MAKING PROGRESS THROUGH RESEARCH

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ABSTRACT

Improvements in pork production efficiencies and pork meat quality, reductions in environmental impacts of pork production, and improvements in well-being of pigs are the results of new knowledge and the effective application of knowledge in commercial pork production. The return on investment in pork research in Canada is very favourable with an estimated cost-benefit ratio of 22.4 to 1. At the University of Guelph a research program is in place that addresses research goals and objectives that have been established based on industry-wide consultations. Two key supporters of this research program are Ontario Ministry of Agriculture Food and Rural Affairs (OMAFRA) and Ontario Pork. This program is the largest pork research program in Canada and is conducted in a wide range of public research facilities and on commercial farms. Increasingly research is conducted in collaboration with partner institutions, such as Agriculture and Agri-Food Canada, commercial companies and, indeed, institutions from around the world. Given the increasing complexity of research activities and high costs of conducting state-of-the-art research, effective collaboration with partner institutions is critical for the development of new and useful technologies, or to support new policies for the industry. A complete overview of research activities and research findings at the University of Guelph can be accessed via the internet (www.uoguelph.ca/research/omafra/animals/pork.shtml). The University of Guelph no longer has a mandate for traditional extension activities. Moreover, greater demands from the society at large and reductions in available resources have forced OMAFRA to focus more on policy development and alter its approach to extension activities. As a result, the University of Guelph and OMAFRA rely increasingly on industry partners, such as veterinarians and feed industry personnel, to facilitate the application of new knowledge in commercial pork production. Continued public support will become increasingly important to maintain a solid research infra-structure in Ontario, to train people that will contribute to the Ontario pork industry, and to respond to new challenges and opportunities that may arise in the future. Feedback to the research at the University of Guelph is welcomed.

INTRODUCTION

For the Ontario pork industry to remain internationally competitive, and sustainable, continued improvements in production efficiencies, meat quality, reductions in environmental impacts, and improvements in well-being of pigs are essential. This, is turn, requires effective and rapid application of new knowledge in commercial pork production. Moreover, solid information and new technologies are required to develop or refine policies and regulations,

such as those related to nutrient management, animal welfare, food safety and quality assurance, and management of disease outbreaks. Finally, conducting research provides an important opportunity for training people that can contribute to future success of the Ontario pork industry.

In this paper, a brief overview of public research activities in Ontario is given, some achievements are highlighted, and future perspectives are provided.

PUBLIC RESEARCH ACTIVITIES AND FACILITIES IN ONTARIO

In Ontario, the University of Guelph is the main centre for publicly funded pork production research, in particular since the regional Agricultural Colleges (e.g. Ridgetown College) have become part of the University of Guelph. During the last several years, the total annual budget for pork research has varied between $6 and $7 million, making the program at the University of Guelph the largest pork research program in Canada. The Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) provides very substantial financial support for this research, about 45% of total funds, under the unique OMAFRA and University of Guelph research partnership program. This agreement is re-negotiated every fours years. Apart from OMAFRA, Ontario Pork (about 15% of total) and the Natural Sciences and Engineering Research Council of Canada (NSERC) are the largest financial supporters of pork research, followed by a large number of public funding agencies and private companies.

The University of Guelph/OMAFRA Pork Research Program currently supports 45 research projects that involve 38 different lead researchers that are supported by an even larger number of graduate students, research technicians, post-doctoral fellows and research associates. Information on each of these projects is available via the internet (www.uoguelph.ca/research/omafra/animals/pork.shtml). These research projects are organized by goals and objectives, which are established based on industry wide consultation and under the direction of the Agricultural Research Institute of Ontario (ARIO). Under this program, researchers have the freedom to explore innovative ideas that are consistent with the program's goals and objectives. A committee of experts, representing the scientific community, OMAFRA, and the commercial industry, reviews new research proposals and research progress annually. In addition, a formal and external review of the entire pork research program is conducted every four years. A listing of projects that are currently registered under this University of Guelph and OMAFRA partnership program is provided in the appendix to this paper. According to the current research plan, close to 20% of funds are dedicated to environmental research, 30% to pork quality and safety research, 40% towards improvement in production efficiency and 10% to research on animal behaviour and well-being. These are the four key aspects of a sustainable pork production industry in Ontario.

Physical research facilities include a number and diverse types of animal holding facilities that are complemented by a range of laboratory facilities (Table 1). In addition, individual researchers control their own nutrition, physiology, microbiology, or molecular laboratories to support their research activities. The most recent expansion of research capabilities have been in the area of molecular biology and food safety, which reflects the use of the newest

techniques in animal biology research and changes in public concerns about food safety. These facilities provide researchers with state-of-the-art facilities to conduct research, but continuous re-investment in these facilities will be required to maintain top quality research. An additional issue is the substantial urban development in close proximity to the Arkell swine unit, which will likely force a relocation of this pork production oriented research facility within the next 5 to 10 years.

Table 1. Listing and brief description of the main public pork research facilities in Ontario.

Animal Holding Facilities	Brief Description
Arkell Swine, Guelph	This is a closed herd with about 300 sows, and a minimal disease unit with capacity to raise about 50% of offspring to market weight. This is the main unit for production type research and was built in the early 1980's. After too many years of rather serious neglect, substantial renovations are now being conducted. Recent renovations include the installation of a group housing system for gestating sows, the liquid feeding research unit, and a unit for management of genetically modified pigs.
Swine herd Ridgetown College, Ridgetown	A closed herd farrow-to-finish unit with about 70 sows for production type research. Some of the growing-finishing pens are equipped with computerized equipment to monitor growth and feed intake of group housed pigs. This unit is closely tied-in with research on manure processing technology.
Animal isolation unit at the Ontario Veterinary College, Guelph	This unit has strict biosecurity and allows researchers to expose small groups of pigs to highly infectious diseases and study their impact on the animals and alternative intervention strategies.
Ponsonby research station, Ponsonby	This flexible unit can accommodate various animal species and has no permanent pig herd. The unit has three identical and completely separate rooms that can accommodate weaned or growing-finishing pigs sourced from different genotypes or health status.
Animal metabolism unit, Department of Animal and Poultry Science, Guelph	This facility includes a surgery unit, facility to maintain surgically modified pigs for intensive and detailed animal metabolism studies, small rooms that allow close control of environmental conditions (temperature, airspeed, humidity), and facilities for housing boars for studying reproductive technologies.

continued (over)

General Laboratory Facilities

Meats Laboratory	This animal slaughter, carcass and meat processing facility is the only federally-inspected meat packing plant within a Canadian university. This facility supports teaching and research facilities for all aspects of meat science. It was built in 1980. Currently efforts are underway to upgrade this facility.
Laboratory Services Division, University of Guelph, Guelph	With a staff of more than 150 professionals this division is dedicated to providing a wide range of analytical services, including analyses of nutrients, toxins, blood parameters, chemical contaminants, genetic material (DNA) and microbes. It includes the Animal Health Laboratory, a full-service, fully computerized veterinary diagnostic laboratory.
Genome Manipulation Laboratory (GML)	The GML is a genetic research facility in the Department of Animal and Poultry Science, which serves as a regional facility for the generation of novel food animals. The GML focuses on improving the health, productivity and environmental sustainability of animal agriculture by generating novel strains of livestock through transgenics and cloning. There are currently no other food animal research facilities of this kind in the Province of Ontario.
Canadian Research Institute for Food Safety (CRIFS)	This institute is dedicated to the generation of new knowledge through basic and applied research, to the training of scientists and to providing information and expertise applicable to all sectors of the food industry. CRIFS' goal is to improve safety and quality by providing sound scientific information, research and development, food safety alerts and technology. This Centre was established in 2002 and with support from various levels of government and the University of Guelph (www.uoguelph.ca/crifs/).

VALUE AND IMPACT OF RESEARCH

It is a challenge to objectively value the (financial) impact of research in commercial pork production. The main outcome of research is new knowledge that can provide the basis for new or refined production practices. In some instances the value of this new knowledge is not immediately apparent. For example, when the structure of DNA was first discovered by Watson and Krick in the 1960's, it was not foreseen that we would be able to characterize and manipulate DNA in such a manner that we are now able to identify animals with genetic defects and or to introduce novel genetically controlled traits into farm-animals (see examples in next section). Along the same lines, the team of Dr. Julang Li, a new professor in the Department of Animal and Poultry Science, has recently been able to produce stem cells from

pig skin (Dyce et al., 2004). Such stem cells may be induced into many different cell types that have different functions in the animals' body, and possibly in the human body. This fundamental research can have a range of practical applications, for example for rapidly multiplying pigs with favorable traits, introducing novel traits in pigs, or generating of tissues and organs for humans. Substantial further research is required before these practical applications can be realized.

In other instances, the practical or commercial value of research is more apparent. For example, when the available nutrient content in pig feed ingredients is characterized more accurately feeding cost and nutrient losses into the environment can be reduced (Fan et al., 2001). In other research at the University of Guelph, a better understanding of the negative impact of feeding mycotoxins to pigs has resulted in intervention strategies when mycotoxins contaminated feed ingredients have to be fed to pigs (Smith et al., 2005). At the University of Guelph it has also been shown that feeding specific combinations of acids or essentials oils to starter pigs can support similar levels of growth performance as compared to in-feed antibiotics (Namkung et al., 2004). Based on on-farm experiments, researchers from the University of Guelph have fine-tuned recommendations about the water and environmental needs of weaned piglets, resulting in improved pig growth performance (de Grau et al., 2005). In veterinary science, the development of diagnostic tests for pig diseases at the University of Guelph will lead to better health management and improved animal productivity (Corzo et al., 2005). Results of research projects that are currently underway at the University of Guelph are provided in the next section.

Economists have conducted cost-benefit analyses of investments in pig and pork research. For example, Dr. Glenn Fox from the Department of Agricultural Economics at the University of Guelph and colleagues at Guelph and Agriculture and Agri-Food Canada, have estimated the cost-benefit ratio of both public and private research that support pork production practices in Canada to be very high at 22.4 to 1 (Thomas et al., 2001). This estimate is based on careful assessment of research support from the various levels of government and the private sector, and the impact of research on production costs, consumer demand, and prices. Clearly, financial support of research in pork production practices is a very good investment.

In addition to new knowledge that results in improvement in pork production practices, research has various important other outcomes. In the process of conducting research, new researchers are trained and young individuals are exposed to the basic principles of science. Many of the people that are exposed to research will apply their knowledge and skills while working in commercial agriculture. Increasingly research is required to support policy development and establishment of guidelines for best management practices. In particular, in the areas of food safety, environmental impact, and animal welfare, solid methodology and benchmarks need to be established for an objective assessment of pig and pork production practices. Finally, researchers can be an important resource in times of major emergencies. We are all aware of the high costs of the foot and mouth disease outbreak in the United Kingdom in 2001. The severity of the outbreak would have been reduced if more researchers and well-trained veterinarians had been involved in the initial stages of this catastrophic epidemic. This is stated clearly in a report prepared for the British Department of Environment Food and Rural Affairs in 2005: "Swift implementation of the revised

contingency plan, in particular the mobilization of sufficient resources to meet key disease control targets such as effective tracing of dangerous contacts and rapid culling of infected premises and dangerous contacts" is a key determinant of the costs of outbreaks of diseases such as foot and mouth (Defra, 2005). Now that contingency plans are updated regularly, the costs of potential future outbreaks of foot and mouth disease in the UK are expected to be much lower than in 2001.

The benefits of training highly skilled individuals, research in support of policy and guidelines, and the ability to respond rapidly during crises are difficult to express in financial terms, but are all critical components of a successful and sustainable Ontario pork industry.

SELECTED RESEARCH HIGHLIGHTS

There is a long and impressive track record of high quality pig and pork research at the University of Guelph. It is clearly beyond this paper to highlight all important research findings. Only few examples are given below. For further information please visit the pork research website at the University of Guelph.

Four examples of older key research projects at the University of Guelph, and that have still important implications in today's pork production practices, are the establishment of procedures to establish specific-pathogen-free (SPF) pig units, understanding of toxic effects of pathogenic *E. coli* strains (Gyles, 1994), the discovery of the gene responsible for porcine stress syndrome (PSS) gene (O'Brien et al., 1993), and the application of advanced mathematical procedures to assist in the development of pig breeding strategies (Kennedy et al., 1986).

In the 1950's, researchers at the Ontario Veterinary College under the leadership of Dr. Chuck Roe established procedures to generate and manage pigs with extremely low loads of pathogens, known as SPF pigs. Dr. Paul Miniats, who ran the SPF laboratory at the University of Guelph from the late 1960's through to his retirement in the late 1980's, greatly improved the procedures. The procedures involve obtaining new-born piglets based on caesarian section and raising new-born piglets in clean environments without access to the sows. These procedures have been adopted by pig breeding companies in Ontario and around the world, and have been an integral part of studying infectious disease - such as atrophic rhinitis, Glasser's disease, and pleuropneumonia - in gnotobiotic pigs.

Dr. Carlton Gyles gained a worldwide reputation for his research on the enterotoxigenic effects of *E. coli,* one of the main gastro-intestinal diseases in weaned pigs. Dr. Gyles recently retired from the University of Guelph, but he is still actively involved in research. Research on this topic is now also led by a Dr. Patrick Boerlin, a new faculty member at the University of Guelph, and is focused on relationships between anti-microbial resistance and disease causing properties of *E. coli* strains. This research program continues to lead to the development of intervention strategies, including the development of vaccines against pathogenic *E. coli* strains.

The discovery of the PSS gene and the development of a probe to detect the gene in individual pigs have been key developments to removing an important contributor to pale soft exudative (PSE) pork from many pig breeding herds and thus the entire pig population. The University of Guelph is still receiving royalties from this discovery.

The late Dr. Brian Kennedy was one of world's leading pig geneticists. His research has been the foundation for the application of advanced mathematical procedure (best linear unbiased predictor, BLUP) to pig breeding strategies. This procedure allowed the establishment of genetic links between different herds and test-stations and objective comparison of genetic merits of individual pigs that are raised on a large number of pig farms. Procedures based on BLUP are still the basis for breeding decisions in all major pig breeding organizations and used in pig breeding research at the University of Guelph, which is now led by Dr. Andrew Robinson. The early adaptation of BLUP and SPF technologies in Ontario are among the main factors that have contributed to the strong position of pure-bred pig breeders in Ontario, and thus the entire Ontario pork industry. These four examples also illustrate that progress needs to be made in fundamental science in order to develop practical application of new knowledge, as was discussed in the previous section.

More recently, the University of Guelph has been among the first institutions from around the world to generate genetically modified pigs (Golovan et al., 2001). In this research program, led by Dr. Cecil Forsberg, pigs have been trademarked as the Enviropig^{TM}. These genetically modified pigs have been a substantial scientific achievement and have lead to research evaluating alternative means to introduce novel traits in pigs, and evaluating food and environmental safety associated with the use of genetically modified food-producing animals. An additional component of this research is to understand the public's perception of foods that are derived from genetically modified animals.

A small sample of findings in current research projects and that have immediate application in commercial pig and pork production is given below. The project numbers are registration numbers under the OMAFRA and University of Guelph research partnership program and can be accessed via in internet (www.uoguelph.ca/research/omafra/animals/pork.shtml).

- A rapid molecular biology based test has been developed to characterize Salmonella in a large number of samples (lead researcher Dr. J. Gray; Project #026207). This will allow for effective monitoring of Salmonella prevalence on Ontario farms and in pig slaughter houses, and to evaluate the effectiveness of intervention strategies.
- The sentinel herd health monitoring projects that was established in 2001 provides a unique resource to monitor the prevalence of disease and the dynamics of disease spreading on Ontario farms (lead researcher Dr. R. Friendship, project #026301). In this project it was established that a new strain of influenza virus (H3N2; different from the bird flu virus) has been spreading rapidly between farms since 2004. This project has been expanded to characterize and reduce the spreading and virulence of circo-virus under the leadership of Dr. C. Dewey (project #026303). This information will be essential for the development of effective disease management or elimination strategies.
- The group housing system at Arkell supports similar levels of performance as compared to conventional gestation stalls, while the group housing system benefits well-being of sows

(lead researcher T. Widowski, project #026181). Research on this system is continuing and is now focusing on the impact of timing of introducing new sows into the group system on reproductive performance.

- On several commercial sow units the use of artificial insemination (AI) is still associated with poorer farrowing rates, while several opportunities exist to improve reproductive performance with AI (lead researchers R. Friendship, C. Dewey, G. Cassar and M. Buhr, project #026289 and #026294). On several farms the fluctuations in temperature in the storage unit is more than 2^{o}C or the temperature is outside the optimum range (15 to 20^{o}C) leading to compromised semen quality. Timing of inseminations, use of injectable porcine luteinizing hormone following equine chorionic gonadotrophin to induce ovulation, and the mixing of frozen semen with seminal fluid of fresh semen are all important determinants of successful application of AI.
- In growing pigs, the impacts of body weight, dietary lysine and fiber levels, feeding frequency, between-pig variability, and compensatory growth on lysine utilization have been established (lead researcher Dr. C. de Lange, project # 026317). This information will allow for accurate estimation of lysine requirements of growing pigs at various stages of growth. Lysine is the first limiting amino acid and is linked directly to dietary protein, the 2nd most expensive nutrient in pig feeds.
- The availability of phosphorus has been established in a wide range of pig feed ingredients using a novel true digestibility assay (lead researcher Dr. M. Fan, project #026319). This project is expanded to evaluate calcium availability, to explore the impact of dietary calcium on phosphorus utilization, to identify biological indicators of phosphorus status that can be used to quickly establish whether phosphorus intake exceeds requirements in specific groups of pigs, and to pre-soak phytate containing ingredients with phytase enzyme in liquid feeding systems (project # 025997). Improved phosphorus utilization will both reduce the environmental impact of pig production and reduce feeding costs.
- Temporary restriction of feed intake in growing pigs and allowing pigs to express compensatory growth results in improvements in meat tenderness (lead researcher Mr. P. McEwan at Ridgetown College, project # 026278).
- There is large between-animal and between-farm variability (3 to 12%) in drip losses from loin and ham muscle sample (project leader Dr. P. Purslow, project # 026176 and 026358). These drip losses represent a substantial loss to the meat packers, and thus to the entire pork production chain. The large variability indicates room for improvement. Identifying means to enhance various aspects of meat quality and to reduce variability is the main objective of a new large and multi-disciplinary research program at the University of Guelph.
- When a stock person walks the pig pens only twice a week, pig behavior is influenced significantly (project leader Dr. T. Widowski, project # 026314). Walking the pen means that a stockperson enters the pen holding a pig board and makes one circuit around the pen in 20 to 40 seconds. Changes in pig behaviour resulted in easier and faster movement of pigs at the slaughterhouse. Relationships with meat quality are now being explored.

This short list of examples highlights the substantial and immediate commercial value of pig and pork research at the University of Guelph. It should be stressed that these applied research projects are often logical extension of more fundamental research. For the long-term

success of any research program an appropriate balance between fundamental and applied research must be maintained.

CONCLUSIONS AND FUTURE PERSPECTIVES

Researchers at the University of Guelph and the Ontario pork industry share similar overall and long-term goals, i.e. sustainable production of high quality foods in a globally competitive market place. At the University of Guelph a research program is in place that addresses research goals and objectives that have been established based on industry-wide consultations. Within this research program there is ample opportunity to explore innovative ideas and fundamental research, while addressing issues that are relevant to the Ontario pork industry.

The nature of research is changing and is now focused on food safety, pig well-being, minimizing environmental impacts, the public's perception of pork production, as well as pork production efficiency. With the advancement of science, new technologies have become available that involve molecular biology, genomics, genetic manipulation, proteomics, nano-technology, and advanced mathematics. The use of these technologies will improve our understanding of underlying biological principles and will ultimately lead to improvements in pork production efficiencies and higher and consistent quality of pork products that meet the consumers demand.

High quality pig and pork research is expensive and requires focus on specific aspects of animal biology. As a result, it is not realistic that high quality research is conducted in Ontario on all key aspects of pork production. Therefore, research needs to be conducted in partnership with other organizations, such as Agriculture and Agri-Food Canada, commercial companies and indeed institutions from around the world. In order to establish and maintain such research partnership with leading research centres around the world it is important that the University of Guelph maintains its critical mass, research infra-structure, and strong reputations in key areas, such as health management, animal behaviour, reproductive physiology, molecular biology, nutritional biochemistry, and meat science.

The University of Guelph no longer has a mandate for traditional extension activities. Moreover, greater demands from the society at large and reductions in available resources have forced OMAFRA to focus more on policy development and alter its approach to extension activities. As a result, the University of Guelph and OMAFRA rely increasingly on industry partners, such as veterinarians and feed industry personnel, to facilitate the application of new knowledge in commercial pork production.

Objective measurement of the financial impact of research in commercial pork production is difficult. However, studies by economists have shown that the cost-benefit analyses of investments in pork research in Canada are very favourable at 22.4 to 1. Moreover, research activities contribute to the training of highly skilled personnel, provide information for the establishing of policy and guidelines for pig and pork production practices, and provide some

infrastructure for dealing with unforeseen emergencies that may arise, such as outbreaks of highly contagious diseases.

Clearly, the pork production industry is an important contributor to Ontario's economy. A healthy, profitable and sustainable industry that generates safe and high quality pork products will benefit Ontarians and Ontario's trade balance. New knowledge will continue to be required to support our industry. Continued public and industry support will become increasingly important to maintain a solid research infrastructure in Ontario, to train people that will contribute to the Ontario pork industry, and to respond to new challenges that may arise in the future. All members of the Ontario pork industry, including researchers, need to continually strive towards a fast and effective implementation of research findings in pig and pork production practices, and to be responsive to emerging challenges and opportunities. Feedback to the research at the University of Guelph is welcomed.

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APPENDIX 1

Research projects that are currently registered under the University of Guelph and OMAFRA Research Partnership Program, organized by research objectives and goals.

For more information on individual projects visit the OMAFRA website (www.uoguelph.ca/research/omafra/animals/pork.shtml), or contact the lead researcher or the coordinator of pork research at the University of Guelph (C. de Lange).

OBJECTIVE 1: STRATEGIES TO ADDRESS ENVIRONMENTAL ISSUES

Goal 1.1. Manure handling, including dead stock disposal

025983 – Emissions from cremation of dead stock – B. van Heyst, School of Engineering

Goal 1.2. Reduction of nitrogen and phosphorus excretion

026015 - The Enviropig: from the research lab to the market place - J. Phillips, Department of Molecular Biology and Genetics.

026082 - Modulation of intestinal fermentation and nutrient utilization for reducing detrimental effects on the environment from swine production – M. Fan, Department of Animal and Poultry Science.

026276 - Determining sow performance and mineral requirements with phytase supplementation of the lactating sow ration – P. Luimes, Ridgetown College.

026317 - Quantitative representation of nutrient utilization in the growing pig
– C. de Lange, Department of Animal and Poultry Science.

026319 - Determination of dietary true digestible calcium to phosphorus ratio and requirements in weanling piglets (10-20 kg) fed corn and soybean meal-based diets – M. Fan, Department of Animal and Poultry Science.

Goal 1.3. Reducing Odour

026001 - Biofiltration as a means of odour and dust control in animal housing facilities – M. Dixon, Department of Environmental Biology.

026177 - Development of a pork farm odour expert system and studying the feed effects on odour – S.Yang, School of Engineering.

OBJECTIVE 2: PORK QUALITY AND SAFETY

Goal 2.1. Food safety

026207 - The natural transmission of Salmonella typhimurium in swine with and without antimicrobial selective pressure – J. Gray, Department of Pathobiology.

026273 - Evaluating effectiveness of interventions against Salmonella in swine using a novel evidence-based tool – S. McEwen, Department of Population Medicine.

026282 - Effect of bacteriophage on the population dynamics of Salmonella within Ontario pig herds – K.Warriner, Department of Food Science.

Goal 2.2. Reducing antibiotic use

026180 - Molecular analysis of important bacterial pathogens of swine
– J. MacInnes, Department of Pathobiology.

026083 - Efficacy of alternative growth promoters for weanling piglets as assessed by visceral organ protein turnover rate – M. Fan, Department of Animal and Poultry Science.

026173 – Dietary means to enhance gut health of newly-weaned piglets – C. de Lange, Department of Animal and Poultry Science.

026272 - Spatial patterns of antimicrobial resistance among pig farms in southern Ontario. – O. Berke, Department of Population Medicine.

026291 - Genetic markers of infectious disease resistance in Ontario swine - A. Brooks, Department of Pathobiology.

Goals 2.3 and 2.4. Improving pork quality and uniformity of carcass

025981 - The effects of feeding high protein corn to pigs based on performance and carcass quality – P. McEwen, Ridgetown College.

026038 - Grow-finish pigs - Improving carcass quality through barn-level parameters analyses – C. Dewey, Department of Department of Population Medicine.

026059 - Quantitative and molecular genetic improvement of swine – A. Robinson, Department of Animal and Poultry Science.

026174 - Development of genetic markers for boar taint – J. Squires, Department of Animal and Poultry Science.

026176 - Development of nutritional strategies to improve the processing and eating quality of pork – I. Mandell, Department of Animal and Poultry Science.

026278 - The effects of gender and feeding strategy on pig growth performance and feed digestibility – P. McEwen, Ridgetown College.

026314 - On-farm management strategies to improve handling, reduce stress and enhance meat quality – T. Widowski, Department of Animal and Poultry Science.

OBJECTIVE 3: TO IMPROVE PRODUCTION EFFICIENCY

Goal 3.1. Feeds, feeding and mycotoxins

025997 - Liquid feeding of swine: gut health, food safety, environmental impact and growth performance – C. de Lange, Department of Animal and Poultry Science.

026171 - The use of byproducts from dry mill ethanol production as a feed ingredient in swine diets – P. McEwen, Ridgetown College.

026276 - Determining sow performance and mineral requirements with phytase supplementation of the lactating sow ration – P. Luimes, Ridgetown College.

026277 - Improving piglet survival by development of a hormone model of lactation – P. Luimes, Ridgetown College.

026278 - The effects of gender and feeding strategy on pig growth performance and feed digestibility - P. McEwen, Ridgetown College.

026317 - Quantitative representation of nutrient utilization in the growing pig
- C. de Lange, Department of Animal and Poultry Science.

026323 - Effect of Fusarium mycotoxins on performance and metabolism of gestating and lactating sows – T. Smith, Department of Animal and Poultry Science.

Goal 3.2. Improving pig health

026005 - Enteric disease control in post-weaned pigs – R. Friendship, Department of Population Medicine.

026068 - Modulation of host cell responses by porcine reproductive and respiratory syndrome (PRRS) virus – D. Yoo, Department of Pathobiology.

026170 - Phenotypic immunological imprinting by the neonatal environment in pigs – B. Wilkie, Department of Pathobiology.

026175 - Tetracycline use and selection of virulent enterotoxigenic Escherichia
coli (ETEC) – P. Boerlin, Department of Population Medicine.

026277 - Improving piglet survival by development of a hormone model of lactation – P. Luimes, Ridgetown College.

026291 - Genetic markers of infectious disease resistance in Ontario swine

- A. Brooks, Department of Pathobiolgoy.

026316 - Production of transgenic pigs that are more resistant to diseases
- J. Li, Department of Animal and Poultry Science.

Goal 3.3. Improving reproductive performance

025670 - PRRS virus: the implications for the breeding herd – C. Dewey, Department of Population Medicine.

026013 - A study of oxytocin-producing reproductive centres in the hypothalamus of the pig brain – G. Partlow, Department of Biomedical Science.

026179 - Analysis of transient lymphocyte functions in implantation sites during early pregnancy – A. Croy, Department of Biomedical Science.

026277 - Improving piglet survival by development of a hormone model of lactation – P. Luimes, Ridgetown College.

026289 - Improving swine reproductive performance through improved semen quality and better methods of insemination – R. Friendship, Department of Population Medicine.

026294 - Use of soy liposomes for cryopreservation of boar semen – M. Buhr, Department of Animal and Poultry Science.

026318 - Sexing of boar sperm using single stranded DNA aptamers
– S. Golovan, Department of Animal and Poultry Science.

026323 - Effect of Fusarium mycotoxins on performance and metabolism of gestating and lactating sows – T. Smith, Department of Animal and Poultry Science.

Goal 3.4. Transgenics

026036 - Artificial insemination mediated modification of pig genome
– S. Golovan, Department of Animal and Poultry Science.

026316 - Production of transgenic pigs that are more resistant to diseases
- J. Li, Department of Animal and Poultry Science.

OBJECTIVE 4: TO IMPROVE ANIMAL WELL-BEING

026069 - Meeting the needs of ill swine to improve well-being and decrease reliance on antimicrobials - S. Millman, Department of Population Medicine.

026081 - Developing a comprehensive framework to assess farm animal welfare – S. Henson, Department of Agriculture Economics & Business.

026181 - Strategies for reducing aggression in loose housed sows
– T. Widowski, Department of Animal and Poultry Science.

026182 - Management practices affecting the behaviour and welfare of piglets
- T. Widowski, Department of Animal and Poultry Science.

026304 - Factors associated with transport losses in market weight finisher pigs
- C. Dewey, Department of Population Medicine.