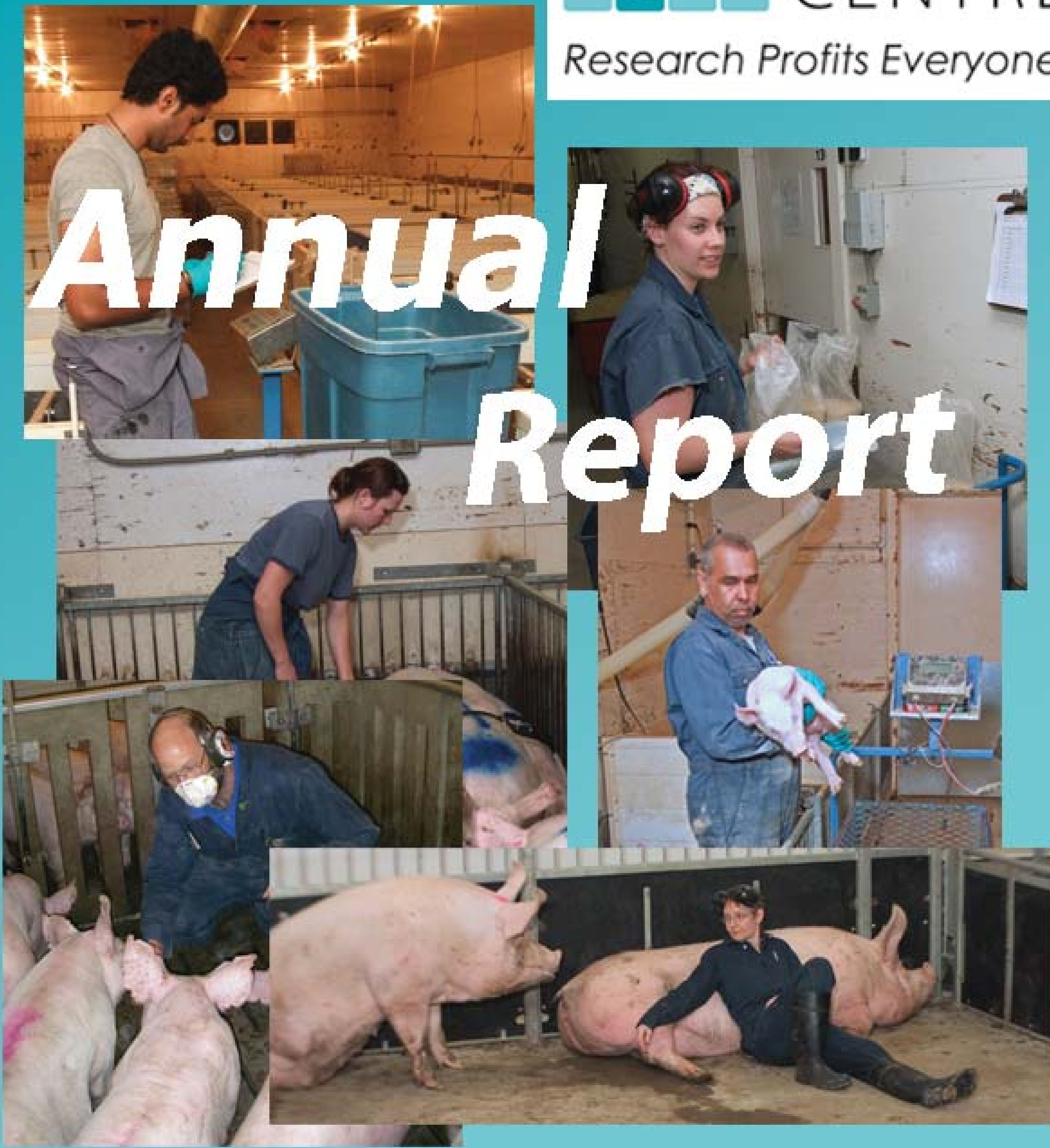
2010 Annual Report

PRAIRIE SWINE CENTRE

Research Profits Everyone



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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2010 Report Highlights

PRAIRIE SWINE CENTRE

Research Profits Everyone

Core Values and Beliefs

Reliability

The accuracy of our research results and reputation of our knowledge are why we exist. There is no single more important aspect of our business than this.

Responsibility

To the Canadian public, our scientific societies, and our funding agencies

Reputation

This includes our 'Brand' but is greater than that. Without a Reputation as a trusted resource we are but a company without customers

Respect

Our co-workers, partners and clients deserve our respect. These relationships are strengthened when transparency, honesty and accountability are practiced by all.

Our Mandate

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

Chairman's Report

Finding Solutions in Challenging Times

SHANNON MEYERS, Chairman of the Board

It's been a pleasure to serve the Prairie Swine Centre (PSC) Board of Directors as Chairman again throughout the last year. I would like to thank my fellow directors for their time and energy that they invest into PSC and the industry at large.

Fortunately, this past year has been much better in terms of industry profitability. Let's hope pork demand can hang on and that feed prices don't continue to escalate. That said, as feed costs rise, it is one more reason to support research in areas like feed ingredients and feed use so that we are as efficient as possible in our feeding programs.

The entire staff at PSC led by President and CEO Lee Whittington has again done an excellent job this year in terms of cranking out a large number of key take home messages in their research programs. I would also like to personally congratulate Dr. Harold Gonyou on his retirement and for an outstanding career in the area of animal ethology. Dr. Gonyou's work is recognized around the world and his contributions will be missed. PSC will continue to work in the area of ethology and we thank Dr. Gonyou for his help and efforts as we transition this program.

Our board representation continued to broaden this year as we consider more research that affects all facets of the pork value chain. The main focus of the PSC research program continue to be on primary production but cetainly scientists at PSC are considering affects on other players in the chain as experiments are designed and as results are analyzed.

Productivity out of the state of the art Sow Research Unit continues to improve. As producers either build or remodel their existing facilities, I would encourage you to visit or at least read up on some of the key findings that are happening in the loose housing facilities at PSC.

Finally, it is refreshing to see the industry start to once again consider reinvestment in R&D. Across North America (and the world for that matter), there are very few swine research institutions left with the ability to do high end and near market research. Thank you to all of our stakeholders who support PSC. We appreciate the support and look forward to it continuing on.

Regards,
Shannon Meyers

Board of Directors
Back Row L-R: Ray Price, Rick Prejet, Dr. Mary Buhr, Dr. Jim Bassinger, Harvey Wagner, Dr. Walter Heuser, Arlee McGrath
Front Row L-R: Darcy Fizgerald, Lee Whittington, Judy Yungwirth, Shannon Meyers

President's Report

Innovative Research Addressing Industry Challenges

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

The challenges of the past three years have fundamentally changed the way we do business, but it has not changed why Prairie Swine Centre exists. That is the Centre serves as a knowledge resource to the commercial pork industry, and we are actively seeking partnerships and supplying information to not only primary pork producers but to corporations and families that operate throughout the pork value chain.

In the past year the Centre has developed 27 new, solidly researched conclusions from our work. This research is benefiting the pork marketer, the packing plant manager, the trucking company, the feed, equipment and animal health supplier, and of course the pork producer, their neighbours, employees and families. As you review this document you will note practical operating procedures (managing large group autosort barns), leading edge science being used to address common problems (nano-particles adsorb odours and gases), numerous ways to reduce production costs (targeting expensive starter diets, and making better use of opportunity ingredients), and improving meat quality (trucking temperatures for market hogs).

I am proud to be associated with such a dedicated group of production, technician, research and administrative personnel. There have been many reasons to look elsewhere and consider alternatives during the recent industry downturn and lingering recession. To survive as a company it took pay reductions, layoffs, unpaid leave and long hours. Throughout this period the loyalty and enthusiasm remained intact and even grew. Indeed hardship does bring out the best in good people.

All of us at Prairie Swine Centre wish you prosperity and good fortune in your pork business, and entrust the knowledge contained in this annual report to you for the betterment of your business, the security of your family and the continued development of the industry.

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, B.Sc. (Agr) • MBA • Manager, Information Services

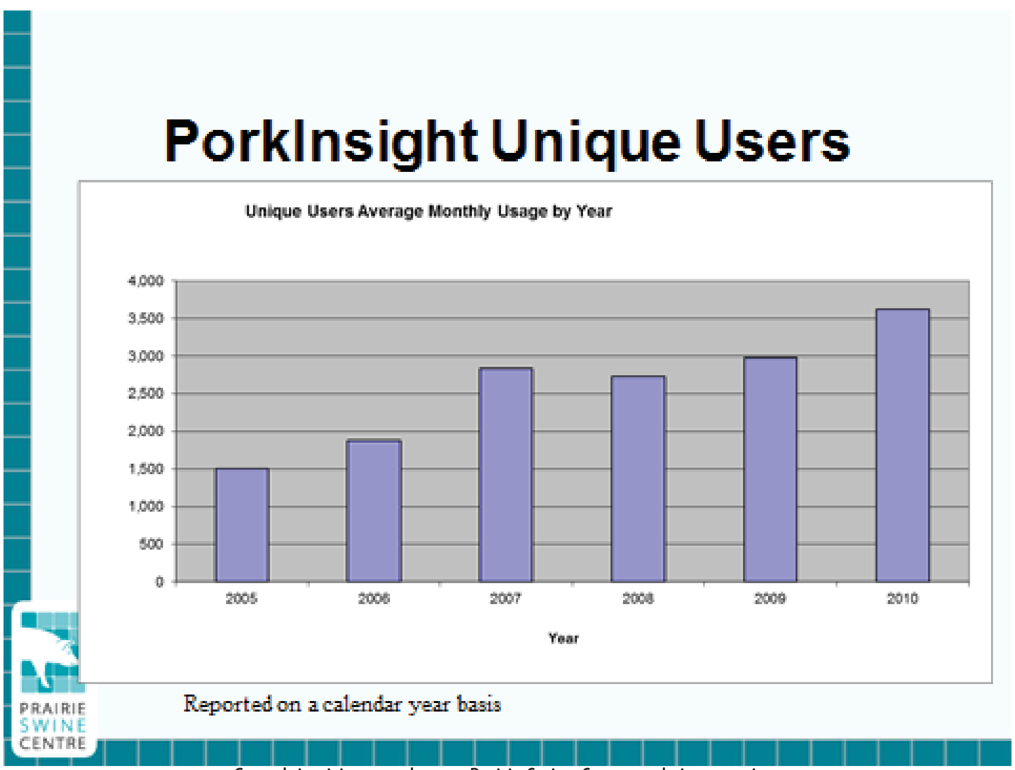
Website and electronic publishing is first but printed materials still important

Our focus is in making sure the most recent information from Prairie Swine Centre as well as relevant information from other institutions can be accessed by the commercial pork industry. To this end we have concentrated our resources on our website www.prairieswinecentre.ca to ensure easy access to the volume of work we produce each year. Prairie Swine Centre's mandate goes well beyond the work we do in our own research barns to include knowledge that we find worldwide that has relevance for the Canadian pig industry. This year we added another 550 references to the PorkInsight database, recognized the excellent quality of the production articles in the Western Hog Journal and added the editions 2008 to the present, and published 12 issues of our electronic newsletter. Below I have shown a graph of the Unique Users we monitor as a way to measure website activity. Unique Users continues to grow with over 3,500 per month average for the entire year, obviously the pork producers that have decided to stay in the business are dedicated information seekers, spending much more time looking for tips to cut production costs and improve productivity.

The printed materials produced this year consisted of 2 issues of Centred on Swine, a mailed piece describing the Annual Research Report, 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.

The highlight of the year was a series of six meetings held across western Canada to speak directly with pork producers on new research and how to adopt these latest finding t reduce cost of production. Our thanks to Elanco Animal Health and Master Feeds for their sponsorship and participation in the meetings. It had been three years since our last "annual" Spring Series of meetings where we have all of our senior researchers presenting their newest information. As always the pork producers and supplier industries supported the meetings with large numbers and lots of feedback. Meeting face-to face with pork producers is so very important to assess the uptake and relevancy of our work and to lay out the challenges still faced that require additional thought and research. We, as always, are indebted to your support and appreciate the frank discussions.

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



Growth in visitor numbers to Prairie Swine Centre website over time

Operations Manager Report

Production Improvements

BRIAN ANDRIES, BSA. • Manager, Operations

Production performance is at a level that has never been achieved at the Centre since the operation was opened by the University of Saskatchewan in 1979. The newly designed gestation and breeding facility fitted with 4 different widths of breeding stalls and free access stalls and loafing areas in gestation, provide a comfortable environment for sows with the ability to roam freely in gestation, if they so desire.

Attention to detail throughout the facility has allowed production to grow and it appears that performance levels will continue to improve. The Centre's 300 sow herd will finish 800 animals this fiscal year above target. As Prairie Swine Centre does not purchase gilts off farm and has its own nucleus herd to produce both grandparent and parent lines out of Pig Improvement Canada, we are at a slight disadvantage for upgrading genetics in a timely manner. We perform caesarean sections on 2-3 highly prolific sows every year, courtesy of PIC, with the Centre responsible for the cost of the caesarean section. We also have access to the PIC boar stud out of Kipling, acquiring semen from their top boars. We have developed our own breeding strategy to improve both female lines, and through stringent selection of animals, the structure of the gilt herd has changed quite dramatically. Only gilts that have cycled twice and have reached 135 kg live weight are bred. Prior to breeding, gilts are on ad-lib feed. Gilt performance over the last 4 years is shown in table 1.

As mentioned, we run our own nucleus herd to produce the Cambourough Plus(L-42) females that are terminal bred to a 337 boar. Approximately

"Whole herd farrowing rate has improved to 92.5%, and 26.4 pigs weaned/sow/year"

26% of the herd are the "pure" L-3 females and it is interesting to look at the difference in productivity between the 2 lines that are managed quite similarly due to the structure of our production system. Running 2 different genetic types in the same facility presents problems especially in relation to amounts fed per sow, body condition and reproductive performance. Staff monitor body condition for all sows with an evaluation preformed every two weeks. Sows requiring extra feed are hand fed extra ration above their daily allotment set for the herd. The L-3 females are also managed differently at breeding considering

Table 1. Gilt Performance for the 2007-2011 fiscal years

Category	07-08	08-09	09-10	10-11
Age at 1st Service/days:	207.0	207.0	210.6	213.8
Farrowing Rate %:	82.9	88.1	91.2	99.0
Average Born Alive/Litter:	10.8	11.5	11.9	11.9
Average Weaned/Litter:	10.7	10.2	10.5	11.3

Sasaktchewan Deputy Minister of Agriculture, Alanna Koch, visits the Centre in May, 2011

time and number of services with all of the L-3 sows serviced am/pm from standing heat. This data is shown in Table 2 for fiscal year 2009-2010.

The health status of the herd has also improved quite dramatically over the last 12 months.

Table 2. Comparison of L-03 and L-42 females, 2009/2010 fiscal year

Category	L-03	L-42	Herd
Conception Rate %:	84.3	88.6	87.0
Farrowing Rate %:	83.6	87.2	85.1
Average Born Alive/Litter:	11.8	12.1	12.0
Average Weaned/Litter:	10.7	10.6	10.6
Pigs Weaned / Sow / Year:	22.1	24.4	24.1

Procedures are in place to ensure an environment exists throughout all areas of the facility that decrease the incidence of bacteria and virus. After power washing and disinfecting rooms, inspections are completed before filling with new groups of animals. The rooms are always brought up to the proper temperature, are dry, and have feed available before animals are moved in. This herd, at times has mortalities associated with Streptococcus Suis, or Circovirus, but are free of all respiratory diseases. We do not attempt to treat any animals that are circovirus suspect, but put these animals down immediately to decrease the incidence of the virus. We do not vaccinate the herd for circovirus. The only vaccinations on the farm are for sows against parvovirus, leptospirosis, and erysipelas. No other vaccinations are used on nursery and grower animals and we have gone as far as taking all medication out of our starter diets except the Stage 1 diet. Only 2 kilograms per pig of our first stage starter, are fed upon entry to the nursery. Over the last 5 years mortalities have steadily declined since 2006-2007, from .61% to .50% in nurseries and from 1.91% to 1.22% in grow/finish, this fiscal year.

The number of animals put on trial for the year 2010 as reported to the Canadian Council of Animal Care was 7,352 very comparable to the previous 5 years. We have successfully completed the Quality Care Assurance partial validation and are currently being validated for the Animal Care Assessment program.

Production and research staff have taken a lot of initiative over the last 2-3 years in producing an excellent product that has surpassed all targeted production parameters set out at the beginning of this fiscal year. You can see the pride they take in the facility by how they manage their respective areas of responsibility. They can be proud in how the animals and the facility, both interior and exterior, are being maintained.

Table 3. Production parameters for the 2007-2011 fiscal years*

Category	07-08	08-09	09-10	10-11
Sows Farrowed, #	728	797	635	694
Conception Rate, %	82.7	84.9	86.7	93.7
Farrowing Rate, %	83.8	82.9	83.3	92.5
Avg. Pigs Born Alive/Litter	11.1	11.9	11.9	12.7
Farrowing Index	2.55	2.48	2.46	2.48
Average Weaned/Litter	10.3	10.3	10.4	11.7
Pre-Wean Mortality, %	11.2	15.8	15.1	12.9
Pigs Weaned / Sow / Year	23.3	23.6	23.8	26.4

*2008-09, 2009-10, 2010-11 (9 months)

Friends of the Centre

LEE WHITTINGTON, B.Sc. (Agr), 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 relationships 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.

Weighing nursery pigs. Left to Right: Karu Bandaralage Research Technician; Raelene Petracek Assistant Manager Contract Research

Controlling Environmental Emissions from Swine Barns using Zinc Oxide Nanoparticles

Predicala, B.[1] and A. Alvarado[1,2]
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[2]Department of Chemical and Biological Engineering, 57 Campus Drive, University of Saskatchewan, Saskatoon, SK S7N 5A9


B. Predicala

SUMMARY

In this present study, the effectiveness of mixing and filtration methods using zinc oxide (ZnO) nanoparticles to control hydrogen sulphide (H_2S), ammonia (NH_3) and odour emissions from swine facilities were evaluated under conditions that represent normal swine production. The addition of ZnO nanoparticles into the manure achieved more than 95% reduction in H_2S level; no significant effect on NH_3 and odour concentrations was observed. ZnO nanoparticles were persistent in maintaining low H_2S level up to 15 days after treatment application. On the other hand, the ventilation air recirculation system with ZnO filter achieved significant reduction in both H_2S and NH_3 concentrations at the animal- and human-occupied zones.

INTRODUCTION

Environmental emissions from hog production operations have been a long-term concern to humans, animals and to the environment despite several abatement strategies that have been investigated and adopted at the farm scale. Taking advantage of recent advances in nanotechnology, our previous work evaluated the use of nanoparticles in controlling H_2S, NH_3 and odour emissions from swine manure in a fully controlled small-scale test set-up and results revealed that filtration and mixing methods using ZnO nanoparticles showed the greatest potential for controlling these environmental emissions (PSC Annual Report 2008, pp. 21-22). In this present study, the effectiveness of these treatment approaches on H_2S, NH_3 and odour emissions was investigated under actual barn production conditions.

RESULTS AND DISCUSSION

Prior to room-scale experiments, semi-pilot scale tests were conducted to evaluate operational factors such as nanoparticle-to-slurry ratio (mixing method), and filter design, face velocity and nanoparticle loading amount (filtration method) in an open system environment. Results showed that the mixing method required a particle-to-slurry ratio of 3 g of ZnO per litre of slurry to control H_2S and NH_3 levels. Using the air filtration technique, a fluidized bed filter design with 1.8 g/in^2 loading rate and face velocity of 0.5 m/s were found to be the most effective combination for controlling gas levels. Using these parameters, room-scale experiments were then carried out in specially-designed chambers at PSCI barn facility to assess the effectiveness of each method under conditions that represent normal swine production; one chamber was operated as a conventional swine room (Control) and the other one as a treatment room.

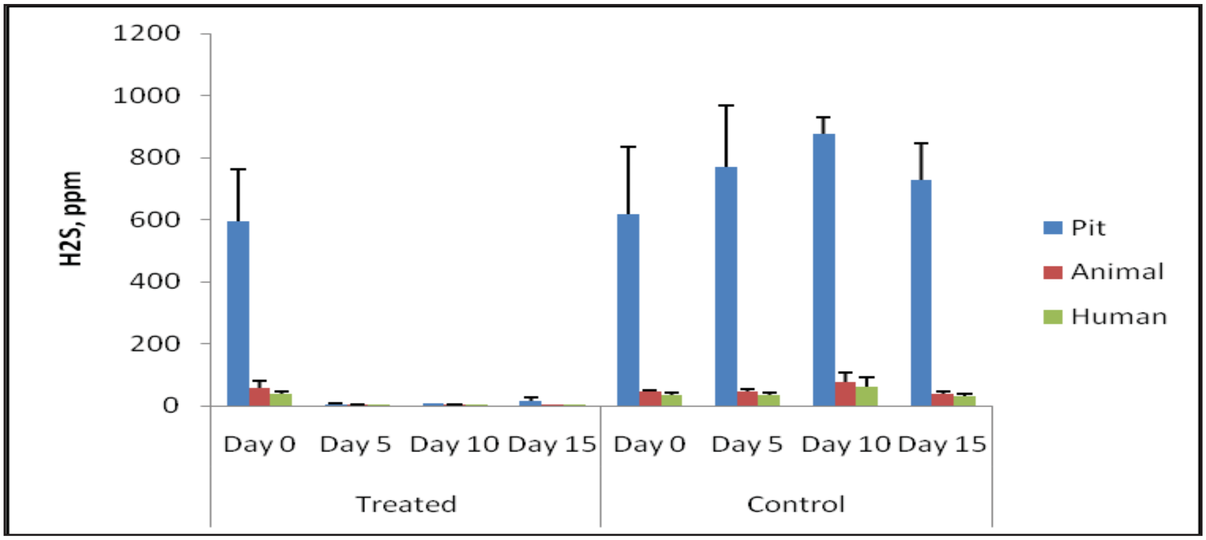
> *"Zinc-oxide (ZnO) nanparticles were effective at reducing hydrogen sulfide (H_2S) emissions from manure slurry."*

Mixing tests

Figure 1 shows the actual concentrations of H_2S (A) and NH_3 (B) from the samples collected in both chambers during manure agitation. To account for the inherent variation in initial concentration of manure gases, gas samples were collected in each chamber prior to the application of ZnO nanoparticles (in the treated chamber). The H_2S and NH_3 concentrations on this day were plotted as Day 0 values which served as baseline for subsequent sampling events. In the treated chamber, initial H_2S concentrations of 596, 57 and 39 ppm in the pit, animal and human levels, respectively, were reduced significantly ($P<0.05$) to 5, 1 and 1 ppm, respectively, on Day 5 after ZnO nanoparticles were applied into the manure. These levels were almost unchanged to Day 15 which implied that the effect of the treatment in reducing H_2S levels was persistent for at least 15 days. The concentrations of H_2S in the different sampling locations (pit, animal and human levels) in the untreated (control) chamber were not significantly different ($P>0.05$) from each other over the 15-day monitoring period. On the other hand, mean NH3 concentrations in the control and treated chambers plotted in Figure 1-B showed no statistically significant reduction in NH_3 levels arising from the treatment ($P>0.05$). Additionally, odour concentrations in the treated chamber were not significantly different from the control chamber ($P>0.05$) with mean values of 1960±642 OU/m^3 and 2423±648 OU/m^3, respectively.

Filtration tests

Actual levels of H_2S (A) and NH_3 (B) in specific locations in each chamber during manure agitation are plotted in Figure 2. Prior to the operation of the air recirculation system with filter pad only in the control chamber (Day 0), H_2S concentrations in the pit, animal and human levels were 326, 82, and 58 ppm, respectively, while the corresponding NH_3 levels were 22, 12, and 10 ppm, respectively. On subsequent sampling days after filter installation (Day 5 to Day 15), no significant change was observed in H_2S and NH_3 concentrations in each sampling location ($P>0.05$) in the control chamber. This observation is consistent with the results from the mixing tests. The installation of a ventilation air recirculation system with filter pad only had no significant impact on H_2S and NH_3 levels in the animal- and human-occupied zones. Similar to the control chamber, H_2S and NH_3 concentrations in the pit level in the treated chamber were not significantly different over time ($P>0.05$). This was expected considering that the ventilation air recirculation system with ZnO filter in the treated chamber was intended to treat the target gases after they have been released from the source (pit). In the animal and human zones, however, significant reduction in the concentrations of the target gases relative to their initial concentrations was observed ($P<0.05$) over the 15-day monitoring period. In the animal level, initial mean H_2S and NH_3 concentrations were 94 and 15 ppm, respectively, and decreased to 46 and 10 ppm, respectively, on Day 15 after the filter with ZnO nanoparticles has been installed. Over the same period, mean initial H_2S and NH_3 levels in the human-occupied zone were 58 and 12 ppm, respectively, and became 23 and 7 ppm, respectively, on Day 15. The operation of filter system with ZnO nanoparticles did not significantly impact the odour emissions from the chamber ($P>0.05$).



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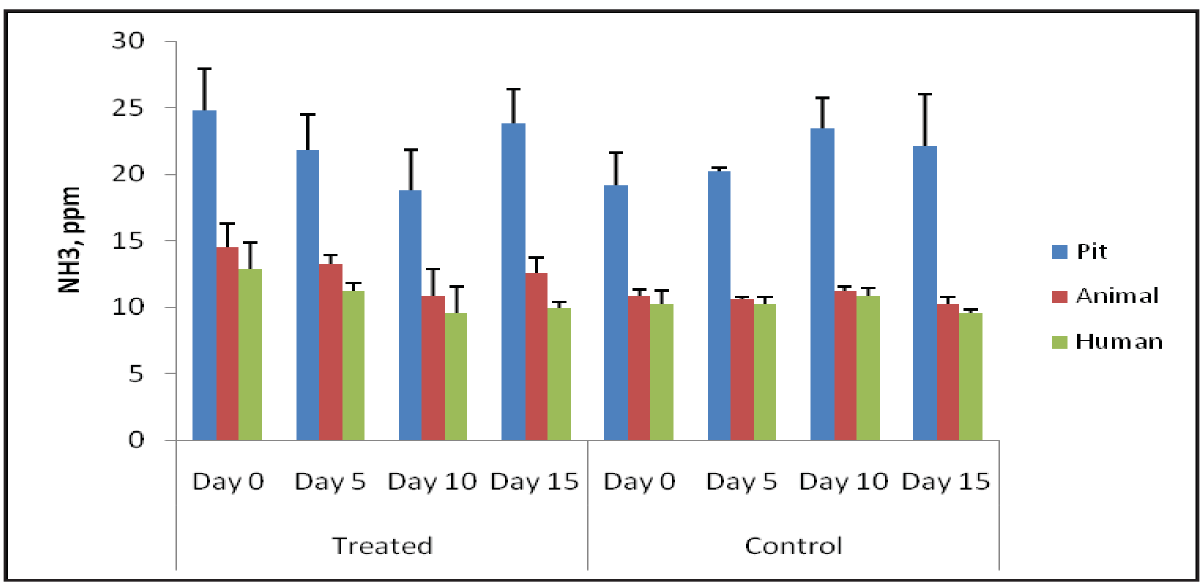
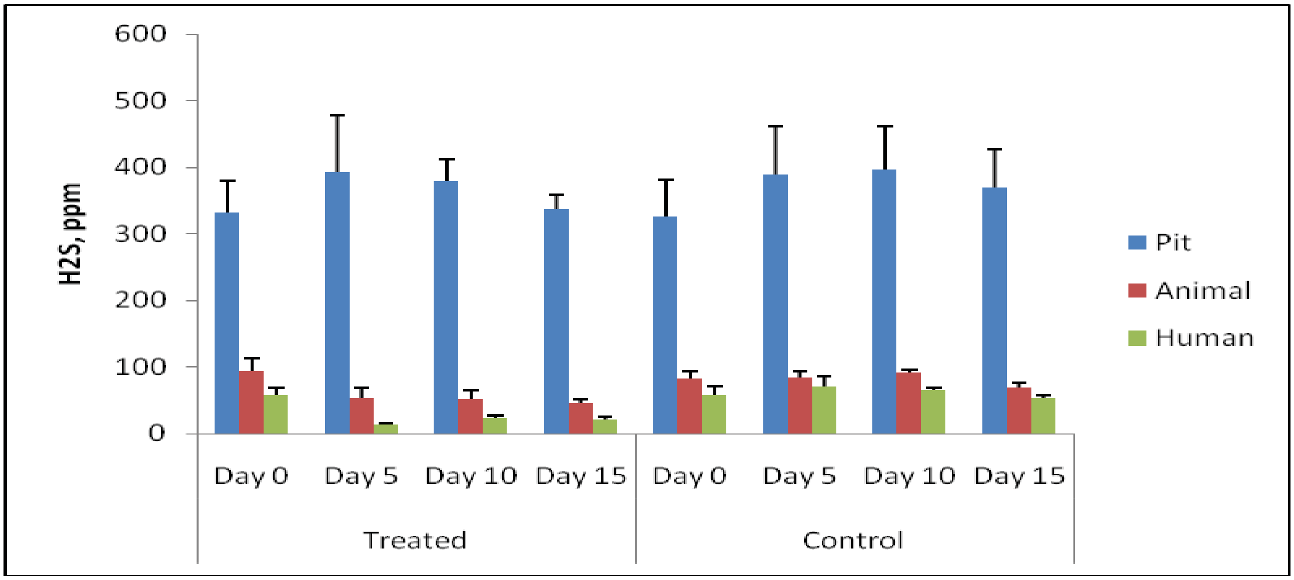


B

Figure 1. Mean (±SE) actual concentrations of H_2S (A) and NH_3 (B) in gas samples collected from untreated (control) slurry and slurry mixed with ZnO nanoparticles at different sampling locations and monitoring periods during room-scale tests using the mixing method n=3.



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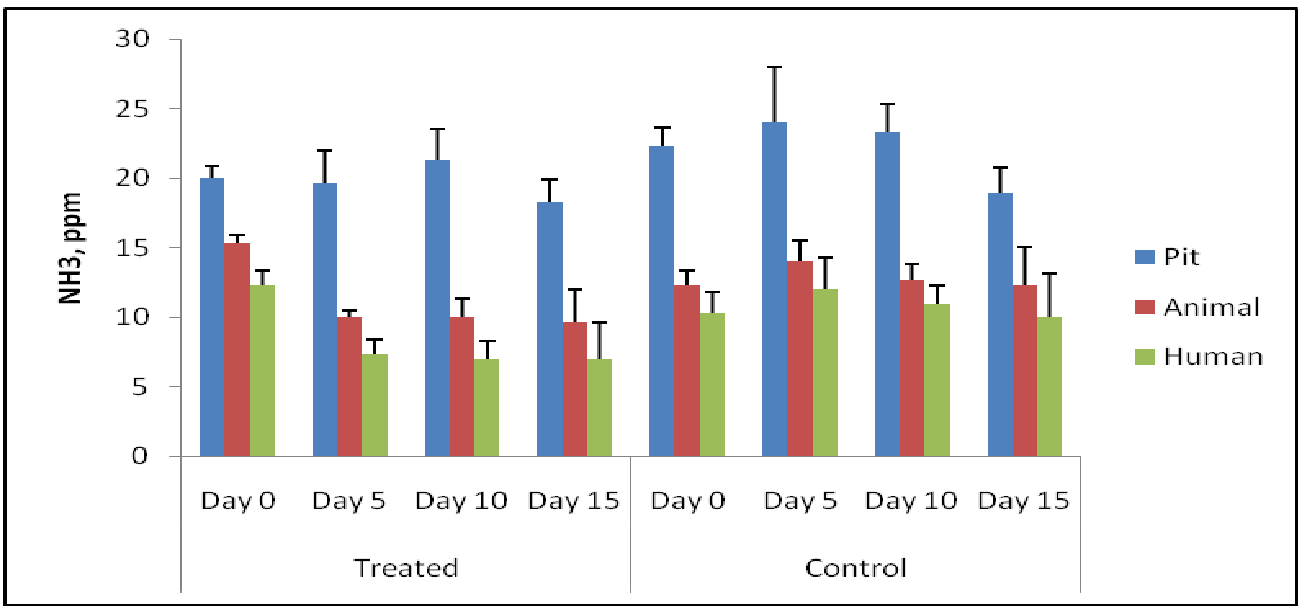

B

Figure 2. Mean (±SE) actual concentrations of H_2S and NH_3 in gas samples collected from untreated (control) chamber and chamber with ZnO filter during room-scale tests using the filtration method, n=3.

CONCLUSIONS

Room-scale experiments revealed that the addition of ZnO nanoparticles into the slurry reduced gas levels, specifically H_2S, at the source (manure pit), resulting in almost undetectable levels at the animal- and human-occupied zones. On the other hand, partial filtration of the gases from the source using a ZnO filter installed in a recirculation duct set-up did not decrease the gas levels at the source but could likely reduce the gas concentrations at the animal and human levels to comply with the Short-term Exposure Limit values (i.e., 15 ppm for H_2S).

ACKNOWLEDGEMENTS

Strategic funding provided by Sask Pork, Alberta Pork, Manitoba Pork Council, and Saskatchewan Agriculture and Food Development Fund to the research programs at PSCI are gratefully acknowledged. Project funding provided by Saskatchewan Agriculture Development Fund and the National Science and Engineering Research Council are also acknowledged.

Comparative Evaluation of the Use of Heat Exchanger, Ground Source Heat Pump and Conventional Heating Systems in Grow-Finish Rooms

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B. Predicala

SUMMARY

A heat exchanger and a ground source heating system were fitted to grow-finish rooms in the PSCI Floral barn to evaluate their performance in comparison with a conventional forced-air convection heater. Data from one heating season showed that the use of heat exchanger and ground source heat pump led to 52% and 39% reduction in energy consumption for heating and ventilation, respectively, compared to the conventional heater.

INTRODUCTION

Any measure that can reduce production cost will help improve the profitability of swine production. Energy cost is one component of production cost that can be further reduced by using energy as efficiently as possible, particularly for many barns currently in use that have not been optimized due to minimal cost of energy in the past. Results from our previous work showed that space heating is an area where energy reduction can be achieved (PSC Annual Report 2008, pp. 19-20). This study aimed to evaluate the performance of heat exchanger, ground source heat pump (GSHP), and conventional heating systems in grow-finish rooms in terms of energy consumption, in-barn environment, and animal productivity.

Figure 1. Heat exchanger installed in a grow-finish room.

MATERIALS AND METHODS

Three heating systems: a heat exchanger with a forced-convection heater, a ground source heat pump, and a stand-alone forced-convection heater, were installed in 120-head grow-finish rooms at PSCI barn facility. The rooms had similar building construction, pen configuration and pig capacity. For each grow-finish cycle, a total of 360 pigs were distributed equally to the three rooms. Metering equipment were installed to monitor the electric consumption of the heat pump, heaters, lights, ventilation and recirculation fans, as well as the natural gas consumption of the forced-convection heaters in the heat exchanger and control rooms.

"Animal performance across these systems was similar as expected. However, energy savings of 39% - 52% were realized using non-traditional heating and ventilation systems"

The heat exchanger installed was a 1500-cfm aluminum core heat recovery ventilator (Figure 1), which recovers the heat energy from exhaust air stream by heat transfer to the incoming fresh air stream.

The ground source heating system, alternatively known as geothermal heat pump, geoexchange, earth-coupled or earth-energy system was composed of a heat pump and 1800 ft of 3/4" diameter polyethylene pipes buried in 8.5 to 10 ft deep trenches on the ground beside the PSCI barn (Figure 2). The buried pipes contained 20% methanol - 80% water solution for absorbing heat from the ground for heating and for using the ground as heat sink when cooling is needed.

RESULTS AND DISCUSSION

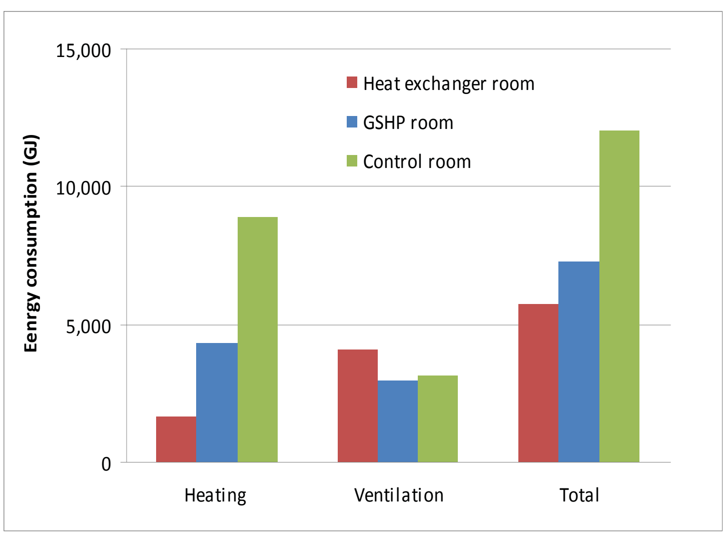
Data collection from two grow-finish cycles was conducted from October to December 2010 and January to March 2011, respectively. The mild weather condition during the first cycle did

Figure 2. (LEFT) Installation of pipes for the ground source heating system installed in a grow-finish room. (RIGHT) in-room heat pump connected to ground source heat system

not necessitate the use of heating. For the second cycle, energy consumption for heating and ventilation of each of the three rooms are presented in Figure 3. The energy consumption for heating included both the electrical and heating fuel consumption of the heat pump and heaters while that for ventilation included the electrical consumption for both ventilation and recirculation fans. The energy consumption data were all converted to gigajoules (GJ) to provide a better comparison of the systems.

Among the three heating systems, the heat exchanger required the least energy for heating but had the highest consumption for ventilation. The heating requirement was reduced as the heat exchanger pre-heated the incoming cold air with heat from the warm exhaust air. In terms of function, the heat exchanger basically replaced the stage 1 fan and because its power rating was higher than that of a regular stage 1 fan, the energy requirement for ventilation for the room was increased. Nevertheless, the use of heat exchanger led to 52% less total energy used for heating and ventilation compared to the conventional room with forced-convection heater.

Figure 3. Energy consumption for the three rooms from January to March 2011.



The GSHP required less energy to extract heat from the ground and heat the room air compared to the conventional heater. The use of the GSHP system led to 39% reduction in total energy needed for heating and ventilation compared to the control room.

Pig performance in all three rooms were relatively similar as shown in Table 1, although feed intake tended to be lower in the rooms with GSHP and heat exchanger compared to the conventional room.

Table 1. Average daily gain (kg/day) and feed intake (kg/day-pig) in the three rooms for the January to March 2011 cycle.

Room	ADG (kg/day)	ADFI (kg/day-pig)
Ground Source Heat Pump	0.99	2.48
Heat Exchanger	0.97	2.37
Control	0.99	2.55

CONCLUSIONS

After one heating season, the use of the heat exchanger and ground source heat pump system resulted in 52% and 39% reduction in energy consumption for heating and ventilation, respectively, relative to the conventional forced-convection heater. However, data collection from multiple heating and cooling seasons is still needed to be able to fully compare the performance and feasibility of these three systems.

ACKNOWLEDGEMENT

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Evaluation of Methods for Controlling and Monitoring Occupational Exposure of Workers in Swine Facilities

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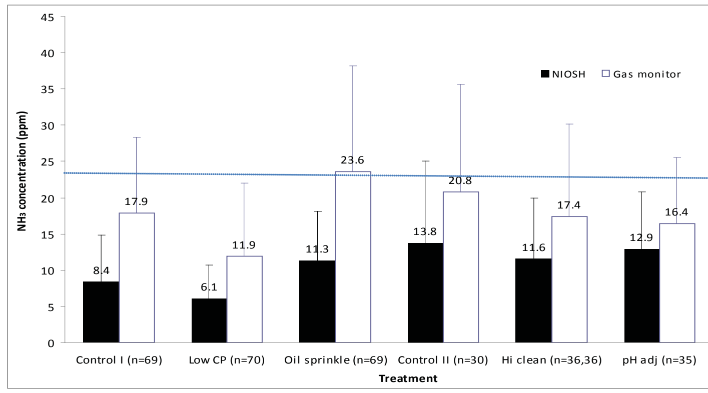
B. Predicala

SUMMARY

This study was aimed to assess the effectiveness of canola oil sprinkling, low crude protein diet, high level of cleaning and manure pH manipulation, in reducing ammonia and respirable dust concentrations in swine production rooms. Among the control measures tested, low protein diet reduced ammonia concentrations while canola oil sprinkling tended to result in lower respirable dust levels. Personal monitoring showed higher level of worker exposure compared to area sampling. Ammonia gas monitors yielded higher readings than the standard (NIOSH) method.

"When compared to the standardized scientific method for measuring gases, portable commercial monitors yielded higher readings"

Figure 1. NH_3 (A) and respirable dust (B) concentrations measured in the control and treatment rooms by area sampling. Ammonia levels were determined using gas monitors and NIOSH method.



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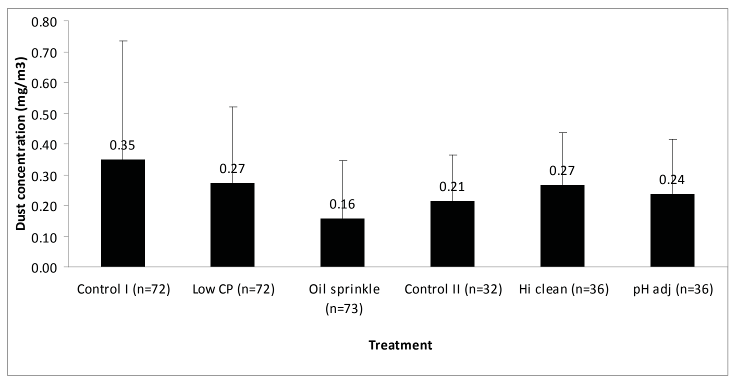


B

INTRODUCTION

Various engineering and management measures have been shown to control the levels of air contaminants such as ammonia and dust in swine production facilities. In this study, the effectiveness of selected control measures was assessed under swine production conditions to document their impact on ammonia (NH_3) and respirable dust levels, and to determine the actual reduction of personal exposure of workers to these contaminants throughout their workday.

EXPERIMENTAL PROCEDURES

Six grow-finish rooms at PSCI barn facility were used in this study. Four (4) types of engineering and management measures (treatment) were applied separately in four of the rooms. These measures include the use of low crude protein diet, canola oil sprinkling, high level of cleaning, and pH manipulation of manure. Two other rooms were managed as conventional (control) rooms with no measures applied. Each trial was run for 16 weeks. Every 3 weeks, the 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 for 2 days. Two workers were assigned to work in the treatment rooms while the other worker was assigned in the control rooms. Each worker had a logbook to document their activities during their work shift while wearing the personal monitoring gear. After each 2-day personal exposure monitoring event, area sampling was conducted in each test room over 24 and 48 hours to determine NH_3 and respirable dust concentrations, respectively.

RESULTS

NH_3 and respirable dust concentrations in the room airspace

Figure 1-A shows the mean NH_3 concentrations in treatment and

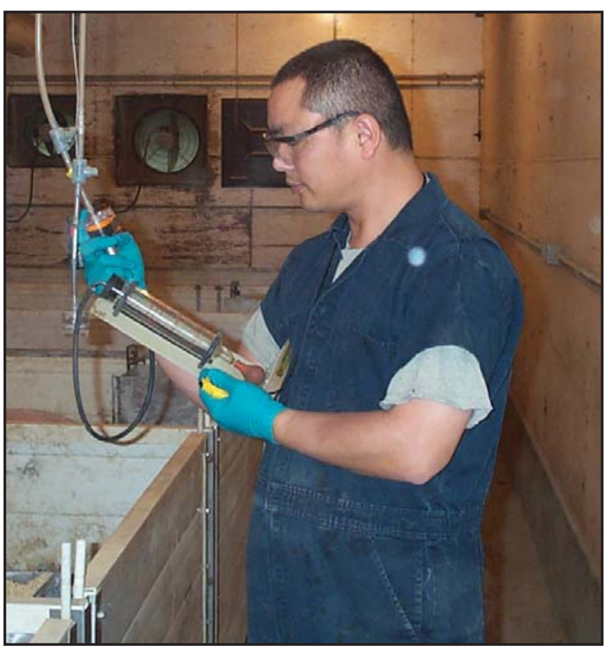
control rooms measured by area sampling. The results showed that the commercial gas monitor readings were higher than the values obtained from the NIOSH method (sorbent tubes) in both control and treatment rooms. This may be attributed to the fundamental differences in the principles employed by the two methods in generating the target gas concentration values. Nevertheless, both the gas monitor and the NIOSH method showed that the treatments with low crude protein diet had significant effect on NH_3 concentration (P<0.05), while the other treatments did not show statistically significant effect compared to the control rooms.

As shown in Figure 1-B, average respirable dust concentration in the rooms applied with canola oil and low crude protein diet was lower than in the corresponding control room, while those in rooms with pH manipulation of manure and high level of cleaning treatments have slightly higher dust concentration than the corresponding control room. However, statistical analysis indicated that the observed differences were not significant (P>0.05).

Worker exposure to ammonia and respirable dust

For NH_3 concentration, the gas monitor values were generally higher than the NIOSH method values as previously observed. However, NH_3 readings from both analytical methods showed that personal monitoring yielded values comparable to area sampling as shown in Figure 2. Regardless of which sampling method was used, most of the personal exposure values were below the 25 ppm NH_3 threshold limit value set by ACGIH.

All personal sampling results showed much higher respirable dust concentrations than area sampling (3.0 to 6.0 mg/m3 vs. 0.16 to



Research Associate Yaomin Jin taking an air sample

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

Treatment	ADG (kg/day-pig)	Mortality (%)
Control	1.00 ± 0.06	2.75 ± 2.68
Low crude protein diet	1.07 ± 0.15	1.28 ± 1.72
Oil sprinkling	0.98 ± 0.04	1.07 ± 0.82
pH manipulation	0.99 ± 0.07	0.37 ± 0.50
High level cleaning	1.02 ± 0.06	1.33 ± 1.88

0.35 g/m^3, respectively) as shown in Figure 3. This was expected since with personal sampling, the sampler was worn by the worker while performing specific tasks (i.e., feeding), thus the samplers could capture more contaminants closer to the source; whereas with area sampling, the sampler was at a fixed location and would be able to capture only the airborne contaminants dispersed by the ventilation system towards the location of the sampler. In addition, personal sampling was usually conducted at daytime when all pigs were active and dust generation was higher, whereas area sampling duration covered both daytime and night time hours when pigs were asleep and dust generation was low. Most of the personal sampling results were over the 3 mg/m3 threshold limit value established by ACGIH for airborne respirable particulates in the workplace.

Pig performance

From the pig weight data taken on Week 0, 6, and 12 of each trial, the observed average daily gain (ADG) of pigs were relatively similar in both control and treatment rooms (Table 1), ranging from 0.98 to 1.07 kg/day-pig. Similarly, the mortality rate in the treatment rooms was not significantly different from that in the control rooms (P>0.05).

CONCLUSIONS

From the completed trials, results showed that ammonia and respirable dust levels in treatment and control rooms were generally below the threshold limit values (25 ppm for NH_3 and 3 mg/m^3 for respirable dust) set by ACGIH. Personal monitoring, however, indicated that worker exposure to dust exceeded the 3 mg/m^3 threshold limit value. Supplemental trials are needed to arrive at definitive conclusion on the effect of the different measures on respirable dust and ammonia. Ammonia gas monitors yielded generally higher readings compared to the standard analytical method; this trend does not compromise worker safety as this would mean that the use of gas monitors would provide early indication of potentially hazardous levels of ammonia.

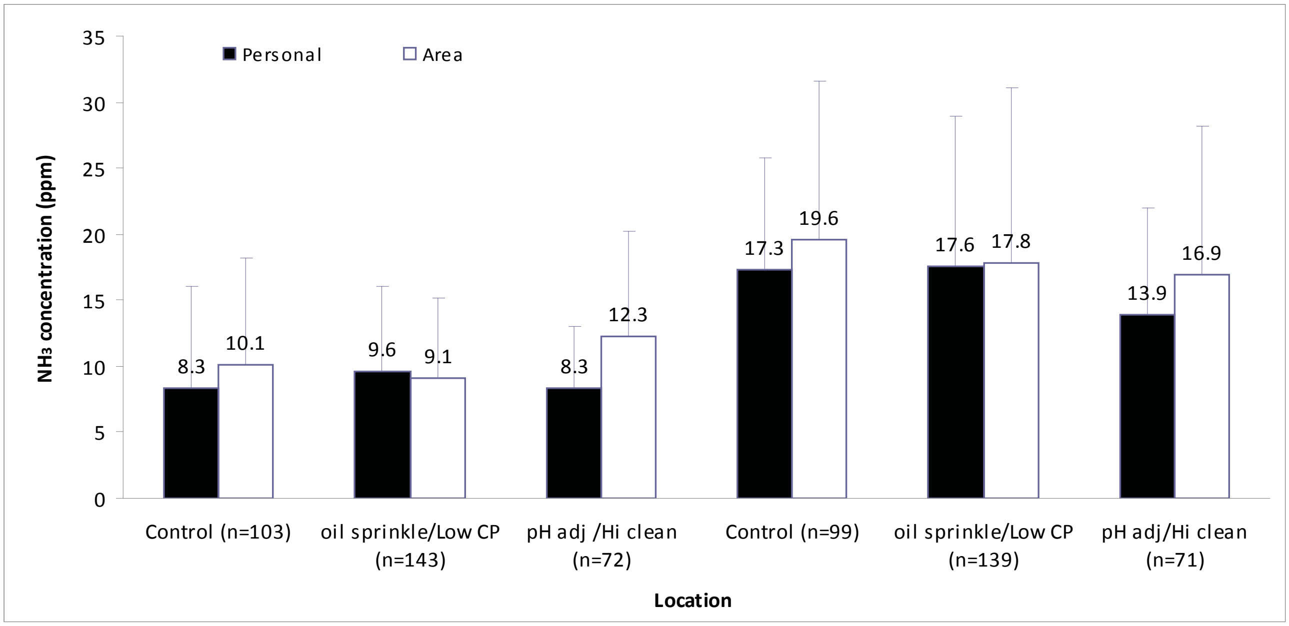


Figure 2. Comparison of NH_3 concentrations obtained by personal and area sampling using gas monitors and NIOSH method

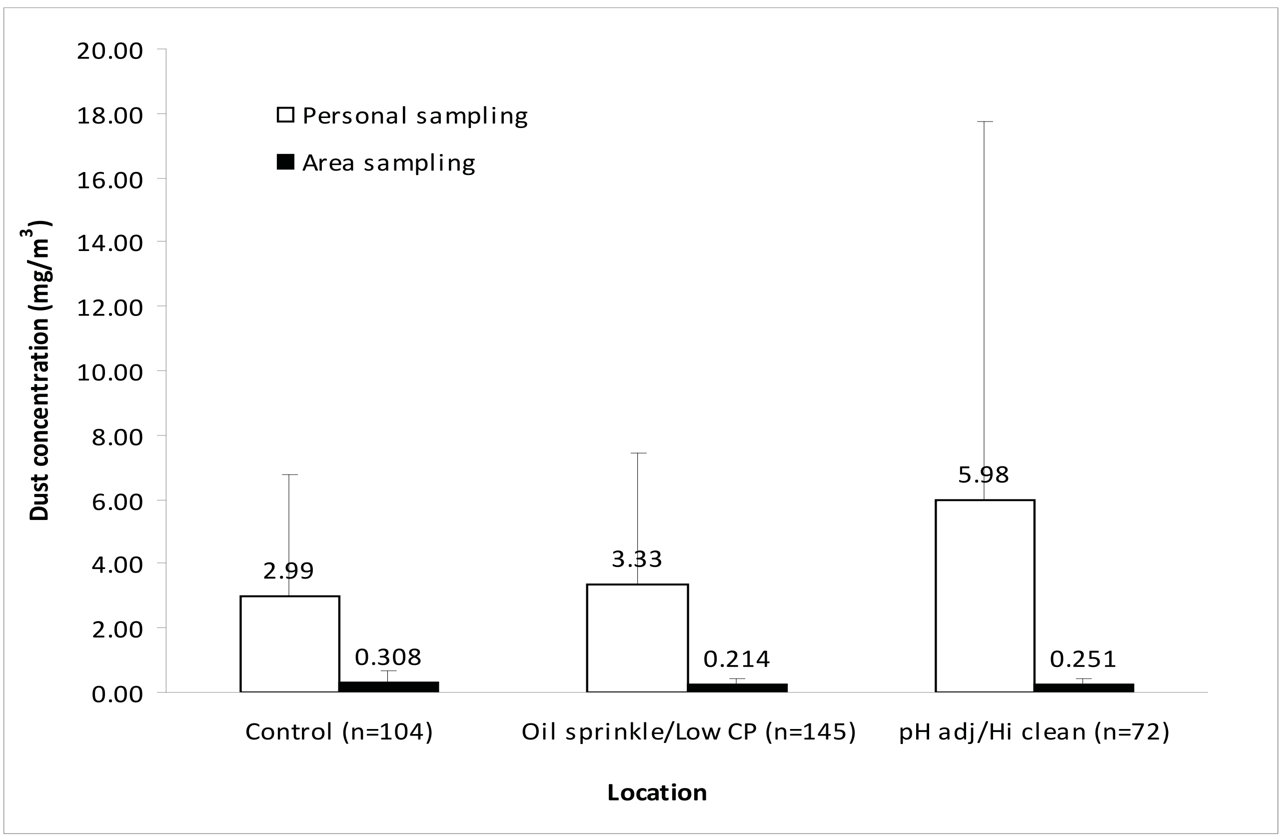


Figure 3. Respirable dust concentrations obtained in the control and experimental rooms by personal and area sampling.

ACKNOWLEDGEMENTS

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

Evaluation of Water Use and Potential Water Conservation Strategies in Swine Barns

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B. Predicala

SUMMARY

Existing water conservation management practices from published literature was identified in this study. In addition, a benchmark survey on actual water use per pig produced in different types of swine operations was conducted. Results from the literature review indicated that animal drinking represented the largest contribution (80%) to total water consumption among all other activities in the barn. The benchmarking survey revealed various options that can be pursued in order to improve water use efficiency in swine operations.

"Water conservation strategies could reduce cost of production"

INTRODUCTION

In swine operations, water is used mainly for animal drinking, cooling, cleaning, and domestic use. The rate of water use in the different stages of swine production has impact on the overall production cost and the environment. However, very little effort has been done to document the actual quantity of water used in different production stages and in different types of production units. Thus, this study was aimed to quantify current water usage in swine operations and to evaluate water conservation measures that can be adopted in swine production.

METHODOLOGY

The overall approach of this study was to conduct a comprehensive search of available information on various water conservation practices for livestock operations in various continents, conduct a benchmark survey on actual water use in different types/sizes of swine operations, and evaluate selected water conservation measures in an actual barn facility.

The literature review was aimed to gather specific information about existing water conservation practices including their description and effectiveness in reducing water use, economic cost and benefits, and their viability for application to swine production operations in Saskatchewan. Following the literature search was the benchmarking survey in different swine operations across Saskatchewan. The survey was aimed to gather information on water usage, water expenses, and production data for the past three years and consequently, to determine the average yearly water expenses per pig sold ($/pig sold) and per 100-kg sold ($/100-kg pig sold).

RESULTS

A. Highlights of literature review

Previous research conducted in Manitoba swine barns showed that animal drinking represented about 80% of the total water consumption in the barn. The rest was contributed by other activities, namely, animal cooling (10-15%), cleaning (5-10%) and domestic use (1%). In terms of produc-

Table 1. Water conservation strategies for swine barns compiled from published literature

Category	Water conservation practices
Animal drinking	1. Use of bowl drinkers (push-lever and float types) 2. Use of nipple drinker (swinging and ball-bite) 3. Use of water trough
Cooling pigs/sows	1. Use of evaporative pads 2. Use of intermittent sprayer/mister
Cleaning	1. Use of hot water 2. Use of soap 3. Pre-soaking rooms
Management practices	1. Wastewater recycle for reuse (i.e. pig's drinking water or flushing manure) 2. Adjustment of drinker's height

Table 2. Water usage, water expenses and production data of the 29 participating swine barns

Operation		# of participating barns	Volume of Water Use		Water Expenses	
Type	Size		Gallons per pig sold	Gallson per 100-kg pig sold	$ per pig sold	$ per 100 kg pig sold
Farrow-to-Finish	12 - 1250 sows	18	67 - 2070	58 - 1558	0.05 - 2.70	0.10-3.19
Farrow-to-Wean	1300 - 6000 sows	3	1907 - 4641	867 - 1856	1.15*	0.46*
Grow-Finish	4500 - 55000 feeders/weanlings	6	164 - 509	207 - 432	NA**	NA
Nursery	23360 - 24000 feeders/weanlings	2	1018 - 1684	3588 - 6122	NA	NA

*data from one barn only
**data not available

tion stages, farrowing stage consumed the greatest amount of water on a per head basis, followed by gestation, grow/finish, and nursery phases. However, due to the large number of animals involved, combined water use in grow-finish units comprised 64% of the barn's total water use (Froese, 2003). The different water conservation strategies implemented in swine barns that were gathered from published literature are listed in Table 1.

B. Highlights of the survey

Information on 29 participating swine barns in Saskatchewan was collected. The common source of water for the participating barns was barn-owned groundwater well (22 barns), dugout (6 barns) and municipal water system (1 barn). Summarized in Table 2 are the volume of water use per pig sold and the corresponding water expenses, which showed a wide range of values thus presenting an opportunity for savings in terms of water use and reducing spillage. In addition, savings in manure management costs (i.e. hauling/storage/application of manure) can also be achieved.

Table 3 shows the list of conservation measures and the percentage of participating barns that employed such measures. Almost all barns had pressure washer with straight nozzle attachment. Only few used soap or warm water for cleaning and 76% of the barns pre-soaked the rooms before cleaning. More than half of the participating barns used wet and dry feeder. Few barns used drippers to cool pigs/sows and 45% used spray/mist. Among the drinkers, nipple drinkers were used by most barns; only few used bowls, troughs and ball-bite drinkers. Less than half of the participants adjusted their nipple drinkers as the pigs grow and about 69% regularly inspected pipelines and drinkers for leaks. The rest of the barns fixed any leaks as the problem occur.

Table 3. List of existing water conservation practices employed in the participating barns

Water conservation practices	Percentage of participating barns that employed the measure
Drinker	
1. Use of nipple drinker (regular standard drinker)	97
2. Use of water trough	34
3. Use of ball-bite drinker	14
4. Use of wet/dry feeder	59
5. Use of bowls/cup drinker	10
Cooling	
1. Use of spray/mist for cooling pigs	45
2. Use of drippers	10
Cleaning (pressure washing)	
1. Use of soap	31
2. Use of warm or hot water	52
3. Pre-soaking rooms	76
Management Practices	
1. Adjustment of nipple drinker's height	41
2. Regular inspection of leaks	69

IMPLICATIONS

Current work demonstrated that there are various opportunities to improve water use in swine operations by carefully choosing the right combination of conservation measures and applying these to the areas where highest savings can be achieved. The benchmarking survey also showed that a large percentage of producers currently do not closely monitor the volume of water consumed and the corresponding cost of water used in their production operations. Tracking the water consumption in each stage of production would allow producers to establish water use baseline and help to detect potential problems associated with water wastage.

ACKNOWLEDGEMENTS

Project funding provided by the Agriculture Development Fund (ADF) is acknowledged. Strategic funding provided by the Saskatchewan Pork Development Board, Alberta Pork, Manitoba Pork Council, and Saskatchewan Agriculture and Food to the research programs at Prairie Swine Center is acknowledged..

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Food Court Design for Large Group Auto-Sort for Grow-Finish Pigs

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SUMMARY
This project studied the behaviour and productivity of pigs in large group auto-sort (LGAS) systems using two different food-court designs. Compared to conventional pens we found that pigs in LGAS modified their feeding behaviour by having fewer (5 vs 10-15) and longer meals. Pigs made use of all of the available feeder spaces within the food courts, visiting several each day, however some had difficulty learning to enter and leave the food court. For successful management of LGAS systems, producers should ensure an adequate number of feeder spaces, sufficient room to move in the food court and training methods to facilitate use of the auto-sort scale.

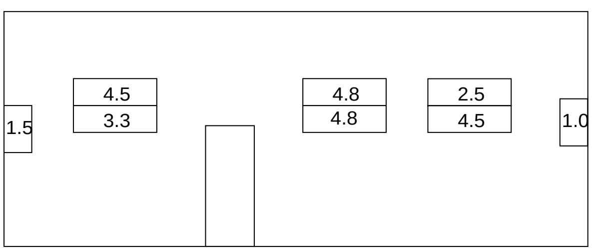

Figure 1a. Food court with feeders located in the Centre of the court. Banks of feeders consisted of 2 or 4 spaces each. Values indicate the percentage of time spent feeding in each bank.

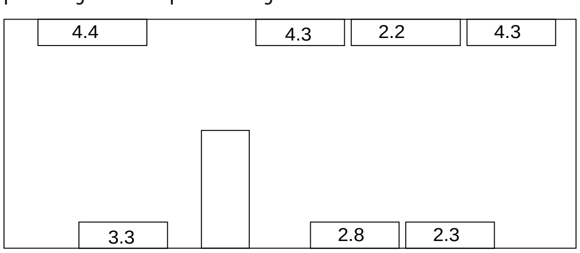

Figure 1b. Food court with feeders located along the walls of the court. Banks of feeders consisted of 4 or 5 spaces each. Values indicate the percentage of time spent feeding in each bank.

INTRODUCTION
The use of large groups for grow/finish pigs makes it economically feasible to introduce new technology, such as auto-sort scales, into pig production. It has been estimated that the ability to sort pigs within their pen has the potential of returning $5-15/pig depending on whether only marketing or marketing and feed control were implemented. One of the initial fears concerning large groups of pigs was that they would fight longer after being put together (English et al., 1988). However, research done at PSC has refuted these concerns, showing that aggression at group formation is similar in small and large groups, and in fact pigs from large groups become more tolerant and show reduced aggression at mixing (Samarakone and Gonyou, 2009).

"Pigs housed in large group auto sort modified their feeding behaviour by having fewer and longer meals... However, some had difficulty learning to enter and leave the food court"

Early attempts to use auto-sort technology encountered problems with variable feed intake and reduced rates of gain among the pigs (Wolter and Ellis, 2002). Many reports of decreased rates of gain can be attributed to poor feed court design. Most LGAS systems require pigs to pass through an automated scale as they move from the loafing area into the 'food court'. After eating they return to the loafing area via one-way gates. Some pigs have difficulty learning the appropriate traffic flow pattern through the scale and one-way gates. Common food court problems are too few feeders, or feeder spaces that are blocked by pig traffic or pigs lying in the food court. Our hypothesis is that lying in the food court is encouraged by the most common design, that of centrally placed feeders, because it provides wall space that is ideal for lying and restricts access to feeders.

The objectives of this study were, 1) to evaluate the feeding behaviour and productivity of pigs in LGAS systems using two food court designs, 2) to study changes in feeding behaviour over time in LGAS, and to 3) compare behaviour and productivity of pigs in LGAS with those in conventional small group pens.

Figure 2. Sample of photos used to assess eating patterns and feeder use in large group auto-sort.

EXPERIMENTAL PROCEDURE

Studies were carried out at two locations; the PSC Elstow Research Farm and a commercial grow/finish operation. The Elstow facility housed pigs both in conventional small group pens (18 pigs/pen, 2 feeders per pen) and in large groups of approximately 250 pigs (approx. 1 feeder per 9 pigs). Pigs were 10 weeks of age when moved to the experimental rooms. At the Elstow facility, three rooms were adapted for the study. One room provided conventional small group pens (Conventional treatment), and the other two rooms were modified for large-group auto-sort management (LGAS). Two different food court designs were used in the LGAS rooms; one had feeders in the centre of the pen (LGAS Centre), while the other had the feeders on the walls of the food court (LGAS Peripheral). Each design provided 24 feeder spaces in total (see Figures 1a and 1b).

At the Elstow facility, we recorded the diurnal pattern of scale use, the use of individual feeder spaces within the food court, and eating patterns of individual pigs in LGAS rooms. Movement through the scale ('hits') were studied using automated output from the auto-sort scale. Feeder spaces were photographed at 5 min intervals using a time lapse camera (Figure 2). To identify individual animals, 10 pigs in each study group were paint-marked. Pigs in the Conventional room were weighed at 3-wk intervals using a hallway scale. Weights for pigs in the auto-sort rooms were obtained from the scale records (average of all weights for the day). Pigs were marketed as they reached target weight. At marketing, carcass data were obtained for a subsample of pigs for a comparison of carcass traits in each treatment.

The commercial farm maintained groups of 650 pigs with 60 feeder spaces. On the farm, feeding behaviour was observed in 10 rooms of approximately 650 pigs to determine the diurnal pattern of feeding behaviour at different ages. We again used output from the auto-sort scale, and supplemented this with live observations of four rooms of pigs at different ages over a 24-hr period.

RESULTS AND DISCUSSION

The analysis of feeding behaviour at the Elstow facility showed a clear diurnal pattern with an 8-fold increase in eating in the daytime 'peaks' compared to the midnight 'low'. The pattern showed peaks at 'lights-on' and 'lights-off', similar to what is found in small group pens. Pigs in small groups typically eat 10 – 15 well defined 'meals' in a day. Pigs in the LGAS had approximately 5 meals per day, but the meals were longer in duration than in small group pens. This adaptation was successful, as the pigs in LGAS performed as well as those in small groups.

No differences in performance or feeding behaviour were found for the two food court arrangements studied. Individual animals visited a number of feeders each day, and on average the feeder spaces were used uniformly in both food court arrangements (Figure 1). The study at the commercial farm allowed us to examine changes in eating behaviour as pigs aged. The study rooms varied in age by six weeks. We determined that the average number of entrances into the food court each day decreased as the size (age) of the pigs increased, from nearly 4 entries per day at 40 kg to approximately

2.5 per day at 90 kg. The pattern of eating showed the typical diurnal, two-peaked, pattern described earlier (Figure 3). Of interest in this pattern was that younger pigs had less of a 'drop-off' in the middle of the day. This suggests that the younger pigs were limited by the number of feeder spaces available, and had to shift from eating during the normal peak periods to the less intensive mid-day period.

CONCLUSION

Large group auto-sort systems pose some significant challenges to pigs in terms of eating behaviour. Because the feeders can only be accessed through a sorter scale, the cost of moving to the feeders is greater than in small pens. Despite these restrictions pigs pass through the sorter and eat in a typical diurnal pattern similar to that seen in small pens. However, pigs in LGAS pens only enter the food court 2-4 times each day, and have fewer meals (5 vs 10-15) than in small pens. They compensate by eating longer during each meal. They also move freely about the food court, eating from several feeders each day. Young pigs, who require more time to eat, may display a higher mid-day rate of eating, indicative of restricted feeder space. We believe that a key to making food courts work effectively is to make sure the pigs know that food is present by introducing them to the food court, rather than the loafing area. The food court should be spacious enough so that pigs have access to all of the feeders, and a feeder space should be provided for every 10-12 pigs.

ACKNOWLEDGEMENTS

Strategic funding provided by Sask Pork, Alberta Pork, Manitoba Pork Council, and Saskatchewan Agricultural and Food Development Fund. The collaboration of Sierens Equipment of Manitoba, as well as that of the participating commercial farm, was greatly appreciated.

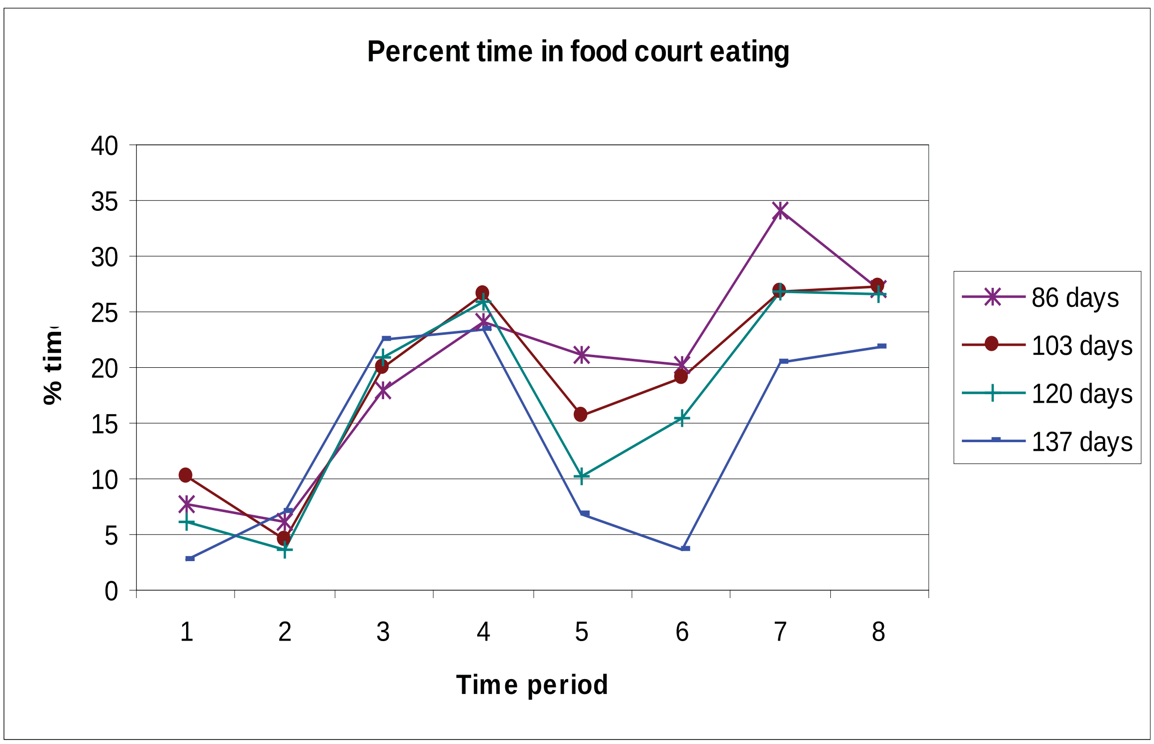

Figure 3. Daily eating pattern of pigs within the food court at different ages. The day was divided into 3-hr periods, starting at midnight.

Evaluation of Temperature Conditions in Trucks During Transport of Market Pigs to Slaughter in Four Seasons

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Harold Gonyou

Jennifer Brown

SUMMARY

Previous research at PSC has shown significant variation in conditions (temperature and humidity) among different compartments on trucks transporting market pigs. This study examined conditions in truck compartments in greater depth by measuring temperature and humidity variation during transportation of market pigs throughout the year. Pigs were transported from a commercial farm in Saskatchewan to a packing plant on a weekly basis, involving approximately 7.5 hours of travel. Pigs were exposed to variable temperatures during transport in different seasons with pigs transported in the 'belly', upper-front and middle-front compartments encountering the least favourable conditions.

INTRODUCTION

Transportation of pigs to slaughter involves economic losses due to deaths, 'suspect' animals on arrival at the processing plant, and reduced meat quality and raises important concerns regarding the welfare of pigs. Death losses. In market pigs during transport in Canada are reported to range from 0.05 to 0.17%, accounting for approximately 16,000 pigs per year, with an additional 0.10 to 0.20% of animals becoming non-ambulatory during transport. Transport losses are seasonal, with higher losses reported in summer and vary among compartments within a truck. Previous research at PSC has demonstrated significant variation in temperature and humidity conditions between different compartments on trailers. In this study, which began in January 2010 and was completed in March 2011, we examined temperature and humidity conditions on a commercial tri-axle trailer to examine how conditions vary in compartments during different seasons of the year.

"Pigs transported in the "belly" compartments encounter lower than average temperatures and those in the upper-front and middle-front compartments encounter elevated temperatures"

Figure 1. Placement of data loggers in the trailer (compartment 3).

EXPERIMENTAL PROCEDURES

Animals used in this study were market pigs weighing approximately 115 kg. The animals included a mixture of males (barrows) and females, and were assembled from multiple pens. All animals were from a single commercial farm in Saskatchewan. The trials were conducted on a weekly basis, beginning January 08, 2010, and completed in March 07, 2011. The pigs were generally loaded early in the morning (approximately 4:00 am) and travelled for approximately 7.5 h, arriving at the packing plant at approximately 12 noon. A single tri-axle livestock trailer was used for the study. Compartments in the upper deck were numbered from 1 at the front to 4 at the back. The middle deck was numbered from 5 at the front to 8 at the back. Compartments in the pot-belly were numbered 9 at the front and 10 at the back. Pigs were loaded in 8 of the 10 compartments. Compartments 6 and 7 were not used due to availability of pigs and load limitations. Loading density was approximately 0.41 m2/pig (0.36 m2/100 kg). Temperatures and relative humidity within the compartments were monitored using data logging devices (iButtons). The devices were programmed to record data at 5 minute intervals. Five data loggers were mounted in each compartment, with all loggers placed 130 cm above the floor to standardize the measures between compartments. They were positioned in the centre of the compartment, and 15 cm from the centre of each wall of the compartment, and were suspended from the ceiling on strips of hard plastic (Figure 1). Two data loggers were mounted outside the trailer on the truck side mirrors to monitor ambient conditions.

To study the seasonal variations in temperature among truck compartments, four seasons were identified based on ambient temperatures at the time of departure (approximately 5:00 a.m.). Season 1 included trips where the ambient temperature was below minus 10°C (extreme cold), Season 2 included ambient temperatures from 0°C to - 10°C (moderate cold), Season 3 included ambient temperatures from 0°C to 10°C (mild, above zero), and Season 4 included ambient temperatures above 10°C (extreme, above zero). Temperatures were determined for each compartment at the time the truck left the farm (departure), and as the truck was travelling (approximately 2.8 hour period) to the packing plant. The number of truck loads per each season, and the average and range of ambient temperatures (outdoors) encountered on departure from farm, during travelling, and on arrival at the packing plant are presented in Table 1.

RESULTS AND DISCUSSION

The temperatures within each compartment of the truck at the time of departure are presented in Table 2. In all four seasons, temperatures at departure were lower in the 'belly' compared to other compartments, and compartments in the middle-front and upper-front decks had the highest temperatures.

During transport, compartments in the middle-front (compartment 5) and upper-front deck (compartments 1 and 2) had higher temperatures compared to others of the truck in all four seasons (Table 2 and Figure 2). These compartments have relatively poor ventilation, as the front of the trailer is solid. Compartment 5 is also immediately above the truck drive wheels and transmission, which will be dissipating heat. Furthermore, previous research indicates that cool air enters at the back of the truck during transport, becoming warmer as it moves towards the front of the truck. All of these factors may have contributed to higher temperatures in front compartments.

Table 1. Average and Range of Ambient Temperatures (outdoors) encountered at the time of departure from farm, during transport, and at the time of arrival at the packing plant.

	Season			
	1 (<10°C)	2 (10°C to 0°C)	3 (0°C to <10°C)	4 (>10°C)
Number of truck loads of pigs	12	8	16	6
Average ambient temperature at the time of departure from the farm (°C)	-19.4	-6.3	4.4	14.7
Range	-31.1 to -10.5	-8.9 to -0.1	-0.6 to 10.4	11.7 to 18.2
Average ambient temperature during transportation of pigs (°C)	-19.1	-6.4	8.6	18.6
Range	-19.5 to -7.0	-7.2 to -7.7	3.6 to 24.2	18.2-30.9
Average ambient temperature at time of arrival at the packing palnt (°C)	-13.8	-1.4	13.2	24.7
Range	-28.9 to -10.5	-11.2 to -1.2	-0.6 to 17.3	15.0 to 22.0

In extreme cold conditions (Season 1), compartments in the 'belly' had the lowest temperatures compared to others, and a similar trend was observed in Season 2 (Table 2 and Figure 2). These compartments had higher ceiling heights as the compartments immediately above them were not loaded. Cool air entering from the back of the truck and cooling these two compartments and pigs above them to warm the ceilings are likely reasons for this.

CONCLUSION

Pigs were exposed to variable temperatures during transport in different seasons with pigs transported in 'belly' compartments encountering lower than average temperatures, and those in upper-front and middle-front compartments encountering elevated temperatures. Further analysis will examine the effects of different boarding and insulation treatments during winter on transport conditions. The results of this study will provide important information on the conditions experienced by pigs during transport and identify methods for improving transport conditions.

ACKNOWLEDGEMENTS

Strategic program funding provided by Sask Pork, Alberta Pork, Manitoba Pork Council, and the Saskatchewan Agricultural Development Fund. Specific project funding was provided by Ontario Pork, Maple Leaf Pork, the Natural Sciences and Engineering Research Council, and Agriculture and Agri-Food Canada. We also thank our commercial partners at Star City Colony.

Table 2. Average temperatures within truck compartments at departure from the farm and during transport to the packing plant

	Compartment									
	1	2	3	4	5	8	9	10	S.E.	F
Season 1 (<10°C)	20.7^{a}	18.5^{ab}	16.7^{ab}	14.4^{b}	14.9^{b}	8.9^{c}	3.5^{d}	3.9^{d}	1.7	<0.01
Season 2 (10°C to 0°C)	18.9^{a}	15.9^{ab}	15.5^{ab}	14.4^{ab}	16.8^{ab}	11.4^{bc}	7.6^{c}	8.4^{c}	2.2	<0.01
Season 3 (0°C to <10°C)	16.3^{a}	13.5^{b}	13.6^{b}	13.1^{b}	17.9^{a}	13.4^{b}	11.2^{c}	12.4^{bc}	0.6	<0.01
Season 4 (>10°C)	20.1	18.0	17.8	18.4	22.7	19.2	17.6	17.6	12	0.44
During Transport										
Season 1 (<10°C)	0.1	-1.0	-3.8	-3.2	2.0	-3.6	-5.4	-8.1	1.4	<0.01
Season 2 (10°C to 0°C)	3.2	2.6	1.0	0.9	4.3	0.9	0.9	-0.6	1.3	0.15
Season 3 (0°C to <10°C)	12.2	11.7	11.0	10.9	13.0	10.9	11.5	10.9	1.2	0.88
Season 4 (>10°C)	20.5	19.9	19.9	20.3	21.7	20.2	20.5	19.8	1.2	0.44

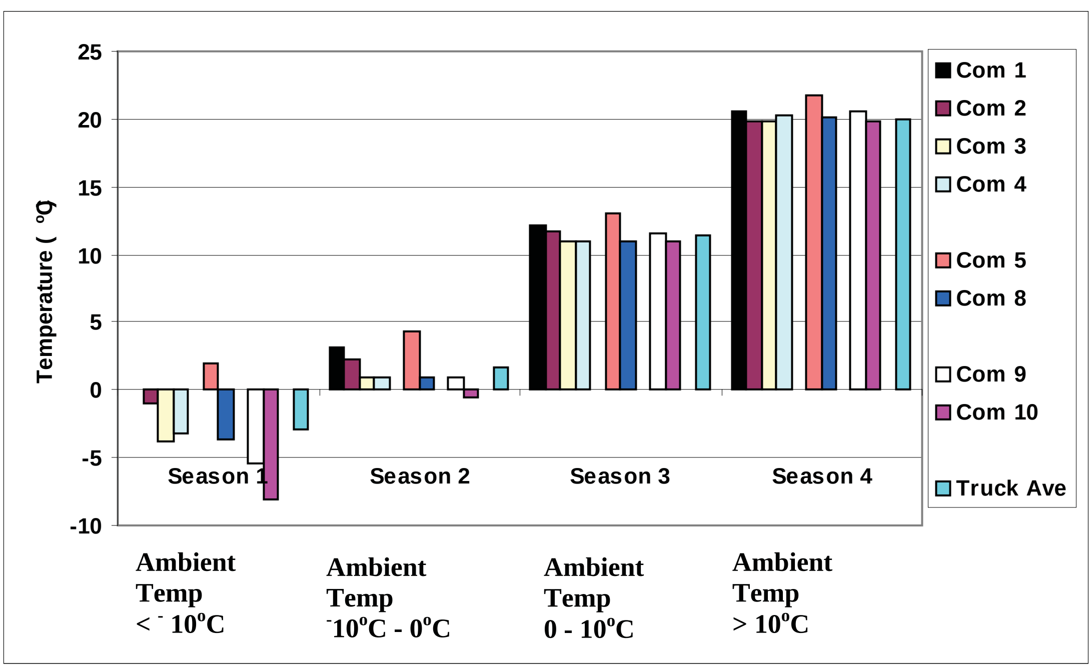

Figure 2. Truck temperatures during transportation in four seasons.

Does Palatability Affect the Intake of Peas in Pigs?

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SUMMARY

The primary use for field peas is as animal feed, particularly swine diets, where they are an economical source of energy and protein. The palatability of peas is a significant concern because it limits the use of this valuable ingredient. In this project, we studied the palatability of peas in swine diets. Our results show that peas used did not cause aversion in pigs, even when inclusion rates were as high as 60%. Pea diets did not cause a taste or post-ingestive aversion, and resulted in consumption levels equivalent to those for soybean meal diets.

INTRODUCTION

With an annual production ranging from 3 to 3.7 million tonnes, field peas constitute a major source of income for farmers in Western Canada. Thanks to their high content in digestible energy and certain essential amino acids, field peas constitute an excellent feed ingredient for swine. A recent survey (Pulse Canada; Feed Pea Network, 2007) among Canadian farmers showed that they were reluctant to use high levels of peas in swine diets mainly because of concerns about taste and feed intake. The aim of this study is to generate information on the possible origin of the problem that reduces feed intake.

MATERIALS AND METHODS

Experiment 1 (Time Course Experiment). The first experiment (Time Course Experiment) examined the effect of pea concentration in the diet on feed consumption; while exp. 2 (Flavour Association Experiment) examined post-ingestive feed-back effects of pea consumption on feed intake. In the Time Course Experiment, 50 mixed-gender pigs were randomly assigned, at 9 weeks of age, to one of five dietary treatments: a soybean meal (SBM)-based control diet, a canola-based control diet and three test diets containing 20, 40 or 60% peas (Table 1). The peas used in the study were a commercial mix of peas obtained from the mill.

"Using peas with inclusion rates as high as 60% did not cause any reduction in feed intake"

Research Technician Karu Bandaralage Feeding Pigs

Table 1. Ingredient and Calculated Nutrient Composition of Diets

Ingredient, %	SBM Control	Canola Control	20% Peas	40% Peas	60% Peas
Wheat	51.45	47.57	35.64	21.84	8.19
Soybean Meal	30.60	24.00	26.50	20.30	15.00
Oatgroats	10.00	10.00	10.00	10.00	10.00
Fish Meal	4.50	4.50	4.50	4.50	4.50
Peas	-	-	20.00	39.99	58.98
Canola	-	10.00	-	-	-
Tallow	1.00	1.50	1.00	1.00	1.00
Minerals[1]	1.93	1.93	1.93	1.93	1.93
Vitamins[2]	0.17	0.17	0.17	0.17	0.17
DL-Methionine	0.02	0.01	0.05	0.10	0.15
L-Threonine	0.08	0.06	0.08	0.10	0.13
L-Tryptophan	-	-	-	-	0.05
Lysine-HCl	0.26	0.26	0.14	0.07	0.01
Nutrient					
DE, Mcal/kg	3.50	3.46	3.48	3.46	3.45
Dlys/Mcal DE, g/Mcal	3.79	3.79	3.80	3.80	3.83
Crude Protein, %	26.99	27.03	27.00	26.39	26.05
Dlys, %	1.33	1.31	1.32	1.32	1.32

[1] 1.00% Mono-Di Cal, 0.50% limestone, 0.20% salt, 0.20% mineral premix and 0.03% zinc oxide

[2] 0.10% vitamin premix and 0.07% choline

Experiment 2 (Flavour Association Experiment). In the Flavour Association Experiment, pigs were trained, over a 10-day period, to associate a unique flavour (grape or orange) with a particular diet; either the canola control diet or the 60% pea diet from exp. 1 (Table 1). Diets were flavoured by the addition of 6g/kg of grape or orange Kool-AidTM immediately prior to feeding, resulting in four dietary treatments (orange/canola, grape/canola, orange/peas and grape/peas). Dietary treatments were assigned in pairs and fed on alternate days, such that 10 pigs alternated between the pea/grape and canola/orange diets and 10 pigs alternated between the pea/orange and canola/grape treatments. A 5-day "wash-out" period, during which all animals received the SBM control diet followed the experimental period. Subsequently, a preference test was carried out. Pigs were simultaneously offered both grape and orange-flavoured SBM control diet and their intakes of each were determined.

RESULTS AND CONCLUSIONS

In Time Course Experiment, the intake of all the diets was lowest on day 1 (Figure 2). By day 4, the intake of pea diets was higher than control, suggesting that a high inclusion rate of peas does not necessarily result in reduced feed intake. Consumption levels during the first 3 days and the final 3 days showed no difference for 20, 40 or 60 % pea diets compared to the soy- or canola-based control diets ($P > 0.10$).

In the Flavour Association Experiment, pigs exhibited a slight preference for grape vs. orange flavour (0.92 ± 0.3 versus 0.85 ± 0.2 kg, respectively; mean ± SD). This was irrespective of which diet had previously been associated with grape flavouring, as evidenced by the similarity in feed intake associated with the two diets (0.88 ± 0.3 and 0.89 ± 0.2 kg for pea- and canola-based diets, respectively; mean ± SD). The results indicate that the palatability of pea- and canola-based diets in this study were similar.

ACKNOWLEDGEMENTS

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Effects of Temperament and Floor Space Allowance on Sows at Grouping

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SUMMARY

Many N. American producers are anticipating a change to group housing for sows. The overall purpose of this study was to determine how to reduce the stress of mixing sows by altering space allowance, and social groups. We also studied how space can influence behaviour and aggression within a goup. The largest space requirement occurred between midnight and 8am when the highest percentage of sows were lying laterally. From a purely physical perspective the sows would require 1.51m2/sow, however this does not account for any movement or interactions between individuals. When sows were initially grouped, they showed a higher occurrence of injury scores (P<0.001) and a greater number of fights (P<0.001) compared to the stable groups (3 weeks post-mixing). Most fighting and injuries occurred within 24 hours of mixing. There was not a significant difference between either injury score and number of fights with the different space allowances. Passive/shy shows appeared to show a reduced stress response compared with active/bold sows.

INTRODUCTION

With the announcements in 2007 by the largest producer/packers in both the USA and Canada that they will transition their production facilities to group housing for sows over the next ten years, many producers are anticipating a change to group housing. Previous studies have demonstrated that spacious accommodation reduces the aggression at regrouping and general health during gestation, but the studies did not identify the point at which crowding begins (ie. space is important, but the specific requirement is unknown). This study was undertaken with the goal of establishing a more precise value. In addition to providing enough space, the temperament of sows was also determined to acertain if 'shy' or 'passive' sows would be less aggressive than 'bold' or 'active' sows. Specifically, we also wanted to determine the space required to accommodate the postures of sows exhibited over a 24 hr period, the space required to decrease aggression at mixing, space required to accommodate normal behaviour patterns in sows after a stable social structure has been established and to determine if grouping sows with specific behavioural characteristics minimizes the aggression in group housing.)

MATERIALS AND METHODS

Sixteen groups of 8 sows were formed based on their behavioural responses to two simple temperament tests (n=128). The groups were either described as being uniform 'passive/shy' or uniform 'active/bold'. Sows were confined to the loafing area for 23 hours per day and returned to the stalls for feeding. The gestation pens used for the study consisted of 32 walk-in/lock-in stalls and a loafing area. Moveable panels were used to create the required space allowances of 1.6 m2/sow; 2.0 m2/sow; 2.4 m2/sow; and 2.8 m2/sow. Aggressive behaviours were observed live for 4 hours after the sows were initially mixed. Photographs were also taken from mounted cameras at regular intervals for 72 hours post mixing. Injuries were

" When mixing gestating sows most fighting occurred within 24 hours of mixing, although no differences between space allowance"

Sows locked out of stalls and confined to loafing area assessed and saliva samples were collected before mixing (baseline) then again at 24 hours and 72 hours post-mixing from 4 focal sows per group. At the end of the 'mixing week', sows were weighed before they were locked into their feeding stalls for one week. At the beginning of the third week, sows entered their new space allowance and stayed there for four weeks, this is referred to as the 'stable weeks'. The sows had their injuries assessed and saliva collected before entering their new space allowance. Live observations of aggressive behaviour were again recorded for 4 hours. Injuries were assessed and saliva samples were also collected again. This same procedure was followed at the end of the four stable weeks. Photographs were taken every 10 minutes for 24 hours at week 1, week 4 and week 10 in order to assess postural behaviour changes over time.

RESULTS AND DISCUSSION

On average, over a 24 hr hour period we observed that 17.2% of sows would be standing, 2.1% sitting, 9.6% lying on sternum, 28% lying relaxed on sternum, and 43.1% lying laterally. These results were consistent over the 'mixed' and 'stable' weeks throughout different stages of gestation (Fig. 1). Using calculations of the total area occupied by sows displaying each of these postures from Ekkel et al, (2003) we calculated how much space would be required for sows over a 24 hour period. The average weight of all the sows involved in the study was 230kg. We used this weight to calculate what the total space requirement would be over 3 different times ever a 24hr period from the postural observations. The 3 periods were 1: midnight – 8am, 2: 8am – 4pm, 3: 4pm – midnight. These space requirements only account for the physical space occupied by sows and does not take the space required for social interactions or free space into consideration. This example shows that sows require the most amount of space between midnight and 8am as this is when the most amount of lateral lying occurs. The least amount of space is used during the day (between 8am and 4pm).

When sows were initially grouped, they showed a higher occurrence of injury scores (P<0.001) (Fig. 2) and a greater number of fights (P<0.001) compared to the stable groups. Most fighting and injuries occurred within 24 hours of mixing, and was consistent across all 4 space allowances (Fig. 3). Sows in the stable groups showed a higher occurrence of threats than the mixed groups. This is likely to be because the aggression would be highest when unfamiliar pigs are first introduced. After a period of time the aggression becomes ritualized (in the form of threats). Threats do not escalate into physical contact due to an established dominance hierarchy. There was not a significant difference between injury score and number of

Walk-in/Lock-in stall group housed sows

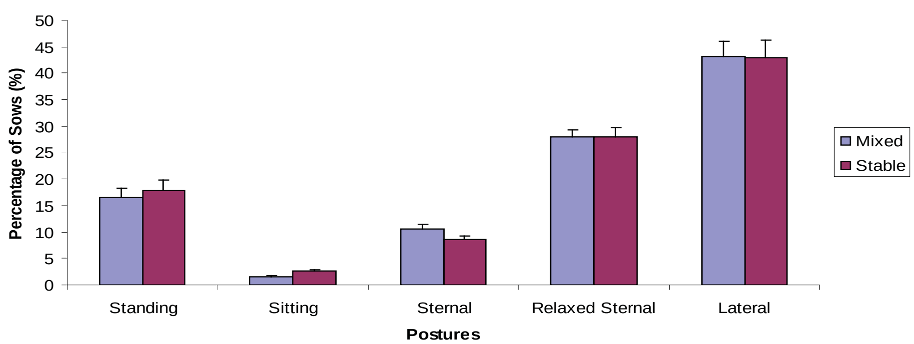

Figure 1: Postural behaviours of sows between 'mixed' and 'stable' phases.

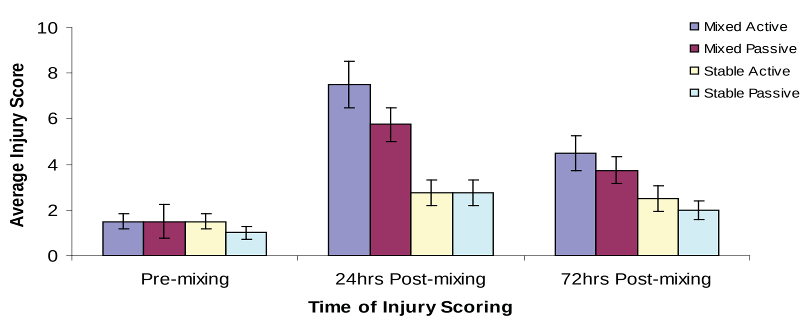

Figure 2: Injury scores of prior to being mixed (0hrs) and 24hrs, 72hrs after being 'mixed' and when 'stable' for both 'active' and 'passive' temperament traits.

fights with the different space allowances. Grouping sows with different behavioural characteristics does appear to minimize aggression as passive animals had lower injury scores and were involved in less fights, however these results did not indicate a significant difference. Passive animals also had lower cortisol levels (Fig 4), indicating that they may were experiencing less stress than the 'active' sows.

CONCLUSION

Aggression and poor control over feed intake of sows in groups are the main reasons for using gestation stalls. Even though these problems still exist in group housing, producers are moving away from stalls and towards groups. Further information is still required to be able to provide advice group housing on to promote the welfare of the sows and the profitability of the producer. Most fighting and injuries occurred within 24hrs of mixing, although no difference was found between space allowances. 'Passive' or 'shy' sows are more likely to be suited to group housing than 'active' or 'bold' sows as they had lower injury scores and had lower levels of salivary cortisol. The walk-in/lock-in stalls used in this study were locked off for 23hrs and only opened for 1hr per day for feeding – similar to a cafeteria system. The results described here specifically relate to this type of group housing and can not necessarily be infered for other group housing systems.

ACKNOWLEDGEMENTS

Strategic program funding provided be Sask Pork, Alberta Pork, Manitoba Pork Council, and the Saskatchewan Agricultural Development Fund. Specific project funding was provided by the Saskatchewan Agricultural Development Fund.

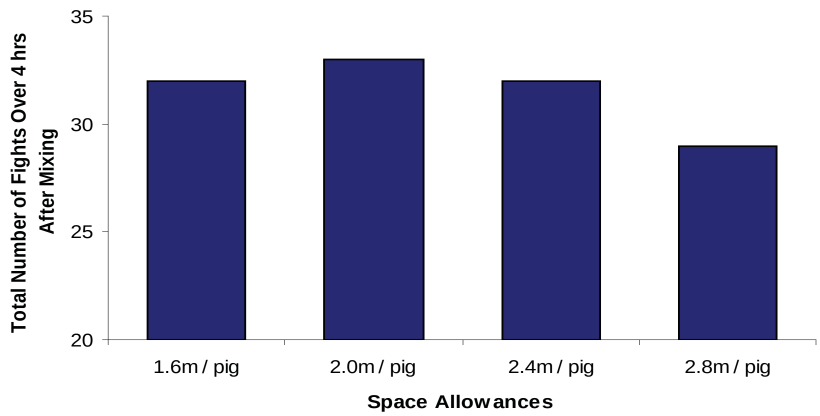

Figure. 3 Effect of space allowance on the total number of fights recorded over 4 hours after mixing. The treatments assessed during the mixing period (first week sows were grouped together) were 4 different space allowances 1.6 m2/sow, 2.0 m2/sow, 2.4 m2/sow, 2.8 m2/sow.

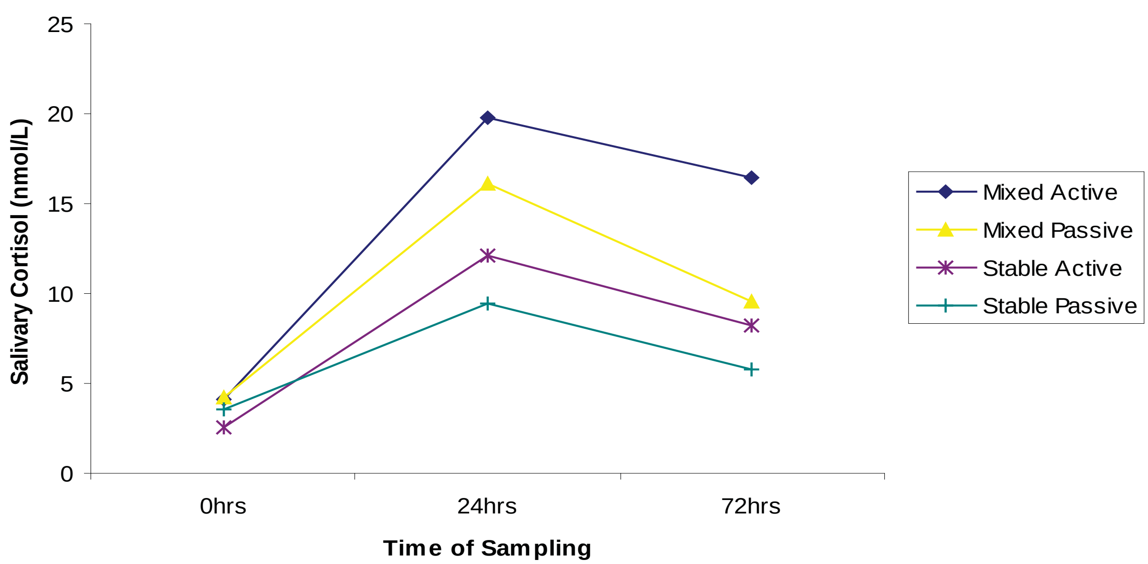

Figure. 4 Salivary cortisol of sows prior to being mixed (0hrs) and 24hrs, 72hrs after being 'mixed' and when 'stable' for both 'active' and 'passive' temperament traits.

Literature Review and Needs Assessment of Housing Systems for Gestating Sows in Group Pens with Individual Feeding

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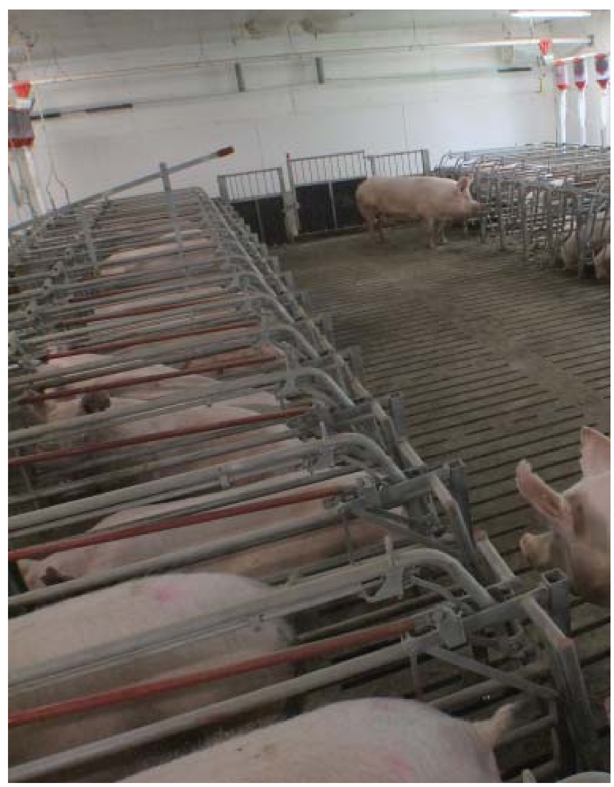
In the U.S., the public has expressed concern over the use of sow gestation stalls via ballot measures in a number of states. Likewise, large companies such as Smithfield Foods and Canada's Maple Leaf Foods are voluntarily restricting the use of gestation stalls by 2017. Gestation stalls have already been banned in the U.K. since 1999, with the rest of Europe phasing them out by 2013, and Australia by 2017. On the surface, it may appear that this is a step towards improving the welfare of gestating sows, however, animal welfare is a multi-faceted concept and scientific data is needed to assess all components. Many aspects of the sow housing environment and husbandry must be taken into consideration in order to accurately determine which types of gestation housing are the most welfare-friendly. Group housing can be a complex system and facilities come in many forms. At present, there is a lack of research adequately comparing all of the different options available for the group housing of gestating sows. An extensive body of literature exists on the influence of environmental enrichment, stocking density, and group size on the behavior of sows in group housing. However, substantial research gaps have been identified with regard to genetics, air quality, physiology and sow productivity.

To measure the overall sow welfare in group sow housing systems which utilize one or more types of individual feeding methods, a variety of outcome measures can be evaluated, including: behavior (i.e., aggression, responses to behavioral tests, general behavioral time budgets, stereotypies), injuries (i.e., scratches, lesions, vulva bites, lameness), physiology (i.e., cortisol concentration, heart rate, muscle/bone strength) and productivity (i.e., fertility, litter size, litter weight, piglets/sow/year, backfat, body condition, longevity). These parameters are based on the Five Freedoms (Webster, 2001), which include freedom from: 1) hunger, thirst and malnutrition, 2) thermal and physical discomfort, 3) injury or disease, 4) suppression of normal behavior, and 5) fear and distress. Additionally, standard parameters used by commercial producers to evaluate production profitability and sustainability can be considered, which include: 1) high biological performance, 2) low labour input, 3) ease of management, 4) acceptable capital cost, and 5) acceptable financial return (Edwards, 1990).

Experts have ranked the following housing systems according to sow welfare: tethers and stalls (lowest); indoor group housing (middle); group housing with outdoor and substrate access (highest) (Bracke et al., 2002). Most of the research conducted on sow welfare has involved comparing group housing with gestation stalls. However, only comparing group and stall housing does not provide adequate information to conclude that one group housing system is better than another with regard to overall sow welfare. Further complicating the fundamental question of how confinement affects pregnant sow welfare is the issue of the number of alternative group housing



Sows in group housing with individual feeders designs and management regimes available. For example, within group sow housing systems there are a variety of feeding methods to choose from: sows may be fed as a group (either on the floor or in troughs) or individually.

In group housed gestating sows managed through individual feeding systems such as electronic sow feeders (ESF) or individual feeding stalls, some key themes were found amongst the scientific literature reviewed.

Space Allowance

Reduced space allowances result in more injuries in systems with both ESF and individual feeding stalls, as reduced space also results in more social interactions and aggression (Weng et al., 1998; Remience et al., 2008). Furthermore, physiological and productivity measures did not differ in sow groups differing in stocking density, regardless of the feeding system used (Remience et al., 2008).

Group Size

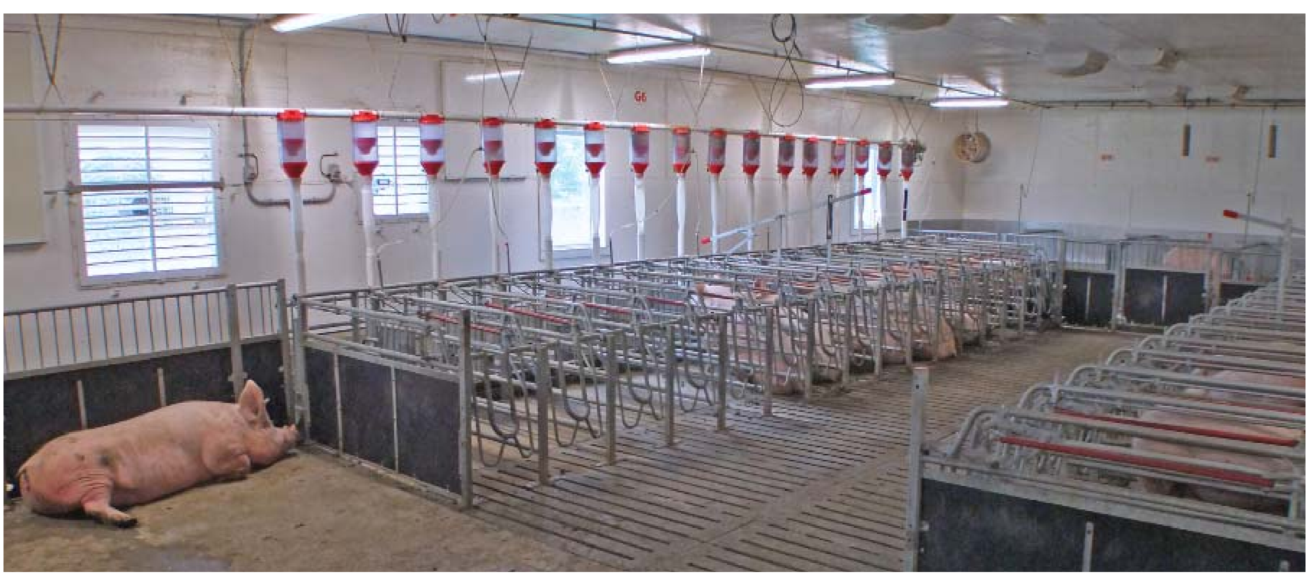
Increasing group size in an ESF system has different implications than in a system with individual feeders. Increasing a group with individual feeding stalls would require more feeding stalls to accommodate all sows. However, in ESF systems, an increase in group size would not only have implications for the social dynamics within the group, but would also put more pressure on the use of the ESF station(s). With more animals expected to use a single feeding station, competition would naturally increase (Svendsen et al., 1992).

Group Type and Composition

With regard to group type, dynamic groups often experience more aggression and injuries than static sow groups. Furthermore, the newest sows added to a dynamic group tend to receive the most injuries (Strawford et al., 2008). Overall, the first week post-mixing results in more aggression compared with the remaining weeks in both static and dynamic groups. Sows in small static groups were less active than sows in large dynamic groups (Durrell et al., 2002). However, sows in static and dynamic groups were found to have similar salivary cortisol concentration (used as an indication of stress in farm animals) (Anil et al., 2006; Strawford et al., 2008). A discrepancy was found in productivity results which compared sows in static and dynamic groups; some studies have found differences while other studies have not. Low ranking sows were also found to be at a disadvantage in both static and dynamic groups, especially in an ESF system, as these sows received more aggression and injuries, while also exhibiting poorer productivity compared with high-ranking sows (O'Connell et al., 2003). However, salivary cortisol levels did not differ among sows of different social status in either static or dynamic groups.

Flooring and Bedding

Providing straw bedding as a source of enrichment has many positive effects on sow behavior, however these same properties may not be unique to straw alone (Arey, 1993). As such, more alternatives to straw bedding need to be investigated further. As a whole, sows provided with good bedding material tend to incur fewer injuries and exhibit less pen mate directed aberrant behaviors (e.g. ear and tail biting). However, both aggression and foot health problems can still persist in deep-bedded group housing systems, regardless of feeder type used (Tuyttens, 2005). The specific impact of bedding on overall performance (e.g. milk production and growth) depends on the quality of the conducted research and what was measured. The effect of bedding alternatives on sow physiology have not been studied to any real extent. However, thoroughly bedded sow housing systems have been shown to decrease reproductive failure, increase pregnancy uptake, and increase farrowing rate. Interactions between feeder type and enrichment materials have not been specifically studied with regard to group housing of gestating sows.



Sow Research Unit at Prairie Swine Centre. Each group of 32 sows can chose between being inside the free access stall or out in the loafing area

Feeding Regime

Restricted feeding in gestating sows is common practice as a means of decreasing farrowing difficulties. However, restricted feeding in group housed sows leads to increased hunger and frustration, which stimulates an increase in stereotypic and aggressive behaviour (Meunler-Salaün et al, 2001). Adding quality fiber to the sow diet increases satiety and doubles eating time, thereby effectively reducing the incidence of aberrant behaviors. The current scientific literature provides many viable ideas of ways to include additional fiber in the sow diet in conjunction with ESF or individual feeding stall systems (Brouns et al, 1994; van der Peet-Schering et al., 2003).

In addition to behavioral concerns, restricted feeding regimes can also lead to increased skin and hoof lesions, vulva biting, and tail biting, which also impact the number of cull sows (Rizvi et al., 1998). Some of these problems can also be reduced through an increase in dietary fiber. However, overall aggression may not differ significantly between feed restricted sows and those given a high fiber diet. The literature suggests that feed restricted sows, regardless of feeding system, show higher basal cortisol levels and rectal temperatures, bulking diets with added high quality fiber may buffer the impact (Stewart et al., 2008).

Feed/Water Resource Allocation

Feed station design is a very important determinant of behavior in group sow housing systems with individual feeding. The majority of studies have focused on aggression and injuries associated with ESF systems (e.g. lameness, vulva biting, tail biting, and agonistic interactions resulting in injuries). Overall, stress cortisol and immune function data in the scientific literature is sparse, but valuable information for assessing different feeding systems, particularly in light of noted behavior and injury problems correlated with varying feeding station designs (Broom et al., 1995; Barnett et al., 1996; Spoolder et al., 1996). More research is needed with regard to the effect of individual feeding systems on sow productivity measures.

Air Quality

Air quality in group sow housing has not been studied with specific attention to feeder type or design. Overall, ammonia emissions are the primary air quality concern with regard to group sow housing, and were found to change considerably with the feeding schedule (Groenestein et al., 2001; Groenestein et al., 2006). In particular, flooring designs which also reduce slipping and lameness in group housed sows also tend to improve the environment with respect to air quality. No research has been conducted on the effects of group sow housing air quality parameters on sow physiology or productivity.

Sow Genetics

Genetics may anecdotally play a role in stereotypy development and general activity in group sow housing, however without sufficient studies to specifically investigate the effect of genetics, no firm conclusion can be drawn. Preliminary data suggest that it may be possible to select against aggression in sows without reducing maternal behavior, however feeding system was not a factor in the study design (Lovendahl et al., 2005).

CONCLUSION

Due to growing concern for animal welfare, group housing of gestating sows has received more attention over the past few years. While group-housed sows may benefit from being able to perform more natural behaviors, and maintain bone and muscle strength, these systems can also result in increased aggression and decreased welfare, particularly for lower ranking animals. As gestation stalls are phased out and group housing is phased in, more research is required in order to understand how to best manage some of the welfare challenges associated with group sow housing systems. There are many components of a group housing system that need to be evaluated when examining the systems' overall impact on animal welfare and economic feasibility for the producer.

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Dietary Omega-6 to Omega-3 Fatty Acid Ratios Affect Colostrum, Sow and Piglet Plasma Fatty Acid Profiles

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SUMMARY
An experiment was conducted to determine the effects of altering the omega-6 (n-6) to omega-3 (n-3) fatty acid (FA) ratio in sow diets on the FA profile of colostrum, and sow and piglet plasma. A reduction in the n-6:n-3 ratio improved circulating levels of eicosapentaenoic acid (EPA) and α-linolenic acid (ALA) in both sows and piglets, indicating that the FA ratio is an important factor for increasing conversion of ALA into its longer chain counterparts.

INTRODUCTION
Polyunsaturated fatty acids (PUFA) are precursors for many important hormones and molecules within the body. Omega-3 PUFA's have proven health benefits. In general, their biological activity is opposite of the n-6 PUFA's. They are considered to be anti-inflammatory, and can affect reproduction by changing the circulating profile of prostaglandins. Within the body, direct competition occurs between the n-3 and n-6 FA's and thus the ratio may be important in maximizing the benefits of including n-3 FA's into sow diets. The type of n-3 FA may also be important, as the biological activity of ALA (found in plant sources such as flaxseed) differs from EPA and docosahexaenoic acid (DHA) which are both found in fish oils.

Our objective was to determine if feeding different n-6:n-3 FA ratios would alter the circulating FA profiles in sow and piglet plasma, specifically elongation to the longer chain fatty acids. We also wanted to determine if feeding plant based n-3's would increase circulating levels of EPA and DHA in pigs.

MATERIALS AND METHODS
This experiment used five dietary treatments, each divided into a gestation and lactation ration. The diets were formulated to have a constant total fat concentration (5% crude fat), but varied in the ratio of n-6 to n-3 FA's. The treatment groups consisted of a control (tallow), 3 diets with plant oil based n-6:n-3 ratios (10:1, 5:1, and 1:1) as well as a 5:1 fish oil diet.

Sows (n=150) were randomly assigned to one of five diets on d 80 of gestation. The sows remained on their diets through a first farrowing to weaning period (referred to as Cycle 1), followed by a subsequent breeding, gestation and farrowing to weaning period (referred to as Cycle 2). Blood was collected from sows (n=12/diet) on d 110 of ges-

"Increasing the intake of plant based n-3 fatty acids in a 1:1 (n-6:n-3) ratio increased circulating levels of EPA in addition to ALA in both sows and piglets."

tation during Cycle 1. During Cycle 2, colostrum was collected from 12 sows per diet at the time of farrowing, and blood was collected from 2 piglets/sow (one pre-suckle and one 1 d post-farrowing).

RESULTS AND DISCUSSION
The FA profiles of sow plasma, pre- and post-suckle piglet plasma and colostrum are shown in Table 1. Total plasma n-3 FA's were greater in sows ($P < 0.0001$) and post-suckle piglets ($P = 0.004$) consuming the 1:1 and fish diets. The ALA content was highest in the 1:1 group whereas EPA and DHA were highest in the fish group. In pre-suckle piglet plasma, ALA and DHA did not differ among treatment groups ($P > 0.05$). Relative to the control piglets, EPA was 2.5 times greater in the 1:1 group and 4 times greater in the fish group ($P < 0.0001$) prior to suckling. In post-suckle samples, ALA was highest in piglets from the 1:1 diet group ($P < 0.005$), and EPA and DHA were highest in piglets from the fish based sows ($P < 0.0001$) which was expected based on the colostrum FA profile.

The FA profile of pre-suckle piglet plasma indicates that the conversion of ALA into EPA can be increased by reducing the dietary n-6:n-3 FA ratio of their mothers. It is possible that reduced competition for the enzymes responsible for the desaturation and elongation occurs, allowing for increased selection of the n-3 FA's by these enzymes and thus improving conversion efficiency.

Table 1. Fatty acid profiles of sow and piglet plasma as well as colostrum (mg FA/ml)

	Dietary Treatment					Statistics	
Fatty Acid (mg/ml)	Control	10:1P	5:1P	1:1P	5:1F	SEM	P-Value
Sow Plasma							
Linoleic Acid (18:2 n-6)	1.20	1.56	1.39	1.12	1.18	0.211	0.599
α-Linolenic Acid (18:3 n-3)	0.06a	0.09a	0.17a	0.39b	0.10a	0.042	<0.001
Arachidonic Acid (20:4 n-6)	0.20a	0.19a	0.14ab	0.09b	0.11b	0.023	0.006
Eicosapentaenoic Acid (20:5 n-3)	0.02ab	0.02a	0.03ab	0.06b	0.26c	0.015	<0.001
Docosahexaenoic Acid (22:6 n-3)	0.02a	0.02a	0.02a	0.02a	010b	0.015	<0.001
Total n-3	0.12a	0.15a	0.25a	0.51b	0.55b	0.050	<0.001
Total n-6	1.44	1.82	1.63	1.41	1.33	0.202	0.462
Pre-Suckle Piglet Plasma							
Linoleic Acid (18:2 n-6)	0.11	0.10	0.20	0.09	0.10	0.039	0.229
α-Linolenic Acid (18:3 n-3)	0.01	0.01	0.02	0.01	0.01	0.006	0.507
Arachidonic Acid (20:4 n-6)	0.24a	0.23a	0.21a	0.13b	0.12b	0.021	<0.001
Eicosapentaenoic Acid (20:5 n-3)	0.01a	0.01a	0.02a	0.04b	0.06b	0.003	<0.001
Docosahexaenoic Acid (22:6 n-3)	0.15	0.08	0.11	0.12	0.16	0.022	0.078
Total n-3	0.21ab	0.14a	0.21ab	0.23bc	0.31c	0.029	0.004
Total n-6	0.26	0.18	0.32	0.21	0.26	0.049	0.331
Post Suckle Piglet Plasm							
Linoleic Acid (18:2 n-6)	0.57a	1.36b	1.24b	0.61a	0.53a	0.204	0.007
α-Linolenic Acid (18:3 n-3)	0.03a	0.11ab	0.16bc	0.22c	0.04a	0.037	0.004
Arachidonic Acid (20:4 n-6)	0.20a	0.30b	0.27b	0.14a	0.15a	0.023	<0.001
Eicosapentaenoic Acid (20:5 n-3)	0.01a	0.02a	0.03a	0.05a	0.16b	0.014	<0.001
Docosahexaenoic Acid (22:6 n-3)	0.09a	0.07a	0.10a	0.09a	0.18b	0.014	<0.001
Total n-3	0.18a	0.36ab	0.51bc	0.61c	0.59bc	0.088	0.003
Total n-6	0.60a	0.143b	1.34b	0.70a	0.70a	0.207	0.010
Colostrum							
Linoleic Acid (18:2 n-6)	44.90a	96.47c	81.88bc	70.04b	28.4a	8.474	<0.001
α-Linolenic Acid (18:3 n-3)	4.54a	16.43a	17.31a	50.38b	4.85a	4.683	<0.001
Arachidonic Acid (20:4 n-6)	1.18ab	1.57a	0.88bc	1.07bc	0.59c	0.163	0.003
Eicosapentaenoic Acid (20:5 n-3)	0.71a	0.80a	0.75a	1.93b	1.86b	0.304	0.006
Docosahexaenoic Acid (22:6 n-3)	0.53a	0.45a	0.38a	0.68a	5.33b	0.346	<0.001
Total n-3	7.29a	19.53a	19.89a	55.01b	12.83a	4.959	<0.001
Total n-6	47.24a	100.08b	84.54bc	72.85c	32.49a	8.805	<0.001

CONCLUSION

Increasing the intake of plant based n-3 FA's in a 1:1 (n-6:n-3) ratio increased circulating levels of EPA in addition to ALA in both sows and piglets. This indicates that flaxseed may be a viable option for reducing the n-6:n-3 ratio and increasing the n-3 content in sow diets, and thus the benefits of including n-3 FA's into swine rations can potentially be achieved using a locally grown crop.

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Dietary Omega-6 to Omega-3 Fatty Acid Ratios Affect Sow Reproduction and Piglet Performance

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SUMMARY

An experiment was conducted to determine the effects of altering the omega-6 (n-6) to omega-3 (n-3) fatty acid (FA) ratio in sow diets on their reproductive performances. Production in the farrowing room was optimal when sows consumed a plant oil based ratio of 5:1 n-6:n-3. The long term feeding of sows with varied dietary n-6 and n-3 fatty acids can affect her reproductive performances, and the performance of her offspring.

INTRODUCTION

In the hog industry the most critical stages of production are the breeding and the farrowing to weaning periods, as this is the time when pig flow through an entire barn can be affected. It is imperative that we maximize the reproductive performance of sows to optimize pig flow and thus improve the economics of pork production.

Over the years we have used many nutritional strategies to improve the performance of sows. Recently there has been a growing interest in the use of dietary polyunsaturated fatty acids, specifically the n-3 FA's α-linolenic acid (ALA), eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). Omega-3 FA's can have positive effects on reproduction, however, there is direct competition between the n-3 and n-6 FA's within the body and thus the ratio may be important in maximizing the benefits of including n-3 FA's into sow diets. The type of n-3 FA may also be important, as the biological activity of ALA (found in plant sources such as flaxseed) differs from EPA and DHA (found in fish oils).

The objective of our experiment was to determine the effect of altering the ratio of dietary n-6 to n-3 FA's fed to sows on reproduction, piglet performance and immune parameters.

MATERIALS AND METHODS

This experiment used five dietary treatments, each divided into a gestation and lactation ration. The diets were formulated to have a constant total fat concentration (5% crude fat), but varied in the ratio of n-6 to n-3 FA's. The treatment groups consisted of a control (tallow), 3 diets with plant oil based n-6:n-3 ratios (10:1, 5:1, and 1:1) as well as a 5:1 fish oil diet.

Sows (n=150) were randomly assigned to one of five diets on d 80 of gestation. The sows remained on their diets through a first farrowing to weaning period (referred to as Cycle 1), followed by a subsequent breeding, gestation and farrowing to weaning period (referred to as Cycle 2). During both cycles performance data was collected. A subset of 12 sows/diet were used during Cycle 2 for colostrum collection at farrowing and piglet serum collection to measure IgG and IgA concentrations.

"The long term feeding of sows with varied dietary n-6 and n-3 fatty acids can affect reproductive performance"

RESULTS AND DISCUSSION

Results for Cycle 1 and Cycle 2 are shown in Table 1. There was no effect of diet on the total number of piglets born, born alive, or lit-

Table 1.: Production Results for Cycle 1 and Cycle 2

	Dietary Treatment					Statistics	
Production Parameter	Control	10:1P	5:1P	1:1P	5:1F	SEM	P-Value
Cycle1							
# Born Alive	12.8	12.6	12.4	13	130	0.50	0.919
# born total	13.7	13.6	13.7	14.3	14.4	0.54	0.729
Live litter birth weight (kg)	18.7	18.3	18.5	17.9	17.7	0.78	0.894
Birth weight (kg/piglet)	1.5	1.5	1.5	1.4	1.3	0.05	0.101
Weaning weight (kg/piglet)	8.2[ab]	8.6[a]	8.6[a]	8.0[b]	7.8[b]	0.19	0.019
Cycle 2							
Sow feed intake (kg/d lact)	7.5[a]	7.4[a]	7.6[a]	7.5[a]	6.8[b]	0.20	0.036
Sow weight change (kg/lact)	-5.6	-8.0	-5.6	-3.3	-11.7	2.63	0.291
Sow backfat change (mm/lact)	-0.8	-1.1	-0.7	-0.9	-0.7	0.22	0.712
Wean to estrus interval (d)	4.1	4.9	4.2	3.9	5.1	0.42	0.171
# born alive	12.5	12.5	11.5	12.3	13.0	0.60	0.538
# born total	13.3	14.0	12.9	14.0	14.4	0.63	0.464
Live litter birth weight (kg)	18.1	17.5	16.8	17.7	16.9	0.77	0.725
Weaning weight (kg/pirglet)	8.8[a]	8.7[ab]	9.2[a]	8.7[ab]	8.2[b]	0.21	0.040

ter birth weights for either cycle, or on the IgA and IgG concentrations in colostrum or piglet serum (data not shown).

As shown in Table 1, average piglet weaning weight was higher for the 10:1 and 5:1 plant based groups when compared to the 1:1 and fish based groups during Cycle 1 (P = 0.02). During Cycle 2, fish oil sows consumed 10% less feed (P = 0.04), had reduced piglet birth weights (P = 0.05), and average piglet weaning weight was reduced by 0.8 kg/piglet (P = 0.04) when compared to control and 5:1 plant oil based sows.

CONCLUSION

The results from this study indicate that the long term feeding of decreased n-6:n-3 ratio diets to sows can affect reproductive performances. A plant oil based ratio of 5:1 (n-6:n-3) maximized piglet growth and sow feed intakes, and did not affect her return to estrus interval. Sows consuming the fish oil diet ate less feed and had reduced piglet birth and weaning weights when compared to the other treatment groups. This indicates that a plant based n-3 FA (such as those found in flaxseed) may be more beneficial for improving performance in the farrowing room than fish based n-3 FA's when included in sow diets.

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Effects of Altering the Omega-6 to Omega-3 Fatty Acid Ratio in Sow Diets on the Immune Responses of their Offspring Post-Weaning

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SUMMARY

An experiment was conducted to determine the effects of altering the omega-6 (n-6) to omega-3 (n-3) fatty acid (FA) ratio in sow diets on the immune responses of their offspring post-weaning. Piglets were subjected to an immune challenge by injecting lipopolysaccharide (LPS), a component of gram-negative bacteria which triggers an immune response. Weanling pigs produced from sows consuming different n-6:n-3 FA ratios respond differently to an LPS induced immune challenge. This allows us to conclude that the FA profile of a sows diet may affect the response of her offspring to immune challenges which occur regularly at the time of weaning

INTRODUCTION

In the swine production industry, weaning is certainly the most stressful time in a piglet's life which is partly due to exposure to new immune challenges. It is during this time that feed intakes are reduced and an immune response will be generated. Although a certain degree of immune response is beneficial during this time, an over-production of immune cells can be detrimental, leading to reduced protein synthesis and muscle degradation.

The n-3 FA's have many different health benefits, and are anti-inflammatory. They alter the body's release of cytokines, (proteins secreted by immune cells in response to stimuli) which assist in regulating the development of an immune response. The most important pro-inflammatory cytokines are tumour necrosis factor (TNF-α), interleukin (IL)-1, IL-6 and IL-8. This project was designed to determine if feeding a diet high in n-3 FA's to sows could improve performance post-weaning when piglets are challenged with E. Coli LPS by altering their immune status.

"Feeding programs for sows can affect how offspring respond to immune challenges presented at weaning"

MATERIALS AND METHODS

The weanling pigs used in this trial were produced from sows consuming diets with varied n-6:n-3 FA ratios. The diets consisted of a control (tallow based), plant based ratios of 10:1, 5:1, 1:1, and a fish based 5:1 ratio. Sows remained on these diets for 2 reproductive cycles and piglets weaned from the 2nd cycle (d 28 of lactation) were used for the immune challenge. The fatty acid profile of the milk was similar to that of the sow diets, with ratios of

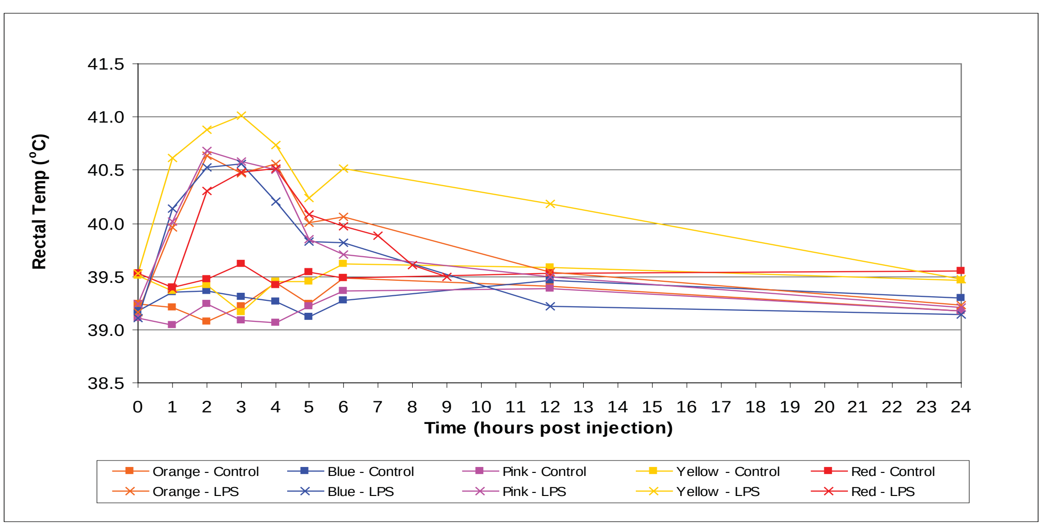

Figure 1.: Average rectal temperatures of pigs treated with LPS or saline after being raised by sows consuming varying n-6 to n-3 fatty acid ratios

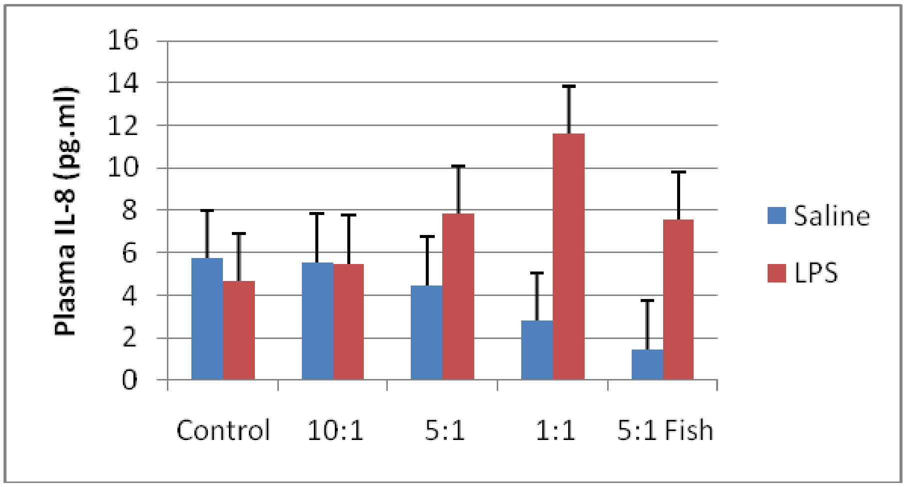

Figure 2.: Diet x Challenge interaction of plasma IL-8 concentration (average value for T0, T2, T6 and T12; bars show the mean +/- SEM)

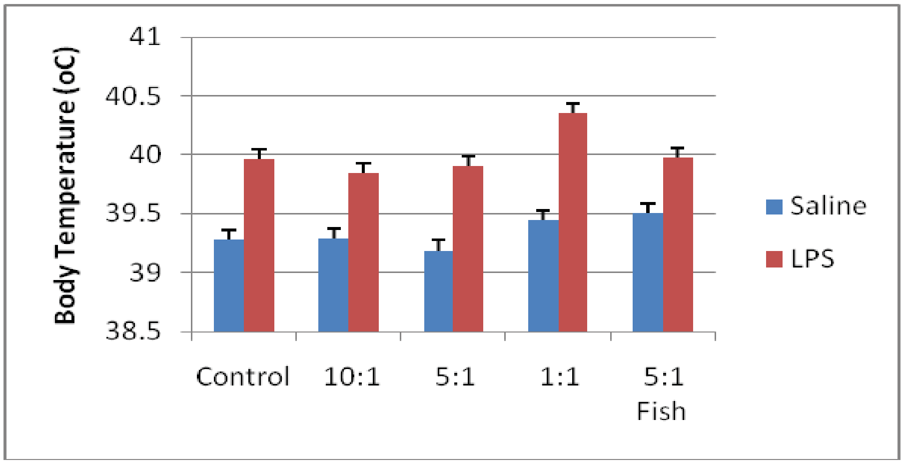

Figure 3.: Diet x Challenge interaction of body temperature in piglets (average value for T0-T6 hourly plus T6, T12 and T24; bars show the mean +/- SEM)

7.5:1, 4.5:1, 1.5:1 and 3:1 for the 10:1, 5:1, 1:1 and 5:1 fish diets respectively. Weanling pigs (n=100) were randomized to a challenge control group (saline injected) or to an LPS injected group (n=10/challenge/diet). Piglets were given 6 days to acclimate to their new environment prior to the immune challenge. Rectal temperatures were recorded at 0, 1, 2, 3, 4, 5, 6, 12 and 24 hrs post injection and blood samples were collected at 0, 2, 6 and 12 hrs post injection for cytokine analysis (IL-1β, IL-6, Il-8, TNF-α).

RESULTS AND DISCUSSION

For all parameters except IL-6, the effect of challenge, time and challenge by time were significant ($P < 0.05$), indicating that an injection of 15 ug/kg body weight LPS was effective in generating an immune reaction. Diet had a significant effect on body temperature (Figure 1), with piglets produced by sows consuming the 1:1 diet having a greater body temperature than those from the control, 10:1 and 5:1 groups. Body temperatures of piglets produced from sows consuming the 5:1 fish based diet were intermediate.

The diet by immune challenge interaction tended to be different for both body temperature (P=0.1163) and IL-8 (P=0.1819). Piglets from the 1:1 and 5:1 fish diet groups had a greater IL-8 response to the immune challenge when compared to piglets from the other diets (Figure 2). A greater febrile response to the LPS challenge also occurred in piglets originating from sows consuming the 1:1 ratio diet (Figure 3).

CONCLUSION

Feeding programs for sows can affect how their offspring respond to immune challenges presented at weaning. It appears that altering the n-3 to n-6 fatty acid ratio in sow diets can affect febrile and cytokine responses of their offspring when challenged with LPS post-weaning. Piglets produced from sows consuming a 1:1 ratio had elevated body temperatures, and a greater response to the immune challenge when compared to the other diets. Further experiments will help determine the energetic costs of these immune responses on the animals.

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Do Peas and Canola Meal have Synergistic Effects when Included in Diets for Growing Pigs?

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SUMMARY

The objective of the study was to evaluate the inclusion of increasing levels of peas with or without canola meal in diets for growing pigs. A total of 64 barrows were fed diets containing different combinations of peas and canola meal to study the effect on performance. No significant differences in performance were observed; indicating that up to 30% peas with or without canola meal can be successfully included in diets for growing pigs.

INTRODUCTION

It has been hypothesized that a bitter taste of field peas impacts palatability and limits their inclusion in swine diets. Canola meal (CM) may mask this taste and allow the use of higher levels of peas in diets for growing pigs. Moreover, peas are often included in diets with CM because both ingredients are produced in Western Canada and have proteins with complementary amino acid profiles. Specifically, the high methionine content of CM protein compensates for this deficiency in pea proteins. The overall objective of this trial was to evaluate the interaction of field pea and canola meal at increasing levels in swine diets on feed intake and growth performance.

"30% peas with or without canola meal can be successfully included in diets for growing pigs"

MATERIALS AND METHODS

Several different approaches to finding the best combination of CM and peas were evaluated including 1) increasing the level of CM from 0 to 15% while maintaining the inclusion level of peas at 30%; 2) maintaining the level of CM at 15% and increasing the inclusion level of peas from 0 to 30%; 3) comparing the diet without peas or CM (control) with the diet with 30% peas and 0% CM and 4) evaluating the effect of the CM alone by comparing it to the diet with 0% peas

Sixty-four barrows with an initial body weight of 33.5 + 2.2 kg were assigned to one of 8 treatments, a control with no peas or canola meal and 7 treatment diets with different combinations of canola meal and peas (Table 1, 2).

Diets were formulated to meet or exceed the nutrient requirements of 25 kg grower pigs (Table 1).

Feed intake was measured daily for the first week of the trial and weekly thereafter. Body weights were measured weekly throughout the entire 42 day trial.

RESULTS AND DISCUSSION

Daily feed disappearance in the first week was not affected by diet, CM or pea level ($P > 0.05$; data not shown).

Inclusion of up to 15% CM or 30% peas in the diet of growing pigs for 6 weeks had no effect on ADG, ADFI or feed efficiency (linear effect $P > 0.10$; Table 2). Similarly, the response of growing pigs to the inclusion of field peas in the diet was not affected by presence of the CM. With 30% peas in the diet daily feed intake ranged

Table 1. Composition of the experimental diets

	Control	Treatments						
Canola Meal	0	15	15	15	15	10	5	0
Peas	0	0	10	20	30	30	30	30
Ingredient[a]								
Wheat	786	680	602	522	441	478	516	546
SBM	180	113	90	70	50	70	90	120
Peas	0	0	100	200	300	300	300	300
CM	0	150	150	150	150	100	50	0
Canola Oil	2	23	25	26	27	20	14	6
Lysine	3.6	3.6	3	2.2	1.4	1.5	1.6	1.4
Methionine	0.5	0.2	0.3	0.3	0.4	0.7	0.9	1.1
Threonine	1.1	0.8	0.7	0.6	0.5	0.6	0.7	0.8
Tryptophan	0.1	0	0.2	0.2	0.3	0.3	0.3	0.3
diCal P.	5.3	9.2	9.2	9.2	9.1	7.8	6.6	5.1
Calculated nutrient content, as fed								
DE (Mcal/kg)	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Protein, %	17	17.8	17.4	17.5	18.4	18.1	17.8	17.7
SID Lys, %	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Calcium, %	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Phosphorus (tota), %	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55

[a] Diets also contained minerals, vitamins, salt and phytase (equal amounts among diets)

from 2.31 to 2.35 kg (SEM 0.08) at different levels of CM inclusion.

Comparing the control diet directly with the 30% peas/0% canola meal diet indicated a tendency toward an improved gain:feed ratio ($P < 0.10$), for the diet with the peas included, providing further evidence that 30% peas can be included in the diet of growing pigs regardless of the presence of CM. There were no effects on any other production parameters.

CONCLUSION

Performance was maintained in growing pigs with inclusion of either 30% field peas or canola meal up to 15% or any combination of the two in diets for growing pigs. Successful inclusion of peas in diets for growing pigs was not affected by simultaneous inclusion of CM.

ACKNOWLEDGEMENTS

The authors acknowledge the strategic program funding provided to Prairie Swine Centre Inc. by Sask Pork, Alberta Pork, the Manitoba Pork Council and the Saskatchewan Agriculture and Food Development Fund. Specific project funding from NSERC and the Saskatchewan Pulse Growers Association is gratefully acknowledged.

Table 2. The effect of inclusion level of peas and canola meal on growth rate, feed intake and feed efficiency in growing barrows

	Inclusion Level in diet (%)									*P Values* Linear Effects		Contrasts	
Canola Meal	0	15	15	15	10	10	5	0				CM	Peas
Peas	0	0	10	20	30	30	30	30	SEM	CM	Peas	0 vs 15%	0 vs 30%
n	8	8	8	8	8	8	8	8					
ADG, kg/d	1.06 (n=7)	1.050	1.09	1.08 (n=7)	1.09	1.06	1.11	1.09 (n=7)	0.03	0.70	0.42	0.92	0.43
ADFI, kg/d	243 (n=7)	2.32	2.39	2.42 (N=7)	2.34	2.35	2.33	2.32 (n=6)	0.08	0.78	0.81	0.28	0.27
Gain:feed	0.44 (n=7)	0.45	0.46	0.44 (n=7)	0.47	0.45	0.48	0.46 (n=6)	0.01	0.82	0.51	0.18	0.08

Weaning at 28 Days. Is Creep Feeding Beneficial?

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SUMMARY

Allowing piglets access to a Phase 1 diet in the farrowing room (creep feeding) for the final 7 days prior to weaning on day 28 did not provide a sustained growth benefit, regardless of weaning weight.

INTRODUCTION

Providing feed to the piglets in the farrowing room, or creep feeding, is practised to ensure a smooth transition onto solid feed at weaning. It is assumed that even a limited intake of the creep feed will familiarize the piglet with solid feed and mitigate a post-weaning growth lag by 1) increasing the body weight of piglets at weaning, 2) encouraging consumption of solid feed immediately post-weaning and 3) initiating the adaptation of the gastro-intestinal tract to solid feed. It can be hypothesized that benefits of creep feeding will be more evident with later weaning when the sows' milk supply becomes limiting and the piglets' gastrointestinal tract is more mature. However, although creep feeding is widely practised, an informal survey of producers in western Canada (Spring 2011) indicated that there is still uncertainty and controversy regarding its benefits. The data reported herein was collected as part of a larger study examining phase 1 diets (see previous report). We hypothesized that allowing piglets access to creep feed in the farrowing room would improve feed intake and growth in the nursery, and that this response would be most evident in the period immediately following weaning.

EXPERIMENTAL PROCEDURES

This experiment used data from 17 weeks of farrowing with 12 sows per room at PSCI. Piglets were provided access to a Phase 1 diet (commercial) in multi-space circular feeders in the farrowing room on days 21 to 28 for the first 9 farrowing rooms. Piglets were weaned on day 28.

Each week, representing one creep treatment, the entire weaning group was weighed and pigs ranked according to body weight within gender. The 24 heaviest and 24 lightest pigs were assigned to pen, 4 pigs per pen. Pens were then randomly assigned to a treatment. Thus each week there were 6 pens of the heaviest and 6 pens of the lightest pigs. Care was taken to ensure that the time between the removal of the piglets from the sow and access to feed in the nursery was the same for all piglets and all weeks.

Video-cameras set up over the pens recorded individual feeder approach which was defined as a pig placing their head over and down into the feeder. Pens were recorded for the 24 hours following each diet change (days 0-1, 1-2, and 4-5). Piglets were numbered on their backs for identification. To accommodate the video-recording, lights were on continuously.

"Piglets who had access to creep feed in the farrowing room had fewer visits to the feeder in nursery"

RESULTS AND DISCUSSION

Response to a diet regime and body weight at weaning were described in the previous report. Piglets who had access to creep feed for the final week prior to weaning weighed 130 grams more at weaning (Table 1). This did not however, approach significance ($P > 0.10$). Regardless of the presence of creep feed in the farrowing room all piglets lost weight during the 24 hours following weaning. Contrary to what we had hypothesized, piglets which had not received creep feed had improved growth during the initial two weeks post-weaning ($P<0.05$). Feed intake was unaffected ($P > 0.10$), and therefore, overall feed efficiency was improved in non-creep fed piglets ($P < 0.05$).

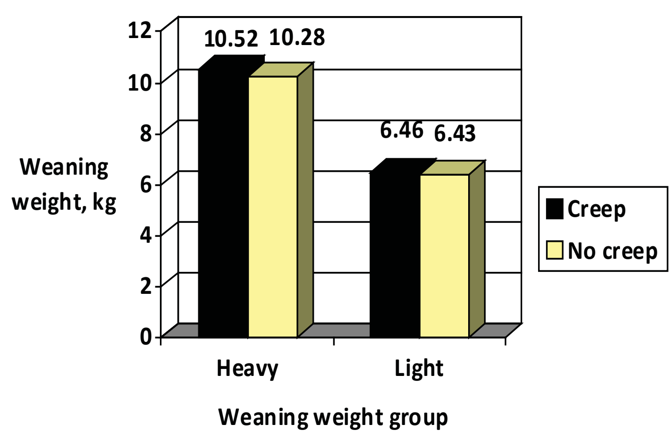

Figure 1. The interaction between weaning weight group and feeding creep in the nursery ($P < 0.05$). Numbers over the bars are the weaning weight for the sub-group.

Table 1. The effect of weaning weight and presence of creep feed in the farrowing room on growth and feed intake in the nursery.

	Weaning Weight				Creep Feed				Creep *BW
	Day[a]	Heavy	Light	P-Value	No	Yes	P-Value	SEM[b]	P-Value
Body, wt, kg	0	10.40	6.44	<0.001	8.36	8.49	0.35	0.10	0.01
	1	10.15	6.42	<0.001	8.24	8.33	0.49	0.10	0.02
	4	10.42	6.76	<0.001	8.56	8.61	0.75	0.11	0.05
	7	10.71	7.13	<0.001	8.88	8.96	0.70	0.14	0.23
	14	12.73	9.48	<0.001	11.17	11.04	0.67	0.21	0.85
ADG, kg/day	0-1	-0.26	-0.02	<0.001	-0.12	-0.16	0.36	0.02	0.79
	2-4	0.07	0.08	0.040	0.08	0.07	0.43	0.01	0.60
	5-7	0.12	0.15	0.001	0.16	0.12	0.11	0.02	0.84
	8-14	0.29	0.34	<0.001	0.33	0.30	0.20	0.02	0.57
	0-14	0.16	0.21	<0.001	0.20	0.17	0.05	0.001	0.63
ADFI, kg/day	0-1	0.09	0.13	<0.001	0.12	0.10	0.10	0.01	0.42
	2-4	0.13	0.13	0.14	0.13	0.13	0.77	0.01	0.68
	5-7	0.22	0.21	0.720	0.22	0.21	0.88	0.01	0.80
	8-14	0.35	0.35	0.770	0.37	0.34	0.16	0.01	0.45
	0-14	0.25	0.25	0.830	0.26	0.25	0.33	0.01	0.59
FCE, G/F	0-1	-5.36	-1.34	<0.001	-2.51	-4.19	0.06	0.59	0.33
	2-4	0.40	0.43	0.840	0.39	0.44	0.75	0.10	0.21
	5-7	0.43	0.52	0.001	0.70	0.25	<0.001	0.06	0.11
	8-14	0.81	0.96	<0.001	0.89	0.88	0.92	0.03	0.47
	0-14	0.59	0.79	<0.001	0.77	0.61	0.05	0.05	0.56

[a]Day 0 is weaning.
[b]Because of the unbalanced design the SEM was slightly different for the effects of weaning and creep feeding. The larger SEM is shown.

The creep by body-weight interaction described in Table 1 (day 0, 1, and 4; body weight $P < 0.05$) is shown in more detail in Figure 1 for day 0 (weaning). The response to creep was greater in heavier (240 grams or 2.3 %) than lighter pigs (30 grams or 0.5%). Further work is underway to determine if this is because the heavier piglets consumed more creep while in the farrowing room.

Piglets who had access to creep feed in the farrowing room had fewer visits to the feeder in the nursery on day 0, 1 and 4 post-weaning. This pattern is most notable in the final 8 hours of each 24 hour period. Again, this is contrary to our hypothesis, that feeding creep would accustom the piglets to solid food and thus encourage consumption in the nursery. Feed intake was comparable, thus it appears that those piglets who had received creep feed in the nursery consumed more feed at each visit when in the nursery. The increased visits by the pigs who hadn't received creep during the final 8 hours of each day could be because these piglets, unaccustomed to the solid feed, were consuming less feed with each visit, and are then motivated by hunger to visit the feeder during the latter part of each day. This awaits confirmation.

Table 2. The effect of creep feeding in the farrowing room on feeder visits in the nursery.

	Creep	No Creep	SEM	P-Value
Day 0	6.3	8.6	0.45	0.02*
Day 1	7.0	9.1	0.32	0.04*
Day 4	7.4	8.0	0.29	0.12*

* Hour by creep, P<0.001

CONCLUSION AND IMPLICATIONS

Allowing pigs access to a Phase 1 diet in the farrowing room for 7 days prior to weaning had no sustained beneficial effect on performance in the nursery, regardless of weaning weight. Research is currently underway to examine these results in more detail before we can make final recommendations on creep feeding with a 28 day weaning age.

ACKNOWLEDGEMENTS

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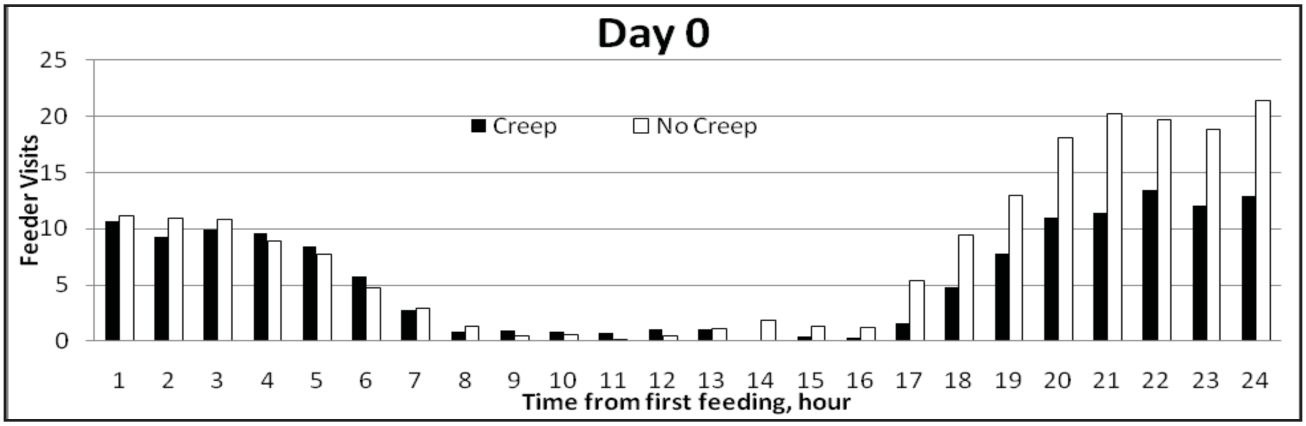

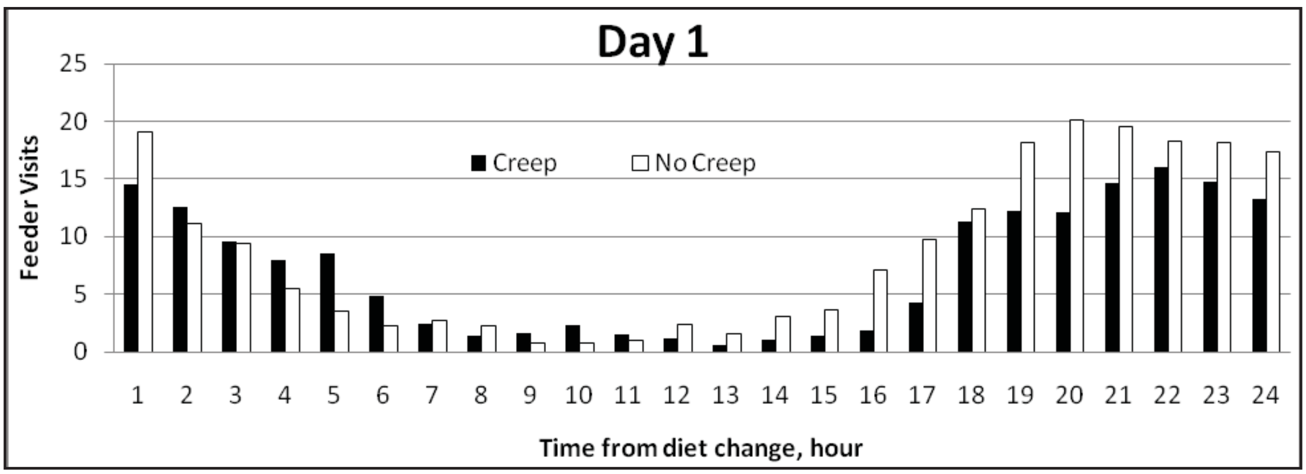

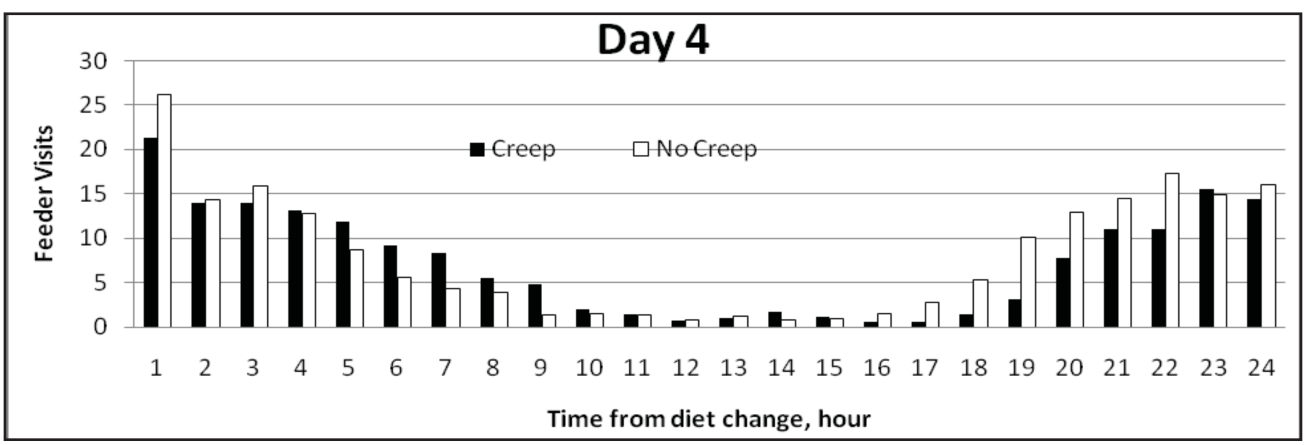

Figure 2. The effect of feeding creep in the farrowing room on feeder visits in the nursery, day 0, 1 and 4 post-weaning. Day 0 refers to the 24 hours following initiation of feeding in the nursery, while day 1 and day 4 are the 24 hours following the morning feeding.

Development of Diets for Low Birth-Weight Piglets to Improve Post-Weaning Growth Performance and Optimize Net Returns to the Producer

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SUMMARY

An experiment which utilized 17 weeks of production was designed to examine the response of weanling pigs to diet complexity. Piglets were divided at weaning (28 days) into heavy or light body weights and fed either a simple diet for 14 days or a complex diet for 1 or 4 days, followed by the simple diet. Feeding the complex diet for 4 days improved growth performance for the first week following weaning when compared to feeding it for 0 or 1 day. Pigs which were lighter at birth, lost less body weight at weaning, and showed a greater positive response to the complex diet than heavier birth-weight pigs. Phase 1 diet could be used more efficiently and cost-effectively by targeting it specifically to the lighter pigs at weaning.

INTRODUCTION

Variability in growth is a cost to commercial pork production, especially those utilizing all-in-all-out production systems. In a recent study at PSCI with a large number of litters, we observed an average birth weight of 1.4 kg, however the range was from 0.40 kg to 2.50 kg. The smaller birth weight piglets in this study (defined as piglets 0.85 grams or less at birth) failed to demonstrate any evidence of compensatory growth, and their rate of gain lagged behind their larger cohorts throughout all stages of growth, resulting in an additional 10 days to reach market weight.

Weaning diets, which are expensive, are designed to safely transition the piglet from the liquid milk diet to a solids diet. They are typically complex and contain ingredients providing benefits beyond basic nutrient consideration. We hypothesized that light-weight piglets would show a relatively greater response to a high-quality weaning diet, specifically one containing blood products, than their heavier birth-weight counter-parts. This would reduce overall variability at nursery exit.

The feed must obviously be consumed to provide any benefit and it takes some piglets more than 24 hours to commence consumption of solid food. The overall objective of this experiment was to optimize the dietary regime fed to piglets immediately post-weaning for greatest overall net return. We focused on adaptation to the solid feed immediately post-weaning.

"Light weight piglets appraoch the feeder sooner after weaning than heavier pigs and made more visits to the feeder in the first 4 days"

EXPERIMENTAL PROCEDURES

Diets were formulated to meet or exceed nutrient requirements for piglets of this age and weight (NRC 1998). The "complex" diet included spray-dried whey, plasma and blood meal and fish meal (Table 1).

There were 3 dietary treatment regimes, and 2 weight group treatments. The 3 dietary regimes consisted of a simple or a complex diet offered as. A: Complex diet day 0 – 1, simple diet, day 2-14, B: Complex diet day 0 – 4, simple diet day 5-14, C: Simple diet day 0 – 14. Day 0 is weaning (Table 2). Individual body weight and feed intake was determined on day 0, 2, 4, 7 and 14.

Pre-Weighting Experiemntal Diets into bags to ensure speed and accuracy at time of feeding

Table 1. Experimental diets

Ingredient, %	Simple	Complex
Wheat	29.86	24.2
Soymeal	25.00	16.90
Peas	10.00	10.00
Canola Meal	7.80	-
Corn	-	20.00
Corn DDGS	20.00	-
SD Whey	-	14.29
SD Plasma	-	2.50
SD Blood Meal	-	2.50
Menhaden Fishmeal	-	5.00
Canola Oil	2.80	1.75
Limestone	0.85	0.70
Mono Calcium Phosphate	1.15	0.15
PSCI Vitamins	0.60	0.60
PSCI Minerals	0.60	0.60
Salt	0.40	0.25
Lysine HCl	0.385	0.02
L-Threonine	0.245	0.19
DL Methionine	0.09	0.130
LS20	0.10	0.10
Choline Chloride	0.08	0.08
$CuSO_4 * 5H_2O$	0.04	0.04
Analyzed Nutrient Content, %		
Moisture	11.74	11.92
Crude Protein	25.45	25.35
ADF	6.35	4.00
NDF	13.52	11.67
Crude Fat	6.17	4.33
Ca	0.92	0.93
P	0.78	0.68
Mg	0.26	0.20
K	1.03	0.99
Na	0.19	0.33
Cst ($ per tonne, ingredient prices, Nov 2010)	343.17	723.02

Table 2. Dietary regime treatments

	Feeding Regime	
Treatment	Complex Diet	Simple Diet
A	Day 0-1	Day 2-14
B	Day 0-4	Day 5-14
C	---------	Day 0 - 14

Each week, for 17 weeks, the entire weaning group was weighed and pigs ranked according to body weight within gender. The 24 heaviest and 24 lightest pigs were assigned to a pen, 4 pigs per pen. Pens were then randomly assigned to a treatment. Thus each week there were 6 pens of the heaviest and 6 pens of the lightest pigs and 2 pens per treatment per weight group. Care was taken to ensure that the time between the removal of the piglets from the sow and access to feed in the nursery was the same for all piglets and all weeks.

Video-cameras set up over the pens recorded individual feeder approach which was defined as a pig placing their head over and down into the feeder. Pens were recorded for the 24 hours following each diet change (days 0-1, 1-2, and 4-5). Piglets were numbered on their backs for identification. To accommodate the video-recording, lights were on continuously.

RESULTS AND DISCUSSION

This experiment used approximately 40% of each weaning group; we selected the 20% heaviest and lightest from each weaning group. Light piglets weighed almost 4 kgs less (40 %) than their heavier littermates on day 0 ($P < 0.0001$) and 25% less on day 14 post-weaning ($P < 0.0001$).

All piglets lost weight over the first 24 hours following weaning, however, body weight loss was less in the light weight piglets (Table 3). This was true even when body weight loss was expressed as a proportion of body weight [(ADG/d 0 BW)*100) = 2.5 % vs 0.3 % for heavy vs light piglets respectively]. Average daily gain of the light weight piglets was approximately 13 % greater than their heavier litter-mates throughout the trial ($P < 0.0001$). Despite this increased rate of gain, heavier pigs weighed 3.25 kgs more (almost 35 %) than the light-weight pigs at weaning.

Piglets on treatment C, receiving the "simple" diet, lost more BW and had reduced feed intake immediately following weaning (d 0-1) than those on treatments A or B. Switching from the complex to the simple diet on day 4 (treatment B) did not have an adverse effect on gain or feed intake in the following days. During the second week of the experiment, dietary treatment had minimal effects on either feed intake or body weight gain and by day 14, body weight was comparable, regardless of treatment (Table 4).

The light-weight pigs responded more to dietary treatment on day 0 than their heavier litter-mates (Figure 1). In fact, light-weight piglets receiving the complex diet immediately following weaning maintained their body-weight over the initial 24 hours. This contrasts with the light-weight pigs receiving the simple diet and the heavy pigs, receiving either simple or complex diets.

Following weaning, the light-weight piglets immediately began approaching the feeder and throughout the initial 4 days of the experiment visited the feeder more than their heavier litter-mates (Figure 2, Table 5). Feed intake was greater in the light-weight piglets, indicating that these feeder visits did result in feed intake. These pigs were housed, 4 pigs of similar body-weight per pen.

During the first 24 hours, the simple diet (trt C) had 20% fewer visits, however this did not approach statistical significance. Switching diets from the complex to the simple (day 1 trt A and day 4, trt C) resulted in a reduction in feeder visits. (Table 6)

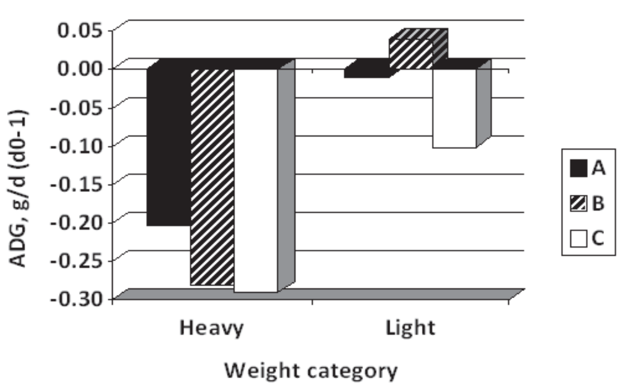

Figure 1. The interaction between weaning weight and feeding regime on the growth and feed intake of piglets day 0 to 1 post-weaning.Treatment A and B piglets were receivng the complex diet and treatment C piglets the simple diet during this period. BW x treatment interaction, P < 0.01, ADG, P < 0.03, ADFI.

Table 3. The effect of weaning weight on growth, feed intake and feed conversion efficiency

		Weaning weight			
Parameter	Day	Heavy	Light	SEM	P-Value
Weaning wt, kg	0	10.40	6.44	0.07	<0.001
	1	10.15	6.42	0.07	<0.001
	4	10.42	6.76	0.08	<0.001
	7	10.71	7.13	0.10	<0.001
	14	12.73	9.48	0.16	<0.001
ADG, kg/d	0-1*	-0.26	-0.02	0.02	<0.001
	2-4	0.07	0.08	0.00	0.04
	5-14	0.25	0.29	0.01	<0.001
ADFI, kg/d	0-1	0.09	0.13	0.01	<0.001
	2-4	0.13	0.13	0.01	0.14
	5-14	0.32	0.32	0.01	0.81
FCE, G/F	0-1	-5.36	-1.34	0.62	<0.001
	2-4	0.40	0.43	0.10	0.84
	5-14	0.70	0.81	0.02	<0.001

*Interaction between body weight and diet, P = 0.01 (shown in Fig 1)

Table 4. The effect of dietary treatment regime on growth and feed intake of growing pigs

		Dietary Treatment				
Parameter	Day	A	B	C	SEM	P-Value
Body wt, kg	0	8.43	8.43	8.41	0.07	0.92
	1	8.32	8.32	8.22	0.08	0.07
	4	8.45[b]	8.90[a]	8.43[b]	0.08	<0.001
	7	8.79[b]	9.18[a]	8.78[b]	0.10	<0.001
	14	10.96	11.25	11.10	0.17	0.14
ADG, kg/d	0-1*	-0.11[b]	-0.12[b]	-0.20[a]	0.02	0.002
	2-4	0.03[b]	0.14[a]	0.06[b]	0.01	<0.001
	0-14	0.18	0.20	0.19	0.01	0.14
ADFI, kg/d	0-1	0.12a	0.12a	0.08b	0.01	0.002
	2-4	0.10b	0.17a	0.12b	0.01	<0.001
	0-14	0.24	0.27	0.25	0.01	0.002

*Interaction between body weight and diet, P = 0.01 (shown in Fig 1)

CONCLUSION AND IMPLICATIONS

In conclusion, in a non-competitive environment, light-weight piglets can perform equal to their heavier litter-mates. This indicates that environmental factors (feeder access) need to be examined to improve the poor performance of these piglets.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the financial support provided for this experiment by the Agriculture Development Fund, Saskatchewan Ministry of Agriculture. The authors also acknowledge the strategic program funding provided to Prairie Swine Centre Inc. by Sask Pork, Alberta Pork, the Manitoba Pork Council and the Saskatchewan Agriculture Development Fund.

Table 5. The effect of weaning weight on feeder visits

24 hour period	Weaning weight group			P-Value	
	Heavy	Light	SEM	Weight	Hour by weight
Day 0	5.61	9.35	0.44	0.08	0.07*
Day 1	6.83	9.28	0.32	0.10	0.07
Day 4	7.37	8.00	0.27	0.007	0.03

*Weaning weight by diet regime, P = 0.05.

Table 6. The effect of dietary regime (Table 2) on feeder visits

24 hour period	A	B	C	SEM	P-Value
Day 0	8.13	8.01	6.30	0.55	0.25
Day 1	7.31	9.43	7.41	0.40	0.004
Day 4/5	7.71	8.48	6.87	0.35	0.05

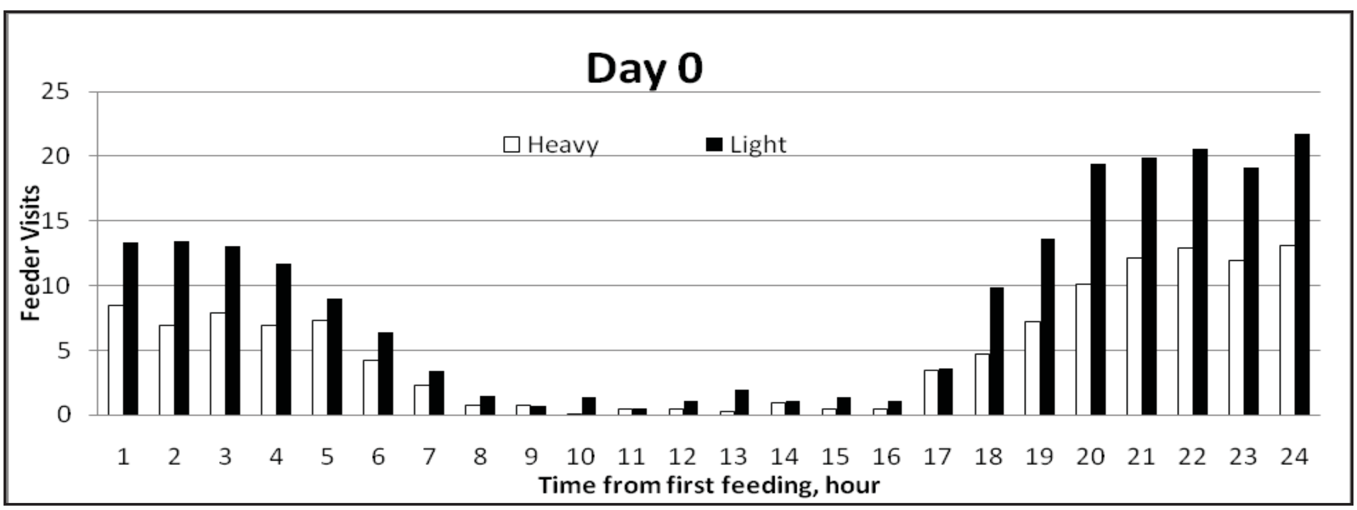

Figure 2. The effect of body weight on feeder visits (per pen, 4 pigs/pen) over the first 24 hours post-weaning.

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