



**Research Report 2004**

**Science Working For You**



# Mission Statement

Foster the sustainability and prosperity of the pork industry for the good of all hog farmers and all Manitobans.

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## Fellow Producer:

Council's fifth annual Research Report has been produced in order to requests for information that we as farmers have made to Directors, members of the Research and Environment Committee, and from staff. As producers ourselves, Committee members direct research funds to programs and projects that hog farmers can use in the day-to-day operation of our barns. The research we fund is focused on food safety, animal care and production, workplace health and safety and environmental stewardship. When evaluating requests for funding, the Committee ensures that the work of the research institution focuses on producers' priorities and also considers the ability of the research to leverage additional funds. These additional funds enable access to research that would cost many times more than we would be able fund on our own.



The process doesn't end with funding and sponsorship of research. Without communicating the information and knowledge gained from research to Manitoba producers, the process would be incomplete. Sharing this information with you is done in a variety of ways, including monthly "Research News" pieces included in Council's newsletter, on Council's redesigned website at [www.manitobapork.com](http://www.manitobapork.com), at seminars provided by funded institutions such as the University of Manitoba and the Prairie Swine Centre, and in this annual Research Report.

The bottom line is that research funded by Council is producer focused, producer directed, and designed to assist all hog farmers in Manitoba. We continue to work hard to help put science to work for you.

Best regards,

A handwritten signature in black ink that reads "Bryan Ferriss". The signature is written in a cursive, flowing style.

Bryan Ferriss  
Chairman, Research & Environment Committee  
Manitoba Pork Council  
February 2005





UNIVERSITY  
OF MANITOBA

The Department of Animal Science  
Faculty of Agricultural and Food Science

2004

## Manitoba Pork Council Funded Research

### **Overview**

The Swine Research Team in the Department of Animal Science, University of Manitoba, is helping Manitoba's pork producers meet industry challenges through our innovative research and teaching programs. Our researchers are examining: 1) strategies to increase the utilization of locally-produced crops with an eye to reducing the need to import feed; 2) management strategies for the optimization of sow productivity; 3) optimum transportation conditions for weanlings; 4) alternative approaches to improving the health and performance of animals, with an eye to addressing issues related to food safety, animal welfare, and environmental quality. In 2004, research funds secured from the Manitoba Pork Council were leveraged against matching funds contributed by the University of Manitoba (salaries, infrastructure support), provincial (ARDI; MRAC; Agriculture, Food and Rural Initiatives; Energy, Sciences and Technology; Brandon Hog Days Committee), national (NSERC), and international (US National Pork Board) agencies. In total, the contributions from the

Manitoba Pork Council make a substantial contribution to the total operating budget of approximately \$1,200,000, from all sources, for swine-related research. This translates to over \$8 of research funding for every \$1 of funding received from the pork producers of Manitoba.

In 2004, we defined our mission statement and have committed ourselves to:

*"To develop, through research, education, and outreach activities, best-management practices for swine production that maximize profitability, optimize animal welfare, and address consumer issues related to food safety, animal and human health, and environmental impact, through the use of a systems-based approach"*

The approach we are taking is a "whole picture" or systems-based approach. For example, where in the past, swine nutritionists have worked in isolation of engineers, soil chemists, and environmental scientists in

dealing with issues such as phosphorus management, a systems-based approach sees these disciplines working together – drawing upon the expertise that individuals possess and applying that to find solutions. Many of the issues facing the industry benefit more from our understanding of the interactions among system components than of the individual components, themselves. A research program that addresses production holistically offers solutions with greater management flexibility, identifies beneficial management practices with enhanced environmental and economic outcomes, and creates safer and healthier conditions for humans and animals. The University of Manitoba, has taken a lead role in using this “whole picture” or systems-based approach, in its research and education programs. The establishment of the **National Centre for Livestock and the Environment (NCLE)**, a centre *unique* in Canada and made possible through financial support from our partners including Manitoba Pork Council, has provided us with the infrastructure to enable us to do systems-based research over the long term. With **NCLE**, we now possess the facility and tools that will allow researchers from many disciplines to work together on long-term solutions to key issues facing swine production, including swine productivity and well being, food safety and environmental health. With new infrastructure and new research personnel the swine research team at the University of Manitoba is well positioned to help the pork producers of Manitoba address critical issues facing our industry today, and those that will likely present themselves in the future.

### **Construction of the National Centre for Livestock and the Environment (NCLE) has begun**

We are very pleased to announce that construction of the research barns and feedmill related to the **National Centre of Livestock and the Environment** has started. The Centre, primarily located at the Glenlea Research Station south of Winnipeg, will enable study of the long-term effects of intensive livestock production systems on health and the environment.

The new facility will tackle issues such as odour, water quality, greenhouse gas emissions, and fertilizer use, with the goal of developing environmentally sustainable livestock production practices. The long-term systems-based research will look at animal housing, manure handling, cropping systems, soil, air and water health, and food safety.

Some of the highlights of this project are:

- Using both conventional and alternative animal housing facilities, conventional and alternative manure storage and handling technologies, long-term crop rotations, and well equipped

laboratories, this will be the only location in North America with the facilities and tools for researchers to work together on long-term solutions to key issues facing animal agriculture, including environmental health, food safety, and animal productivity and well being.

- The only Canadian Centre to test the opportunities and limits of increased nutrient recycling through novel cropping and feed processing strategies.
- Canada's only long-term livestock production research model with specific focus on environment from the molecular to the landscape level
- The only national archive of soil, plant, water and manure samples form a time prior to establishment of the intensive livestock production models throughout the life of the operation.
- The most comprehensive testing and monitoring for weather events, nutrient balance, and flow, presence and shifts in pathogen populations, and characterization and movement of various microbial genetic elements in a livestock based agriculture production system.
- The Centre will provide key data for economic analysis of alternative animal, manure and land management practices, quantify economic and other risks, as well as identify economic opportunities.

Engineering services for the Centre's animal facilities have been provided by Dennis Hodgkinson of DGH Engineering in conjunction with EarthTech and Stantec Architecture. Penfor Construction has been awarded the contract to build two 130 sow farrow-to-finish barns, an off-site antibiotic free test barn, solid manure storage facilities, and an 80 head beef feedlot. Design and construction of the feed mill has been awarded to Superior Agri Systems.

### **The Glenlea Farm Education Centre: A New and Innovative Agri-Food Experience**

The **Glenlea Farm Education Centre (GFEC)** will be a new and innovative interpretive centre located at the University of Manitoba's Glenlea Research Station just south of the City of Winnipeg. The Centre will be housed in the **National Centre for Livestock and the Environment (NCLE)** which is scheduled to open in the fall of 2005. This will provide a unique opportunity to bring together a state-of-the-art research facility and an interpretive centre under one roof.

The NCLE will be unlike other in North America, allowing scientists to study ecological interactions and the effects of management practices in a total crop and animal production system. The Glenlea Farm Education

Centre will showcase the work of these scientists through dynamic exhibits of grain and feed production, viewing galleries of the farrow-to-finish hog barn, food retailing and food safety exhibits. It will be the only interpretive centre in Canada to feature sustainable production practices for all components of an agricultural enterprise, with emphasis on intensive swine production. Although school students will be the primary audience for the Centre, university students, researchers, farmers and the general public will also gain important information about Canada's entire agricultural industry during their visit.

The Centre's mission and goals have been developed, interpretive themes have been established and a \$ 4.0 million fundraising campaign has recently been launched by the University of Manitoba. The Planning Committee which includes Diane Wreford (now with Canola Council of Canada), Ted Muir, Agriculture in the Classroom and several University researchers is now engaged in the next phase which includes the development of a sound interpretive exhibit plan that will include detailed designs, interpretive messages and text, and visitor programming. This will be done by retaining the services of an exhibit design team that will deliver a detailed interpretive exhibit plan that meets the goals and objectives of the Centre, and which will excite the imagination of its visitors.

The Glenlea Farm Education Centre will be a model for interpretive centres in Manitoba and across the country. The exhibits will pay tribute to our farm heritage and to the work accomplished by the Faculty of Agricultural and Food Sciences. By linking the Education Centre with the on-going research occurring at NCLE, visitors will get an unprecedented opportunity to witness first-hand the work of some of Canada's leading agricultural scientists as they conduct research to develop and refine environmentally sustainable and healthy food production practices.



Manitoba  
Livestock  
Manure  
Management  
INITIATIVE INC.

**Manitoba Livestock Manure  
Management Initiative Inc.**

# 2004

## **Manitoba Pork Council Funded Research**

### *Overview*

The Initiative was established out of an appreciation in the hog industry and in government of the importance of ensuring the growth of the industry without damage to the environment and without compromising goodwill among neighbours of producers in the industry. A meeting was convened by the Economic Development Board and the Department of Agriculture in September, 1997 to facilitate the establishment of an organization which would seek out and fund, where applicable, promising technological solutions to environmental challenges facing the industry. Various stakeholders in the hog industry attended the meeting. Those in attendance identified representatives of each stakeholder group which would serve on the governing council of the organization. The groups represented were: Manitoba Government, Consumers Associations, Financial Institutions, Livestock Producers, Technology Providers, Feed Companies, Livestock Research (Academia), Livestock Processors and Municipal Governments.

In January, 1998, the Manitoba Livestock Manure Management Initiative was incorporated as a not for profit Manitoba Corporation without capital shares with a Chairman, eleven Directors and a Secretary – Treasurer. The Board of Directors serves as volunteers, while the chairman is paid an honorarium by the Initiative. The Department of Agriculture pays the salary of the Secretary – Treasurer and provides office space and services as its contribution to the Initiative. The Initiative's mandate is to encourage sustainable development of the livestock industry in an environmentally sound and community-friendly way, through research and development and demonstration.

The Initiative received \$100,000 start-up funds from the Sustainable Development Innovations Fund. The Initiative's ongoing operations are funded by industry stakeholders with the largest portion of funding provided by Manitoba Pork Council and the feed manufacturers in the province. As well, the Initiative has leveraged its funds by obtaining the participation of other funding agencies in the funding of investigative work into better methods of manure management.

Since its inception, the Initiative has funded a total of fifty projects exploring better methods of manure management with a combined value of \$3,782,845. This amount is broken down as follows: Initiative Funds \$1,337,505, Funding by Other Agencies \$1,010,713 and Contribution by Project Performers \$1,434,627. The funds are released in the form of progress payments upon the receipt of quarterly reports on the progress of the projects. The projects are managed by the Chairman and the Secretary – Treasurer.

While the Initiative accepts applications for funding on an ongoing basis, there have been six calls for proposals issued. The Initiative has received and considered a total of 182 applications for funding.



**Prairie Swine Centre Inc.**

## **Manitoba Pork Council Funded Research**

# 2004

### ***Overview***

Prairie Swine Centre Inc. is a non-profit research and technology transfer corporation, affiliated with the University of Saskatchewan, with expertise in three disciplines – behaviour, nutrition, and engineering. The mission of Prairie Swine Centre Inc. is *“to provide a centre of excellence in research, education and technology transfer, all directed at efficient sustainable pork production.”* The research program, with a decidedly near-market emphasis, seeks to improve the financial position of pork producers by defining feeding and management systems that maximize net income. In addition, the Centre carries out research to address issues and opportunities in environment, barn air quality and animal well-being.

Dr. Harold Gonyou's team of applied ethologists are addressing such issues as floor space requirements, optimal group size, improved equipment design and dry sow housing alternatives. Dr. Predicala assumed the responsibilities of Dr. Lemay in January 2004, and his team of agricultural engineers are evaluating manure pit additives, ammonia control, hydrogen sulphide emissions, odour and dust control. Dr. Patience and Dr. Zijlstra operate two nutrition teams to define the pig's requirement as well as the ingredient profile of western Canadian ingredients available to satisfy the nutrient needs of the animal. The nutrition team also investigates dietary ways to reduce nitrogen and phosphorus emissions in the slurry, as well addressing different causes of variation in the grow-out barn. Multidisciplinary projects are addressing water conservation, young pig management and environmental management. While the Prairie Swine Centre cannot solve these problems, we can provide information that the pork industry can use to make important decisions about its future.

The Technology Transfer Program utilizes a wide range of activities, from a quarterly newsletter and database driven website to an annual technical conference, tradeshow and farm calls all with a view to communicating and encouraging the early adoption of research results by the commercial pork industry.

Education activities are diverse and involve partnerships with universities

and community colleges. Undergraduate and graduate students at the University of Saskatchewan utilize the facilities as part of their training programs. Students resident at the Centre and enrolled in the College of Graduate Studies and Research at the University of Saskatchewan conduct their research in our extensive animal facilities and complete their work on campus. The result is a graduate program that blends a strong academic foundation with exposure to the commercial pig industry.

Prairie Swine Centre's facilities include a 280 sow farrow-to-finish operation near Floral, Saskatchewan, and PSC Elstow Research Farm a 600 sow farrow-to-finish sow operation near Elstow, Saskatchewan, combining to market 20,000 hogs annually. In October 2003 Prairie Swine Centre opened the newly constructed Pork Interpretive Gallery. Constructed within the PSC Elstow Research Farm, it provides an opportunity for pork producers, school groups, municipal councillors, and other interested individuals an opportunity to view the operation of a modern swine production unit, and learn about the science and facts of modern livestock production.



## **VIDO - Vaccine and Infectious Disease Organization**

# **Manitoba Pork Council Funded Research**

# 2004

***“Mandated to serve the livestock and poultry industry by conducting animal health related research, communicate livestock management techniques and information, and facilitate the transfer of technology for international commercial development”***

### **Overview**

#### **Then and now**

The Vaccine and Infectious Disease Organization was created in 1975 with a mandate to develop vaccines for the protection of livestock against serious and economically devastating diseases, and to ensure the technology reached the producer. Originally the Veterinary Infectious Disease Organization, VIDO had a staff of five, temporarily housed in trailers. Today, VIDO has a new name, a brand-new state-of-the-art building, and more than 135 employees and researchers occupying 100,000 square feet on the University of Saskatchewan campus.

Through the leadership of Dr. Lorne Babiuk, VIDO director, and the dedication of VIDO staff, the Organization has become an internationally recognized leader in developing innovative vaccines and mechanisms of vaccine delivery to improve health and quality of life for livestock. VIDO's facilities include modern virology, immunology, bacteriology and biochemistry labs as well as a 160-acre research station. The Organization recently celebrated the opening of its new \$19 million expansion, supported by the Canada Foundation for Innovation, Western Economic Diversification Canada, the Province of Saskatchewan, the Province of Alberta, and the University of Saskatchewan.

#### **An industry presence**

VIDO is a preferred partner in the development and commercialization of products and resources used by producers in the food animal industry, and participates in collaborative agreements, research and service contracts with a growing number of multinational animal health and pharmaceutical companies, along with government and academic institutions. Collaborative opportunities with scientists around the world are firmly established and VIDO is an enthusiastic host to visiting scientists. The Organization also

offers a challenging and rewarding training environment for undergraduate and postgraduate students as well as postdoctoral fellows.

Always mindful of its roots, VIDO encourages Canadian livestock producers to regard it with a sense of ownership – as a research facility working to alleviate infectious disease in food animals and poultry. Two multidisciplinary technical groups established by the Organization, the VIDO Swine Technical Group and the VIDO Beef Technical Group, investigate the methods and challenges of swine and beef production and act as a resource for the industry.

### **New challenges, continued success**

In March 2004, VIDO was awarded funding towards a \$62 million International Vaccine Centre and final funding commitments should be confirmed shortly. The highly secure facility, to be completed by 2009, will enable researchers to better respond to emerging diseases such as SARS, avian influenza (“bird flu”), and West Nile virus.

With the extension over the past decade of VIDO’s research into platform technologies, which offer multiple applications across species and diseases, the Organization is augmenting the applications of its research to human health. For example, investigation of the mechanisms of immunity at sites such as the lungs and the intestinal tract – known collectively as mucosal immunity – will lead to stronger immune responses in the areas of the body most often exposed to pathogens. Neonatal immunization and needle-free delivery methods, such as oral and nasal delivery, are also being developed.

VIDO continues to be competitive nationally and internationally, with more than 60 awarded patents and more than 30 pending as of the winter of 2005. Its place in a \$27 million Genome Canada award attests to its standards of excellence. The project, entitled Functional Pathogenomics of Mucosal Immunity, is applying the power of genomics and bioinformatics to investigating and enhancing mucosal immunity to infectious agents.

A wholly owned University of Saskatchewan not-for-profit institute, VIDO operates with substantial support from the governments of Alberta and Saskatchewan as well as Government of Canada and industry competitive grants. Public visits are encouraged and welcomed, preferably by appointment.

More than 15 major project areas include:

	<b>Target species</b>
<i>Food safety vaccines</i>	<i>poultry, cattle</i>
<i>Bacterial virulence determinants</i>	<i>livestock, poultry, humans</i>
<i>Vaccine formulation and delivery</i>	<i>livestock, poultry, humans</i>
<i>Neonatal immunization</i>	<i>livestock, poultry, humans</i>
<i>DNA immunization</i>	<i>livestock, poultry, humans</i>
<i>CpG immune modulation</i>	<i>livestock, poultry, humans</i>
<i>Hepatitis C</i>	<i>humans</i>
<i>SARS</i>	<i>humans</i>
<i>Bovine mastitis</i>	<i>cattle</i>
<i>Pathogenomics</i>	<i>cattle, poultry, humans</i>
<i>Vectored vaccine</i>	<i>cattle, swine, humans</i>
<i>Equine vaccines</i>	<i>horses, humans</i>

Successes in Vaccine Development:

- **Pneumo-Star™**, the world's first genetically engineered commercial subunit veterinary vaccine against *Pasteurella* infection in cattle;
- **Somnu-Star Ph™** and **Somnu-Star™** against *H. somnus* and *Pasteurella* infection in cattle;
- **Vicogen™**, world's first calf scours vaccine protecting against K-99 *E. coli* enteritis;
- **Ecolan-RC™**, vaccine for calf scours, protecting against K-99 *E. coli*, rotavirus and coronavirus;
- **Hevlan-TC™**, type II adenovirus vaccine against hemorrhagic enteritis in turkeys and splenomegaly of chickens; and
- **Pleuro-Star 4™**, a recombinant subunit vaccine for *Actinobacillus pleuropneumoniae* infection in swine.





## Canadian Research Network on Bacterial Pathogens of Swine

### Manitoba Pork Council Funded Research

# 2004

#### *Overview*

The Canadian Research Network on Bacterial Pathogens of Swine is the first collective research effort of specialists in porcine bacterial diseases across Canada. As the Network approaches the end of its third year of operation it now includes 30 researchers from 11 research-based institutions across Canada, including all four Canadian veterinary colleges. Three new members joined the Network this year: Dr. Patrick Boerlin from the Ontario Veterinary College, University of Guelph; Dr. Volker Gerdts from the Vaccine and Infectious Disease Organization (VIDO), Saskatoon and Dr. Mikaël Mourez for the Faculty of Veterinary College, Université de Montréal.

The total five year funding period (2000-2005), which represents an investment of more than \$4.2 million, is provided 73% by the Natural Science and Engineering Research Council of Canada (NSERC), and 7% by the provincial affiliates of the Canadian Pork Council (of which Manitoba Pork Council has contributed over \$10 000 for this year alone), and 20% by the private sector (i.e. Elanco Animal Health, Pfizer Animal Health, Gallant Custom Laboratories Inc. and the Institute for Veterinary and Alimentary Biotechnology of the Université de Montréal)

The primary objective of our Network is to establish nation-wide collaborations that foster the sharing of knowledge and expertise in the development of new products destined to improve the health of Canadian swine herds. Our main objectives are: **a)** to study and characterize virulence factors associated with bacterial diseases of swine, **b)** to develop molecular diagnostic tools aimed at more efficient diagnosis of porcine bacterial diseases, **c)** to develop new vaccines and immunization strategies to prevent bacterial diseases of swine, and **d)** to train highly qualified personnel by providing opportunities for collaborative graduate studies and post-doctoral fellowships. To fulfill these four objectives, the Network has developed six research themes:

- Infections caused by *Escherichia coli*
- Infections caused by *Actinobacillus spp.*
- Infections caused by *Streptococcus suis*

- Vaccine development
- Development of Molecular and Immunological Diagnostic tools
- Public Health

We are particularly proud of the work that has so far been accomplished during our first four years of operation: About 12 molecular diagnostic tests have been developed, validated and transferred to diagnostic laboratories for ready access to users; More than 65 articles have been published in referred journals; Network members have trained over 80 trainees to become highly qualified personnel and three patent applications have been filed. Furthermore, three new bacterial vaccine formulations for, *Escherichia coli* against Post Weaning Diarrhea (PWD), and *Streptococcus suis* and *Actinobacillus pleuropneumoniae* are in the final phases of development and are currently being evaluated in animals. The Network is also maintaining a bilingual website and publishing a bilingual Newsletter on a regular basis. We believed that the concerted effort on behalf of pork producers and scientists across Canada will yield a net benefit for all parties involved and will assist in maintaining the internationally acclaimed superior reputation of the Canadian pork industry.

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**Lake Winnipeg Research Consortium Inc.**

**2004**

## **Manitoba Pork Council Facilitated Research**

### ***Overview***

The Lake Winnipeg Research Consortium Inc. (LWRC) is dedicated to the facilitation of multidisciplinary research on the lake to gain a better understanding of the physical, chemical and biological processes that are critical to its well-being. The Lake Winnipeg drainage basin is vast, stretching from the foothills of the Rocky Mountains in the west, almost to Lake Superior in the east, and south into the United States to South Dakota. There is a great deal of agricultural activity in this drainage basin, and there are many urban centres along major waterways, some with large populations and significant industry. Nutrients and toxins have found their way into Lake Winnipeg because of the activities that take place within this vast drainage basin. There is a need to identify and quantify these substances and to determine the effects that they are having on the lake ecosystem. Therefore, research activities have focused on this area to date. A complete survey of the lake was accomplished onboard the CCGS NAMAQ in 2002, 2003, and 2004. This report summarizes the activities and some results of the 2004 open water season.

### **The Nature of the Research**

Three research cruises took place in 2004. The objectives were similar to the 2002 and 2003 seasons. At each station, the phytoplankton (plant plankton), zooplankton (animal plankton) and benthos (bottom organisms) were sampled. As well, water samples (500 ml) were taken and analyzed for suspended carbon/nitrogen, phosphorus, iron, chlorophyll and total suspended solids. Also these samples were analyzed for dissolved organic and inorganic carbon, chlorides and sulphates, total dissolved nitrogen and phosphorus, conductivity, magnesium and pH. Continuous water samples were drawn in from an intake near the bow of the vessel as it traveled from one station to another. Parameters measured from these samples included pH, conductivity, surface oxygen, fluorescence, turbidity, and pCO<sub>2</sub> (partial pressure of gaseous carbon dioxide). Between stations, a 3 m x 3 m trawl was towed along side the vessel at 2 knots for a period of 30 minutes to sample for fish, in particular rainbow smelt. Simultaneously, a large plankton net (250 µm mesh) was towed from the stern for surface plankton.

Cruise 1 began May 27 and ended June 23. All 65 regular stations were sampled as well as two additional stations. Six days were lost to weather and two days to mechanical problems. Cruise 2 began on July 23 and ended on August 19. Five days were lost to weather, and an open house was held at Gimli, Victoria Beach, Grand Rapids and Matheson Island over four days. The hosting of open house events brought significant public attention to the research. Fifty-three of the 65 regular stations were sampled as well as one additional station. Cruise 3 began on September 16 and ended on October 13. Eight days were lost to weather. Fifty-seven of the regular stations were sampled. Overall, over the three cruises, 545 water samples were taken on station, 386 profiles were taken, 175 plankton hauls were made, and 157 bottom samples were taken. In total, 175 fish trawls were carried out over the three cruises. The cost to the LWRC for the three cruises was \$391 K.

The 2003 season was dominated by relatively warm temperatures, few wind events and very low water levels. In contrast, the 2004 season was dominated by unseasonably cool weather, many wind events (hence the number of days lost to weather) and very high water levels. To a degree, these conditions have had a measurable influence on the biological community within the lake. This observation emphasizes the importance of and need to carry out this research over many years to account for natural annual variation.

2004 saw the continuation of remote sensing research sponsored by the Canadian Space Agency during all three cruises. The continuous (bow mounted instrumentation operated while the *NAMAO* was under way) measurement of solar irradiance spectra and reflectance spectra from lake surface was coupled with synchronized continuous measurement surface chlorophyll and turbidity. This was the final year of work designed to calibrate MODIS and MERIS satellite images for the quantitative mapping of chlorophyll and turbidity in the uniquely complex waters of Lake Winnipeg. The calibration algorithms developed will now be used to develop software applications that will allow researchers to monitor surface algal biomass in Lake Winnipeg and study the relationships between climate, nutrient loading algal productivity and the productive capacity of the Lake Winnipeg fishery.

An ongoing study of the carbon budget of Lake Winnipeg sponsored by Manitoba Hydro was linked to the remote sensing work. Using a combination of continuous monitoring of surface water pCO<sub>2</sub> and O<sub>2</sub> from the *NAMAO* and 24/7 monitoring of pCO<sub>2</sub> and O<sub>2</sub> at meteorological buoys, we have continued to refine estimates of CO<sub>2</sub> flux into and out of the Lake. As in previous years the South Basin was identified as a net source of CO<sub>2</sub> (dominated by respiration) while much of the North Basin was a sink for carbon (dominated by photosynthesis).

In 2004 we were able to directly measure photosynthesis and respiration at 50+ stations on all three cruises (150 samples). These direct estimates of carbon fixation and respiration complement both the remote sensing work and the carbon budget studies and will allow more refined spatial/temporal mapping of algal productivity and CO<sub>2</sub> flux. Direct estimates of photosynthesis and respiration also complement studies of nitrogen fixation and algal nutrient status to provide a uniquely complete picture of the physiological condition and response of the Lake Winnipeg algal community to climate and nutrient loading.

Most of the data collected above are still being analyzed. To date the most striking (but not surprising due to the unusually cool summer) observation was that the development of algal blooms was delayed and did not reach significant levels until the third cruise in September.

As in previous years, detailed physical, chemical and biological profiles were made at most of the 65 stations during all three cruises, in spite of several periods of serious storm events. One observation of note following one of these severe gales was the persistence of thermal stratification in the region between Reindeer Island and Long Point, a region that appears to be sheltered from wind events from the NW and SE. A large area of oxygen-depleted bottom water was observed in the north basin during August of 2003. While no oxygen depletion was noted this year, this is a region of the lake that bears scrutiny in years when major algal blooms occur.

Most of the data collected over the past three years have been entered into an Access relational data base and is now available for use by a variety of researchers and LWRC members.

The phytoplankton, or plant plankton (algae), provide the basis of the food chain in the lake, because they convert solar energy into organic matter. They are significantly nutrient-dependant, and are primarily controlled by the availability of nitrogen and phosphorus. However, some species of blue-green algae are capable of fixing nitrogen directly from the atmosphere. Rates of this nitrogen fixation were measured in the surface waters and profiles down to 5 metres at 99 stations in 2004. Similar to 2003, nitrogen fixation was a significant source of new nitrogen into the lake. This is a crucial measurement in light of stated intentions to manage inputs of nitrogen to the lake. Very large blooms of these algae were observed in the north basin in 2003. Large blooms were also observed in 2004, but did not appear to develop to the extent that they did in 2003, possibly due to the cooler temperatures experienced in 2004. There exists a significant backlog of phytoplankton samples that have yet to be analyzed. The most effective way to deal with this is through contract work that will require additional resources.

Annual zooplankton development is an important indicator of food web performance and is critical for the survival, growth and reproduction of valuable commercial fish species in Lake Winnipeg. As the primary consumers of phytoplankton, zooplankton are key to the transformation of plant carbon into animal tissue. Most of the 34 zooplankton species inhabiting Lake Winnipeg complete their life cycles within a few months or less depending on water temperature and food resources. Thus, they respond rapidly and measurably to ecosystem perturbations such as excess nutrients, contaminants and exotic species. Habitat modification resulting from shoreline erosion, lake regulation, floods or droughts can also affect specific ecological requirements for several zooplankton species and may contribute to biodiversity loss.

Zooplankton samples collected during 2002 and 2003 reflected continuing enrichment of Lake Winnipeg with nutrients from watershed sources. Comparison with previous data obtained using identical methods revealed a 500% increase in settled net plankton volume since 1929 (~300% since 1969). Total crustacean abundances in the North Basin and Narrows increased consistently over the period 1969 to 2003. Zooplankton densities in the spring of 2003 reached record levels (>500 individuals/L) in the South Basin. In addition, based on evidence from these recent samples, the structure of the zooplankton community now appears to be changing throughout Lake Winnipeg. In the North Basin, large bodied, deeper dwelling crustacean plankton species are declining while mid-sized species that normally inhabit mid-water layers are increasing. Environmental conditions in bottom waters of the North Basin may be deteriorating as a result of blue-green algal blooms that have increased in frequency and extent during the last decade. On the other hand, the same near-bottom species have increased in the South Basin possibly as a result of declining water transparency.

The current Lake Winnipeg zooplankton community appears to be regulated by a complex of factors that will require further assessment. In 1969, crustacean dynamics were mainly a function of temperature and phosphorus ( $r^2 = .98$ ). Now, other additional forces, including food web restructuring and hydrology, are contributing to changes in the crustacean plankton assemblage in Lake Winnipeg. The analyses of samples collected in 2004 will perhaps help to illuminate these other factors.

Results of the 2004 fish trawls were consistent with those taken in 2002 and 2003. A total of 255,877 fish were sampled, of which 94% were emerald shiner (*Notropis atherinoides*), 4.1% were rainbow smelt (*Osmerus mordax*), and both yellow perch (*Perca flavescens*) and cisco (*Coregonus artedii*) comprised 0.06% of the total catch each. Rainbow smelt, a recent invader to Lake Winnipeg (1990) was found primarily in the north basin and channel area of the lake. The emerald shiner, a key forage species, dominated the catch in the south basin.

Several high school groups were taken out for day trips out of Gimli to evaluate the potential of the *NAMA*O as a floating classroom and several university staff toured the vessel to evaluate its potential to meet their future research interests on the lake.

Overall, 2004 was a very successful research effort. The Lake Winnipeg Research Consortium Inc. was presented with an award for an “Outstanding Program” by the Red River Basin Commission at their annual meeting in Fargo, ND, on January 13 2005. Once again, the LWRC thanks the Manitoba Pork Council for helping to fund this important endeavour. Without support such as this, this research effort would not be possible.

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# Section I. Feed & Nutrition



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## DEVELOPMENT OF THE ENZYMES OF SULPHUR AMINO ACID METABOLISM FROM BIRTH THROUGH WEANING IN THE PIGLET

### Introduction

The sulphur amino acid cysteine plays a critical role as a building block of body protein and as a component of glutathione, a compound that is important for optimum immune function. As such, it is important that we have an understanding of the factors that regulate the production of cysteine in the pig during the neonatal period – a period when the piglet is highly susceptible to infections. Understanding the ability of the pig to make cysteine will lead to the development of optimal nutritional programs for the piglet and the sow.

### Experimental Procedures

Eight random farrowings were used and piglets from each litter were terminated at six timepoints: birth (pre-suckle), day 1, 9, 18 (pre-weaning), 19 (post-weaning) and 26. Blood, liver and kidney samples were obtained and analyzed for enzyme activities and metabolite concentrations. Specifically, the enzymes that make cysteine from the amino acid methionine, through the intermediate homocysteine, were measured, including cystathionine-beta-synthase and cystathionine-gamma-lyase (the rate limiting enzymes for cysteine formation). Plasma amino acid concentrations, including cysteine, homocysteine, and methionine were measured, as were the concentrations of key vitamins, folate and B-12, which play critical roles in sulphur amino acid metabolism.

### Results and Discussion

Our results provide evidence that the enzymes responsible for cysteine formation are developmentally delayed, reaching maximal levels between days 9 and 18. Plasma concentrations of cysteine increased during the first 9 days post-farrowing, mirroring changes in enzyme activity levels. These data provide evidence that the very young pig's ability to produce cysteine has not reached its full capacity. In addition to changes in cysteine concentration, the piglet's stores of vitamin B-12 and folate change dramatically during the first 9 days, with

folate concentrations increasing and B-12 concentrations decreasing. The latter result may point to a need to further evaluate vitamin B-12 status in lactating sows, in order to ensure the optimal supply of co-factors that participate in the metabolism of sulphur amino acids in young pigs

### **Implications**

An understanding of the factors that influence sulphur amino acid metabolism in the young pig will help identify optimal nutritional regimens for both early weaned pigs and for lactating sows. As cysteine plays a critical role in the body's defense mechanisms against infections, through its role as a component of glutathione, further research will help to ensure that the young pig is capable of producing sufficient cysteine to meet its needs.

### **Funding Sources**

National Sciences and Engineering Research Council (NSERC), Manitoba Pork Council, University of Manitoba

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## **DIETARY PHYTASE REDUCES PHOSPHORUS EXCRETION BY WEANLING PIGS\***

\*This work received the 2004 National Pork Board Research Award.

### **Summary**

Excessive phosphorus (P) output in the manure is a concern because it can leach into groundwater and/or may limit manure application onto certain lands. The addition of phytase enzyme to the diet of weanling pigs decreased total and water-soluble P output in the manure. This effect was reduced when dietary calcium was high relative to P (Ca:P ratios above 1.7:1). Phytase had only modest effects on performance.

### **Introduction**

The use of phytase in pig diets is rapidly increasing as extensive research has documented its efficacy in improving the digestibility of phosphorus (P) in cereal grains. This allows diets to be formulated with less total P (tP), resulting in decreased P output in the manure and potentially reducing feed costs. It is well known that when diets are formulated with less total P, the dietary calcium:P ratio (Ca:P) becomes extremely important in terms of maximizing the utilization of P. As the industry moves to diets with little or no excess P present, and the use of phytase increases, the need to clarify the Ca:P ratio increases.

It has been suggested that the environmental benefit of reduced phosphorus output in manure is partially dependent upon the solubility of the excreted P. If the use of phytase results in a greater proportion of the P excreted to be water soluble, then the environmental benefits may be reduced.

The objectives of this experiment were to: 1) examine the effect of the dietary Ca:P ratio on phytase efficacy, and 2) determine the effect of the phytase enzyme on the amount and form of the excreted P

### **Results and Discussion**

In experiment 1, there was a modest improvement in growth rate with the added phytase. Phytase had no effect on feed intake and therefore feed efficiency improved. Total

excreted P ranged from about 4 g/pig/day when dicalcium phosphate was added to the diet (0(0.31) treatment) to 2.1 g/pig/day when the diet contained no added dicalcium phosphate and 1000 U/kg phytase enzyme (1000(0.43) treatment). Additionally, the P excreted as soluble inorganic ranged from 75 to 80% of total P and was not affected by treatment. Therefore, the pattern of excretion of the soluble inorganic P was similar to total P; ie. decreased with the addition of phytase.

The beneficial effect of phytase on the excretion of total and soluble P was repeated in experiment 2. Moreover, this experiment demonstrated that the effect of phytase is mitigated when the dietary Ca:tP ratio exceeds 1.7:1.

### **Conclusion**

The addition of phytase enzyme to the diet of weanling pigs resulted in approximately 1.4 g/d per pig less P excreted compared to the same diet with the phosphorus provided from an inorganic source (dicalcium phosphorus). The effectiveness of phytase is reduced at Ca:P ratios above 1.7. We saw no effect of phytase on the proportion of P excreted that was water soluble. Phytase allows us to formulate diets containing less total P and effectively reduces the excretion of total and soluble P.

### **Funding Sources**

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## DIGESTIBLE ENERGY, PROTEIN AND AMINO ACIDS IN SELECTED MANITOBA-GROWN CORN CULTIVARS FED TO GROWING PIGS

### Introduction

Corn is an excellent source of energy in swine diets. It also contributes significant amounts of other nutrients like protein and amino acids because it is often included at high levels in swine diets. Traditionally, barley and wheat have been used as the main energy sources in pig feeds in western Canada. However, the increased production of corn in Manitoba presents an opportunity to swine producers to increase corn usage in swine diets. To effectively utilize locally grown corn in swine diets, it is critical that its nutritive value is well characterized. This is because it is well documented that the feeding value of feed ingredients vary with cultivar and field location and thus far, the feeding value of corn cultivars grown in Manitoba has not been evaluated. Therefore, this experiment was designed to evaluate digestible energy, protein and amino acid contents of representative Manitoba-grown corn cultivars. Corn cultivars 39W54 and 39M27, which are the most widely grown in Manitoba, were evaluated. In order to test the effect of field location, samples of the two cultivars were obtained from St. Pierre, Reinland and Carman. The study utilized growing pigs at approximately 22 kg body weight.

### Results and Discussion

There was an effect of location on digestible ileal crude protein and amino acids and on fecal digestible energy. Standardized ileal digestible crude protein content of cultivars from Carman and Reinland (7.3%) was higher compared with those from St. Pierre (6.8%) Cultivars from Reinland had highest contents of standardized ileal digestible aspartic acid, methionine, histidine and arginine (0.64, 0.23, 0.22 and 0.37 %, respectively) compared with those from Carman and St. Pierre. Cultivars from Carman had highest contents of standardized ileal digestible phenylalanine and cysteine (0.50 and 0.27, respectively) compared with those from Reinland and St. Pierre. Digestible energy content of cultivars from Carman was higher compared with those from St. Pierre (3673 vs 3644 kcal/kg) but similar to those from Reinland (3669 kcal/kg). Cultivar had an effect on digestible ileal crude protein and

amino acids and on fecal digestible energy. Cultivar 39W54 had higher contents standardized ileal digestible CP, histidine, aspartic acid, threonine, serine, glutamic acid, proline, glycine, alanine and arginine (7.70, 0.21, 0.59, 0.24, 0.61, 1.62, 0.57, 0.18, 0.69 and 0.36 %, respectively) than cultivar 39M27. Cultivar 39M27 had higher contents of standardized ileal digestible methionine, isoleucine and tyrosine (0.22, 0.31 and 0.29%, respectively) than cultivar 39W54. The digestible energy content of 39M27 was higher compared with that of 39W54 (3674 vs 3651 kcal/kg). These values of digestible energy were about 100 kcal/kg higher than the value of digestible energy for corn published by the current National Research Council.

### **Implication**

The current data suggest that ileal digestible protein and amino acids and fecal digestible energy contents of corn vary with location and cultivar and this should be considered when formulating diets for pigs.

### **Funding Sources**

Manitoba Corn Growers Association, Manitoba Pork Council, University of Manitoba

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## **EFFECT OF WHEAT QUALITY AND XYLANASE SUPPLEMENTATION ON PERFORMANCE OF WEANED PIGS FED PELLETTED DIETS**

### **Summary**

The feed processing procedure xylanase supplementation was tested to reduce the existing variability in wheat quality. Xylanase enzyme supplementation partially reduced the variation in performance of weaned pigs caused by wheat sample.

### **Introduction**

Nutritional quality between wheat samples is influenced by protein and fiber content. Supplementation with a fiber-degrading enzyme may reduce the impact of wheat quality variance on pig performance.

### **Results and Discussion**

For day 0 to 7, wheat affected average daily gain and feed efficiency. Enzyme improved average daily gain and feed efficiency. However, wheat and enzyme interacted, because pigs responded positively to enzyme for five wheat samples (+0.26 kg at day 7) and negatively for one wheat sample (-0.30 kg). Wheat and enzyme did not affect ADFI, see Figure 1.

For day 8 to 14, average daily gain and feed efficiency were not affected by wheat or enzyme but average daily feed intake was affected by a wheat x enzyme interaction, producing 0.36 kg heavier pigs from enzyme-supplemented diets.

For day 15 to 21, average daily gain and feed intake were not affected by wheat or enzyme and wheat sample affected feed efficiency.

Overall for day 0 to 21, average daily gain was not affected by wheat or enzyme, average daily feed intake was affected by a wheat x enzyme interaction, and feed efficiency was affected by wheat sample and improved 2% by enzyme, resulting overall in 27kg pigs.

### **Conclusion**

In summary, wheat quality affects performance of weaned pigs and specific wheat samples may affect the response

by pigs to enzyme supplementation. Wheat quality should be analyzed prior to diet formulation and processing to achieve a predictable performance.

### Funding Sources

Sask Pork, Alberta Pork, Manitoba Pork Council, and Saskatchewan Agriculture Food and Development Fund provided strategic program funding. Project contributors included Danisco Animal Nutrition, Saskatchewan ADF-Agri Value Program, Alberta Agriculture, Food and Rural Development, Canadian International Grains Institute, FeedRite (Ridley Inc.), Degussa, Big Sky Farms, and Norwest Labs.

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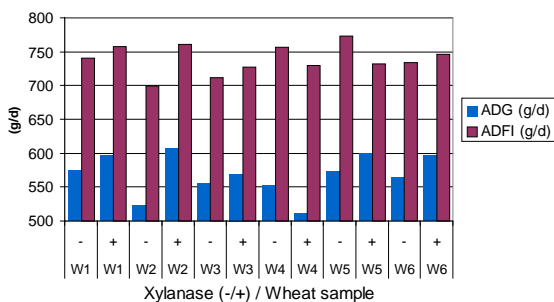


Figure 1. Effect of wheat sample and xylanase supplementation on average daily gain and feed intake for day 0 to 7.

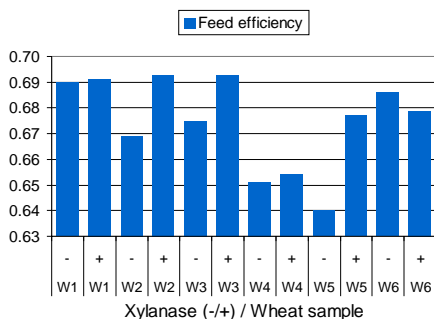


Figure 2. Effect of wheat sample and xylanase supplementation on feed efficiency (gain/feed) for day 0 to 21.



## **EFFECT OF XYLANASE AND (OR) PHYTASE SUPPLEMENTATION ON NUTRIENT DIGESTIBILITY AND GROWTH PERFORMANCE OF GROWER PIGS FED WHEAT-BASED DIETS CONTAINING WHEAT MILLRUN**

### **Summary**

The nutritional value of wheat millrun with xylanase and (or) phytase supplementation in wheat based diets for growing pigs was evaluated. Wheat millrun inclusion depressed energy and P digestibility and also ADG, but had no effect on ADFI and G:F. Xylanase and phytase reduced ADFI and improved nutrient digestibility. However, the improved nutrient digestibility did not result in improved growth performance which may be indicative of a nutrient imbalance.

### **Introduction**

Feed cost might be reduced or nutrient intake might be enhanced if nutrients bound by the arabinoxylans and phytate of wheat millrun could be released through enzyme supplementation to a higher extent. This would allow for large inclusion rates of wheat millrun into swine diets, while maintaining growth performance. An increased energy and amino acid digestibility in the small intestine is especially beneficial to the pig, but increased energy digestibility in the large intestine will also be beneficial to improve the energy status. Improved utilization of dietary phosphorus will be beneficial economically, but will also reduce the pressure of swine production on the environment.

### **Results and Discussion**

Ileal and total tract energy digestibility was affected by millrun inclusion, xylanase and phytase addition. Millrun addition reduced P digestibility linearly and phytase and xylanase supplementation improved P digestibility. In contrast to digestibility data, performance data were less conclusive. Millrun inclusion reduced ADG linearly, but did not affect ADFI or G:F. Xylanase and phytase reduced ADFI, and phytase tended to reduce ADG. Enzyme supplementation did not affect final BW or G:F.

## Conclusions

Overall, millrun inclusion reduced nutrient digestibility and growth performance. Xylanase and phytase improved nutrient digestibility; however, the improved digestibility did not result in improved growth performance which may have been indicative of a nutrient imbalance.

## Funding Sources

Program funding was provided by Sask Pork, Alberta Pork, Manitoba Pork Council and Saskatchewan Agriculture and Food Development Fund. Danisco Animal Nutrition funded the project.

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## THE FEEDING VALUE OF WHEAT DRIED DISTILLERS' GRAINS WITH SOLUBLES FOR SWINE

### Introduction

Availability of dried distillers' grains with solubles (DDGS) derived from wheat is expected to increase in western Canada as the production of ethanol increases. In North America, corn has been used as the main cereal grain in ethanol production and the resulting DDGS have been extensively evaluated as a feedstuff for swine. However, the potential of wheat derived DDGS as a feed ingredient in swine diets has been examined only to a limited extent. Published data on the chemical composition of wheat derived DDGS show that it has high concentrations of nutrients including protein and amino acids. Because chemical analysis alone is not a good measure of the feeding value of an ingredient, this product must be evaluated in animal experiments to better assess its potential as feed ingredient for pigs. Therefore, an experiment was conducted to characterize the chemical composition of wheat-based DDGS and to determine its digestible energy and nutrient contents. The wheat DDGS evaluated in this experiment were obtained from the Husky Mohawk ethanol plant at Minnedosa, Manitoba.

## **Results and Discussion**

The results showed that wheat DDGS contains high levels of nutrients including energy, protein, amino acids and non-phytate phosphorus. Although the digestibility data showed high digestible contents of the various nutrients in DDGS relative to wheat, the digestibility coefficients for most nutrients including key amino acids such as lysine and threonine were quite low. Causes of such low digestibilities must be identified to allow development of means of improving the nutritive value of wheat DDGS for swine. On average, the digestible energy content in wheat DDGS was 13.50 MJ/kg. This value is about 7.5% lower than the digestible energy content in wheat, which was 14.6 MJ/kg. The ileal digestible lysine and threonine contents in the wheat DDGS averaged 2.9 and 8.5 g/kg, respectively.

## **Implications**

The results indicate that wheat DDGS could be effectively utilized in pig diets. However, additional research is required to fully characterize its nutritive value in terms of nutrient availability and pig performance measurements and to explore means of enhancing its nutritive value.

## **Funding Sources**

Department of Energy, Science and Technology,  
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## **GROWTH PERFORMANCE AND CARCASS CHARACTERISTICS OF PIGS FED MANITOBA-GROWN CORN CULTIVAR BASED DIETS**

### **Introduction**

Production of colored and soft fat is one of the carcass quality concerns associated with feeding corn-based diets to growing-finishing pigs. This speculation was based on the fact that yellow corn contains higher amount of carotenoids, naturally occurring fat soluble pigments, and unsaturated fatty acids compared with barley and wheat. Since dietary fatty acid profiles influence fatty acid profiles of pork, feeding diets containing high amount of unsaturated fatty acids results in high amount of soft fats (unsaturated fats) in lieu of firm fat desired in pork. Although, dietary unsaturated fats can have some health benefits such as reducing the risk of cardiovascular diseases in humans, high amount of unsaturated fats in pork has been associated with some serious product processing and quality problems such as difficulty in belly slicing, visually unattractive sausage and susceptibility to rapid oxidative rancidity. However, the effects of feeding corn to swine relative to barley on growth performance and carcass characteristics are not yet conclusive. Furthermore, the effects of specific corn cultivars on growth performance and carcass characteristics have not been well researched. Therefore, an experiment was conducted to determine growth performance, carcass characteristics and fat quality of growing-finishing pigs fed diets based on two widely grown corn cultivars in Manitoba.

### **Results and Discussion**

The pigs were fed on a three-phase dietary program for 20-50 kg, 50-80 kg and 80-110 kg body weight pigs. The performance (average daily gain, average daily feed intake and gain:feed ratio) of the pigs fed diets based on Manitoba-grown corn cultivars was comparable with those fed barley-based diet. Average daily gain, average daily feed intake and gain:feed ratio averaged 0.87 kg, 1.96 kg and 0.45, respectively, in phase I, 0.85 kg, 2.46 kg and 0.34, respectively, in phase II and 0.90 kg, 2.86 kg and 0.31, respectively, in phase III. Carcass length, dressing percentage, loin eye area, loin depth, midline backfat thickness, 10th rib backfat thickness and belly firmness

were similar in pigs fed corn- and barley-based diets. There were no dietary effects on fat color with pigs fed diets based on Manitoba-corn cultivars having similar fat lightness ( $L^*$ ), yellowness ( $b^*$ ) and redness ( $a^*$ ) compared with those fed barley-based diet. Pigs fed the diet based on corn cultivar 2 had a higher amount of polyunsaturated fatty acids in their backfat compared with those fed the barley-based diet but the amount of saturated, monounsaturated and total unsaturated fatty acids in the belly fat and backfat were similar across dietary treatments.

### **Implication**

The results suggest that growth performance, carcass characteristics and fat quality of pigs fed diets based on Manitoba-grown corn cultivars and those fed the barley-based diet were comparable.

### **Funding Sources**

Manitoba Corn Growers Association, Manitoba Pork Council, University of Manitoba

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## **INCREASING THE UTILIZATION OF *FUSARIUM*-CONTAMINATED GRAINS: I) THE EFFICIENCY OF DEOXYNIVALENOL (DON; VOMITOXIN) REMOVAL FROM NATURALLY-CONTAMINATED BARLEY THROUGH THE USE OF A COMMERCIAL PEARLING MACHINE**

### **Introduction**

The contamination of cereal grains with the mycotoxin vomitoxin (deoxynivalenol; DON) is generally considered to be problematic for swine producers, due to negative effects on feed intake when DON is present in excess of 1 to 2 ppm in the diet. Effective strategies for the removal of DON from grains are critical, especially in regions where this mycotoxin is well established. Results from previous studies in our lab have documented the effectiveness of abrasive dehulling, or pearling, to remove DON from contaminated barley. Using a small, laboratory-scale pearler, we were able to remove 70% of the DON from contaminated barley simply by removing the outer hull fraction (equivalent to 15% of the weight of the barley kernels). Chemical analysis of the grain indicated that pearling also increased the protein content, reduced the fibre content, and improved the calculated level of digestible energy in the grain. With new information from our lab on the tolerance levels of swine to DON, this process appears to convert DON-contaminated barley into a form that would be highly usable in swine diets. Before this process can be implemented, we need to test the efficiency of commercial units for the removal of the hull fraction of contaminated grains, including barley, and determine the feeding value of the pearled grains.

### **Experimental Procedures**

A Satake model RMB 10G-T rice whitener was used for all studies. Two lots of barley were secured with analyzed DON contents of 1.2 (Barley A) and 7.6 (Barley B) ppm. Four synthetic blends of barley (100 kg) were produced which contained 0:100, 33:67; 67:33, and 100:0 percent of Barley A:Barley B. The barley samples were then passed through the pearling machine 0, 1, 3, 5, or 7 times. Each pass resulted in sequentially more of the outer kernel being pearled away. At each pass, sub-samples of the grains were analyzed for % of grain mass remaining and % of DON remaining.

## **Results and Discussion**

The commercial pearling machine was effective in removing DON from naturally-contaminated grain. The efficiency of removal was consistent with that observed with the laboratory-scale pearling machine. Removal of 10% of the hull resulted in the removal of 41% of the DON, irrespective of the initial level of contamination. Pearling to remove 20% of the hull resulted in the removal of 73% of the DON. Further reductions are possible through continued pearling, however the highest efficiency of DON removal was observed during the removal of the outer hull fraction (10-20% of the barley kernel weight). These results confirm the feasibility of the pearling or abrasive de-hulling procedure in removing DON from barley, and provide a starting point for the continued refinement of the dehulling procedure. In addition to refining the technique, it is critical that we determine the feeding value of the decontaminated grain for swine.

## **Implications**

The use of a commercial pearling machine is effective in removing DON from barley. The establishment of this procedure may prove a useful strategy to deal with contaminated grains in years of heavy *fusarium* pressure.

## **Funding Sources**

Manitoba Pork Council, Manitoba Rural Adaptation Council, Brandon Hog Days Committee, University of Manitoba

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## **INCREASING THE UTILIZATION OF *FUSARIUM-CONTAMINATED GRAINS:* II) *IN VIVO* DETERMINATION OF THE DIGESTIBLE ENERGY CONTENT OF DE-HULLED BARLEY**

### **Introduction**

With evidence of the feasibility of the commercial pearling procedure to remove DON from naturally-contaminated grains, a study was conducted to determine the feeding value of the grains for swine. This component is critical in order to determine the ultimate success of the procedure. In addition to removing DON, the pearling procedure removes the fibrous hull which should increase the digestible energy value of the grain. Increasing the digestible energy value of the grain will lead to a reduction in the amount of supplemental energy required in the ration (eg. vegetable oil), and thus have a bearing on the economic efficiency of the procedure.

### **Experimental Procedures**

6 Cotswold pigs (initial weight = 20 kg) were housed individually in metabolic crates, to permit the measurement of individual feed intake and the total collection of feces. The experiment was designed as a 6x6 latin square, with 6 diets being fed in random order to each of 6 pigs. Three lots of barley were used as the primary cereal for the test diets, and they contained 1.2, 4.4, or 7.6 ppm DON. Three diets were formulated to contain the intact barley and three were formulated to contain the same barley that had previously been passed 3 times through a Satake rice whitener. The digestible energy value of the barley samples was determined by measuring the gross dietary energy consumed and subtracting the fecal energy excreted.

### **Results and Discussion**

Feed refusal ranged from 50 to 100% for the diets containing intact, contaminated barley. Therefore, it was not possible to determine the digestible energy value for the intact grains. However, when the same contaminated grains were first de-hulled and then offered, pigs readily consumed the diets with no evidence of feed refusal. These results provide strong evidence that even heavily contaminated barley sources are tolerated by pigs if they are first de-hulled. Measurement of the digestible energy

value of the pearled barley yielded values averaging 3389 kcal/kg (as-fed basis). By using prediction equations from the literature, we calculated the digestible energy value of the intact barley to be 2944 kcal/kg (as-fed). De-hulling therefore results in a measured 15% increase in the digestible energy value of barley, primarily by removing the fibrous hull fraction which dilutes the energy value. This has important ramifications since, on a \$ per nutrient basis, energy is the most expensive component of the diet.

### **Implications**

De-hulling of DON-contaminated barley removes the feed refusal factor, and increases the energy content of the barley. As a result, the need for additional sources of energy is reduced. The added value of the de-hulled grain, in terms of nutrient availability, in combination with the potential to acquire contaminated grains at a reduced cost, must be considered when assessing the economic viability of the de-hulling procedure as a means of increasing the utilization of fusarium-contaminated grains.

### **Funding Sources**

Manitoba Pork Council, Manitoba Rural Adaptation Council, Brandon Hog Days Committee, University of Manitoba

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## **INCREASING THE UTILIZATION OF *FUSARIUM*-CONTAMINATED GRAINS: III) FEED INTAKE AND PERFORMANCE OF STARTER PIGS CONSUMING DIETS DECONTAMINATED OF DEOXYNIVALENOL THROUGH THE USE OF AN ABRASIVE PEARLING PROCEDURE**

### **Introduction**

Studies conducted in other regions of Canada, the U.S. and Europe, have provided strong evidence that the presence of DON (vomitoxin) leads to reductions in feed intake in swine, with subsequent negative impacts on performance. The high incidence of DON-contaminated grains in Manitoba, due to heavy *Fusarium* pressure, has led to a deficiency of feed grains in the province and has eroded the competitive advantage that Manitoba has for swine production.

### **Experimental Procedures**

96 Cotswold pigs (initial weight = 5.9 kg, equal males and females) were randomly assigned (6 pens per diet; 4 pigs per pen) to one of four diets containing either corn (CONTROL) or DON-contaminated barley for which the DON levels had been reduced through an abrasive dehulling procedure. For the three diets containing de-hulled barley, the original DON content of the grain had been 1.2 (BARLEY1), 4.4 (BARLEY2) or 7.6 (BARLEY3) ppm DON. The barley was de-hulled by passing 250 kg lots through a Satake model RMB 10G-T rice whitener 3 times, to remove roughly 20% of the grain mass. All diets were formulated to contain the same amount of crude protein, total lysine and digestible energy. Digestible energy coefficients for the de-hulled barley were determined in a previous study. Phase I diets were fed for days 0 to 14 and phase II diets were fed days 15 to 28. Average daily gains, average daily feed intake and feed conversion efficiency were determined for phase I, phase II, and the overall nursery period.

### **Results and Discussion**

Average daily feed intake overall was significantly lower for pigs consuming diets containing the BARLEY2 diet and this was mainly due to a reduced consumption during phase I, as there was no differences due to diet in feed intake values during phase II. However, pigs consuming

the de-hulled barley diets gained significantly more weight during phase II (CONTROL: 484; BARLEY1 = 503; BARLEY2 = 525; BARLEY3 = 539 grams/d). The net result of improved gains with slight reductions in feed intake was an improvement in feed efficiency, as overall, the pigs consuming the de-hulled barley diets had a higher feed conversion efficiency (CONTROL: 0.77; BARLEY1 = 0.83; BARLEY2 = 0.87; BARLEY3 = 0.88 kg gain per kg feed consumed).

### **Implications**

De-hulling of DON-contaminated grains yields a product that is well tolerated by early weaned pigs and supports performance values that are similar, if not slightly better, than those provided by corn-based diets. Improvements in the digestible energy content of the barley, coupled with the removal of the mycotoxin(s) should position de-hulling as a viable means of managing DON-contaminated grains during years of heavy fusarium pressure.

### **Funding Sources**

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## **THE INTERACTION AMONG LACTOSE, PLASMA PROTEINS, AND CROWDING IN WEANLING PIGS**

### **Summary**

The addition of 4% plasma and 30% lactose to the diets of weanling pigs modestly improved performance; however this effect was observed only during the initial 7 days post-weaning. There were no interactive effects of plasma with lactose, and the results were independent of starting weight. Crowding decreased performance by day 49 of the nursery period.

### **Introduction**

Lactose and porcine plasma are two key ingredients in current starter programs that may become even more important if antibiotic use in the diet is restricted. Feed additives such as plasma and lactose could have differential effects depending on the weight or age of the pigs. Floor space allowance is always an important variable in pig production. This experiment was designed to 1) determine the interactive effects of plasma proteins and lactose on weanling pig performance when fed antibiotic-free diets 2) compare the response to lactose and plasma proteins in crowded and non-crowded pigs 3) determine the impact of weaning weight on the response to lactose and plasma proteins.

### **Results and Discussion**

Overall, the performance of the pigs in this trial was less relative to the performance typically observed in this barn, probably a reflection of the absence of antibiotics in the feed. The inclusion of plasma and/or lactose in the diet had no effect on performance over the entire experimental period (day 0 to day 49). However, there were interactions between plasma proteins and days, and lactose and days, indicating that an early response to these two products was observed, but this was not sustained through to the end of the nursery period. As expected, heavier pigs grew faster than lightweight pigs; interestingly, this effect was independent of diet. A detrimental effect on performance of increased numbers of pigs per pen (18 or 24 pigs per pen) was observed, but only during the final two weeks of the experiment (day 36 to 49).

The plasma and lactose increased the cost of these starter diets. Therefore, due to the lack of an overall effect of these ingredients on performance, the cost per kg of gain increased with their inclusion.

### **Conclusion**

A modest improvement in performance during the initial 7 days post-weaning was observed with the addition of 4% plasma and 30% lactose in the diet of weanling pigs. There were no interactive effects of plasma with lactose, and the results were independent of starting weight. Although not directly tested in this experiment, the performance of the pigs in this trial indicates that plasma protein and lactose dietary supplementation do not replace antibiotics in a nursery diet. Providing pigs with less than recommended floor space allowance will decrease performance. The detrimental effect of crowding becomes increasingly evident as the pigs grow.

### **Funding Sources**

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## **NUTRITIONAL VALUE OF CORN AND WHEAT DISTILLER'S DRIED GRAIN WITH SOLUBLES: DIGESTIBILITY AND DIGESTIBLE CONTENTS OF NUTRIENTS AND GROWTH PERFORMANCE OF GROWER-FINISHER PIGS**

### **Summary**

Nutritional value of corn, wheat+corn (4:1) and wheat distiller's dried grains with solubles (DDGS) for grower-finisher pigs was evaluated. Corn DDGS had the highest digestible energy (DE) and ileal digestible lysine contents but the digestible phosphorus (P) content was similar among DDGS samples. Following characterisation of its digestible nutrient profile, DDGS still resulted in reductions in growth performance, suggesting that either the reduced average daily feed intake (ADFI) or other nutritional factors for DDGS deserve further investigation to ensure a successful implementation of DDGS in swine diets.

### **Introduction**

DDGS is primarily a by-product from the cereal grain-based ethanol industry. With the growth of the ethanol industry, increasing quantities of DDGS are available for livestock rations. However, the potential of DDGS in swine industry is not fully realized because of the scarcity of information on its nutritional value for swine. In general, DDGS has higher concentrations of nutrients such as protein, fat, vitamins, minerals, and fibre than its parent grain. These nutrients are concentrated due to the removal of most of the cereal starch as ethanol and carbon dioxide during the fermentation process. Wheat and corn DDGS are potential feed ingredients for the swine industry, although DDGS is presently not an important ingredient in western Canada.

### **Results and Discussion**

The chemical and nutritional properties varied among the three DDGS samples. Despite the equivalent or higher total nutrient content, nutrient digestibility was lower for the DDGS than the wheat, except for P, which had a digestibility higher for DDGS than wheat. Nevertheless, the digestible contents of nutrients of interest were higher for DDGS than for the wheat. Finally, DDGS inclusion reduced growth performance of pigs, without affecting feed efficiency.

## Conclusion

Overall, the results of this study indicate that the complex carbohydrate profile appears to be a major constraint to the nutritional value of DDGS for pigs due to its influence on feed intake, retention time, and the digestion of energy and other nutrients. Further, the nutritional value of DDGS might be enhanced by improving the AA balance through supplementation with limiting AA like lysine, in synthetic form and concomitant reduction of high fiber level with supplementary enzymes.

## Funding Sources

Program funding was provided by Sask Pork, Alberta Pork, Manitoba Pork Council and Saskatchewan Agriculture and Food Development Fund. The Agriculture Development Fund of Saskatchewan Agriculture, Food and Rural Revitalization funded the project.

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## THE NUTRITIONAL VALUE OF ZERO-TANNIN FABA BEANS FOR GROWER-FINISHER PIGS

### Summary

Zero-tannin faba beans are a potential replacement of soybean meal in swine diets. The chemical characteristics, energy and amino acid (AA) digestibility, the content of DE and NE, and tannin content of zero-tannin faba beans were determined and indicate, together with the subsequent growth performance variables and carcass quality of grower-finisher pigs, that zero-tannin faba beans can replace soybean meal and result in similar performance in grower-finisher pigs.

### Introduction

Faba bean (*Vicia faba minor*) production is not new to Alberta. Research was completed in the early 1970's; however, tannin and other anti-nutritional factors limited the use faba beans in swine diets. Presently, zero-tannin

faba bean varieties are available. The general purpose of this project was to remove barriers, which were preventing increased production and use of zero-tannin faba beans in Alberta, especially in the Parkland and Peace regions. Analysis of the nutrient content of zero-tannin faba beans and a subsequent performance study confirming equal performance were thus needed. Objectives were (1) to determine chemical characteristics, energy and amino acid (AA) digestibility, the content of DE and NE, and tannin content of zero-tannin faba beans; and (2) to compare growth performance variables and carcass quality of grower-finisher pigs fed zero-tannin faba beans to soybean meal.

### **Results and Discussion**

The chemical characteristics, energy and AA profiles suggest that zero-tannin faba beans have a desirable nutrient content (slightly better than peas). Overall, ADG (Figure 1) and ADFI did not differ between zero-tannin faba beans or soybean meal suggesting that faba bean inclusion up to 30% might be possible without reducing ADG. The higher ADG for barrows during the grower phase and higher lean depth for gilts fed soybean meal compared to zero-tannin faba beans (Figure 2) suggest that the available energy content needs further investigation.

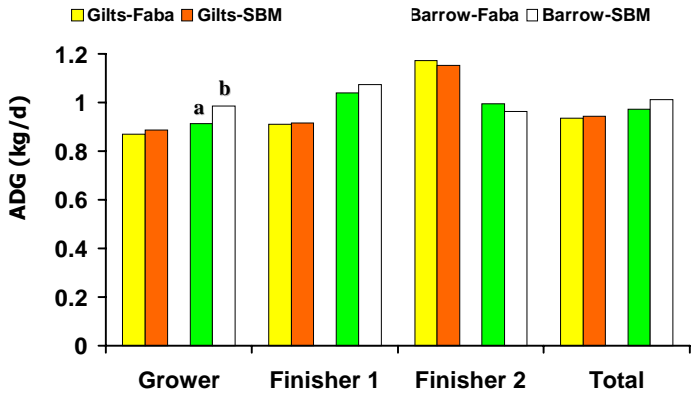
### **Conclusion**

In conclusion, the zero-tannin faba bean is a worthwhile protein ingredient to consider as a replacement for soybean meal.

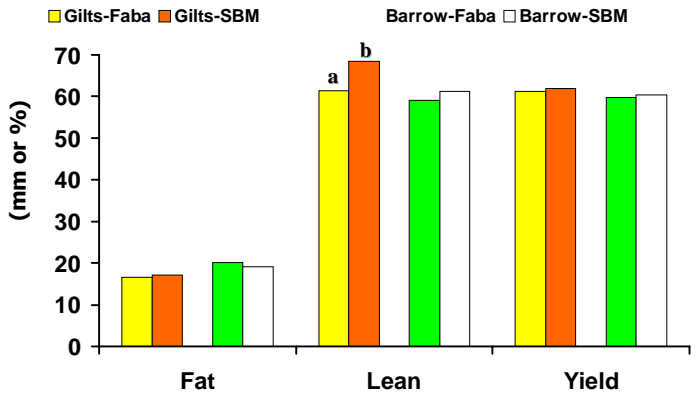
### **Funding Sources**

The AAFRD Industry Development Sector – New Initiatives Fund is funded the project. Alberta Pulse Grower – Zone 3 funded the zero-tannin faba beans. Mr. Clayton Wierenga stimulated the start and Dr. Eduardo Beltranena the completion of the project. Strategic program funding to PSCI was provided by Sask Pork, Alberta Pork, Manitoba Pork Council, and Saskatchewan Agriculture Development Fund.

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**Figure 1.** Average daily gain (ADG) of pigs fed zero-tannin faba beans or soybean meal



**Figure 2.** Carcass data of pigs fed zero-tannin faba beans or soybean meal



## RESPONSE OF GROWING AND FINISHING PIGS TO DIETARY ENERGY CONCENTRATION

### Summary

The objective of this experiment was to develop an energy response curve for pigs in the growing and finishing phases of production. The diets varied in DE content (3.1, 3.2, 3.3, 3.4 and 3.6 Mcal DE/kg) and were fed from 25 kg to market. Feeding lower energy, lower cost diets, had no effect on ADG or on loin thickness, but did improve feed efficiency and reduced backfat thickness. These results indicate that lower energy diets may be used to increase net income. The applicability of these results amongst a diversity of commercial herds probably depends on feed intake, and the ability of pigs to increase feed intake on the lower energy diets. Nonetheless, the potential for substantially increasing net income warrants careful consideration of dietary energy levels during the grow-out period. In this experiment, return over feed cost varied by more than \$10 per pig across the 5 dietary treatments.

### Introduction

The primary objective of pork production is to produce lean meat in a cost effective and sustainable manner. Because energy is considered to be the most important driver of growth in the diet, achieving the full genetic potential for growth in the modern pig requires a clear and definitive understanding of the energy response curve in all phases of production. Despite the importance of energy in the design of commercial feeding programs, and the impact that daily intake has on energy supply, there has been surprisingly little information developed on animal response to energy intake. The little information that is available tends to emphasize whole body growth and reveals little in terms of the partitioning of energy into protein, lipid, water and ash. Establishing responses to nutrient intake levels is particularly critical in defining feeding programs to maximize carcass quality.

The objective of this experiment was to develop an energy response curve for pigs in the growing and finishing phases of production.

## **Results and Discussion**

Energy density of the diet had no effect on ADG during any phase, or when calculated over the entire experimental period (Table 1). Feed intake declined as the energy density of the diet increased and feed efficiency was improved. Increasing the energy density of the diet resulted in a reduced lean yield and reduced backfat thickness (Table 2); surprisingly there was no effect on carcass value or on carcass premiums.

It is important to note that by commercial standards, pigs on this experiment exhibited a high feed intake and this could explain the lack of growth response to increases in dietary energy concentration. If feed intake had been lower, the response of the pigs to dietary energy concentration may have been different. A similar experiment is presently being conducted at a commercial farm to test this hypothesis.

## **Conclusion**

In this trial, feeding lower energy, lower cost diets had no effect on ADG or on loin thickness, but did improve feed efficiency, and reduced backfat thickness. This indicates that lower energy diets may be used to increase net income. This experiment was conducted in an environment of high feed intake, and different results may accrue under conditions of lower feed intake. At the time of this trial, the lowest energy diet increased return over feed cost by more than \$10 per pig sold, as compared to the highest energy diet.

## **Funding Sources**

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**Table 1.** The effect of dietary energy density on body weight, ADG, ADFI and feed conversion over 3 phases of growth.

Parameter	Diet (Measured DE, Mcal/kg) <sup>1</sup>					SEM	Regression
	3.09	3.24	3.34	3.42	3.57		
<b>Phase 1</b>							
Wt, kg (d0)	31.17	31.06	31.52	31.19	31.08	0.24	ns <sup>2</sup>
ADG, kg/d	0.95	0.97	0.98	0.98	0.99	0.01	ns
ADFI, kg/d	1.95	1.95	1.91	1.88	1.87	0.03	ns
FCE, gain:feed	0.49	0.50	0.52	0.52	0.53	0.01	L
<b>Phase 2</b>							
Wt, kg (d0)	53.15	52.97	53.38	53.39	53.48	0.32	ns
ADG, kg/d	1.04	1.08	1.10	1.07	1.06	0.02	ns
ADFI, kg/d	2.74	2.72	2.74	2.61	2.51	0.04	ns
FCE, gain:feed	0.38	0.40	0.41	0.41	0.43	0.01	L
<b>Phase 3</b>							
Wt, kg (d0)	80.10	79.47	80.30	80.16	80.22	0.44	ns
Wt, kg (end)	115.07	115.51	115.26	115.02	115.58	0.41	ns
ADG, kg/d	1.04	1.08	1.10	1.07	1.06	0.02	ns
ADFI, kg/d	3.29	3.19	3.20	3.05	2.94	0.05	ns
FCE, gain:feed	0.30	0.32	0.32	0.33	0.35	0.01	L
<b>Overall</b>							
ADG, kg/d	1.00	1.02	1.03	1.01	1.05	0.01	ns
ADFI, kg/d	2.76	2.69	2.67	2.59	2.49	0.03	L
FCE, gain:feed	0.36	0.38	0.38	0.39	0.42	0.01	L

<sup>1</sup>Refers to the energy concentration which was determined experimentally at the mid-point of each phase.

<sup>2</sup>ns; the response to dietary energy level was not linear ( $P > 0.05$ ), L; a significant response to dietary energy level was observed ( $P < 0.05$ ).

**Table 2.** The effect of dietary energy density, gender and initial bodyweight on carcass value, days on test and feed cost over 3 phases of growth.

Parameter	Diet (Measured DE, Mcal/kg)					SEM	Regression
	3.09	3.24	3.34	3.42	3.57		
Settlement price, \$	89.91	90.00	90.88	90.72	91.22	0.37	L <sup>1</sup>
Index	113.81	112.91	113.45	111.70	113.24	0.48	ns
Yield	61.58	61.13	60.88	61.14	60.63	0.18	L
Fat, mm	16.83	17.79	18.33	18.62	19.39	0.34	ns
Lean, mm	61.65	60.55	62.72	60.25	61.06	1.06	ns
Price, \$	1.10	1.10	1.10	1.10	1.10	0.01	ns
Value, \$	111.36	111.63	111.67	110.20	112.75	1.16	ns
Premium, \$	5.56	5.33	5.53	5.06	5.00	0.18	L
<b>Days on test</b>							
Phase 1	23.3	23.0	22.8	22.9	22.9	0.48	ns
Phase 2	25.9	24.8	24.6	25.0	25.0	0.49	ns
Phase 3	35.4	35.8	36.8	34.6	34.0	1.07	ns
<b>Feed costs, \$/pig</b>							
Phase 1	8.36	8.96	9.38	10.39	11.36	0.19	L
Phase 2	12.00	12.70	13.93	14.81	15.46	0.25	L
Phase 3	17.40	19.13	21.85	21.82	22.70	0.55	L
Total	37.76	40.79	45.16	47.03	49.52	0.61	L

<sup>1</sup>ns; the response to dietary energy level was not linear ( $P > 0.05$ ), L; a significant response to dietary energy level was observed ( $P < 0.05$ ).

## Section II. Animal Care & Production



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### **ADVISABILITY OF USING HIP-INJECTION FOR LOW VOLUME, ROUTINE INJECTIONS IN BREEDER GILTS AND SOWS AS RELATES TO FOOD SAFETY AND ANIMAL WELFARE**

#### **Introduction**

Currently, for any pork producer to be part of the quality assurance program (CQA), all intramuscular (IM) injections must be administered in the neck. This relates to issues of meat quality & safety (avoiding the higher valued ham) and animal comfort/welfare (avoiding weight bearing muscles of the leg). However, sows in stalls can be difficult to inject in the neck muscle. It can be more traumatic for the sow, as the attendant must reach into the stall from in front of her head, resulting in a natural aversion reaction. This makes proper technique more difficult for the attendant, who also risks danger of injury from the stall bars and/or the sow, and can result in the sows being fearful of humans approaching, particularly at the front of the stalls. An injection site in the hip area of the sow is readily accessible to the attendant from the top rear of the stall without the sow being aware of the attendant's presence. Field observations indicate that sows are not bothered by this technique, as it can be done quickly and effectively with little or no reaction by the sow. It is easier to inject at right angles to the skin, ensuring the vaccine goes deep into the muscle rather than into the fat. However, before the CQA program can allow the use of the hip-injection technique for sows it must be demonstrated to be safe and effective. Therefore, the overall objective of the current research is to compare neck-injection and hip-injection techniques in order to determine the advisability of using hip-injection for low volume routine injections in sows as it relates to food safety and animal welfare.

#### **Results and Discussion**

The research is being conducted in two parts – an intensive study to closely examine the effects on tissue and carcass; and an on-farm trial to assess efficacy, overt effects on the sows and worker accuracy. For the first phase, at the Glenlea Research Station Swine Unit, replacement gilts weighing approximately 150 kg were

housed in stalls and injected IM in the neck and in the hip with either SowVac vaccine or with saline (controls). Procedures were video-recorded. IM hip-injection was done quickly with minimal response by the gilts. Giving neck-injections correctly proved challenging as gilts showed strong aversion when the attendant tried to approach at the front of the stall. All injection sites were circled with a marker and observed closely for 48 hours, then daily. No inflammation, redness, or obvious tissue reactions were seen at any of the injection sites. After a 3-week withdrawal time, gilts will be sent to the abattoir and carcasses evaluated for gross tissue damage, abscesses, etc. Cutouts at the injection sites will also be submitted for histopathology in order to detect subtle changes not readily visible.

The second part of this project involves injection site comparisons using replacement gilts and sows in a commercial unit. Comparison will be made of ease of injection, animal behaviour responses, injection site inflammation or tissue reaction, accuracy of site selection by the attendant(s), incidence of bent needles, damage to non-muscle tissue (e.g. nerve damage expressed as locomotor problems; hitting bone) and abscess formation.

### **Implications**

Results of this research will provide the type of scientific documentation, regarding potential food safety, animal welfare and worker safety, needed to determine the advisability of the CQA program allowing intramuscular hip-injection of low volume compounds to replacement gilts and sows that are housed in stalls.

### **Funding Source**

Manitoba Pork Council

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## **CONJUGATED LINOLEIC ACID (CLA): IMPACT ON SOW AND LITTER IMMUNE STATUS AND SOW REPRODUCTIVE PERFORMANCE**

### **Introduction**

With the current trend to eliminate feed antibiotics in the pork industry, Manitoba can retain a globally competitive advantage if routine medication of pig feeds and water can be eliminated. Conjugated linoleic acid (CLA), considered a nutraceutical by some, has been implicated in a host of biological functions including protein and fat deposition and immune system function. In several species CLA has been demonstrated to enhance production of serum immunoglobulins, which are important components of the passive immunity transferred via colostrum. In addition, CLA transferred in sows' milk may have a direct impact on development of the piglets' own immune system as well as enhanced post-weaning growth performance. While CLA may have benefits for immune system development, any effects on sow reproductive function have not been defined. In other species, CLA supplementation can depress prostaglandin precursors and therefore have potential negative impacts on ovulation rate and normal cycling. This requires clarification in the sow. In swine, if CLA proves beneficial for immune responsiveness, without compromising subsequent sow reproduction, it may prove particularly useful for modulating immunoglobulin production and enhancing performance in first and second parity sows which generally have less immune competence than older sows. Although CLA actions have been studied in several species, including growing pigs, the potential for CLA supplementation to benefit gestating and lactating sows and their piglets, both before and after weaning, requires investigation.

## **Results and Discussion**

This investigation, which is just beginning, will feed CLA to nulliparous and first litter sows from mid-gestation and throughout lactation until approximately 6 weeks following rebreeding. Any changes in immune status and blood hormone and metabolite levels will be evaluated from blood samples taken throughout the trial from sows and from piglets. Body composition changes of sows, ovulation rates and embryo survival will also be evaluated as indicators of impact on reproduction. Piglet growth performance while suckling and post-weaning, will be monitored and assessed. CLA in sows' milk may have a direct protective benefit for piglets' gut mucosa which will be reflected in improved growth. Post-weaning performance may be enhanced by improved immune status achieved while suckling CLA enriched milk resulting in reduced growth-lag, improved performance in nursery and feeder pigs, and improving overall production efficiency while lessening the need for antibiotics.

## **Implications**

With the potential to enhance immune-status in sows and piglets, CLA supplementation could lead to healthier sows, which, in turn could produce more viable piglets. This can translate into greater sow longevity and productivity, more piglets weaned per litter and better post-weaning growth performance without the use of sub-therapeutic antibiotics.

## **Funding Sources**

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## **CROWDING REDUCES PERFORMANCE OF WEANLING PIGS**

### **Summary**

The effect of floor space allowance on the performance of weanling pigs was examined by housing groups of 17 pigs in pens with a floor space of either 5.58 m<sup>2</sup> (uncrowded) or 4.00 m<sup>2</sup> (crowded). Crowding adversely affected growth and feed intake by week 4 post-weaning. These data support the current recommendations on floor space allowance for weanling pigs.

### **Introduction**

Floor space allowance is an important variable in pig production. However, the effect of floor space on performance is often examined by using different group sizes within a constant floor space. This confounds the results because group size per se may affect performance as well as floor space. In this experiment, floor space allowance was examined using a constant group size of 17 pigs, but housed in pens of varying square footage. According to the Recommended Code of Practice floor space allowance can be calculated using the formula,  $A = k BW^{0.67}$  where  $A$  = area in m<sup>2</sup> and  $BW$  is in kilograms. It is recommended that the coefficient,  $k$ , be 0.035 when fully slatted pens are used (ie. for a 20 kg pig,  $A = 0.035 (20)^{0.67}$  or  $A = 0.26$  m<sup>2</sup> per pig).

This experiment was part of a larger trial designed to examine the interaction of various dietary treatments and crowding on the growth and variability in growth of weanling pigs. There were no interactions, and only the main effects of the crowding are reported here.

### **Results and Discussion**

An effect of crowding on growth was evident by the 5th week of this experiment when ADG was reduced by about 40 grams per pig per day in the crowded treatment. At this point in the experiment, bodyweight in the crowded treatment was about 19 kg or just slightly above the 17 kg predicted by the Agriculture Canada formula. A reduced feed intake was observed by the 4th week of the experiment in the crowded pens, when the pigs weighed almost 12 kg. Neither feed efficiency nor the cost per kg of gain were affected by floor space allowance and there

was no effect of crowding on the variability in growth (data not shown).

### **Conclusions**

Housing pigs with less than the recommended floor space allowance will reduce growth and feed intake. The current recommendations for floor space of weanling pigs would appear to be correct.

### **Funding Sources**

Strategic funding provided by Sask Pork, Alberta Pork, Manitoba Pork Council and Saskatchewan Agriculture and Food Development Fund. The authors would like to acknowledge the financial support provided for this experiment by Ridley, Inc.

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## **EFFECT OF INJECTION METHOD ON PIGS INJECTED AT ONE DAY OF AGE**

### **Introduction**

An experiment was done to evaluate the effect of needle-free injection, conventional method of injection, or no injection on piglets. Piglets were provided with nutritional iron (Dexafer) and immunization (Suvaxyn® MH/HPS) by injection at 1 day of age and control piglets were given Dexafer by gavage. Health, hematologic and serologic responses were assessed and growth rate was calculated at weaning.

### **Result and discussion**

*Health of piglets* – The overall rates for pre-weaning mortality ( $17/240 = 7.1\%$ ) and pre-weaning morbidity ( $34/223 = 15.3\%$ ) were typical for well-managed, specific pathogen-free commercial operations. Some piglets in all experimental groups were treated for or died from undifferentiated disease, as shown in Table 04-043-1. Immunity to *M. hyopneumoniae* or *H. parasuis* (vaccine antigens) was not expected to play a role in piglet health,

since these agents were not causing disease in this herd.

**Table 04-043-1, Level of Health**

	<b>1- Conventional IM</b>	<b>2 - Needle-free</b>	<b>3 - Oral</b>
<b>Healthy</b>	56	64	69
<b>Treated for disease</b>	17	10	7
<b>Died</b>	7	6	4

Piglets were classified as healthy or sick (treated or dead) in order to estimate the relative risk of sickness associated with the injection methods that were tested. The proportion of sick pigs in the group given needle-free injection was not significantly different from either of the other 2 groups. However, the rate of death or treatment for disease was 2.2 (95% CI 1.2 – 4.2) times greater amongst pigs administered iron by conventional IM injection compared to those that received oral iron and no injections. This occurred despite a mean hematocrit, which was significantly lower in the group that was given iron orally.

Overall herd health was very good and pre-weaning disease or death was 2.2 times more likely to occur in piglets injected with a conventional needle and syringe (Group 1) than in piglets given no injection (Group 3). Group 3 received no vaccine and iron dextran by oral gavage. As expected, the mean hematocrit as well as the mean antibody level for group 3 was significantly lower than the means of the other groups, which were not different. No significant differences in daily gain or weaning weight were demonstrated. The needle-free injection method resulted in equivalent hematocrit, antibody response and growth and did not result in the increased nonspecific sickness that was observed in the group injected with conventional needle and syringe.

**Funding Sources:** Ontario Pork, Manitoba Pork Council, Sask Pork, Alberta Pork, Alberta Agricultural Research Institute, BC Hog Marketing Commission, Saskatchewan Agriculture Development Fund, Canadian Network for Bacterial Pathogens of Swine, NSERC & commercial partners

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## **THE EFFECT OF SPACE ALLOWANCE AND SEASON ON THE BEHAVIOUR AND GROWTH OF EARLY WEANED PIGLETS DURING TRANSPORTATION**

### **Introduction**

The swine industry has adopted a segregated early weaning (SEW) management system, necessitating transport of piglets to a site separated from the breeding herd. This results in the transport of millions of piglets each year and problems affecting even a small percentage of the piglets can have a large economic and welfare impact. The objective of this study was to assess the effect of season and density during transport on behaviour and growth in early weaned piglets as an assessment of stress and welfare during transport.

### **Methods and Materials**

**Study 1:** Transport was simulated in 3 temperature controlled rooms representing summer, spring and winter transport. Within each season piglets were stocked at 3 densities: recommended (0.06 m<sup>2</sup>/pig), high (0.048 m<sup>2</sup>/pig) or low (0.12 m<sup>2</sup>/pig). Serum samples were drawn at four times, 1) a baseline the day before weaning, 2) after transport 3) 24 hours and 4) 48 hours after entry to the weanling pens. Serum samples were used to determine cortisol levels, a measure of stress. A total of 72 piglets (3 seasons x 2 groups x 3 densities x 4 piglets/group) were sampled.

**Study 2:** Six groups of forty eight Cotswold piglets were weaned at 17 ± 1 day of age and placed on trial in one of three seasons: summer, spring or winter. Piglets in each group were transported for 24 h at one of 3 densities. During transport, behaviour was recorded in each density defined area using a VCR and 3 infra-red cameras. After transport, piglets were moved to weanling pens in groups

of 4. Behavioural observations were continued and daily weights were recorded.

### **Results and Discussion**

Serum cortisol levels were significantly higher following weaning irrespective of temperature or density during transport. Baseline serum cortisol levels averaged 42,601 pg/ml the day before weaning and transport. After weaning/transport (24 hours) cortisol levels had almost doubled to 82,915 pg/ml. Twenty four hours later serum cortisol level had returned to baseline levels. Although temperature and density are likely to contribute to stress this was not measurable against the background of stress due to weaning. Behavior is a sensitive measure of acute stressors and may be a better indicator of transport stressors. Resting is associated with fatigue and was observed more frequently during winter transport (85.7%) than during summer (71.1%) or spring (68.7%). Resting post transport was highest on the first 2 days then dropped on day 3 and again on day 4 indicating fatigue during transport. Resting was higher for 3 days post transport in winter indicating a higher level of fatigue following winter transport. Sitting is a behaviour which tends to be infrequent (3.3 %) but appears to be associated with stressful transport. Sitting was observed more frequently during transport in the high density group (5.8%) than in the standard (3.1%) and low density groups (1.2%) on average. This pattern was seen as a trend in summer (H-5.4%; S-2.3%, L-1.0%) and as a significant difference in spring, when sitting was more frequent (H-10.2%; S-4.8%, L-2.0%). However in winter, when the high density was unlikely to be stressful due to the propensity to huddle, sitting was not higher in the high density group (H-1.6%; S-2.0%, L-0.7%). Sitting frequency was generally lower post transport (0.2%) but still reflected the stress of transport. Following high density transport the frequency of sitting was higher on day 1 (0.41%) than on subsequent days (0.1%). Following standard and low density transport, sitting was the same and low across all days (0.2%). Sitting consequently appeared to follow the theoretical transport stress level. Sitting is a behaviour easily recognized by producers and with more study may be a useful indicator of stressed piglets. On average piglets dropped to 5.4 kg from a weaning weight of 5.9 kg, a weight loss of 7.8%.

Piglets reached their lowest average weight at 2.7 days post-weaning and recovered their weaning weight at 4.3 days post weaning. Piglets transported during the summer showed consistently poor production compared to winter and spring transport. Piglets transported in summer had a higher % weight loss (9.6% vs 6.9%), took longer to reach minimum weight (3.7 days vs 2.2 days) and longer to recover from the growth check (4.9 days vs 4.0 days) than piglets transported in the winter and spring. These poor production values were also reflected in feeding frequency in the first 4 days post transport, which was lower in summer (2.9%) than during winter (5.2%) or spring (4.5%). Most poor doers were observed in the summer group (34: 64.2%), less were observed in the winter group (13: 24.5%) and least following spring transport (6: 11.3%). In the previous study, winter transport was found to be most detrimental to production. In comparing the two trials spring and winter transport production values were similar but summer transport became much more detrimental. This may have been due to the longer transport and the use of a high density treatment in this study.

### **Implications**

Stressful summer transport can substantially reduce post transport production. Behaviour is a more sensitive measure of transport stress than serum cortisol levels. Transport causes fatigue in piglets, especially following winter transport. Frequency of sitting may be a method of determining piglets which have been stressed by transport.

### **Funding Sources**

National Pork Board (US) and Manitoba Pork Council

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## THE EFFECT OF SPACE ALLOWANCE AND SEASON ON THE MICROCLIMATE OF THE EARLY WEANED PIGLET DURING TRANSPORTATION

### Introduction

The swine industry has adopted a segregated early weaning (SEW) management system, necessitating transport of piglets to a site separated from the breeding herd. This results in the transport of millions of piglets each year and problems affecting even a small percentage of the piglets can have a large economic and welfare impact. Both temperature and density will impact the degree of stress experienced during transport. Current temperatures experienced by transported SEW piglets can vary greatly from the recommended comfort range of 26-32°C. Stocking densities and the propensity for piglets to huddle can greatly influence the thermal microclimate at the level of the piglet. The objective of this study was to assess the thermal microclimate of SEW piglets at 3 stocking densities in 3 seasons.

### Methods and Materials

Six groups of forty eight Cotswold piglets were weaned at  $17 \pm 1$  day of age and placed on trial in one of three seasons: summer, spring or winter. Piglets in each group were transported for 24 hours at one of 3 densities: recommended (0.06 m<sup>2</sup>/pig), high (0.048 m<sup>2</sup>/pig) or low (0.12 m<sup>2</sup>/pig). During transport, air and bedding temperatures were recorded in each density defined area. Behavioral data were collected using a VCR and 3 infra-red cameras. Piglet skin temperatures were recorded at the end of each 6 hour period of transport.

### Results and Discussion

Average hourly air temperatures above the pigs ranged from 20.4°C to 32.2°C in summer. In winter air temperatures rarely exceeded 8.0°C, with temperatures dropping to hourly averages of -9.8°C. Spring temperatures tended to be intermediate ranging from 7 to 26°C. Ear temperatures were higher during summer transport (35°C) than in winter (16.5°C), with spring intermediate (29.6°C). In the summer, more piglets (81.3%) spent 75-100% of the time in transport on top of bedding or other piglets. In the winter piglets showed a

preference for being underneath other piglets or bedding. However, piglets varied in their ability to stay covered. Most piglets (36%) spent 75-100% of the time covered, 26% were covered for 25 – 50% of the time, 30% for 50 - 75% of the time and 8.6% could remain covered for less than 25% of the time in transport. Density affected the microclimate of piglets during transport. At high density, air temperatures were higher (15.1°C) than at low density (14.0°C) with standard density intermediate (14.7°C). Higher ear temperatures were also recorded at the high density (27.6°C) when compared to standard (26.6°C) or low density (26.9°C). In addition, higher densities may have interfered with thermoregulatory behaviour in summer. At the high density, fewer piglets were able to stay exposed for 75-100% of the time (high: 39, standard: 58, low: 61) although this did not meet the criteria for significance. At the high density in summer, piglets have a higher air temperature to contend with, which is reflected in higher ear temperatures. They also have more difficulty staying exposed to the air and run the risk of hyperthermia. Higher densities in winter did not appear to be detrimental, possibly because the piglets tended to huddle irrespective of space available.

### **Implications**

In summer, densities which exceed recommendations result in higher air temperatures, higher ear temperatures and reduced ability to move away from other piglets, putting piglets at higher risk for hyperthermia. In winter, higher densities produce higher air temperatures and higher piglet ear temperatures, indicators of a warmer microclimate. The ability to reduce exposure to the environment could be improved. More research is needed into bedding depth, bedding type and density to improve the microclimate during winter transport.

### **Funding Sources**

National Pork Board (US) and Manitoba Pork Council

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## **THE EFFECTS OF CROWDING ON THE PERFORMANCE OF GROWER AND FINISHER PIGS ON FULLY AND PARTIALLY SLATTED FLOORS**

### **Summary**

Crowding affects the productivity of grow/finish pigs and it is generally believed that floor types differ in required space. This study was designed to determine if there is a significant interaction between the two factors. Crowding resulted in a reduction in ADG, but the type of flooring did not make a difference.

### **Introduction**

Floor space allowance remains one of the more contentious issues in the debate on modern farm practices and animal welfare. It is generally believed that space requirements for maximum growth will vary with housing conditions. The Code of Practice recommends that pigs on partially slatted floors be provided with more total floor area than those on fully slatted floors. However, some research has suggested that there are no differences in the effect of crowding on these two floor types. This study was conducted to gain a better understanding of space required for pigs housed on either fully or partially slatted floors.

### **Results and Discussion**

ADFI was not affected by floor type or floor space allowance in either the grower or finisher phases. ADG tended to be less on partially than on fully slatted floors during the grower phase, but did not differ in the finisher phase. Pigs on the lowest floor space allowance grew slower than pigs on the other two space allowance treatments during the grower phase (Figure 1). ADG tended to be reduced by crowding during the finisher phase (Figure 2). There were no significant interactions between floor type and space allowance.

## Conclusion

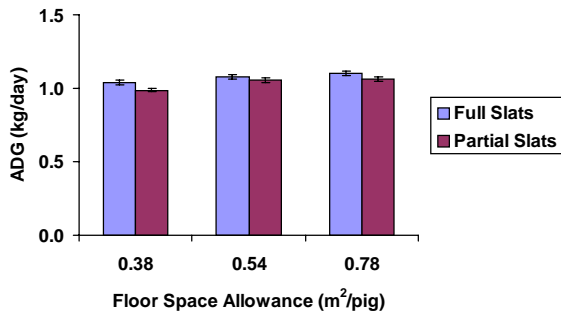
Although crowding to a space allowance coefficient of 0.026 resulted in a reduction in ADG, there was no evidence that this effect differed depending on whether the floor was fully or partially slatted.

## Funding Sources

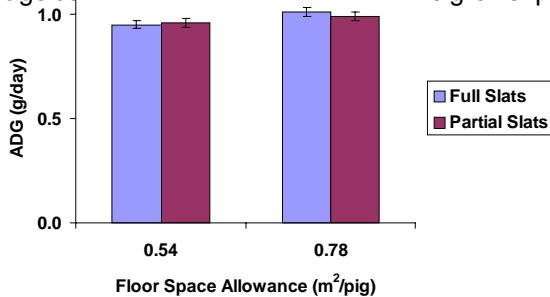
Strategic funding provided by Sask Pork, Alberta Pork, Manitoba Pork Council, and the Saskatchewan Agriculture and Food Development Fund. Project funding was provided by NSERC and AAFC.

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**Figure 1.** Effect of floor space allowance and floor type on average daily gain (ADG) of pigs during the grower phase.



**Figure 2.** Effect of floor space allowance and floor type on average daily gain (ADG) of pigs during the finisher phase.



## EFFECTS OF STALL WIDTH AND SOW SIZE ON BEHAVIOUR OF GESTATING SOWS

### Summary

It is recommended that gestating sows of various weights should be kept in different sizes of stalls. However the proper size of stall has not been well defined. A study was conducted to evaluate stall width by assessing the interaction between stall width and sow size on behaviour. As stall width decreased, sows spent less time standing, more time sitting, and their udders extended into the adjacent stall more frequently. Using udder extension during less than 50% of lateral lying as a criteria for stall width, a 65 cm (26") stall is adequate for gilts and small sows, but a 70 cm (28") stall is required for larger sows if in stalls for the entire gestation period.

### Introduction

Gestation stalls are usually uniform in size within a farm in North America despite the wide range in body weights among gestating sows (150 to 350 kg). The adequacy of typical stalls to accommodate large sows is questioned. The Code of Practice suggests producers use different sizes of stalls to accommodate various sized sows. However the proper stall size for sows of different body size is not well defined. As an inadequate stall size is likely to affect the behaviour of the sow, a study was conducted to evaluate stall width by determining the effects of stall width, sows size and the interaction on sow behaviour.

### Results and Discussion

At post breeding, average body weights of gilts, small, medium and large sows were 145, 180, 216, and 259 kg, respectively, and the animals gained 60-80 kg during pregnancy (Table 1). At week 14 of gestation, sows spent more time lying (82.5% vs 77.5% of their total time) and less time standing (14.4 vs 19.8%) than at week 4. The proportion of time spent standing increased in wider stalls (Fig 1), but sitting decreased. Extension of the udder into the adjoining stall was expressed as a proportion of time spent lying laterally. This increased from week 4 to week 14 (20.8 vs 60.0%), with larger sows (51.0 vs 77.8%, for gilts and large sows during week 14) and in narrower

stalls (23.5 vs 91.7%, for 70 and 55 cm stalls during week 14). Extension of the udder into the adjoining stall was significantly affected by the interaction of stall width and sow size, indicating that large sows in narrower stalls were quite crowded (Fig 2). Using the criteria that the udder should not extend into the adjoining stall more than 50% of the time that a sow is lying on her side, we suggest that a 55 cm stall is suitable for gilts and small sows, a 60 cm stall for medium sows, and a 65 cm stall for large sows during the early stage of gestation (week 4), as would be the case if sows were moved into group housing after implantation. But in later stages (week 14) gilts and small sows should be housed in 65 cm, and medium and larger sows in 70 cm stalls.

### Conclusions

Pork producers should use a variety of stall widths to accommodate various sized gestating sows. If stalls are used for the entire gestation period, 65 cm stalls appear to provide adequate space for gilts and small sized sows, and 70 cm stalls for larger sows.

### Funding Source

Strategic funding provided by Sask Pork, Alberta Pork, Manitoba Pork Council, and the Saskatchewan Agriculture and Food Development Fund. Project funding was provided by Ontario Pork, AAFC and NSERC.

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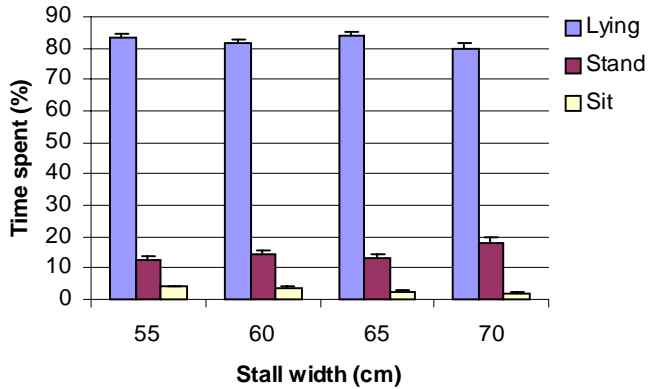
**Table 1.** Body weight of animals

Item	Gilts	Sows			N
		Small	Medium	Large	
39	47	45	53		
Ave.parity	0	1.4	2.8	4.8	
BW1, kg	145±13	180±14	216±10	259±21	
BW2, kg	223±20	250±24	282±21	316±22	
▲BW, kg	78	70	64	57	

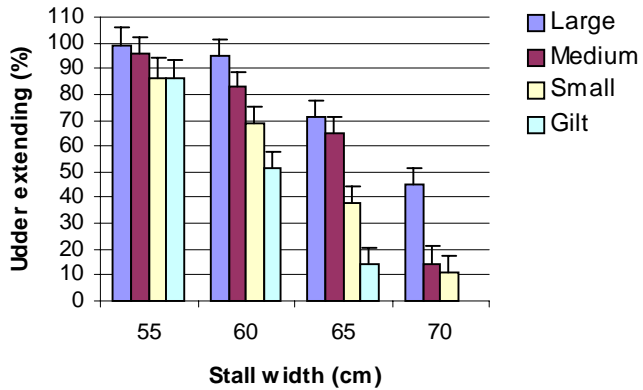
BW1 = average body weight post breeding

BW2 = average body weight before farrowing

▲BW = BW2 – BW1



**Figure 1.** Time budget (as % of total time) for each posture at week 14 of gestation.



**Figure 2.** Time spent (as % of lateral lying time) with udder extending into the adjacent stall at week 14 of gestation



## ENHANCING PROTECTIVE IMMUNITY AGAINST COLIBACILLOSIS IN POST-WEANED PIGS

### Introduction

Infection with enterotoxigenic *E. coli* (ETEC) bearing the K88 ac+ (F4) fimbriae causes post-weaning colibacillosis in 4-6-week-old pigs. This economically important disease is characterized by high morbidity and reduced weight gain, resulting in economic losses for the pig industry. Infection is dependant upon pigs that have the presence of the receptor for K88 on their intestinal epithelial cells. Current vaccine strategies are based upon maternal immunization with subsequent transfer of passive immunity to the offspring. However, vaccines composed of *E. coli* strains that cause colibacillosis in newborn piglets, when administered to sows, have limited cross-protective efficacy. Moreover, maternally derived immunity wanes around 5-6 weeks leaving the piglet susceptible to infection. Oral vaccination with the F4 fimbriae generates immune responses in the F4 receptor (F4R) positive pigs, but only weak responses in the F4R negative ones. Thus F4R negative pigs may represent an important source of contamination within the herd. We are currently using novel adjuvants and delivery vehicles in pigs to induce protective mucosal immunity in both F4R positive and F4R negative pigs. We use CpG DNA and porcine *B*-defensin in combination with the F4. Both adjuvants are capable of targeting and recruiting immature dendritic cells eliciting T and B cell immunity. We therefore hypothesize that a protective mucosal immune response can be generated in both receptor positive and negative pigs by orally immunizing with an F4-defensin fusion, or F4 CpG mixture with either delivered within a micro-polymer. Induction of local immunity in the small intestine will be analyzed using the recently developed gut-loop model in vivo. Independent intestinal segments (jejunum) are created in 3 week old piglets. Each of the loops containing a Peyer's patch will be immunized with the F4 and the F4-fusion construct, or a combination of the F4 and CpG DNA. The local immune response will be assessed. To analyze the induced immune response each loop will be infected with *E.coli* and protective immunity will be assessed by reduction of the bacterial load within the loop. Optimal doses and formulations will be used for oral vaccination of 3-week-old piglets and protection will be determined in a subsequent challenge infection.

## **Results and discussion**

We have established protocols to purify the F4 protein for immunization. The identity of the F4 was verified using a F4-specific serum (western blot). The challenge model was established in post-weaned pigs for ETEC F4 +. Infecting four weeks old piglets with an inoculum containing  $1 \times 10^{10}$  cfu ETEC induced diarrhea and reduced weight gain in challenged animals. Six out of 9 animals died within two days. All infected animals shed significant amounts of ETEC for up to six days post infection. The infection primarily occurred within the small intestine where the receptor for ETEC F4 is located. Post mortem analysis of the pigs' intestines allowed us to group the pigs into F4R+ and F4R – subtypes. It was shown that a majority of the pigs have the receptor for ETEC F4. We are currently analyzing the local immune response in F4-immunized loops using our gut-loop model.

**Funding Sources:** Manitoba Pork Council, Alberta Pork, Sask Pork, Ontario Pork, BC Hog Marketing Commission, Agriculture Development Fund Saskatchewan, and Canadian Institutes of Health Research (CIHR).

## **Researchers**

M. Danabassis, M. Salles, J. Foley, P. Willson, L. Babiuk and V. Gerdts. The abstract was presented during the University of Saskatchewan Research Day 2004.

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## JOINT PROBLEMS IN GILTS AND SOWS IN GESTATION HOUSING TYPES DIFFERING WITH RESPECT TO EXERCISE AND SOCIALIZATION OPPORTUNITIES

### Introduction

Gestation housing is a contentious welfare issue. Fueled by the Welfare Movement, the switch to group housing has been progressing rapidly in Europe and similar pressure can be seen in North America. The major concerns associated with gestation stalls stem from the level of confinement which restricts the ability to perform many natural behaviours. Confinement also restricts the opportunity for exercise and can negatively affect the sow's physical state including reduced muscle mass and bone strength. Conversion of gestation crates into free choice pens housing small groups of pigs represents a potential compromise in housing, providing socialization opportunities and more exercise. In this study two factors, lameness and behaviour associated with activity, were studied to determine the possible benefits of group housing.

### Experimental Procedures

Sixty one gilts were randomly assigned to one of 3 housing types; locked-stall [*LS*], stall-pen [*SP*] or straw [*S*] over a period of 20 months. *LS* housing consisted of standard gestation stalls (1.85 m x 0.62 m). *SP* housing consisted of four standard gestation stalls that opened into a rear pen area (1.85 m x 2.5 m). *S* housed gilts were moved to a straw pen (8.53 m x 3.05 m) following confirmation of pregnancy in the total group (2nd ½ of gestation). Lameness was evaluated at early, mid and late gestation using a scoring system adapted from Main et al. (2001). A combined lameness score (CL) was calculated using the initial response, standing posture and gait. Scores ranged from 0 (normal) to 5 (severe lameness). The behaviour of the gilts was assessed from video tapes.

### Results and Discussion

No significant difference between housing treatments was noted for CL. In early gestation, greater than half the gilts in all housing systems were assigned a CL score of zero. A non-significant tendency for the number of gilts scoring

zero to increase from *LS* (57.9%) to *SP* (62.5%) to *S* (73.3%) housing was observed. No significant difference was found as gilts progressed from early through mid to late gestation. Although there was a tendency for gilts in *LS* housing to have higher CL scores these higher scores were not severe enough to be categorized as lameness requiring treatment. Consequently, the conclusion of this study is that standard gestation housing does not exacerbate lameness in first gestation gilts. A consistent pattern emerged in which *LS* gilts performed significantly different levels of behaviours and postures than *S* gilts. *SP* gilts were observed to be intermediate. The housing characteristics, namely group size, social interaction and possibility for exercise, reflect the same relationship and are therefore likely to be implicated in influencing this pattern. Locomotion, nosing at the straw and lateral recumbency were observed to increase as space and the opportunity for social contact increased. Ventral recumbency, abnormal behaviours, time spent idle and inactive behaviours were observed more frequently as the level of social and physical confinement increased. These observations are consistent with reduced welfare in *LS* housing, an improvement in *SP* housing but better welfare in *S* housing.

### **Implications**

Joint health does not appreciably decrease in gestation housing. Based on the behaviours studied, *S* housing appeared to be better for the welfare of gilts.

### **Funding Sources**

IRAP, Leading Breeding Company, Manitoba Pork Council

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## **MUCOSAL DELIVERY IN PIGS OF BACTERIAL ANTIGENS AND CPG ODN FORMULATED IN BIPHASIC LIPID VESICLES**

### **Introduction**

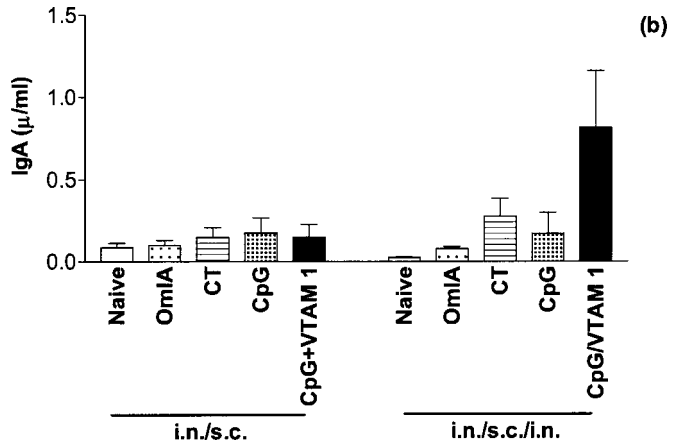
The importance of stimulating mucosal immune responses as a first line of defense against invading pathogens was recognized by a number of investigators. Furthermore, the use of non-invasive routes for vaccine delivery is necessary to make administration simple, painless and economically practical. The ineffectiveness of simple delivery of soluble antigens to mucosal membranes for immunization has stimulated extensive studies of strategies for appropriate delivery systems and adjuvants.

CpG ODNs have been used as systemic adjuvants for inducing cellular and humoral responses to various antigens given alone or associated with liposomes and for the induction of mucosal immunity mostly in rodents, while only limited studies have investigated their usefulness as adjuvants in pigs.

### **Results and Discussion**

Biphasic lipid vesicles are formulations suitable for the delivery of proteins, peptides and oligo/polynucleotides. The purpose of these studies was to investigate the ability of biphasic lipid vesicles (VTA) containing a bacterial antigen and CpG ODN to induce systemic and mucosal immune responses in pigs.

Results showed that administration of antigen and CpG ODN in biphasic lipid vesicles resulted in induction of systemic and local antibody responses after immunization with a combined mucosal/systemic approach, while the protein either alone or with CpG ODN did not induce mucosal immune responses.



**Figure 2. Antibody responses in nasal secretions after a mucosal/systemic immunization protocol.** Animals received two i.n. immunizations with different formulations at day 0 and 30 and one s.c. at day 21 with OmlA and CpG ODN in Emulsigen. Anti-OmlA IgA (b) concentrations in nasal secretions were determined 7 days after each boost and compared with s.c. immunizations. Results are expressed as the mean concentration  $\pm$  SEM of 7 pigs.

**Funding Source:** Manitoba Pork Council, Alberta Pork, Sask Pork, Ontario Pork, BC Hog Marketing Commission, NSERC, Canadian Network for Bacterial Pathogens of Swine

**Researchers**

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## NOVEL VACCINE DELIVERY SYSTEMS FOR SWINE

### Introduction

Infections due to mucosal pathogens are among the most common diseases of piglets worldwide and cause substantial economic loss to swine producers. Effective immunity to these infections is based on specific response at the mucosal surface (Bozic *et al.*, 2002). However vaccine formulation and delivery to this surface remains a major challenge.

Current vaccination strategies against enterotoxigenic *E. coli* (ETEC) are not sufficient to suppress this economically significant pathogen. In the first section below, we describe our progress in the application of novel adjuvants and delivery vehicles for oral vaccines. These vaccines are aimed at inducing mucosal immunity either before or after they are exposed to ETEC.

One of the ways to improve the mucosal immune response is by including immunostimulatory (CpG) DNA motifs in the vaccine formulation (Alcon *et al.*, 2003). Subcutaneous or combined (subcutaneous and intranasal) immunization using an intranasal device (Alcon *et al.*, 2002) induces systemic and nasal antibodies at mucosal surfaces. We go on to describe results of our investigations of lipid vesicles and CpG oligodeoxynucleotides as delivery vehicles and adjuvants respectively, in stimulating mucosal immunity. Such vesicles are compatible with needle-free delivery methods.

Vectored vaccines offer an additional needle-free delivery method to the mucosal surfaces. In such vaccines, non-essential genes of a neutral virus are replaced with genes for a pathogen, or pathogens, of choice. The engineered vaccine acts something like a modified live vaccine; however one significant difference is that MLV can revert to virulence; whereas the engineered vaccine is based on a harmless virus so that there is no potential to become virulent. We have developed porcine adenovirus-3 vectors expressing PRRS proteins and describe our results.

Effective vaccines require understanding of how the

pathogenesis or disease process occurs. The factors of the infecting organism that make it able to cause disease are called virulence factors and these virulence factors often make good candidates for vaccine development. Although *Streptococcus Suis* continues to pose a major threat to pigs, its virulence factor(s) are not yet identified. Here we describe the discovery of a mutant strain showing a hyper-hemolytic phenotype, and our identification and investigation of the gene showing increased expression.

Finally, we present results of a study evaluating delivery methods (needle-free vs. conventional vs. no injection) on vaccine efficacy and post-infection clinical condition.

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## **PORCINE ADENOVIRUS-3 (PAV-3) VECTOR BASED PORCINE VACCINES**

### **Introduction**

New approaches have been developed for the efficient delivery and production of safe and cost-effective viral vaccines. Live vaccines produced by conventional means ensure that the live organism is always present in the animals, which can mutate back to a virulent form and cause fatal disease. The novel PAV-3 viral vectors can be engineered to carry genes for other pathogens thus making it possible to immunize animals to produce protective immunity at the mucosal surface to various disease organisms at one time.

### **Results and Discussion**

We tested the safety and immunogenicity of recombinant PAV-3 expressing PRRS proteins in pigs. The pigs were

vaccinated twice, 25 days apart with recombinant PAV310, PAV312 or PAV300, either oro-nasally or subcutaneously. All pigs were challenged intranasally with 10<sup>6</sup> TCID<sub>50</sub> / ml of PRRS virus on day 40. Serum samples were collected at different times and analyzed for PRRS specific antibodies using HerdCheck PRRS Virus antibody test kit 2XR (IDEXX Laboratories Inc.) and virus neutralization tests.

Interestingly, PRRS specific IgG titers remained higher in animals immunized subcutaneously with PAV310 or PAV312 compared to the control (PAV300) group. However, pigs vaccinated subcutaneously developed weak PRRS virus neutralizing antibody response even after 21 days post challenge. Only one pig from each group (PAV310 or PAV312) showed high levels of PRRS virus neutralizing antibodies.

After challenge, pigs developed mild fever. There was no difference in rectal temperatures of animals vaccinated oro-nasally or subcutaneously. In addition, lungs showed changes consistent with interstitial pneumonia. However, there was no evidence of proliferation of type 2 pneumocytes or necrosis (alveolar or bronchiolar). We have been awarded one patent and have filed three additional patents on the use of PAV3 as a live virus vector.

**Funding Sources:** Manitoba Pork Council, Alberta Pork, Sask Pork, Ontario Pork, BC Hog Marketing Commission, NSERC, Commercial partners, and HSURC PDF Fellowship

**Researchers:** The adenovirus team, under the leadership of Suresh Kumar Tikoo included Alexander Zakhartchouk, Li Xing, Mahavir Singh, Jill van Kessel, Andrew Ficzyz, and Philip Willson.

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## **SOCIAL FACTORS THAT AFFECT INJURIES LEVELS AND THE BEHAVIOUR OF SOWS REGROUPED INTO AN ELECTRONIC SOW FEEDER SYSTEM**

### **Summary**

The total number of injuries detectable on sows increased until 28 days after regrouping before declining. First parity sows and post-implantation sows ate later in the feeding cycle, while first parity sows and unfamiliar sows rested in the less optimal areas of the pens. Thus, the behaviour of older, familiar and pre-implantation sows indicates that they are experiencing less stress during regrouping.

### **Introduction**

Regrouping is a stressful time for pigs. When sows are regrouped shortly after breeding, stress may alter behaviours and result in a decrease in farrowing rate. The severity of the stress the sows are experiencing can be reflected in injuries, eating order and resting locations. The goal of this study was to determine the effect that stage of implantation, familiarity with penmates, and parity have on the behaviour.

### **Results and Discussion**

The total injury scores rose until 28 days after regrouping, at which time they started to decrease (Figure 1). There were not any effects due to stage of implantation, familiarity and parity on injury scores. As seen in Figure 2, the younger and post-implantation sows ate later in the feeding cycle than the older and pre-implantation sows. In relation to where the sows rested in the pen, familiar and older sows rested on the solid portion of the pen more often than the younger and unfamiliar sows (Figure 3). The social factors studied affected the priority of access to both the feeding station and preferred lying areas in the pen.

### **Conclusion**

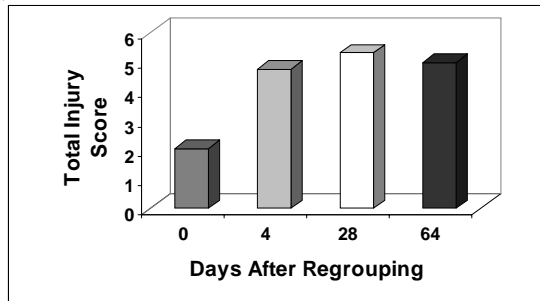
After regrouping, the younger, unfamiliar and post-implantation sows showed behaviours indicating that they experienced mores social stress than the older, familiar and pre-implantation sows.

## Funding Sources

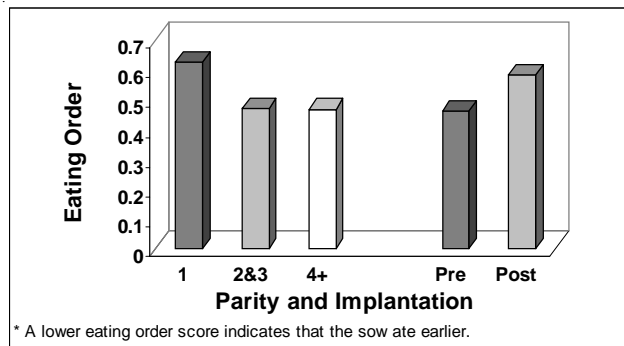
Strategic program funding provided by Sask Pork, Alberta Pork, Manitoba Pork Council and ADF. Additional project funding provided by Ontario Pork, NSERC and AAFC.

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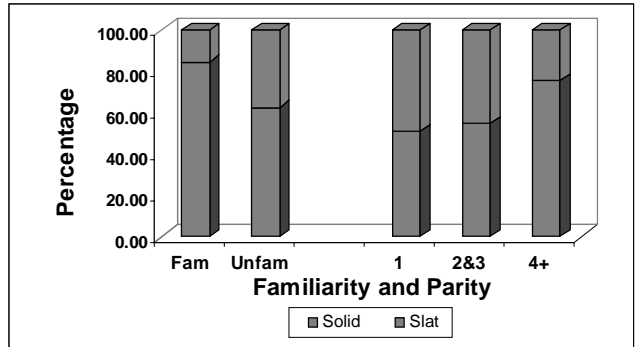
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**Figure 1.** The total injury scores of sows on days 0, 4, 28 and 64 after regrouping into the ESF pen.



**Figure 2.** The effect of parity and stage of gestation on feeder entry order 4 days after regrouping into the ESF pen.



**Figure 3.** The effect that familiarity with penmates and parity have on the relative proportion of time the sows spent lying on the solid and slatted areas of the pen during the week following regrouping.



## VIRULENCE FACTORS OF *STREPTOCOCCUS SUIIS* TYPE 2

### Introduction

Serotype 2 *Streptococcus suis* infection can cause meningitis, septicemia, arthritis, and sudden death in young pigs. The virulence factor(s) of *S. suis* remain unclear. We have identified a DNase that is produced by virulent strains of *S. suis* and may be involved in pathogenesis

### Results and Discussion

In this study, we generated a genomic mutant library from a North American strain of serotype 2 *Streptococcus suis* using the pGh9:ISS1 transposition vector. Suilysin is the hemolysin made by *S. suis*. A hyper-hemolytic mutant was identified by screening for the hemolytic phenotype using media with human blood. The hyper-hemolytic phenotype was characterised by a quantitative hemolysis microplate method. The use of green fluorescent protein (GFP) as a reporter also showed that suilysin gene expression was greater in the mutant. DNA sequence analysis of 3.8 kb surrounding the ISS1 insertion site revealed four open reading frames (ORFs) with three consecutive ORFs that belong to a putative mannose-specific phosphotransferase system (PTS). The *S. suis* gene homologous to mannose permease IID, *manN*, was

interrupted by the transposon. A complementation test showed that *manN* repressed the expression of suilysin and the absence of *manN* was responsible for the hyper-hemolytic phenotype. However, both wild type and isogenic hyper-hemolytic mutant *S. suis* fermented mannose, glucose and lactose. Thus, despite its potential roles in carbohydrate transport, phosphorylation and metabolism, the *manN* homologue in the putative mannose-specific PTS regulates gene expression in *S. suis*.

**Funding Sources:** Manitoba Pork Council, Alberta Pork, Sask Pork, Ontario Pork, BC Hog Marketing Commission, NSERC, Canadian Network for Bacterial Pathogens of Swine

### **Researchers**

Lun S., Fontaine M.C., Perez-Casal J., Willson, P.J. This work has been peer reviewed and accepted for publication "Lun, S., Willson, P.J. Putative mannose-specific phosphotransferase system component IID represses expression of suilysin in Serotype 2 *Streptococcus suis*. Veterinary Microbiology. 2005 Feb; 105(3-4): 169-180."

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## Section III. Environment



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### **BEST MANAGEMENT PRACTICES TO IMPROVE ENVIRONMENTAL SUSTAINABILITY AND PRODUCTIVITY OF GRASSLAND SYSTEMS USING HOG MANURE**

#### **Objective**

To develop a series of *Best Management Practices* that can be employed by beef, dairy and hog producers to ensure effective utilization of hog manure as a fertility source for forages and to improve production efficiencies of grassland agricultural systems utilizing hog manure.

The establishment of a high profile demonstration site will enable the project partners including local forage/livestock producers, industry partners, provincial organizations and research scientists to work together to not only identify best management practices but also to ensure that they are rapidly and effectively communicated to producers such that they may be implemented on-farm.

#### **Impact Statement**

This project will provide much-needed information regarding the avenues through which pasture quality and productivity may be improved. Historically, this is an area that has received little attention but may prove to be economically beneficial as the forage and cattle exports continue to increase.

This project will also provide valuable information regarding the relationship between forage quality and methane emissions when consumed by cattle, as well as pathogen and microbial movement in pastures receiving hog manure.

#### **Activity**

Second progress report received November 1, 2004. Third progress report due April 1, 2005.

**Start Date:** November 1, 2003

**Finish Date:** November 1, 2006

**Amount Funded:** \$60,000 **Performer Funding:**  
\$416,540 **Total Cost:** \$476,540

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## **DETERMINATION OF PHOSPHORUS SORPTION- DESORPTION CHARACTERISTICS OF MANITOBA SOILS**

### **Objective**

Develop a relationship between routinely measured soil properties and the sorption maxima and degree of P saturation of Manitoba Soils and to develop a technique for measuring the degree of phosphorous saturation in representative Manitoba soils.

The short-term objective is to determine the P sorption maximum of representative Manitoba soils using both a multi-point adsorption isotherm and the single point isotherm. The long-term objective is to within a period of two years develop, test and calibrate a Phosphorous Index that can be used to estimate the risk of phosphorous loss from Manitoba soils.

### **Impact Statement**

P is the limiting nutrient in most surface and fresh waters, the ability to limit the export of P from agricultural land to surface water will protect water quality. The project will develop management tools whose use will ensure that the expansion of the animal industry in Manitoba does not occur at the expense of the environment. At the same time, this research will also help to ensure the environmental standards are not set at an unjustifiable level that will cause unnecessary harm to agriculture.

The project developed important P sorption parameters for Manitoba soils that will form part of a phosphorous index for Manitoba. The phosphorous index can be used to rank the relative risk of P loss from land to water based on site and management factors. When developed for Manitoba soils, PI can be used to evaluate site and management

factors for risk of P loss and alternative management options can be adopted to reduce the risk of P loss if they are too high.

**Activity**

Final report received July 29, 2005.

**Start Date:** July 1, 2003

**Finish Date:** July 1, 2004

**Amount Funded:** \$80,000 **Performer Funding:** \$0  
**Total Cost:** \$80,000

**Other Sources of Funds:** MRAC \$40,000; SDIF \$25,000

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**EFFICIENCY OF BUFFER STRIPS IN THE MANITOBA LANDSCAPE AS A BEST MANAGEMENT PRACTICE**

**Objective**

To quantify the benefit of vegetated buffer strips (VBS) (natural riparian zones and managed buffer strips) in reduction of phosphorus runoff from fields to streams in Manitoba settings. VBS can have the ability to mitigate and almost eliminate the entry of nutrient, especially P from farmland to water bodies. At the same time, VBS can be costly in terms of lost arable land and weed management. It is well anticipated that VBS are a useful best management practice (BMP), and they are almost unavoidable in many places because land near a water-way is often too wet to cultivate and so becomes a *de facto* buffer strip. Natural VBS or riparian zones, often treed, are also very common and important, yet need to be better understood.

So the question is not should there be a buffer strip, but rather how wide should it be, what vegetation type is best and how should it be managed.

## **Impact Statement**

VBS have been reported as a BMP, and are reportedly successful in some landscapes. However, there has been a suggestion that in Manitoba, VBS will have limited ability to reduce loss of P from flat landscapes, because much of the P is soluble or that the vegetation itself becomes a source of P. This issue needs to be resolved before producers are required to implement this or other related BMPs.

The outcome of this project on natural and managed VBS will provide data to indicate what percentage reduction in P runoff can be expected (if any), provide information on widths, vegetation types and management practices that increase the efficiency of VBS, and provide information of the relative roles of soluble particulate P in P loss from fields to streams.

The major impact will be that Provincial manure management guidelines and farm-level manure management plans will have data to show the quantitative benefit of VBS in Manitoba, and this will help end the present speculation about the usefulness of this BMP.

## **Activity**

Second progress report received September 30, 2004.  
Third progress report due March 1, 2005.

**Start Date:** September 1, 2003

**Finish Date:** September 1, 2005

**Amount Funded:** \$66,356 **Performer Funding:** \$0  
**Total Cost:** \$66,356

**Other Sources of Funds:** MRAC \$33,178

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## FORMS & REACTIVITY OF MANURE PHOSPHORUS FROM PHYTASE FED SWINE IN MANITOBA SOILS

### Objective

To determine the solubility and reactivity of manure P from phytase amended diets (and other dietary manipulations) in Manitoba Soils.

To develop techniques that can be used to assess the environmental reactivity and mobility of manure P.

To develop a fundamental understanding of the relationship between increased dietary efficiency of feed P and reduced environmental impact of manure.

### Impact Statement

An important issue confronting the expansion of the swine industries in Manitoba is water quality. P is the limiting nutrient in most surface and fresh waters, therefore the ability to limit the export of P from agricultural land to surface water will protect water quality.

This project will develop feeding strategies that can be used by swine and poultry producers to reduce the P content of manures thereby reducing the potential for P export from soil to surface water. It is anticipated that the research will lead to the development of P nutrient management options that combine to reduce manure P with reduced loss of P from the soil. At the end of this study, recommendations will be made on best management practices (BMP) that reduce manure P without making the P more soluble and prone to loss when added to the soil. The adoption of these BMP will create an atmosphere where the swine industry can thrive and even expand, with significant economic benefits to the province of Manitoba.

### Activity

Second progress report received January 6, 2005. Third progress report due July 1, 2005.

**Start Date:** January 1, 2004

**Finish Date:** January 1, 2006

**Amount Funded:** \$85,000 **Performer Funding:** \$2,000  
**Total Cost:** \$87,000

**Other Sources of Funds:** SDIF \$25,000; MRAC \$12,007

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## **GASIFICATION OF HIGH-SOLID-CONTENT LIVESTOCK MANURE AS AN ENERGY SOURCE**

### **Objective**

To determine the economic and technical feasibility of biomass gasification as a rural energy source and, in particular, evaluating six existing manufacturers of gasification equipment in Manitoba, all of them using downdraft technology.

After an initial feasibility and economic analysis study, a project plan would be developed to build a pilot gasification unit at Charison's Hatchery of Gunton that would serve as a public demonstration of farm scale application of this technology.

The project will determine the available energy, identify technical problems, and confirm the ability of gasification equipment to work with high solids content manure. It would also provide a cost benefit analysis and identify constraints and knowledge gaps for the successful application of this technology on farms.

### **Impact Statement**

There is a drive to increase alternative energy sources, as demonstrated by the recent wind farm being constructed in southern Manitoba. This project will evaluate and demonstrate the feasibility of a possible renewable energy source that can be used by farmers and rural communities to reduce their demand of standard energy sources.

In addition there will be an added value to the manure that livestock producers have as a by-product. High solids content manure has not commanded a very large value to

producers. Many livestock producers give it away as fertilizer in order to have it removed. If it could be shown to be a viable energy source, its value as fertilizer will increase as well, providing another additional revenue stream.

### **Activity**

First progress report is due on November 20, 2004.

**Start Date:** September 20, 2004

**Finish Date:** January 20, 2005

**Amount Funded:** \$12,000 **Performer Funding:** \$0  
**Total Cost:** \$20,000

**Other Sources of Funds:** MRAC \$6,000; Agri-Energy \$4,000; Charison's Hatchery \$4,000

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## **LAND REQUIREMENT FOR MANURE FROM HOGS FED PHYTASE-AMENDED RATIONS**

### **Objective**

To determine if the longevity of a parcel of land utilized for manure spreading will be reduced or enhanced with the use of Phytase in hog rations.

The project focuses on the forms (inorganic, organic and water-soluble) phosphorus in manure from hogs with phytase-amended rations and the extractable concentration of phosphorus in soil on which such hog manure has been applied. It would determine whether manure from hogs spread on land would enhance or reduce sustainability when phytase is used in hog rations compared to conventional diets.

## **Impact Statement**

This project will address and assess whether the use of phytase in rations will reduce the accumulation of available and soluble phosphorus within the soil of agricultural lands used for the spreading of hog manure.

This project will also provide the livestock industry an assessment of a method to managing phosphorus levels within existing and future manure storage facilities that could be more acceptable for compliance and regulation purposes and to the general public.

## **Activity**

First progress report was received on October 29, 2004. Second progress report is due on May 1, 2005.

**Start Date:** May 1, 2004

**Finish Date:** May 1, 2006

**Amount Funded:** \$69,720 **Performer Funding:** \$0  
**Total Cost:** \$69,720

**Other Sources of Funding:** MRAC \$34,860

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## **ODOUR & GREENHOUSE GAS EMISSIONS FROM HOG OPERATIONS (MLMMI 03-HERS-01) (U OF M)**

### **Objective**

To quantify the relative and absolute contributions to odour and greenhouse gas emissions from hog barns and manure storage structures in Manitoba. To characterize these emissions and to develop and validate a model for predicting the dispersion of odours from hog operations in surrounding communities.

This project will be carried out in two parts; Part 1 will measure odour and greenhouse gas emissions from two

barns and two earthen manure storage basins, one uncovered and one covered with a negative air pressure system. Part 2 will develop/modify and validate a model for predicating downwind odours.

### **Impact Statement**

A setback model is usually a simple empirical equation(s) for estimating the minimum separation distance between a livestock operation and the neighbouring facilities (e.g., residence) to ensure the minimum odour impact on the neighbouring facilities.

This study will focus on comparing and evaluating the existing setback models for Manitoba conditions, and on selecting and modifying setback models for implementation in Manitoba. The goal is to develop a setback model not only for Manitoba but in developing an all-encompassing Canada-wide mode(s).

### **Activity**

Second progress report received August 31, 2004.

**Start Date:** July 1, 2003

**Finish Date:** March 31, 2005 (extended from January 1, 2005)

**Amount Funded:** \$129,630 **Performer Funding:** \$0  
**Total Cost:** \$129,630

**Other Sources of Funds:** MRAC \$64,815

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## REDUCING *SALMONELLA* TRANSFER FROM MANURE TO THE ENVIRONMENT

### Objective

Characterize current manure storage conditions and examine land management practices for their influence upon *Salmonella* survival in manure and manure-amended soil in Manitoba. Study the influence of differences in nutrient content of manure upon *Salmonella* survival as well as the soil type (clay, sandy) upon *Salmonella* viability in the presence and absence of manure. Utilize scientifically validated data to identify manure management practices that will serve to minimize the potential transfer of *Salmonella* from hogs to the environment.

### Impact Statement

Data characterizing *Salmonella* survival in manure storage systems and when applied to soil will be interpreted. Manure management strategies that minimize the survivability and potential transfer of *Salmonella* to the environment will be identified in consultation with Elite Swine.

### Activity

Second progress report received November 17, 2004.

**Start Date:** November 17, 2003

**Finish Date:** July 15, 2005 (extended from May 17, 2005)

**Amount Funded:** \$74,780 **Performer Funding:** \$0  
**Total Cost:** \$74,780

**Other Sources of Funds:** SDIF \$25,000

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## **SPREADING HOG MANURE ON PASTURE: EFFECTS ON ANTIBIOTIC RESISTANCE AND PATHOGENS**

### **Introduction**

In 2003, the Manitoba cattle population, generated \$344,690,000 in farm cash receipts – down \$215,730,000 from the previous year as a consequence of the US border closure in response to the discovery of Bovine Spongiform Encephalopathy (BSE). In this same period, Manitoba has experienced the largest increase in cow numbers - up 15.3% to 638,000 head. Although calves in Manitoba have historically been shipped east, west or south of the border for backgrounding, finishing and slaughter, fewer market options are now available. A similar situation exists in other western provinces and there is an existing opportunity for producers to add value to their calves through forage-based backgrounding programs. Concurrent expansion in the hog sector, resulting in an increased supply of available plant nutrients in the form of manure, has made this a viable marketing alternative for many western Canadian producers. Together with an increase in hog production is an increase in manure. For example, in Manitoba, over 23.6 million tonnes of manure were produced during 1997, with cattle representing the largest single contributor. Because it is inconvenient to transport manure for any distance, manure is stored in pits, under buildings and in earthen manure storages, and later spread on fields. In recent years this manure has been seen as a nutrient resource, replacing some of the inorganic fertilizer used in crop production and increasing the fertility of low fertility grasslands. It is viewed as a means of increasing pasture production and in so doing increase the productivity of cattle grazing the manured pasture.

### **Experimental Procedures**

Cattle are currently being grazed on a research/ demonstration site consisting of a 12-paddock, replicated, rotational grazing system located in the RM of La Broquerie on land owned and operated by Hytek Inc., one of the largest swine producers in Western Canada. The current study represents an extension of a larger study funded by a coalition of provincial and national commodity groups, provincial and national government agencies, and industry partners. The soil, according to the Canadian-

Manitoba Soil Survey, is 70% Berlo loamy fine sand, and 30% Kergwenan loamy sand to gravel. Treatments include: 1) no manure - graze; 2) no manure – harvested as hay; 3) spring application of manure - grazed; 4) spring application of manure – harvested as hay; 5) fall application of manure - grazed; 6) fall application of manure – harvested as hay. Sixty steers will be utilized in the trial — ten steers in each grazed treatment.

### **Results and Discussion**

*Escherichia coli*, *Salmonella*, and *Yersinia* species were cultured from hog manure, cattle feces, soil and ground water below the plots. For the purposes of this discussion only *E. coli* will be discussed because the dataset for these bacteria are at present the most complete. In summary the findings are: (1) *E. coli* could be isolated from all parts of the system but very few bacteria could be grown from the ground water. However, if a special resuscitation medium was used, far higher number could be recovered. This has implications for how long organisms can survive in water. (2) Molecular typing indicates that hog manure, cattle feces, and soil mainly have their own individual populations of *E. coli*. Analysis is now under way to determine if, as the season progresses, the strains found in the hog manure appear in the cattle feces which means that bacteria from hogs are being transferred to cattle. (3) Antibiotic profiling for erythromycin is also being conducted to determine if, as the season progresses, the number of erythromycin resistance isolates is increased in cattle.

### **Implications**

A better understanding of the role of manure application to land is being obtained which has implications for best management practices.

### **Funding Sources**

Manitoba Pork Council, University of Manitoba

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# Section IV. Workplace Safety & Health



## ENGINEERING CONTROLS TO REDUCE HYDROGEN SULFIDE EXPOSURE OF WORKERS IN SWINE BUILDINGS

### Summary

Three engineering control measures were developed and tested for effectiveness in protecting swine barn workers from exposure to hydrogen sulfide ( $H_2S$ ) gas during manure handling events. A remote manure pit plug pulling system allowed the worker to pull the manure pit plug from outside the room, thereby significantly reducing risk of worker exposure to  $H_2S$ . A water sprinkling apparatus was also devised, which resulted in 79% reduction of  $H_2S$  gas concentration under optimal laboratory conditions. However, the use of a similar system on agitated manure showed the opposite effect. A manure scraper system was installed to remove manure daily from the manure pit of a grower-finisher room. Preliminary measurements showed that  $H_2S$  levels were 80 to 96% lower in the scraper room than in a similar room with a conventional pull-plug system. However, higher ammonia emissions were observed in the scraper room compared to the conventional grower-finisher room.

### Introduction

High levels of  $H_2S$  can have detrimental effects on both workers and swine. Previous research by the Prairie Swine Centre Inc. (PSCI) indicated that workers are at risk of exposure to potentially hazardous  $H_2S$  levels when performing manure management tasks, such as pulling manure pit plugs. The main goal of this project is to develop practical measures that can prevent or reduce worker exposure to high  $H_2S$  concentration in swine buildings. Three different systems were investigated in separate modules.

### Module 1 – Improved Design for Pit Plugs

In this module, an improved pit plug concept that allowed for pulling the plugs from a remote location was designed and evaluated. Two undergraduate students, assisted by technical staff at University of Saskatchewan and PSCI, designed and built a prototype system (Fig. 1). The

system was installed in two grower-finisher rooms at PSCI and tested by measuring H<sub>2</sub>S concentrations using a H<sub>2</sub>S monitor (Draeger Pac III monitor with a H<sub>2</sub>S sensor) during the plug-pulling operations.

After examining several plug designs, the extended cone plug was selected and installed. Monitoring of H<sub>2</sub>S levels during nine plug-pulling events showed that the maximum H<sub>2</sub>S concentration in the room over the plug area was 68 ppm, while corresponding concentrations at the alleyway near the winch was 0 ppm. Hence, the system was very effective in protecting the worker from being exposed to H<sub>2</sub>S by allowing the worker to perform the task away from the plug area.

## **Module 2 – H<sub>2</sub>S Abatement by Water-based Liquid Spray**

Because H<sub>2</sub>S is water soluble, it was hypothesized that spraying a water-based liquid over agitated manure would reduce emissions into the air. In this module, a laboratory spray chamber was set up to determine the impact of a water-based spray on H<sub>2</sub>S levels in the chamber (Fig. 2). Preliminary tests were done to investigate the reduction in H<sub>2</sub>S levels as affected by various parameters such as type of spray nozzle, water pressure, temperature and pH, as well as the use of various chemical additives.

Laboratory tests with various combinations of test parameters consistently reduced the concentration of pure H<sub>2</sub>S gas released into the chamber. Using a hollow cone nozzle at 200 kPa with water at pH = 9 resulted in a 79% reduction of the peak H<sub>2</sub>S levels. The treatment was applied to a set of barrels filled with swine manure. In four control barrels where no spray was applied, manure agitation produced an average of 148 ppm, with a peak reading of 520 ppm measured from the exhaust air. However, application of the water-spray treatment increased the average and maximum H<sub>2</sub>S concentrations to 273 and 690 ppm, respectively. Because these were not consistent with the observations in the laboratory study, it was suspected that other gases generated in the manure barrel affected the Draeger Pac III monitor. Additional tests are on-going to investigate the water-spray treatment further.

### **Module 3 – Manure Scraper System to Reduce H<sub>2</sub>S Levels**

In this module, a manure pit scraper system (Fig. 4) was installed in a grower-finisher room to remove swine manure on a daily basis. Its effectiveness was evaluated by comparing the air quality in the scraper room and a similar room (Control) with conventional manure pit-plug system.

The scraper system was evaluated over two production cycles; during each trial both rooms were monitored closely over four one-week periods. Compared to the control room, the maximum H<sub>2</sub>S concentrations were lower in the scraper room by an average of 80% over the plug area and by an average of 96% over the middle pen. Additionally, the maximum H<sub>2</sub>S levels in the control room exceeded the 15-ppm ceiling occupational exposure limit (OEL) value on three occasions during the two trials, while no peak H<sub>2</sub>S readings were higher than this limit value in the scraper room. The ceiling OEL is the maximum concentration of a biological or chemical agent to which a worker may be exposed, i.e., no worker should be exposed to any levels above this limit at any time.

During the two trials, significant levels of ammonia were measured in the incoming inlet air for both rooms, possibly due to recirculation of air exhausted from the fans into the supply air as well as from possible back draft of ammonia from adjacent rooms into the barn attic. The weekly average ammonia concentrations measured at the exhaust was significantly higher in the scraper room (11.3 ppm, SD = 2.3 ppm) than in the control room (9.8 ppm, SD = 2.1 ppm), although the mean difference was smaller than the indicated accuracy of the ammonia analyser. The calculated ammonia emissions were about 44% higher in the scraper room, which was attributed to the formation of a film of excreta on the pit bottom surface after scraping; this has been previously reported as possibly causing increased ammonia emissions in scraper systems. However, the observed ammonia levels were still lower than the 25-ppm OEL for ammonia, despite the presence of ammonia in the incoming air. Additional tests are on-going to determine the effectiveness of maintaining a layer of standing water at the bottom of the manure channel to control ammonia emissions.

## Conclusions

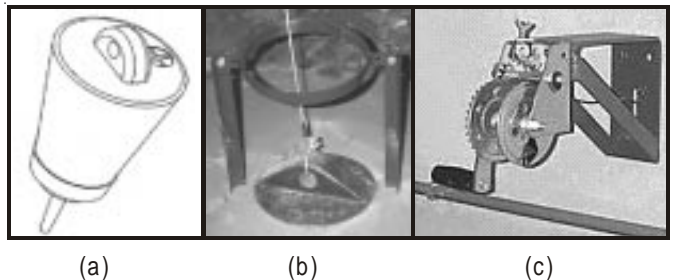
A remote manure plug pulling system was successfully developed. Results showed that the system was effective in preventing worker exposure to  $H_2S$  by allowing the pulling of the plugs from the alleyway. A water-spray treatment showed consistent reduction in  $H_2S$  levels in a laboratory study. However, application of the treatment on agitated manure showed opposite effect on  $H_2S$ . A manure scraper system used for daily manure removal from a swine room was effective in reducing  $H_2S$  to levels below the maximum exposure limit for worker's safety. The system generated higher ammonia levels, although peak readings did not exceed the ammonia exposure limit value. Additional tests are being conducted to further investigate both the scraper and the water-spray systems.

## Funding Sources

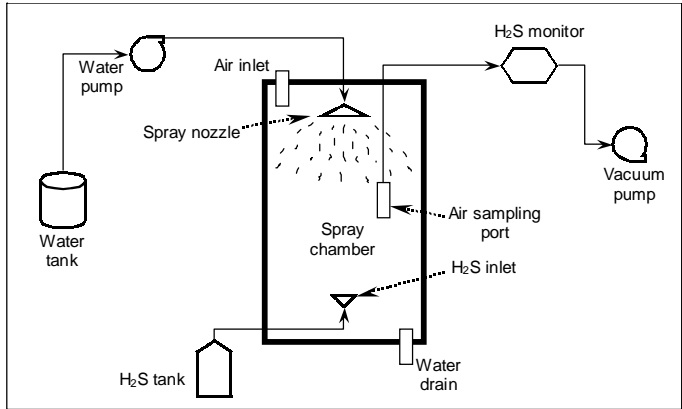
Strategic funding provided by Sask Pork, Alberta Pork, Manitoba Pork Council, and Saskatchewan Agriculture and Food Development Fund. Project funding provided by Sask Pork, Agriculture Development Fund, and PIC Canada.

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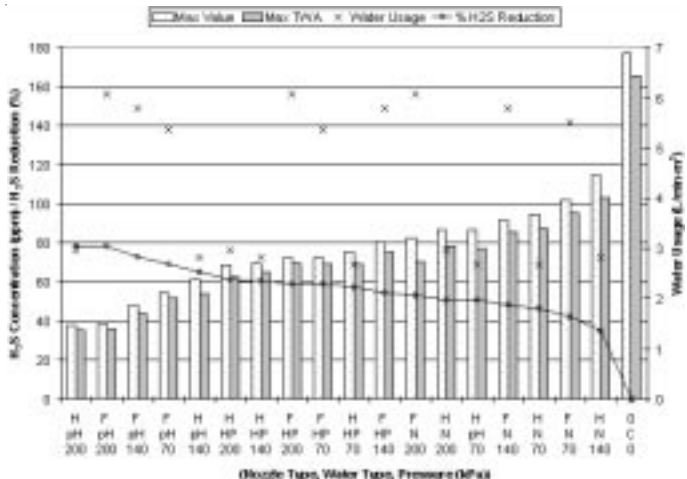
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**Figure 1.** Improved pit-plug design showing the (a) extended cone plug, (b) with cable attached and plug-height stop, and (c) the cable-winch system for remotely pulling the plug from outside the room.



**Figure 2.** Schematic diagram of laboratory set-up used to determine the effect of water-based spray on H<sub>2</sub>S levels in the chamber.



**Figure 3.** Summary of laboratory test results (Nozzle Types: H (hollow cone) and F (full cone); Water Type: pH (water at pH 9), HP (water with hydrogen peroxide added), and N (normal water); Pressures: 70, 140 and 200 kPa).



**Figure 4.** Scraper blade used for daily removal of manure from the pit. The manure pit has drains at both ends, through which the scraped manure was emptied to the sewer line.



## **MANURE HANDLING SYSTEM FOR REDUCTION OF AIR CONTAMINANTS IN A SWINE BARN**

### **Summary**

Two manure-handling systems, a washing gutter and an inclined washed conveyor belt, were tested to determine which system best eliminates all manure contamination from the experimental chambers in an air quality laboratory. Both systems proved efficient at reducing the air contamination from the excreta. However, neither system totally eliminated the release of contaminants to the airspace.

### **Introduction**

Air quality in swine confinement buildings is a growing concern as the impact of poor air quality on the health of pigs and workers becomes better documented. Changes in barn design and management practices in the last 30 years have resulted in many improvements, but the problems associated with poor indoor quality in barns are far from being completely resolved. To understand better the sources of air contamination in an intensive swine operation, this study will look at various factors separately (i.e., feed, manure, and the animals themselves), and attempt to eliminate the effect of each factor on air quality. It is anticipated that once the effect of each factor is reduced to zero, these factors can then be varied

individually to find out their effect on overall air quality. The first focus of the study was the manure handling system. Two methods of removing the manure were tested, one was a washing gutter using nozzles and pressurized water to clean the dunging area (Fig. 1), and the other was a washed, inclined conveyor belt (Fig. 2). The objective was to attain zero air contamination from the manure in the room using these manure handling systems.

### **Results**

The average ammonia emissions from the washing gutter and the conveyor belt rooms were 48.7 mg/day/kgpig and 57.0 mg/day/kgpig, respectively. Even though these emissions were 38% and 47% lower than previous observations from grower-finisher rooms with a conventional pit-plug design in the same swine building, both systems failed to achieve near zero ammonia emissions. There were no differences at a statistically significant level between the ammonia emissions from the two manure handling systems nor among the three frequencies tested (Fig. 3).

### **Implications**

Another manure handling system will have to be found to achieve zero contamination levels for testing of the origin of contaminants. The washing gutter system is recommended for health and productivity testing with a range of contamination levels, as it was simpler and easier to operate than the conveyor belt system.

### **Funding Sources**

Strategic funding for this project was provided by SaskPork, Alberta Pork, Manitoba Pork Council and Saskatchewan Agriculture and Food Development Fund. Project funding was provided by NSERC and Cement Association of Canada.

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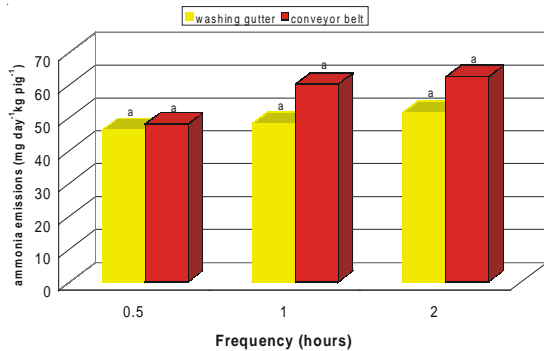
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**Figure 1.** Water nozzles used to wash the manure from the gutter portion of the pen.



**Figure 2.** Conveyor belt system used to remove manure from the pen



**Figure 3.** Average ammonia emissions from the experimental chambers over all the trials. Averages followed by the same letter are not significantly different.

# Committee Responsibilities

## Environmental Research

- Lake Winnipeg Research Consortium
- Manitoba Livestock Manure Management Initiative (MLMMI)

## Swine Research

- National Centre for Livestock and the Environment (NCLE) Advisory Committee
- Prairie Swine Centre Advisory Committee
- Swine Research and Development Consortium

## Technology Transfer

- Council Research News
- Research Report
- Research and Environment sections on [www.manitobapork.com](http://www.manitobapork.com)
- Glenlea Farm Education Centre Advisory Committee

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- Canadian Research Network on Bacterial Pathogens of Swine
- Lake Winnipeg Research Consortium Inc.
- Manitoba Livestock Manure Management Initiative
- Prairie Swine Centre Inc.
- University of Manitoba:
  - Swine Research Team
  - National Centre for Livestock and the Environment (NCLE)
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- Vaccine and Infectious Disease Organization (VIDO)



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