Our Mission

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

PRAIRIE SWINE CENTRE INC.

Table of Contents

NUTRITION

Glossary

ADF - A fibre fraction used to identify characteristics of feed stuffs.

ADFI - Average daily feed intake.

ADG - Average daily gain.

Ad Libitum - Full access to feed or unrestricted feeding.

Aerobic - Process that takes place with oxygen in the environment.

Ammonia - NH_3 a nitrogen compound found in household cleaners, commercial fertilizers, and manure. Evaporates easily at relatively low temperatures.

Ammonium - NH_4 a nitrogen compound found in commercial fertilizers and manure.

ANOVA - Analysis of variance. A statistical tool used to compare independent variables.

Anthropogenic - Caused or produced by human activity.

ß-glucanase - Beta glucanase; an enzyme that breaks down beta glucans, a type of carbohydrate.

BW - Body weight.

Caecum - the cal-de-sac where the large intestine begins.

Cannulated - To insert a small flexible tube into the small intestine to measure ingredient absorption.

Chromic Oxide - Cr_2O_5 a stable compound that doesn't dissolve in water and is largely unaffected by digestive acids.

CP - Crude protein.

CV - Coefficient of variation. A statistical tool for measuring dispersion.

DE - Dietary energy.

DM - Dry matter.

Digesta - Digested feed.

EMB - Earthen manure basin

Endotoxin - Poison produced by certain bacteria and released upon the destruction of the cell.

Glucosinolates - Naturally produced anti-nutritional chemicals that can hamper growth rate and cause thyroid problems in animals.

Gram test - Bacteria are classified as Gram negative or positive using stains to determine differences in their cell walls.

H_2S - Hydrogen sulphide. A colourless, poisonous gas that produces a "rotten egg" odour. In pig barns, it is produced by the breakdown of manure.

Hedonic tone - Subjective measure to the pleasantness or unpleasantness of odour.

Ileal - Pertaining to the latter part of the small intestine, or ileum. Nutrients from feed are absorbed in this area.

Ileum - Lowest portion of the small intestine

K - Potassium

Kcal - Kilocalorie, or one-thousand calories. One calorie is the amount of energy required to raise one gram of water one degree Celsius.

Lysine - An amino acid essential for growth. Cereal grains are generally ppor in lysine.

Nitrate - NO_3 a nitrogen compund found in manure.

N - Nitrogen, a major component of the atmosphere and essential plant nutrient.

NDF - Neutral detergent fibre. One fraction of the total fibre found in a feed stuff.

P - Phosphorus.

Plasma Urea - Urea contained in blood plasma. Urea is the principal end product of nitrogen metabolism in mammals.

Proximate analysis - A testing protocol used to determine the makeup of a food stuff. (ex. fats, proteins)

Psychrometer - An instrument used to measure water vapour or relative humidity using a pair of moist and dry thermometers.

Regression analysis - A standard statistical tool for comparing the relative behaviour of two or more variables.

SEM - Standard error of the mean.

Sonicating - Mixing or homogenizing a liquid using sound waves.

Spectrophotometry - Using different wavelengths of light to analyze materials.

Xylanase - An enzyme ehichs breaks down xylans, a type of carbohydrate.

Chairman's Report

Surviving the Tough Times

Just when the Prairie Swine Centre, like all of us in the hog business, thought we seen enough financial challenges in 2002, along came 2003. Adding to the continuing effects of low prices and drought were BSE and a much less favourable exchange rate. Agriculture was hit hard in 2003 as realized net farm income for Canada was negative for the first time since records have been kept. Once more, the Prairie Swine Centre was forced to address reduced revenues at the same time as increasing costs.

While it may seem somewhat unusual to report on our industry's financial situation when discussing a research facility, the production component of the Prairie Swine Centre plays a very important role in the centre's fiscal well being. Research funding sometimes becomes harder to obtain when the production sector struggles.

The entire management team at Prairie Swine Centre worked hard and met those financial challenges head on. This was accomplished while maintaining high levels of research and technology transfer. Support by producer organizations, governments, universities, firms in the industry and individuals are all key in maintaining the high standards expected of the Prairie Swine Centre.

A real highlight during 2003 was the completion of the Pork Industry Interpretive Centre at Elstow. The official opening in October which included tours by school children, clearly showed the importance of providing a "window" on the industry. The challenge will be for all of us in the industry to assure that it is effectively used.

Food safety, animal welfare and environmental concerns are climbing among a public influenced by ideas presented by media that are decreasingly sympathetic to agriculture. The Prairie Swine Centre has an important role to play in giving the public solid information while at the same time providing the industry with knowledge we can use to enhance our industry.

Bryan Perkins
Chairman of the Board

The board of directors of the Prairie Swine Centre brings together diverse interests from producers, government and the University of Saskatchewan. The board is pleased to work with the strong management team at Prairie Swine Centre led by John Patience.

Those of us in the hog industry need the co-operation of the various producer agencies, governments, research organizations and of course the University of Saskatchewan in continuing to support the important work at Prairie Swine Centre.

President's Report

Maximizing Value and Opportunity for the Pork Industry

Simply stated, 2003 was a very difficult year, for the Prairie Swine Centre and for the pork industry as a whole. Low commodity prices, increasing feed costs, uncertainty of foreign markets, turbulence in the cattle and poultry industries. The list is long indeed. Like any pork producer, the Prairie Swine Centre faced difficult times in 2003; about 25% of the budget of the Prairie Swine Centre comes from the sale of stock.

The economics of pork production have certainly changed in the Canadian pork industry in the past decade. For example, during the first five years of the Centre's history (1993-1997), we accumulated total profits of $883,000 from the sale of stock. These profits from animal sales subsidized our research effort, reduced our cost of research and helped us upgrade our older facilities. In the following 6 years (1998-2003), animal sales barely broke even. This change in fortune occurred despite the fact that herd productivity flourished during this period. Overall, annual animal sales have grown from less than 5,000 head more than a decade ago to about 7,500 head today. Like all pork producers, the Prairie Swine Centre must continually seek ways to increase our operating efficiency.

Nonetheless, the change that we experienced in animal sales was no greater than the change we saw in research and technology transfer. Demand for our services exploded, with the greatest interest in research that either increased revenues or decreased expenses. During this period, we were invigorated by the commitment of our pork producers to succeed in spite of the many challenges, and the commitment they made to the Centre to help them in this regard. For example, our focus on "hitting the core" (maximizing the number of pigs that are marketed within the core area of the grid), started in 2001 and hit its stride in 2003 as many pork producers realized the great increase in potential income that would accrue from reducing sort losses. Indeed, we saw many producers reduce sort losses from as high as 35% to as little as 5 or 10%. For producers that achieved such improvement, their net income increased by about $2 per pig, averaged across all animals sold!

A more recent initiative in increasing net income has been audits of feed budgets, to determine if the feeding program applied in the barn was, in fact, the one expected on paper. In many cases, there were notable discrepancies, and again, the improvements saved producers $2 to $5 per pig sold.

The best way to serve the pork industry is to ask the players for their input, then act on it decisively

We also saw great interest in ingredient purchasing strategies that minimized feed cost per pig while maintaining performance, because barn throughput is so critical. Based on research at the Prairie Swine Centre, we no longer consider barley as a commodity, but rather one that displays a surprising degree of variability. Prediction equations are increasingly used to estimate the true feeding value of individual barley samples, and to a lesser extent, this is also applied to wheat.

John Patience Ph.D.
President and CEO

Prudent ingredient purchasing and careful diet formulation was another way producers significantly reduced their cost of production last year.

The founding Advisory Board of the Prairie Swine Centre, which held its deliberations more than a decade ago, realized the long-term nature of research, and the importance of planning for the future. This vision was reaffirmed in our new strategic plan, implemented last year. Our research program therefore embraces financial as well as sustainability objectives. As the industry progresses through its normal cycles, our research will continue to provide relevant, practical information to the pork industry. Today, the greatest interest is on topics with a primary financial focus; three years ago, when the industry was expanding and building new barns, questions from the industry related more to housing design, such as group size in the grow-finish barn, or housing options for dry sows. Prior to that, it was issues related to barn environment and safety. In every case, because of the strong and effective input we receive from the pork industry, and the strategic approach to developing a research program, the Prairie Swine Centre had something to offer the pork industry. It is our intention to continue to maintain this relevance. We exist because of – and for – the pork industry; this will not change. Our success in responding to the needs of pork producers means we must have a long-term vision of our research program, diversified according to the input received from the industry, and of course, effective research management by our Research Scientists within this defined context.

Technology transfer is also changing, as there is greater interest in the use of the Internet as a vehicle to be used by the industry to obtain information when it is required. The Prairie Swine Centre has adopted a push-pull approach to technology transfer. The "push" strategy involves us delivering the information to the pork industry as it arises from our research; this includes our annual conference "Focus on the Future," our quarterly newsletter "Centred on Swine," our Annual Research Report and our biweekly email updates. Our "pull" strategy allows producers to access the information when they need it; this includes our website, our convenient 667-PIGS (7447) phone line and our consulting activities. Both serve important roles in ensuring that all pork producers, irrespective of size, have ready and consistent access to the best possible information, to ensure their long-term success in the industry.

Last year also saw the opening of P.I.G., the Pork Interpretive Gallery, at our Elstow research facility. Built because the pork industry asked us to, and paid for by donations from the pork industry, suppliers to the industry, government and private individuals, P.I.G. represents a truly unique facility. It allows people from all walks of life to see how a commercial pig barn operates. Comments from people who tour the facility are almost uniformly positive, with very few criticisms of either the facility itself, or the pigs observed in the barn. The excitement of school children seeing newborn piglets for the first time, or weanlings engaged in playful fighting, is truly a treat. More than 1,000 people visited P.I.G. in its first year, and we hope to grow this to 3,000 visitors annually within 3 years.

Industry support is the key to our success, both in the past and the future

While the public face of the Prairie Swine Centre is our Research Scientists and our Managers, there are many more people working "behind the scenes" to care for the animals, implement the research protocols, keep our organizing running as an efficient business, and so on. Nothing in this annual report would be possible without the commitment and effort of these men and women. Our graduate students also play an essential role, because their M.Sc. and Ph.D. thesis projects form an important part of our research program, as they study to become leaders in the pork industry of the future.

Our unique relationship with the University of Saskatchewan greatly enhances our Research Scientists' ability to meet our research objectives, accessing facilities and expertise that would be well beyond our own financial reach. This is a relationship built on mutual interest and benefit, producing a truly win-win situation. We similarly benefit from our partnerships with other research institutions across Canada and around the world; indeed, one of our goals as an organization is to establish strategic partnerships and collaborations that enhance our success, as well as that of our partners.

The Prairie Swine Centre receives tremendous guidance and counsel from our Board of Directors, a volunteer group of 11 individuals who take time out of their busy lives to ensure that the Centre is the best that it can be. With strong representation from pork producers, the Board ensures that we keep our feet flat on the ground and remain responsive to the needs of the pork industry. With additional representation from the University of Saskatchewan and from the Province of Saskatchewan, as well as appointees who bring specific expertise identified as important to the Board, the Centre

Report from Manager - Operations

High Management Standards Mark 2003

Production over the last fiscal year 2002-2003, at both the Floral and Elstow facilities, dropped below targets that were required to achieve goals defined in the Centre's strategic plan. At Prairie Swine Centre pig productivity is measured against Pig Champ data base to identify what production levels the top 10% percent of herds in Canada are currently achieving and use indicators like farrowing rate, total born alive, pre-wean mortality, number weaned, pigs weaned per sow per year, etc. to assure our production is comparable to what top producers in the industry are achieving.

Shortfalls in production prompted an internal review of all management practices and special emphasis was focused on feed and feeding for all replacement gilts as well as lactating and gestating sows. We also re-evaluated farrowing and breeding procedures in an effort to improve farrowing rate and increase numbers born alive.

Standard Operating Procedures dealing with the above changes were written to ensure easy incorporation into the current production systems at both the Floral and Elstow facilities. The SOP dealing with herd breeding management deals with estrus detection, heat detection procedures, preheat and standing heat signs, insemination procedures and mating schedules. The SOP on lactation sow feeding management deals with feeding prior to and during farrowing and from weaning to mating.

Production staff are aware that production is important to the overall success of Prairie Swine Centre Inc., but that our main focus is and always will be research. Performance in most research trials improves production targets, but some of the research protocols are developed to change normal management practices or have an affect on nutrition or behaviour that impairs the pigs' performance for growth and development. If this is the case researchers are required to contribute financially to the production side of the operation to compensate for any losses incurred because of the trial.

Brian Andries B.Sc.
Manager, Operations

Some success has been achieved with changes made over the last 4-5 months and further improvements are expected, but we will be closely monitoring production to ensure this trend continues as the year progresses.

A total of 47 experiments have been started at both the Floral and Elstow facilities since January 2003 and as an average this year 20% of the sows at Floral and 75% of all sows at Elstow have been on trial.

The National Body of the Canadian Council of Animal Care toured the Elstow facility on September 9th 2003, as

Table 1. Production Parameters for the 2001 - 2003 fiscal years

	2001-2002	2002-2003	2003-2004*
Sows Farrowed, #	750	799	384
Farrowing Rate, %	88.1	87.2	88.2
Pigs born alive/litter	11.0	10.7	11.3
Pre-weaning mortality	10.9	10.0	10.1
Litters weaned	754	793	390
Pigs weaned	7,415	7,618	3,970
Weaned/female inventory	23.9	23.4	24.7

* data compiled from July 1 - December 31, 2003

part of its work for the improvement of the care and use of animals in research, teaching and testing Canada. Some of the committees recommendations include the following:

- That the University Committee on Animal Care and Supply be commended for its ongoing commitment to high standards of animal welfare at the Prairie Swine Centre.
- That the Prairie Swine Centre be commended for its high management standards, including group housing of dry sows, for its construction and maintenance of well designed animal facilities and for its progressive and proactive efforts at public education through its new interpretive centre at Elstow Research Farm Inc.
- That the researchers at the Prairie Swine Centre be commended for their progressive management practices, their animal welfare and environmental enrichment research and for their efforts to promote improvements in the Swine Industry.

The only recommendation to Prairie Swine Centre Inc. was to continue to address concerns of lameness in the herd. We believe we have already made considerable progress in this regard.

We are currently repopulating both the Floral and Elstow facilities with new genetic lines (*Camborough Plus, L03*) from Pig Improvement Canada. This action is being taken to ensure the genetics used at Prairie Swine Centre is typical of that used by the commercial pig industry. Animals will be derived by hysterectomy and the piglets will be transferred to sows currently in the herd. This process is being used as a training tool for graduate students, technicians, and production staff as they assist in reviving piglets and cross fostering on sows after delivery to the barns.

Report from Manager - Information Services

Informing Producers and the Public

Why is the morning paper a favourite ritual in North America? Established a little over 100 years ago in most western Canadian provinces, as a media for the masses, the 'need to know' is now fed with millions of daily papers read, email updates scanned and news broadcasts listened to. There appears to be no limit to the volume of information available. Acquiring the information is the easy part, absorbing, digesting and acting on this resource is now the bottleneck. The news industry has addressed the problem of burgeoning volumes of information by developing the 15-20 second soundbite, and writing the best descriptive headline. Being concise is not only desirable but essential to surviving the information overload.

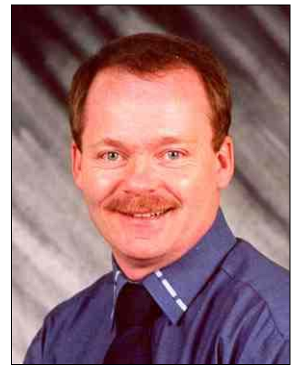
Relating all of this to pork production and our services has continued to evolve at PSC. The sound bite approach however isn't enough to move the pork producers' decision process along the road from awareness to adoption of new technology and management methods. Personal contact is still the preferred method of both receiving and delivering information, and your phone calls and attendance at the Focus on the Future Conference demonstrate this. However, with 4500 hits per month on the website and over 270 registered users of our online database it is obvious how the volume of information is being handled.

Our information database contains over 1400 entries and is available 24 hours a day, 7 days a week at no charge to pork producers. With two-thirds of our visitors being repeat visitors we can see that this resource has some perceived value for our clients.

Keeping the information pertinent to your needs means focusing on the implications of the research. In the *Annual Research Report,* **Implications to the industry** takes up a larger proportion of the article that the procedures. In *Centred on Swine* this is the last section of each article known as **The Bottom Line**. Here the producer can have the pros and cons of any trial presented in a way that will assist with the decision making process to adopt the technology. The new Strong Concluding Statement of Research Results (or **RESULTS**) is a one-page summary of a series of related trials that concludes with the implications, including financial implications of adopting this technology. Watch for the new RESULTS logo in future mailings from Prairie Swine Centre.

Table 1. Annual Technology Transfer Activities for 2003

Activity	Frequency/Distribution
Annual Research Report	1 / 3,000
Centred on Swine	4 / 4,200
Telephone Inquiries	500+
Speaking Engagements	60+ / 2,000
Industry Magazine Article	8
Fact Sheets	2
Training Program (H_2S Awareness)	45 / 400
Posters at Conferences	8
Website Visitors	54,000
Bi-weekly e-mail	25 / 270
Focus on the Future	1 / 130
Farm Calls	30



Lee Whittington B.Sc., MBA.
Manager, Information Services

Why have we evolved these documents over the years? To assist the reader to make the leap from concept to application as quickly as possible, thus sustaining their competitive edge in a worldwide marketplace.

The new PSC Strategic Plan identified the development of Strong Concluding Statement of Research Results as being an important outcome of applied research. During the coming year look for the RESULTS symbol as an indicator of practical applied results which can be adopted on your farm to reduce costs, improve performance or barn conditions for animals and staff.

What does it take to succeed in the

Report from Manager - Pork Interpretive Gallery

An Open Window into the Pork Industry

First and foremost, we have a new name for our facility! Originally titled the "Pork Interpretive Centre and Sask Pork Viewing Gallery", we have now abbreviated it to the "Pork Interpretive Gallery". Or P.I.G. for short!

After much work and anticipation, the Pork Interpretive Gallery (P.I.G.) officially opened for tours in October, 2003 with the Grand Opening! The Western Producer designed 4 colorful and informative pages with photos featuring the
P.I.G. and its Grand Opening.

The P.I.G. started with a few tours back in March, 2003 even before construction was completed, just because people could not wait to see it! By December 31, 2003 at total of 1,100 visitors had toured – in only 9 short months of being open!

The Gallery is being very well received by all. Young and old, industry and general public alike have enjoyed the tours. As hoped, interest groups have been varied – school groups, 4-H Beef Club, rural municipalities, university students, out-of-province university organizations, producers, researchers, and varied sectors of the industry. Guests have also included those from Denmark, Australia, Philippines, Ireland, United States, Scotland, Germany, Finland, New Zealand, and all across Canada.

All tours are hosted by our tour guides. They add a lot to each tour by offering our visitors insight into the operations of the barn, but also into the pork industry itself. Everyone appreciates having the tour guides there to answer questions.

The new name creates a unique acronym – the P.I.G.! We have been fortunate to be able to capitalize on this acronym in our marketing. We have been able to use it with our toll-free telephone number (1-866-PIG-Tour)(1-866-744-8687) and our website (www.PIGTour.ca).

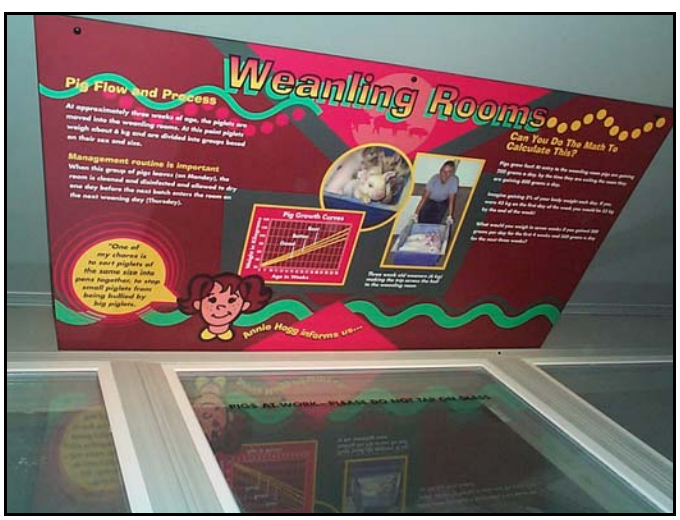
We are very close to reaching the goal of $1 million to support the construction and operations of the P.I.G. Our most recent fundraising event was the

Cindy Jelinski.
Manager, Pork Interpretive Gallery

Silent Auction at the Saskatchewan Pork Industry Symposium 2003 that was successful in raising over $8,000.

A part time manager was hired in August 2003. That position will function to organize the tours and market to the schools, government officials and general public.

Work is ongoing informing elementary and high schools that the P.I.G. is a new resource for them as a unique educational tool. Marketing tools, including the website, will be developed and expanded in the next year. The website will offer not only awareness of the facility and tours, but resource in-



The Centre's Goals

Goal #1	To meet the technology needs of the pork industry by developing original, practical information that ensures maximum profitability combined with acceptability of the industry and its products
Goal #2	To serve the pork industry by maintaining a timely, effective and focused technology transfer program
Goal #3	To ensure the relevance of the Prairie Swine Centre to the pork industry and to meet the needs of our research programs by operating efficient, highly productive and profitable pig herds at its research sites while concurrently meeting or exceeding the standards of the Canadian Council of Animal Care
Goal #4	To enhance the Centre's effectiveness and sustainability, and to encourage increased research on pigs, by developing collaborations, co-operative action and strategic alliances in research education, and technology transfer
Goal #5	To meet the long-term needs of our stakeholders through effective management of our human, financial, intellectual and physical resources
Goal #6	To achieve financial and operational sustainability through diversity of funding, efficiency of operations and accountability of stakeholders
Goal #7	To contribute to the development of highly qualified personnel through active and full participation in the graduate program at the University of Saskatchewan

Design of a Manure Handling System for - Air Quality Laboratory in a Swine Barn

K.J. Stewart, S.P.. Lemay, C. Laguë, E.M. Barber, and T. Crowe

Summary

Two manure-handling systems are currently being tested to determine which system best eliminates all manure contamination from the air in a air quality laboratory. The two systems include a washing gutter and an inclined, washed conveyor belt. Both systems can be adjusted to run at various frequencies and are currently being tested to find out how often they need to run to eliminate contamination from the manure.

Introduction

There have always been concerns about air quality in intensive swine operations, and these concerns have grown with the size of production units. There is no firm understanding of where the components in the air contamination originate. In an effort to understand the source of the air contamination in an intensive swine operation, this study separates the factors (feed, manure, and the animals themselves), and attempts to obtain zero effect of each factor on air quality. Once the effect of each of the factors can be reduced to zero, the factors can be varied individually to find out their effect on air quality. The first focus of the study is the manure handling system. Two methods of removing the manure will be tested, one is a washing gutter, using nozzles and pressurized water to clean the dunging area, and the other is a washed, inclined conveyer belt. The objective is to have zero air contamination from the manure in the room using these manure handling systems.

Experimental Procedure

An air quality laboratory has been built into the Floral barn. The laboratory consists of two rooms, and each room is lined with stainless steel to reduce absorption of contaminants by the room surface. The washing gutter is installed in one room, and the inclined conveyor belt is installed in the second room. Testing of the manure handling systems will also focus on the frequency of cleaning the dunging areas. Three different frequencies will be tested - every half hour, every hour and every two hours. Groups of 10 female pigs weighing about 30 kg will be used in each room, and data will be collected for one week in each trial. Three trials will be run at each frequency for a total of nine trials in each room. Ammonia levels will be used to measure the effectiveness of the systems, as ammonia comes only from the manure, and is measured at the inlet and outlet of each room over a period of a week.

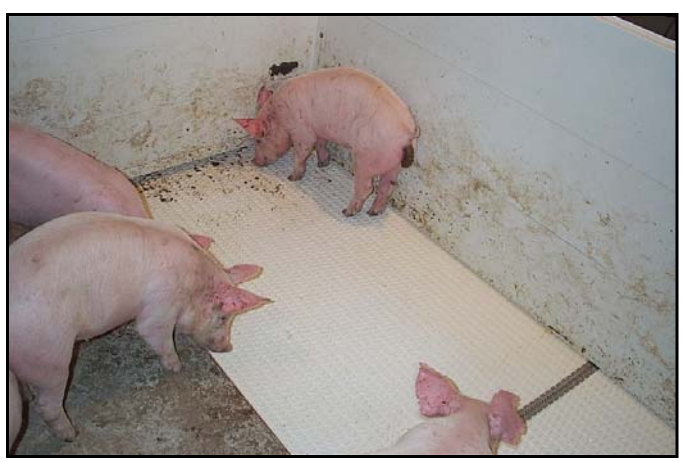
Implications

Once the manure handling systems have been optimized to produce minimum contaminants from the manure, further testing will be done on other sources of air contaminants. The next series of tests deal with contaminants from the pig and the feed, and ultimately the effects of the various air contaminants on both pigs and people will be studied.

Acknowledgments

Figure 1. Pigs using a washing gutter manure handling system

Figure 2. Pigs using a conveyor belt manure handling system



Greenhouse Gas Odour Emissions from Pig Production Buildings, Manure Storage and Manure Treatment Facilities

C. Laguë, et al.*

Introduction

Agriculture as a whole could account for 9.5% of the total Canadian greenhouse gas (GHG) emissions. It is also estimated that 42% of the agricultural GHG emissions originate from livestock operations and one third of these are associated with manure management. There exists a need to better determine the relative contributions of the different stages of livestock production and manure management to the GHG emissions caused by this agricultural sector. Another important emission issue for livestock operations, particularly in swine production, is odours. As for GHG emissions, there is a need to better assess the effects of the different components of livestock operations (animal housing and diet, manure management) on the overall operation emissions.

Objectives

The general objective of this study was to evaluate methane (CH_4), carbon dioxide (CO_2) and nitrous oxide (N_2O) emissions, and also odour emissions for swine operations in two provinces (Québec and Saskatchewan) under liquid manure management. More specifically, the research has been targeted at: 1. determining GHG and odour emissions from different types of swine production buildings and building floor designs; 2. determining GHG and odour emissions from different types of manure storage facilities, and 3. determining GHG and odour emissions from two manure treatment systems. Greenhouse gas and odour emission results have been expressed in terms of unit animal mass in order to allow for direct comparisons between the different sources. Researchers from four different organizations - the Institut de recherche et développement en agroenvironnement (IRDA), Prairie Swine Centre Inc. (PSCI), Université Laval and the University of Saskatchewan - actively participated in the project.

Table 1. GHG emissions from different room types in two swine production buildings.

Room type	GHG emission ($g/day-kg_{pig}$)			GHG emission – CO_2 equivalence ($g\ CO_2$ equivalent/$day-kg_{pig}$)[1]		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
PSCI Floral site						
Farrowing	49.2	0.63	0.000	49	13	0
Gestation	21.0	0.27	0.000	21	6	0
Nursery	89.0	1.96	0.000	89	41	0
Grower-Finisher	144.5	0.14	0.002	145	3	1
PSC Elstow Research Farm Inc. site						
Farrowing	36.8	0.10	0.000	37	2	0
Gestation	26.9	0.07	0.000	27	1	0
Nursery	30.4	0.39	0.000	30	8	0
Finisher (Partially slatted)	90.5	0.24	0.000	90	5	0
Finisher (Fully slatted)	92.3	0.43	0.001	92	9	0

Experimental Procedures

Greenhouse gas and odour emissions from intensive swine housing gestation, farrowing, nursery and grower-finisher rooms were determined at both the PSC Floral and Elstow sites, with grower-finisher rooms with both partially and fully slatted floors at Elstow. In Saskatchewan, GHG and odour emissions were measured at four dif-

* IRDA :	Dr. Stéphane Godbout, ing., agr. Mr. Roch Joncas, ing., agr., M.Sc. Mr. Jean-Pierre Larouche, Chemist Dr. Stéphane P. Lemay, ing.	PSCI:	Dr. Stéphane P. Lemay, P.Eng. Ms. Liliane Chénard, P.Eng., M.Sc. Ms. Shala Christianson, EIT, M.Sc. Mr. Robert Fengler, Technician Ms. Karen Stewart, M.Sc. Student
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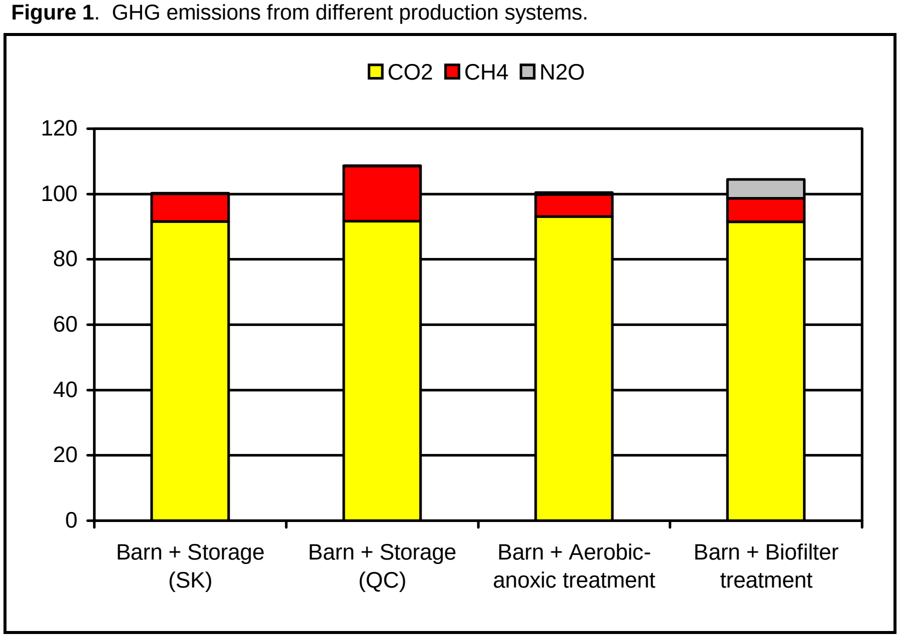
ferent sites that make use of an uncovered concrete tank (1 site), an uncovered 2-cell earthen manure basin (EMB; 1 site) and covered 2-cell EMB (2 sites). Blown chopped straw was used to cover the EMB facilities at those last two sites. One uncovered concrete tank and two manure treatment facilities were monitored in Québec. One of those treatment facilities uses the bio filtration principle and the other one uses alternate periods of aerobic and anoxic phases.

All emission data has been reported in terms of mass (g) of CO_2-equivalent per day per unit animal mass (kg_{pig}). Based on the respective global warming potential (GWP) of the three GHG, the conversion factors are as follows: 1 g of CO_2 = 1 g of CO_2-equivalent; 1 g of CH_4 = 21 g of CO_2-equivalent; 1 g of N_2O = 310 g of CO_2-equivalent.

Results

Figure 1. GHG emissions from different production systems.



Greenhouse gas emissions (all values expressed in g of CO_2-equivalent per day per kg of animal mass)

The most important contributor to GHG emissions from swine buildings was carbon dioxide (Table 1). On an animal mass basis, methane emissions were much lower than CO_2 emissions, and nitrous oxide production was found to be negligible. The lowest CO_2 production was measured in gestation rooms, and the largest was in grower-finisher rooms.

Greenhouse gas emissions from different types of manure storage facilities (i.e. earthen manure storage basins (EMB) uncovered or covered with blown chopped straw; concrete storage tanks) were measured during the 2001, 2002 and 2003 seasons in Saskatchewan. Average (range) GHG emissions from manure storage facilities were as follows: 2.41 (0 to 25.00) for methane; 0.94 (0 to 7.00) for carbon dioxide and, <0.01 for nitrous oxide. Average total GHG emissions from uncovered EMB, covered EMB and uncovered tank storage facilities measured in this study were 4.23, 2.52 and 6.65 respectively. Average total GHG emissions from EMB primary cells measured in this study were 1.90 (uncovered) and 1.41 (covered) while corresponding values for EMB secondary cells were 10.08 and 1.46 respectively. These two series of results confirm the positive impacts of blown chopped straw covers on GHG emissions from manure storage facilities. Average total GHG emissions during the spring, summer and fall seasons respectively amounted to 0.47, 3.91 and 3.49. Finally, average total GHG emissions during the daytime (between 06:00 and 18:00) and night (between 18:00 and 06:00) periods, as measured in this study, were 9.35 and 13.92 respectively.

Greenhouse gas emissions from a concrete tank manure storage facilities were monitored during the 2001, 2002 and 2003 seasons in Québec. Average (and range) GHG emissions were as follows: 10.81 (1 to 40) for methane and 1.03 (0.1 to 4) for carbon dioxide. Nitrous oxide emissions were found to be negligible. Greenhouse gas emissions were not affected by the depth of manure in the storage facility, Similarly, no diurnal/nocturnal effects on GHG emissions could be determined from the experimental results. However, summertime methane and carbon dioxide emissions were respectively ten and five times more important than those observed during the fall.

Greenhouse gas emissions from an aerobic-anoxic manure treatment system were monitored during the 2002 and 2003 seasons. Average GHG emissions were as follows: 0.77 for methane, 2.39 for carbon dioxide and 0.38 for nitrous oxide. No diurnal/nocturnal or seasonal effects on GHG emissions were detected. However, treatment phases (aerobic or anoxic) did influence GHG emissions. Carbon dioxide emissions were more important during the aerobic phase while nitrous oxide and methane emissions were more important during the anoxic phase. Greenhouse gas emissions from a biofilter manure treatment system were monitored during the 2002 and 2003 seasons. Average (and range) GHG emissions were as follows: 1.05 (0 to 3.59) for methane, 0.87 (0 to 3.35) for carbon dioxide and 5.63 (0.13 to 35.79) for nitrous oxide.

Figure 1 summarizes the total GHG emissions of different productions sys-

tems based on the emission results observed in this study. It can be seen that the main contributor is the carbon dioxide emitted from the production buildings. Overall emissions for different types of production systems (i.e. storage or treatment of the manure produced by the animals) are all of the same order of magnitude.

Odour emissions

Nursery pigs at the PSCI Floral site produced the highest odour emission followed by the grower-finisher rooms at the PSC Elstow Research Farm Inc. site. The nursery room at the Floral site is based on an older design where more manure accumulates on the floor compared to the nursery room at the Elstow site. However, the gestation room produced the most important odour emissions.

Odour emissions from three types of manure storage facilities (uncovered and covered EMB, uncovered concrete tank) were measured in Saskatchewan during the 2001, 2002 and 2003 seasons. All experimental data has been expressed in terms of odour units (O.U.) per second per kg of animal mass. Average odour emissions from all types of manure storage facilities during those three seasons were 0.0342 (in 2001), 0.0224 (in 2002) and 0.0362 (in 2003). Average odour emissions from covered EMB, uncovered EMB and uncovered tank storage facilities were respectively 0.0208, 0.0335 and 0.0481. Average odour emissions from EMB primary cells measure`d in this study were 0.0265 (uncovered) and 0.0089 (covered by chopped straw) while corresponding values for EMB secondary cells were 0.0481 and 0.0328 respectively. As for GHG, these two series of results indicate that odour emissions were positively impacted by the presence of a blown chopped straw cover on the surface of the stored manure. Average odour emissions during the spring, summer and fall seasons measured in this study were respectively 0.0369, 0.0276 and 0.0294. Finally, average odour emissions during the daytime period, as measured in this study, were 0.0241 during the morning (07:00 to 10:00), 0.0273 at noon (11:00 to 14:00) and 0.0235 during the afternoon (15:00 to 18:00).

Odour concentrations and intensities were measured over a 2-year period (2002 and 2003) on three swine operations equipped with a conventional pig manure storage tank, an aerobic-anoxic manure treatment system and a biofilter manure treatment system in Québec. The aerobic-anoxic manure treatment system (1.7 OU/s-m^3) emitted fewer odours than the biofilter treatment system (7.3 OU/s-m^3). Odour intensities, in ppb equivalent of 1-butanol, emanating from the site with the aerobic-anoxic treatment system

Simulating Ammonia Emissions from Slurry Pits

E.L. Welford, S.P. Lemay, E.M. Barber, and S. Godbout

Summary

By modelling the production and transmission of ammonia in a swine building, we will be better equipped to investigate methods to reduce ammonia concentration inside the buildings. Ammonia emission from slurry was measured and compared to two sets of model calculations to determine which model is more suitable for use in an overall room model. Both models simulated the fluctuation in emissions relatively well, but neither model sufficiently predicted the concentration levels. Slurry pH was deemed the most significant input parameter in the model calculations.

Introduction

The slurry pit and urine puddles on the slatted and solid floor have been identified as the main sources of ammonia in a pig-housing unit. Decreased protein in the diet will result in decreased nitrogen in the excreta. Increased fermentable carbohydrates, such as sugar-beet pulp, will increase the amount of nitrogen excreted in the feces compared to the urine. Nitrogen that is excreted in the feces is more stable and takes longer to decompose, whereas nitrogen in the urine is in the form of urea, which readily converts to nitrogen. The objective of this experiment was to measure the ammonia emission from slurry samples produced by pigs fed different diet compositions, and compare the measured results to model calculations. Two models will be compared and one will be chosen to represent the slurry emission in the future overall room emission model.

Experimental Procedures

Eight pigs in 58-kg and 94-kg weight ranges were housed individually in metabolism crates. Four different diet treatments were used: low protein, with and without sugar-beet pulp added, and high protein, with and without sugar-beet added. The urine and feces from individual pigs was collected, mixed and placed in emission boxes. The emission boxes were designed to simulate the slurry pit, with a low airspeed over the surface of the slurry and very little mixing. Air was pulled through the boxes and the ammonia in the outgoing air was continuously monitored over three to four days using an infrared ammonia analyser. Ammonia concentration in the boxes was simulated using two different models: a model developed by Aarnink and Elzing[1] (Model 1), and a new model developed by the authors (Model 2).

Results and Discussion

In this experiment, lowering the crude protein content and adding sugar beet pulp to the diets did not result in lower ammonia emissions. Both models showed the fluctuation in ammonia levels over the sampling period (Fig. 1). However, neither model simulated the level of concentration very well (Fig. 2). Model 2 calculations were chosen to represent the slurry pit emission process in the overall room model because Model 2 considers the pit concentration and previous concentration levels. Additional work is required to adjust the level of ammonia concentration predicted by Model 2.

Figure 1. Measured and simulated ammonia concentration in an emission box containing slurry from a finisher pig fed a high protein, sugar-beet pulp added diet

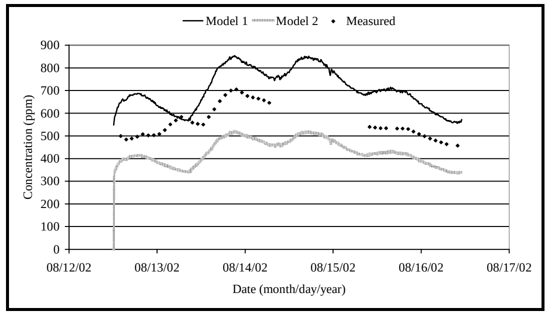
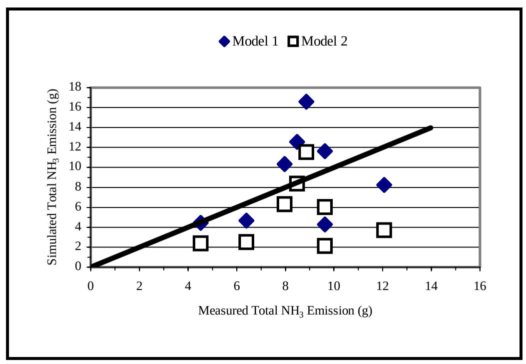


Figure 2. Comparison of the total simulated ammonia emission by both models to the total measured emission for all slurry samples in the second trial.



Based on a sensitivity analysis, slurry pH is the most influential factor in model calculations. A 1.0 unit decrease in pH will decrease ammonia emissions by 90%, but a 1.0 unit increase in pH will increase emissions by 833%.

Implications

The ammonia emission from the slurry pit is a major contributor to the ammonia concentration in a pig-housing unit and the ammonia emission to the environment. By validating model equations to simulate ammonia emission

Systems Engineering for Handling and Land Application of Solid and Semi-solid Livestock Manure

C. Laguë, M. Roberge, J. Agnew, M. Alam, H. Landry, C.Iskra, S. Siroski, and R. Lorenz

Background

Research on manure handling and land application has been recognized as a top priority by a number of national and provincial organizations across Canada as a means to increase the environmental sustainability and to improve the social acceptance of intensive livestock production. Handling and land application systems for solid and semi-solid manure (i.e. manure containing more than 10% of solids by weight) have experienced much less technical research and development efforts than comparable systems for liquid manure and slurry over the last thirty years or so. However, these types of manure management systems have been identified as potential alternatives to liquid manure systems in terms of reducing environmental and societal problems that may be associated with liquid manure management. Solid and semi-solid manure as well as organic fertilizers resulting from the combination of solid (separated or composted) manure and other materials (eg. wood chips, paper mill residues, industrial or municipal sludges, etc.) have highly variable physical and flow properties. Adapted handling and land application systems are therefore required if one wants to optimize their value as a source of nutrients for field crops while minimizing environmental and nuisance risks. The most important technical characteristics of handling and land application systems in terms of optimizing the agronomic value of manure are those related to the control of the application rate of the product and to its uniform application and distribution to the cropped land.

Table 1. Summary of least squares regression estimation analysis for the factorial designs used to evaluate the effects of the gate, the speed of the conveyor and the angle of the side walls (the cells of the table with an 'X' indicate statistically significant

	Scraper Conveyor		**Screw Conveyor**	
	Specific energy	Characteristic flow rate	Specific energy	Characteristic flow rate
Gate	X	X	X	X
Speed		X		X
Walls		X		
Gate x Speed Interaction				X

Objectives

The purpose of this research and development project is therefore to provide the designers and operators of equipment used for the handling and land application of solid and semi-solid manure with the engineering and technical information required to optimize the design and performance (e.g. energy requirements, uniformity of application) of that equipment. The specific objectives of the project are:

1. To determine representative ranges of values for the physical and flow properties of different types of solid and semi-solid manure that have a direct impact on the performance of handling and land application equipment: solids content, apparent density, angle of repose, coefficient of friction, particle and lump size distribution of the solid phase, shear strength.
2. To determine the efficiency of different discharge systems at providing controlled discharge rates for the different types of manure identified in 1.
3. To determine the efficiency of different distribution and land application systems in terms of uniformity of application rate and coverage for the different types of manure identified in 1.

Progress Report

Objective 1: Determination of the physical and flow properties of the manure products

Objectives 2 & 3: Comparative evaluation of manure discharge systems

The design component of this project was broken down into two "test-bench" components. The first test bench involves the main body or box of the spreader and controls the flow and movement of the material to the back of the spreader. The second test bench deals with the transverse distribution of the material across the full width of application (3 m, 10 ft). A transitional hopper between the test benches will also be designed to help facilitate flow from the back of the spreader to the transverse conveyor.

Main Test-bench

A commercial box manure spreader (New Idea, model 362) was used as the body for the main test-bench. Four load cells (Massload Technologies,

Table 2. Summary of unit energy requirements and discharge rates for tested components.

Component	Material	Unit Energy Requirement (W per kg/s)	Maximum Total Discharge Rate Achieved (kg/s)	Comments
Main test-bench (scraper)	Feedlot manure	117	10.5	
	Swine manure and straw	194	15.1	No repetitions
Main test-bench (screws)	Feedlot manure	374	47.4	
	Separated solid swine manure	212	36.9	No repetitions
Transverse test-bench (belt)	Compost	37	22	3 m span
	Sheep manure and straw	-	-	Unable to obtain results
Transverse test-bench (screw)	Compost	1,000	3.84	2.4 m span
	Sheep manure and straw	838	2.4	

model ML-100BC, Saskatoon, SK) were installed between the spreader box and frame for continuous mass measurement. The spreader box also includes inclinable sidewalls that can be lined with different types of materials for which the friction characteristics have been determined: steel (bare and painted), plastic PVC and plywood. A hydraulically actuated gate was installed at the back of the box to help control the flowrate of material into the transverse conveyor. The gate opening could be adjusted to any height between 0.0254 and 0.9144 m (between 1 and 36 inches). Two types of floor conveyors were implemented (scraper and screw conveyors) which are discussed next.

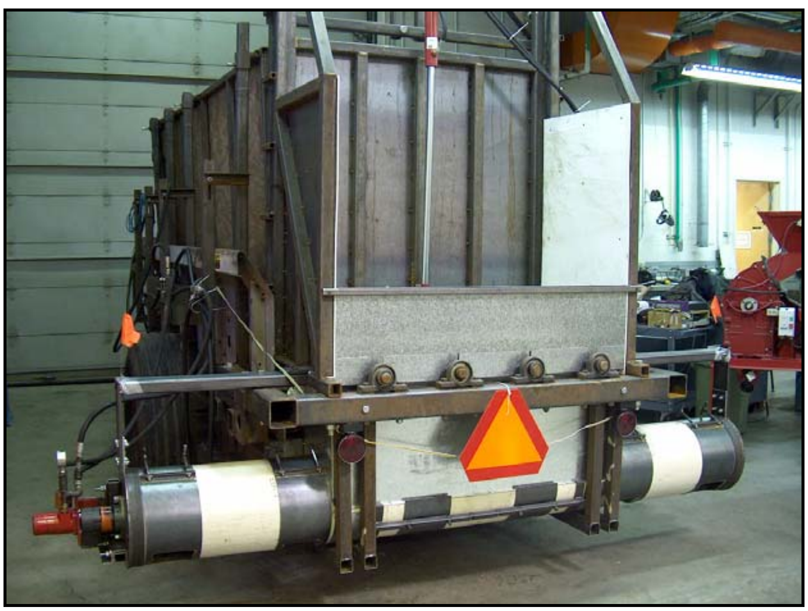


Figure 1. Prototype design for transverse distribution.

Scraper Conveyor

The scraper conveyor consisted of a traditional chain and slat device that spanned the full 1.524 m (5 ft) width and 3.05 m (10 ft) length of the box. The drive shaft was positioned at the back end of the box and the gearbox between the PTO at the front and the drive shaft at the back provided the required speed reduction from 540 rpm to 10 rpm. A torque transducer (Lebow Associates, model 1248H-20K, Troy, Michigan) and a magnetic speed sensor were positioned at the front of the spreader to monitor the PTO torque and speed for power requirement calculations.

Screw Conveyors

Four 0.3048 m (12 inch) diameter, standard pitch (2 right hand, 2 left hand flighting) screws were installed across the entire width of the floor to eliminate bridging in the hopper and to provide an even flowrate across the entire width at the back of the spreader. Stainless steel troughs were constructed to house the screws to provide stability and allow for more predictable material behaviour. The drive system included two gearboxes (one each for the right hand and left hand screws) 100-chain sprockets of varying size to achieve further speed reduction.

Test-bench for Transverse Distribution

Designs for the transverse distribution of solid and semi-solid manure included two types of conveyors: screw and belt.

Belt Conveyor

Specifications:

- 3.05 m (10 ft) long, 0.457 m (1.5 ft) wide belt on a trough support with rollers and idlers at each end
- 80 L (21 gallon) hopper, adjustable height
- Set of 3 dividers and gates (adjustable position and angle) to provide evenly spaced drop points (3 or 4) along length of conveyor
- Hydraulic drive system with instrumentation to measure hydraulic flow and pressure for power determination (rotational speed measured manually with digital tachometer)

Screw Conveyor

Specifications:

- 2.44 m (8 ft) long, 0.203 m (8 in) diameter standard pitch screw conveyor
- Complete, circular steel trough adapted from an auger conveyor
- 50 L (13.2 gallon) hopper
- 4 evenly spaced drops, with slide plates for drops 1, 2 and 3 to adjust opening width
- 0.0762 x 0.0254 m (3x1 inch) “paddles” welded to the flighting at each drop point to help material flow out of openings
- Apertures changed from 0.1016 m (4 in) diameter circular to 0.1016 m (4 inch) 180º rectangular openings
- Final drop point at end of conveyor completely open

Figure 2. Preliminary results obtained for banded application of chicken wastes compost (three repetitions are shown).

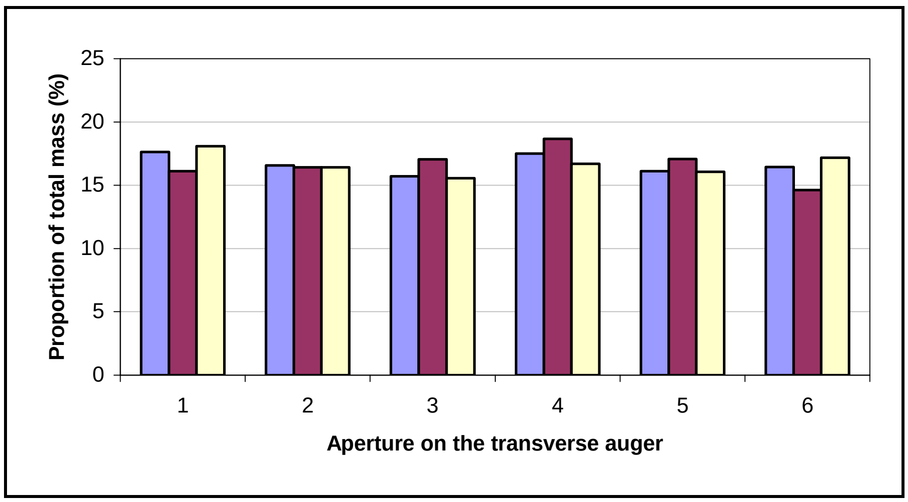
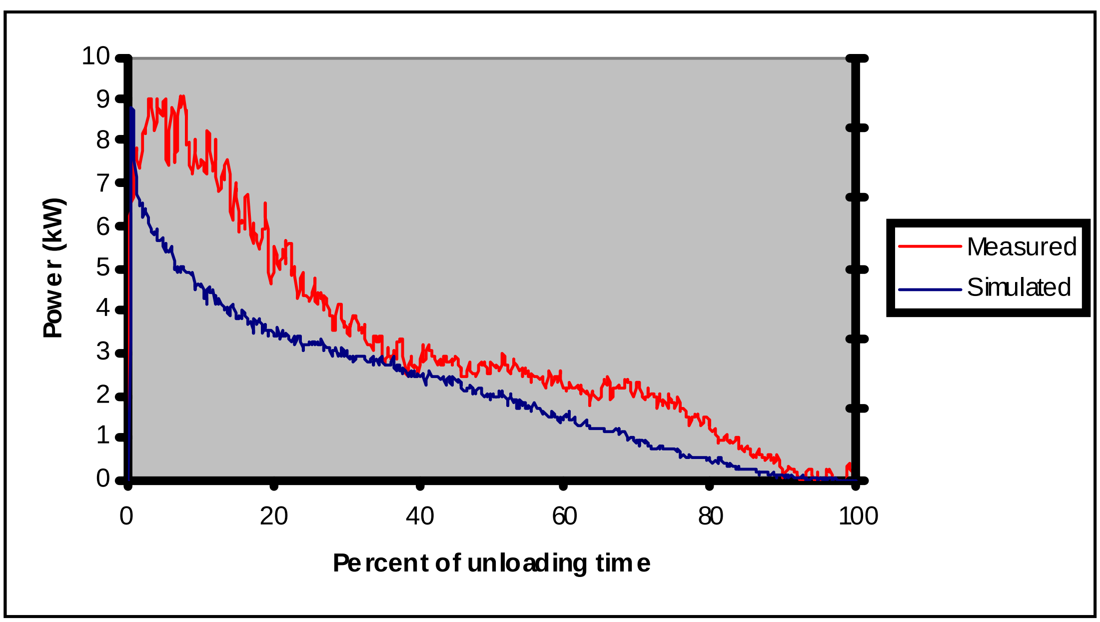


Figure 3. Comparison between results from DE model and actual testing.



- Hydraulic drive system with instrumentation to measure hydraulic flow and pressure for power determination (rotational speed measured manually with digital tachometer)

Results

The main test-bench performed well with the scraper conveyor configuration. Inclining the sidewalls to 10º from vertical significantly reduced the power requirement while using the gate increased the power requirement while helping to control the distribution pattern. Analysis of the energy requirements (power per unit discharge rate) showed no wall effect, but the energy requirements were higher when the gate was closed. Refer to Table 1 for a summary of significant factors and to Table 2 for a summary of flowrates and energy requirements.

The main test-bench with the screw conveyors was tested with composting feedlot manure and freshly separated solid swine manure. The gate height and PTO speed significantly affected the total flowrate while the wall inclination did not affect flowrate. The gate height was the only variable to significantly affect the unit energy consumption while the PTO speed and wall inclination had no effect on the unit energy consumption. Refer to Table 2 for flowrate and energy values.

The transversal distribution test-benches showed that a screw conveyor is more suited to handle the solid and semi-solid materials the unit is required to deal with. While the belt conveyor provided flexible and accurate distribution of compost, it did not perform well with the fresh manure sample. The 0.203 m (8 inch) diameter screw conveyor, while requiring more power, handled the manure samples well, but the observed flowrates did not satisfy the requirements for the expected application rates. The final prototype design will incorporate a 0.305 m (12 inch) diameter screw conveyor for the transverse distribution component. The low standard error (<20%) observed for the flowrates between each of the drop points of the transverse screw should provide the required even distribution pattern of solid and semi-solid manure.

Prototype Design

The prototype precision land applicator to include transverse distribution can be seen in Figure 1. The machine includes four 0.305 m (12 in) diameter screw conveyors (2 right hand, 2 left hand flightings), inclinable sidewalls and an adjustable gate for control of the flow to the back of the spreader. A transitional hopper leads to the transverse screw (0.305 m, 12 in diameter) which is housed in a PVC tube with 6 equally spaced, adjustable openings for banded application.

Preliminary work shows that it is possible to obtain the same flowrate from each of the drop points (Figure 2) with a unit energy consumption of approximately 520 W per kg/s. Including the energy required to run the four screws in the box of the spreader, the total unit energy requirements of the system are approximately 894 W per kg/s. More trials are required to validate the achievable flowrates and energy consumption.

Future work will also focus on adapting the prototype for broadcast application and subsurface incorporation. For the broadcast application, hydraulically powered spinners will be added to each of the drop points and soil openers and/or disks will be added to the current configuration for subsurface incorporation.

Modeling activities

Discrete element models of machine-manure interactions are being developed to better understand the flow of organic fertilizers in land application equipment. The results obtained during the spreading experiments are used to develop those models. Figure 3 presents an example of the results obtained with the DE models. The measured and simulated powers for the four augers with the gate at its lowest setting are presented. The models will need to be further refined to better replicate the properties and behaviours of manure products.

Acknowledgements

Strategic Program funding provided by Sask Pork, Alberta Pork, Manitoba Pork Council, and the Saskatchewan Agriculture and Food Development Fund. Funding to the Sask Pork Chair in Environmental Engineering for the Pork Industry provided by the Agri-Food Innovation Fund of Saskatchewan, PSCI, and Sask Pork. Project funding was provided by the Alberta Agricultural Research Institute (AARI) and the Livestock Environmental Initiative (LEI) program of Agriculture and Agri-Food Canada.

Effect of Social Group Size on Aggressive Behaviour of Grower-Finisher Pigs in Fully-Slatted Floor Rearing System

T.S. Samarakone and H.W. Gonyou

Summary

The impact of large group size on social behaviour of pigs is poorly understood. A study was conducted to assess the social aggression of grower-finisher pigs in large groups. Pigs with large social group experience displayed a significant reduction in aggressive behaviour compared to those living in small social groups.

Introduction

Most studies into social behaviour in pigs have been limited to relatively small group sizes (<40 pigs/group) compared to those that are now used in some commercial practices. The social strategy adopted by pigs in large social groups is not well understood, but it could be expected that the pigs in larger groups will adopt different social strategies than those exhibited by pigs in small social groups. Any changes in the social behaviour of pigs in larger groups could directly affect the overall welfare and productivity of animals. The objective of the present study was to determine the effect of large social groups on aggressive behaviour of grower-finisher pigs**.**

Experimental Procedures

Eight blocks, each comprising four pens of 18 pigs (SG) and two pens of 108 pigs (LG) on fully slatted floors (0.76 m^2/pig) were used in the experiment. Initial body weights averaged 31.8 ± 5.4 kg, with equal numbers of barrows and gilts in each pen. Pigs were fed from multi-space wet/dry feeders, with a pig to feeder space ratio of 9:1. Three studies were conducted to evaluate the aggressive behaviours of pigs. Study1: Initial level of aggression was recorded for two hours, starting 0, 24hr and 48hr following group formation. Study 2: On weeks 1, 6 and 12 on test, a selected pair of pigs from a pen (SG or LG) was transferred to another pen (SG or LG) to asses the effect of social experience (SG vs. LG) on aggressive behaviour upon mixing to an established social group (SG vs. LG). Aggressive behaviours were recorded for 2 hr and a total of four different combinations were tested (88 pigs/combination). Study 3: After 8 weeks on test, a total of 200 pigs were re-grouped in a separate small pen for 2 hr in groups of four to asses the effect of prior social experience (SG vs. LG) on aggression with pigs from their own pen or unfamiliar pigs from SG and LG.

Results and Discussion

There was no difference in the per-

centage of time spent fighting observed between the two group sizes up to 48hr following grouping (Figure 1). When pigs with large social group experience were mixed into an established large social group (LL), a significant reduction in time spent in aggressive behaviours was observed between the intruder and the resident pigs (P<0.05) than when pigs with LG experience were introduced to SG (LS), or SG experience were introduced to LG (SL) or SG (SS) (Figure 2). Upon re-grouping into pens of 4 pigs at week eight, pigs derived from two SG showed an increased level of aggression towards unfamiliar pigs compared to those that were derived from two LG. When pigs derived from SG and LG were combined an intermediate level of aggression was observed (Figure 3). This indicates reduction in aggressive behaviour by pigs living in large social groups.

Conclusion

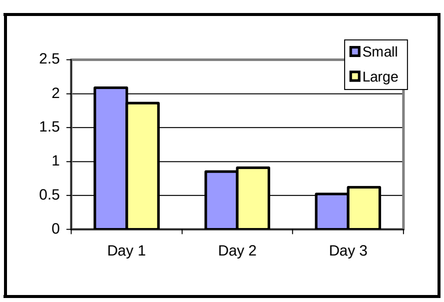


Figure 1. Percentage of time fighting observed at 0, 24 hrs and 48 hrs following formation of groups.

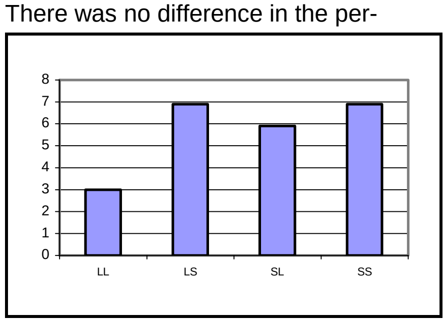


Figure 2. Percentage time spent on aggression (P<0.05) upon mixing of pigs.

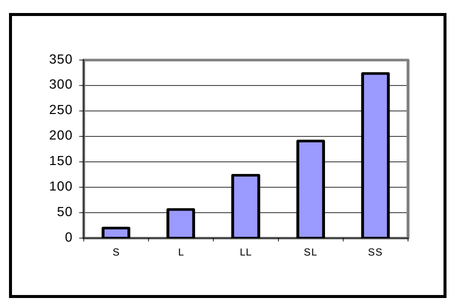


Figure 3. Mean duration of fighting observed in five different pig combinations tested (P<0.05).

Electronic Sow Feeder: A Preliminary Report

Y. Li and H.W. Gonyou

Introduction

One of the more controversial aspects of pig production is the housing of gestating sows. Gestation stalls have been identified as one of the three most restrictive practices, along with battery cages for hens and crates for veal calves, throughout the history of the modern animal welfare movement. As a result, there is considerable interest in group housing systems for gestating sows. There are at least four major group housing systems, with several management options within each, that are available to the industry. We have selected the electronic sow feeder (ESF) system as a group system for PSC Elstow Research Farm, and are examining a number of management options within that system.

Experimental Procedures

Approximately half of the 600-sow herd is now on electronic sow feeders in which each animal passes through a feeding station to obtain her daily feed allottment. Our system currently operates on partially slatted floors without bedding. We are studying social management of the groups in order to identify and correct problems with specific age classes. We have housed gilts with older sows even though we recognize this may result in some problems. However, our belief is that a combined gilt/sow program would be easier for producers if we can resolve the problems. Similarly, we recognize that first parity animals may also be at risk in groups. We are comparing:

1. The productivity and behaviour of gilts and sows of different parities.
2. The relative benefits of grouping animals shortly after breeding (pre-implantation) or after implantation (at 7 weeks; 'add-in'), and its interaction with parity.
3. The management of animals in static (45 sows) and large (135 sows) dynamic groups.
4. All electronic sow feeder groups are compared with animals managed in conventional stalls.

The results of the first three reproductive cycles (60 weeks of breedings) have been summarized and presented in table 1. The values presented represent live piglets born per 100 animals bred. This is a combination of farrowing rate and live litter size. The 'Adjusted' values represent a herd comprised of 25% gilts, 25% 1st parity, and 50% older sows. These results are only preliminary as they represent a limited number of animals in each category.

Table 1. Productivity (live piglets/100 females bred) of gilts and sows in Stalls and various management programs within an Electronic Sow Feeder system.

	Stall	Static	Dynamic	Add-in-Static	Add-in-Dynamic
Gilt	771	633	739	762	776
1st Parity	930	872	794	967	942
Mature	983	932	907	1,059	998
Adjusted[1]	917	842	837	962	929

[1]Based on a herd comprised of 25% gilts, 25% 1st parity, and 50% mature sows.

Productivity increased from gilts to 1st parity to older sows as expected in both ESF and stall systems. However, the younger animals tended to perform better in stalls, and the older sows better in ESF. There was considerable variation in performance of age groups in the different electronic sow feeder management systems.

The 'add-in' or post-implantation animals performed better (945) than those grouped shortly after breeding (840). Somewhat surprisingly, all parity groups performed much better as add-ins than when re-grouped early.

The Static program (combined pre and post-implant, 902) outperformed the Dynamic (883). However, gilts did relatively poorly in the Static system (698) but fairly well in Dynamic (758). The older animals (including 'add-ins') did better in the Static program.

Overall, the stall system (917) outperformed the electronic sow feeder system (892), but this was not the case for all electronic sow feeder management programs. The Add-In (945) animals in electronic sow feeders (both programs combined) produced more piglets than did the Stall animals (917). The post-implant static program for electronic sow feeders outperformed the stalls by 5%. The 'add-in' static gilts performed about as well as those in stalls, but the 1st parity animals and sows exceeded those in stalls by 4% and 8%, respectively.

As we continue this study we will be including behavioural and physiological observations. We are also collecting data on injuries, lesions, and mortality throughout the six cycles.

Implications

The electronic sow feeder system can

The Effect of Starter Feeding Regimen on Variability in Bodyweight and Performance in the Nursery

A.D. Beaulieu, J.F. Patience, R.T. Zijlstra, and R. Mohr

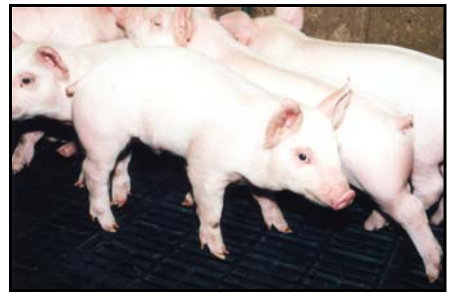
Summary

Variability in growth and performance is a concern to pork producers due to the associated negative impact on revenues and expenditures. This experiment was designed to determine the effect of starter program on the variability in animal weights at nursery exit. Treatments consisted of 4 starter programs, formulated and fed according to manufacturers' specifications from weaning (d 0) to nursery exit (d 50). Overall ADG was similar between programs, however, the ADFI differed thus, feed efficiency was affected by the program used. Variability in pig growth, determined as the coefficient of variation, was not affected by starter program. This was true regardless of the starting weight of the group of pigs. Therefore, although performance may be affected slightly by the use of a specific starter program, the change in performance is uniform across a group; and the variability in body weight at nursery exit will not be affected.

Introduction

Variability in growth and performance is a concern to pork producers due to the associated negative impact on revenues and expenditures. The challenge of reducing the impact of variability on pork production is a serious one and two options are available. The first is to reduce variability and the second is to manage it. If variability is considered to be excessive the implementation of management practices to reduce it will be a reasonable approach.

The starter program has the potential to influence the relative growth of individual pigs within a group by allowing the smaller and/or younger pigs to excel relative to the older and/or larger contemporaries. Variability will be reduced if the feeding regimen allows the smaller pigs to "catch-up" or meet the performance of the larger animals in their cohort. It is recognized that the subject of nursery diet impact on variability is complex; determining whether a feeding program can reduce the impact of variability was considered a first step.



Experimental Procedures

A total of 560 pigs were used in this experiment. This represented all the

Table 1. The effect of starter program on the performance of nursery pigs. The data were indexed to diet A which was arbitrarily assigned a value of 100.

	Treatment					
	A	B	C	D	Mean[a]	SEM[a]
Initial weight, kg	100.00	100.00	100.00	100.00	6.26	0.018
Final weight[b], kg	100.00	100.31	104.37	101.92	32.36	0.341
ADG, kg/d	100.00	100.00	103.15	102.95	0.52	0.008
ADFI[b], kg/d	100.00	99.31	105.82	105.13	0.74	0.009
FCE[b]	100.00	100.57	97.30	99.29	0.70	0.004
Feed cost/kg gain[b]	100.00	104.92	109.84	101.64	0.64	0.006
Feed cost/pig[b]	100.00	104.74	113.89	105.39	16.34	0.193

[a]Calculated from untransformed data
[b]Significant effect due to treatment (P<0.05).

Table 2. The effect of grouping by weaning weight on the performance of nursery pigs.

	Weight Group				
	Lightest	Light	Heavy	Heaviest	SEM
Initial weight, kg	4.93	5.80	6.55	7.76	0.018
Final weight, kg	29.19	31.74	32.94	35.55	0.341
ADG, kg/d	0.479	0.519	0.521	0.545	0.008
ADFI, kg/d	0.665	0.730	0.756	0.800	0.009
FCE[a]	0.719	0.711	0.689	0.681	0.004
Feed cost/kg gain	0.64	0.63	0.64	0.64	0.006
Feed cost/pig[a]	15.29	16.24	16.49	17.33	0.193

[a]Significant effect of weight group (P<0.05).

Table 3. The effect of starter program on the coefficient of variation (CV, %) calculated from body weight[a] within pens. Pigs had been blocked by weight at weaning. The data were indexed to diet A which was arbitrarily assigned a value of 100.

	Treatment					
Phase	A	B	C	D	Mean[b]	SEM[b]
d 4	100.00	98.77	101.97	95.08	8.05	0.42
d 7	100.00	89.81	97.98	92.04	8.94	0.65
d 20	100.00	91.37	94.34	95.21	13.13	1.16
d 34	100.00	104.43	83.14	97.59	12.39	0.84
d 50	100.00	94.13	85.43	99.36	10.33	0.68

[a]Calculated from pen data, averaged for each treatment. The overall CV for each nursery room averaged 17.8% at d 0 and 12.6% at d 50.
[b]Calculated from untransformed data.

Table 4. The effect of grouping by weaning weight on the coefficient of variation (CV, %) calculated from body weight[a].

	Weight Group				
Phase	Lightest	Light	Heavy	Heaviest	SEM
d 4[b]	8.13	8.03	8.29	7.73	0.42
d 7	9.42	8.46	9.23	8.67	0.65
d 20	13.79	12.60	13.01	13.13	1.16
d 34[b]	12.87	13.44	10.70	12.56	0.84
d 50[b]	10.91	10.27	9.32	10.84	0.68

[a]Calculated from pen data, averaged for each weight group. The overall CV for each nursery room averaged 17.8% at d 0 and 12.6% at d 50.
[b]Significant effect due to weight group (P<0.05).

available pigs from two consecutive weeks of weaning at PSC Elstow Research Farm. The only pigs excluded from the experiment were those deemed to be suffering from an obvious medical or physical problem. The experimental group represents a typical and complete weaning group. Animals were blocked into one of 4 weight groups. The treatments consisted of 4 commercial programs currently in use in Western Canada. The feeding programs were fed according to the manufacturers' directions. The only restriction on the program was the medication, all diets were required to include LS20 at the recommended level.

Piglets were weighed individually when they were placed on test (d0) and on d4, d7, d13, d20, d34 and d50 (nursery exit). The CV was computed within a pen and analyzed as a variable across pens. To ensure confidentiality of participating companies, the performance data from one company was arbitrarily assigned a value of 100, and the data from the other companies is expressed relative to this. Significance was declared at the $P < 0.05$ level.

Results and Discussion.

Starter program had a modest effect on performance (Table 1). However, when examined within specific phases (data not shown), no specific program outperformed the others. There were no starter program by weight group interactions, meaning that a starter program did not elicit an improvement within specific weight groups. Feed cost per pig or per kg of gain did differ between feeding program. Feed costs were based on information provided by the collaborating feed companies and was intended to reflect the price charged to a customer for this program.

As mentioned above, the objective of this experiment was to determine if differences exist among commercial starter programs in terms of their impact on variability at nursery exit (not to determine the "best" commercial starter program, nor examine specific nutrients which impact pig growth during the nursery phase). Although weight group had an effect on CV at nursery exit, starter program had no effect on uniformity. Moreover, there were no interactions of starter program by weight group, implying that within a specific weight group, no starter program consistently improved uniformity.

Implications

Within every weaning group there are some very lightweight pigs. Uniformity at nursery exit will be improved if we can specifically increase the growth rate of these pigs. The effect of starter program was not specific for any

Soluble and Insoluble Non-Starch Polysaccharides on Digesta Passage Rate and Voluntary Feed Intake of Grower Pigs

A. Owusu-Asiedu[1], J.F. Patience[1], B. Laarveld[2], P.H. Simmins[3], and R.T. Zijlstra[1]

Summary

The effects of purified non-starch polysaccharide (NSP) fractions (soluble, guar gum (SOL) and insoluble, cellulose (INSOL)) NSP fractions on digesta passage rate, retention time and voluntary feed intake was studied in grower pigs. Compared to control, adding SOL+INSOL increased digesta viscosity, slowed digesta flow rate and increased retention time in the total tract. Voluntary feed intake and daily weight gain reduced with SOL+INSOL NSP, compared to pigs fed the control diet. Reduction in voluntary feed intake associated with feeding high fibrous diet in pigs may be a direct effect of the fibre fractions slowing the flow rate of digesta through the gastrointestinal tract. Thus, reducing the negative effects of soluble and insoluble NSP may enhance feed intake and improve grower pig performance.

Introduction

The use of alternative non-conventional feed ingredients to supplement and/or as a substitute to conventional feed ingredients in pig ration can be attractive economically. However, voluntary feed intake and feed utilization of pigs may be compromised due to broad range of NSP present in the cell walls of plant-based feedstuffs. Non-starch polysaccharides are not digestible, and in certain cases, may act as anti-nutrients due to the lack of appropriate digestive enzymes. The mechanism for the reduction in voluntary feed intake associated with feeding fibrous ingredients is complex and poorly understood. To reduce negative effects of NSP on voluntary feed intake, the physical and chemical characteristics of NSP and the physiological changes occurring in grower pigs due to NSP fractions need to be understood. The hypothesis that reduction in voluntary feed intake associated with feeding high fibrous diets to grower pigs may be directly relate to the NSP fractions (soluble or insoluble) altering digesta passage rate through the gut was tested.

Experimental Procedure

Twelve grower pigs fitted with ileal T-cannula were used in a two-period change-over design, providing 3 pigs/

diet/period in the first trial. Experimental period was 18 d: a 13-d acclimation to the experimental diet, a 2-d faeces sampling, a 2-d digesta collection for passage rate and a 1 d blood sampling for plasma glucose and ghrelin levels. Experimental diets were; 1) corn-soybean meal diet with 14% cornstarch, as a purified carbohydrate source (**control**); 2) control diet with 7% soluble NSP (**SOL**); 3) control diet with 7% insoluble NSP (**INSOL**); and 4) control with 7% soluble + 7% insoluble NSP (**SOL+INSOL**), with purified NSP fraction replacing cornstarch at a 1:1 ratio. The control diet was formulated to 3.5 Mcal DE /kg and 2.4 g Dlys/Mcal DE and diets were fed at 3 x maintenance based on the control diet. In trial two, 20 individually housed pigs (5 pigs per treatment) were randomly

Figure 1. Fibre fractions on ileal digesta viscosity

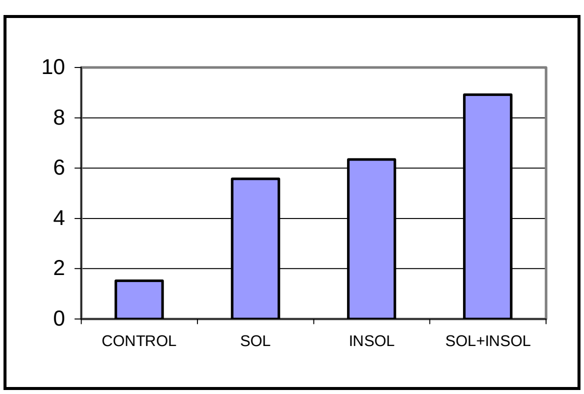
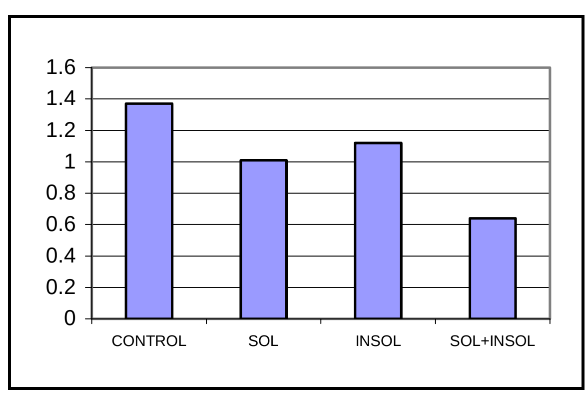


Figure 2. Fibre fractions on ileal digesta passage rate in grower pigs



[1]Prairie Swine Centre Inc. Saskatoon, SK, [2]University of Saskatchewan, Saskatoon, SK, [3]Danisco Animal Nutrition, Marlborough, UK

assigned to one of four dietary treatments in a 14-d performance trial. Pigs had free access to feed and water daily, and weight gain and feed disappearance were recorded weekly.

Results and Discussion

Addition of SOL and INSOL NSP increased digesta viscosity from 1.52 to 8.92 centipoids, while digesta passage rate decreased from 1.37 to 0.64 %/h, indicating that less digesta flow through the gut with addition of NSP (Fig. 1 and 2). Total tract mean retention time based on initial appearance of ferric oxide in feces was highest for SOL-fed pigs (Figure 3). Plasma glucose reduced by SOL+INSOL prior to morning feeding, but not after feeding, while plasma ghrelin level was highest for SOL and INSOL but not for the control or SOL+INSOL-fed pigs (Fig. 4). Average daily feed intake and daily weight gain decreased with addition of SOL and INSOL NSP, compared to the control diet (Figure 5).

The above studies indicate that purified soluble and insoluble NSP are not inert in the gut and that, individually, or in combination act to increase intestinal viscosity and reduced the flow of digesta through the gastrointestinal tract, thereby reducing voluntary feed intake.

Bottom Line

Both purified soluble and insoluble NSP slowed digesta passage rate and increased total tract retention time in grower pigs, resulting in reduced voluntary feed intake. Reducing the negative effect of dietary NSP by either addition of enzyme or processing may

Figure 3. Fibre fractions on digesta retention time based on initial appearance of ferric oxide in faeces

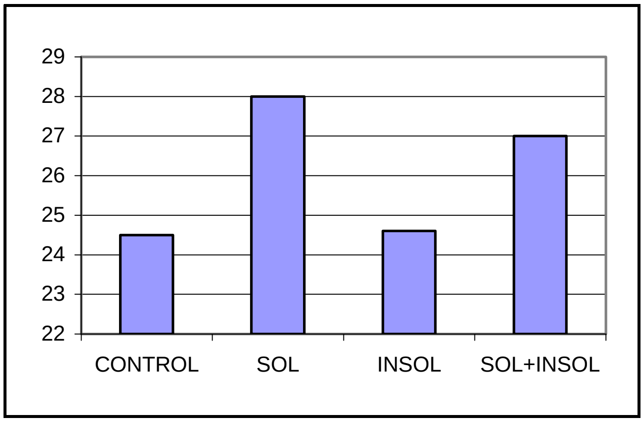


Figure 4. Fibre fractions on plasma ghrelin levels

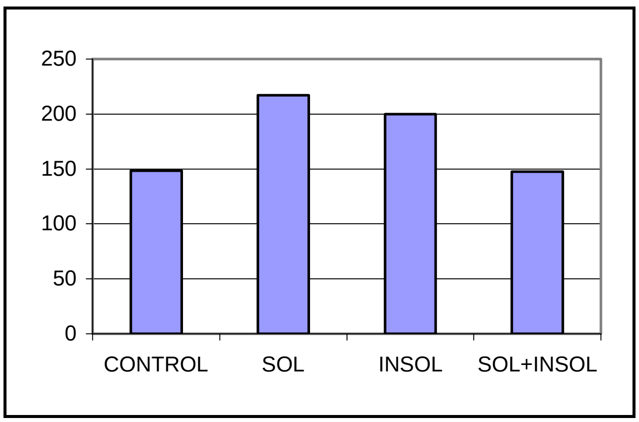
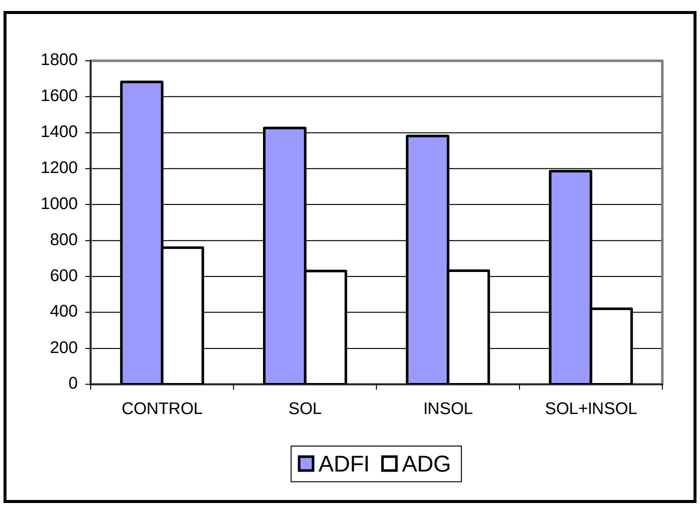


Figure 5. Fibre fractions on daily feed intake and weight gain in grower pigs



Soluble and Insoluble Non-Starch Polysaccharides on Nutrient Digestibility and Ilieal Bacteria Populations in Grower Pigs

A. Owusu-Asiedu[1], J.F. Patience[1], P.H. Simmins[2], A.G. Van Kessel[3], and R.T. Zijlstra[1]

Summary

Soluble (SOL) and insoluble (INSOL) NSP may influence gut bacteria populations, reflecting changes in fermentable material in the gut. Effects of purified (SOL, guar gum; INSOL, cellulose) NSP fractions on ileal bacteria populations and energy digestibility were studied. Pigs surgically fitted with an ileal T-cannula were fed four experimental diets (14% cornstarch basal [control]; 7% SOL NSP [SOL]; 7% INSOL NSP [INSOL]; and 7% SOL+7% INSOL NSP [SOL+INSOL]). Diets were fed for 13 d, ileal digesta was collected under CO_2, and bacteria were cultured on selective media. Overall, NSP increased bacteria counts except for Bifidobacteria. Compared to control, addition of soluble and insoluble NSP reduced energy digestibility from 73 to 39% in the ileum, but only marginally across the total tract. Increasing dietary purified soluble and insoluble NSP reduces nutrient digestibility and subsequently, increases the amount of fermentable dry matter in the small intestine, thereby providing further substrate for ileal bacteria proliferation in grower pigs.

Introduction

Several factors influence microbial growth and its metabolic turnover. Apart from body temperature, which provides optimal growth condition, microbial growth depends on the presence of substrate to be metabolized. The substrate further depends on the number of meals, the composition, structure and technological treatment of the diets, and endogenous digestion processes. Digestion process in the upper part of the gut, digesta flow rate and retention time may influence gut microbial processes. Dietary fibre is usually an integral part of swine diets. An increase in dietary fibre is directly related to a reduction in the amount of available nutrients and energy for the pig. The decrease in nutrient digestibility will increase the amount of undigested organic matter present in the ileum, and subsequently influence ileal microflora populations.

Experimental Procedure

Twelve grower pigs fitted with an ileal T-cannula were used in a two-period

Figure 1. Fibre fractions on energy digestibility

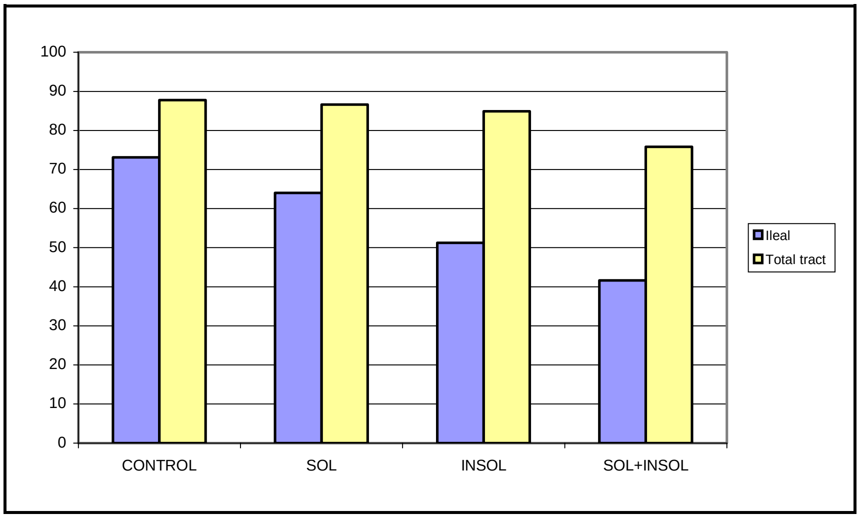
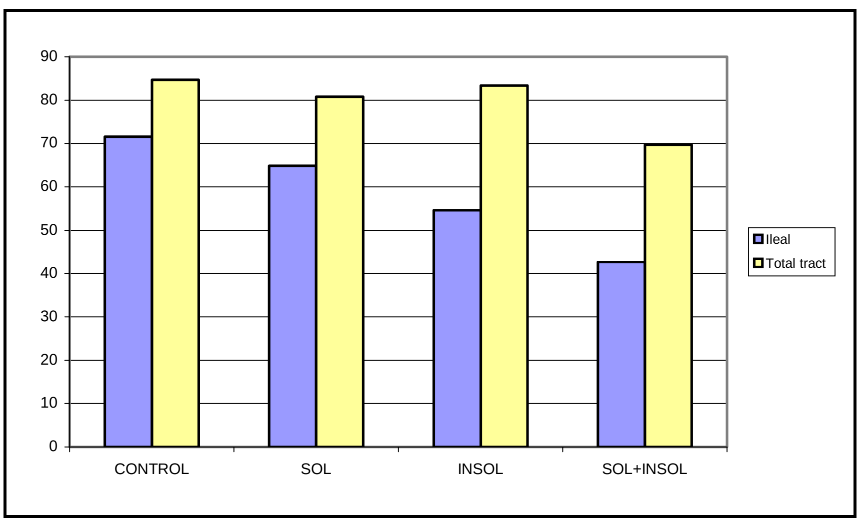
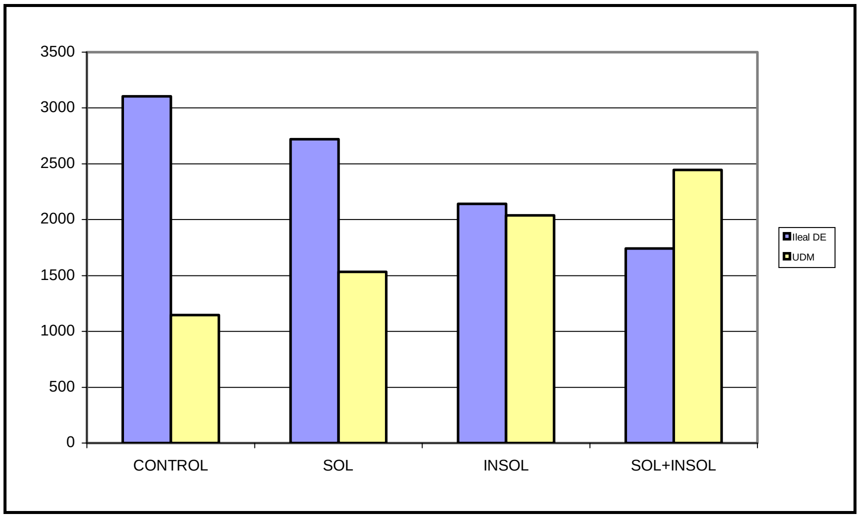


Figure 2. Fibre fractions on crude protein digestibility



[1]Prairie Swine Centre Inc. Saskatoon, SK, [2]Danisco Animal Nutrition, Marlborough, UK, [3]University of Saskatchewan, Saskatoon, SK

Figure 3. Fibre fractions on ileal DE and UDM



change-over design, providing 6 pigs per treatment. Pigs were fed experimental diet for 18 d, a 2-d faecal sampling and a 3-d digesta collection for microbial and nutrients digestibility assays. Experimental diets were; 1) corn-soybean meal diet with 14% cornstarch, as a purified carbohydrate source (**control**); 2) control diet with 7% soluble NSP (**SOL**); 3) control diet with 7% insoluble NSP (**INSOL**); and 4) control with 7% soluble + 7% insoluble NSP (**SOL+INSOL**), with purified NSP fraction replacing cornstarch at a 1:1 ratio. The control diet was formulated to 3.5 Mcal DE /kg and 2.4 g Dlys/Mcal DE, and diets were fed at 3 x maintenance based on the control diet.

Results and Discussion

Addition of soluble and insoluble NSP reduced ileal and total-tract energy and crude protein digestibility (Fig. 1 and 2). The ileal DE content decreased with addition of soluble and insoluble NSP, while the amount of undigested organic matter available for microbial fermentation increased with addition of SOL and INSOL NSP (Fig. 3). Lactobacilli, Clostridia, Enterococci and Enterobacteria populations were highest for pigs fed SOL + INSOL compared to pigs fed the control diet (Table 1).

Decreased in protein and energy digestibility was due to replacing high digestible carbohydrate with poorly degradable NSP, indicating increased availability of protein and energy in the ileum for the microbes, thereby creating a fertile environment for bacterial to colonize and proliferate readily. In addition, the increase in ileal bacteria populations may be related to increased viscosity associated with adding soluble and insoluble NSP to the diet. High viscosity reduces the interaction between substrate and digestive enzyme, and may reduce the effective absorption of nutrients and subsequently increased organic matter for microbial growth.

Table 1. Effect of fibre fractions on ileal bacteria populations

Bacteria, log_{10} cfu/g digesta	Control	SOL	INSOL	SOL+INSOL	SEM
Total anaerobes	7.87^{a}	8.12^{ab}	8.00^{ab}	9.02^{b}	0.27
Total aerobes	7.69^{a}	8.16^{ab}	7.74^{a}	8.91^{b}	0.30
Lactobacilli	7.58^{ab}	8.07^{ab}	7.43^{a}	8.68^{b}	0.34
Bifidobacteria	7.04	7.89	7.12	7.70	0.29
Clostridia	6.75^{a}	7.39^{ab}	6.43^{b}	7.89^{b}	0.39
Enterococci	7.39^{a}	7.55^{ab}	7.57^{ab}	8.63^{b}	0.33
Enterobacteria	7.12^{a}	7.13^{a}	7.46^{ab}	8.61^{ab}	0.27

SOL = soluble, INSOL = insoluble, SEM = standard error of the mean
^{ab}Means within a row with different superscript letter differ ($P < 0.05$).

Implications

Supplementing high NSP containing diets with NSP degrading enzyme may enhance fibre degradation in the ileum and subsequently improved nutrient digestion and absorption. Also, gut microbial population can be altered by

Digestible Energy Content of Low Quality Barley Fed to Pigs

E.J. Clowes[1], R.T. Zijlstra, D. Overend[2], J.F. Patience, P.H. Simmins[3], and M. Blair[4]

Summary

Current equations may not estimate the digestible energy (DE) content of low quality barley. In this experiment, equations were developed using barley's chemical and physical characteristics to accurately predict the DE content of low quality barley. The best equation explained up to 6% of the variation in barley DE content.

Introduction

The DE content of Western Canadian barley has a large range (637 kcal/kg DM). Being able to predict DE content is essential to accurately formulate diets, reach a predictable swine performance, and minimize feed costs. Current equations that predict barley DE content:

1. do not reflect the DE content of very low quality barley (DE content < 2,984 kcal/kg DM),
2. may not give accurate results to the swine and feed industry, because these were developed using a analytical lab different than the lab used by the swine and feed industry.

Barley from the 2002 Western Canada harvest was used, because much of this harvest was of low quality due to poor weather conditions.

Experimental Procedures

Chemical and physical characteristics of 21 barley samples collected in Saskatchewan were measured in a commercial laboratory (Norwest Labs, Lethbridge, AB). An total tract energy digestibility study was conducted collecting six DE measurements per barley sample, using 63 crossbred barrows (initial weight: 33 kg). Pigs were housed in individual pens for 30 days, starting with a 10-day acclimation to a 96% barley diet followed by two consecutive 10-day periods feeding different experimental diets. Each 10-day period comprised of a 5-day adaptation and a 5-day feces collection. Daily feed allowance was adjusted to three times maintenance.

Results and Discussion

Barley grain chemical and physical characteristics are listed in Table 1. Higher (1 to 2 % units) acid detergent fibre (lignin + cellulose), and lower field test weights (-30%) than previously recorded were measured, and the DE content of 3 samples was lower than previously recorded (< 2,984 kcal/kg DM). The new prediction equations

Table 1. Chemical and physical characteristics of the 21 barley grain samples

	Mean	SD	CV	Lowest	Highest
Physical Characteristics					
Field test weight, kg/hL	55.00	7.20	13.1	31.5	66.1
Clean test weight, kg/hL	56.10	6.60	11.7	35.1	66.8
Dockage, %	1.72	1.12	65.2	0.26	4.10
Moisture, %	13.80	1.60	11.5	10.2	17.9
Chemical characteristics on a DM Basis[a]					
DE, kcal/kg					
Measured	3136	229	7.3	2316	3428
Calculated using Fairbairn et al. (1999)	3153	157	5.0	2674	3330
Reported by Northwest	3721	75	2.0	3500	3840
Crude protein, %	13.70	1.40	10.5	10.0	16.4
Acid detergent fibre, %	6.79	1.52	22.4	4.50	11.4
Neutral detergent fibre, %	26.2	2.90	11.1	21.9	35.1

[a] All chemical analyses were conducted at Norwest Labs, Lethbridge

[1]Alberta Agriculture Food and Rural Development, Edmonton, AB [2]Ridley Inc., Mankato, MN
[3]Danisco Animal Nutrition, Marlborough, UK [4]Adisseo, Alpharetta, GA

Table 2. Barley DE (kcal/kg DM) prediction equations[a]

No.	Equation	R^2
1	DE = 4,054 (± 107) – 135.2 (± 15.3) x ADF	0.80
2	DE = 3,542 (± 206) – 138.8 (± 13.3) x ADF + 39.3 (± 14.1) x CP	0.86
3	DE = 4,796 (± 286) – 63.3 (± 10.8) x NDF	0.64
4	DE = 3,388 (± 560) + 14.2 (± 5.08) x test wt - 39.4 (± 12.6) x NDF	0.75
5	DE = 2,927 (± 516) + 13.7 (± 4.40) x test wt – 43.6 (± 11.0) x NDF + 43.8 (± 16.6) x CP	0.82

[a] Test wt (kg/hL) were measured "as is", all other grain characteristics were measured on a DM basis

explained up to 86% of the data's variability (Table 2), and more accurately predict the DE content of low quality barley than regular laboratory reports (Figure 1), because the DE content reported by the commercial laboratory were higher than our measured DE values. The equation by Fairbairn et al. (1999) estimated the measured DE content based on ADF (R^2 = 0.75), but was not as accurate as the new equations presented here.

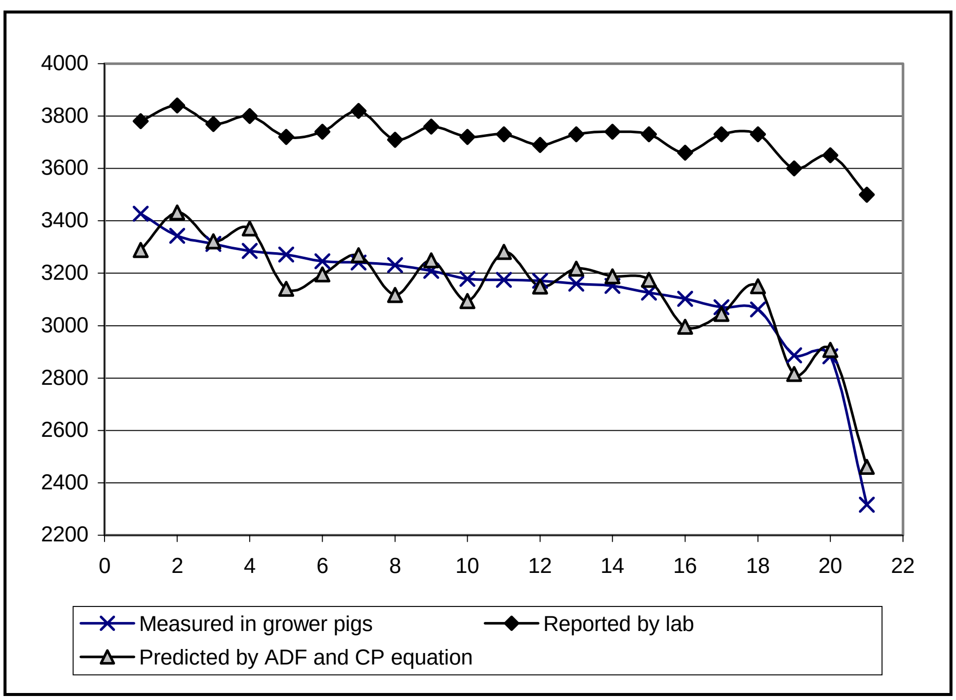
Conclusion

New equations to predict barley DE were created, using chemical characteristics measured in a commercial lab, that explain a large proportion of the variability in barley DE content. Such an index of barley DE content will allow barley to be more effectively utilized in swine diets.

Acknowledgements

Strategic program funding by Sask Pork, Alberta Pork, Manitoba Pork Council, and Saskatchewan Agriculture Food and Development Fund. Other project contributors: Danisco Animal Nutrition, Adisseo, 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.

Figure 1. Comparison of DE Values by analysis, ADG equation and actual pig response



Effect of Barley Sample, Particle Size and Enzyme Supplementation on Energy Digestibility of Barley Fed Grower Pigs

T.N. Nortey[1,2], R. Hawkes[1,2], D. Overend[3], M.D. Drew[2], J.F. Patience[1], M. Blair[4], and R.T. Zijlstra[1]

Summary

The feed processing procedures grinding and enzyme supplementation were tested to reduce the existing variability in DE content of barley. Particle size reduction but not enzyme supplementation increased energy digestibility of barley and partially reduced the variation in energy digestibility.

Introduction

The DE content of Western Canadian barley has a large range. The variation in DE content of barley is caused by changes in energy digestibility. Specific processing procedures, for example, reduced particle size using grinding and supplementation of enzymes that degrade ingredient factors that limit energy digestibility (fibre) may hypothetically increase energy digestibility and thereby reduce the variation. This hypothesis was tested using three barley samples that were selected based on their ADF content, specifically 5.7, 8.1, and 11.4% ADF for B1, B2, and B3, respectively.

Experimental Procedures

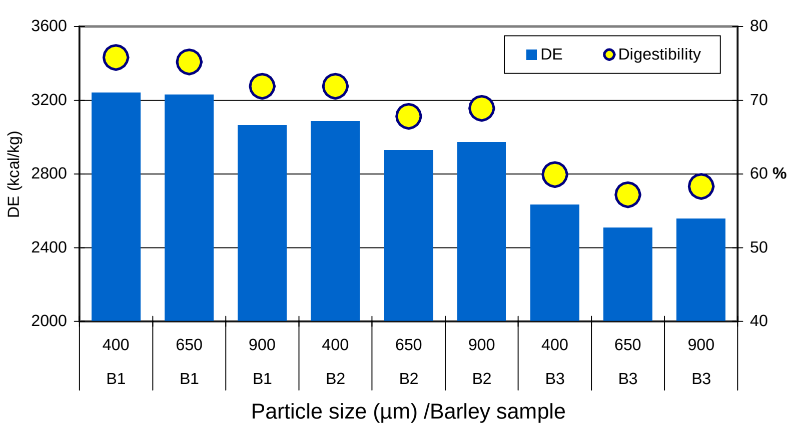
Three barley samples (B1, high; B2, medium and B3, low predicted DE), three particle sizes (fine, 400 mm; medium, 650 mm and coarse, 900 mm), and two enzyme treatments (control and 500 U ß-glucanase per kg diet plus xylanase) were tested in a 3 x 3 x 2 factorial arrangement. Grower pigs were fed two different diets containing 96% barley in subsequent periods for 6 observations per diet. Feed and collected faeces were analyzed for gross energy, dry matter, and chromic oxide to determine apparent total-tract energy digestibility and DE.

Results and Discussion

Energy digestibility was affected by barley sample ($P < 0.001$), particle size ($P < 0.001$), and a barley sample x particle size interaction ($P < 0.05$). But unlike previous studies, energy digestibility was not affected by enzyme supplementation ($P > 0.10$).

The diet DE content for B1, B2 and B3 were each different ($P < 0.001$; 3180, 2997 and 2567 kcal/kg DM, respectively). The reduced DE contents for B2 and B3 thereby confirmed the predicted ranking based on increased ADF content, and was correlated to reductions in energy digestibility ($P < 0.001$; 74.3, 69.5 and 58.5%, respectively).

Figure 1. Effect of barley sample and particle size on DE and energy digestibility (%)



Overall, the DE content for fine was 3.4 and 4.2% higher than for medium and coarse particle size ($P < 0.001$; 2988, 2891 and 2866 kcal/kg DM, respectively). The reduced DE contents for medium and coarse particle size were correlated to reductions in energy digestibility ($P < 0.001$; 69.2, 66.7 and 66.4%, respectively). Energy digestibility was similar for barley sample B2 ground finely and barley sample B1 ground coarsely, suggesting that reducing particle size for medium DE barley may reduce variation in DE content (Figure 1).

The lack of enzyme response suggests that ß-glucans or xylans did not cause the reduced DE content for barley samples B2 and B3.

Conclusion

Prediction of barley quality prior to processing and subsequent adjustments in processing may be components in a decision model to achieve a

[1]Prairie Swine Centre Inc. Saskatoon, SK, [2]University of Saskatchewan, Saskatoon, SK, [3]Ridley Inc., Mankato, MN, [4]Adisseo, Alpharetta, GA

Effect of Wheat Sample, Particle Size and Xylanase Supplementation on Energy Digestibility of Wheat Fed to Grower Pigs

R.T. Zijlstra[1], T.N. Nortey[1,2], D. Overend[3], R. Hawkes[1,2], M.D. Drew[2], J.F. Patience[1], and P.H. Simmins[4]

Summary

The feed processing procedures grinding and enzyme supplementation were tested to reduce the existing variability in DE content of wheat. Particle size reduction and xylanase enzyme supplementation increased energy digestibility of wheat and partially reduced the variation in energy digestibility.

Introduction

The DE content of Western Canadian wheat has a large range. The variation in DE content of wheat is caused by changes in energy digestibility. Specific processing procedures, for example, reduced particle size using grinding and supplementation of enzymes (xylanase) that degrade ingredient factors that limit energy digestibility (fibre) may hypothetically increase energy digestibility and thereby reduce the variation. This hypothesis was tested using three wheat samples that were selected based on their NDF content, specifically 20.1, 29.3, and 35.7% NDF for W1, W2, and W3, respectively.

Experimental Procedures

Three wheat samples (W1, high; W2, medium and W3, low predicted DE),

three particle sizes (fine, 400 mm; medium, 650 mm and coarse, 900 mm), and two enzyme treatments (control and 2625 U *Trichoderma* xylanase per kg diet) were tested in a 3 x 3 x 2 factorial arrangement. Grower pigs were fed two different diets containing 96% wheat in subsequent periods for 6 observations per diet. Feed and collected faeces were analyzed for gross energy, dry matter, and chromic oxide to determine apparent total-tract energy digestibility and DE.

Results and Discussion

Energy digestibility was affected by wheat sample, particle size, xylanase, sample x particle size, and sample x xylanase (P < 0.01).

The diet DE content for W1, W2 and W3 were each different (P < 0.001; 3694, 3412, and 3368 kcal/kg DM, respectively). The reduced DE contents for W2 and W3 thereby confirmed the predicted ranking based on increased NDF content, and was correlated to reductions in energy digestibility (P < 0.001; 85.1, 77.4 and 76.7%, respectively).

Overall, energy digestibility for fine was 2.3 and 3.0% higher than for medium and coarse (P < 0.001; 81.1, 79.3 and 78.7%, respectively). Fine improved energy digestibility 4.8% for W2 and 3.8% for W3 compared to CPS (P < 0.01), but not for W1 (P>0.10), see Figure 1.

Energy digestibility was 0.9% higher for xylanase than for control (P < 0.01). Xylanase improved energy digestibility 2.0% for W2 and 1.4% for W3 (P < 0.01), but not for W1 (P > 0.10).

Together, these results indicate that beneficial effects of processing depended on wheat sample.

Conclusion

Prediction of wheat quality prior to processing and subsequent adjustments in processing may be components in a decision model to achieve

Figure 1. Effect of wheat sample and particle size on DE and energy digestibility (%)

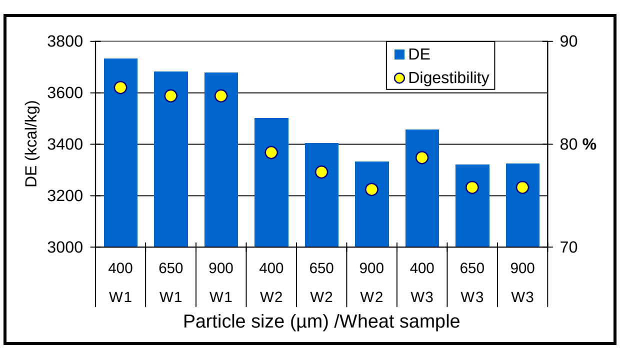
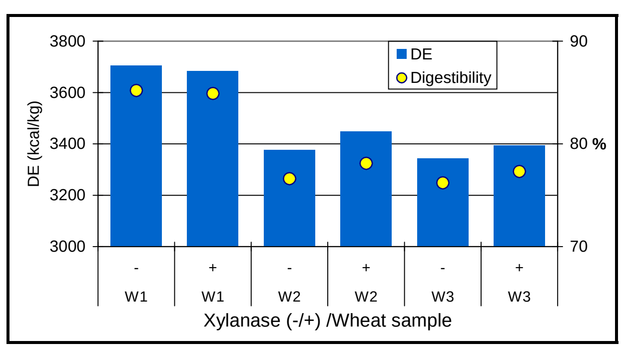


Figure 2. Effect of wheat sample and xylanase supplementation on DE and energy digestibility (%)



[1]Prairie Swine Centre Inc. Saskatoon, SK, [2]University of Saskatchewan, Saskatoon, SK, [3]Ridley Inc., Mankato, MN, [4]Danisco Animal Nutrition, Marlborough, UK

Voluntary Feed Intake and Growth Performance between Grower Pigs Fed Diets Containing Mustard Meal or Canola Meal

R.T. Zijlstra[1], D.R. Hickling[2], and J.F. Patience[1]

Summary

A sample of either mustard meal (Brassica juncea) or regular canola meal was included at 15% in diets fed to grower pigs for 28 days. Pigs fed mustard meal tended to have a 5% better growth performance and had a 2.5%-unit better feed efficiency and an equal feed intake than pigs fed canola meal. Mustard meal might thus be a good opportunity ingredient with minimally a nutritional value equal as canola meal.

Introduction

Mustard meal might be a valuable ingredient for the swine industry domestically and internationally. In some export markets, concerns exist regarding the voluntary feed intake of pigs fed mustard instead of canola meal in their diets. This study therefore compared two diets with either mustard meal or canola meal in the diet at a 15% inclusion rate, which is an inclusion rate that should allow to assess if the feed intake concerns are indeed valid, or not and if growth performance differences exist.

Table 1. Analyzed nutrient content of mustard and canola meal

Nutrient, % as fed	Mustard Meal	Canola Meal
Moisture	7.2	9.9
Ash	7.3	7.0
Crude Protein	42.4	39.0
Acid Detergent fibre	11.4	17.0
Neutral detergent fibre	18.8	27.8
Crude fibre	7.7	11.4
Crude fat	1.4	2.5

Experimental Procedures

A diet containing 15% canola meal was formulated based on 48% corn, 17% soybean meal and 15% wheat was formulated to 3.45 Mcal DE/kg and 2.60 g apparent digestible lysine/Mcal DE. Replacing canola meal 1:1 with mustard meal created a diet containing 15% mustard meal. The pelleted diets were each fed for 28 days to grower pigs housed 5 pigs per pen.

Results and Discussion

The standard chemical characteristics of mustard meal and canola meal are listed in Table 1.

For each of the four weeks of the experiment, voluntary or average daily feed intake of the grower pigs increased gradually, and differences in voluntary feed intake were not observed between pigs fed mustard meal or canola meal (Table 2).

For the first three weeks of the experiment, average daily gain and feed efficiency did not differ statistically between pigs fed mustard meal or canola meal ($P > 0.10$). However, pigs fed mustard meal grew 17% more and had a 6-% unit higher feed efficiency during the last week of the experiment ($P < 0.05$), resulting in an overall tendency for pigs fed mustard meal to grow faster than pigs fed canola meal.

Based on these results for feed intake and gain, mustard meal had a higher content of digestible nutrients than canola meal.

Table 2. Voluntary feed intake and growth performance of grower pigs fed either mustard or canola meal

Variable	Mustard Meal	Canola Meal
Average daily fed intake (g/d)		
Day 1-7	1,744	1,780
Day 8-14	1,892	1,937
Day 15-21	1,960	1,979
Day 22-28	2,163	2,129
Total: Day 1-28	1,940	1,956
Average daily gain (g/d)		
Day 1-7	981	1,001
Day 8-14	861	872
Day 15-21	947	889
Day 22-28	964[a]	825[b]
Total: Day 1-28	939[A]	897[B]
Feed efficiency (%)		
Day 1-7	55.9	56.3
Day 8-14	45.4	44.9
Day 15-21	48.4	45.4
Day 22-28	44.6[a]	38.8[b]
Total: Day 1-28	48.5[a]	46.0[b]

[1]Prairie Swine Centre Inc. Saskatoon, SK, [2]Canola Council of Canada, Winnipeg, MB

Starch Content and in Vitro Digestibility of Barley and Wheat Samples Differing in Fibre Content

R.T. Zijlstra[1], J. Fledderus[2], and M.D. Drew[3]

Summary

Starch content and in vitro starch digestibility were measured in three barley and three wheat samples differing in fibre content. Starch content was positively and fibre content was negatively related to DE content; however, in vitro starch digestibility indicated that starch was rapidly-degradable for all samples.

Introduction

The DE content of Western Canadian barley and wheat has a large range. The variation in DE content of barley and wheat is caused by changes in digestibility of energy. Starch is the main source of energy in cereal grains, and starch content differs among samples of barley and wheat, although it is the changes in fibre content that are mostly associated with the changes in energy digestibility. Apart from energy digestibility measured as a percentage at certain points of the gastro-intestinal tract (ileum or total-tract), rates of starch digestibility might also be important to achieve consistent protein deposition rates. Kinetics of starch digestion or degradation might be related to fibre content of cereal samples. The hypothesis was tested using three barley and wheat samples differing in fibre content.

Experimental Procedures

Three barley samples and three wheat samples differing in fibre content were tested for chemical characteristics, DE content, and also in vitro starch digestibility using the analysis developed by Schothorst Feed Research.

Results and Discussion

In vitro starch digestibility as a percentage did not differ among the three barley or the three wheat samples (Figure 1). The results suggest that starch in each of the samples was rapidly-digestible or rapidly-degradable. The DE content of the barley and wheat samples was measured in a total-tract energy digestibility experiment with grower pigs using 96-% cereal diets.

Starch, acid-detergent fibre (ADF), neutral-detergent fibre (NDF), and DE content differed among the cereal samples (Table 2), but crude protein (CP) content did not. These results suggest that the measured DE content was positively related to starch content and negatively related to fibre content.

Conclusion

Although fibre and DE content differed among the barley and wheat samples, in vitro starch digestibility did not, suggesting that starch for regular barley and wheat samples differing in fibre content is all rapidly degradable. For these cereal samples, rate of starch digestion does therefore not have to be considered for practical diet formulations. This project does not exclude the possibility that rate of starch digestion is different among samples of cereal grains that, for example, differ in

Figure 1. In vitro degradation curves of barley and wheat samples

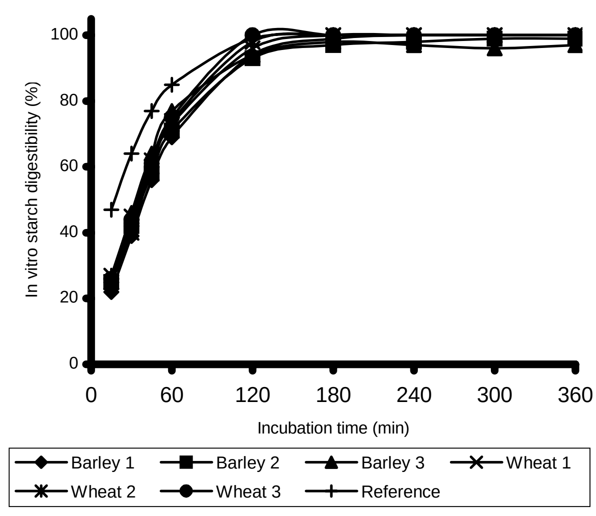


Table 1. Chemical characteristics of barley and wheat samples

Sample	Starch (%)	NDF (%)	ADF (%)	CP (%)	DE (Kcal/kg DM)
Barley					
1	48.6	22.1	5.7	13.6	3,180
2	45.5	22.0	8.1	12.8	2,997
3	40.8	32.0	11.4	12.8	2,567
Wheat					
1	54.1	20.1	3.2	19.4	3,694
2	46.1	29.3	4.1	18.8	3,412
3	43.6	35.7	6.0	19.7	3,368

[1]Prairie Swine Centre Inc. Saskatoon, SK, [2]Schothorst Feed Research B.V., Lelystad, The Netherlands, [3]University of Saskatchewan, Saskatoon,

Variation in Pig Performance: Can We Do Anything About It?

J.F. Patience, A.D. Beaulieu and H.W. Gonyou

Introduction

Variation is a cost to producers due reduced barn utilization and loss of revenue at market. As our barns become larger and more sophisticated in both design and in management, there is an increased focus on variation in pig performance. The implementation of all-in-all-out systems further directs attention to this topic, because the impact of variation on space utilization is much more obvious; in continuous flow barns, sorting at marketing tends to hide the problem.

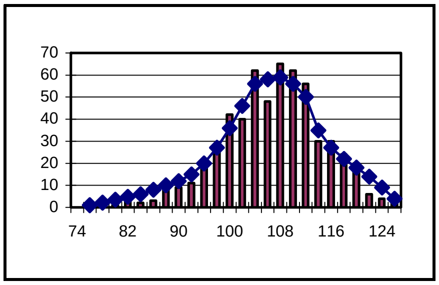
Measuring Variation

Statistically, variation can be defined in a variety of ways; the most common terms are standard deviation (SD) and coefficient of variation (CV). The SD is a measure of dispersion. The more dispersed the weights of pigs, the larger will be the standard deviation. In a normal distribution, 1 standard deviation about the mean will include 68.27% of the pigs in the total group. The CV is calculated by dividing the standard deviation by the mean, and multiplying by 100. Table 1 describes the statistics from groups of pigs at 3 different ages. The CV's shown in Table 1 would be typical of a well-managed herd. Figure 1 is an example of a bell curve of pig weights at 20 weeks of age. Clearly, these data do not show a perfect bell-shaped curve, but it is very close and reflects the range from "ideal" that is seen under commercial conditions.

Causes of Variation

There are many causes of variation, but fundamentally, they can be considered as being in one of two categories:

Figure 1. A plot of pig weights at 20 weeks of age showing the typical normal distribution or "bell" curve



genetic or environmental. Classical genetics defines the genetic make-up of an animal as its "genotype." Other sources of variation specific to an individual pig include birth weight, weaning weight, litter of origin, gender, and the parity of its dam.

In an ideal world, adverse environmental effects are eliminated, so that the performance of the pig reflects its fundamental genetic make-up. In reality, it would be extremely difficult to completely eliminate all negative effects of the environment; nonetheless, a key goal of management is to minimize their influence. Environmental effectors of variation include access to resources, including food and water, exposure to pathogens, and behavioural challenges, such as dominance hierarchy in dynamic and static housing circumstances.

Reducing the Impact Variation

The management practices that can be employed to reduce variation will depend on the size of the CV already existing in the barn. If CV is larger than normal (>15%), then it is likely that certain "resources" are limiting, and addressing these limitations will not only lower variation but probably also improve performance. However, when CV's are in the range of 8 to 12%, people have generally been frustrated in their attempts to further reduce variability.

An alternative approach is to segregate production in some manner. One option is to segregate barrows and gilts; because barrows eat more feed than gilts, they tend to reach market weight 5 to 7 days sooner than gilts. Another form of segregation involves separating a group of animals into two groups; in most instances, the smallest 10 or 15% of the pigs at weaning or nursery exit are split off into a separate barn, or sold altogether. Alternatively, large groups can be split into two, with the heaviest half in one group and the lighter half in the other.

Two research articles focused on vari-

Table 1. Measured variation in body weight at 3 ages within an unselected population.

	Age		
	19	68	140
No. of Pigs	1264	700	632
Weight, kg			
Mean	5.39	29.14	103.72
Median	5.40	29.10	104.4
Mode	5.40	30.95	98.1
Minimum	2.40	23.80	74.4
Maximum	9.20	40.90	124.9
Range	6.80	17.10	50.5
Range, % of mean	121	59	48
Standard Deviation, kg	1.21	3.74	8.31
Coefficient of variation, %	22.4	12.82	8.02

Body weights determined on whole groups of animals without pre-selection at weaning (19 days) nursery exit (68 days of age) and at 20 weeks of age before the first market pull. All were collected at the PSC Elstow Research Farm. The weights were collected at different times, so the three groups of pigs are not related to each other.

Pre-Planned Segregation: The Effect of Grouping by Weight at Weaning on Variability in Body Weight at Nursery Exit

J.F. Patience, A.D. Beaulieu, H.W. Gonyou and R.T. Zijlstra

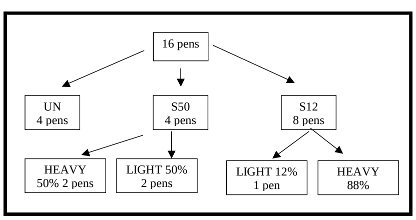
Summary

Variability in pig growth costs producers due to sort losses at marketing and reduced barn utilization. This experiment was designed to determine if pre-planned segregation (PPS), the separation of the total population of pigs into sub-groups expected to differ in performance, could improve barn utilization. A total of 2080 pigs, weaned over 8 weeks, were divided into groups based on weight at weaning. Segregation had no effect on variability of the entire group, or percentiles of the lightest or heaviest subsets of that group at d 50. Since it is expected that the rooms housing the heavier pigs would turn over more quickly, PPS could therefore be used to improve overall barn utilization.

Introduction

Variability in pig growth is emerging as a critical issue for pork producers. It has been estimated that variability costs Saskatchewan pork producers $3.41 per pig at market due to sort losses and an additional $1.25 per pig sold due to reduced barn utilization.

Figure 1. Treatment allocation for one room. The number of pigs per pen varied between weeks (15 to 18) but was constant within a week.



One option for managing variability is called "pre-planned segregation" or PPS. PPS is the separation of the total population of pigs into sub-groups expected to differ in performance. Under current operating methods, room throughput is dictated by the slower growing pigs. Segregating a heavier group allows the rooms housing these animals a faster turnover which will improve overall barn utilization is overall variability remains unaffected.

Objectives

1. To determine if PPS improves the uniformity of growth of the total population compared to contemporary pigs that remain in random weight groups.
2. To determine if the segregation of pigs by weaning weight will result in the faster growth of heavier pigs compared to contemporary pigs that remain in intact groups.
3. To determine if the segregation of pigs by weaning weight will result in the faster growth of lighter pigs compared to contemporary pigs that remain in intact groups.

Experimental Procedures

This experiment utilized all pigs (n=2080) farrowed over 8 weeks at PSC Elstow Research Farm Inc. Each week, all available pigs were weaned into one nursery of 16 pens. Genders were equalized across treatments, but not within pens. Pigs were weighed at weaning (d0) and on d9, 19, 29, 40 and 51.

The unsorted (UN) treatment represented the control. The sorted 50:50 (S50) treatment segregated the heavier half of the pigs from the lighter half. The sorted 12:88 treatment (S12) sorted the heaviest 88% of the pigs from the lightest 12% (Figure 1). The coefficient of variation (CV) was calculated within a room and for the lightest and heaviest 12th and 50th percentiles for each sorting regime.

Table 1. Initial and final (d50) body weights of the light and heavy subsets of the treatment groups.

	UN	S50 HV	S50 LT	S12 HV	S12 LT
Day 0 (kg)	5.82	6.86	4.93	6.31	4.16
Day 50 (kg)	31.17	33.55	29.15	32.35	26.77

Table 2. The effect of pre-planned segregation on bodyweight and CV for the entire data set, and the 12th and 50th lightest percentiles of each sorting regime

	Bodyweight (kg)		CV (%)	
	d0	d50	d0	d50
100th percentile				
UN	5.82	31.17	19.56	14.25
S12	6.04	31.70	19.96	14.15
S50	5.77	31.14	20.31	13.45
P value	*0.25*	*0.57*	*0.78*	*0.53*
12th percentile light				
UN	4.15	26.76	8.40	11.93
S12	4.16	26.77	7.63	12.49
S50	4.08	26.54	7.45	10.88
P value	*0.77*	*0.91*	*0.80*	*0.68*
50th percentile light				
UN	4.90	28.90	11.30	13.32
S12	5.07	29.17	12.35	12.54
S50	4.93	29.06	12.03	11.90
P value	*0.23*	*0.85*	*0.68*	*0.35*

Results

The initial and final bodyweights of the light and heavy subsets of each sorting treatment are shown in Table 1. The differences between the light and heavy groups were maintained through to day 50. The CV at day 50 was similar between sorting regimes. Moreover, the CV of the 12th or the 50th percentile at day 50 was similar regardless of whether 0 (unsorted), 12% or 50% of the pigs had been removed at weaning (Table 2).

Implications

Segregating pigs by weight at weaning

The Dose Response to Phytase Inclusion in Diets for Growing Swine

A.D. Beaulieu, R.T. Zijlstra, M. Bedford and J.F. Patience

Introduction

Most of the phosphorus (P) in grains and oilseeds used in swine diets is in the form of phytic acid which is unavailable to the pig and thus excreted into the manure. Inorganic P is usually added to swine diets to meet the animals' requirements, thus increasing diet cost. The phytase enzyme releases the P from the phytic acid, allowing the formulation of diets with less total P. Because the enzyme increases the amount of available P, the Ca concentration in the diet may need to be re-examined, since the Ca:P ratio is critical to the utilization of these minerals. Currently, we do not know the optimum Ca:P ratio to use in the presence of phytase.

This experiment was designed to:

1.Define the growth response of growing pigs to 4 levels of a unique, new, phytase enzyme.

2. Determine how critical the Ca: available P ratio is to optimizing the utilization of the phytase enzyme in practical swine diets.

Methods and Materials

Fifty-four barrows (40.3 ± 1.9 kg) were fed one of 18 different diets (5 levels of phytase plus a positive control, at 3 different Ca:P ratios) for a 28-day growth and digestibility experiment. The corn and soybean diets were supplemented with either 0, 250, 500, 1000, or 2000 U/kg of a novel phytase enzyme. The diets contained 0.38% total P, and either 0.50, 0.60, or 0.70% Ca. The estimated available P at the 0 level of phytase inclusion was 0.11%, which is below the requirement for pigs of this age. The positive control diet was formulated to contain sufficient dicalcium phosphate to meet the pigs' P requirement.

Results and Discussion

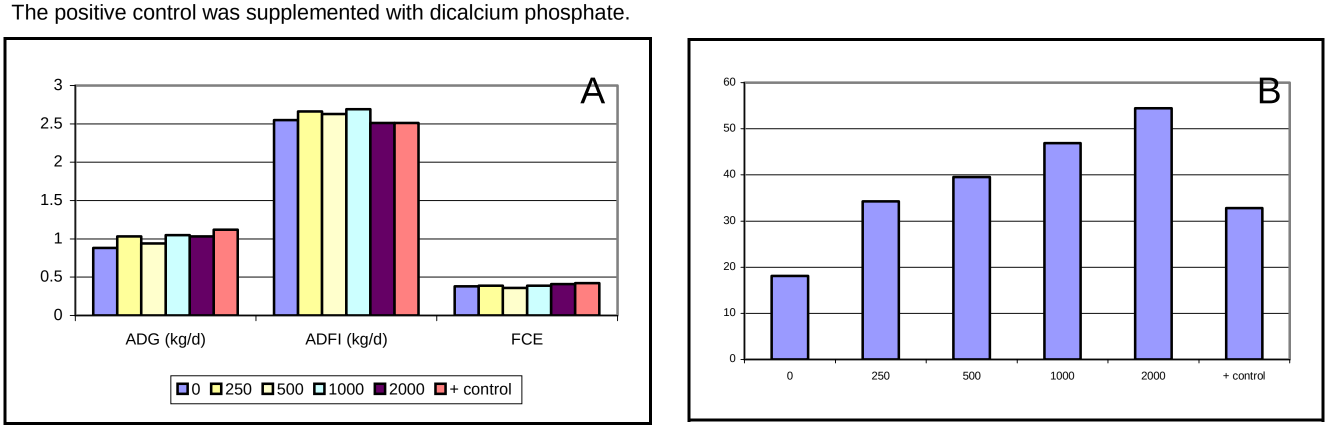
Neither performance (ADG, ADFI, feed conversion) nor P digestibility was affected by the Ca concentration in the diet ($P>0.1$; data not shown). This was surprising and will be investigated in future studies.

Although the inclusion of the phytase enzyme in the diet improved ADG, ADFI and feed efficiency ($P<0.05$); this improvement plateaued at about the 250 U/kg inclusion level (Figure 1A). Conversely P digestibility was improved linearly ($P<0.001$) with each increment of supplemental phytase (Figure 1B). This implies that each incremental increase in phytase addition improved P availability, however, beyond the 250 U/kg level, the pigs did not require or utilize this additional P.

Conclusions and Implications

The inclusion of 250 U/kg phytase into diets for growing swine allows the formulation of diets containing less total P without sacrificing performance. This results in less total P excreted into the manure. For example increasing the P digestibility of a diet from 18% (without phytase) to 54% (with phytase) would reduce P excretion in the manure from 7.4 g/d to 4 g/d. Moreover, reducing the P content of the manure also im-

Figure 1. The effect of supplementing corn-soybean diets with phytase on growth, feed intake, feed efficiency (A) and P digestibility (B). The positive control was supplemented with dicalcium phosphate.



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