PRAIRIE SWINE CENTRE

2008 Annual Research Report

PRAIRIE SWINE CENTRE

MISSION STATEMENT

"To provide a Centre of Excellence in Research, Technology Transfer, and Graduate Education, all directed at efficient sustainable pork production in Canada."

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Chairman's Report

Finding Solutions in Challenging Times

SHANNON MEYERS, Chairman of the Board

It's been a pleasure to serve the Prairie Swine Center (PSC) Board of Directors as Chairman since our past chair, Mr. Eric Peters (Manitoba), retired from the board. Eric did a great job as Chairman and I would like to thank him on behalf of the board and the entire industry for his years of service.

I would like to congratulate Mr. Lee Whittington on his appointment to President and CEO of PSC. After an intense international search, Lee demonstrated that he had the skill set, experience, and desire to take PSC on into the future.

Our industry has continued to be challenged in ways that many of us have certainly never seen before. These challenges have resulted in changes throughout the pork industry and PSC has certainly not been immune to those changes given the funding structure of the business. I would like to congratulate Lee and the entire team at PSC for making tough, courageous decisions that will long term make the Center stronger and more competitive.

"As pork producers it is our contribution through our various research check-off programs that are the real fuel behind the research."

Certainly a highlight of the year was watching the new Sow Research Unit become fully operational. This loose sow housing facility will provide insight into many of the questions producers have today as they contemplate the move to this type of sow housing.

PSC has continued to put out strong concluding statements from research results in the areas of environment, nutrition and ethology. Some of the recent work on transportation has given the industry great insight on ways to better handle and move pigs prior to market that will provide great value to the entire pork value chain.

In addition to the above areas of research, I am pleased to report that the PSC Management Team and Board of Directors spent many hours focusing on a strategic plan that will bring the most value to the stakeholders of PSC. Amongst many creative ideas that are being implemented, you will see the Center moving further up and down the value chain which will do a number of things to strengthen the Center and the research it produces long term.

Finally, amidst the turmoil in the industry, I reflect back to the contributions PSC has made to the pork industry that has led to more efficient production. Many of us can simply look at our diets, our feeder settings, our manure management plan or the way we house our pigs and we will see direct and tangible management tools that we have implemented from the near market research that was created at PSC. Although the industry is being reshaped in ways we didn't imagine, there is no doubt that a pork industry will re-emerge out the other side of this market crash. When it does, I hope that we all had the foresight to ensure we held on to an infrastructure including research institutions like PSC so that we can continue to be one of the most competitive places to raise pork in the world.

President's Report

Innovative Research Addressing Industry Challenges

Lee Whittington, MBA• CEO / President

Change was the watchword of the day in 2008; personnel changes topped the list with the career change of Dr. John Patience, first President/CEO of Prairie Swine Centre, taking a position with Iowa State University. John's career at the Centre predated the development of the non-profit corporation status and in addition to leading the Centre's growth in new facilities and people since 1991, John maintained an active research program in swine nutrition. Seeking a replacement became an important function of the Board of directors in 2008. I am pleased to be writing this report today as the Centres new President/CEO.

"If change is a good thing - 2008 may be remembered as having too much of a good thing!"

The year saw the opening of the new Sow Research Unit at our Floral Saskatchewan location. Every part of the 300 sow F-F operation facility has now been completely rebuilt over the past 17 years, providing very good quality, flexible research facilities and at the same time match the typical commercial barns in Canada. Brian Andries, Operations Manager, has prepared a discussion on the pig unit for this report. Suffice it to say our production staff are very pleased with the loose-housing system selected and both behaviour and nutrition studies currently have all of the sows on trial in the new Sow Research Unit. The year was also marked with the disappointment of closing the PSC Elstow research Farm. The 600 sow F-F farms had been operated since 2000 and contributed greatly to the development of knowledge in nutrition, engineering and behaviour through its ability to provide large numbers of pigs for experiments. The ability to simulate a typical larger production operation was essential in work such as sow management with electronic sow feeders, the use of alternative strategies in auto-sort grow-finish management and investigation of variability in piglet growth rate across thousands of piglets. This facility is certainly missed and alternative arrangements have been made to locate these larger group-size related trials at commercial pig farms. We are hopeful of a return to industry profitability soon so that this facility can once again be utilized to provide the kind of knowledge pork producers can use to lower production costs and address other challenges.

In fall 2008 we embarked on a revision to our strategic plan. So many changes had overtaken the industry in the past 5 years that certain aspects of how and what was needed, and whom we served were all up for discussion. In all the books on the subject of strategic planning one quote bears repeating here:

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

Change is invigorating

Where to start? Prairie Swine Centre had a business and research funding model that worked well for 17 years. That success of course affects your thinking and colours your outlook to the future. As does the success enjoyed by the Centre locally and internationally in recognition of its contribution to the various members of the pork value chain. Our emphasis on the pork producer has allowed our technology transfer and research efforts to succeed in adoption of change at the farm. For example, from the selection of feeders, to the level of feed in those feeders and the NE value of that feed – all of these developments over the past decade and a half can be traced to a study, a report and countless producer and supplier meetings. There is no question the old formula worked to instil a competitive advantage for the Canadian pork producer. But times have changed and the current income crisis within the industry challenges us all first to survive and secondly to predict what the new industry that rises from this period will look like.

The future makes a mockery of our attempt to predict its coming, but we are obliged to try. So this coming year we are on a path to reinvent our company, and its service to our stakeholders. Firstly, by broadening the definition of stakeholders to aggressively seek solutions for the many players within the pork value chain. This is a natural extension of the base of knowledge and expertise PSC personnel have within the barn and extend that up the value chain to include the transportation and packer components and down the chain in the opposite direction to the cereal breeder and genetics supplier for example. What about something more novel? How can we demonstrate a greater value to the broader Canadian population? The pig as a model for human or pet health and nutrition, does our in-depth knowledge of the pig allow us to provide greater value to a greater portion of society? Might this be part of the solution to ensure animal research facilities and intellectual horsepower remains available and interested in serving the commercial pork industry of the future?

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

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

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

Technology Transfer Report

Providing Producers Answers at Their Fingertips

LEE WHITTINGTON, MBA • Manager, Information Services

PorkInsight – a unique resource on our website.

With over 4000 summarized scientific articles, this is one of the largest databases of swine-specific knowledge available to the pork industry. After going through a major restructuring in 2005, the popularity and use of the on-line information source has grown every year. Figure 1 shows the steady increase in Unique Users year over year since 2005. The measure Unique Users identifies the number of visitors by their IP address and although they may have searched for several items while on the site they count as one user we average over 2,500/month last year and are approaching 3,000 this year. 'Hits" are often reported by website, and these are a record of all of the images and articles viewed by visitors. We receive about 170,000 'hits' per month, or 8,500 'hits' per business day. This website has become the place where the pork industry comes for its information!

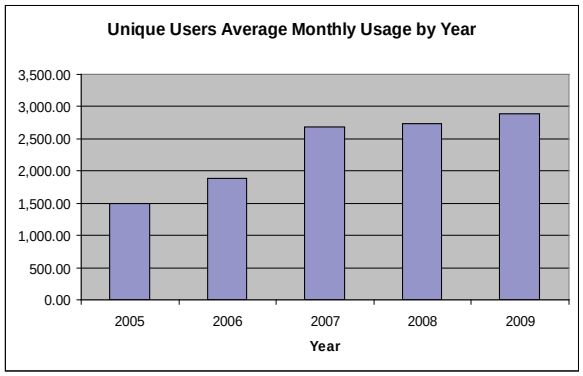
To receive updates biweekly on what is new at PSC you can sign up for our FREE Ezine delivered by email (go to www.prairieswine.ca and click on sign up for Research Updates Ezine.

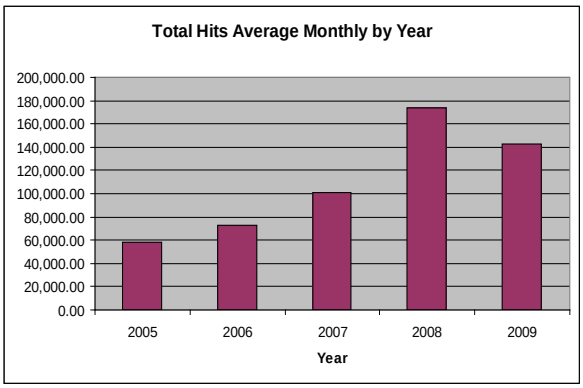
Enterprise Model

Turning our research into dollars and cents is the role of the Enterprise Model. This computer financial simulation model allows Prairie Swine Centre scientists to evaluate the impact the research has on the farm. Applying new knowledge or technologies on the farm is always a case of cost versus return. For this reason a joint effort between the George Morris Centre (Guelph, Ontario) and Prairie Swine Centre was established in 2006 to build a sophisticated financial simulation model that can account for the biological changes in pig production and the costs and revenues associated with

"Net Promoter Score was 90.6%"

that changed. For example, if a diet change causes a change in average daily gain and feed conversion the benefit is more kilograms of pork sooner and less feed, offset of course by any costs associated with making that diet change. The model can account for changes in any variable costs (such as feed, labour, or utilities), as well as changes to fixed costs (buildings, equipment including amortization and financing costs). In this way pork producers and their suppliers can estimate the impact of adopting a new technology or management best practice and view the effect on revenues, profitability or return on investment. This tool is making decisions to adopt new information more precise and easier.





Publications

The past year saw reductions in our publication schedule as a way to save money. This is the second year of offering the Annual report as a downloadable document rather than incurring printing charges. Centred on Swine is now produced twice a year (reduced from quarterly) but it was enlarged by 50% to ensure we have the space to share with you all of the recent research findings.

Getting a publication when you want it is important because you never know when selecting a replacement feeder, or changing diet formulation will be the priority. For that reason all of the previous publications, including the factsheets can be located on the website under Publications.

The phone still important

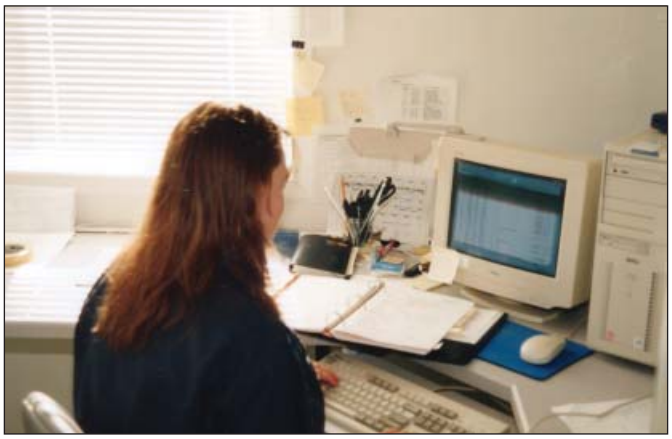
Nothing replaces the advice of a person who is addressing your specific concern. For that and timeliness reasons the phone is still an important link to stakeholders. Calls to 306-667-PIGS (7447) and directly to individual Research Scientists may still be the best technology transfer tool available. The following direct phone lines should help you get the kind of information you need.

Dr. Harold Gonyou – Applied Animal Behaviour research 306-667-7443
Dr Denise Beaulieu – Nutrition research 306-667-7441
Dr. Bernardo Predicala – Engineering research 306-667-7444

Your Opinion Counts

In winter 2009 we conducted an on-line and fax survey of the industry to seek opinions on a variety of topics affecting the Centre's strategic plan. These included questions about outlook on the industry, research focus, and evaluation on ways to communicate with the many organizations and individuals that make up the pork value chain.

One key measure was Question #10 - "Would you recommend Prairie Swine Centre as a knowledge source to others in the industry?" This question is our ultimate measure of value to the industry and is calculated as the 'Net Promoter Score'. This involves simply taking the Yes score and subtracting the No score to produce the net stakeholder base that finds value in our work. During the period January to April 2009 our Net Promoter Score was 90.6%. Although we are very pleased with that we will be measuring this from time to time to ensure we continue to earn the support of the pork industry.



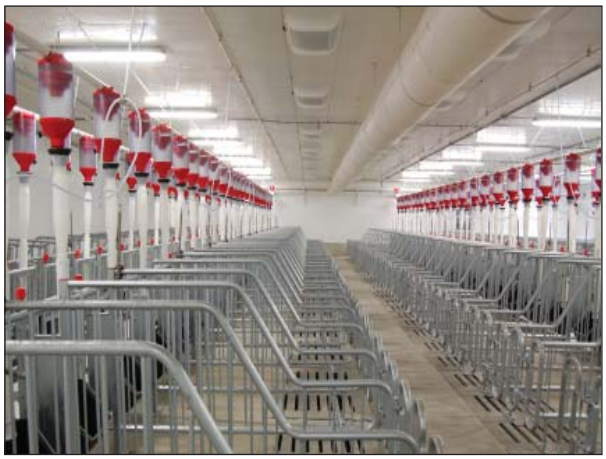
Operations Manager Report

New Facilities Provide New Answers

BRIAN ANDRIES, BSA. • Manager, Operations

Fiscal year 2008-2009 was very exciting for production and research staff as we opened the new sow research unit in July 2008. The entire facility was fitted with equipment from Egebjerg International out of Denmark. This includes 108 artificial insemination stalls with widths of 24, 26, 28, and 30 inches, free access gestation stalls divided into 4 groups with loafing areas and 2 without, and adjustable farrowing crates. For a more complete description please see the report on the sow research unit on page 12 of this report.

We started moving sows into the new barn the first week of July 2008. This was shortly after the grand opening so the barn and all equipment was washed and disinfected. Rather than moving only the sows due to farrow into our new farrowing crates, we decided to move all farrowed sows from the old facilities into the new rooms to assist staff in concentrating farrowing responsibilities at one location.



Construction of the new facilities at Prairie Swine Centre (Floral) was fitted with equipment from Egebjerg International out of Denmark.

"Farrowing rate is up to 85.9%, numbers born alive above 11.8 and pigs weaned/ female inventory at 23.8."

We also moved all bred and gestating sows over the next 2 weeks into the new facility.

Breeding in the new barn started the week of July 12, 2008 and this was the first time in the history of Prairie Swine Centre that sows could remain in a breeding stall for a 4-5 week period after breeding, not having to be moved. The purchase of a motorized boar cart also allowed heat checking of all in sows in the breeding room on a daily basis. This again was historic for the Center as prior to this, heat checks on all sows to 5-weeks of pregnancy was impractical for production staff, due to the layout of the old gestations.

We moved to 4-week weaning on July 24th, and in preparation for this had assembled a group of 18 gilts to come into heat for the week of July 26th. This was required to ensure that we had animals to breed when moving from 3 to 4 week weaning. Piglets are put on a non-medicated starter diet for a 7 day period before weaning.

All rooms in the new barn were equipped with automatic feeding systems but due to two nutrition research projects, one examining an enzyme that effects feed intake and body composition on lactating sows and another looking at the long-term effects of polyunsaturated fatty acids on

Table 1. Production parameters for the 2006-2009` fiscal years

Category	2006-2007	2007-2008*	2008-2009*
Sows Farrowed, #	770	728	668
Farrowing Rate, %	83.2	83.8	82.9
Pigs Born Alive/Litter	11.2	11.4	11.8
Pre-Weaning Mortality, %	10.1	10.7	10.8
Litters Weaned	757	692	673
Pigs Weaned	7602	7139	6920
Weaned/Female Inventory	23.4	23.3	23.8

* Housing in temporary facilities during construction

reproductive functions in sows, required at least 80% of the sows in farrowing, breeding and gestation to be hand fed. These experiments are still ongoing to this day. Overall sow condition has greatly improved. Having a nutritional research trial hand feeding weighed rations, along with condition scoring sows at two week intervals, allows proper levels of feed for under-conditioned sows. This attention to detail has improved the health status and overall condition of the herd.

Since populating the new barn there have been only a few minor problems, some dealing with the automatic feed system, the controllers, and a couple of feed motors. Efficiencies in the new system allowed us to decrease production staff by 1.5 people and production has steadily increased since the opening.

See Table 1 indicating production parameters over the last three years. We are slowly improving on all production parameters other than pre-wean mortality. We do have some issues with the new flooring but are working our way through to weaning over 25 pigs per sow per year. We are also conducting another experiment in which we are intentionally trying to decrease litter size to characterize the extent and impact of fetal programming in order to more clearly understand what alters immune response and ultimately disease resistance. This has also decreased numbers born alive and farrowing rate. If these sows on this trial were excluded from the herd average, numbers born alive would be at 12.1 with a farrowing rate of 84.3%.

The start of the fiscal year also brought an increase incidence of circo virus in the grow-finish facility with the highest incidence occurring November, December, 2008. At this time mortality in the finisher rooms increased to 8.5%. No vaccination program was initiated and control of the virus was centered on improving sanitation procedures in farrowing and nursery, and reducing the incidence of the virus by putting down circo virus suspects as quickly as possible. Grow-finish mortality since January 2009 has dropped to 2.2%.

For fiscal year 2008 staff and students worked on 30 different research trials, a few that were still running from start dates in 2006, and 2007 and some of the 30 trials registered for 2008. A total of 13 different animal care protocols including our standard nursery, sow, and grow-finish protocols were utilized that involved 1,282 nursery pigs, 6,246 grow finish animals and 280 sows at both the Floral and Elstow facility. A total of 7,808 animals were put on test last year compared to 6,958 in 2007, 7,984 in 2006 and 7,888 in 2005.

SOW RESEARCH UNIT

Expanded Research to Answer Timely Questions

Lee Whittington

The Sow Research Unit houses the 300 sow herd. Opened in July 2008, the 126' x 203' barn includes breeding, gestation, gilt development, lab facilities and a small office.

The new Sow Research Unit has five farrowing rooms to accommodate a shift to four week weaning. When the idustry was surveyed prior to designing the new barn in Spring 2007 the suggestion to go to four week weaning came from many producers.

Specifications: pen 72" x 108", stall 64" x 76", 12" adjustment in rear crate width. Featured in this photo is the Egebjerg adjustable farrowing stall, covered creep area and sure-foot Ubar flooring, as well as low wattage plastic heat lamps.

The farrowing rooms consist of 16 creates with semi-automated feeding. Extra wide 6' alley between rows of crates acommodates containers for experimental diets and feed carts as well as weight, handling and processing activities.

Free access stalls allow sows the option to seek protection of a stall or they can choose to be part of the group. Two rows of 16 stalls (two weeks breeding) share the 10' x 35' slatted area between the rows.

Specifications: 80" long x 26" wide

FRIENDS OF THE CENTRE

Lee Whittington

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 on the "Friends of the Centre" wall of distinction located at the Prairie Swine Centre for all visitors to see.
- Your logo will be published on all Prairie Swine Centre materials, website and publications as a "Friends of the Centre" contributor.
- Friends will be provided with exclusive opportunity to advertise on the Prairie Swine Centre website which has the most comprehensive swine production information on-line database in Canada.
- 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 have the ability to provide their contributions through a "Friends of the Centre" membership or via in-kind value through product discounts on purchases by the Prairie Swine Centre.
- 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 - Jim Haggins
Fast Genetics
Standard Nutrition Canada
Sunterra Farms
- Howard and Joan Fredeen
- Alwyn Woolley and Ken Woolley Memorial
- Dave Price
- Stan and Flow 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.

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 to external institutions/agencies.

Interim Research Objectives

Information is the 'Value' We Provide

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.

Objective #6
To meet or exceed the research data and scientific analysis expected by our clients, and demanded by regulatory guidelines.

Evaluation of a Treatment Method to Control Hydrogen Sulphide Emission from Swine Manure

B. Predicala[1,2], L. Moreno[1,3] and M. Nemati[4]
1 Prairie Swine Centre Inc., 2105-8th St. E., Saskatoon, SK, S7H 5N9; 2 Department of Agricultural and Bioresource Engineering; 3 Division of Environmental Engineering; 4 Department of Chemical Engineering, 57 Campus Drive, University of Saskatchewan, Saskatoon, SK S7N 5A9

B. Predicala

SUMMARY

Based on results from previous work, further experiments were conducted to evaluate the use of metabolic inhibitors to control hydrogen sulphide (H_2S) emission from swine manure under room-scale conditions. Manure storage period impacted the extent of H_2S emission, with fresh manure generating the most H_2S gas in closed systems. Adding a metabolic inhibitor, molybdate, maintained low levels of H_2S over a 6-month monitoring period. In the semi-pilot scale open system and in room scale tests, the average concentration of H_2S measured just above the surface of agitated fresh manure slurry were 831 $\pm$ 26 ppm and 88.4 ppm, respectively; addition of molybdate at 0.1 to 1.0 mM levels reduced the emission of H_2S to about 18 and 2.5 ppm, respectively. A cost analysis for application of the molybdate treatment in the grow-finish stage of a 300-sow operation showed that total material and labour cost would amount to less than 1% of the overall production cost for each market hog.

INTRODUCTION

Effectiveness of manure amendment with nitrite or molybdate as a means to control the emission of H_2S from swine manure has been investigated in our previous work (Prairie Swine Centre Annual Report 2007, pp 14-15). This treatment approach has been developed originally in the oil industry to mitigate the souring of oil reservoirs. However, our previous proof-of-concept study was conducted in closed systems in which H_2S levels in the headspace were significantly higher than those expected in an open system. In this present work, molybdate mediated control of H_2S emission was investigated in semi-pilot scale open system, and in room-scale tests simulating an actual swine barn.

EXPERIMENTAL PROCEDURE

The effect of manure age on the extent of H_2S emission and the levels of nitrite and molybdate required to control these emissions were investigated using fresh, 1, 3, and 6-month old manures. Laboratory tests were conducted in closed systems with 125 ml serum bottles containing 30 ml of manure, capped with a rubber septum. Different concentrations of sodium nitrite ranging from 2 to 120 millimole (mM) and sodium molybdate (from 0.5 to 3 mM) were tested. The analysis of H_2S concentration in the gas samples was carried out with a Varian CP-3800 gas chromatograph (GC).

Because results from the closed system tests could potentially lead to overestimation of the required level of the treatment reagents, a number of experiments were conducted in semi-pilot scale with open top containers in order to simulate practical conditions. These tests were conducted with 6 open top cylindrical containers, each filled with approximately 250 L of manure collected from the manure pit of a grow-finish room. The desired amount of molybdate solution was sprayed on the surface of the manure using a conventional hand pump sprayer. Sampling for H_2S emissions was done on days 10, 20, and 30 following the addition of molybdate.

Room scale tests were conducted in a setup similar to a commercial grow-finish pig production facility. Two identical and fully controlled environmental chambers located at the PSCI facility were configured to house a pen for 8 pigs in each chamber. Trials were conducted with one chamber used as the control and the other with treatment applied. The first 18 days of the trial served as manure accumulation period. On day 18, a solution of molybdate was sprayed on the manure slurry in the collection tub under the floor slats of one of the chambers (Treatment) to achieve a final concentration of 0.1 mM. The levels of H_2S emitted from the manure collection tubs and the spatial H_2S distribution at the animal and human occupied zones within the chamber were determined on days 28, 38 and 48.

"Adding the metabolic inhibitor molybdate to swine manure maintained low levels of H_2S over a 6-month monitoring period"

RESULTS AND DISCUSSION

Laboratory tests with closed systems

Figure 1 (presents the H_2S concentration profiles in the headspace gas of sealed serum bottles containing fresh, 1-month and 3-month old manures treated with various levels of molybdate ranging from 1.0 to 2.0 mM (applied on Day 1), as well as those for the control systems (no treatment added). The H_2S concentration profiles observed in the control bottles indicated that the level of emitted H_2S decreased as the manure age increased, with the average H_2S concentration in the bottles containing fresh, 1-month and 3-month old manures at 4856 $\pm$ 460, 3431 $\pm$ 208 and 1037 $\pm$ 98 ppm, respectively. With 6-month old manure, H_2S concentration in the headspace gas in the control bottles was below the detection limit (<0.4 ppm), even after 2 weeks of monitoring.

For all treatment levels and regardless of manure age, addition of molybdate caused an immediate decrease in the concentration of H_2S, which was maintained or decreased further during the 30-day monitoring period.

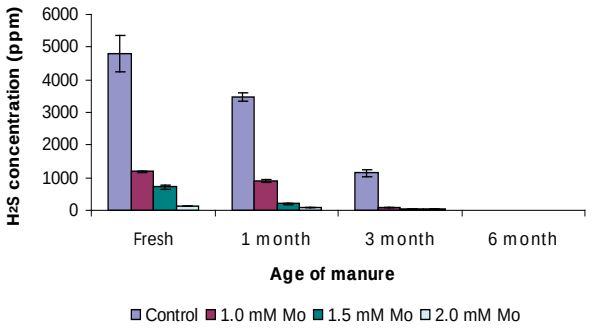


Figure 1. Average concentration of H_2S at the end of 30-day monitoring period in the control and treated (1.0 to 2.0 molybdate (Mo)) serum bottles containing swine manure of different ages.

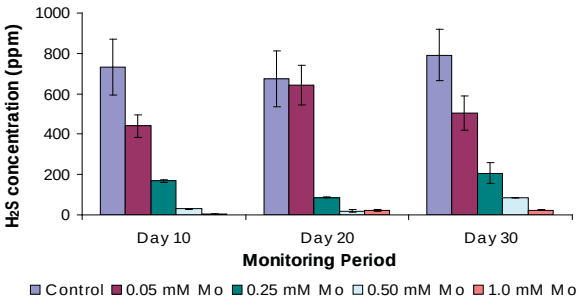


Figure 2. Concentrations of H2S from open-top containers containing fresh manure treated with various amounts of molybdate.

Higher levels of molybdate and increase in manure age both led to lower levels of H_2S. The final concentrations of H_2S at 30 days following the treatment with 2.0 mM molybdate were 142 ± 22, 105 ± 19, and 42 ± 5 ppm, for fresh, 1-month and 3-month old manure, respectively. In all tested cases, final H_2S concentration was lower than the level observed in the corresponding control system. Subsequent measurements over a period of six months confirmed the persistence of the molybdate treatment (data not shown in the graphs).

Semi-pilot scale tests in open top containers

Figure 2 shows concentrations of H_2S from the semi-pilot open top container treated with various amount of molybdate, as well as the untreated container (control). The average H_2S concentration from three sampling events ranged from 734 ± 59 and 831 ± 26 ppm for the Control container. The corresponding H_2S concentrations in the gas samples collected from the container treated with various amounts of molybdate were significantly lower than that of the control system ($P<0.05$). Furthermore, increasing the amount of molybdate added led to lower H_2S concentrations. The final H_2S concentration (day 30) in the gas samples collected from the containers treated with 0.05, 0.25, 0.5 and 1.0 mM Mo were 529.7, 153.1, 44.7 and 17.7 ppm, respectively.

Room scale experiments

Figure 3 shows H_2S concentrations from the control chamber (with untreated manure) and in the chamber in which manure was amended with 0.1 mM molybdate measured at different locations within the chamber on day 10 and 30 after application of the treatment. During gas sampling, manure was agitated for five minutes to simulate pit pulling event in actual pig production rooms, and gas samples were collected at various intervals over a period of 15 minutes. As expected, the highest H_2S concentration was observed at the pit level and during the first two minutes after start of agitation. The addition of molybdate led to much lower H_2S concentrations in all sampling locations. At 10 days after treatment application, H_2S concentration taken after two minutes of agitation at the pit, animal, and human levels in the control room were 88.4, 18.8 and 1.5 ppm, respectively, while respective concentrations in the treated chamber were 18.8, 0.6 and below the detection limit. Over the 15-minute sampling period, a decrease in H_2S concentration with time was observed mainly because manure agitation was stopped after five minutes and the ventilation system for both chambers was running continuously. Continuous monitoring of ammonia (NH_3) and carbon dioxide (CO_2) concentrations in the air exhausted from both chambers indicated that addition of molybdate did not impact the emission of these gases, although temporary spikes in NH_3 concentration were observed during manure agitation.

Based on the results of the present work and prior experiences in control of H_2S production in oil reservoirs, it is hypothesized that addition of molybdate contributed to control of H_2S emission from manure through two mechanisms which include catalysis of the chemical oxidation of sulphide resulting in an immediate sharp decrease in H_2S concentration, followed by the known inhibitory effect of molybdate on the activity of sulphate reducing bacteria (SRB) and biogenic production of sulphide.

A cost study for application of molybdate in a typical 300-sow operation showed that the main cost components included the costs of material (molybdate), labour, and the required application equipment. Calculations based on actual amounts used and the number of hours to prepare and apply the treatment in this study showed that applying the treatment in the finishing rooms of the operation will cost around CAN$1.00 per market pig, about 70% of which is labour and equipment.

CONCLUSION

Building on the findings from our previous work which demonstrated the effectiveness of nitrite and molybdate application for controlling H_2S emission from swine manure in closed systems, the present study showed that the extent of H_2S emission from the manure depended on manure age. Furthermore, molybdate application at a rate of 0.1 to 0.25 mM, which was lower than previously estimated from closed system experiments (2 mM), was established as effective for control of H_2S emission under conditions close to an actual swine production room with open manure holding system. A cost study for a typical 300-sow operation that produces 7500 market hogs per year revealed that costs associated with control of H_2S emission through application of molybdate in the finishing stage amounted to less than 1% of the total costs conventionally associated with a complete growth cycle.

Additional tests are on-going to assess the impact of the treatment on nutrient properties of the treated manure, as well as the fate of the treatment agents in manure applied to crop lands. Based on these results appropriate recommendations in proper application of the treatment in the actual barn will be drawn up.

ACKNOWLEDGEMENTS

Strategic Program funding provided by Sask Pork, Alberta Pork, Manitoba Pork Council and Saskatchewan Agriculture and Food. Project funding provided by the Alberta Livestock Industry Development Fund (ALIDF), Saskatchewan Agriculture Development Fund (ADF), and the Alberta Agriculture and Food Council.

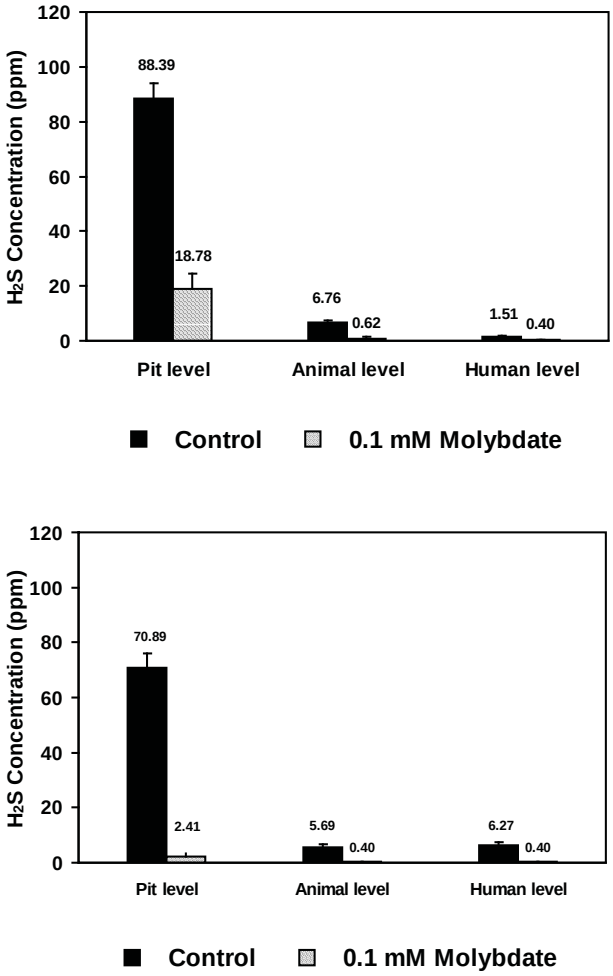
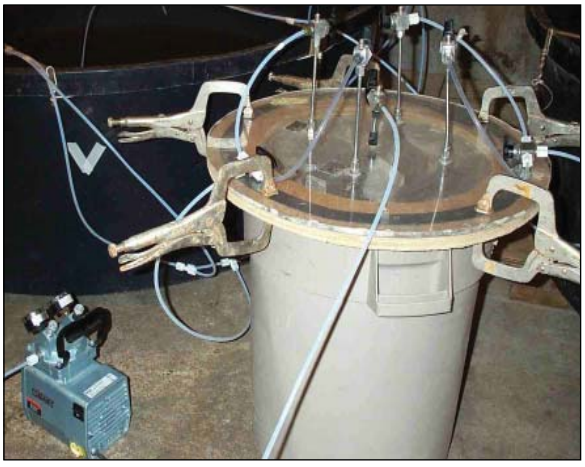


Figure 3. Concentration of H^2S at different sampling locations within the room-scale chambers, one with manure treated with 0.1 mM molybdate and the other untreated (Control). Gas samples were taken at two minutes after start of manure agitation to simulate pit pulling. Number on each bar represents the average concentration (Detection Limit: 0.40 ppm).



Sampling Apparatus

Evaluating Energy Usage and Various Energy Conservation Strategies for Swine Barns

B. Predicala, E. Navia

B. Predicala

SUMMARY

Energy usage in swine barns and potential energy conservation measures were evaluated in this study. A survey of 28 swine facilities showed large variability in energy used per hog produced between barns. Energy audits conducted in four selected barns identified the various areas, equipment, and practices in the barn that contributed significantly to the total overall energy consumption, thereby aiding in prioritizing areas for intervention. Using computer simulation, various potential strategies that can be applied in a barn in terms of lighting, creep and space heating, fans, feed motor, and heat recovery were examined. Simulation results for a typical 600-sow operation showed that potential annual savings up to 47,391 kWh electricity (79 kWh/sow) or 88,404 m^3 natural gas (147 m^3/sow) can be attained.

"Energy savings up to 47,391 kWh electricity (79 Kwh/sow) or 88,404 m^3 natural gas (147 m^3/sow) can be attained"

INTRODUCTION

Swine production in temperate regions like Canada requires substantial energy input. With the recent upward trends in energy prices, the cost of energy input to swine operations have been steadily rising such that for many operations, utilities now represent the third largest variable cost component of the total cost of production. The goal of this work is to assess the current energy usage and examine energy conservation measures that can improve the energy use efficiency in swine production operations, thereby reducing overall energy costs.

EXPERIMENTAL PROCEDURES

A survey questionnaire was developed and sent out to various swine producers to collect pertinent data from each operation over a 3-year period from 2004 to 2006 to be able to calculate the average monthly utility cost per animal marketed ($/pig marketed) for each operation.

Based on the survey results, two barns which used the most energy per hog produced and two which used the least energy were selected for energy audits and monitoring of actual energy consumption during winter and summer seasons. Following the barn monitoring, a mathematical model which simulated the energy use in a typical barn operation was developed based on fundamental principles of heat transfer, thermodynamics, and other engineering concepts. The model was applied to a typical 600-sow operation to simulate the theoretical energy consumption in the barn based on the building properties, climatic factors, barn management and practices, number and growth stage of animals, and equipment used in the barn. The baseline model was validated by comparing the predicted energy consumption in different operations within the barn with actual values obtained from barn monitoring. Finally, a number of potential energy conservation strategies were incorporated into the model and the projected energy savings resulting from each measure were calculated.

RESULTS AND DISCUSSION

Benchmarking results

Table 1 shows the range and average values of utility cost per animal marketed ($/head) based on the three-year information obtained from the survey. The average utility cost between types of barns were significantly different ($P<0.05$)

Table 1. Results of benchmark survey of utility cost per animal marketed in different types of barns.

			Utlitiy Cost per Animal Martketed			
			$/head pig sold		$/100-kg pig sold	
Type of Barn	Size Range	No. of barns, n	Range (min-max)	Average (SD)	Range (min/max)	Average (SD)
Farrow-to-Finish	300 to 1,500 sow	9	3.0 -12.0	6.8 (3.41)	3.5-12.0	6.56 (3.05)
Farrow-to-Finish (excluding feedmill)	300 to 2,000 sow	7	3.8-13.0	6.5 (2.98)	6.0-11.5	6.75 (2.31)
Grower-Finisher	10,000 to 40,000 feeders	6	1.3-2.1	1.7 (0.58)	1.2-2.6	1.7 (0.74)
Nursery	130,000 to 140,000 feeders	2	0.5-0.7	0.6 (0.12)	1.7-2.2	2.0 (0.41)
Farrow-wean	150 to 1,200 sow	4	0.8-4.3	1.9 (1.64)	8.2-17.8	12.2 (4.67)

Table 2. . Average annual energy savings determined by different energy-saving strategies applied to a typical 600-800 operation.

	Average energy savings	
Areas	**kWh/yr**	**kWh/yr/sow**
1. Lighting (from T12 to T5 fluorescent)	25, 957	43
2. Creep Heating (Heat lamps to Heat pads)	47, 391	79
3. Recirculation fan (High efficiency motor)	9,872	16.4
4. Exhaust fan (High efficiency motor)	42, 501	71
5. Feed motor (High efficiency motor)	1,846	3.1
6. Heat recovery (air-air heat exchanger)	88, 404 m3/yr	147 m3/yr/sow

for all comparisons except between grow-finish and farrow-wean barns ($P>0.05$). The survey results also showed almost 4x difference in energy consumption (per head) between the lowest and highest energy user barns. This indicated significant opportunities for improving energy use practices in some barns in order to reduce overall energy costs.

Monitoring of energy use in the four selected barns showed that the grow-finish rooms had the highest contribution to electrical energy consumption in the barn during summer months followed by farrowing, nursery, and gestation. The high energy consumption in the grow-finish area can be explained partly by the relatively larger footprint of this part of the barn compared to the other production stages in a typical farrow-to-finish operation and to the lower temperature set-point in grow-finish rooms (which meant all fan stages were operating almost continuously at full capacity during warm months). During winter, the highest natural/propane gas consumption was observed in nursery rooms followed by the grow-finish and farrowing rooms. This can be attributed to the high temperature set-point in nursery rooms relative to other production rooms. The gestation room had the lowest gas energy consumption because the heat generated by the sows was adequate to maintain the room at its set-point temperature.

Ventilation plays an important role in keeping the environment of the pigs at a level where production performance is optimized. The results of this study showed a medium to high negative correlation (i.e. -0.6 to -0.9) between the fan energy consumption and concentrations of NH_3, H_2S and CO_2 gases which are indicators of indoor air quality. This correlation indicated the need for careful consideration of conservation measures to reduce energy cost so as not to compromise the health of workers and animals in the barn.

Simulation results

Simulation of the baseline case and the cases in which energy-conservation strategies were applied showed that significant energy savings can be attained in the areas of ventilation and heating as shown in Table 2. Using higher efficiency fans can reduce electrical energy consumption by 21% while the natural/propane gas consumption can be reduced by 70% using a heat recovery system (i.e. air-to-air heat exchanger). Furthermore, replacing conventional space heaters with gas-fired radiant heaters can reduce the gas consumption by 40%. Applying conservation strategies to other areas such as recirculation fans, feed motors, lighting, and creep heaters can reduce energy consumption by 12% and 20%, 26%, and 39%, respectively.

CONCLUSION

Benchmarking showed that the average utility cost (electricity and gas) per animal marketed is about $6.80/head, but can be as high as $12.0/head for some types of operations. Energy audits identified areas and operations in the barn such as ventilation and space heating in the grow-finish and nursery rooms as significant contributors to the overall energy consumption in the barn. Examination of a number of energy conservation strategies using computer simulation quantified the potential impact of the application of each measure on the overall energy use. Simulation results also identified the most promising measures that would merit further evaluation under actual swine barn conditions. Overall, the findings from this study would aid pork producers in focusing on specific areas and practices in the barn and in prioritizing conservation strategies to be considered for implementation, which would result in the most significant energy savings.

ACKNOWLEDGEMENTS

Strategic program funding was provided by Sask Pork, Alberta Pork, Manitoba Pork Council, and Saskatchewan Agriculture. Project funding provided by the Advancing Canadian Agriculture and Agri-Food Saskatchewan (ACAAFS) is acknowledged. Thanks must also be given to the participating swine producers for providing access to their swine facilities and business information.

Effectiveness of Various Methods of Deploying Nanoparticles to Reduce Odour and Gas Emissions from Swine Manure

B. Predicala and D. Asis

B. Predicala

SUMMARY

Controlled experiments were conducted to evaluate various types of nanoparticles and deployment techniques for their effectiveness in controlling emissions from swine manure. Nanoparticles were deployed by mixing with the slurry, spraying into the headspace above the manure slurry, and acting as a filtering medium for the manure gases. Among the 12 types of nanoparticles tested, zinc oxide (ZnO) was able to reduce hydrogen sulphide (H_2S) concentration by up to 99% using the mixing and filtration methods in laboratory-scale tests. Up to 86% reduction in ammonia (NH_3) concentration and up to 79% reduction in odour concentrations were achieved by filtration and mixing with ZnO nanoparticles. About 55% reduction in methane was achieved from the mixing method using ZnO, but no other application of the treatments had significant impact on other greenhouse gases (nitrous oxide and carbon dioxide) and on manure nutrient properties.

INTRODUCTION

Nanoparticles are materials with at least one dimension in the 1-100 nanometer scale. At this scale, nanoscale materials exhibit unique quantum properties that may be radically different from the properties of the same material at macro-scale. Recent advances in the ability to manipulate and build at the atomic and molecular levels led to creation of nanomaterials with specific properties desired in a wide range of applications. A variety of nanoparticles had been used for treatment and remediation of environmental pollutants. Their small size, large surface area, unusual crystal shape and lattice order can make specific nanoparticles highly reactive and very flexible in terms of deployment, while remaining non-toxic to humans and environmentally benign. The goal of this study was to examine the application of nanoparticles as an effective, safe, and viable means for reducing odour and gas levels in swine barns.

EXPERIMENTAL PROCEDURES

The overall approach for this work was to conduct a systematic evaluation of the effectiveness of various types of nanoparticles and deployment techniques that can be potentially implemented in swine barns to reduce odour and gas levels. Initial tests were conducted to develop the experimental test protocols and the test parameters that will be applied in subsequent experiments. The deployment techniques tested included: filtration – which involved passing the target gas through a packed-bed filter with the test powder; headspace spraying – which involved spraying the nanoparticles into the headspace above the manure slurry; and mixing – which involved adding the nanoparticles to manure slurry.

For all tests with the various deployment methods, the effect of the treatments on the concentrations of ammonia (NH_3), hydrogen sulphide (H_2S), odour concentration, and greenhouse gases (GHGs) such as methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2), as well as on manure physical and chemical properties were monitored. Direct reading instruments for NH_3 and H_2S were used to measure the concentrations of these gases before and after treatment. Gas samples for odour measurement were collected using 10-L Tedlar® bags and sent for olfactometry analysis. Prior to sending the sample bags, a 10-mL gas sample was transferred from each bag to an evacuated gas tube and sent to a gas chromatography laboratory for analysis of GHG concentrations. Manure samples collected from the untreated and treated slurry were sent to a commercial laboratory for analysis of manure characteristics and properties.

RESULTS AND DISCUSSION

Filtration method

Figure 1 shows a comparison of the effectiveness of various nanoparticles, a common powder (AC – activated carbon), and a blank filter and pad cassette, in reducing the levels of NH_3 and H_2S. The plots are expressed in normalized concentrations (derived by dividing the concentration of the gas in the filtered sample by the initial concentration of the gas), indicating that values much lower than 1.0 signify better effectiveness in reducing the gas levels. From these tests, ZnO was significantly ($p<0.05$) better than the other materials as it was able to reduce H_2S to levels below the detection limit (<1 ppm) of the H_2S monitor used. For NH_3, ZnO showed the highest reduction (46%) although it was not significantly different ($p>0.05$) from the other materials. Additional tests showed that increasing the amount of ZnO nanoparticles applied resulted to increased capacity to reduce H_2S.

"Zinc Oxide (ZnO) nanoparticles have the potential to significantly reduce ammonia and hydrogen sulphide levels."

Mixing method

The top 4 nanoparticles (namely, Fe_3O_4, MgO, MnO and ZnO) were subjected to verification tests and the results shown in Table 1. Untreated samples showed 15% increase in NH_3 and all samples treated with nanoparticles resulted in 16 to 33% increase in NH_3 levels one day after treatment application; the effect of the treatment on NH_3 was not significant ($p=0.64$) but it did cause an undesirable increase in NH_3 levels. For H_2S, treated samples showed 22 to 53% decrease in concentration while untreated samples showed 26% increase; the effect of the treatment on H_2S was significant ($p=0.02$). From this test, the biggest reduction in H_2S concentration was achieved using ZnO nanoparticles, which was used in subsequent tests.

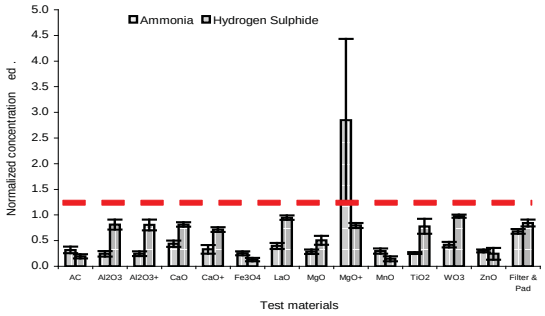


Figure 1. Normalized NH_3 and H_2S concentration of manure gas passed through a packed-bed filter with test particles. Each value is the average of 3 replicates and the error bars represent the standard error of the mean.

Table 1. Gas concentration of samples after mixing with top four most effective nanoparticles.

Treatment	Initial concentration, ppm				Day 1 concentration, ppm			
	NH_3		H_2S		NH_3		H_2S	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Control	34	1.8	108	22.1	38	0.7	127	10.8
Fe_3O_4	29	1.0	128	1.3	34	0.2	70	9.7
MgO	30	1.2	136	13.4	35	2.1	107	21.3
MnO	27	2.7	110	15.7	35	0.9	81	7.3
ZnO	28	2.7	122	14.9	35	0.8	56	2.8

Figure 2 shows the actual gas concentrations after mixing ZnO at various application rates. The H_2S concentration of the sample treated with 1.5 g/L was significantly different ($p<0.05$) from the control and the samples treated with 0.1 g/L and 0.25 g/L. At 1.5 g/L application rate, 75% of H_2S was removed 1 hour after treatment application, and was further decreased to 95% relative to the initial value 1 day after treatment. Hydrogen sulphide concentration was observed to continuously decrease until the end of the treatment period. The decrease in H_2S concentration was probably due to precipitation of H_2S when directly in contact with ZnO.

Headspace spraying method

The 12 different types of nanoparticles were tested using the headspace spraying method at an application rate of 0.01 g per liter of headspace volume. Similar to the results from the mixing method, headspace spraying did not result in desirable impact on NH_3 levels; either the gas levels were reduced minimally or the levels actually increased 1 day after treatment application. From the results of the tests, tungsten oxide (WO_3) nanoparticles was able to reduce NH_3 levels by about 16% one day after treatment. For H^2S, all treatments resulted to almost negligible H^2S levels 1 day after treatment application, but this can not be fully attributed to being the effect of the nanoparticles because the control (untreated) samples showed a similar trend as well. From these observations, it was evident that the treatment did not result in the expected beneficial outcome for these tests.

Effect on odour, greenhouse gases, and manure properties

summarized in Table 2 are the average gas concentrations from the different tests for each deployment method as well as the results from the analysis of odour and greenhouse gases. In general, no treatment had significant impact ($p>0.05$) on N_2O and CO_2 concentrations although the CH_4 from slurry treated by mixing ZnO nanoparticles had almost 55% lower concentration ($p=0.014$) compared to untreated samples.

Table 2. Summary of gas concentration, odour concentration and hedonic tone of the manure gas after treating with nanoparticles using filtration, mixing and spraying methods.

Parameter	Filtration, using 6 g ZnO		Mixing, using 1.5 g of ZnO /L of slurry		Spraying, using 0.05 g of WO3/L of headspace	
	Input	Treated, volume of gas = 30 L	Initial/ Control	1 day after treatment application	Initial/ Control	1 day after treatment application
NH_3, ppm*	133	20	98	128	85	143
H_2S, ppm*	409	4	849	48	850	0 [b]
CO_2, ppm*	11,604	9,459	12,573	10,274	15,410	13,983
CH_4, ppm*	2,870 **	2,455 **	720	332	2,206	2,354
N_2O, ppm*	0.46 **	0.49 **	0.31	0.32	0.40	0.37
Odour concentrtion,** OU/m^3	22,170	5,804	22,170	4,696	3,352	2,331
Hedonic tone**[a]	2.90	3.30	2.40	3.0	3.30	3.20

* n=4; ** n=3; [a] 9-point scale; [b] reduction in concentration not fully attributed to nanoparticles

Manure analysis showed that the treatments had no significant effect on manure physical and chemical properties, except for the mixing method which resulted to a slight increase in pH (by 0.02 pH value) and the Zn content (which was 1.2 kg/m^3 higher than the untreated samples). These results were expected because ZnO nanoparticles were mixed directly with the slurry samples.

CONCLUSIONS

Based on the results of the study, using filtration and mixing methods with zinc oxide (ZnO) nanoparticle were effective in reducing the concentrations of NH_3, H_2S and odour in the manure gases generated from swine manure slurry. Methane was reduced by mixing ZnO with the manure slurry, but the other greenhouse gases monitored were not affected.

Direct mixing and spraying of other nanoparticles into the headspace above the manure slurry showed no significant desirable effect on gas and odour concentrations. These methods need further evaluation using possibly higher application rates and other types of nanoparticles.

This exploratory study confirmed that nanoparticles can be effective in controlling gas and odour emissions from swine manure. Further tests are needed to evaluate other types of nanomaterials and other possible deployment methods. The economic, environmental, and health aspects of this application should be assessed to determine its feasibility and overall impact on the swine industry.

ACKNOWLEDGEMENT

Strategic program funds were provided by Saskatchewan Pork Development Board, Alberta Pork, Manitoba Pork Council, and Saskatchewan Agriculture. Project funding provided by the Saskatchewan Agriculture Development Fund and the National Science and Engineering Research Council.

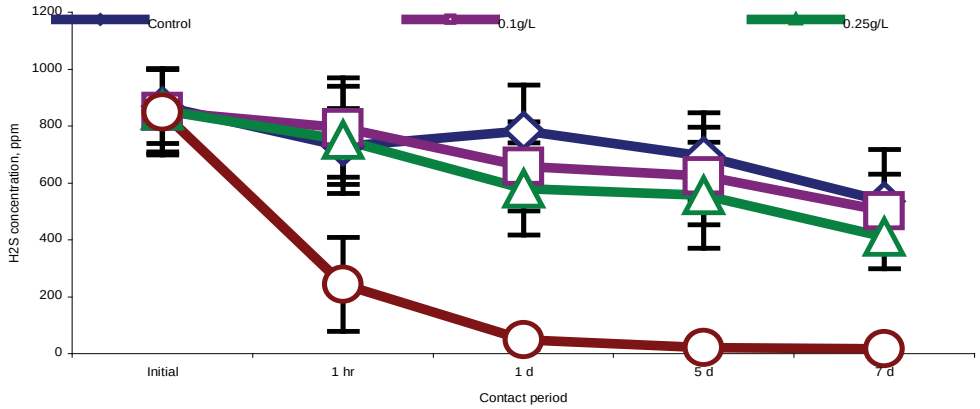


Figure 2. H_2S concentrations from mixing ZnO nanoparticles with slurry, n = 3.

Stress responses and Meat Quality of Pigs Transported in a Pot-Belly Truck During Summer and Winter

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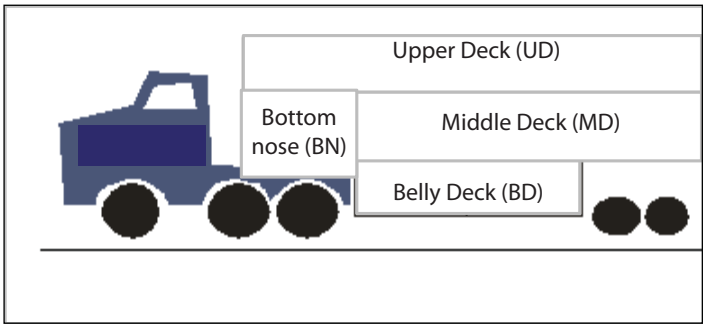


SUMMARY

Pigs transported in the bottom nose compartment of a conventional pot-belly trailer experienced greater stress than did pigs in other compartments, and this resulted in differences in meat quality. Pigs loaded into the bottom nose had to negotiate two ramps within the truck, first going up to the top deck, and then down to their compartment. As a result their heart rates were higher at the time of loading and, in the winter trials, remained so during the entire transport period. These pigs had higher lactate levels when exsanguinated at the plant, indicating an activation of energy sources, but a higher ultimate pH in several muscles suggesting that energy stores had been depleted during the travel. The meat from these pigs showed signs of the dark, firm and dry condition generally indicative of an extended period of stress.

INTRODUCTION

Pigs are exposed to a large number of potential stressors during transport, and at a time that could have a significant effect on the meat quality, and therefore value, of the animals' carcass. Producers in western Canada may face greater challenges transporting their pigs than other regions due to the long distances involved and the extremes of conditions in winter and summer. Although some producers are transporting their pigs on single purpose vehicles, many use dual purpose trailers designed to accommodate either pigs or cattle. Loading and unloading pigs from dual purpose pot-belly trucks involves moving pigs up and down several steep internal ramps, depending upon the compartment involved. This study was conducted to examine some physiological indicators of stress and meat quality in pigs transported in different compartments of a pot-belly truck in summer and winter from Saskatoon to Brandon.

EXPERIMENTAL PROCEDURES

In two seasons, summer and winter, a total of 1,170 market pigs were transported during six weeks every season in a pot-belly trailer, from Saskatoon to Brandon (approximately 8 hrs). Nine compartments in the trailer were used, and these were categorized by the ramp usage required during loading and unloading. Pigs in the middle deck (MD) did not have to use an internal ramp. Pigs in the belly (BD) had to descend a ramp during loading and ascend the ramp when unloading. Pigs in the upper deck (UP) ascended a ramp during loading, and descended it at the packing plant. Finally, pigs in the bottom nose (BN) compartment had to ascend and then descend ramps during both loading and unloading. On each load of pigs (195 pigs/week), 30 animals, individually identified, were equipped with monitors that recorded heart rate from the barn until arrival at the plant and were used to determine lactate levels at exsanguination. An additional 15 pigs were identified to evaluate meat quality for a total of 45 pigs every week. These subsets of animals were distributed throughout the compartments of the trailer. All pigs were fasted 8-9 hours before loading (21 hours before slaughter), and kept in lairage for 1.5 hours at the plant before stunning by cardiac arrest and exsanguination. Following slaughter, pigs were eviscerated, their carcasses split, and blast chilled for 2 hours. The carcasses were cut the following day.

"Pigs transported in the bottom nose portion of a pot-belly trailer showed the greatest degree of stress due to the amount of ramps the pigs had to use during loading and unloading"

Pork quality was assessed by muscle pH taken at 6 h and 24 h (pHu) in the longissimus dorsi muscle, in the semimembranosus muscle and in the adductor muscle at 24 h, and light reflectance and drip loss taken at 24 h post-mortem in the longissimus dorsi and semimembranosus muscles.

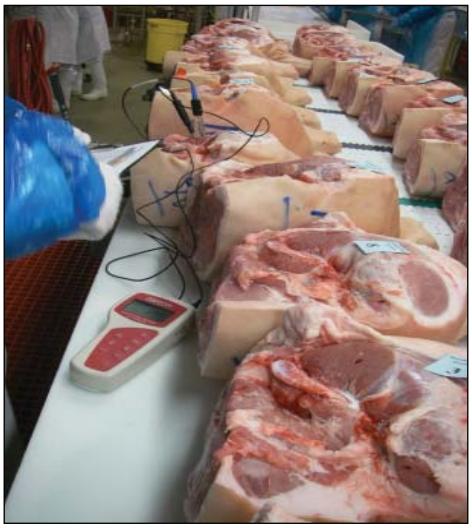
Separate analyses were conducted for winter and summer, to determine differences among compartments within each season.

RESULTS AND DISCUSSION

During summer, pigs loaded in the BN presented higher heart rate at loading compared to those located in the BD ($P<0.05$), with those of pigs loaded in the MD and UD being intermediate. During the waiting at loading, pigs from the BN showed a lower heart rate compared to pigs loaded in the other compartments ($P<0.05$), as they were the first to load and had longer to recover from loading stress before departure. Overall, during transport, pigs loaded in the UD and MD had higher heart rates compared to those transported in the BD ($P<0.05$), with those of pigs in the BN being intermediate. Blood lactate levels at exsanguinations were higher in pigs transported in the BN compared to pigs loaded in the other compartments ($P<0.05$). The higher heart rate and lactate levels may indicate the higher physical

effort of pigs to negotiate the very steep ramp (32°) giving access to the BN. Meat quality was somewhat affected by this physical effort as shown by the higher pHu value in the adductor muscle and lower drip loss in the semimembranosus muscle ($P<0.05$).

During winter, pigs loaded in the BN showed a higher heart rate at loading compared to pigs in the MD ($P<0.05$), with the other compartments being intermediate. The initial stress shown by pigs in the different compartments during loading was reflected in the overall heart rate of pigs during transport. Similarly, blood lactate levels were higher in pigs transported in the BN compared to those in the MD ($P<0.05$). Meat quality was also affected by animal location during transport in winter with pigs transported in the BN showing higher pHu values and lower drip loss levels in the longissimus dorsi and adductor muscles ($P<0.05$). High pH values and low drip losses indicate that these pigs are prone to the form of poor meat quality referred to as dark, firm and dry. This usually indicates an extended period of stress pre-slaughter, resulting in depleted glycogen stores post-mortem.of moving pigs into and out of such compartments.



Meat Quality Assessment of Pork

IMPLICATIONS

This study confirms that the design of the pot-belly trailer, commonly used for pig transport, imposes a certain level of stress related to the use of multiple steep internal ramps at loading and unloading. In this case, with a dual-purpose pot-belly truck, the bottom nose compartment evidenced the greatest degree of stress. Additional studies are planned to determine means of reducing the stress of moving pigs into and out of such compartments.

ACKNOWLEDGEMENTS

Strategic program funding provided by Sask Pork, Alberta Pork, Manitoba Pork Council and Saskatchewan Agriculture and Food. Project funding provided by Maple Leaf, the Natural Sciences and Engineering Research Council and Agriculture and Agri-Food Canada. J.A. Correa thanks F. Menard Inc. for allowing him to pursue his Ph.D. studies while under their employ. Appreciation is expressed to the more than 30 students, technicians and employees of Maple Leaf who assisted in this project.

A pig wearing a belt with the heart rate monitor installed

Table 1. Summer

Compartment	Upper Deck	Bottom Nose	Middle Deck	Belly Deck	Significance [x]	SEM
N	101	30	57	69		
Longissimus dorsi						
pH 6h	6.03	5.98	6.02	6.02	NS	0.05
pH 24h	5.65	5.67	5.61	5.62	NS	0.03
L*	49.37 [a]	48.33 [b]	48.87 [ab]	49.62 [a]	*	0.37
Drip loss (%)	3.88 [ab]	3.51 [b]	4.29 [a]	4.44 [a]	*	0.32
Semimembranosus						
pH 6h	6.29	6.30	6.35	6.34	NS	0.05
pH 24h	5.62 [b]	5.67 [a]	5.62 [B]	5.66 [ab]	*	0.02
L *	47.13 [a]	46.10 [b]	47.18 [a]	46.26 [b]	*	0.35
Drip loss (%)	3.94 [a]	2.85 [b]	3.80 [a]	3.84 [a]	*	0.28
Adductor						
pH 24h	5.82 [b]	5.90 [a]	5.77 [b]	5.79 [b]	*	0.03
Lactate (mmol/L)	10.86 [b]	12.51 [a]	9.04 [c]	10.11 [bc]	*	0.91

[x] NS : Not significant; * : $P < 0.05$

[y] According to Japanese Color Scales (from 1 = pale to 6 = dark; Nakai et al., 1975)

Table 2. Winter

Compartment	Upper Deck	Bottom Nose	Middle Deck	Belly Deck	Significance *	SEM
N	83	25	47	60		
Longissimus dorsi						
pH 6h	6.05	6.01	6.03	5.98	NS	0.07
pH 24h	5.73 [b]	5.83 [a]	5.71 [b]	5.71 [b]	*	0.03
L*	49.21	48.26	49.30	48.65	NS	0.80
Drip Loss (%)	3.53 [a]	2.90 [b]	3.50 [a]	3.25 [ab]	*	0.24
Semimembranosus						
pH 6h	6.08	6.12	6.03	6.09	NS	0.07
pH 24h	5.70 [b]	5.85 [a]	5.68 [b]	5.72 [b]	*	0.03
L *	46.58	45.58	46.14	45.66	NS	0.51
Drip loss (%)	4.40 [a]	3.28 [b]	4.14 [a]	4.08 [a]	*	0.26
Adductor						
pH 24h	5.99 [b]	6.15 [a]	5.92 [b]	6.06 [ab]	*	0.05
Lactate (mmol/L)	13.63 [b]	15.92 [a]	11.13 [c]	13.60 [b]	*	0.97

[x] NS : Not significant; * : $P < 0.05$

[y] According to Japanese Color Scales (from 1 = pale to 6 = dark; Nakai et al., 1975)

Validation of Sampling Techniques for Assessing Stress in Pigs by Salivary Cortisol

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Harold Gonyou

SUMMARY

Salivary cortisol (a stress hormone) is a measure that can be used along with health, behaviour, and productivity as an indication of the stressfulness of a management procedure or system. Saliva sampling is believed to be relatively stress-free, but this needed to be confirmed before using it for tests involving multiple sampling of animals individually or in groups. We sampled individually penned animals repeatedly for 30 minutes, or at 30 minute intervals for 3 hours. Only minor changes in salivary cortisol levels were evident, indicating that multiple sampling could be conducted without inducing significant stress. We also sampled pigs within a group, and determined that repeatedly sampling one pig did not result in an increase in cortisol levels in the other pigs. When conducted according to the protocol used in this study, multiple samplings of saliva can be used to assess cortisol levels in a research barn.

INTRODUCTION

Cortisol is released into the blood from the outer layer (cortex) of the adrenal gland in response to stress. Thus, we measure cortisol in order to determine the stressfulness of events in pigs' lives, such as regrouping of sows, loading market pigs, or castration of young males. Rather than taking a single sample, we often take multiple samples over time to determine not only the peak level of cortisol, but also how long it remains elevated in response to the stressor. In addition to assessing such short term (acute) stressors, we may also sample cortisol to assess long term (chronic) stressors such as prolonged confinement, overcrowding at feeders, or prolonged social stress. In this case we conduct 'adrenal function' tests in which we monitor release of cortisol over an extended time after first stimulating or blocking the adrenal gland. These tests tell us if the adrenal gland has changed in response to long term stress.

One of the problems associated with using cortisol as an indicator of stress is that we may be measuring the animals' response to our collecting the sample. Laboratory studies typically catheterize animals so that blood can be sampled from outside the room to avoid disturbance. Such techniques are not possible in more applied research settings such as groups of sows or finisher pigs. Blood sampling will result in a stress response, particularly if the animal is sampled several times. But we have found that cortisol is present in the saliva, at levels proportional to those in the blood, and we feel that sampling saliva may be non-stressful enough to allow us to sample repeatedly without causing a stress response. This series of studies asked the question: Is it possible to repeatedly sample saliva from animals without inducing a significant stress response?

EXPERIMENTAL PROCEDURES

We sampled pigs that were approximately 70 kg in weight. They were housed either individually or in groups of five. To sample saliva we placed absorbent cotton on the end of a thin metal rod. The cotton was held in place by two rubber stoppers. When this rod was held near the pig's mouth, the pig would chew on the stoppers, allowing the cotton to absord saliva. The saliva soaked cotton was frozen, later to be thawed, centrifuged, and the cortisol concentrations in the saliva determined by enzyme immunoassay.

"Pigs can be sampled for salivary cortisol multiple times without inducing a stress response."

We sampled pigs under three protocols:

1) Individually housed pigs (10) were sampled as many times as possible in 30 minutes.
2) Individually housed pigs (10) were sampled every 30 minutes for 3 hours.
3) One pig in a group of five (10 groups) was sampled every 30 minutes for 3 hours. The other four pigs were sampled at the beginning, and once more at either 30, 60, 120 or 180 minutes.

Sampling the saliva of one pig in a group of five

RESULTS AND DISCUSSION

For individually penned pigs, sampled repeatedly over 30 minutes, there was a gradual increase in cortisol levels (Figure 1). There was no dramatic increase at any time during the period indicating that the procedure was only mildly stressful.

For individually penned pigs sampled every 30 minutes, there was a slight decline in cortisol levels over time (Figure 2). This could be due to diurnal variation in cortisol concentrations (a gradual decrease during the time of day we sampled), or an adaptation to our presence in the room. From these first two studies it would appear that repeated sampling does not result in a dramatic change in cortisol levels, and thus the technique can be used to sample cortisol levels over time.

For the group housed animals we did not see a change in cortisol levels over time. Repeatedly sampling one pig in the pen did not affect the cortisol levels of the other pigs. At no time did the cortisol levels of the frequently sampled pig differ from those of the infrequently sampled pigs.

IMPLICATIONS

These results indicate that pigs can be sampled for salivary cortisol multiple times without inducing a marked stress response. Thus, we are confident that the cortisol levels obtained are reflective of the environmental conditions (eg. housing or social) rather than due to sampling. In addition, the results demonstrate that several animals in a group can be sampled without distressing the other animals. Our study will continue to develop adrenal function tests which rely on extensive sampling of the animals.

ACKNOWLEDGEMENTS

Strategic program funding provided by Sask Pork, Alberta Pork, Manitoba Pork Council and Saskatchewan Agriculture and Food. Project funding provided by the Alberta Livestock Industry Development Fund of Alberta.

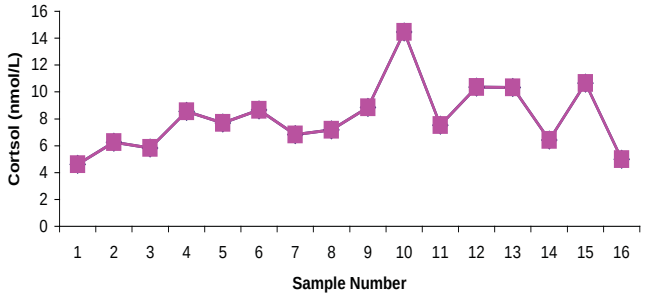

Figure 1. Effect of repeatedly sampling the same pig over 30 minutes on cortisol concentration

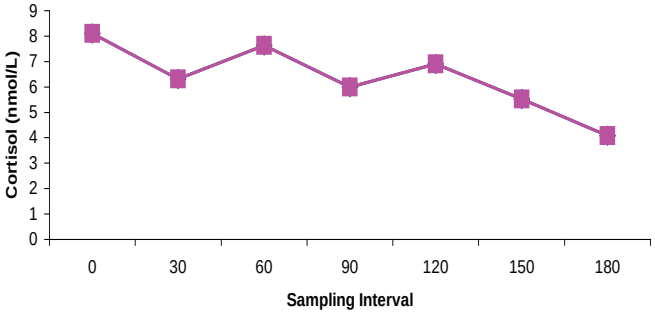

Figure 2. Effect of sampling individually housed pigs every 30 minutes for 3 hours

Temperatures Within a Truck Transporting Pigs During Winter and Summer Months in Western Canada

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Harold Gonyou

SUMMARY

This study investigated the temperatures within a truck transporting pigs in western Canada, during summer and winter months. Pigs were transported from PSC Elstow Research Farm, and involved approximately 8 hours of travel to the Maple Leaf plant in Brandon. The temperature conditions pigs were exposed to during transport varied considerably between seasons and among compartments within the vehicle, and pigs were exposed to temperatures as low as -15 °C or as high as 30 °C.

INTRODUCTION

Transportation, which is an unfamiliar and threatening episode in an animal's life, is one of the most critical periods in pig handling before slaughter. It involves economic losses due to deaths, 'suspect' animals on arrival at the processing plant, and reduced meat quality. Death losses during transportation in Canada are reported to range from 0.05 to 0.17%, which accounts for approximately 16,000 pigs per year. Losses are reported to be higher in summer and vary among compartments within a truck. However, little is known about micro-environmental conditions that develop within compartments during transportation and its relationship to pig welfare and quality of meat. As part of a larger project on handling and transport of pigs, we examined the temperature conditions in trucks to determine if differences exist among compartments during summer and winter months.

EXPERIMENTAL PROCEDURE

All animals used in the study were market animals weighing approximately 115 kg. Animals included both males and females and were assembled from multiple pens. The pigs were transported from the PSC Elstow Research Farm to the Maple Leaf plant in Brandon and it involved approximately 8 hours of travel. Pigs were loaded in the evening and transported overnight to arrive at the packing plant at 6 am. Trials were conducted in both winter and summer months and the range of outdoor temperatures encountered were 7.7 to 22.9 °C for summer and -24.5 to -3.8 °C for winter. The truck used for transportation was a dual (cattle and pigs) purpose, pot-belly trailer. Compartments in the upper deck were numbered from 1, at the front, to 4, at the back and in the middle it was numbered from 5 to 8 (fron to back). The bottom was numbered from 9 at the front, to 10, at the back. Compartment 6 was not used due to load limitations. Loading density was 0.41 m^2/pig. Eleven loads of 195 pigs (six loads in the summer and five loads in the winter) were used in the study. The temperature and humidity within each compartment were measured using iButtons. Five iButtons per compartment were mounted 5-6 cm below the ceiling. These were positioned in the centre of the compartment, and 15 cm in from the centre of each wall of the compartment. The values of temperature and humidity were recorded at 5 minute intervals. Temperatures reported here represent the mean of all five sensors within each compartment. Temperatures were determined at the time each compartment was filled with pigs (loading), at the time the vehicle left the farm (departure), at arrival at the processing plant (arrival), and at the time of unloading of each compartment (unloading).

"During transport pigs can be exposed to temperatures as low as -15°C or as high as 30°C depending on season and compartment."

RESULTS AND DISCUSSION

There were significant differences between summer and winter truck temperatures for all time periods assessed (Table 1). The temperatures were highest during loading and at departure from the farm, and then cooled during transport. In the summer temperatures tended to increase while waiting to unload, however, they decreased in the winter.

Table 1. Average temperatures at the time of loading, departure from the farm, arrival at the processing plant, and unloading for summer (6 loads) and winter (5 months) months

Season	Loading	Departure	Arrival	Unloading
Summer	20.3*	21.7*	15.0*	19.1*
Winter	11.8	12.3	1.6	-1.8

* indicates a significant difference between summer and winter ($P < 0.05$)

The temperatures within each compartment of the truck during summer and winter trials are presented in Figures 1-4. At the time of loading, during the winter, compartment 5 was considerably colder than the rest, with compartments 9 and 10 being intermediate. Compartment 5 is at the front of the truck and its divider is relatively solid. Warm barn air being ventilated through the truck 30 minutes prior to loading in winter does not effectively reach this compartment. The compartment is generally the first to be loaded, and is considered to be difficult to fill. The very cold temperatures that exist here in the winter may add to the difficulty. Compartments 9 and 10 are also likely to be poorly ventilated during the warming period, but they are not loaded until the entire upper deck has been filled. By this time the heat from the pigs has warmed the trailer considerably. By the time of departure, the compartments in the middle deck and compartment 10 were the warmest in both summer and winter. All of these compartments have pigs immediately above them, and compartments 7 and 10 have low ceilings. These factors would contribute to their warming from the heat of the pigs. By the end of the journey, temperatures in all compartments had decreased significantly.

In both seasons the middle and the bottom decks remained the warmest. The temperatures in the top deck fell below freezing during the winter. These decks had no pigs above them to warm the ceiling and heat loss through the roof was likely considerable. Between arrival at the plant and unloading, approximately 30 minutes in these trials, the truck is stationary and the compartments warm up in the summer. The hottest temperatures are seen in compartments 5 and 10. Compartment 5 has relatively poor ventilation as the front of the compartment is solid. It also is immediately above the tractor drive wheels and transmission which will be dissipating heat. Compartment 10 is also poorly ventilated and has a low ceiling. During the winter the temperature in the warmer compartments decreases during the waiting period prior to unloading. This is surprising as we could assume that heat loss would be greater while the truck was in motion. It may be that pigs begin to arouse themselves during this stationary period and this facilitates heat loss from the compartment.

Figures 5 and 6 indicate patterns of temperatures within each compartment during the first 90 minutes of travel during warmest summer and coolest winter days. Within 30 minutes of travel the pattern of temperatures seen at the time of arrival at the packing plant has become evident. All the compartments cool somewhat, however, the compartments in the upper deck and compartment 8 (rear, middle deck) are the coolest during travelling. During the coolest day of travel, temperatures in the 'cool' compartments averaged -10°C, with that in compartment 3 going below -15°C.

IMPLICATIONS

The temperature conditions pigs are exposed to during transport vary considerably between seasons and among compartments within a vehicle. It may be possible to better standardize these temperature variations by changing ventilation and insulation values in each section/compartment of the trailer. The results found in this study will provide direction for important studies in the future.

ACKNOWLEDGEMENTS

Strategic program funding is provided by Alberta Pork, Sask Pork, Manitoba Pork Council and the Agriculture Development Fund of Saskatchewan. Project funding is provided by Ontario Pork, Maple Leaf Pork, Natural Sciences and Engineering Research Council, and Agriculture and Agri-Food Canada. A collaborative project at Agriculture and Agri-Food Canada, Lennoxville was funded by the Swine Producers Board of Quebec, the Animal Compassion Foundation, and F. Menard Inc.

Figure 1. Temperatures at Loading

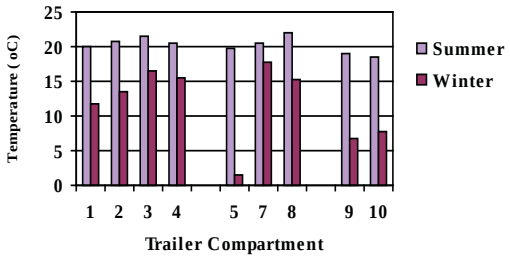


Figure 2. Temperatures at Departure

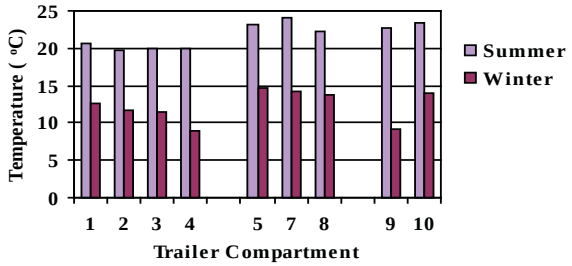


Figure 3. Temperatures at Arrival

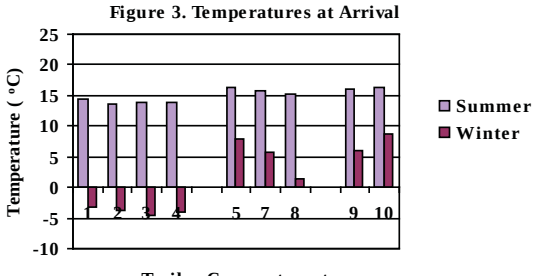
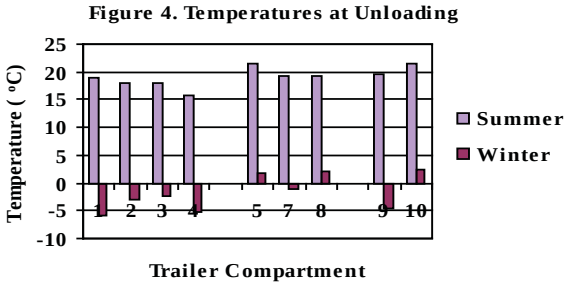


Figure 4. Temperatures at Unloading



Figures 1 - 4. Temperatures at loading, departure, arrival and unloading of each compartment during winter (5 loads) and summer (6 loads)

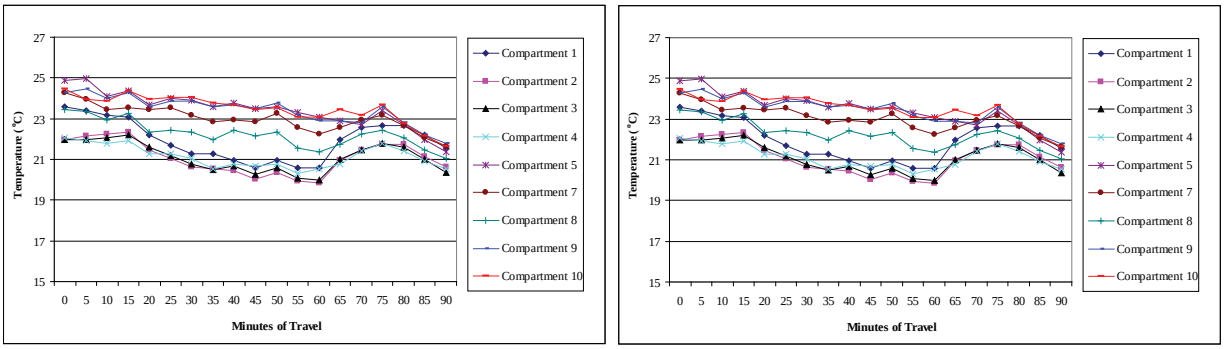


Figure 5 and 6. Compartment temperatures during the first 90 minutes of travel in a warm summer and cooler winter day.

Feeding Co-Extruded Flaxseed to Pigs: Effects of Duration and Feeding Level on Growth Performance and Backfat Fatty Acid Composition of Grow-Finish pigs

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Denise Beaulieu

SUMMARY

A co-extruded flaxseed:field pea product was fed to growing pigs for 4, 8 or 12 weeks to determine which combination of duration of feeding and dietary level would provide optimal enrichement of the backfat with 18:3 n-3 (an omega-3 fatty acid). The inclusion of 15% flaxseed in the diet decreased feed intake; there was no effect on average daily gain, and feed efficiency was improved. If 2.5 grams of backfat was incorporated into a serving (100 g) of processed pork, then feeding 10% flaxseed for 8 weeks or 15% for 12 weeks would achieve the n-3 fatty acid levels required for an enrichment claim in Canada.

INTRODUCTION

Flaxseed is the richest oilseed source of 18:3 n-3 (omega-3) fatty acids and feeding flaxseed to pigs has been used to increase the levels of n-3 fatty acids in pork. Consuming n-3 fatty acids may provide health benefits by reducing the risk factors for several diseases. Thacker, Racz and Soita (2004) from the University of Saskatchewan reported that feeding flax co-extruded with field peas (LinPro, O&T Farms, Regina, SK) could avoid the grinding and storage problems which occur with flaxseed, also a collaborative study with PSCI and the University of Alberta optimized the extrusion conditions for 18:3 availability in pigs.

"Feeding a co-extruded flaxseed: pea mixture can be used to optimize enrichments of n-3 fatty acids in the back fat of pigs"

Incorporation rates of 18:3 n-3 into pork fat with flaxseed feeding have been variable. Therefore the overall objectives of this study was to feed a flaxseed:field pea blend (LinPro®; O&T Farms, Regina, SK) extruded using conditions which optimized 18:3 availability for various durations and at different levels in the diet to determine which provided optimal and consistent elevated 18:3 n-3 levels in pork fat.

MATERIALS AND METHODS

Four barrows and four gilts, with an initial body weight of 31 ± 3 kg were randomly assigned to one of ten dietary treatments. Treatments were 3 levels of extruded flaxseed (5, 10 and 15%; Table 1) and 3 durations of feeding (4, 8 and 12 weeks) arranged as a 3 x 3 factorial, plus a control (0% flaxseed). Diets were formulated and adjusted every 4 weeks to meet the nutrient requirements of the growing pig. Field peas were added to the diets at a constant level to compensate for the peas in the co-extruded product. Tallow was used to balance energy levels among diets within phases. A backfat biopsy was collected from each pig the day prior to slaughter and analyzed for fatty acid concentrations.

RESULTS AND DISCUSSION

The inclusion of up to 30% (15% flaxseed) of a co-extruded flaxseed:pea mixture for 12 weeks in the diet of growing pigs had only modest effects on performance (Table 2). Feed intake decreased from 2.60 to 2.47 kg/d ($P<0.01$; Table 2) but ADG was unaffected ($P=0.40$) and therefore feed conversion improved ($P=0.01$) as the amount of flaxseed in the diet increased from 5 to 15%. Feed intake on the control diet was similar to the 15% flaxseed diet; there is no obvious explanation for this.

Backfat obtained from gilts had less saturated fatty acids and more n-6 fatty acids ($P<0.04$; data not shown), however the actual differences between genders is small and probably of limited practical significance. Both the amount of flaxseed in the diet and duration of feeding impacted fatty acid composition of the backfat. Increasing flaxseed in the diet resulted in increases in the percentage of n-3 fatty acids in backfat , including 18:3 (Figure 1A), 20:3, 20:5 n-3, and 22:5 n-3. Although, not as dramatic, the proportion of n-6 fatty acids also increased (Figure 1B) due to increases in 18:2 n-6 ($P<0.01$) and 20:2 n-6 ($P<0.05$). Conversely 20:4 n-6 declined from about 0.19% to 0.12% as the flaxseed concentration of the diet increased from 5 to 15%. As the level of flaxseed in the diet increased, the percentage of 18:2 n-6 fatty acids decreased, however, because of the greater amount of fat in the diets with added flaxseed the absolute amount of 18:2 n-6 consumed increased, leading to the enrichment of these fatty acids in the backfat. Overall, the ratio of n-3/n-6 fatty acids in backfat increased (Figure 1C; $P<0.05$). Generally, when 5% flaxseed was included in the diet, a plateau in total n-3 fatty acids was observed if it was fed for longer than 8 weeks. Conversely, when the diet contained 10 or 15% flaxseed, the level of n-3 fatty acids did not plateau and continued to increase between 8 and 12 weeks ($P<0.01$). The consistent production of pork with enriched levels of n-3 fatty requires a balance between high levels of flax for short durations, which provides efficient rates of deposition, and feeding higher levels for longer durations, which allows for a more consistent rate of deposition.

The Canadian government requires 300 mg n-3 fatty acids per 100 g serving for an enrichment claim. In the present study, 2.5 g of backfat from pigs fed 10% flaxseed for 8 weeks or 15% for 12 weeks would achieve the n-3 fatty acid levels for a claim. Additionally, if 15% flaxseed was fed for 12 weeks, 2.0 g of backfat would achieve the required levels of n-3 fatty acids (assuming 85% fat in backfat). The backfat could potentially be used to manufacture pork products enriched in n-3 fatty acids.

Additionally, commercial lean meat form pigs fed flax co-extruded with field peas would probably have sufficient fat (subcutaneous, inter- and intramuscular) in retail cuts to achieve the required enrichment levels.

CONCLUSION

Feeding flax co-extruded with field peas can be used to optimize consistent enrichments of n-3 fatty acids in back fat of pigs. Relatively small amounts of this fat used to manufacture pork products would be required to meet the Canadian standard for a n-3 enrichment claim.

ACKNOWLEDGEMENTS

Strategic program funding was provided by Sask Pork, Alberta Pork, Manitoba Pork Council and Saskatchewan Agriculture and Food Development Fund. Specific funding for this project was provided by Vandeputte s. a., Belgium.

Table. 1 Ingredient and nutrient composition of experimental diets. Weeks 1 to 4.

Ingredients, % as fed	Flaxseed, %			
Wheat	53.4	39.0	24.5	10.0
Barley	10.0	21.6	33.1	44.6
Soybean Meal	17.0	15.3	13.5	11.8
Field Peas	15.0	10.0	5.0	0.0
Lin Pro[2]	0.0	10.0	20.0	30.0
Tallow	1.03	0.68	0.34	0.0
DiCalcium phosphate	0.85	0.83	0.82	0.80
Limestone	0.80	0.78	0.77	0.75
Vitamin premix	0.50	0.50	0.50	0.50
Mineral premix	0.50	0.50	0.50	0.50
Salt	0.50	0.50	0.50	0.50
L-lysine HCL	0.23	0.25	0.28	0.30
L-threonine	0.10	0.10	0.10	0.11
DL-methionine	0.06	0.07	0.07	0.08
Calculated nutrient content, as fed				
DE (Mcal/kg)	3.38	3.39	3.40	3.42
Dig lys/Mcal DE	2.80	2.80	2.80	2.80
Calcium, %	0.82	0.82	0.82	0.87
Phosphorus, (total) %	0.61	0.56	0.57	0.61

[1] Diets were reformulated for weeks 5 to 8 and 9 to 12 to meet the changing nutrient requirements of the pigs as they grew.

[2] Co-extruded 50% flaxseed and 50% field peas (LinPro; O&T Farms, Regina, SK

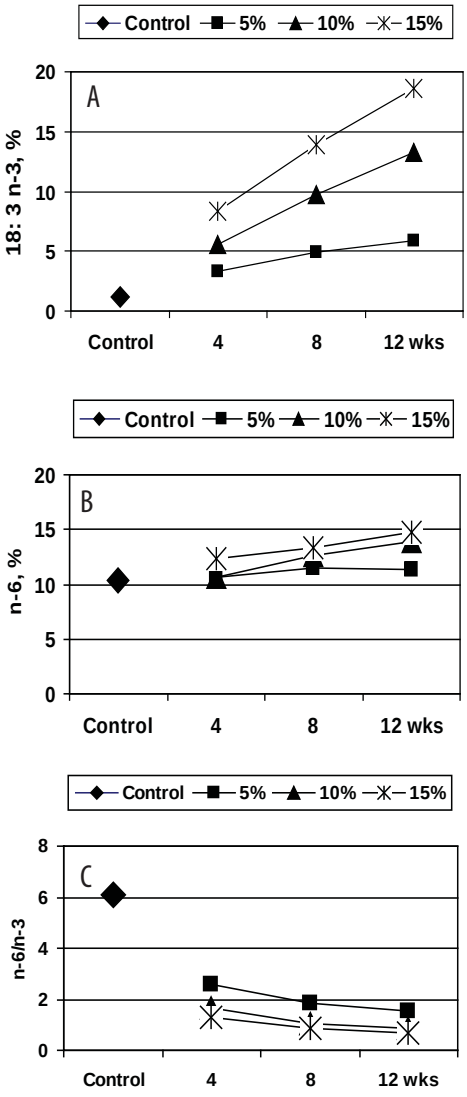

Figure 1. The influence of flaxseed in the diet on the percentage of 18:3 n-3 (A), sum of n-6 (B) and the n-3/n-6 (C) ratio in the backfat of growing swine when fed for either 4, 8 or 12 weeks. The control pigs were fed a diet containing 0 flaxseed for 12 weeks. Effect of diet, week, and diet by week interaction ($P < 0.05$).

Table 2. The Performance of grow-finish pigs fed different levels of extruded flaxseed for different durations

		Diet			Weeks				
Variable	Control	5	10	15	4	8	12	SEM	P Value
Initial BW, kg	31.1	30.8	30.9	31.4	30.9	31.2	31.0	1.48	0.31
Final BW, kg	109.7	114.6	112.9	115.2	115.6	115.7	111.4	2.09	0.36
ADG, kg/d	0.94	1.00	0.98	1.00	1.01	1.01	0.96	0.01	0.42
ADFI, kg/d	2.46	2.60	2.50	2.47	2.58	2.55	2.45	0.03	0.01
Gain:feed	0.38	0.39	0.39	0.41	0.39	0.40	0.39	0.01	0.01

Ractopamine, at 5 or 10 mg /kg, increases protein deposition in the carcass

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Denise Beaulieu

SUMMARY

A comparative slaughter experiment utilizing 120 barrows was conducted to measure growth performance and nutrient retention in the carcass when either 0, 5 or 10 mg/kg ractopamine hydrochloride was added to the diet at 3 levels of dietary lysine. Therefore, there were 9 different dietary treatments (3 ractopamine x 3 lysine:DE ratios). Growth performance and nutrient retention in the carcass were determined. Ractopamine did not affect ADG, ADFI or the gain to feed ratio (P>0.10). With increasing lysine G:F improved (0.35, 0.35 and 0.39; P<0.05), ADG and ADFI were unaffected (P>0.10). Protein deposition rates tended to increase (162.1, 185.4 and 189.2 g/d with 0, 5 and 10 mg/kg ractopamine; P<0.11) and lipid deposition rates tended to decrease (619.8, 461.6, and 542.3 g/d) with 0, 5 and 10 mg/kg ractopamine, respectively, (P<0.10).

"Inclusion of 5 mg/kg ractopamine hydrocholoride improved protein deposition"

INTRODUCTION

Ractopamine hydrochloride, (RAC) is a ß-adrenergic agonist that belongs to the class of chemicals that includes, for example, clembuterol. Ractopamine hydrochloride is the active ingredient in Paylean®, widely used in the swine industry due to benefits such as increased growth rate, feed efficiency and carcass lean deposition. We (Patience et al. 2006 PSCI Annual Report) have shown improvements in growth performance and carcass quality when RAC was included in the diet at 5 mg/kg. The following experiment is part of a larger series of experiments examining the potential to utilize Paylean as a tool to reduce the environmental impact of pork production. We hypothesized that including Paylean in the diet would improve N retention, thus decrease N output in the urine and faeces of finishing swine. The specific objective in the experiment reported herein was to examine the effect of Paylean, added to the diet to supply 5 or 10 mg/kg RAC, on carcass nutrient deposition.

MATERIALS AND METHODS

A growth experiment was conducted which compared 9 different treatments. These included Paylean added to the diet to supply 0, 5 or 10 g/tonne RAC x 3 levels of dietary lysine (1.75 g/Mcal, 2.25 g/Mcal) and 2.75 g standardized ileal digestible lysine/Mcal DE. Additionally, because we know that the efficacy of Paylean reaches an optimum and then decreases, we included two slaughter weights as an additional factor.

Diets were based on wheat, barley, and soybean meal and also contained canola oil, vitamin/mineral premix, synthetic amino acids and Paylean. All diets were formulated to contain 3,300 kcal DE/kg) and formulated to meet or exceed the nutrient requirements of the finisher pig (NRC, 1998).

The experiment began when the barrows reached 95 ± 3 kg bodyweight and ended when they reached a final weight of either of 108 or 120 ± 3 kg. Pigs were euthanized by captive bolt stunning, followed by exsanguination; all blood was collected and returned to the carcass. The carcass was split down the midline from the groin to the chest cavity and the entire gastrointestinal tract (GIT) was removed, emptied of digesta and patted dry. The gall and urinary bladders were also drained of contents. The emptied GIT was then returned to the carcass and an empty body weight recorded. Carcasses were ground, freeze-dried and subsequently analyzed for moisture, N, fat and ash (indicative of total mineral content).

RESULTS AND DISCUSSION

Paylean had no effect on ADG, ADFI or G:F (Table 2; P > 0.10). Lysine had no effect on ADG or ADFI (P>0.10). However, G:F increased with high dietary lysine concentration (P<0.05). ADFI was higher in the 120 kg slaughter weight treatment (P<0.05) when compared to the 108 kg slaughter weight. Slaughter weight did not affect ADG or G:F (P>0.05).

Paylean tended to increase protein deposition in the carcass (25 g/d increase, 0 vs 10 mg/kg RAC; P<0.12; Table 3), increased water deposition rate (P<0.05), and tended to reduce fat deposition rate (P<0.10; Table 3). The lowest fat deposition was observed with the 5 mg/kg RAC level (620, 462, and 542 g/d fat deposition for 0, 5 and 10 mg RAC/kg feed). Protein, but not fat deposition rate increased in response to lysine (P<0.05). The 120 kg slaughter weight pigs had increased deposition rates of protein, fat and water (P<0.05) compared to the barrows slaughtered at 108 kg however, there was no RAC by slaughter weight interaction (P>0.10).

The lack of a growth response to Paylean in this experiment is contrary to the preponderance of previous research. The response to Paylean diminishes after it has been fed for about 28 days. The average time on Paylean in these experiments was 17 and 9 days for the 120 and 108 kg slaughter groups, respectively, therefore a growth response was expected.

A response to increasing dietary lysine : DE ratio was observed. Pigs received 18.9, 23.6 and 25.8 g SID lysine per day which exceeds NRC (1998) lysine requirements. However, present day pigs may require more lysine than the NRC (1998) recommendations. Additionally, because of the improvement in lean growth with Paylean, the finishing pig's requirement for lysine increases when Paylean is added to the diet. However, if lysine was limiting the response to Paylean we would expect to see a lysine by Paylean interaction due to a greater response to Paylean at the higher lysine levels. This, however, was not observed (Table 2).

Table 1. Ingredient composition of experimental diets (% as fed)[1]

SID Lys (g/Mcal DE)	1.75	2.25	2.75
Ingredient, %			
Wheat	59.27	54.52	47.93
Barley	30.00	31.00	32.00
Soybean Meal	6.40	10.00	15.50
Limestone	0.750	0.750	0.750
Dicalcium Phosphate	0.550	0.500	0.450
Salt	0.500	0.500	0.500
PSC Mineral Premix [2]	0.500	0.500	0.500
PSC Vitamin Premix [3]	0.500	0.500	0.500
Lysine HCL	0.135	0.250	0.310
dL-Methionine	-	0.010	0.050
L-Threonine	-	0.070	0.115
Canola Oil	1.000	1.000	1.000
Celite [4]	0.400	0.400	0.400
Paylean [3]	0.000	0.000	0.000
Formulated Analysis			
DE, kcal/kg	3,300	3,300	3,300
Crude Protein, %	16	17	19
Total Lysine, %	0.650	0.840	1.030
SID Lysine, %	0.580	0.750	0.850

1 Each of these diets was fed with either 0, 5 or 10 mg/kg RAC added to provide 9 different treatments.
2.Provided per kg of diet: zinc, 100 mg as zinc sulphate; iron, 80 mg as ferrous sulphate; copper, 50 mg as copper sulphate; manganese, 25 mg as manganous sulphate; iodine, 0.50 mg as calcium iodate; selenium, 0.10 mg as sodium selenite.
3 Provided per kg of diet: Vitamin A, 8250 IU; Vitamin D, 825 IU; Vitamin E, 40 IU; niacin, 35 mg; D-pantothenic acid, 15 mg; menadione, 4 mg; folacin, 2mg; thiamine, 1 mg; D-biotin, 0.2 mg; Vitamin B12, 25 ug.
4.Included as a marker for digestibility measurements.

Table 3. The effect of Paylean (RAC), lysine and slaughter weight on carcass nutrient deposition rates in finishing barrows

Item	Protein	Fat	Ash	Water
RAC (ppm)		g/d		ml/d
0	162.1	619.8	26.3	466.3
5	185.4	461.6	25.2	608.7
10	189.2	542.3	27.1	572.5
Lysine (g/Mcal)				
1.75	160.0	574.2	24.1	479.0
2.25	178.8	553.3	28.7	548.9
2.75	198.0	496.2	25.8	619.7
SEM[3]	*10.77*	*49.68*	*2.18*	*45.80*
Slaughter Weight (kg)				
108	166.1	600.1	24.2	476.7
120	191.7	482.4	28.3	621.7
SEM	*9.20*	*42.22*	*1.78*	*38.97*

Statistics	P-value			
Paylean	0.111	0.055	0.837	0.050
Lysine	0.027	0.461	0.329	0.066
Paylean x Lysine	0.786	0.754	0.338	0.726
Slaughter Weight	0.027	0.029	0.109	0.004

It is interesting that even though we didn't observe a growth response to Paylean we did see an increase in protein and water and a decrease in lipid deposition when Paylean was added to the diet. Overall, this would be expected to result in a leaner carcass. Moreover, the rate of protein deposition (g/d) was higher for the pigs slaughtered at 120 than at 108 kg ($P<0.05$). The opposite was seen with lipid deposition ($P<0.05$). Lean tissue is approximately 80% water, while adipose tissue contains only about 15% water, thus we expect increased water deposition to accompany the higher protein deposition. It should be noted that the baseline protein deposition rates in these pigs was high. This can be attributed to a multitude of factors including genetics, diet, environment or due to the slaughter process used in this experiment (entire carcass was ground). Regardless, even at the 5 mg/kg level, RAC improved protein deposition above the baseline.

IMPLICATIONS

Although there was no response in growth rate, 5 mg/kg RAC improved protein deposition. The response to RAC may not be evident if growth rate is the only criteria measured. Lysine requirements may be higher than recommended when Paylean is used in a herd with high rate of protein deposition.

ACKNOWLEDGEMENTS

Program funding is provided by Sask Pork, Alberta Pork, Manitoba Pork Council and the Saskatchewan Agricultural Development Fund. Project funds were provided by Elanco Animal Health.

Table 2. Effect of Paylean, lysine, and slaughter weight on growth rate, feed intake and feed conversion in finishing barrows[1]

Item	Initial Body Weight, kg	ADG kg/d	ADFI, kg/d	G:F, kg/kg
RAC (ppm)				
0	96.5	1.4	4.0	0.35
5	95.9	1.4	3.9	0.36
10	96.0	1.5	3.8	0.38
Lysine (g/Mcal)				
1.75	95.9	1.4	4.0	0.35
2.25	96.3	1.4	3.9	0.35
2.75	96.3	1.5	3.9	0.39
SEM[2]	*0.56*	*0.06*	*0.11*	*0.01*
Slaughter Weight (kg)				
108	95.9	1.4	3.8	0.37
120	96.4	1.5	4.0	0.36
SEM	*0.52*	*0.05*	*0.10*	*0.01*

Statistics		P-value		
RAC	-[2]	0.775	0.277	0.164
Lysine	-	0.232	0.783	0.029
RAC x Lysine		0.636	0.108	0.756
Slaughter Weight		0.307	0.009	0.636

1 Data expressed as least square means. Data analyzed with initial body weight as a covariate.
2 (–) indicates no statistics were calculated on that parameter

Ractopamine Hydrochloride and the Environmental Sustainability of Pork Production

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Denise Beaulieu

SUMMARY

PSCI and others have shown improvements in lean growth and feed efficiency when ractopamine (Paylean®) was fed to finishing pigs. The objective of the following experiment was to determine if the improvements in nutrient utilization with Paylean can lead to a demonstrable reduction in the environmental footprint of pork production. A metabolism experiment was conducted to measure the effect of 5 or 10 mg/kg ractopamine (RAC) from Paylean on nitrogen (N) and water balance in finishing swine. Paylean improved average daily gain (ADG), N retention in the carcass and feed efficiency and decreased water intake and urine output. Because of the improvement in N and water utilization in finishing pigs, we concluded that Paylean can reduce the environmental impact of pork production.

INTRODUCTION

The excretion of nitrogen (N) in the manure of swine is problematic because it is in the form of NH_3 which has odour and other environmental implications. Ractopamine hydrochloride (RAC), or Paylean (Elanco Animal Health, Guelph, ON) is a ß-adrenergic agonist which, when added to the diet of finishing swine, improves ADG, feed efficiency, and carcass lean growth. These growth performance and carcass improvements are well noted in the literature but there is limited research on other potential benefits of Paylean.

A small number of studies have looked at RAC's impact on reducing nutrient excretion; however inclusion levels of 18 to 20 mg/kg were used. Currently, the Canadian Food Inspection Agency approves RAC at inclusion levels of 5 and 10 mg/kg, thus, these were the levels used in the following study.

The overall objective of this experiment was to define the impact of RAC on the efficiency of pork production with a view to reducing the environmental impact of pork production. Specifically we wanted to determine the effect of RAC on the efficiency of N utilization, and to evaluate the effect of RAC on the efficiency of animal performance, including carcass quality and water and feed requirements for growth.

MATERIALS AND METHODS

The experiment utilized 54 barrows assigned to one of 9 treatments when they reached 95 ± 3 kg bodyweight. Treatments were 3 levels of RAC (0, 5 or 10 mg/kg) x 3 lysine:DE ratios (1.75, 2.25 or 2.75 g ileal digestible lysine:kcal DE). Barrows were on test for 15 days and maintained in pens which allowed the collection of faeces and urine. Collection of urine and faeces occurred on days 6 to 8 and 13 to 15 of the experiment allowing us to determine if the response to RAC changed over time. Diets were based on wheat, barley, and soybean meal and also contained canola oil, vitamin/mineral premix, and synthetic amino acids. All diets were formulated to contain 3,300 kcal DE/kg and formulated to meet or exceed the nutrient requirements of the finisher pig.

Table 1. The effect of (RAC) and lysine on final body weight, growth rate, feed intake, feed efficiency and water intake in finishing barrows[1]

	Body Weight, kg		ADG	ADFI	G:F
Item	**Initial**	**Final**	**kg/d[2]**	**kg/d[2,3]**	**kg/kg[2,3]**
RAC (ppm)		g/d		ml/d	
0	93.8	110.2	1.1	3.2	0.34
5	93.8	112.9	1.3	3.2	039
10	94.1	112.7	1.3	3.0	0.41
SEM	*0.65*	*0.54*	*0.04*	*0.06*	*0.01*
Lysine (g/Mcal)					
1.75	93.5	110.9	1.1	3.3	0.35
2.25	94.2	112.9	1.3	3.1	0.40
2.75	94.0	112.0	1.2	3.0	0.40
SEM	*0.65*	*0.54*	*0.04*	*0.06*	*0.01*
Statistics			**P-value**		
RAC	-[4]	0.002	0.002	0.051	<0.001
Lysine	-	0.039	0.039	0.027	<0.001
Paylean x Lysine	-	0.654	0.650	0.918	0.579

1Data expressed as least square means. Data analyzed with initial body weight as a covariate
2Calculated based on 15 d experimental period.
3As-fed basis.
4(–) indicates no statistics were calculated on that parameter

"It is proven that Paylean can reduce the environmental impact of pork production because of the improvement in nitrogen and water utilization"

RESULTS AND DISCUSSION

Final BW, ADG, ADFI and G:F ($P<0.05$) increased as RAC concentration in the diet increased. Final BW, ADG ($P<0.05$), and G:F increased ($P<0.001$) and ADFI decreased ($P<0.001$) with increasing Lysine (lys) levels (Table 1). Pigs fed no RAC averaged 19 days (d) to reach market and RAC fed pigs required 17 d.

Table 2 describes water balance and fecal ouput. A decrease in water intake and excretion (urine output and fecal moisture) ($P<0.05$) was observed with increased RAC. Apparent water retention tended to decrease with RAC inclusion ($P=0.10$). Fecal output (dry basis) was greatest for the 5 mg/kg RAC-fed pigs when compared to the 0 and 10 mg/kg treatments ($P<0.05$). Greater Lys concentrations tended to decrease fecal output ($P<0.10$) but Lys had no effect on water intake, excretion, and apparent water retention ($P>0.10$).

Nitrogen intake, N digestibility, urinary N excretion, fecal N excretion, and total N excretion decreased and N retention increased (P<0.05) with increased RAC (Table 3). Nitrogen intake, N digestibility, urinary N excretion, total N excretion, and N retention increased with greater dietary Lys concentration (Table 3, P<0.05) but fecal N excretion was unaffected (P>0.10; Table 3).

Calculations based on the present data were applied to a commercial situation to define the potential impact of RAC on the environment. The values obtained in the metabolism study were utilized to calculate nutrient balance in a 1,000 head finishing barn (Table 4). In these calculations, we assumed that pigs started on treatment diets at 95-kg and finished at 120-kg.

Our calculations indicated that 10 mg/kg Paylean supplemented at 95-kg and fed for 17 days would reduce feed intake and water consumption by 7.5 kg and 33.1 liters per pig, respectively. Water and faecal excretion would be reduced by 18.6 liters and 0.9 kg per pig, respectively. N intake was reduced by 0.2 kg per pig, and N excretion declined by 0.2 kg per pig. When comparing the 5 mg/kg Paylean level to the 10 mg/kg level, the 10 mg/kg Paylean-fed pigs had the most substantial reduction in intake and excretion of both water and nitrogen. Utilizing the results obtained in this experiment and applying them to a commercial situation demonstrates that Paylean can have a significant impact on reducing the environmental footprint from pork production. Therefore, feeding either 5 or 10 mg/kg RAC can improve environmental sustainability of market hogs by reducing feed requirements, decreasing water consumption and excretion, and improve utilization of dietary N.

IMPLICATIONS

RAC feeding has the potential to reduce the environmental footprint associated with marketing hogs. Results from these experiments indicate that supplementing either 5 or 10 mg/kg RAC in finishing swine diets can improve N utilization. A decrease in urinary N excretion from 35.1% to 29.8% and improvement in N retention from 49.3 to 54.0% in control and 10 mg/kg RAC-fed pigs, respectively, can reduce excess N being released in soil and water when manure is spread on land. RAC also improved protein deposition rates to 189.2 g/d in the 10 mg/kg RAC-fed pigs, whereas lipid deposition rates decreased to 542.3 g/d. Supplementing RAC produced a leaner carcass with improved nutrient utilization. As well, RAC-feeding reduced water intake by 1 l/d and water excretion was reduced by 0.7 l/d with 10 mg/kg RAC–feeding, which can decrease water consumption requirements for finishing hogs.

ACKNOWLEDGEMENTS

Strategic program funding is provided by Sask Pork, Alberta Pork, Manitoba Pork Council and the Saskatchewan Agricultural Development Fund. Project funds were provided by Elanco Animal Health.

Table 2. The effect of RAC and lysine on feed and water intake, faecal and urine output, water excretion and retention in finishing barrows[1]

Item		ADFI (dry basis), kg/d	Water Intake, l/d[2]	Faecal Output (dry basis), kg/d	Urine Output, l/d	Water Excretion, l/d[3]	Apparent Water Retention, l/d[4]
RAC (ppm)							
	0	2.8	8.3	0.4	3.5	3.9	4.4
	5	2.9	7.9	0.5	3.2	3.6	4.4
	10	2.7	7.3	0.4	2.9	3.2	4.1
SEM		0.05	0.25	0.01	0.18	0.18	0.12
Lysine (g/Mcal)							
	1.75	2.9	7.9	0.5	3.2	3.6	4.4
	2.25	2.8	7.5	0.5	3.0	3.3	4.2
	2.75	2.7	8.1	0.4	3.4	3.7	4.4
SEM[3]		*0.05*	*0.25*	*0.01*	*0.18*	*0.18*	*0.12*
Sample Period (days)							
d	6-8	2.7	7.7	0.4	3.0	3.4	4.3
d	13-15	2.9	8.0	0.5	3.3	3.7	4.3
SEM		*0.04*	*0.15*	*0.01*	*0.12*	*0.12*	*0.09*

Statistics	P-value					
RAC	0.057	0.017	0.018	0.031	0.033	0.102
Lysine	0.053	0.186	<0.001	0.221	0.276	0.337
RAC x Lysine	0.846	0.994	0.060	0.840	0.769	0.125
Sample Period	<0.001	0.051	0.025	0.022	0.014	0.828

1Data expressed as least square means. Data analyzed as repeated measures with sampling periods and the Toeplitz model used for the covariance structure.
2Includes water consumption and diet moisture.
3Sum of faecal water output and urine output.
4Calculated as the difference between water intake and urine and faecal excretion. Other moisture losses (ie. respiration) were not accounted for.

Weighing feed

Table 3. The effect of RAC and lysine concentration on nitrogen balance in finishing barrows

Item	N Intake g/d	N Digestibility, %	Urinary N Excretion, g/d	Faecal N Excretion g/d	Total N Excretion, g/d	N Retention g/d
RAC (ppm)						
0	80.5	84.4	28.5	12.6	41.1	39.4
5	84.1	83.2	25.5	14.1	39.6	44.5
10	77.0	83.8	23.3	12.6	35.9	41.1
SEM	1.43	0.26	0.95	0.37	1.12	1.03
Lysine (g/Mcal)						
1.75	76.0	83.0	24.6	13.0	37.6	38.4
2.25	80.4	83.7	24.1	13.2	37.3	43.0
2.75	1.44	0.26	0.96	0.37	1.13	1.07
SEM[3]	*1.44*	*0.26*	*0.96*	*0.37*	*1.13*	*1.07*
Sample Period (days)						
d 6-8	77.1	83.7	24.1	12.7	36.8	40.3
d 13-15	89.0	83.9	27.4	13.5	41.0	43.0
SEM	*1.10*	*0.20*	*0.74*	*0.27*	*0.84*	*0.79*

Statistics	P-value					
RAC	0.003	0.008	0.001	0.003	0.004	0.003
Lysine	<0.001	<0.001	0.002	0.907	0.010	0.001
RAC x Lysine	0.441	0.001	0.137	0.080	0.072	0.002
Sample Period	<0.001	0.412	0.002	0.021	0.001	0.015

Table 4. Calculated water and nutrient balance for the finishing period (95-120 kg BW)[1]

Item	RAC (mg/kg)		
	0[2]	5[2]	10[2]
Feed Intake (as-fed), kg	60.8	54.4	51.0
N Intake, kg	1.5	1.4	1.3
Water Intake, liters	157.5	134.8	124.4
Water Excretion, liters [3]	73.2	60.4	54.6
Urine Output, liters	66.9	54.1	48.8
Faecak Output (dry fasis), kg	8.4	8.3	7.5
N excreted, kg	0.8	0.7	0.6
N retained, kg	0.8	0.8	0.7

[1] Except days to market, which were obtained from the growth experiment, calculations were based on results obtained in the metabolism experiment.

[2] Pigs fed ractopamine were considered to reach market weight (120-kg) in 17 days from 95-kg and pigs fed no ractopamine were considered to reach market weight in 19 days from 95-kg

[3] Water excretion is the sum of urine output and fecal moisture

Digestible and Net Energy Content of Toasted and Non-Toasted Canola Meals of Yellow- and Black-Seeded Brassica napus and Brassica junceae in Growing Pigs

C.A. Montoya, Kathryn Neufeld, Pam Kish & Pascal Leterme

Pascal Leterme

SUMMARY

The project aimed to generate reliable information on the digestible and net energy (DE and NE) content of different canola meals (CM) in growing pigs, differing in treatment (toasted or not) and in origin (yellow-seeded Brassica junceae and yellow- or black-seeded Brassica napus). The yellow-seeded Brassica napus CM presented the highest dry matter and energy digestibility and DE and NE content. No difference was observed for toasting. It is concluded that yellow CM could have higher interest for swine than black varieties.

"The digestible energy and net energy content of the black-seeded canola meal of Brassica napus was lower than the yellow-seeded canola meal of Brassuca napus and Brassica. junceae"

INTRODUCTION

Canola meal (CM) is a valuable source of essential amino acids for pigs, although the digestibility of these nutrients is limited by both composition (high dietary fibre level) and processing (toasting). Its low energy value is probably the most limiting factor for its use in swine nutrition and is explained by the absence of digestible carbohydrates and oil and by the relatively high level of dietary fibre.

A breeding program has been initiated in Canada to develop canola seeds with lower fibre content. It is based on cultivars of Brassica napus and Brassica junceae carrying the yellow-seed colour genes.

On the other hand, with the progress obtained in terms of levels of antinutritional factors in the seed, research scientists are wondering if the toasting process is still required. Non-toasted meals are yellow but toasting can have a negative impact on the availability of the amino acids.

The present project aimed at evaluating the digestible and net energy content (DE and NE) of non-toasted and toasted canola meals obtained from yellow- and black-seeded B. napus and yellow-seeded B. junceae.

MATERIALS AND METHODS

Canola meal samples were prepared at POS pilot plant (University of Saskatchewan) to grind, extract oil and apply heat treatment to simulate commercial canola meal production. A total of 42 barrows (28 kg on average) were used. The pigs were randomly allocated to one of 7 experimental diets (limit feed), these consisted of a basal diet, composed of wheat, soybean meal and a mineral/vitamin premix, and six CM-based diets composed of 1/3 CM and 2/3 basal diet. After an adaptation period to the diet of 10 days, the faeces were quantitatively collected for 10 days. The samples were then pooled per animal, freeze-dried and analysed at the University of Saskatchewan. The digestibility and DE/NE content of the diets were calculated. The digestibility and DE/NE content of the CM alone were then also calculated (Table 1).

RESULTS

The composition of the six CM samples is detailed in Table 1. The crude protein content ranged from 46 to 52% of the DM, and the NDF content from 16 to 23%. All the CM were very low in fat.

The results of digestibility and energy content are detailed in Table 1. No effect of toasting was observed ($P>0.05$). On the contrary, differences were observed between the canola types. The DE and NE content of the black-seeded CM of Brassica napus was lower ($P<0.01$) than that of the yellow-seeded CM of Brassica napus and Brassica junceae.

CONCLUSION

Yellow-seeded canolas, thanks to their lower fibre content, have a better DE and NE content in pigs than black-seeded canolas. Thanks to low antinutritional factors found in the new canola cultivars, the toasting step does not seem to be required anymore to improve the nutritional value.

ACKNOWLEDGEMENTS

Strategic program funding was provided by Sask Pork, Alberta Pork, Manitoba Pork Council and Saskatchewan Agriculture and Food Development Fund. Specific funding for this project was provided by the Canola Council of Canada.

Table 1. Digestibilities and energy values of different toasted and non-toasted canola meals in growing pigs.

Treatment	Toasted			Non-Toasted			P			
Brassica	*junceae* yellow	*napus* black	*napus* yellow	*junceae* yellow	*napus* black	*napus* yellow	RSD[1]	CM	Treatment	CM*T
Composition										
DM	884	894	895	907	915	912				
Crude Protein	499	456	519	480	464	516				
Ash	73	73	69	72	73	70				
Fat	12	16	19	17	17	13				
ADF	115	170	100	121	162	98				
NDF	166	228	170	167	205	156				
Gross energy [2]	4.73	4.75	4.78	4.75	4.79	4.74				
Dry Matter	0.81^{a}	0.75^{b}	0.82^{a}	0.78^{ab}	0.76^{b}	0.84^{a}	5.0	0.004	0.879	0.568
Protein	0.87	0.82	0.87	0.86	0.84	0.87	5.2	0.129	0.911	0.762
Energy	0.81^{a}	0.76^{b}	0.83^{a}	0.78^{b}	0.76^{b}	0.84^{a}	5.1	0.006	0.875	0.662
DE (Mcal/kg)	3.83^{a}	3.60^{b}	3.95^{a}	3.71^{b}	3.65^{b}	4.00^{a}	243	0.006	0.875	0.662
NE (Mcal/kg)	2.63^{a}	2.47^{b}	2.72^{a}	2.55^{ab}	2.50^{b}	2.74^{a}	170	0.006	0.880	0.669

[1] RSD: residual standard deviation. 2 in Mcal/kg DM

^{a,b} Values with different letters in the same row differ significantly at $P < 0.05$.

Canola field in bloom

Net Energy Content of Canola Meal and Full-Fat Canola Seeds in Swine

Carlos A. Montoya, Kathryn Neufeld, Pam Kish & Pascal Leterme

Pascal Leterme

SUMMARY

The project aimed to estimate the net energy (NE) content of canola meal (CM) and full-fat canola seeds (FFCS) in swine and to validate these values, through growth studies using diets containing graded levels of CM or FFCS. No difference in average daily gain and feed conversion ratio was observed between the treatments. This confirms that the estimation of the NE content (CM 2.41 and FFCS 3.53 Mcal/kg DM) was correct and that it is possible to formulate balanced diets for growing pigs that contain up to 15% FFCS and 22.5% CM.

INTRODUCTION

Canola meal (CM) is used in animal nutrition but has to compete with other protein sources such as soybean meal and peas. Currently, CM is not used to its full potential in swine nutrition, due in part to a lack of confidence in its nutritional quality. It is perceived as a poor energy source, due to its low starch and oil content and high protein and fibre content.

Thanks to their high oil content, full-fat canola seeds (FFCS) could partly contribute to correct the low energy content of CM. However, the seeds must be crushed to liberate the drops of oil entrapped within the cell walls and little information is available on the efficiency of the process.

"No difference was observed in average daily gain and feed conversion ratio when canola meal or full fat canola seeds were included at different levels in the swine diets"

The NE system is the best estimator to predict pig growth and its ability to convert feed into lean meat. However, it is often estimated by means of prediction equations because the direct determination is time-consuming and expensive. It is possible to confirm the validity of the NE content of CM or FFCS by measuring the feed conversion ratio of pigs fed with canola-based-diets. If the growth rate does not correspond to the predicted value, it means that the current values of NE over- or underestimate the real energy potential of these canola products.

Canola Meal

The present project aimed to estimate the NE content of CM and FFCS and validate them through a growth trial using different graded levels of both ingredients in growing pigs.

MATERIAL AND METHODS

A total of 18 growing pigs (36 kg on average) were used for the digestibility study. Three experimental diets were prepared: a control diet (composed of barley, soybean meal and a mineral/vitamin premix) and two diets composed of 2/3 of the control diet and 1/3 of CM or FFCS. Each diet was tested on 6 growing pigs. After an adaptation period to the diet of 10 days, the faeces were quantitatively collected for 10 days. The samples were then pooled per animal, freeze-dried and analysed at the University of Saskatchewan. The digestible and net energy (DE and NE) content of the diets were calculated. The same parameters were calculated for the CM or FFCS alone (Table 1).

Based on the results of NE content of both CM and FFCS, two separate growth studies were conducted with graded levels of CM or FFCS. In each study, 72 growing pigs were used and four diets containing graded levels of FFCS (0, 5, 10 and 15%) or CM (0, 7.5, 15 and 22.5%) were formulated in order to meet the pig's nutritional requirements. Each diet was tested on 18 growing pigs (9 females and 9 males) for 35 d.

RESULTS

The DE content was 3.51 and 4.99 Mcal/kg DM and the NE 2.41 and 3.53 Mcal/kg DM for CM and FFCS, respectively. The DM and nitrogen digestibility for CM was 74 and 79% and for FFCS 75 and 74%, respectively (Table 1). The results of growth performance are detailed in Table 2 and Figure 1. No difference in average daily gain (ADG) and feed conversion ratio (FCR) was observed when CM (ADG, 1.07 ± 0.29 kg/d and FCR, 1.99 ± 0.56) or FFCS (0.97 ± 0.24 kg/d and 2.27 ± 0.56) were included at different levels in the diets (P>0.05).

CONCLUSIONS

The validity of the values of NE obtained for CM (2.41 Mcal/kg DM) and FFCS (3.53 Mcal/kg DM) was confirmed through growth experiments. The latter also showed that inclusion rates up to 22% canola meal and 15% full-fat canola seeds in rations have no detrimental effect on the performance of growing pigs.

ACKNOWLEDGEMENTS

Strategic program funding was provided by Sask Pork, Alberta Pork, Manitoba Pork Council and Saskatchewan Agriculture and Food Development Fund. Specific funding for this project was provided by the Canola Council of Canada and the Saskatchewan Canola Development Commission.

Table 1. Digestibility values and energy content of canola meal (CM) and full-fat canola seeds (FFCS) in growing pigs.

	CM	FFCS
Digestibility (%)		
Dry Matter	74	75
Nitrogen	79	74
Energy	74	73
Digestible Energy (Mcal/kg DM)	3.51	4.99
Net Energy (Mcal/kg)	2.41	3.53

Table 2. Feed intake and growth in growing pigs fed with different levels of canola meals (CM) or full-fat canola seeds (FFCS) in the diets.

	Inclusion level (%)				RSD[1]	P			
CM	**0**	**7.5**	**15**	**22.5**		**Diet**	**Time**	**D*T**	**Gender**
FFCS	**0**	**5**	**10**	**15**					
Average daily feed intake (kg)									
CM	2.09	2.02	2.01	2.09	0.55	0.664	0.001	0.122	0.023
FFCS	1.97[a]	1.99[a]	1.84[ab]	1.75[b]	0.45	0.001	0.001	0.651	0.002
Average Daily Gain (kg)									
CM	1.08	1.09	1.03	1.08	0.25	0.483	0.001	0.925	0.360
FFCS	0.98	1.00	0.94	0.95	0.24	0.070	0.001	0.437	0.018
Feed conversion									
CM	1.94	1.95	2.06	2.00	0.63	0.190	0.001	0.694	0.814
FFCS	2.07	2.05	2.03	1.92	0.56	0.068	0.002	0.056	0.245

[1] RSD: residual standard deviation.
[a,b] Values with different letters in the same row differ significantly at $P < 0.05$.

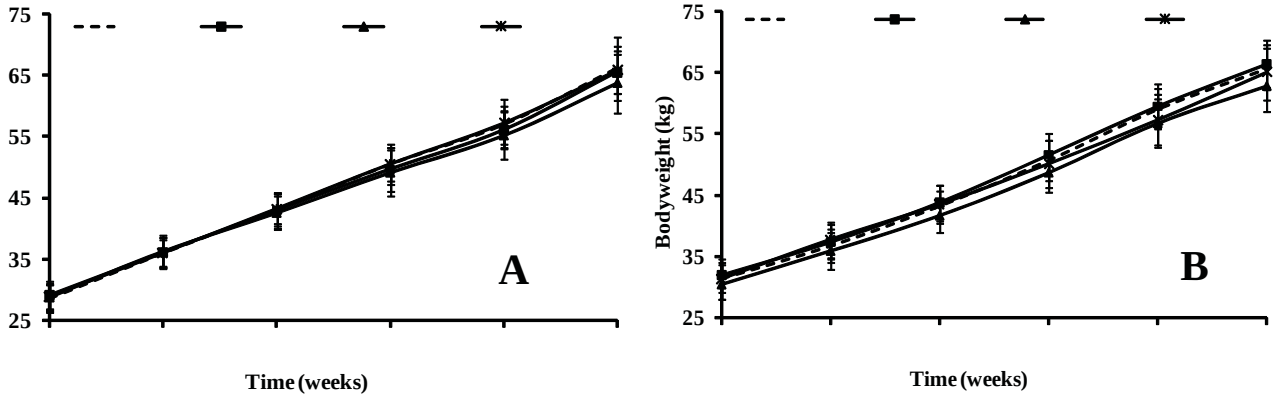

Figure 1. Growth curve of growing pigs fed with diets containing graded levels of canola meal (A) or full-fat canola seeds (B). Values are means and SD for 18 pigs (9 females and 9 males).

Flaxseed Meal in Swine Rations: Standardized Ileal Amino Acid Digestibility

L. Eastwood and P. Leterme

SUMMARY

Flaxseed meal (FSM) is a good source of dietary protein for hogs, containing 34% crude protein (CP). With the exception of a characteristic low Lysine content (3.6% of CP), the CP fraction of FSM is comparable to that of canola meal in terms of both quantity and quality (Standard Ileal Digestibility values), making it an attractive alternative to conventional protein sources.

INTRODUCTION

Recently, there has been a growing interest in the use of flaxseed and its related products such as FSM within the swine industry. Flaxseed meal is a by-product of the flaxseed crushing industry, and depending on the oil extraction process used, the meal may contain up to 12% oil with 34% CP. Prior to the routine acceptance and inclusion of FSM by the pork industry, a full nutritional profile must be made available to producers and nutritionists. A major component of this nutritional profile includes the apparent (AID) and standardized ileal amino acid digestibility (SID) content of the meal.

"Flaxseed meal is an attractive alternative to conventional protein sources"

Flaxseed meal

MATERIAL AND METHODS

This experiment used a total of 5 growing barrows (38 kg initial weight) fitted with T-cannulas at the terminal ileum. The pigs were housed in metabolism pens, and following a 7 day recovery period from surgery, were fed a semi-synthetic diet containing 40% FSM. Feeding of the test diet lasted for 7 days, including a 4 day adaptation period followed by 3 days of digesta collection. Following this, the pigs were then fed a nitrogen-free diet for a similar time period in order to correct the digestibility calculations for basal endogenous losses. Chromic oxide was included in both diets as an indigestible marker.

Pascal Leterme

RESULTS AND DISCUSSION

Table 1 shows the apparent and standardized ileal amino acid digestibilities for FSM, along with the quantity of AID and SID amino acids found in FSM. The AID digestibility values ranged from 25.1 to 86.1% on a DM basis, whereas SID values ranged from 67.6 to 93.8%. The digestibilities of Threonine and Cysteine are both low, with the AID values falling below 60% and the SID values at 73%; however, many of the amino acids are over 80% digestible.

CONCLUSION

Flaxseed meal contains 34% CP and also contains appreciable amounts of many of the essential amino acids. The SID coefficients for the essential amino acids range from 67 to 94%, which affects the overall protein quality of the product; however, the amounts of SID essential amino acids in FSM are very similar to those reported for canola meal (NRC, 1998). Flaxseed meal is characterized by a low lysine content (3.6% of CP) in comparison to other meal products and when compared to the requirements of the pig (5.3% of CP for pigs 25 to 50 kg), and will likely be the limiting factor for the dietary inclusion of FSM into swine rations. This is also confounded by the fact that FSM has a low Lysine digestibility (74%). It will be critical to consider this low Lysine content and digestibility when formulating rations to ensure the requirements of the animals are met.

ACKNOWLEDGEMENTS

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Table 1. Apparent and standardized ileal digestibility of amino acids in flaxseed meal and its digestible amino acid content (dry matter basis)

	Amino Acid Digestiblity, (%)			Amino Acid Content, g/kg DM		
Nutrient	AID	SID	SD	AID	SID	SD
Indispensable						
Arginine	86.1	90.3	2.9	28.2	29.6	1.0
Histidine	67.3	76.4	4.4	5.0	5.7	0.3
Isoleucine	73.6	82.3	5.7	10.8	12.1	0.8
Leucine	71.3	80.6	4.9	14.8	16.8	1.0
Lysine	61.7	73.9	2.9	8.6	10.3	0.4
Methionine	75.3	81.8	3.9	4.9	5.3	0.3
Phenylalanine	78.4	84.7	4.2	12.9	14.0	0.7
Threonine	58.9	73.5	3.7	7.5	9.4	0.5
Tryptophan	25.1	70.5	4.4	1.0	2.9	0.2
Valine	71.2	79.8	4.4	12.3	13.8	0.8
Dispensable						
Alanine	65.5	81.3	3.9	10.4	12.2	0.6
Aspartic Acid	70.3	84.1	4.4	22.4	25.4	1.4
Cysteine	51.6	73.0	10	3.0	4.0	0.6
Glutamic Acid	78.8	86.9	3.5	52.6	56.2	2.3
Glycine	59.6	78.8	4.5	12.2	15.4	0.9
Proline	51.8	95.0	6.1	6.9	12.5	0.8
Serine	65.7	80.4	3.5	9.8	11.4	0.5
Crude Protein	61.4	78.0	3.4	222.5	282.7	12.3

Laura Eastwood

Effect of Grinding on the Digestible and Net Energy Content of Field Peas in Growing Pigs

Carlos A. Montoya, Kathryn Neufeld, Pam Kish & Pascal Leterme

Pascal Leterme

SUMMARY

The project aimed at generating reliable information on the digestible and net energy content (DE and NE) in growing pigs fed with field peas ground at 3 different screen-opening sizes (fine, medium and coarse) to obtain different average particle sizes: 156, 650 and 1035 µm, respectively. The digestibility values and DE and NE content increased as the pea particle size decreased from 1035 to 156 µm. Differences were also observed among pea cultivars. It is concluded that the energy content of peas is influenced by its particle size.

"Digestible and net energy content increased as the pea particle size decreased from 1035 to 156 µm"

INTRODUCTION

Previous research at Prairie Swine Centre has shown that field peas vary in energy content by at least 22%, compared to about 15% for wheat and barley. This problem of variability is compounded by our inability to predict the DE content of field peas from chemical or physical composition.

One possibility to improve the nutritional value and, at the same time, reduce variability is the processing of field peas. Grinding improves digestibility by offering a greater surface of contact between the digestive enzymes and the substrate. However, a too fine grinding is expensive and negatively affects the pig since it causes gastric ulcers. The optimal grinding for the use of field peas in swine nutrition is unknown.

The present project aimed at studying the effects of grinding on the digestible and net energy (DE and NE) content of field peas in growing pigs.

MATERIAL AND METHODS

A total of 204 growing pigs (28 kg on average) were used. Thirty-four experimental diets were prepared: a control diet (composed of wheat, barley, soybean meal and a mineral/vitamin premix) and 33 diets composed of 70% control diet and 30% field peas. The diets were supplemented with Celite®, used as a source of acid-insoluble ash, an indigestible marker. Each diet was tested on 6 growing pigs (limit feed). After an adaptation period of 10 d, faecal samples were collected by the grab sampling method for 3 d. The samples were then pooled per animal, freeze-dried and analysed at the University of Saskatchewan. The digestibility and DE/NE content of the diets were calculated. The digestibility and DE/NE content of the peas alone were then also calculated.

RESULTS

The results of digestibility and energy content are detailed in Table 1. Differences in digestibility, DE or NE content were observed among the field peas ($P<0.05$). The Pekoe pea cultivar presented the lowest values and Mozart the highest. The digestibility and energy content increased linearly as the screen opening size decreased from 1035 to 156 µm ($P<0.001$). The average DE content was 3.84, 3.52 and 3.34 Mcal/kg and the NE content 2.69, 2.47 and 2.34 Mcal/kg for fine, medium and coarse grinding peas, respectively ($P<0.001$).

CONCLUSIONS

The digestibility values and energy content of peas improved as the particle size decreased from 1035 to 156 µm in growing pigs. However, in order to determine the optimal particle size of peas for growing pigs, it will be necessary to establish a compromise between energy costs and nutritional value. In the present case, energy cost was not evaluated.

ACKNOWLEDGEMENTS

Strategic program funding was provided by Sask Pork, Alberta Pork, Manitoba Pork Council and Saskatchewan Agriculture and Food Development Fund. Specific funding for this project was provided by the Saskatchewan Pulse Growers.

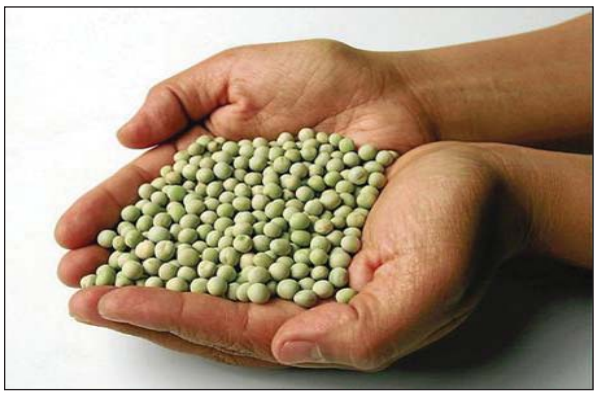

Table 1. Digestibility values and energy contents of the different peas ground to obtain different particle sizes in growing pigs.

		Digestibility (%)				Mcal/kg	
		DM	OM[1]	CP[1]	Energy	DE	NE
Pea							
Acer		81.8 [ab]	81.8 [ab]	73.8 [abc]	78.7 [ab]	3.51 [ab]	2.45 [ab]
Bronco		83.9 [ab]	83.7 [ab]	65.7 [bc]	79.1 [ab]	3.51 [ab]	2.46 [ab]
Camry		83.8 [ab]	83.7 [ab]	65.4 [bc]	79.2 [ab]	3.50 [ab]	2.45 [ab]
Golden		83.5 [ab]	83.2 [ab]	72.8 [abc]	79.4 [ab]	3.59 [ab]	2.51 [ab]
Midas		82.4 [ab]	81.9 [ab]	66.1 [bc]	78.0 [ab]	3.48 [ab]	2.43 [ab]
Mozart		88.8 [a]	88.5 [a]	82.3 [bc]	86.3 [a]	3.84 [a]	2.69 [a]
Nitouche		84.3 [ab]	83.5 [ab]	72.4 [abc]	81.0 [ab]	3.66 [ab]	2.56 [ab]
Pekoe		75.8 [b]	75.1 [b]	61.0 [c]	71.9 [b]	3.20 [b]	2.24 [b]
Salute		85.8 [ab]	84.8 [ab]	78.8 [ab]	83.8 [ab]	3.72 [ab]	2.60 [ab]
Scuba		81.6 [ab]	80.4 [ab]	76.1 [ab]	78.7 [ab]	3.54 [ab]	2.47 [ab]
Soldem		87.2 [a]	86.9 [a]	79.9 [ab]	84.2 [ab]	3.72 [ab]	2.60 [ab]
Screen[2]							
Fine		88.6 [a]	87.7 [a]	79.0 [a]	86.4 [a]	3.84 [a]	2.69 [a]
Medium		82.8 [b]	82.4 [b]	71.5 [b]	79.0 [b]	3.52 [b]	2.47 [b]
Coarse		79.2 [c]	79.0 [c]	66.1 [c]	74.7 [c]	3.34 [c]	2.34 [c]
Pea Screen[2]							
Acer	Fine	85.8	86.0	76.8	83.6	3.73	2.60
	Medium	80.1	79.7	72.5	76.2	3.40	2.37
	Coarse	79.4	797	72.1	76.2	3.40	2.37
Bronco	Fine	89.6	89.4	74.9	85.9	3.81	2.67
	Medium	83.5	83.7	62.7	78.3	3.47	2.43
	Coarse	78.7	78.0	59.5	73.1	3.24	2.27
Camry	Fine	85.5	84.9	64.8	82.1	3.63	2.55
	Medium	85.0	85.3	66.2	79.6	3.52	2.47
	Coarse	80.8	80.9	65.2	75.8	3.35	2.35
Golden	Fine	92.1	91.8	82.2	89.3	3.95	2.77
	Medium	86.2	85.6	74.7	81.9	3.62	2.54
	Coarse	72.1	72.2	61.5	67.0	3.20	2.24
Midas	Fine	86.5	85.1	71.4	83.3	3.71	2.60
	Medium	81.3	81.2	64.6	76.4	3.40	2.38
	Coarse	79.5	79.5	62.3	74.4	3.31	2.31
Mozart	Fine	92.5	91.3	85.9	91.7	4.07	2.85
	Medium	89.6	89.3	82.3	86.3	3.83	2.67
	Coarse	84.2	84.7	78.6	81.0	3.60	2.52
Nitouche	Fine	89.5	88.4	78.1	86.8	3.85	2.70
	Medium	81.4	81.3	73.7	78.1	3.65	2.56
	Coarse	81.9	80.8	65.4	78.1	3.46	2.43
Pekoe	Fine	83.2	81.9	72.5	80.8	3.60	2.52
	Medium	67.5	66.3	50.4	62.8	2.79	1.95
	Coarse	76.7	77.1	60.1	72.0	3.20	2.24
Salute	Fine	91.7	90.4	86.7	90.1	4.00	2.80
	Medium	84.1	82.9	79.2	82.7	3.67	2.56
	Coarse	81.7	81.1	70.4	78.5	3.48	2.43
Scuba	Fine	87.0	85.4	84.5	86.2	3.88	2.71
	Medium	80.5	79.3	78.6	77.6	3.49	2.44
	Coarse	77.2	76.6	65.4	72.3	3.26	2.27
Soldem	Fine	91.1	90.6	91.7	90.2	3.98	2.78
	Medium	91.5	91.8	81.3	88.7	3.91	2.74
	Coarse	78.8	78.3	66.6	73.6	3.25	2.27
Standard Error		2.8	2.8	3.7	3.4	147	103
Statistical Analysis							

[1] Organic matter (OM), Crude protein (CP)

[2] Grinding screen-size: Coarse, 13/64 (5.4 mm opening); Medium, 8/64 (3.28 mm \ opening); and Fine, 1/64 (0.74 mm opening).

Porcine Circoviral Disease – From Inception to Successful Control

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John Harding

TERMINOLOGY

Porcine Circovirus Diseases (PCVD) and Porcine Circovirus Associated Disease (PCVAD) are synonymous names for a disease syndrome caused by porcine circovirus type 2 (PCV2) and originally described in the mid-1990's as Postweaning Multisystemic Wasting Syndrome (PMWS). While the acronyms PCVD and PMWS have been widely used over the last decade, the American Association of Swine Veterinarians in 2006 endorsed "PCVAD". Their desire to avoid using "PMWS" was due to the potentially negative connotations the word "wasting" may have on consumer purchasing habits, and because PCV2-affected pigs do not always demonstrate weight loss.

HISTORICAL PERSPECTIVE OF PCVD

Postweaning multisystemic wasting syndrome (PMWS) was first described by Harding and Clark at the Western Canadian Association of Swine Practitioners' (WCASP) conference in 1996, and later at the American Association of Swine Veterinarians' (AASV) meeting in Quebec City in 1997. These conference presentations described a novel, devastating disease in a select number of biosecure high health western Canadian herds affecting nursery and grower pigs characterized by wasting, respiratory disease, enteritis, enlarged lymph nodes, pallor and jaundice. These first herds were located in Alberta and Saskatchewan, two provinces in the Canadian prairies, and included the widely publicized Saskatchewan 600 sow farrow to finish farm that experienced a 16-20 month epizootic. The fact that this 600 sow farm was a closed, high health status farm, confirmed negative for porcine reproductive and respiratory syndrome (PRRS) virus, and virtually all other swine respiratory and enteric pathogens, strongly suggested the epizootic was associated with a new pathogen. Moreover the frequent observation of liver and kidney lesions in early PMWS cases was paramount to our recognition in 1995 of a novel syndrome, and more specifically that this was not a manifestation of PRRS.

"Effective PCV2 vaccines are now widely available, and enhance the profitability of the pork production systems"

PCV2 was later isolated from lesions of affected pigs and the first experimental reproduction of PMWS clinical signs and lesions was completed using PCV2 and porcine parvovirus (PPV) coinfection in gnotobiotic pigs. In 2001 Krakowka experimentally reproduced disease in immunostimulated gnotobiotes using PCV2 alone leading to the hypothesis that PCV2 is the necessary but insufficient cause of PMWS. Since the mid-1990's, PCVD has been diagnosed in virtually all pig rearing areas of the globe with the notable exception of Australia.

STAIN VARIATION AND VIRULENCE

The circular genome of PCV2 consists of single stranded DNA of 1768 nucleic acids, and 4 major open reading frames (ORF). ORF 1 and 2 code for proteins essential for replication and the capsid respectively. ORF 3 appears to code for protein(s) involved in apoptosis. The function of ORF 4 and 2 other minor ORFs is not known. PCV2 isolates from diseased and non-diseased pigs are genetically similar, and all greater than 90% homologous. However, the simultaneous identification of a distinct porcine circovirus genomic cluster (PCV2b; genogroup 1; RFLP 321) with the devastating 2005-2006 epizootic outbreaks in North America led to speculation that PCV2b is of higher virulence than is PCV2a (genogroup 2; RFLP 422). Except for one recent study in which a genotype 1 PCV2 isolate was reported to be highly pathogenic, there is no clear evidence that isolates from genotype 1 are more pathogenic or virulent than those from genotype 2. While PCV2b provided a possible explanation for the eastern Canadian outbreak, concurrent infections with new strains of PRRSv and SIV, which were also circulating in the eastern Canadian pig population, cannot be ruled out as contributors to the PCVD outbreak.

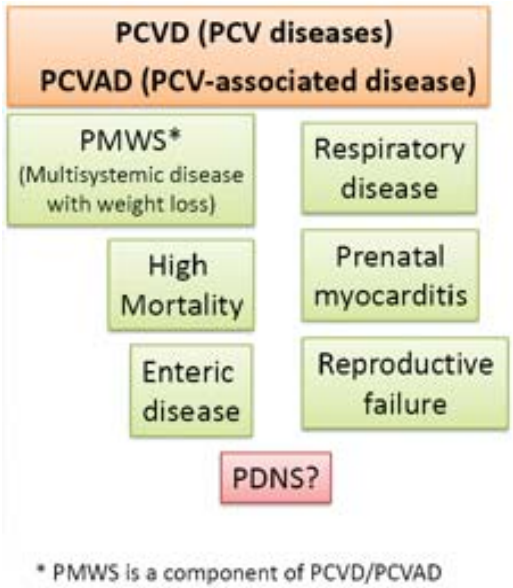

Figure 1 . Porcine circovirus associated disease (PCVAD) case definition

Our research team has recently completed experiments indicating that the severity and incidence of clinical signs and lesions in PCV2b-infected gnotobiotes, with and without KLH/ICFA immunostimulation, were indistinguishable from those of gnotobiotes inoculated with PCV2a using the same experimental model and reported in the past decade. This data suggests that infection of swine with PCV2b alone is not the single causal event responsible for the North American PCVD epizootic.

CASE DEFINITIONS

Sorden was the first in North America to formally propose a case definition for PMWS which provided pathologists and field veterinarians critical diagnostic guidelines for individual animals. Faced with a mounting number of herd epizootics in 2005/06, the AASV developed a PCVAD case definition for affected herds in an attempt to distinguish farms with epizootic disease (PCVAD positive), from those experiencing only sporadic losses (PCVAD negative). Fulfillment of this latter case definition requires the presence of characteristic lesions associated with PCV2 antigen or DNA in affected pigs, as well as significant levels of clinical disease affecting the population. The AASV's case definition is not specific to PMWS; it is more encompassing and recognizes other clinical manifestations of PCV2 including respiratory, reproductive or enteric disease (Figure 1). However, this case definition fails to objectively set out intervention levels or upper-level mortality or prevalence targets that are indicative of PCVD. Although a global agreement on such targets does not exist, Segales proposed that elevations in herd mortality more than 1.66 standard deviations above a historic mean for the herd, or exceeding a national or regional standard by more than 50% should be used.

PATHOGENESIS AND CLINICAL EXPRESSION OF PCV

Multisystemic immunosuppressive disease with wasting, enteric and/or respiratory involvement

Known also as PMWS, multisystemic disease implies the involvement of multiple organ systems and requires by definition, systemic lymphoid depletion in advanced cases. There are several classic clinical signs and gross lesions of PMWS that should form the basis of a preliminary clinical diagnosis including: enlarged lymph nodes, wasting, dyspnea, diarrhea, pallor, nephropathy, thymic atrophy and jaundice. While all of these signs or lesions will not be noted in a single pig, the majority if not all of these signs will be noted over a period of time on affected farms.

The clinical signs of PMWS were historically restricted to the post-weaned aged groups, particularly the late nursery and early grower stages, between 7 and 15 weeks of age. More recently however, some of the 2005/06 North American outbreaks affected older hogs, likely due to farm-related production factors altering PCV2 epidemiology, or the type and infection dynamics of other pathogens on the affected farms.

Passively acquired PCV2 antibody appears to be protective in young piglets, and may persist for 6-8 weeks in the progeny of unvaccinated sows (Harding, unpublished). While piglets are clearly exposed to PCV2 in their dam's milk and feces at a very young age, the timing of initial infection is not fully understood. Following infection PCV2 is most commonly associated with monocytic cells and less frequently in endothelial, epithelial cells or lymphocytes. In vitro analysis has demonstrated that PCV2 accumulates in monocytic cells, particularly the plasmacytoid dendritic cell (DC), for prolonged periods of time, but the virus does not replicate substantially within these cells. PCV2 both infects and replicates in endothelial cells and gut epithelium, particularly when these cells are stimulated as would occur during inflammation. This possibly explains why high levels of PCV2 can be found in DC, and why clinical disease is associated with immune stimulation and/or coinfections with other pathogens such as PRRS, Mycoplasma hyopneumoniae, Mycoplasma hyorhinis, swine influenza virus, porcine parvovirus, swine hepatitis E virus, and torque teno virus. Moreover, through its modulation of the innate immune response, specifically the impairment of interferon alpha and tumour necrosis factor alpha production in some plasmacytoid DC, PCV2 infection eventually induces immunosuppression and may render the host more susceptible to secondary infections.

Reproductive failure and prenatal myocarditis

Porcine embryos and fetuses are susceptible to PCV2 infections, but their susceptibility is dependent on their developmental stage. Embryos appear to be resistant to PCV2 infection as long as the zona pellucida is intact, but are susceptible to infection after hatching. PCV2 replicates in fetuses experimentally infected in mid- and late-gestation, but replication is age dependent being significantly higher in young (57 day) versus older (75 and 92 day) fetuses. Moreover, fetuses inoculated at 57 days of gestation demonstrated myocarditis resulting in congestion and heart failure, whereas fetuses inoculated at gestation day 75 and 92 were free of pathological lesions but developed PCV2 antibodies within 21 days of inoculation

Although transplacental infection has been demonstrated experimentally and PCV2-induced reproductive failure has been reported in commercial herds it is not a consistent finding in PCVD outbreaks. Affected farms experience elevated abortions, stillbirth and fetal mummification rates, prenatal myocarditis, and variable amounts of PCV2 antigen present in fetal tissues and sera. It must be noted that PCV2-associated reproductive failure is most commonly reported in start-up herds. While other causes of infective and non-infective reproductive failure including PRRS are no doubt significant, the relevance of PCV2 as a cause of reproductive failure in commercial farms needs to be clarified. However, several studies have demonstrated the presence of PCV2 in semen of experimentally and naturally infected boars. In one study involving a commercial AI stud, boars less than 52 weeks of age, or less than 26 weeks post-entry were 2.6 and 3.0 times more likely to shed PCV2 in their semen than older boars. While it is clear that PCV2 can be shed intermittently in semen, the duration and frequency of seminal shedding, and concentration of PCV2 in semen is poorly understood. However, PCV2 appears to be more concentrated in the seminal fluid and nonsperm fractions rather than adherent to the spermatozoa suggesting that PCV2 enters semen via migrating immune cells or in seminal plasma.

DIAGNOSIS

Although the classical gross and histopathological lesions associated with PMWS were described over a decade ago, the definitive diagnosis of PCVD in individual pigs is not always simple. In individual cases, the classical clinical signs (wasting, diarrhea, dyspnea, lymphomegaly, jaundice), histopathological lesions (granulomatous inflammation, lymphoid depletion) and PCV2 antigen associated with the lesions must be evident. However, the presence of simultaneous infections often makes diagnosis difficult. In these cases, diagnostic results may yield multiple viral or bacterial pathogens in addition to PCV2, and the significance of each must be ascertained. Another complicating factor in the diagnosis of PCVD is that PCV2 may be present, albeit at low levels, in the tissues of subclinically infected but seemingly healthy pigs. Thus, antibody testing in serum is not an effective tool to determine if a farm or pig is affected by PCVD. It only shows that PCV2 is present in a herd or that a pig was exposed. However, quantifying the levels of PCV2 in tissues may be useful in ascertaining the significance of PCV2

infection. In research settings, PCV2 levels may be semi-quantified in any lymphoid or non-lymphoid tissue using immunohistochemistry (IHC) or in situ hybridization (ISH). In commercial laboratories, semi-quantitative IHC or ISH is rarely performed, but quantitative polymerase chain reaction (qPCR) is becoming routine. However, ring tests performed in North America, indicate that the detection limits and the capability of qPCR assays to accurately quantify PCV2 DNA levels varies widely. Given this, the establishment of a "cut-off" level that could be used by all laboratories globally to distinguish PCVD from non-PCVD tissues is impractical. Cut off levels must be established and validated independently at each lab using their own PCR assay and standards. At our laboratory, PCV2 DNA levels above logarithm (base 10) 107 to 108 per gram in tissues, and above 104 to 105 per milliliter in serum are indicative of PCVD. Moreover, PCV2 DNA levels are most highly correlated ($.75 < r < .84$) with PCV2 IHC staining intensity scores in Peyer's Patches, spleen, lung and lymph nodes (Figure 2). Variable levels of PCV2 DNA are noted in some tissues of unvaccinated pigs in the absence of PCV2 IHC staining.

PCVD CONTROL & PCV2 VACCINES

Good production practices might help to reduce the impact of PCVD and coinfections. Thus, the MADEC 20 principles were at least partially effective in controlling PMWS in many European herds prior to the use of PCV2 vaccine. However, the concensus view is that the use of PCV2 vaccines, led to the rapid decline in the number of PCVD herd epizootics in North America in 2007. At the time of writing, there are four vaccines licensed (full or restricted) in Canada, and 3 licensed in the USA. Peer-reviewed research demonstrating the efficacy of these vaccines is expanding and clearly demonstrates that PCV2 vaccines, particularly if administered to piglets, are very efficacious reducing viremia, viral load, mortality, lesions and improving growth rates. PCV2 vaccination around weaning (about 3 weeks of age) is the routine protocol for piglet vaccination and protects until slaughter.

Because PCV2 exposure typically coincides with the waning of passive immunity between 6 and 8 weeks of age, it is not necessary to determine the time course of infection through serology or PCR prior to implementing an optimal vaccination program. However, if unacceptable levels of mortality continue after a PCV2 vaccination program is implemented, additional diagnostics to identify significant coinfections should be undertaken. Serology (testing for antibodies) is not a tool for testing efficacy of PCV2 vaccines. One-dose vaccines do not always induce seroconversion, but nevertheless are very successful in stimulating protective immunity. To judge the efficacy of a vaccine in the field, reduction of mortality, reduced number of culls and improved performance are the most relevant parameters. Based on these the economical benefit of piglet vaccination can be estimated, and is reported to be as high as 9.85 USD in a non-complicated case of PCVD. Importantly, the piglet vaccines are efficacious in the presence of maternal antibodies, and when coinfections including PRRS and Mycoplasma hyorhinis exist. Moreover, there appears to be cross-protection between the two PCV2 genogroups. Thus, the North American and the global swine industries are very fortunate, in that effective PCV2 vaccines are now widely available, and enhance the profitability of pork production systems.

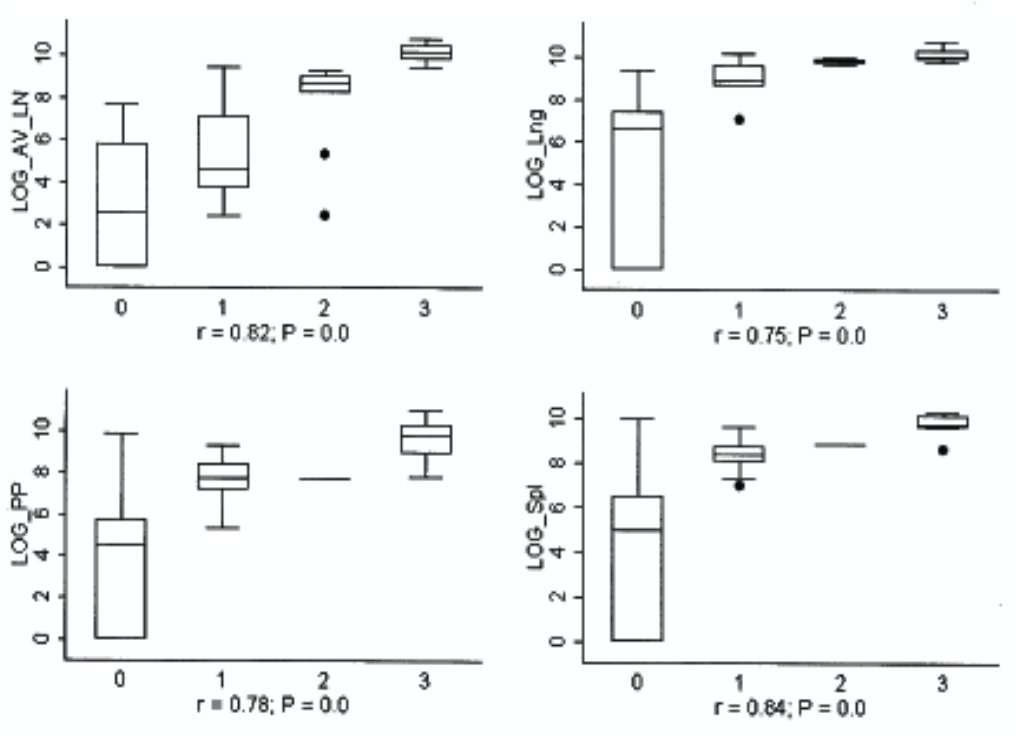

Figure 2. Box and whisker plots demonstrating the correlation between tissue porcine circovirus type 2 (PCV2) DNA concentrations and the intensity of PCV2 immunoperoxidase staining in tissue

Y-axis: Viral load log10 DNA concentration copies per gram (tissues); X-axis: PCV2 (immunohistochemistry) staining intensity score (0–3) in the tissue characterized. Abbreviations: LN = lymph node; Spl = spleen, PP = Peyer's patches, Lng = lung; Staining intensity scores: 0 = absent, 1 = mild, 2 = moderate, 3 = severe.

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