INNOVATION FOR THE SUSTAINABILITY OF THE SWINE INDUSTRY

RESEARCH ACTIVITY REPORT





Swine Innovation Porc increases Canadian swine industry competitiveness through a national R&D structure

Business office: Place de la Cité, Tour Belle Cour 2590, boul. Laurier, suite 450, Québec, QC G1V 4M6

Telephone: 418-650-4300 Fax: 418-650-1626

www.swineinnovationporc.ca

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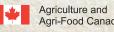
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Canadian Pork Council Conseil canadien du porc

Swine Innovation Porc is a corporation of the Canadian Pork Council.

The Canadian Swine Research and Development Cluster is established within the Growing Canadian Agri-Innovation Program - Canadian Agri-Science Cluster Initiative of Agriculture and Agri-Food Canada (AAFC).



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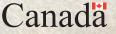


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INTRODUCTION

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THE CLUSTER

From April 2010 to March 2013, Swine Innovation Porc (SIP) managed and coordinated a portfolio of research projects worth \$12M titled the Canadian Swine Research and Development Cluster which was created within the framework of Agriculture and Agri-Food Canada's (AAFC) Growing Forward - Canadian Agri-Science Clusters Initiative.

COLLABORATION

This research program brought together over 100 researchers from 27 research organizations across Canada and around the world, working together on 14 multi-institutional research projects. Moreover, the partnerships established with 22 industry contributors, including producer organizations and private companies contributed a total of \$1.8M.

ENHANCED EXPERTISE

These projects not only contributed to generating knowledge aimed at reducing the cost of production and differentiating the product in various markets, they also contributed by training highly skilled professionals for the pork sector: 28 Master's students, 16 doctoral candidates and 23 postdoctoral scholars.

DISSEMINATION OF RESULTS

The results were disseminated throughout the industry and scientific community either through SIP's technology transfer program or by the researchers themselves. In fact, more than 210 technology transfer activities and documents were prepared and shared with the industry. Seventy percent of these activities and documents were destined for producers. In addition, the researchers in our program wrote more than 190 peer-reviewed papers. To date, more than 70% have been published in scientific journals.

CONCLUSION

The following pages briefly present the 14 Canadian Swine Research and Development Cluster projects and their results, together with, our technology transfer activities with the names of our contributing partners in this three year research program.

We hope you enjoy consulting the findings and outcomes of these projects.



THE RESEARCH PROGRAM WAS DESIGNED TO ENHANCE THE COMPETITIVENESS AND DIFFERENTIATION OF CANADA'S PORK INDUSTRY, AND INCLUDED 14 PROJECTS.

The use of tools related to molecular characterization, systemic analysis of stakeholders and geomatics for identification of the principal vectors and of contamination by bacteria and viral indicators at farm and slaughterhouse level (<i>A. Letellier et al.</i>)	р. 7
Sow housing: risk factors and assessment techniques for lameness, productivity and longevity in group and individually housed gestating sows <i>(L. Connor et al.)</i>	p. 8
A study of the efficiency of water sprinkling in the truck after loading and prior to unloading at two different environmental temperatures on core body temperature and carcass and meat quality in pigs (<i>L. Faucitano et al.</i>)	p. 10
A comparison of three animal welfare assessment programs on Canadian swine farms (<i>T. Widowski et al.</i>)	p. 11
Use of non-penetrating captive bolt for euthanasia of neonate, suckling and weaned piglets up to 9 kg (<i>T. Widowski et al.</i>)	p. 12
Development of an innovative air cleaning system for swine buildings (S. Lemay et al.)	p. 13
Development of an innovative precision farming system for swine (C. Pomar et al.)	p. 14
Evaluation and development of standards for swine production systems (L. Whittington et al.)	p. 15
Novel swine feeding programs to enhance competitiveness and pork differentiation: The Canadian feed & pork value chain <i>(R. Zijlstra et al.)</i>	p. 16
Novel nutritional strategies for optimum sow and piglet productivity (M. Lessard et al.)	p. 19
Efficacy of feed additives to mitigate the negative impacts of mycotoxin contaminated feed on performance and health of piglets (<i>F. Guay et al.</i>)	p. 21
Mycotoxin contents evaluations of corn hybrids adapted to Québec growth conditions (G. Tremblay et al.)	p. 22
Capturing genetic merit in differentiated pork production systems through genomics (G. Foxcroft et al.)	p. 23
Development of new genomic tools to improve meat quality traits and production efficiency in pigs (B. Sullivan et al.)	p. 24

THE USE OF TOOLS RELATED TO MOLECULAR CHARACTERIZATION, SYSTEMIC ANALYSIS OF STAKEHOLDERS AND GEOMATICS FOR IDENTIFICATION OF THE PRINCIPAL VECTORS AND OF CONTAMINATION BY BACTERIA AND VIRAL INDICATORS AT FARM AND SLAUGHTERHOUSE LEVEL

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PROJECT LEADER

Ann Letellier, University of Montréal

PROJECT OBJECTIVE

To identify potential vectors and microbial dissemination among herds and at a slaughterhouse using geomatics, systemic and genomic tools.

nXstream Technologies Inc

Biosecurity is a shared responsibility. All stakeholders must be involved in the food safety process to limit the microbial dissemination and animal health/food safety impact.

FINAL RESULTS

Results of the systemic analysis showed that food safety among industry stakeholders could be improved by establishing a proactive, reactive, interactive and systemic approach.

Results from the geomatic analysis showed that half of the identified viral and bacterial contaminations came from the slaughterhouse. The slaughterhouse yard showed to be highly and diversely contaminated. Trucks can become an important vector of microbes dissemination in a production network. Results showed that cleaning and disinfecting procedures constitute a good basis to minimize the presence of Salmonella and E. coli in trucks. Although current procedures should be improved as evidence of viral contamination was found after washing and disinfecting transportation trucks. Furthermore, the inside carpets and the outside of the truck should be included in the cleaning protocol.

Results showed that ETEC (Enterotoxigenic E. coli): F4 and Salmonella spp. can be used as markers to describe bacterial dissemination events in a network and that rotaviruses can be good indicators of viral contamination in the environment.

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Simple actions such as cleaning and disinfection of transportation trucks can have a significant impact!

SOW HOUSING: RISK FACTORS AND ASSESSMENT TECHNIQUES FOR LAMENESS, PRODUCTIVITY AND LONGEVITY IN GROUP AND INDIVIDUALLY HOUSED GESTATING SOWS

PROJECT LEADERS

Laurie Connor, University of Manitoba and Nicolas Devillers, Dairy and Swine Research and Development Centre – Agriculture and Agri-Food Canada (AAFC)

PROJECT OBJECTIVE

The assessment of risk factors affecting the productivity and longevity in gestating group housed sows, and over a variety of management systems, with a special focus on lameness.

A model to determine the optimal time for culling a sow from an economic standpoint was validated.

FINAL RESULTS

LAMENESS ASSESSMENT USING A FORCE PLATE SCALE

A force plate scale, specially designed to measure weight distribution and weight shifting of gestating sows, was successfully developed. Results indicate that the force plate scale could become an effective tool for early detection and measurement of lameness. Also, the multi-technic and multivariate approach studied (force plate scale, kinematics and accelerometers) enabled the definition of two types of lameness expression characterised by stiff gait and high weight shifting, respectively.

LAMENESS ASSESSMENT USING INFRARED THERMOGRAPHY (IRT)

Results showed that limb conformation, weight and parity affected the IRT temperatures. However, IRT was effective when compared to visual scores and may be a useful method of detecting

Force plate scale, a promising technique developed to identify early lameness.

early signs of inflammation and injury in the lower limbs and hooves of sows in the future. Currently the cost is prohibitive for routine on-farm diagnostics.

FACTORS CONTRIBUTING TO SOW LAMENESS, PRODUCTIVITY AND LONGEVITY

Temperament traits

Sow temperament traits associated with active-passive and confident-fearful dimensions showed significant differences between breeds and between housing systems. In free-access housing, sow breed line and age affected temperament measures but not floor type or pen configuration. In the electronic sow feeding (ESF) systems, flooring type and age (parity) influenced sow behaviour responses in temperament tests. However, within the management and group housing systems investigated, there were only minor effects of temperament on production variables. Body injury score was related to temperament which differed between the two ESF systems. Flooring in the ESF systems was associated with the incidence of lameness; lameness was significantly higher on the partial-slatted flooring system and in that system only, there was a relationship between injury score and lameness.

Simulation model predictor of sow longevity and profitability

A sow longevity simulation model was validated and refined using data sets from two group housing systems. It demonstrated that, as expected, the model can determine the optimal time for culling a sow from an economic standpoint.

Calcium-phosphorus balance and bone density

Group housed sows fed a low calcium diet had reduced serum calcium and serum phosphorus. However, bone biomarkers (resorption or formation) were similar; litter sizes and growth rate were unaffected by diet and were improved with group housing. The requirement for dietary calcium as prescribed by the 1998 NRC, and thus for NRC 2012 is adequate for high producing sows of modern genetics, whether housed in groups or stalls.

Methods of synchronizing gilt breeding and impact on sow longevity

Early induction of puberty with hormone treatment decreased the age of first farrowing in gilts and resulted in larger first litters. Culling before first breeding was higher in hormonally-induced gilts, however, culling rate and reasons

for culling subsequently were not different between treated and control sows. The culling rate for lameness and downers was about 15.6% overall. Longevity of gilts in the breeding herd was not affected by hormone treatment for puberty induction.



RESEARCH ACTIVITY REPORT 2010-2013

A STUDY ON THE EFFICIENCY OF WATER SPRINKLING IN THE TRUCK AFTER LOADING AND PRIOR TO UNLOADING AT TWO DIFFERENT ENVIRONMENTAL TEMPERATURES ON CORE BODY TEMPERATURE AND CARCASS AND MEAT QUALITY IN PIGS

PROJECT LEADER

Luigi Faucitano, Dairy and Swine Research and Development Centre – Agriculture and Agri-Food Canada (AAFC)

PROJECT OBJECTIVE

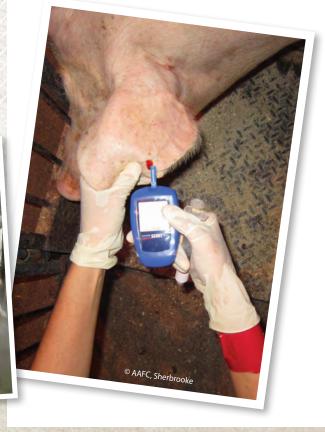
This project aimed to provide the pork industry with a clear procedure to be employed on the truck in warm conditions, with the intention of limiting animal losses during transportation and improving pork quality.

As its recommendations are now included in the training handbook of the Canadian Livestock Transport Certification Program, this project is believed to have a definite impact on transport practices, pig welfare and meat quality.

FINAL RESULTS

Water sprinkling in stationary trailers after loading (on-farm) and just prior to unloading at the slaughterhouse was effective in reducing stress associated with transport, and subsequently improving carcass meat quality of pigs located in critical compartments when outside air temperatures exceed 20 °C. In addition, no detrimental effects on unloading procedures (e.g. slipping) were observed. Results were obtained by measuring blood lactate levels at slaughter, pH one hour after slaughter and drip loss 24 hours after bleeding in the loin muscle.

During summer, the temperature inside a stationary pot-belly trailer can be hotter than the ambient outside temperature by up to 6 °C, especially in the lower compartments and those on the front of the middle deck. When outside air temperatures exceed 20 °C, it is beneficial to cool pigs through sprinkling, reducing body temperature and improving the pig's well-being.



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A COMPARISON OF THREE ANIMAL WELFARE ASSESSMENT PROGRAMS ON CANADIAN SWINE FARMS

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PROJECT LEADERS

Tina Widowski, University of Guelph and Penny Lawlis, Ontario Ministry of Agriculture, Food and Rural Affairs

PROJECT OBJECTIVE

- To compare three on-farm animal welfare programs as they pertain to Canadian farms:
 - Canada's Animal Care AssessmentTM (ACA)
 - USA's Pork Quality Assurance® (PQA) Plus
 - EU's Welfare Quality® Assessment
- To determine inter-observer reliabilities for different measures included in each of the assessments

The data obtained can be used to identify the best measures and to review the training for on-farm animal welfare assessment programs.



FINAL RESULTS

COMPARE THREE ON-FARM ANIMAL WELFARE PROGRAMS

The Welfare Quality[®] program works on a scoring scale and places farms into one of four categories (excellent, enhanced, good, not classified). PQA Plus[®] and ACA[™] both use a pass or fail system.

Results showed that farms consistently earned "enhanced" level scores for the Welfare Quality® measures, but most of the 20 farms were unable to meet all the requirements for the PQA Plus® or the ACATM. Although producers kept records on many critical animal welfare procedures, they were not able to produce all records required by the ACATM or the PQA Plus®.

Some Animal-based measures (ABM) can easily and reliably be included in an on-farm animal welfare assessment program. Management-based measures (MBM), previously thought to be a simpler way to measure on-farm welfare, need to be relevant to the producer before being included in an on-farm animal welfare assessment program. Resource-based measures (RBM) can be useful in an assessment also, and should be included when there is not an ABM that is reliable enough to give accurate results.

INTER-OBSERVER RELIABILITY

RBMs and MBMs generally have a higher agreement among observers than most ABMs. When using two different scales to compare two similar ABMs, such as body condition score, the simpler ABM displayed greater reliability. Surprisingly, some measures that should have had a clear yes or no answer showed variability. The wording of questions, the personal standards or the experience of observers may have affected responses.

USE OF NON-PENETRATING CAPTIVE BOLT FOR EUTHANASIA OF NEONATE, SUCKLING AND WEANED PIGLETS UP TO 9 KG

PROJECT LEADERS

Tina Widowski, University of Guelph and Suzanne Millman, Iowa State University

PROJECT OBJECTIVE

To investigate the effectiveness of the modified design of the non-penetrating captive bolt for euthanasia of neonates, as well as older piglets.

The Zephyr-E is a highly effective and humane method of euthanasia for piglets weighing up to 9 kg. It is now available for use on farms.

FINAL RESULTS

Overall, the Zephyr-E non-penetrating captive bolt is a highly effective and humane, single step method of euthanasia for piglets weighing up to 9 kg. It provides a practical, science-based alternative to blunt force trauma for euthanasia of young piglets.

During the experiments, application of the Zephyr-E consistently resulted in immediate, sustained insensibility until death for all piglets. Skull fractures and subdural and parenchymal hemorrhage were present in all piglets indicating that the device induced severe traumatic brain injury leading to death. For all piglets, loss of sensibility was immediate, involuntary movement ceased in less than 5 minutes and cardiac arrest occurred in less than 15 minutes.

The device is now commercially available. It is safe for the operator and comes with training material.





DEVELOPMENT OF AN INNOVATIVE AIR CLEANING SYSTEM FOR SWINE BUILDINGS

PROJECT LEADER

Stéphane P. Lemay, Research and Development Institute for the Agri-Environment (IRDA)

PROJECT OBJECTIVE

The overall objective of this project is to improve the acceptability of swine facilities in rural areas by reducing their potential environmental impacts.

The air treatment unit, tested at both the laboratory and commercial scale, offers promising results to reduce odour, ammonia, dust and bacteria emissions from new or existing swine buildings.

FINAL RESULTS

LABORATORY-SCALE AIR TREATMENT UNIT (ATU) DEVELOPMENT AND EVALUATION

An innovative ATU was developed based on biotrickling filters which use microorganisms to degrade pollutants. Extensive tests were conducted in the laboratory using bench scale pig chambers to determine the effect of different operating parameters. The removal efficiencies obtained were up to 68%, 82%, 96% and 36% for ammonia, odours, bacteria and viruses respectively.

COMBINATION OF A BIOFILTRATION TREATMENT WITH THE ATU

Reductions in odour and gas emissions were measured by combining the ATU with one of four biofiltration treatment units. Results showed a significant increase in removal efficiency but the size required by both systems could hinder any gains.

EVALUATION OF A COMMERCIAL-SCALE ATU IN AN ACTUAL SWINE BARN

The performance of a commercial-scale ATU was assessed under real barn conditions at the Prairie Swine Centre inc. over a 12-week period. The ATU provided robust and consistent performance. Weekly average removal efficiencies obtained during these tests were up to 77%, 92% and 75% for ammonia, dust and odour, respectively. The biotrickling air treatment unit shows great promise in alleviating one of the long-standing challenges the pork industry faces, reducing odour and airborne emissions from hog facilities.



DEVELOPMENT OF AN INNOVATIVE PRECISION FARMING SYSTEM FOR SWINE

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PROJECT LEADER

Candido Pomar, Dairy and Swine Research and Development Centre – Agriculture and Agri-Food Canada (AAFC)

PROJECT OBJECTIVE

To acquire the required scientific knowledge to feed pigs individually with tailored daily diets for optimal management of feed and animals and develop the numerical procedures necessary for development of a fully automated commercial precision feeder system for swine.

Adjusting the nutrient supply in order to meet the individual requirements is one way to reduce environmental impacts (25%) and feeding costs (by more than \$8 per pig) during the growing-finishing period.

FINAL RESULTS

MODEL THE METABOLISM OF PHOSPHORUS (P) AND CALCIUM (CA) AND DEVELOP A SYSTEM APPROACH TO ESTIMATE EACH PIG'S INDIVIDUAL DAILY REQUIREMENTS

The model developed in this project adequately simulates the metabolic fate of P and Ca along with their interactions. The model is helpful for fine-tuning P and Ca levels depending on the economic and feeding contexts.

MODIFY CURRENT FEED FORMULATION PROGRAMS FOR SIMULTANEOUS OPTIMIZATION OF TWO PREMIXES WITH ENVIRONMENTAL CONSTRAINTS AND OPTIMAL NUTRIENT DENSITY

Reducing feed cost by 5.2% could be performed through a daily phase feeding strategy with a free energy formulation using two optimised premixes. However, nitrogen and P excretions could be increased by 7% and 11% respectively. To control this negative effect on nutrient excretion, a multi-criteria model needs to be developed.

CALIBRATE THE MODEL FOR OPTIMAL LYSINE

The model developed within the precision farming system underestimates lysine requirements of pigs from 25 to 50 kg, while it adequately estimates the needs for pigs from 70 to 100 kg. This model has to be re-evaluated using different genetics of pigs.

UPDATE THE ACTUAL MODEL FOR REAL-TIME PREDICTION OF FEED INTAKE, WEIGHT GAIN AND PREDICTING NUTRIENT REQUIREMENTS

The developed model can monitor the feed intake and weight trajectories of each individual animal of the farm in real-time with good accuracy. Based on these trajectories and using classical factorial equations, the model allows estimating dynamically each individual animal nutrient requirements and optimal dietary nutrient concentration. In an effort to develop sustainable precision farming systems for swine, the proposed model can be integrated into feeders and provided to each pig with daily tailored diets.

STUDY THE INDIVIDUAL FEED INTAKE PATTERNS FOR EARLY IDENTIFICATION OF DISEASES

The developed tool helps to predict feed intake patterns but more work needs to be done in order to improve this tool and avoid variation by taking into account pig growth and pig daily feed intake behaviour.

EVALUATE THE ECONOMIC AND ENVIRONMENTAL IMPACTS OF PRECISION FEEDING SYSTEMS

Evaluation showed that the transition from a conventional to a precision feeding system would lead to an \$8 per pig reduction in feed costs. Trial results indicated that in relation to three phase feeding systems, individual precision feeding systems reduced lysine intake by 27% while nitrogen excretion by 30%, without affecting animal performance.



SWINE INNOVATION PORC

EVALUATION AND DEVELOPMENT OF STANDARDS FOR SWINE PRODUCTION SYSTEMS

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PROJECT LEADERS

Lee Whittington and Bernardo Predicala, Prairie Swine Centre

PROJECT OBJECTIVE

- To develop a methodology for analyzing the cost/benefit of system optimization and standardization that can be applied to commercial swine farms.
- To ensure that concepts identified in this project can be translated to the farm, providing a competitive advantage to Canadian pork producers.

The current knowledge and value people place on standards in barn design, construction and operation is very low and 'rules of thumb' dominate equipment purchase and barn design decisions. Other industries have demonstrated significant economic returns from adoption of standards.

FINAL RESULTS

Over 150 relevant animal agricultural standards in the five major systems (physical building, mechanical systems, animal handling, electrical systems and waste systems) were catalogued. Although information on the net financial benefit of these standards was rarely available.

A pre-survey was conducted and highlighted 14 system failure areas. Then, a main survey to quantify the impact and importance of concerns in the 14 system failure areas was conducted. Analysis of the answers revealed that only 18% of respondents reported no problems with any of the 14 areas identified. The areas of most frequent issues were: feeders and waterers, space requirements and crowding, load out and farrowing crates.

Based on the analysis of the responses, a list of recommendations to optimize pig production and research areas to be pursued was drawn up.

The Canadian pork industry could reduce costs and producer frustration through the adoption of standards particularly in the areas of feeder/waterer, space requirement, loadout and farrowing crate design.



NOVEL SWINE FEEDING PROGRAMS TO ENHANCE COMPETITIVENESS AND PORK DIFFERENTIATION: THE CANADIAN FEED & PORK VALUE CHAIN

PROJECT LEADERS

Ruurd Zijlstra, University of Alberta, Kees de Lange, University of Guelph, Eduardo Beltranena, Alberta Agriculture and Rural Development and Andrew Van Kessel, University of Saskatchewan

PROJECT OBJECTIVE

To develop knowledge to support a unique Canadian feed management strategy and feed ingredient database for optimum productivity that also considers nutrient excretion, reduced antibiotic use during the growth phase, and pork quality. This unique database combines digestibility and bioavailability trials and novel feedstuff analyses.

Relevant information on nutritional value of co-products was developed and gathered in a database. When formulating pigs' diet, this new knowledge of co-products can be used and help to reduce feed costs.



FINAL RESULTS

FEEDSTUFF DATA

1. Co-product digestibility and enzymes

(Ruurd Zijlstra, University of Alberta)

Activities within this project enabled the following key findings:

- Treatments targeted to reduce the impact of fiber and protein may increase the digestibility and fermentability of wheat co-products from flour milling.
- Carbohydrases better unlocked the fiber-starch-protein matrix for fermentation than the combination of Carbohydrases+Protease, indicating that the substrate for Carbohydrases hinders degradation of the distillers dried grains with solubles (DDGS) matrix. The matrix of corn DDGS is less imbedded and hence more fermentable than wheat DDGS.
- The energy content of diets based on Canadian feedstuffs of major importance for pig production was determined. Measured net energy contents ranked feedstuffs similarly to NRC (1998).
- Some grain legumes provide more digestible energy (DE) with higher apparent total tract digestibility (ATTD) of energy than corn; thus, can serve as an alternative feed ingredient for growing pigs. However, variation due to type and composition of grain legume should be considered in pig diet formulation. The current in vitro digestibility technique needs further development to better predict the ATTD of energy in grain legumes.
- The NE values of field pea (FP), juncea canola meals (JCM), and wheat millrun (WM) were similar to that of soybean meal (SBM). However, the NE value of napus canola meals (NCM) was lower than that of SBM, likely due to the lower energy digestibility and the known higher fiber content of the NCM than of SBM. The NE values of FP and NCM were lower than the NRC (2012) values by 16% and 5%, respectively, whereas the NE value of WM was higher the NRC (2012) value by 8%.
- Nutrient profiles and digestibility of wheat co-products from flour milling (WFM) vary widely; although some WFM have a DE content comparable to corn. Thus, type and composition of wheat co-products should be considered for pig feed formulation. The existing in vitro technique accurately predicts ATTD of energy in WFM.

- In 2013, the overall findings of the project were part of:
 - Summary articles in Pig Progress, Animal Frontiers, Symposia of the American Association of Swine Veterinarians and American Society of Animal Science, as a book chapter, and will be submitted as a symposium article to the Journal of Animal Science in September, 2013
 - One research article in Western Hog Journal
 - Six research abstracts
 - Two submitted research articles

2. Starch digestion and fiber fermentation

(Ruurd Zijlstra, University of Alberta)

Several studies were conducted and enabled to develop a database on starch digestion and fiber fermentation.

- The in vitro trial showed that physicochemical properties of fiber and starch type affect fermentation kinetics and short-chain fatty acid (SCFA) production; and influence the net portal appearance (NPA) of glucose, glucagon-like peptide-1 (GLP-1) and insulin production.
- High amylose starch increased methane (CH4) production and reduced NE content due to increased fermentation instead of digestion.
- Slowly-digestible starch increased ileal glucose and decreased ileal short chain fatty acid (SCFA) transporter mRNA abundance, possibly due to an increased presence of glucose in the lumen of the ileum. Effects of starch on colonic SCFA transporter mRNA abundance were inconsistent, with slowly-digestible starch increasing monocarboxylic acid transporter-1 (MCT1) but decreasing Na+-coupled monocarboxylate transporter (SMCT).
- Manipulating dietary amylose content altered the microbial profile of Lactobacillus spp (LAC) in the cecum and colon and Bacteroides-Prevotella-Porphyrmonas (BAC) in the colon; however, amylose content did not affect crypt depth and villus height.
- Slowly-digestible starch influenced signalling pathways for glucose and SCFA transport. Although studies indicate sweet taste receptor T1R3 is directly related to Na+-dependent glucose transporter-1 (SGLT1) expression. Results suggest multiple pathways may be responsible for absorption and metabolism of glucose and SCFA.
- Increasing amylose content can modulate gut microbial profiles, volatile fatty acid concentrations, and pH that may play a protective role against pathogenic bacteria.
- For 50 feedstuff samples that contained starch (cereal and pulses), in vitro starch digestion kinetics were determined indicating that starch digestion kinetics vary among feedstuffs, but not to the same extent as purified starch feedstuffs that differ in starch chemistry.
- In 2013, the overall findings of the project were part of:

- One research abstract.

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- One manuscript was prepared and is undergoing review by the co-authors.
- One manuscript was prepared, but requires additional data.

3. Intestinal microbial composition

(Andrew Van Kessel, University of Saskatchewan)

This project enabled to establish a model to examine the impact on intestinal health of lower quality protein sources common in by-product feed ingredients.

It was demonstrated that diets containing high levels of heat damaged soybean meal resulted in high levels of protein fermentation products in the colon. The addition of sugar beet pulp and wheat bran as fiber sources lowered the levels of these putative toxins although not to the level observed with low protein content. Independent of fiber content, diets containing high levels of heat damaged soybean meal were also associated with evidence of colon inflammation, including increased mucus and reorganization of cell junctions to maintain barrier function. Increased protein fermentation in colon could not be confirmed with high levels of pea protein formulated using either CDC Fibar, hulless barley (high β -glucan), CDC McGwire, hulless barley (low β -glucan), or pea starch as the primary carbohydrate source. Carbohydrate source interactions with protein unpredictably affected protein digestibility.

<u>4. Liquid feeding of grower pigs – in vitro steeping</u> and fermentation studies

(Kees de Lange, University of Guelph)

The nutritional value of a large number of corn DDGS samples supplied to Ontario were determined based on nutritional analyses, near infrared spectroscopy (NIRS) and objective color measurements, as well as in vitro and in vivo nutrient digestibility. Results confirmed substantial variability between samples. Even if color provided a reasonable prediction of the nutritional value of individual DDGS samples, this simple measure had limitations.

New user-friendly software is now available to estimate nutrient requirements of different categories of pigs under varying conditions. This information is already published in NRC 2012.

MODEL

5. Model development

(Kees de Lange, University of Guelph)

The project enabled the development of user-friendly software to estimate the nutrient requirements of different categories of swine under varying conditions. New knowledge about nutrition utilization in growing-finishing pigs was integrated into two different packages of user-friendly software. It was used for the evaluation of the financial and environmental impact of alternative feeding management strategies for individual growing-finishing pig units (NRC 2012 and PorkMaster). New applications of this software are to predict nutrient requirements of entire male pigs that are immunized against gonadotrophin releasing factor (GnRF; for control of boar taint) and to estimate nutrient losses into the environment.

Additional software (PorkMaster), which includes a feed ingredient data base and a least-cost feed formulation package, has been made available to industry experts and allows assessment of financial and environmental impacts of alternative feeding strategies for individual growing-finishing pig units.

VALIDATION

6. Validation of the net energy value of wheat DDGS for growing-finishing pigs under commercial scale conditions (Ruurd Zijlstra, University of Alberta and Eduardo Beltranena, Alberta Agriculture and Rural Development)

When pigs were fed diets with assumed net energy values of wheat DDGS of 1.5, 1.7, 1.9, 2.1, 2.3 to 2.5 Mcal/kg; net energy value of wheat DDGS was confirmed at 2.1 and 2.15 Mcal/kg. The benefit of having validated the NE value of wheat DDGS under commercial pig production conditions gives industry nutritionists practical confidence on a value that was previously based merely on calculations.

7. Increasing dietary inclusions of yellow-seeded, expellerpressed, juncea canola meal on pig growth performance, carcass characteristics and lipid composition of pork grown under commercial scale

(Ruurd Zijlstra, University of Alberta and Eduardo Beltranena, Alberta Agriculture and Rural Development)

Increasing dietary inclusions of extruded and expeller-pressed B. juncea canola meal up to 200 g/kg linearly reduced feed disappearance, weight gain, carcass weight, loin depth, and increased jowl fat unsaturation. The reduction in feed intake was attributed to high 3-butenyl (10 μ mol/g) content, a bitterer glucosinolate compared with others found in conventional canola meal. Despite the promise of improved feed efficiency owing to the higher dietary energy value of B. juncea compared with conventional canola meal, its high 3-butenyl levels would prove deterrent.

<u>8. Liquid feeding - pig performance studies</u>

(Kees de Lange, University of Guelph)

Across all five DDGS liquid feeding studies, inconsistent pig growth performance responses to using fiber degrading enzymes and microbial inoculants were observed. In the first two studies, beneficial and additive effects of using enzymes and microbial inoculants in swine liquid feeding were observed, which coincided with substantial increases in lactic acid content in steeped DDGS. Such responses were not seen in the subsequent studies. Additional studies are warranted to better control DDGS fermentation conditions and better understand interactions between different batches of DDGS and the use of enzymes and microbial inoculants. Indeed, very preliminary in vitro test results indicate differences in initial pH during steeping of different batches of DDGS.





NOVEL NUTRITIONAL STRATEGIES FOR OPTIMUM SOW AND PIGLET PRODUCTIVITY

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PROJECT LEADERS

Martin Lessard, Dairy and Swine Research and Development Centre - Agriculture and Agri-Food Canada (AAFC), Kees de Lange, University of Guelph and Ron Ball, University of Alberta

PROJECT OBJECTIVE

The ultimate goal was to develop unique Canadian feeding management strategies for optimum sow and piglet productivity, taking into consideration production efficiencies that include pig performance up to market weight, food safety, pig welfare and use of antibiotics. We investigated underlying mechanisms so that we capitalized on potential synergies between the different sow and piglet feeding strategies that were evaluated. Secondary goals were to further stimulate interactions among multidisciplinary (physiology, immunology, microbiology, nutrition) Canadian swine researchers in nutrition.

Feed costs could be reduced by \$2/pig or more, by using low complexity diets for piglets.



FINAL RESULTS

THE IMPORTANCE OF IN UTERO VS. POST-NATAL TRANSFER OF SOME VITAMINS AND MINERALS IN PIGS (Jacques Matte and Martin Lessard, Dairy and Swine Research and Development Centre – AAFC)

A simple approach was set up to assess the importance of maternal perinatal transfer of vitamins and trace elements from sows to piglets. Globally, in terms of net balance for the newborn piglets, both the pre- and post-natal transfers are active for some micronutrients (vitamin C, vitamin B12 and zinc) while for others the placenta appears as a barrier against the prenatal transfer which is either compensated by the colostral transfer (folates and vitamin E) or not (retinol, vitamin D, iron, copper and selenium). In this last case, piglets are likely to suffer from a deficit in these micronutrients shortly after birth and thereafter during lactation because milk is a very poor source.

Strategies are already well known for iron (injections of iron dextran) and selenium (colostrum and milk enrichment through dietary organic selenium). However, it appears that the preand post-natal transfers of retinol, vitamin D and copper might be insufficient for the whole lactation period and deserve to be further studied.

DEVELOPMENT OF NOVEL FEEDING STRATEGIES AIMING TO IMPROVE GUT DEVELOPMENT, DEFENSE FUNCTIONS, HEALTH AND PERFORMANCE OF PIGLETS

(Martin Lessard, Dairy and Swine Research and Development Centre – AAFC)

Results showed that dietary treatments (cocktail diet: a combination of nutraceuticals and functional feed ingredients; colostrum diet: cocktail diet + bovine colostrum; antibiotics diet) clearly influenced vitamin status after weaning as well as homocysteine blood level. Cocktail and colostrum diets affected the microbiota of both ileum and colon after weaning and after inflammatory challenge induced by bacterial lipopolysaccharides. Globally, results suggest that the colostrum diet improved intestinal health of piglets. Antibiotic, cocktail and colostrum diets had different effects on gene expression in the intestinal tissue and their actions were generally more marked on low weight piglets. It appears, therefore, that low weight piglets could benefit from the colostrum and cocktail diets even more than high weight piglets.

BIOMARKERS TO RELATE MANAGEMENT OF PIGLETS POST-WEANING TO SUBSEQUENT GROWTH PERFORMANCE, CARCASS AND MEAT QUALITY

(Kees de Lange, University of Guelph)

Results showed that feeding nursery pigs rather simple diets, based on corn and soybean meal, reduced post-weaning growth performance, but had no long-term effect on growth performance up to market weight and carcass characteristics. Indeed, pigs showed compensatory growth during the growing-finishing phase. Therefore, a reduction in feed costs of more than \$2 per pig could be obtained in the nursery phase without compromising subsequent growth performance and carcass value.

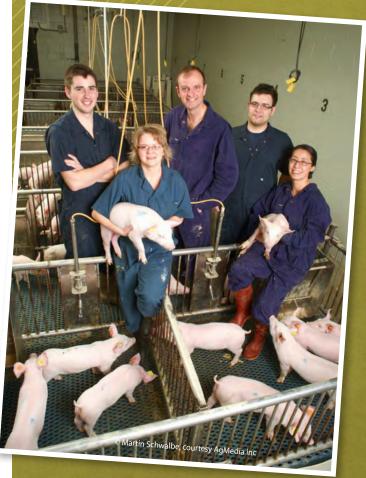
However, in the event of a severe health challenge, the use of simple nursery diets compromises the pig's ability to achieve compensatory growth and recuperate from earlier reductions in performances. Potential genetic markers were identified to help select pigs for better performances and stronger innate response against infectious agents. The impact of nursery feeding programs on the pig's ability to deal with health challenges deserves to be further explored.

Parity segregated phase feeding could reduce feed costs by more than \$10 per sow per year based on sow amino acids and energy requirements during gestation.

SOW NUTRITION DURING GESTATION (Ron Ball, University of Alberta)

Results showed an increase in requirements for energy and all amino acids studied in late gestation compared to early gestation. These changes in nutrient requirements indicate that feeding sows a single diet throughout their entire gestation is not appropriate.

Parity segregated phase feeding with two diets is proposed to supply sows with the correct amount of nutrients throughout their life cycle. Results showed that two phases, one from breeding to 84 days of gestation, and one from 85 days of gestation to entering the farrowing room would be appropriate. The two diets suggested are one with lower amino acids content and one with increased amino acids content. Those diets can be used separately or mixed to meet sows' different amino acid requirements. The feed allowance should be adjusted according to the energy expenditure of sows and should then be greater in late gestation and for gilts.



EFFICACY OF FEED ADDITIVES TO MITIGATE THE NEGATIVE IMPACTS OF MYCOTOXIN-CONTAMINATED FEED ON THE PERFORMANCE AND HEALTH OF PIGLETS

PROJECT LEADERS

Frédéric Guay, Laval University, Martin Lessard, Dairy and Swine Research and Development Centre – Agriculture and Agri-Food Canada (AAFC), and Younès Chorfi, University of Montréal

PROJECT OBJECTIVE

Develop a protocol to evaluate the efficacy of feed additives available in Canada to attenuate the toxicity of naturally contaminated grains that may contain more than one mycotoxin, and to mitigate the negative impact of mycotoxins on immune and intestinal functions of pigs.





FINAL RESULTS

EFFECTS OF MYCOTOXIN-CONTAMINATED FEEDS AND FEED ADDITIVE SUPPLEMENTS ON GROWTH PERFORMANCE

Comparison of the four commercial mycotoxin inhibitors (IntegraITM, Biofix[®], MXM and Defusion[®]) in piglets at weaning showed that there are differences in the effectiveness of various mycotoxin inhibitor products to counteract the negative effect of mycotoxin contaminated feeds on growth performances. Average daily gain and feed intake were higher for piglets consuming the Defusion[®] supplement during the experiment. However, Defusion[®] is currently not registered for use in Canada.

Also, the four mycotoxin inhibitors showed varying effects on the nutrients digestibility (calcium, phosphorus, nitrogen and energy), particularly with respect to nitrogen. If these differences are corroborated in field trials, it would mean that judicious selection of commercial mycotoxin inhibitors could have a considerable impact on the profitability of swine producers.

An additional benefit derived from this project is the availability of a serological test for early detection of DON contamination in piglets, thus providing a means to monitor contamination and/ or the effectiveness of feed supplements to counteract such contamination.

EFFECTS OF MYCOTOXIN CONTAMINATED FEED ON SUSCEPTIBILITY TO VIRAL INFECTIONS AND ON IMMUNE RESPONSE IN PIGLETS

The results obtained demonstrate a negative effect on antibody response of pigs fed with a highly DON contaminated diet. Concentrations over 3.5 ppm of DON could therefore undermine the efficacy of a live attenuated vaccine directed against PRRSV or PCV2 by interfering with the humoral response of the animal.

Results also suggested that PRRSV infection could exacerbate the anorectic effect of DON, when ingested in large doses.

MYCOTOXIN CONTENT EVALUATIONS OF CORN HYBRIDS ADAPTED TO QUÉBEC GROWTH CONDITIONS

PROJECT LEADERS

Gilles Tremblay and Sylvie Rioux, Centre de recherche sur les grains (CEROM)

PROJECT OBJECTIVE

The main objective of this research is to determine, under natural disease pressure, whether there are any differences between hybrids (Genotype effect, G) in grain content levels of four different mycotoxins (Deoxynivalenol (DON), fumonisin (FUM), zearalenone (ZEN) and T-2 toxin) in three different environments (Environment effect, E). G x E interactions will also be evaluated.

FINAL RESULTS

Results indicated that grain corn is usually under critical content levels for Deoxynivalenol (DON), fumonisin (FUM), zearalenone (ZEA) and T-2 toxin (T2).

- For the FUM, ZEA and T2 toxins, 98 to 100% of the hybrids had toxin content under the critical levels.
- For DON toxin, 84% of the hybrids had \leq 1 ppm in 2700-2900 and 2500-2700 CHU areas but only 58% in the 2300-2500 CHU area. Still, for DON toxin, 96-98% of the hybrids had \leq 2 ppm in 2700-2900 and 2500-2700 CHU areas and 86% in the 2300-2500 CHU areas.
- Fungicide (Headline[®]) application was effective in reducing T2 toxin levels, but had no impact on DON, FUM or ZEA.

Of all the toxins analyzed, DON was the most prevalent and most frequently exceeded critical levels associated with, feeding corn to pigs. The results will help farmers with the selection of hybrids with a better tolerance to mycotoxins, helping to minimize the negative impacts of feeding mycotoxin contaminated grain.



CAPTURING GENETIC MERIT IN DIFFERENTIATED PORK PRODUCTION SYSTEMS THROUGH GENOMICS

PROJECT LEADER

George Foxcroft, University of Alberta

PROJECT OBJECTIVE

To demonstrate that alignment of the excellent genetic potential of Canadian dam-line sows with management strategies that recognize the origins of major variation in phenotypic traits of terminal line litters provides major competitive advantages to Canadian pork producers.

Segregated management strategies for low birth weight and high birth weight litters might provide more economic value than targeting the entire sow herd.

FINAL RESULTS

This project confirmed two main concepts:

- In less prolific litters (up to 16 total born), less than 5% of the variance in litter average birth weight is explained by the number of piglets born.
- Litter birth weight phenotype is a repeatable phenotypic trait.

This and other projects have established that the litter birth weight phenotype is driven by an inappropriate interaction among the key component traits that determine litter size. High ovulation rates (25-30 ovulations) in mature sows result in greater than 50% pre-natal loss. In many sows, much of this pre-natal loss of embryos occurs after the implantation stage of pregnancy. As a result, intra-uterine crowding of embryos in early gestation is inevitable. This crowding adversely affects placental development as the primary mechanism that drives later problems with intrauterine growth restriction and low litter birth weight.

The present project indicates that as a low birth weight phenotype results in poorer survivability of the litter before weaning and poorer post-natal growth performances, there is considerable merit in continuing to search for genomic markers of the component phenotypic traits determining litter birth weight. The markers could then be used to affect continued increases in numbers born without compromising the performance of the litters born to more prolific sows.

From a production management perspective, the results of this project suggest that more focus on monitoring the repeatability of a litter birth weight phenotype would allow for 1) segregated management of these sows and litters at farrowing and 2) possible savings in feed costs by segregated management of litter birth weight offspring through the nursery and grow-finish stages of production.





DEVELOPMENT OF NEW GENOMIC TOOLS TO IMPROVE MEAT QUALITY TRAITS AND PRODUCTION EFFICIENCY IN PIGS

PROJECT LEADERS

Brian Sullivan and Mohsen Jafarikia, Canadian Centre for Swine Improvement (CCSI)

PROJECT OBJECTIVE

Develop new genomic tools to improve meat quality traits as well as enhance product differentiation and the efficiency of pork production.

Genomic evaluations of economically important traits linked to productivity and meat quality were developed and implemented. The swine industry is now positioned to start routinely applying genomic evaluations in breeding programs.

FINAL RESULTS

The porcine 60K SNP panel provided tools for using genomic evaluation for selecting breeding animals early in life to improve important production and meat quality traits. Guidelines and recommendations on the use of genomic information in swine breeding programs were provided for the Canadian swine industry.

Significant impacts of this project are:

- Development of the tools and infrastructure for the application of genomic evaluation to be used for production efficiency and pork differentiation.
- Specific major genetic markers and SNPs on the 60K panel that were significantly associated with traits economically important to the swine industry were explored.
- Gene expression analyses allowed studying expression patterns in animals with distinct phenotypes. SNPs within targeted genes could potentially be used to select for specific pork quality attributes and production efficiency.

TECHNOLOGY TRANSFER REPORT

Both the Centre de développement du porc du Québec (CDPQ) and the Prairie Swine Centre were mandated to carry out the Technology Transfer Program, an integral part of the Canadian Swine Research and Development Cluster. The strategy of having two organizations, one in Eastern Canada and another in the West was sensible. This concept allowed for a very diverse range of activities accomplished by both centers which contributed to an effective and efficient Technology Transfer Program across Canada.

The primary goal of the program was to inform the pork industry across Canada of the outcomes of Swine Innovation Porc (SIP) funded research. Numerous activities were also carried out to encourage the adoption of some results obtained in the research program.

The following list summarizes the technology transfer activities that were carried out primarily during the last two years of the program.

- Swine Innovation Porc's Annual Reports for 2011 and 2012 were produced, in both English and French including all 14 research projects. They are available both, in print and electronic versions.
- Two annual Swine Innovation Porc seminars were held in conjunction with the 2012 and 2013 Banff Pork Seminar. In 2012 the session "Breakthroughs in Canadian Swine Nutrition" was presented and more than 120 people attended. In 2013, three topics were presented, one on animal welfare and two on genomics. Over 200 people attended these seminars.
- A Symposium on Mycotoxins titled "Risk management, from seed to feed" was held in December 2012 in Boucherville, Quebec. This event gathered 273 attendees. Twelve conferences were prese-nted by speakers from France, Ontario, Manitoba, Saskatchewan and Quebec. Simultaneous translation was offered for all the conferences. A video along with each speaker's presentation is available on the symposium's Web site at <u>www.symposium-mycotoxines.ca/en/program</u>.
- A bilingual Web site was developed and can be visited at <u>www.swineinnovationporc.ca</u>.
- A database housing all the reference material and publications associated with Swine Innovation Porc's research projects is available on SIP's website. A total of 90 publications related to SIP project areas have been posted to the database.

- 15 e-newsletters were published in English and 10 in French concerning projects of the research program. These publications addressed existing challenges or opportunities touching the pork industry.
- Bruce Cochrane from Farmscape.ca produced 28 articles and interviews regarding SIP projects.
- In 2012 and 2013, 8 issues of the Western Hog Journal and 4 issues of Centered on Swine featured technical articles featuring SIP research and advertisements.
- In the April 2013 issue of Porc Québec, a special feature was published on research including ten articles on SIP's activities and research projects. Another article was also published in the June 2013 issue.
- In June 2013, Prairie Swine Centre's Annual Research Report featured three articles related to collaborative projects between SIP and Prairie Swine Centre.
- A key element of the technology transfer activities was the development and the implementation of the Lead-User Program. Six research projects were identified as key activities for the program. Financial support was obtained from the Agricultural Council of Saskatchewan, the Conseil pour le développement de l'agriculture du Québec, Ontario Agricultural Adaptation Council, Agriculture and Food Council of Alberta to initiate the Lead-User Project. It is being carried out in the major pork producing provinces across Canada and will extend over the course of spring, summer and fall of 2013.
- SIP was represented at all major swine events across Canada.
- Pull-up banners, featuring the SIP's mission and objectives, were displayed at all major pork industry events.
- Three posters highlighting the economic benefit of SIP research were produced targeting producers and were displayed at industry events.
- A five year preliminary work plan along with its corresponding budget was prepared regarding the implementation of the precision feeding technology for growing-finishing operations.

HIGHLIGHTS 2010-2013





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ENHANCED EXPERTISE: CONTRIBUTED BY TRAINING HIGHLY SKILLED PROFESSIONALS FOR THE PORK SECTOR

SWINE INNOVATION PORC

28 MASTER'S STUDENTS

L DOCTORAL CANDIDATES

23 POSTDOCTORAL SCHOLARS

DISSEMINATION OF RESULTS

27

210 TECHNOLOGY TRANSFER ACTIVITIES AND DOCUMENTS SHARED WITH THE INDUSTRY

SEVENTY PERCENT DESTINED FOR PRODUCERS

15 e-newsletters

28 Farmscape interviews, 8 articles in Western Hog Journal and 11 in Porc Québec

SYMPOSIUM

ON MYCOTOXINS

PARTICIPANTS

6 conferences at the Banff Pork Seminar/ 320 people attended in all

90 references and publications associated with Swine Innovation Porc's research projects

RESEARCHERS WROTE MORE THAN 190 PEER-REVIEWED PAPERS

To date, more than **70%** published in scientific journals

INDUSTRY PARTNERS

28



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Agriculture and

Agri-Food Canada

Canada



Agroalimentaire Canada

Agriculture et











Centre de recherche industrielle Québec 🏕 😫

















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NXStream



SWINE INNOVATION PORC

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PARTNERS IN RESEARCH

Canadian Food Inspection Agency Agence canadienne d'inspection des aliments

Agriculture and Agri-Food Canada Agriculture et Agroalimentaire Canada





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