

# The 9<sup>th</sup> Mike Wilson Swine Research Day

May 22, 2012

9:30 AM – 3:30 PM

Arboretum Center, University of Guelph



# PROGRAM

- 9:30 AM Registration and coffee
- 10:00 AM Bob Friendship: Welcome
- 10:05 AM Dr. Peter Davies, University of Minnesota: The Paradox of Progress
- 11:00 AM Barb Wilhelm: Assessing the risk of three emerging and potentially zoonotic viruses
- 11:15 AM Vahab Farzan: Occurrence of Cryptosporidium and Giardia on Ontario swine farms
- 11:30 AM Durda Slavic: Clinical bacteriology in 21st century: How far have we come?
- 11:45 AM Tim Thalen: Changes at Arkell Swine
- 12:00 Lunch, posters
- 13:15 PM Andrea Bedford: Epidermal growth factor-expressing *Lactococcus lactis* enhances growth performance of early-weaned pigs fed diets devoid of blood plasma
- 13:30 PM Hein Snyman: Variation in constitutive expression of innate immune genes in healthy swine
- 13:45 PM Randy Duffy: Impact of Debt on Ontario Swine Farms
- 14:00 PM Elyse Love: Video imaging for real-time performance monitoring of growing-finishing pigs
- 14:15 PM Jessica Fox : A water sprinkling method to cool market pigs during summer transport
- 14:30 PM Lee-Anne Huber: Nutrient utilization in entire male pigs immunized to control boar taint
- 14:45 PM Ryan Tenbergen: Analgesia to reduce pain of castration
- 15:00 PM Kees deLange: Announcement of winning posters and closing remarks

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# **The Paradox of Progress: Implications for the future of meat production**

Peter R. Davies BVSc, PhD  
College of Veterinary Medicine, University Of Minnesota

There is no question that we are living in interesting times. The rate of technological change in science and day-to-day life is stupefying. Social change on varying dimensions occurs at unprecedented rates - from the “Arab Spring” and its fall out, to a black US president endorsing same sex marriage in an election year. Population growth and hyper-connectedness bring a new sense of shared vulnerability (see global financial crisis) and shared responsibility to a global citizenry closing in on 9 billion. Over 10,000 years, innovation in food production has arguably been the most fundamental platform of societal change. In relatively little time we have shifted from a scenario where most people engaged in food production to our current situation where only a small minority are primarily engaged in food production – with the remainder relatively free for other creative pursuits. Is this a time for optimism or pessimism? On one hand people in many developing countries are escaping poverty at rapid rates and changing their consumption patterns to consume more animal proteins – towards a bigger, wealthier and more carnivorous world. On the other hand, the ‘global food system’ in general, and livestock production in particular, are under a cloud regarding “sustainability” and other attributes as we stretch the boundaries of available arable land resources and possibly technology.

The term ‘paradox of progress’ has been applied in various settings to discuss the phenomenon of change, and its impact upon our world and upon our perceptions of that world. A few of the ‘angles’ raised by others have been:

- As we move forward as a society we create more problems
- Higher economy growth and consumerism leads to more stress as people work more and society falls behind
- The more we know, the more we have to discover
- The better things become, the worse they are perceived

L.P. Hartley stated “The past is a foreign country: they do things differently there”. So therefore is the future! By the middle of this century, pig production and its needs for research will be unimaginably transformed. Who and what will lead this transformation?

# ASSESSING THE RISK PROFILE OF THREE EMERGING AND POTENTIALLY ZOO NOTIC VIRUSES

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The objective of this study is to profile the potential zoonotic public health risks of three viruses in Canada: hepatitis E virus, Norovirus, and rotavirus, using a combination of evidence synthesis, field surveys, and expert opinion. The publicly available evidence for zoonotic risks of the selected viruses will be synthesized using scoping study, systematic review and meta-analysis methods. The scoping study will involve a comprehensive literature search, followed by independent screening of each citation by two reviewers for relevance, categorisation, and targeted data extraction. Evidence gaps identified by the scoping study will guide the content of an expert elicitation. Where appropriate, specific quantitative aspects of the broad research question will be investigated using systematic review and meta-analysis. Concurrently, a national prevalence survey of these viruses in on-farm swine, retail pork chops, and pork livers will be conducted, using the Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS) sampling frame. Diagnostics will be based on recognized reverse transcriptase polymerase chain reaction (RT-PCR) tests. Finally, this evidence will be summarised in the form of a risk profile to guide future risk assessments and inform federal public health and agri-food policy.

## Occurrence of *Cryptosporidium* spp. and *Giardia duodenalis* on Ontario swine farms

Farzan, A.<sup>1</sup>, Dixon, B.<sup>2</sup>, Pollari, F.<sup>3</sup>, Friendship, R.<sup>1</sup>, Cook, A.<sup>3</sup>, Farber, J.<sup>2</sup>, Parrington, L.<sup>2</sup>, Pintar, K.<sup>3</sup>

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### Background

The apparently healthy pigs may shed *Cryptosporidium* oocysts and *Giardia* cysts into environment. It is possible that those zoonotic agents get into ground water and contaminate the environment. Exposure to infective oocysts/cysts through the contaminated water, food and produces is an important mode of infection in human. Although human, livestock, and wildlife have been shown as potential source of *Cryptosporidium* and *Giardia* in the environment, a little is known about attribution of each source to the presence of those parasites in environment.

### Objective

To describe the prevalence, the genotypes and species of *Cryptosporidium* spp. and *G. duodenalis* among pigs in different stage of production and in stored manure on a subset of Ontario swine farms.

### Material and Methods

Ten swine farms were visited three times between September 2005 and May 2006. Fecal samples were collected from the stored manure pit and fresh samples obtained from finishers, sows, and weaners. *Cryptosporidium* oocysts and *G. duodenalis* cysts were detected in the manure samples using immunofluorescence microscopy. Also a nested PCR was used to determine the presence of *Giardia* and *Cryptosporidium*. PCR products were sequenced to determine species and genotypes. A logistic regression modeling method was used in order to compare the presence of *Giardia* and *Cryptosporidium* among samples collected from different stage of production.

### Results

*Cryptosporidium* oocysts and *Giardia* cysts could be recovered on the all 10 farms. *Cryptosporidium* oocysts and *Giardia* cysts were present in 62 (50.1%) and 54 (44.3%) of samples, respectively. However, using PCR, 68 (55.7%) and 81 (66.4%) of fecal samples were positive for *Cryptosporidium* and *Giardia*, respectively. *Cryptosporidium* was more likely (OR=3.6) detected from manure pit samples and weaners (OR=3.3) compared to finisher pigs. However, it was less likely (OR=0.06) to be recovered from sows compared to finisher pigs. Prevalence of *Giardia* in samples collected from manure pits and finisher pigs did not differ ( $P > 0.05$ ). However, *Giardia* had a decreased chance (OR=0.2) to be isolated from sows. For *Cryptosporidium* spp., four different genotypes were determined; *C. parvum* (55.4%), pig genotype II (37.5%), *C. muris* (5.4%), and *C. suis* (1.8%). The two different *Giardia* genotypes were Assemblage B (92.1%) and Assemblage E (7.9%).

### Conclusion

The occurrence of *Cryptosporidium* spp. *G. duodenalis* and was high in the swine manure samples. The manure management procedures may not be effective in order to eliminate the zoonotic agents from hog manure and as such fails to prevent the environmental contamination. Therefore, it warrants serious attention. The molecular characterization of *Cryptosporidium* spp. and *G. duodenalis* found in this study is useful to investigate possible sources of infection in human.

### Acknowledgement

We would like to acknowledge the Public Health Agency of Canada for funding the C-EnterNet program. We thank Bryan Bloomfield for the field work, as well as the pork producers for their participation in this study.

## **Clinical bacteriology in 21<sup>st</sup> century: How far did we get?**

Durda Slavic, DVM, MSc, PhD

Clinical bacteriology has always been a labour intensive and time consuming part of diagnostic testing. Bacteria are grown on agar plates, pure cultures are obtained and then individual colonies are used for biochemical testing to determine bacterial species. For biochemical testing a set of sugars is inoculated and incubated for a day, two or sometimes a week before bacterial ID can be obtained. A few systems have been introduced in the past that help speed up that process. However, even with these systems available it still takes a day or two before bacterial ID is obtained. In addition, there are some organisms that cannot be cultured, are very slow growing and/or have fastidious growth requirements. At present, these bacteria are mostly detected by using polymerase chain reaction (PCR). While PCR has a great value in detection and identification of these organisms it does have some limitations too.

Recently, AHL acquired two new instruments, namely MALDI-TOF MS and GS Junior that have a great potential for establishing quick and accurate diagnosis of bacterial diseases. This presentation will discuss the use of these two systems in clinical bacteriology and how they are/will be applied to improve diagnostic of bacterial diseases of swine.

## **Changes Coming to the Arkell Swine Research Facility**

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Robert Friendship, Swine Research Co-ordinator, University of Guelph

### **Background**

The Arkell Swine Research Facility has been operating for over thirty years, and the farrowing and nursery rooms are operated all-in/all-out but the wing is a continuous flow. For the most part the herd health has been good, and pigs are free of most important swine pathogens. However over the past year Strep suis meningitis has become difficult to control. Autogenous vaccine has been tried but not very successful. In order to try to achieve an improvement in piglet health, we will try to create a gap in production, allowing clean out and disinfection of the wing and then move to 4-week batch-farrowing to facilitate more of an all-in and all-out flow.

### **Methods**

The goal will be to create 40 farrowings in a batch and farrow a batch of 40 sows once every 4 weeks, instead of the current 10 farrowings each week. In order to accomplish these larger group sizes we will strategically wean some sows a week later than usual, weaning two weeks worth of sows at once, as well as allowing certain sows to skip a breeding in order to fit into a batch. When necessary sows will be weaned and medicated with altrenogest (Regu-Mate®, Merck Animal Health) to prevent cycling until the desired time. The same strategy will be used in selecting gilts. The timing of puberty induction will be synchronized to match the weaning of sows. Regu-Mate® might be used to synchronize gilts already cycling. Along with timed-onset of boar exposure, the use of a combination of hCG and eCG (PG600®, Merck Animal Health) will be used to help induce a synchronized puberty. It will be necessary to transform the current 20 groups of sows into 5 larger groups. The groups will be maintained by controlling gilt introductions and care in rebreeding sows.

### **Implications**

The advantages to batch farrowing will be that there will be larger pools of similar aged pigs available for research studies, the flow of pigs may help to control disease, and labour may be more efficiently used. The disadvantages are that there will not be a continuous supply of pigs and therefore researchers will need to be aware that new piglets will be only available every 4 weeks and plan research projects accordingly. Sows farrowing as a result of this new system will begin in late fall.

## EGF-expressing *Lactococcus lactis* enhances growth performance of early-weaned pigs fed diets devoid of blood plasma

Andrea Bedford<sup>1</sup>, Zhi Li<sup>2</sup>, Ming Li<sup>2</sup>, Shaoli Ji<sup>2</sup>, Kees De Lange<sup>1</sup>, Julang Li<sup>1</sup>

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Stress and incomplete gastrointestinal development in early-weaned pigs represent significant challenges in commercial pork production. Largely because of food safety concerns, there is a trend to limit animal-derived ingredients in pig feeds. Therefore, alternative methods should be developed to stimulate intestinal development and provide disease resistance. Previously we have shown that feeding early-weaned piglets *Lactococcus lactis* that was engineered to express epidermal growth factor (*EGF-LL*) improves mean villous height in the intestine. In this study, we examined the effect of supplementing EGF-LL to early-weaned pigs that were fed diets with typical levels of blood plasma (5%; high complexity) or diets without blood plasma (blood plasma was substituted with soybean meal and fish meal, based on amino acid supply; low complexity). A total of 108 newly weaned piglets (19-26 days of age, mean BW 6.58 kg; 9 pigs per pen) were fed ad libitum according to a 2-phase feeding program without growth promoters. Three pens were assigned to each of four treatments: 1) high complexity diet with blank bacterial growth medium (HiCon), 2) high complexity diet with fermented EGF-LL (HiEGF), 3) low complexity diet with blank bacterial growth medium (LoCon), and 4) low complexity diet with fermented EGF-LL (LoEGF). The amount of EGF was determined in the fermentation product and pigs were allotted 60 ug EGF/kg/day during the first 3 weeks post-weaning. There were no differences ( $P>0.10$ ) in growth performance between HiCon and HiEGF pigs and no differences ( $P>0.10$ ) in total growth performance between LoCon and LoEGF pigs. LoEGF pigs showed increased daily body weight gain (410 vs. 260 g/d;  $P<0.01$ ) and Gain:Feed (0.67 vs 0.58;  $P<0.05$ ) compared to LoCon pigs in the third week of treatment; this was comparable to the HiCon group (400 g/d and 0.64). These results indicated that supplementation with EGF-LL can be effective in enhancing the performance of early-weaned piglets fed a low complexity diet, and reduces the need for feeding high-quality animal proteins and antibiotics.

**Key words:** epidermal growth factor, probiotics, growth performance

## Variation in constitutive expression of innate immune genes in healthy swine

HN Snyman, JD Hammermueller, MA Hayes, BN Lillie

**Abstract:** Infectious diseases remain an important factor limiting production, growth performance, economics and welfare in the global swine industry with both environmental and genetic factors contributing to this multifactorial problem. A critical component in the defence against infectious disease is represented by the various secreted, membrane bound and intracellular proteins that make up the innate immune system, which is particularly important in young animals. Identification of genetic defects within innate immune proteins that impair the innate immune response would allow for selection for swine with improved disease resistance and growth performance. To date a number of single nucleotide polymorphisms (SNPs) have been identified within some innate immune genes of swine and some of these have been shown to be more prevalent in pigs with various common, economically important infectious diseases (enteritis, serositis, pneumonia) and/or specific pathogens. Using genome wide microarray technology we are studying constitutive hepatic gene expression to identify other functionally significant genetic defects in innate immune genes with widely variable expression. Agilent microarrays were performed on liver mRNA from 96 healthy market weight pigs. Constitutive variation was identified by determining gene expression ratios of the mean expression values of the top 50% of pigs to the mean expression values of the bottom 5% of pigs after excluding high expressing outliers. Various innate immune genes with widely variable expression were identified and the promoter regions of some of the identified innate immune genes with the highest and lowest expression ratios are being sequenced to identify genetic differences in their promoter regions. The discovery of these SNPs ultimately will result in the development of a more complete genetic selection panel leading to increased disease resistance within the commercial swine population and will: increase production, promote animal health and welfare, and decrease use of antimicrobials.

## **Impact of Debt on Ontario Swine Farms**

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### **Introduction**

The Ontario swine industry has endured poor profitability since at least 2006. As a result, many producers have left the industry while many of the producers remaining in the industry have taken on more debt. This has raised concern over what effect rising interest rates will have on the industry. This abstract is intended to provide some highlights from a report analyzing the debt situation on Ontario swine farms for the period from 2003 to 2009.

### **Methodology**

Data from several sources (Statistics Canada, United States Department of Agriculture, OMAFRA and the University of Guelph, Ridgetown Campus) was used to compare debt related financial ratios for Ontario swine farms against swine farms in Manitoba, Quebec and the U.S. as well as other Ontario farm sectors. Analysis using the Ontario Farm Income Database (OFID) was further disaggregated into results for swine farms by farm size (i.e. gross revenue range) and production type.

### **Selected Key Findings**

- Estimated debt per farm has increased significantly from 2003 to 2009, especially during the 2007 to 2009 period.
- There is a lot of variability within the OFID data. Often more variability exists within categories than between categories (i.e. different farm sizes or production types).
- Profitability is not necessarily related to debt level, farm size or production type.
- On an aggregate industry level, debt levels and debt servicing requirements on average do not appear to be the major determining factor in profitability. However, looking at data disaggregated into five quintiles showed that there are farms that are doing very well financially (i.e. top 20%) while there are farms that are struggling (bottom 20%), regardless of the year, farm size or production type.
- The ability to maintain a debt level that is balanced with the farm's ability to generate revenue and control costs is important. The ratio or balance of total debt to total revenue will be unique to each farm due to the many other variables (i.e. management, productivity, importance of off-farm income, etc.) that can affect profitability.
- Sensitivity analysis showed that the estimated impact of a 2% interest rate increase would have resulted in additional interest expenses of \$2-\$3 per pig sold.

### **The entire report is available at:**

[http://www.ridgetownc.uoguelph.ca/research/documents/mcewan\\_AMI\\_Swine\\_Farm\\_Debt\\_-\\_Final.pdf](http://www.ridgetownc.uoguelph.ca/research/documents/mcewan_AMI_Swine_Farm_Debt_-_Final.pdf)

### **The benchmarking comparison spreadsheet tool is available at:**

[http://www.ridgetownc.uoguelph.ca/research/documents/mcewan\\_Impact\\_of\\_Debt\\_on\\_Ontario\\_Swine\\_Farms\\_-\\_Debt\\_Comparison\\_Tool.xls](http://www.ridgetownc.uoguelph.ca/research/documents/mcewan_Impact_of_Debt_on_Ontario_Swine_Farms_-_Debt_Comparison_Tool.xls)

### **Acknowledgements**

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Thank you and appreciation is extended to Ontario Pork for their support.

## Video imaging for real-time performance monitoring of growing-finishing pigs

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**Background:** Knowledge of daily growth rates of pigs allows producers to optimize feeding programs and marketing practices. Feeding and management of growing-finishing pigs is typically based on retrospective analysis of historical growth performance. The latter reflects limitations of conventional data collection methods for real-time monitoring of pig growth performance. Visual image analysis (VIA) uses aerial-view images of animals to determine body surface dimensions and may be used for real-time monitoring of pig growth. Qscan is a VIA system that is available for commercial use in growing-finishing pig units in the United Kingdom.

**Objectives:** To assess the ability of Qscan to accurately and precisely estimate: (1) live BW of individual pigs, and (2) mean BW for groups of growing-finishing pigs.

### Material and Methods:

Trial 1: Examined the ability of Qscan to estimate weekly BW of individual and pens of pigs in a research setting. 96 purebred Yorkshire pigs in 12 pens were monitored over a 6 week period between 50 and 92 kg BW in a 2 x 2 factorial design, allowing assessment of the effects of gender (barrows vs. gilts) and feeding ractopamine (0 vs. 5 ppm) on the Qscan system's precision and accuracy.

Trial 2: Examined the ability of Qscan to estimate weekly mean pen BW of pigs in a commercial facility. 240 Hypor x Danbred pigs (4 pens with 30 barrows and 4 pens with 30 gilts) were monitored over a 12 week period between 36 and 108 kg BW.

All pens of pigs were continuously monitored using the Qscan system and all pigs were weighed individually at weekly intervals using a conventional weigh scale in both trials.

### Results:

Trial 1: There were no differences between actual (scale) and Qscan BW for individual pigs ( $P>0.10$ ); there was no bias due to gender or feeding ractopamine ( $P>0.10$ ). When predicting BW of individual pigs with Qscan a residual standard deviation between 3.0 and 5.4 kg is expected. Actual and Qscan estimated mean pen BW differed in week 3 only ( $P<0.05$ ). The accuracy of Qscan differs between genders, with interactions between gender and methods for determining BW occurring in weeks 2 and 3 ( $P<0.05$ ). The difference between actual and Qscan estimated mean pen BW was less than 1.46 kg for gilts ( $P>0.10$ ). On average Qscan overestimated mean pen BW of barrows by 3.51 kg for weeks 1 to 3 ( $P<0.05$ ) and week 4 ( $P<0.10$ ), but was within 0.45 kg of actual mean pen BW for weeks 5 and 6 ( $P>0.10$ ).

Trial 2: Actual and Qscan estimated mean pen BW differed in weeks 1 to 5 and 7 to 9 ( $P<0.05$ ), with estimates within 3.33 kg of actual weight over these weeks. Actual and Qscan estimated mean pen BW did not differ in week 6, or 10 to 12 ( $P<0.10$ ), with estimates within 1.35 kg of actual weight for each of these weeks. The accuracy of Qscan differed between genders in week 8 only ( $P<0.05$ ). During this time, Qscan overestimated mean pen BW for barrows by 2.28 kg, while underestimating mean pen BW for gilts by 0.07 kg.

**Take home message:** Video imaging is a promising method for performance monitoring of growing-finishing pigs, but refinements are required. Filtering of poor quality images requires improvement. Variation in the number of weight measurements of individual pigs relative to the total number of images per pen contributes to the discrepancy between Qscan estimated and actual pen mean BW. Separate algorithms may be required to account for gender and genotype effects on relationships between area and actual BW.

**Acknowledgements:** Financial support for this research is provided by the Farm Innovation Program, Ontario Pork and Wallenstein Feed and Supply Ltd.

## **A water sprinkling method to cool market pigs during summer transport**

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Heat stress in market pigs resulting from transport during hot weather is one of the leading causes of reduced transport welfare and increased in-transit death losses. It has been shown that water sprinkling during lairage decreases micro-climate and pig body temperatures and improves welfare, but there is no evidence of these effects during transport. The aim of this study was to observe if sprinkling pigs in trailers before and after transport decreased signs of heat stress. In each of 12 weeks from May to September 2011, 2 pot-belly trailers with 208 pigs per trailer were transported 2h to slaughter. One was outfitted with a sprinkler system that ran for 5min (~125 litres) before departure from the farm and before unloading at the plant. In each trailer, 4 test compartments (1 on the top deck, 2 on the middle deck, and 1 on the bottom deck) were outfitted with cameras, and the core body temperature (CBT) of 4 randomly chosen pigs (n=384) in each were recorded using orally administered iButtons. Trailer and deck loading order were randomized. Behaviors during transport, unloading and during lairage were recorded from video or live observations. Data were analyzed through ANOVA with ambient temperature external to the truck (AmbT) as a co-variant. AmbT averaged  $19.5^{\circ}\text{C} \pm 3.8^{\circ}\text{C}$  (range:  $14\text{-}26^{\circ}\text{C}$ ). At  $\text{AmbT} > 23^{\circ}\text{C}$ , there was no effect of sprinkling on behavior on-truck (standing, sitting or lying), but at  $\text{AmbT} < 23^{\circ}\text{C}$ , more pigs stood on sprinkled trucks ( $P < 0.05$ ). Sprinkling did not affect slips or falls during unloading. In lairage, latency to lie was shorter when  $\text{AmbT}$  exceeded  $23^{\circ}\text{C}$  ( $P < 0.05$ ) and sprinkled pigs spent more time lying and less time sitting ( $P < 0.05$ ) and had fewer drinking bouts than controls ( $P < 0.0001$ ) regardless of  $\text{AmbT}$ . CBT increased between loading and departure and decreased while in transit for all pigs ( $P < 0.0001$ ), and sprinkling further reduced CBT at arrival at  $\text{AmbT} > 24^{\circ}\text{C}$  ( $P < 0.10$ ). Therefore, sprinkling pigs when ambient temperature exceeds  $23^{\circ}\text{C}$  may help to cool pigs and improve welfare, indicated by reduced number of drinking bouts and reduced body temperature at arrival. Adding water to the trailer did not have any detrimental effects during unloading.

## **Nutrient utilization in entire male pigs immunized to control boar taint**

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### **Background**

Due to decreased production costs and improved lean gain, raising entire male pigs is preferred. However, the presence of boar taint compounds in meat from entire male pigs raises consumer acceptability issues. Additionally, the conventional use of surgical castration to circumvent boar taint is under continuing scrutiny from animal welfare groups and consumers. Immunization against gonadotropin-releasing factor (GnRF) with IMPROVEST inhibits the action of the hypothalamic-pituitary-gonadal axis, reduces the production of boar taint and affects subsequent growth and feed intake in immunized male pigs.

### **Objectives and methods**

Using a series of nitrogen balances the dynamics of whole body protein deposition (PD) were determined in immunized males and compared to entire male pigs, conventional, early castrates and male pigs castrated between 25 and 40 kg (late castrates). Furthermore, serial blood and fat sampling were conducted to measure the boar taint compounds androstenone and skatole, and to identify potential hormones regulating changes in PD. Immunized males received the initial dose of IMPROVEST at 30 kg and the booster dose at 70 kg. All male pigs were fed common corn-soybean meal based diets that were highly fortified to allow for high levels of PD.

### **Results**

Immunization against GnRF was effective at removing androstenone from both plasma and fat tissue by d 18 after administering the booster dose. Feed intake increased in immunized males in the first week after administering the booster dose and remained higher than entire male pigs but similar to early and late castrates until slaughter. Across periods, PD for early and late castrates were similar ( $P > 0.10$ ), and lower than entire male pigs ( $P < 0.001$ ). The PD in entire male pigs and immunized males was similar until d 7 ( $P > 0.10$ ), tended to be higher for entire male pigs than immunized males between d 9 and 16 ( $P = 0.07$ ) and was higher for entire male pigs than immunized males after d 20 ( $P < 0.05$ ). Between d 9 and 36 PD in immunized males was similar to early and late castrates ( $P > 0.10$ ). The dynamics of plasma urea nitrogen, as a measure of amino acid catabolism, confirmed the relative differences in PD across treatments. Plasma levels of estrone sulphate (E1S) were similar in entire male pigs and immunized males up to d 5 ( $P > 0.10$ ). From d 8 to d 37 E1S levels were higher in entire male pigs than immunized males ( $P < .0001$ ) and after d 5 E1S level did not differ between immunized males and early and late castrates ( $P > 0.10$ ).

### **Significance to the industry**

Entire male pigs immunized against GnRF maintain entire male-like PD until approximately one week after administering the booster dose. This suggests that diets high in essential nutrients for PD should be offered to immunized male pigs until approximately one week after administering the booster dose. Thereafter, feeding diets appropriate for early castrates would also be suitable for immunized male pigs as PD decreases and feed intake becomes similar to early castrates.

### **Funding**

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## **Analgesia to Reduce Pain of Castration**

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### **Background**

In Canada, all male piglets are routinely castrated. Surgical castration involves several events likely to be painful including scrotal incision, extraction of the testes, and severing the spermatic cords. It is common for the procedure to be carried out in the absence of anaesthesia and post-operative analgesia. There are few products licensed for use in food-producing animals for pain control, and few studies have been done to compare their relative effectiveness. The lack of pain control associated with these procedures is of growing scientific and public concern due to consideration of piglet welfare. The objective of this paper is to evaluate the efficacy of two non-steroidal anti-inflammatory drugs (NSAIDs), meloxicam<sup>1</sup> and ketoprofen<sup>2</sup>, for the treatment of post-operative pain associated with surgical castration of male piglets.

### **Materials and Methods**

Two different studies were carried out on the same swine operation and involved a combined total of 2,990 piglets from 997 litters (meloxicam: 1,499 piglets from 407 litters; ketoprofen: 1,491 piglets from 590 litters). In both studies, piglets were randomly allocated to receive an intramuscular injection of either the analgesic (meloxicam: 0.4mg/kg; ketoprofen: 3mg/kg) or a placebo at least 30 min prior to castration. All piglets were weighed on the day of castration (5-7 d of age) and prior to weaning (meloxicam: 19-21 d of age; ketoprofen: 19-23 d of age).

### **Results**

Castrated piglets receiving meloxicam had lowered plasma cortisol levels at 30 min ( $P<0.01$ ), 60 min ( $P<0.01$ ), and 90 min ( $P<0.01$ ) following castration compared to those receiving the placebo, but cortisol levels at 4 h were not different ( $P=0.45$ ). The same was true for piglets receiving ketoprofen at 30 min ( $P<0.01$ ), 60 min ( $P<0.01$ ), 90 min ( $P<0.01$ ), and 4 h ( $P=0.09$ ). In the meloxicam study, castrated piglets receiving meloxicam displayed less isolated behaviour compared to piglets receiving the placebo ( $P=0.02$ ). There were no significant treatment effects for weight gain or mortality in either study.

### **Conclusion**

Despite pressure for animal welfare advancement, the use of analgesia or anaesthesia in farm animals during routine painful procedures is still not a general practice. Producers in the future may need to consider using pain control as part of their standard operating procedures in order to improve piglet welfare and meet their consumers' expectations, but are unlikely to see an economic return associated with using analgesia because growth performance is not affected. The NSAIDs meloxicam and ketoprofen appear effective in the treatment of post-operative pain associated with surgical castration of male piglets based on plasma cortisol levels and no detrimental effects of the drugs were observed.

### **Acknowledgements**

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# **The impact of lower gut nitrogen supply on nitrogen balance and urea kinetics in growing pigs fed a valine-limiting diet**

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## **Background**

Nitrogen (N) absorption from the lower gut is generally thought to be of little nutritional significance. However, studies have shown the presence of amino acid transporters in colonocytes. Nitrogen disappearance from the lower gut, in the form of ammonia, may be recycled into the upper gut as urea and incorporated into microbial AA that may be absorbed and utilized by the host. The objective of this study was to determine the utilization of lower gut N supply for protein deposition (**PD**) and urea kinetics in growing pigs fed a diet limiting in an indispensable amino acid.

## **Methodology**

Growing pigs (initial BW of  $22.6 \pm 1.2$  kg) were fitted with a simple T-cannula in the caecum and catheters in the left and right external jugular veins. All pigs received the same cornstarch and soybean meal-based diet that was formulated to be first limiting for valine. Among indispensable AA, the largest potential contribution of microbial protein to the host's AA supply is for valine. Pigs were randomly assigned to 1 of 3 caecal infusions (saline, casein, or urea) infused at a rate equivalent to 40% of daily dietary N intake. A continuous infusion of isotopic urea was used to determine urea kinetics.

## **Results**

1. The majority of infused N, as either casein or urea, was absorbed.
2. Urinary excretion of urea and N was increased with the infusion of casein and urea. Urinary excretion of urea and N did not fully account for the lower gut disappearance of N.
3. Body protein deposition was not affected by the caecal N infusions, however, N and valine utilization for PD were improved with the infusion of N. The utilization of lower gut N for PD was the same for both caecal N infusions.
4. Urea flux and the total amount of urea recycled into the upper gut were increased with both the caecal N infusions.

## **Conclusions and Implications**

Lower gut N disappearance is in the form of non-protein N which can be used for microbial AA production of indispensable amino acids in the upper gut and, based on valine and N utilization for PD, improves PD by more than 10%. Lower gut N metabolism should be considered when determining N and amino acids requirements.

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# **Impact of nursery pig feeding practices on subsequent growth performance and carcass quality**

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## **Background**

There is debate surrounding the extent to which piglet growth performance in the nursery impacts subsequent growth performance and carcass quality at market weight. The general notion is that reduced growth in the nursery will negatively impact overall performance up to market weight. However, reduced growth performance in the nursery may induce compensatory growth during the grower-finisher phase.

## **Objectives and Methods**

The objective of this study was to determine the impact of nursery diet complexity on lifetime growth performance and carcass quality at market weight. Five blocks of pigs (N=552) were weaned at  $7.03 \pm 0.07$  kg BW and pigs were randomly assigned to 1 of 4 dietary treatments: complex (highly digestible ingredients) or simple (corn-soybean meal) with or without in-feed antibiotics (273g of Aureomycin 220 per 100 kg complete feed). Pigs were fed according to a 3-phase nursery feeding program for 6 weeks post-weaning. Thereafter, pigs were moved to grower-finisher pens and fed common non-limiting diets. Individual body weight, pen feed disappearance and feed efficiency were measured weekly in the nursery and every 2 weeks in the grower-finisher unit. At 110+ kg BW pigs were sent to market and carcasses were graded according to the Canadian grading system. All data was analyzed in SAS using the MIXED procedure; repeated measures were included for growth performance data (significance at  $P < 0.05$ ).

## **Results**

In the nursery, feeding simple diets and not using in-feed antibiotics reduced growth performance. Average daily gain (ADG) and gain:feed (G:F) were 438 g/d and 0.66 g/g for pigs fed the complex ration with antibiotics respectively while these values were 377 g/d and 0.58 g/g for pigs fed the simple diet without antibiotics. However, there were no differences among treatments for wean-to-finish performance and carcass characteristics. Overall ADG, G:F and carcass lean yield were 872 g/d, 0.43 g/g and 60.2% for pigs fed the complex diet with antibiotics while these values were 872 g/d, 0.43 g/g and 60.3% for pigs fed the simple diets without antibiotics.

## **Conclusions and Implications**

Feeding simple nursery rations reduced performance in the nursery but did not compromise wean-to-finish growth performance or carcass characteristics. Feeding simple rations may reduce feed costs may without compromising wean-to-finish growth performance or carcass quality. However, the impact of nursery feeding strategy on the pig's ability to handle stress requires further examination

## **Funding**

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# Producing Antimicrobial Porcine Protegrin-1 in *Pichia pastoris* for Potential Use as an Alternative to Conventional Antibiotics

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## Background

Antibiotics remain at the forefront for treatment of microbial infections in humans and animals; however, the increase prevalence of bacterial resistance to conventional antibiotics is a growing public health concern. To overcome antibiotic resistance, searching for effective antibiotic alternatives is a challenge. Antimicrobial peptides (AMPs) are innate immune defense molecules that are naturally produced by animal cells. In contrast to conventional antibiotics, AMPs can exert its activity against a broader range of microorganisms including bacteria, fungi and enveloped viruses. Moreover, it is more difficult for pathogens to generate resistance to AMPs due to the distinct mechanism of action of AMPs. Porcine protegrin-1 (PG-1) has been well studied and structurally characterized allowing it to be an attractive candidate for therapeutic use as an alternative to antibiotics. However, chemically synthesized AMPs are too costly to be feasible for routine use in the food-animal industry. Recombinant expression of PG-1 using a safe and nonpathogenic microbial such as yeast is a potentially inexpensive alternative approach to chemical peptide synthesis for larger-scale food and animal application.

## Methodology

**Generation of recombinant *P.pastoris* expressing proform PG-1:** Porcine proform PG-1 DNA was codon optimized and cloned into an expression vector, and introduced into *Pichia pastoris*. Twenty four hours after induction for expression, proform PG-1 in the supernatant was detected by Western blotting using anti-PG-1 antibody. **Antimicrobial activity assay:** Antimicrobial activity of uncleaved proform PG-1 and enterokinase cleaved proform PG-1 were tested by two-stage radial diffusion assay against *E.coli*. Clear inhibition zone around wells indicated antimicrobial activity.

## Results

The 13.5 kDa proform PG-1 was detected in the recombinant yeast supernatant. After concentration and cleavage with enterokinase, antimicrobial activity of the recombinant porcine PG-1 was evident via the radial diffusion assay against *E.coli*.

## Benefits to swine industry

Resulting data establishes the potential feasibility of using microbes, in particular the yeast *P. pastoris*, as bioreactors to express and secrete biologically active animal-derived antimicrobial peptides for potential large-scale application. Further study will improve the efficiency of the recombinant PG-1 expression system.

## Acknowledgements

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## **Impact of post-weaning feeding strategies on subsequent productivity of growing pigs**

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### **Background**

The relationship between growth performance in the nursery and of the growing-finishing pig is a subject of considerable debate but of great practical relevance. The common view suggests that compromised growth in the nursery reduces overall performance up to market weight; however, recent work in the UK indicated that reduced weaning performance due to a lower quality diet does not influence subsequent growth performance.

### **Objectives and methods**

A performance study is currently underway to test the effect of compromised post-weaning growth on growth performance in the growing-finishing phase and carcass characteristics at market weight. During the nursery phase (28 – 70 d of age), pigs are fed 1 of 4 test diets: complex (highly digestible ingredients) or simple (corn and soybean meal based) diets with or without in-feed antibiotics. All pigs receive identical diets during the growing-finishing phase. Body weight, feed intake and feed efficiency are calculated on a weekly basis in the nursery phase and every 2 weeks in the growing-finishing phase. In subsamples of pigs, digesta and tissue samples are obtained to better understand how diet impacts the pigs' physiology. A total of 5 blocks of 120 pigs each will be used. The following growth performance results are a preliminary analysis of data obtained for 2 blocks up to market and 1 block up to 6 weeks post-weaning. Carcass data for 1 block has been obtained.

### **Results**

There was little interaction between diet and antibiotic inclusion for growth performance in either the nursery or growing-finishing phase. Pigs fed the complex diet or diets with antibiotics were heavier ( $P < 0.05$ ) from wk 1-6 and wk 3-6 post-weaning; however, there was no difference in market weight at the same age among pigs. Similar results were observed for daily gain. In the nursery, feed intake was greater ( $P < 0.05$ ) in pigs fed the complex diet but there was no effect of antibiotic on feed intake and no differences in feed intake were observed in the growing-finishing phase. In the first week post-weaning, pigs fed complex diets had greater ( $P < 0.05$ ) feed efficiency; however, feed efficiency of pigs fed the simple diet increased from wk 2-6 such that there was no difference over the entire nursery phase. There was no effect of post-weaning diet on days to market ( $122 \pm 1$ ) or carcass characteristics; however, a numerical trend to greater lean yield and value in pigs fed the simple diet and greater fat content and lower value in pigs fed the complex diet was observed.

### **Significance to industry**

Feeding simple diets (corn and soybean meal) to nursery pigs reduced growth performance post-weaning but had no long-term effect on growth performance in the growing-finishing phase, days to market or carcass characteristics. Therefore, a reduction in feed costs may be obtained in the nursery phase by feeding less complex diets without compromising subsequent growth performance and carcass value.

### **Funding**

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# Low complexity starter pigs diets do not induce long-term negative effects on digestive function

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## Background

Using low complexity diets can significantly reduce feeding costs but can result in reduced starter pig growth performance. We have previously demonstrated that feeding low complexity diets compromises growth performance of nursery pigs but induced compensatory growth and improved feed efficiency thereafter, such that there was no difference in overall performance, days to market or carcass quality at slaughter.

## Objectives and methods

A longitudinal study was undertaken to explore physiological mechanisms involved in compensatory growth following compromised post-weaning growth. 56 pigs were fed a complex (highly digestible ingredients) or simple (corn and soybean meal based) diet with or without in-feed antibiotics (273g of Aureomycin 220 g per 100 kg complete feed) during the nursery phase (28 – 70 d of age). All pigs receive identical diets during the growing-finishing phase. Pigs were killed at 2, 4, and 8 weeks post-weaning and proximal jejunum and distal ileum were sampled for evaluation of histology and enzyme activity. Sucrase and lactase activity were determined in the proximal jejunum while aminopeptidase N (APN) activity was determined in the distal ileum.

## Results

There was no effect of in-feed antibiotic on gut morphology or digestive function. In the proximal jejunum gut morphology was affected by diet at wk 2 and 4, but not at wk 8. Villus height was lower ( $P = 0.03$ ) at wk 2 in pigs on L than H (352 vs 424  $\mu\text{m}$ ) but not different at wk 4 (519 vs 490  $\mu\text{m}$ ). There was no effect of diet on crypt depth; villus height/crypt depth ratio increased ( $P = 0.02$ ) from wk 2 to wk 4 (2.1 vs 2.8) in pigs on L, but was not changed (2.3 vs 2.5) in pigs on H. Diet did not impact gut morphology at the distal ileum. Intestinal alkaline phosphatase (IAP) substrate affinity ( $\text{IAP}_{K_m}$ ) was highest at wk 2 (2.20 mmol/L,  $P < 0.05$ ) in the jejunum but highest at wk 8 (1.81 mmol/L,  $P < 0.05$ ) in the ileum, regardless of diet. Similarly, maximal specific activity of IAP ( $\text{IAP}_{V_{\max}}$ ) was highest ( $P < 0.005$ ) at wk 2 in the jejunum and highest at wk 8 ( $P < 0.06$ ) in the ileum regardless of diet. Enzyme activity was lowest ( $P < 0.05$ ) at wk 2 for sucrase and APN and lowest ( $P < 0.06$ ) at wk 8 for lactase. Sucrase activity was highest ( $P < 0.01$ ) at wk 4 in pigs fed L but highest at wk 8 ( $P < 0.05$ ) in pigs fed H. Lactase and APN activity were not affected by diet.

## Significance to industry

This study aids in understanding the physiological processes involved in compensatory growth and, although it does not provide information on the physiological control, it does indicate that compensatory growth following the use of low complexity diets in the starter phase may be due in part to an improvement in digestive capacity. However, the influence of restricted growth in the nursery on long-term pig robustness requires further examination.

## Funding

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# Hepatic gene expression of starter pigs fed simple and complex diets

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## Background

Reduced use of complex animal proteins in pig diets can reduce both feed costs and growth performance in the nursery. However, the long term consequences of this practice are unclear as it may induce compensatory growth in the grower-finisher phase. In particular, the expression of the insulin-like growth factor (IGF) system, a major endocrine component of regulating pig growth, can be affected by nutrition but it is not known whether changes in its expression can persist over time. The objective of this research was to explore potential indicators of health status, immune function, and nutrient partitioning that predict the effect of diet stressors on subsequent growth performance of pigs.

## Methodology

Starter pigs (2 blocks of 120 pigs per block) were fed either simple (plant protein, non-medicated; n=12 pens) or complex (milk and plasma proteins, medicated; n=12 pens) diets formulated to be otherwise equivalent for 6 weeks. After 6 weeks, all pigs were switched to common grower-finisher diets. Microarray analysis was completed on liver tissue collected from pigs at week 2 post-weaning (n=4) in a reference design. The gene expression data was normalized, filtered, and analyzed using a simple linear (ANOVA) model ( $P < 0.10$ , Benjamini-Hochberg false discovery rate adjustment). Differently expressed genes identified by the microarrays were confirmed by qPCR. Real time quantitative PCR (qPCR) was completed on liver tissue collected from pigs at weeks 2, 4, 8, and 12 post-weaning to confirm microarray results and to quantify expression of growth hormone receptor (GHR) and IGF-1 over time. qPCR data was interpreted using the  $\Delta\Delta CT$  method and analyzed ANOVA according to the general linear model procedure of SAS.

## Results

A total of 182 genes were detected to be differently expressed between the diets based on microarray analysis. Pigs fed simple diets had higher hepatic expression of urea cycle enzymes (arginase-1 and carbamoyl phosphate synthase-1,  $P < 0.10$ ) and antioxidant enzymes (glutathione peroxidase-1 and -3,  $P < 0.10$ ). Pigs fed complex diets had higher hepatic expression of exogenous antigen processing and presentation (swine leukocyte antigen (SLA)-DM, SLA-DR, SLA-DQ, CD74, and cathepsin S,  $P < 0.10$ ). qPCR confirmed the expression their expression. At weeks 2, 4, and 12 post-weaning, hepatic expression of GHR and IGF-1 did not differ between diets but at week 8 post-weaning, pigs fed complex starter diets had higher expression of both GHR (4.45 versus 1.13,  $P < 0.001$ , values relative to GHR expression in pigs fed the complex starter diet at week 2 post-weaning) and IGF-1 (7.99 versus 3.17,  $P < 0.001$ , values relative to GHR expression in pigs fed the complex starter diet at week 2 post-weaning). The expression of GHR complements the expression of IGF-1 in the liver of pigs fed either simple or complex starter diets.

## Conclusions and implications

Microarray and qPCR data were consistent with one another. Based on microarray analysis, nursery feeding program impacted immune function at week 2 post-weaning. The difference in hepatic expression of GHR and IGF-1 at week 8 post-weaning appears to be a long term consequence of feeding pigs simple starter diets.

## Acknowledgements

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# Optimal dietary methionine to methionine plus cysteine ratio is increased during immune system stimulation in growing pigs

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## Background

Chronic subclinical levels of disease occur frequently in intensive swine production and compromise nutrient utilization efficiency. In an effort to maximize protein deposition (Pd; closely associated with lean gain) and optimize nutrient utilization in pigs, there is a need to determine the dietary amino acid (AA) requirements for Pd under varying environmental conditions. Immune system stimulation (ISS) results in the development of anorexia, fever as well as changes in amino acid (AA) metabolism. The synthesis of hepatic proteins and peptides, such as acute phase proteins (APP) and glutathione (GSH), increases to support the immune response, at the expense of skeletal muscle protein. The mismatch between the AA profile of these up-regulated hepatic proteins and peptides and that of skeletal muscle protein reflects requirements for specific AA during disease. Sulfur amino acids (methionine plus cysteine; M+C) have been implicated in improving the animal's response to ISS. It has been noted that cysteine is released from skeletal muscle protein in quantities closest to the theoretical requirements for the synthesis of acute phase proteins (APP) and that ISS leads to enhanced cysteine utilization for the synthesis of GSH. These findings suggest that cysteine is limiting during ISS unless it is adequately supplemented in the diet. Since methionine can be converted to cysteine, but not vice versa, it has been suggested that there is a minimum dietary methionine to methionine plus cysteine ratio (M:M+C), at which methionine and M+C utilization for Pd is maximized.

## Objectives and methods

A nitrogen (N) balance study was conducted to assess the optimal dietary M:M+C during ISS in 20 kg pigs. Thirty-six pigs were fed 800 g/d of one of five M+C-limiting diets, containing graded levels of M:M+C (0.42, 0.47, 0.52, 0.57, 0.62) and supplying 2.5 g/d of M+C. After adaptation, N balances were determined sequentially during a 5-d pre-challenge N-balance period and two ISS challenge N-balance periods of 3 and 4 d, respectively. To induce ISS, pigs were injected intramuscularly with repeated and increasing doses of *E. coli* lipopolysaccharide. Eye temperature and plasma APP concentrations were measured to confirm effective ISS.

## Results and discussion

Eye temperature and plasma APP concentrations confirmed effective ISS. In the ISS challenge N-balance period 1, ISS reduced the mean N-balance more severely than in the ISS challenge N-balance period 2 (8.7±0.3 vs. 9.6±0.4 g/d) and was lower than the pre-challenge N-balance period (10.0±0.2 g/d). An interactive effect of ISS and diet on N-balance was observed ( $P < 0.001$ ). Based on quadratic-plateau regression analysis the optimal dietary M:M+C was determined to be  $0.57 \pm 0.03$  and  $0.59 \pm 0.02$  for the pre-challenge period and ISS challenge period 2, respectively. The optimal dietary M:M+C for the ISS challenge N-balance period 1 was found to be greater than 0.62, suggesting that the optimal M:M+C is greater during initial ISS. It is suggested that this may be a result of preferential use of methionine during ISS.

## Implications

ISS results in an increase in the optimal dietary M:M+C in growing pigs. It is important to consider the pigs' health status when determining AA requirements.

## Funding

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## **Enhancement of human iron uptake from dietary supplements using pork meat proteins**

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In both developed and developing countries, iron deficiency anaemia is the most common of all nutritional deficiencies. One major cause is poor iron-bioavailability due to presence of inhibitors such as phytates in the diet. Food fortification with iron and iron uptake enhancers is one of the preferred approaches for preventing and eradicating iron deficiency, but conventional iron supplements are inefficiently absorbed (only approx.10% absorbed). It is known that meat proteins promote iron uptake from phytate-rich vegetable diets in humans, probably by preventing chelation of iron by phytates.

This study investigates the optimal conditions for iron uptake by gut epithelial cells from iron supplements in combination with peptides isolated from pork muscle. We use the IEC-6 rat epithelial cell-line which is known as a good cell model of iron uptake in the gut. Initial results show that ferrous and ferric iron uptake by IEC-6 cells is increased in slightly acidic conditions and by the presence of ascorbic acid. We have also shown that a pepsin-digested salt soluble fraction of pork longissimus proteins is more effective in promoting iron absorption than other fractions. Current findings suggest that peptides less than 30 kDa in molecular weight enhance iron absorption more effectively than bigger peptides. Work is currently underway to identify exactly which size class of peptides are responsible for maximal iron absorption and study the mechanisms involved. Basic knowledge of the cellular mechanisms of iron uptake will allow design of mixtures of proteins and mineral iron supplements with enhanced bioavailability and minimum side effects due to iron overdose. A future aspect of the work is to deliver the high-bioavailability iron-supplement to the small intestine in a controlled release delivery vehicle. A successful outcome of our study will lead to the development of meat-based functional foods and nutraceuticals with added value.

# **The effects of mitigating the pain piglets experience during and after castration**

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## **Background**

Pain control needs to be considered with respect to routine piglet processing procedures, such as castration. Implementing pain control will be a challenge because it needs to be practical under farm conditions and it must take into consideration issues such as food safety. The aim of this study is to establish, using a variety of behaviour measures, whether providing piglets with a local anaesthetic and analgesic (lidocaine and meloxicam) may be an effective way to mitigate pain during and post castration.

## **Methods**

Lidocaine is given via intratesticular (IT) injection, and meloxicam is given immediately after that, via intramuscular (IM) injection. A total of 400 male piglets will be used. Four piglets (4- to 8-days-old) from the same litter are chosen and then randomly assigned to one of four castration treatments. Each treatment consists of 3 injections (2 IT and 1 IM). For the control treatment, we are using placebo injections of sterile saline. Because we are interested in weight gain at weaning, in order to account for the weight differences of each piglet, the treatments are balanced by weight. Castration is occurring 3 to 6 minutes after the first injection of the lidocaine. In order to evaluate acute pain, a 3-point subjective score system of either 0, 1, or 2 is given to assess the physical response of the piglet during initial handling, IT injection, IM injection, the incision, and the pulling of the spermatic cord. A score of 0 represents no physical movement, whereas a score of 1 represents slight movement with intermittent gaps of stillness, and a score of 2 represents sustained struggling (>3s). Another indicator of acute pain that we are recording during the procedure is piglet vocalizations. To assess post-surgical pain, we are using an instantaneous scan sampling method to record the behaviour of a subset of the piglets from every treatment group, when returned to the sow post-castration. The piglets are weighed one or two days prior to castration and at weaning to see if pain relief affected growth rate.

## **Implications**

The results of this study will help to demonstrate whether the acute and post-surgical pain associated with castration is effectively controlled by a combination of local anesthetic (lidocaine) and a relatively long-acting analgesic, meloxicam and will help to determine whether there are any treatment benefits in terms of the weight gained by the piglets during the nursing period.

## **Acknowledgments**

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# Investigation of the Use of Meloxicam Post-Farrowing for Improving Sow Performance and Reducing Pain

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## Background

Pre-weaning mortality is an important issue in pig production. Crushing of piglets by sows is a major source of economic loss and reduced welfare, with most deaths occurring within the piglets' first 24 hours of life. Piglets must quickly gain access to a teat and consume colostrum soon after birth in order to obtain sufficient energy supplies and protection from disease. However, piglets are often crushed while in close proximity to the sow when suckling and massaging the udder. Therefore, it is important that a sow settles quickly after farrowing and readily begins to nurse her litter. Administering analgesics to sows at farrowing may alleviate pain and allow them to lie more restfully, and thus provide piglets more opportunity for colostrum intake without the risk of being crushed. The objective of this trial was to determine the efficacy of meloxicam<sup>1</sup> administered to sows at the time of parturition with regard to nursing behaviour and piglet survival and growth.

## Materials and Methods

A total of 3,006 piglets from 289 litters were used. Sows were randomly allocated to receive a single intramuscular injection of one of the following treatments within 12 hours of farrowing: injection of 0.4 mg/kg meloxicam or injection of 0.4 mg/kg placebo. All piglets were weighed at birth, at castration and tail-docking at 5-7 days-of-age, and at 19-21 days-of-age prior to weaning. A total of 20 blood samples were collected from sows at farrowing and 4-6 hours post-farrowing for determination of cortisol concentrations. HOBO data loggers were used on a total of 43 sows to record position changes for the first 24 hours after farrowing. Temperature readings were taken on a total of 30 sows at treatment, 4-6 hours post-farrowing, and at 24 hours post-treatment in addition to feed intake scores.

## Results

There was a tendency for sows receiving meloxicam after farrowing to have lower plasma cortisol levels than sows receiving the placebo at 4 hours following treatment ( $P=0.09$ ). There were no significant treatment effects for piglet weight gain and mortality or sow position changes, rectal temperatures, and feed intake scores.

## Conclusion

Meloxicam may be effective in the treatment of post-farrowing pain based on plasma cortisol levels, but a larger sample size is needed to evaluate this further. Although meloxicam did not improve piglet growth or survival, its administration to sows after farrowing appeared to be safe based on these measures. The use of analgesics to alleviate pain immediately after farrowing may be a useful tool for a subset of animals (possibly those with prolonged or difficult parturitions), and this area will require further study.

## Acknowledgments

This work was financially supported by Boehringer-Ingelheim and Ontario Pork.

<sup>1</sup>Metacam<sup>®</sup>, Boehringer-Ingelheim Ltd., Burlington, ON

# **An investigation of sow lameness in relation to leg and foot conformation, lesions and hoof cracks**

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## **Background**

Lameness is a common problem in sows, with 10-14% of sow culling in Canadian herds attributed to locomotor problems (Stone, 1981; Friendship et al., 1986). The causes of lameness vary from farm to farm and possibly between age groups within a herd. Like many swine health problems lameness is complex and there are often multiple contributing factors. Lameness is ranked as an important welfare concern (Whay et al., 2005). Lameness has also been studied in terms of productivity, studies show that lame animals have decreased productivity as a result of premature culling and reduced reproductive performance. Lame sows have been shown to produce smaller litters including fewer pigs born alive and weaned (Berg, 2010). Furthermore, lifetime productivity is negatively affected, with lame sows producing on average fewer than 3 litters, compared to 4.5 litters for non-lame sows (Anil et al., 2004). Therefore, lameness is an interest of study because it is a common problem with negative effects on animal welfare and productivity.

## **Objectives**

The objectives of this study are to investigate the prevalence of lameness on a number of commercial swine farms by scoring gait, foot/leg injuries and abnormalities and examine the correlation between lameness scores and lesions, hoof cracks and physical abnormalities.

## **Methods**

A sample of 60-70 sows is being assessed on each farm. Each sow is gait scored on the way to the farrowing crates. Their feet and leg injuries/abnormalities are assessed in the crate. The gait scoring system is a 6-point system adapted from Main and colleagues (Main et al., 2000). Feet and leg injuries/abnormalities are scored using several subjective visual scoring systems, assessing different areas of the legs and feet. Such areas include: leg and foot conformation, lesions, hoof cracks and other leg/foot injuries. Correlation between lesion scores and lameness scores will be performed. Along with this information, productivity data and housing will be noted. Once established, the prevalence of feet and leg injuries/abnormalities will be used to create a baseline for herd to herd comparison.

## **Implications**

This work will help to determine if there is value in scoring hoof abnormalities and lesions as an indirect measure of lameness and animal welfare.

## **Acknowledgments**

This work is financially supported by the Canadian Swine Cluster Research Program through Agriculture and Agri-Food Canada.

# **Supplemental Lactose via Dried Whey Powder is Completely Digested Independent of Dietary Supplementations of Various Prebiotics in Weanling Pigs**

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## **BACKGROUND**

Early studies demonstrated that dietary supplemental lactose via whey powder or crystalline lactose was essential to improve growth performance and efficiency of whole body nitrogen retention in weanling pigs (Mahan, D.C. 1992. *J. Anim. Sci.* 70:2182-2187). It is known that intestinal lactase activity declines dramatically during the weaning transition. This led to subsequent studies to examine the potential prebiotic effect of dietary supplemental lactose in weanling pigs by Krause D. et al. (1995, *J. Anim. Sci.* 73:2347-2354) and they failed to prove this concept. Thus, the biological role of dietary supplemental lactose in weanling pig nutrition remains unclear while enriching weanling swine diets with lactose is widely practiced.

## **OBJECTIVES**

This study was conducted to determine effects antibiotic and prebiotic supplements on the small intestinal lactase digestive capacity and the total tract lactose digestibility in weanling pigs.

## **METHODOLOGY**

Six experimental diets were corn (40%) and soybean meal (28%) based and supplemented with fishmeal (9%) and dried whey powder (20%) in supplying about 10% lactose. Diet 1, being a negative control, was the basal diet, containing no antibiotics and supplemental prebiotics. Diet 2, being a positive control, was formulated by adding antibiotic lincomycin (lincommix 44 at 0.10%) at the expense of cornstarch. Diets 3 to 6 were formulated to contain 0.75% of four test prebiotics of inulin,  $\beta$ -glucan, resistant cornstarch and Fibersol-2 (a resistant maltodextrin) at the expense of corn starch, respectively. Titanium oxide (0.3%) was used as a digestibility marker. Intestinal lactase digestive capacity in weanling pigs was referenced from Lackeyram D. (2012, Ph.D. Dissertation at the University of Guelph).

## **RESULTS**

No fecal lactose was detectable in all tested weanling pigs. Fecal lactose digestibility was at 100% independent of dietary supplementation of antibiotics and various tested prebiotics. The small intestinal digestive capacity was estimated to be ranging 480-522 g lactose/pig.day in comparison of the measured average voluntary daily feed intake of 570-640 g/pig.day. We have provided evidence showing that lactose at commercial levels of dietary supplementation is highly digestible independent of dietary supplementations of antibiotics and prebiotics in weanling pigs.

## **BENEFITS TO SWINE INDUSTRY**

Lactose is a highly digestible carbohydrate in optimizing weanling pig growth performance and efficiency of whole body nitrogen utilization.

**FUNDING SUPPORTS:** Supported by Ontario Pork, Agricultural Adaptation Council and the OMAFRA-University of Guelph Partnership Research Program.

## Investigating a Genetic Solution to Decrease Boar Taint Levels in Canadian Pigs

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### Background

Boar taint is an unpleasant odour produced by the accumulation of androstenone and skatole in fat tissues of intact male pigs. Castration, a common practice for preventing boar taint, raises animal welfare concerns.

### Objectives and methods

This research project intends to find a genetic solution for reducing boar taint using 116 SNP markers in genes involved in the synthesis and degradation of boar taint compounds. A total of 900 Landrace, Yorkshire and Duroc pigs will be genotyped to assess marker allele frequencies and the potential impact of the SNP markers on economically important performance traits. In addition 700 boars per breed will be genotyped and boar taint compounds will be measured from fat samples. Genotypes and boar taint levels in the genotyped animals will be used to estimate the effect of the markers. The predictability of the marker effects will be validated using boar taint measured in fat from 700 additional boars.

### Results

Analysis of genotypes from an initial set of 188 pigs showed 72 markers segregating with minor allele frequency (MAF) greater than 10%. Estimated correlations showed low redundancy among markers. More than 43% of markers showed correlations lower than 0.10 with other markers and 97% had correlations lower than 0.50. An initial group of 90 boars weighing more than 110 kg (live weight) were measured for boar taint compounds and showed an average androstenone and skatole levels of 587.5 (85.0-4552.0) ng/g and 126.7 (9.9-1085.4) ng/g, respectively. In this initial sample, 17% and 12% of the boars had levels for androstenone and skatole that would be unacceptable to consumers. In total, 26% of pigs exceeded the acceptance level in at least one of the compounds.

### Significance to industry

These preliminary results show that studied markers are not redundant and are mostly segregating with reasonably high MAF, and that a large variation on boar taint compounds exists among pigs, with a substantial proportion of pigs exceeding the acceptance levels. Identifying a genetic solution to boar taint offers a natural and wholesome way of reducing boar taint compounds in meat from intact boars and will reduce stress in boars by avoiding castration or needle injections for immunocastration.

### Funding

Financial support provided by the Canadian Agricultural Adaptation Program (CAAP), regional swine improvement centres across Canada and participating Canadian breeders.

# An investigation into the association between *C. perfringens* type A and diarrhea in neonatal piglets

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## Background

Attributing a pathogenic role to *C. perfringens* in neonatal enteritis of piglets is problematic due to the gastrointestinal colonization of neonatal piglets within the first hours of life. Therefore the diagnosis *C. perfringens* Type A-associated porcine neonatal diarrhea requires the isolation of large numbers of bacteria and the exclusion of other causes.

## Objective

To investigate the possible role of *C. perfringens* Type A in neonatal diarrhea in pigs.

## Materials and methods

Ten swine farms with history of diarrhea problem in suckling piglets were identified. On each farm, 2-4 piglets with diarrhea and 1-2 matched normal piglets were tested for *C. perfringens*, *Clostridium difficile* toxins, *Salmonella*, enterotoxigenic *Escherichia coli*, rotavirus, transmissible gastroenteritis (TGE) virus, and coccidia. The Colony Forming Unit (CFU) of *C. perfringens* in the intestinal contents was determined, and the isolates were tested by PCR for presence of *cpa*, *cpb2*, and other virulence-associated genes.

## Results

The numbers of *C. perfringens* in the intestinal contents were lower in diarrheic piglets ( $\log_{10}$  5.4 CFU/g) compared to normal piglets ( $\log_{10}$  6.5 CFU/g) ( $P < 0.05$ ). No significant difference in distribution of the *cpa* and *cpb2* was observed between isolates in healthy and diarrheic piglets. However, a lower proportion of isolates recovered from pigs with diarrhea carried atypical *cpb2* ( $P < 0.05$ ). The presence of beta2 toxin in the intestinal contents of normal and diarrheic piglets did not differ significantly. *C. difficile* toxins and rotavirus were each detected in 33% diarrheic piglets. Rotavirus, *C. difficile* toxins, *Salmonella*, or enterotoxigenic *E. coli* were concurrently recovered in different combinations in 19% of diarrheic piglets. The cause of diarrhea in 38% piglets remained unknown.

## Conclusion

The number of *C. perfringens* Type A in the intestinal contents was not a useful approach for making a diagnosis of *C. perfringens* Type A enteritis in piglets. The diagnosis of etiology of porcine neonatal diarrhea was complex because other pathogens might form a multiple cause of the enteritis.

## Acknowledgments

We would like to acknowledge the OMAFRA- University of Guelph Research Program, and the OMAFRA Animal Health Strategic Initiative for funding this project. We thank Drs Templeton, Charbonneau, and Scorgie for recruiting the farms as well as Vivian Nicholson and Yanlong Pei for their laboratory assistance.

## Approaches to risk-based surveillance on southern Ontario sow farms

K. Bottoms, Z. Poljak, R. Friendship, R. Deardon, C. Dewey

### OBJECTIVES

The objectives of this project were to: (i) determine the best number of groups to describe external biosecurity practices on southern Ontario sow farms, (ii) identify demographic and geographic variables that are significant predictors of biosecurity group membership, (iii) develop a map of southern Ontario that can be used as a tool in the risk-based surveillance of contagious swine diseases, and (iv) investigate strategies for the introduction and transportation of replacement gilts in regards to the porcine reproductive and respiratory syndrome virus (PRRSV).

### METHODOLOGY

Data pertaining to external biosecurity protocols were obtained from the Production Animal Disease Risk Assessment Program's survey for the breeding herd. A subset of 24 categorical external biosecurity variables was selected for two-step cluster analysis; this method objectively determines the best number of groups to describe the data. These groups were then named and described in terms of their major characteristics. Significant predictors of biosecurity group membership were identified using multinomial logistic regression. Information about the geographic location of farms was combined with the density of swine sites and grower-finisher pigs in the study region to develop a weighted map that demonstrates areas of risk for the spread of contagious swine diseases. Finally, multiple correspondence analysis allowed insight into strategies for the introduction and transportation of replacement gilts.

### RESULTS & CONCLUSIONS

External biosecurity in our sample of sow herds was best described by three groups, named by the authors as: (i) high biosecurity herds that were open with respect to replacement animals, (ii) high biosecurity herds that were closed with respect to replacement animals, and (iii) low biosecurity herds. Variables identified as significant predictors of biosecurity group membership included: the number of sows on the premises, site production type, and herd density. The qualitative risk map (Figure 1) identified geographic areas of risk of the spread of contagious swine diseases. The planning of surveillance projects for specific diseases would benefit from focusing their efforts in the areas identified as high-risk. Finally, results from the

multiple correspondence analysis provided insight into strategies for the introduction and transportation of replacement gilts. In some cases, one variable that is generally considered risky was closely associated with other variables that mitigate the associated risk. This indicates that biosecurity cannot only be viewed as a set of individual practices; the overall strategy on individual farms must be assessed.

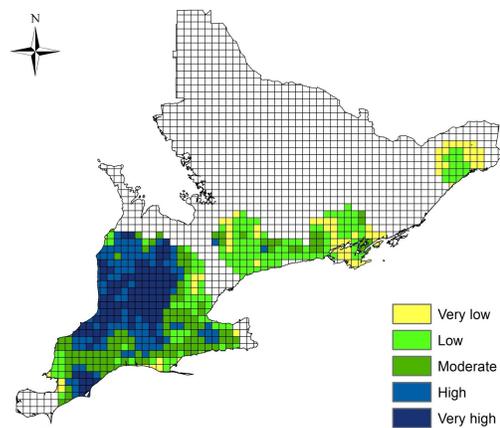


Figure 1: qualitative risk map depicting areas of risk for the spread of contagious swine diseases

## A case-control study of ear necrosis

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**Introduction:** Ear necrosis is commonly seen on swine farms. The cause of the condition is not well understood and the factors that influence severity have not been well documented. The objectives of this study were to investigate possible causative agents through bacterial culture and histological examination of lesions and to determine farm-level risk factors.

**Materials and Methods:** Eleven case farms were visited and tissue biopsies and oral swabs taken from pigs in early, mid and late stages of the disease. Three pigs in each disease group in the case farms were selected for sampling (8.6pigs/farm). Bacteriology was performed specifically for: *Staphylococcus hyicus*, *Staphylococcus aureus* and spirochetes. Antimicrobial susceptibility of recovered isolates of *S. hyicus* and *S. aureus* was performed and formalin-fixed tissues were examined histologically. The management and environment were assessed and clinical signs of diseases and behavioral vices were noted on 14 case farms and 9 control farms.

**Results:** On a case farm basis, the mean age of early stage disease pigs was 6.6 wk (range: 3-12 wk), the mean age of mid stage disease pigs was 7.7 wk (range: 5-13 wk) and the mean age of late stage disease pigs was 10wk (range: 5- 16 wk). The mean prevalence of ear necrosis at each stage disease group was: 31.6% (sd: 32.8), 44.2% (sd: 36.1), and 54.8% (sd:38.1) for early, mid and late stage , respectively. Variables in the questionnaire that were significantly associated with the presence of ear necrosis on farms with univariable analysis were: earlier minimum weaning age, earlier average weaning age, and age of farm ( $P < 0.05$ ). Variables in the observations that were significantly associated with the presence of ear necrosis with univariable analysis were: perception of high humidity in early-disease stage groups, less drinker availability, perception of high humidity and the presence of ear biting in mid-disease stage groups, and high temperature and the presence of ear biting and tail biting in late-disease stage groups ( $P < 0.05$ ). In the multivariable model, high humidity and presence of ear biting in the pen were significantly associated with the presence of ear necrosis. *S. aureus* and *S. hyicus* were recovered from 91% and 66% of pigs affected by ear necrosis, respectively. A high prevalence of resistance for *S. aureus* isolates to penicillin G (94.6%), ampicillin (94.6%), tetracycline (74.2%), and ceftiofur (41.9%) and for *S. hyicus* isolates to penicillinG (87.7%), ampicillin (87.7%), ceftiofur (82.2%), and tetracycline (65.8%) was noted. Spirochetes were identified in 9.4% of formalin-fixed tissue samples but were not successfully cultured in tissue samples. Histological examination consistently showed that the disease began as damage from the outer surface of the skin and not as vascular damage from within.

**Conclusions and Discussion:** In this study samples were cultured for staphylococci and for spirochetes because there are reports in the literature claiming that ear necrosis is caused by *S. hyicus* (1, 2) and there are other reports asserting that spirochetes and in particular *Treponema* sp. are the primary agents involved (1, 3). Based on our findings we speculate that the disease may be initially caused by toxins produced by certain staphylococci and those spirochetes, if present, are likely secondary invaders. It appeared that ear necrosis and ear biting were closely associated and we speculate that lesions of ear necrosis may attract chewing by pen mates resulting in trauma and contamination that lead to infection of secondary bacteria and more severe lesions. High humidity has found to increase the risk of ear necrosis.

**Acknowledgments:** Funding support was obtained from the Ontario Ministry of Agriculture Food and Rural Affairs through the Animal Health Strategic Investment Fund.

## **Is tilmicosin useful in reducing viremia and the clinical impact of Porcine Reproductive and Respiratory Syndrome (PRRS)?**

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PRRS is the most important swine disease in the world today. A common strategy for controlling PRRS in a breeding herd is to inoculate pregnant sows with PRRS virus to create uniform exposure and develop herd immunity rapidly. It has also become common practice to medicate the sow herd with antibiotics during this controlled exposure to the disease with the intention of controlling secondary bacterial infection. There have been anecdotal reports that tilmicosin has become the preferred option and this is based on a belief that the antibiotic has antiviral properties. The objective of this study was to determine if feed medication with tilmicosin reduced viremia in pigs exposed to PRRS. Two hundred pigs were randomly assigned to one of 5 treatment groups. Negative control: receiving feed containing 400ppm of tilmicosin but not infected with PRRS virus, Negative-negative control: receiving non-medicated feed and not infected with PRRS virus, Positive control: infected with PRRS virus but not receiving tilmicosin, infected with PRRS virus while receiving feed containing 200 ppm of tilmicosin, and infected with PRRS virus while receiving feed containing 400 ppm of tilmicosin. Clinical signs and body temperature were also recorded daily. Quantitative PCR was performed on sera to assess viremia. Statistical analysis of the PRRS titers was conducted in SAS 9.1 using PROC MIXED. Preliminary statistical analysis of the PRRS titers suggests that tilmicosin reduced the viremia in the treated groups ( $P < 0.001$ ). The results of this research benefit pork producers by highlighting the reduction of PRRS viremia in pigs fed tilmicosin during a controlled disease exposure and support swine veterinarians by providing them with more information to develop PRRS control strategies.

## **The association between the PCVAD outbreak in Ontario and the positivity of Porcine Reproductive and Respiratory Syndrome virus (PRRSV) ELISA and PCR test results**

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Animal disease monitoring and surveillance are crucial activities for ensuring the health of animals. Limited research has focused on how negative test results from veterinary diagnostic laboratory data can be used to improve our knowledge of disease outbreaks e.g. if a diagnostic laboratory was seeing a disproportionate number of negative test results could this information be an indication of a novel disease outbreak? The objective of this study was to determine the association between the porcine circovirus-associated disease (PCVAD) outbreak in Ontario 2004-2006 and the weekly probability of PRRSV enzyme-linked immunosorbent assay (ELISA) positivity and the weekly probability of PRRSV polymerase chain reaction (PCR) test positivity. Retrospective data were collected from the Animal Health Laboratory (AHL) at the University of Guelph, Guelph, Ontario Canada and were comprised of the weekly count of PRRSV ELISA and PRRSV PCR tests ordered by swine practitioners from 2000-2007. The test results were analysed separately in two separate models using logistic regression with the dependent variables: the weekly probability of PRRSV ELISA positivity, and the weekly probability of PRRSV PCR positivity, respectively. The association between PRRSV test positivity and the outbreak of PCVAD was determined after controlling for a PRRS outbreak, season, and year. The weekly probability of PRRSV PCR positivity decreased during the PCVAD outbreak (OR=0.66,  $P<0.01$ ). The weekly probability of PRRSV ELISA positivity was not associated with the PCVAD outbreak. The results indicate that during the PCVAD outbreak in Ontario from 2004-2006, the probability of PRRSV PCR positivity at the AHL decreased. Tracking the test results of commonly used screening tests has the potential to be a novel data source for the timely identification of disease outbreaks in swine populations.

# **Maltose and Sucrose Are Highly Digestible Carbohydrates for Optimizing Growth and Efficiency of Nitrogen Utilization in Weanling Pigs**

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## **BACKGROUND**

Raw cereal starch is poorly digested in weanling pigs due to underdeveloped gastric acid secretion and starch digestive capacity, contributing to growth check and diarrhea. Dietary supplementation of rapidly digestible carbohydrates is essential for optimizing growth and efficiency of whole body nitrogen utilization in weanling pig nutrition (Fan M.Z. and C.F.M. de Lange, Chapter 16 in Sustainable Swine Nutrition, L.I. Chiba, editor, 2012, in press). Dietary supplementation of lactose via whey powder or crystalline lactose has been widely practiced for this purpose in the past two decades (Mahan, D.C., 1992., J. Anim. Sci. 70:2182-2187), which has been more recently elucidated for its biological roles. Expression of the small intestinal mucosal alpha-disaccharidases sucrase and maltase is shown to be highly up-regulated during the weaning transition in pigs from our recent studies. Thus, sucrose and maltose that are processed via food processing technologies may be cost-effective highly digestible carbohydrates alternative to lactose in certain swine production regions for weanling pig feeding.

## **OBJECTIVES**

This study was conducted to determine if sucrose and maltose are highly digestible carbohydrates by taking the combined biochemical and physiological approaches of estimating the small intestinal digestive capacity of sucrase and maltase activities in weanling pigs.

## **METHODOLOGY**

Ten Yorkshire piglets at the age of 10 days were weaned onto a corn and soybean meal based solid diets formulated by meeting all nutrient requirements for 12 days. The small intestinal digestive capacity of sucrase and maltase activities was measured with details as described by Lackeyram, D. (2012, Ph.D. Dissertation at the University of Guelph).

## **RESULTS**

Voluntary feed intake (about 6% of its live body weight) of weanling pigs is projected at about 60 g/kg body weight/day. The small intestinal digestive capacity for digesting sucrose is estimated at about 63.2 g /kg body weight/day, while the small intestinal digestive capacity for digesting maltose is estimated at about 42.6 g/kg BW/day in weanling pigs. Thus, these results have provided evidence in showing that both sucrose and maltose at potential commercial levels of dietary supplementations are highly digestible in weanling pigs.

## **BENEFITS TO SWINE INDUSTRY**

Sucrose and maltose are highly digestible carbohydrates alternative to lactose in optimizing weanling pig growth performance and efficiency of whole body nitrogen utilization.

**FUNDING SUPPORTS:** Supported by the Natural Science and Engineering Research Council (NSERC) of Canada and the OMAFRA-University of Guelph Partnership Research Program.

# **Porcine Gut Microbial Metagenomic Library for Mining Novel Cellulases and Hemi-Cellulases Established from Growing Pigs**

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## **BACKGROUND**

Cellulose and hemi-cellulose are the major polymer components of the plant cell wall-lignocellulose complex. Discovery of novel and potent cellulases and hemi-cellulases as effective industrial enzymes could contribute to the commercial production of the cellulosic ethanol and improvement in the efficiency of carbon utilization in animal production (Hess M. et al., 2011, *Science*, 331:463-467). Anaerobic fermentation of cell wall components, i.e., dietary fibre, has been well documented in the hindgut of growing-finishing pigs (Varel V.H. and J.T. Yen, 1997, *J. Anim. Sci.* 75:2715-2722). The metagenomic approach, including metagenomic sequencing and metagenomic expression library, is an emerging and powerful molecular tool for the discovery of novel cellulases and hemi-cellulases.

## **OBJECTIVES**

We present an effort to construct a metagenomic expression library from the hindgut of growing pigs for discovering novel bacterial cellulase and hemi-cellulase genes.

## **METHODOLOGY**

A plasmid metagenomic expression library was constructed from the hindgut microbiota of grower six Yorkshire grower pigs (25-40 kg) fed a high-fat basal diet supplemented with 10% Solka-Floc™ for 28 d. Fresh cecal and colonic digesta samples were collected and flash-frozen in liquid N<sub>2</sub>. Metagenomic DNA was extracted, mechanically sheared and the resulting DNA fragments were subjected to blunt-end polishing, fractionation and purification by using commercial kits. The end-modified DNA fragments were ligated to pCR4Blunt-TOPO vector and transformed into competent cells *E. coli* TOPO 10. Metagenomic plasmid libraries were screened for carboxymethyl cellulolytic activities by using LB agar plates.

## **RESULTS**

Fourteen positive colonies were screened out for the capability of hydrolyzing AZO-carboxymethyl cellulose. All together, eleven assembled inserts sequences were obtained with 4 function-related gene clusters, and eighteen putative carbohydrate active enzyme genes were identified, including 11 cellulase genes, 5 hemicellulase genes, 1 polygalacturonase gene, and 1 cellobiose phosphorylase gene.

## **BENEFITS TO SWINE INDUSTRY**

The coupling of functional metagenomic mining with biochemical characterization of fibre-degrading enzymes is a powerful strategy for the discovery of novel porcine gut cellulases and hemi-cellulases.

**FUNDING SUPPORTS:** Supported by the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) New Directions & Alternative Renewable Fuels Research Program.

## ***Lactobacillus* fermented diets reduced *Salmonella* Typhimurium infection in newly weaned pigs**

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*Salmonella* Typhimurium is a food-borne pathogen often associated with swine. Recently, we identified *Lactobacillus* isolates that protected *Caenorhabditis elegans* from death due to *S.* Typhimurium infection<sup>1</sup>. Two of the isolates were evaluated in the present pig-challenge study. Three trials were conducted with 16 piglets (BW: 6.55±0.20 kg) for each trial. There were four dietary treatments (in a liquid form with a liquid/solid ratio of 2.2, four piglets per treatment): 1) basal diet (BD, control), 2) naturally-fermented basal diet (NF), 3) *Lactobacillus* LB1-fermented basal diet (LB1), and 4) *Lactobacillus* CL11-fermented basal diet (CL11). All pigs consumed the experimental diets for 3 d prior to *S.* Typhimurium DT104 challenge (approximately 10<sup>6</sup> CFU/pig) through gavage. The challenge was given twice (d4 and d5) in Trials 1 and 3, but once (d4) in Trial 2. Clinical signs (rectal temperature and diarrhea scores), and the level of haptoglobin in serum were examined. *Salmonella* counts of feces, and ileal and cecal digesta were quantified in Trials 2 and 3, while the presence of *Salmonella* in ileocecal lymph nodes (ILN) and spleen was determined only in Trial 3. Pigs from Trials 1 and 3 demonstrated clinical signs of infection, which were absent in Trial 2. Pigs receiving fermented diets had lower rectal temperature, diarrhea scores, and *Salmonella* counts in feces and digesta than the control group ( $P < 0.01$ ); particularly, the diarrhea scores in NF and CL-11 treated-group was nearly 1 unit lower than that in BD treated-pig. *Salmonella* was detected in the ILN and spleen from all the pigs on BD, NF, or CL11, but only 50% in spleen from pigs on LB1. The haptoglobin concentration was lower in pigs on fermented diets ( $P < 0.01$ ) with the lowest detected in LB1 treated pigs. In summary, these trials suggest that feeding a fermented diet, particularly one inoculated with LB1, can reduce *Salmonella* infection in pigs.

**Key words:** *Salmonella* Typhimurium; *Lactobacillus*; Fermented diets; Pigs

1. Wang, C., et al. (2011) Use of *Caenorhabditis elegans* for pre-selecting *Lactobacillus* isolates to control *Salmonella* Typhimurium. *J. Food Protect.* 74, 86-93.

## Alginate-whey protein microencapsulation for target delivery of hydrophobic antimicrobials to the pig intestine

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The objective of this study was to develop novel encapsulation technology for target delivery of hydrophobic antimicrobial agents (carvacrol) to specific intestinal regions of pigs. Alginate-LBA-whey protein microencapsulation was made by ionotropic gelation. The antimicrobial activity of free and encapsulated carvacrol (1,000 ppm) in the present of digesta from different intestinal regions of growing pigs was determined *in vitro* by measuring the inhibition of *E. coli* K88 growth. The free form of carvacrol totally lost its antimicrobial activity when mixed with the digesta from the duodenum; however, it reduced 1.11 log *E. coli* k88 counts in the digesta from the jejunum and totally inhibited the growth of *E. coli* k88 in the present of digesta from the ileum and cecum, respectively. Addition of TSB broth to the digesta enhanced the antimicrobial activity of carvacrol. The encapsulated carvacrol had the same degree of antimicrobial activity as free carvacrol in the present of digesta from the ileum. An *in vivo* study was also conducted to investigate the release of carvacrol, in either free or encapsulated form, in the pig intestine. A majority of free carvacrol (95.1%) was absorbed at 6 hours postprandially in the stomach and duodenum. In contrast, the encapsulated carvacrol was able to pass the stomach and duodenum with about 22.8%-48.5% and 34.7%-53.8% losses, respectively, at 4-6 hours postprandially and 75.7% release in the jejunum at 6 hours postprandially. This suggests that the encapsulation has the potential as a biocompatible carrier for target delivery of hydrophobic antimicrobial agents to the gastrointestinal tract of animals to achieve their functions, although further improvement of the encapsulation is required for a more effective delivery and resistance to the pressure during feed pelleting.

Key words: Alginate, Whey protein, Encapsulation, Carvacrol, Antimicrobial activity, Pig