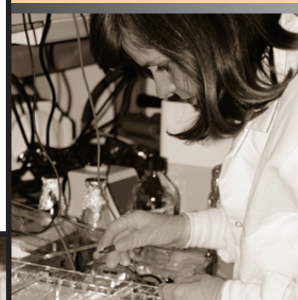
1999 ANNUAL RESEARCH REPORT

PRAIRIE SWINE CENTRE INC.



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GLOSSARY

A guide to some of the acronyms and terms in this publication

ADFI	average daily feed intake.
ADF	acid detergent fiber . A fibre fraction used to identify characteristics of a feedstuff.
ADG	average daily gain.
ad libitum	"at one's pleasure". In the context of feeders, a set up that allows the pigs access to feed as they want it.
AME	apparent metabolizable energy. This is measured only in poultry.
C	carbon
CP	crude protein.
DE	digestible energy.
EE	ether extract. A process to extract and measure fat content in a feedstuff.
GE	gross energy. Total amount of energy in a feedstuff. Not all is available to the animal. lysine an amino acid essential for growth. Cereal grains are generally poor in lysine.
N	nitrogen, a major component of the atmosphere and an essential plant nutrient. The chemical formula of its gaseous form is N_2.
NH_3	ammonia, a nitrogen compound found in household cleaners, commercial fertilizers and manure. Evaporates easily at relatively low temperatures.
NH_4	ammonium, a nitrogen compound found in commercial fertilizers and manure.
NO_3	nitrate, a nitrogen compound found in manure. Microrganisms convert NH_3 to NH_4 and NH_4 to NH_3. Nitrogen is readily available for plant uptake in both forms.
NDF	neutral detergent fiber. One fraction of total fibre found in a feedstuff.
NDIN	neutral detergent insoluble nitrogen. A fraction of total nitrogen found in feedstuff.
NIRS	near infrared reflectance spectroscopy. Uses wavelength of reflected light to determine chemical composition of a sample.
MVR	minimum ventilation rate
PID algorithm	proportional integral derivative algorithm. A mathematical tool used in engineering for control systems.
PRRS	porcine respiratory and reproductive syndrome. A viral disease characterized by late term abortions, stillbirths, piglets born weak, and respiratory signs in pigs of all ages.
R^2	amount of total variation that is explained.
RH	relative humidity
SEW	segregated early weaning
regression analysis	a standard statistical tool for comparing the relative behavior of two or more variables.
THC	temperature and humidity control
threonine	amino acid essential to growth and tissue maintenance
tryptophan	amino acid essential for growth and vitamin production in the body
µm	micrometre, or micron. Equivalent to one millionth of a metre. A human hair is 80 to 100 microns thick.

A YEAR OF CHALLENGE AND PROMISE

Jim Smith
Chairman of the Board

It was a year filled with promise and challenge. In 1999 every pork producer faced the lowest market prices in 35 years. This meant tightening the belt, postponing repairs and stock replacement and curtailing any expansion plans.

The Centre finishes over 6,000 pigs each year, and, like all pork producers, relies on favourable market conditions to thrive. The board was pleased with management in its ability to weather the storm. They eliminated and deferred in areas that maintained the integrity of the facility, its research and technology transfer programs.

During this period, staff stepped up efforts to deliver information through more documentation and meetings. This ensured individual pork producers could use the best technology available to reduce their costs. The *Survival Strategies Checklist** was probably the most useful publication we as pork producers received during the past year. The *Checklist* tips mean several dollars per pig in reduced costs and improved revenues. As market prices increase, these savings will give producers the tools to improve profits and retire debt as quickly as possible.

The most significant project for the year was the start of construction of the Elstow Research Farm. In the last 18 months this project has gone from a dream to a reality. This 600 sow commercial-like barn is a significant step for the Centre and for the western Canadian pork industry. This tripling of size will provide the capacity to answer questions of larger group sizes, including group housing of sows, welfare and environment. These questions could not be addressed with current facilities, which were designed and built in the late 1970s.

PSC Elstow Research Farm Inc. will provide the tools for researchers, technicians and graduate students to conduct leading edge research. The information gained will continue to be provided to all pork producers, both independent and those aligned with production systems. With Prairie Swine Centre, our industry ensures our technical production knowledge base is locally owned and operated and available to all.

In light of our industry's serious financial constraints over the past year, we have all looked closely at what we do. Effective businesses constantly review, and if required, reinvent themselves to meet the current needs of the marketplace. This is one area where the board feels the Centre does particularly well.

In the past two years, the Centre has conducted two reviews. In 1998, the Centre looked at industry needs before setting the priorities of the then proposed Elstow research farm. In 1999, the technology transfer program was examined. In both cases, a significant component was to meet with groups of pork producers and various service industry personnel. The purpose was to listen and hear, first-hand, what the industry is thinking.

The Prairie Swine Centre is supported by, and works for, the industry. We feel strongly that pork producers should have abundant opportunity to learn from and have input into the future direction and activities of the Centre.

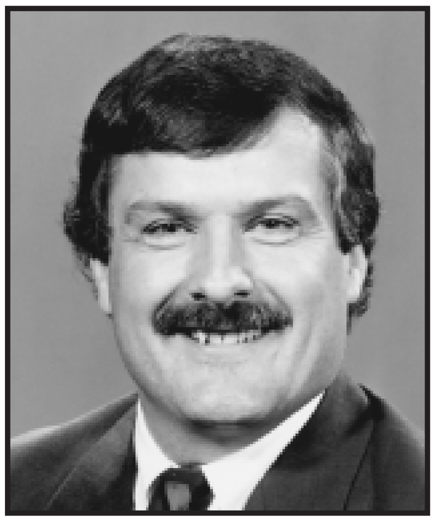
Our objectives continue to emphasize the needs of commercial pork producer. The results of the Centre's work will be available to all who contribute to the research through their provincial research check-off. We will do our best as a board to represent the interests of a growing pork industry for efficient and sustainable production bolstered by applied practical research.

* *The* Survival Strategies Checklist *is available online at the Centre Web site. Go to http://adminsrv.usask.ca/psci/ and follow the "Survival Strategies" link.*

MAINTAINING FOCUS IS CRITICAL IN A CHANGING INDUSTRY

Dr. John Patience
President

As everyone involved in pork production knows, the industry is changing. But few predicted the extent of this change so far, or how much more is yet to come. Everyone in the industry must therefore follow developments closely, and decide for themselves how best to react. The best strategy is likely to chart a course and be proactive rather than reactive.



During this past year, the Prairie Swine Centre undertook two very important initiatives, both of which were driven by change in our industry. The first was a review of our technology transfer program. Under the leadership of Lee Whittington, Manager – Information Services, meetings were held across the Prairie provinces to obtain feedback on current activities and to get ideas on new initiatives.

For example, gone is the Centre's trademark annual Satellite Conference. After five years of beaming into communities across Canada, the message was clear: producers prefer meetings with a more targeted agenda and with more face-to-face contact with our scientists. 2000 will therefore see the introduction of our new Focus on the Future Conference. This event will offer reports on the most recent research results from the Centre, with a few invited speakers to round out the program.

Another change is our Internet Web site. Rapid developments in Internet technology, and growing access to the Web have made it clear to us this is a technology transfer vehicle with tremendous potential. We expect 100 to 200 hits to our new site per week, an access rate that cannot be ignored. Other changes to our program will be announced in the coming months, as we move more to technology adoption as opposed to technology transfer. The other important initiative was the consultation process undertaken, again across the Prairies, to develop the research program for our new facilities under construction at Elstow, Sask. The objective was to ensure the research at Elstow was industry driven. By defining the program before designing the building, we ensured the research plan defined the building, rather than the other way around.

Speaking of Elstow, I would like to thank Saskatchewan Agriculture and Food for its support of this new facility. A $3 million construction grant and $300,000 a year for three years in new research funding will make PSC Elstow Research Farm Inc. a reality in 2000. This new 600 sow farrow-to-finish research unit includes an associated feed mill, manager's residence, off-site nursery and growout unit.

PSC Elstow will allow us to answer more questions, more quickly. For example, how does group housing of sows compare to gestation stalls? How can we formulate diets to lower the losses of nitrogen and phosphorus into the slurry? How much water is required for intensive pork production and are there ways of reducing overall water usage? How does chimney ventilation compare to side wall ventilation? These and other practical questions will be answered in the first few years of the barn's operation. Of course, much of the research will also focus on lowering the cost of production, as well as addressing questions related to animal welfare and the environment.
In addition to our own in-house research teams, other scientists will be able to use the Elstow facility as well. For example, the Department of Agricultural and Bioresource Engineering already has three studies underway, including defining the impact of an intensive pig unit on surrounding

soil, water and air quality. Another experiment will monitor the movement, if any, of water and nutrients from the slurry stored in earthen manure storage.

PSC Elstow will operate much like a commercial facility. The unit has been designed so revenues from the sale of stock can cover all operating costs and loan repayment. Like our current Floral facility, we believe that near-market research and overall herd productivity go hand in hand. Thus, Brian Andries, our Manager – Operations at Floral will use common industry benchmarks to compare herd performance with our own to see how we stack up to the commercial industry.

Finally, in a changing industry, maintaining a strong focus is critical to success. With so much movement, it would be easy to float with the prevailing currents, chase the latest fad, react to the current crises or focus on the hottest research topic. However, research is most effective when it is strategically planned, takes a longer view of the industry and most critically, emphasises industry input and reaction. To this end, I would like to thank the pork producers of Saskatchewan, Manitoba and Alberta, and the Saskatchewan Agriculture Development Fund for their continued financial and moral support of the Centre. The full list of current funding agencies is listed elsewhere in this Annual Report.

I must also acknowledge the central role of our staff that works so very well together to achieve our goals, and the Board of Directors whose members receive nothing other than reimbursed expenses for contributing in so many ways to our success.

PSC Elstow Research Farm Inc. in December, 1999. The new 600-sow farrow-to-finish operation was officially opened in March, 2000.

RECORD-SETTING PRODUCTION AND EXEMPLARY STANDARDS OF CARE

Brian Andries, B.Sc.
Manager-Operations

Production for this fiscal year, 1998-99, reached a new record for total numbers sold at 7,339. This compares to 6,476 animals for the previous year. An expansion of our farrowing capacity through funding from a contract research project allowed us to farrow out a test group of 80 gilts. This project did have some effect on farrowing rate, and litters per female per year. The project created a lack of space in the nursery room, so some open sows were not bred. All gilts were artificially inseminated, and cross fostering was not allowed at the time of farrowing. The effects of these can be seen in our production results.

Table 1. Production parameters for the 1997/1998 and 1998/1999 fiscal years

	1997/1998	1998/1999
Sows farrowed, #	698	784
Farrowing rate, per cent	90.8	87.4
Pigs born alive/litter	10.8	11.0
Litters weaned	686	776
Pigs weaned	6615	7767
Weaned/female inventory	23.9	24.2

Since PRRS (porcine respiratory and reproductive syndrome) was first introduced into the herd in 1997, we have carefully monitored residual effects through production performance in the breeding herd or nursery and grow-finish animals. We have continued to do testing on the entire herd to see if any new infections from PRRS are present. This primarily is done by blood sampling a percentage of animals entering grow-finish. As of yet all of these animals have tested negative for PRRS. The only animals at PSCI that are PRRS positive are a few older sows. We are blood sampling all sows to ensure their antibody levels remain relatively low. Any sows that test above a certain level are culled from the herd as they "may" pose a risk of infection.

The herd at PSCI may be considered as being nearly PRRS negative. As we will be using PSCI as a nucleus herd to populate PSC Elstow Research Farm Inc., we want to ensure all gilts going to the new facility are PRRS negative. We are randomly blood sampling all the gilts being bred at PSCI that will later be moved to PSC Elstow Research Farm Inc. So far, all of these gilts are PRRS negative.

For the 1998 calendar year, Prairie Swine Centre Inc. used 5,692 animals in the research program assigned to the University of Saskatchewan Assurance of Animal Care Forms. We had our annual inspection from the Canadian Council of Animal Care committee on May 5, 1999. They determined that all areas visited were well managed and that all animals were in excellent condition. They were particularly impressed with the new metabolic crates that were built on site by Garth McDonald under the supervision of Doctors Gonyou and Beltranena. The committee left with the recommendation that the Prairie Swine Centre Inc. be commended for our high standard of care for the animals. I congratulate my staff for this achievement.

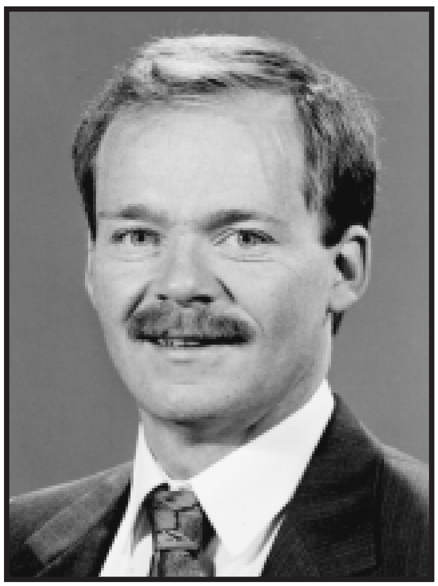
Over the last year, we have officially set up our Occupational Health and Safety Committee. Committee members have successfully achieved their Level I and II Occupational Health Training sessions and have also done facility inspections. All staff were involved in determining the safety of their workplace. It was a positive experience for all.

TECHNOLOGY TRANSFER PROGRAM GETS INDUSTRY GO AHEAD

Lee Whittington
Manager Information Services

Activity, in itself, does not guarantee success. Sometimes the best way to move forward is to stop.

With this in mind, in 1998-99 a questionnaire was mailed out with *Centred on Swine* and surveys were conducted at trade shows. A series of workshops were held across the Prairies — not to talk about new research, but to listen. Our purpose was to see how well current technology transfer activities were meeting the needs of pork producers and their suppliers.



Since establishing a technology transfer program in 1992, the Centre has mailed 105,000 copies of the quarterly newsletter *Centred on Swine*, 20,000 copies of the *Annual Research Report*, made hundreds of presentations at producer meetings, produced two books (*Swine Nutrition Guide, Ventilation Guide*), one software program (*GrowthMaster*), produced eight videos, broadcast five satellite conferences, published four fact sheets, participated in over 20 trade shows, and provided countless interviews and articles for magazines, newspapers and television. Most recently, the age of electronic communication has meant recreating our Web site established in 1995 to become a much larger, interactive and database-driven information source on pork production.

In keeping with our efforts to move from traditional technology transfer to technology adoption, the review conducted this year focused on identifying the most effective means of communication. The aim is not only to inform, but to encourage pork producers to adopt what they learn to improve net profit, reduce labour or add to the long term viability of their farms.

Producers and suppliers who answered the questionnaires gave us confidence that, for the most part, we were communicating often enough and in the right ways.

New ideas began to form early in the process, which culminated in a series of workshops where a new technology transfer program was proposed. During the one-day meetings, pork producers; consultants; veterinarians; feed, equipment, breeding stock, and major services providers all had their chance to critique and modify the proposal. In October 1999, the process was complete.

With our plans in place, we set about with new vigour to introduce new information to improve profits. This was a challenge, in an industry that had just had the worst setback in 30 years due to poor markets.

But change and adversity seem to invigorate the human spirit. During this period, contact with the industry increased and needs became more defined. Phone calls became more frequent and hits on the Web page jumped.

Some of the changes being implemented as a result of the review are:

- Hiring Ken Engele as Assistant Manager, Information Services to ensure prompt responses to information requests, and to give staff more opportunity to be in the field (or more accurately, the barn) detailing research results.
- Dropping the Satellite Conference in favour of more face-to-face meetings.
- Adding a new technical conference to allow in-depth presentations on applications of new research developed at PSC and elsewhere.
- Adding emphasis on working through veterinarians and other on-farm consultants to encourage early adoption of new technology.
- Providing additional details on research findings via a printed monograph available on most trials conducted at the Centre.
- Completely revise the *Annual Research Report* to create a document that is easier to read and addresses opportunities for adoption of each new management technique or technology discussed.

Publications such as *Centred on Swine* were rated very high in surveys recently conducted by the Centre and a third party report on pork producer's preferences. Look for minimal changes in the content, however, a modified format is under consideration.

A special thank you to all who participated in the review and renewal process and who sent us their suggestions for improvement. We hope you will enjoy the many changes to be implemented over the coming two years.

A Pig's Tale. Darla Andrews and Deanne Miller of the Manitoba Pork Council with PSCI's Lee Whittington at the live animal display "Touch the Farm" at the Red River Exhibition in Winnipeg.

ENVIRONMENTAL ISSUES RESOURCE CENTRE ONLINE

Ken Engele
Assistant Manager
Information Services

Larger production units and greater media attention are increasing public awareness of, and concern about, intensive livestock operations and their relationship with the environment.

This has created a need for a reliable, unbiased source of information that can be used by pork producers, policy makers, industry representatives and the public. The Environmental Issues Resource Centre (EIRC) was created to respond to this need. This online resource currently contains about 130 pages of information. A paper version is also available.

The Centre offers about 600 literature reviews on 14 environmental issues related to pork production. Topics covered include:

- siting
- odours
- gas emissions
- manure management
- nutrient management
- soils
- water
- dust in livestock buildings
- human health
- sociology
- noise
- dead-animal management
- traffic
- legislation
- regulation

The Centre includes information specific to Canada as well as regulations and implications associated with the pork industry in Europe and North America.

The material encompasses research papers and reports published in scientific journals; reference texts; conference and symposium proceedings; fact sheets and industry journals. The literature is reviewed and summarized in each chapter. This tells what information is known, who is contributing to the body of knowledge and what questions still remain unanswered.

Each chapter contains: a glossary of terms, a general overview of the issue, and the current status of world knowledge on the subject. A discussion of technologies and cost-benefit information is included where applicable, as is the role of farm management. The material is fully referenced, making it a valuable starting point for researchers and the public.

The Internet was chosen as the main delivery medium for the EIRC, as it allows large amounts of information to be offered to many people at once, and users can get their answers how and when they want.

Future plans for the EIRC include a French translation, more literature reviews and links to the proposed Canada Pork Network. The Environmental Issues Resource Centre is jointly funded by Alberta, Manitoba, Ontario Agri-Food Innovation Fund and Saskatchewan pork boards, Agri-Food Innovation Fund as well as HEMS (The Hog Environmental Management Strategy, a three way partnership between the provincial and federal governments and the hog industry).

The Environmental Issues Resource Centre is located on the Web at:
http://adminsrv.usask.ca/Psci/PSC_DB/index.html.

Fast and easy answers to questions about the pork industry

MAKING MANAGERS

Mary Petersen, B.Ed
Coordinator of Training Programs

Management training program aids transition from herdsperson to barn manager

Three years ago, it became evident that the growing swine industry was unable to attract enough experienced managers.

With production units becoming larger and more specialized, sound management is essential. However, people placed in these positions generally need more skills to make the transition from herdsperson to barn manager.

To meet this need, Prairie Swine Centre set up the Management Training Program. In May, 1998, I was hired as Coordinator of Training Programs to deliver this initiative. Funding for the program is provided by Saskatchewan Pork Central, Alberta Pork, Alberta Agriculture, Food and Rural Development. Prairie Swine Centre for its part, makes in-kind contributions.

The Program is a regional effort rather than a provincial initiative, as funding comes from both Saskatchewan and Alberta. Saskatchewan Institute of Applied Science and Technology (SIAST); Alberta Agriculture, Food and Rural Development; and Olds College in Alberta are ensuring that skills and knowledge gained through the SIAST Pork Technician program and the Alberta Green Certificate ladder into the Management Training Program.

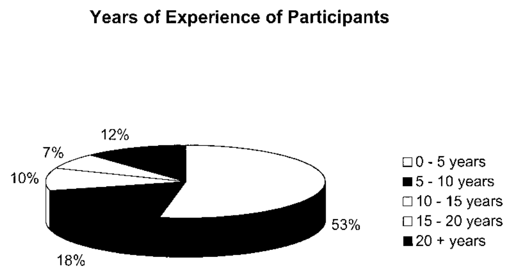
Certification for the program will be issued by the Prairie Swine Centre. This will offer a career path for people who want to be involved in the hog industry for the long term, whether they be owner-operators, managers, assistant managers or aspiring managers.

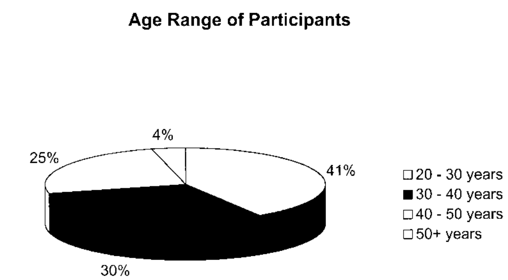
With these people in mind, training covers practical pork production from the manager's point of view. Courses fall into four topic areas: Human Resources, Production, Business, and Facilities.
Course developers are people from within the industry who are experts in their areas. The intent of the program is not only to introduce the most current technologies, but also to teach managers how to understand and implement these tools to improve production and efficiency.

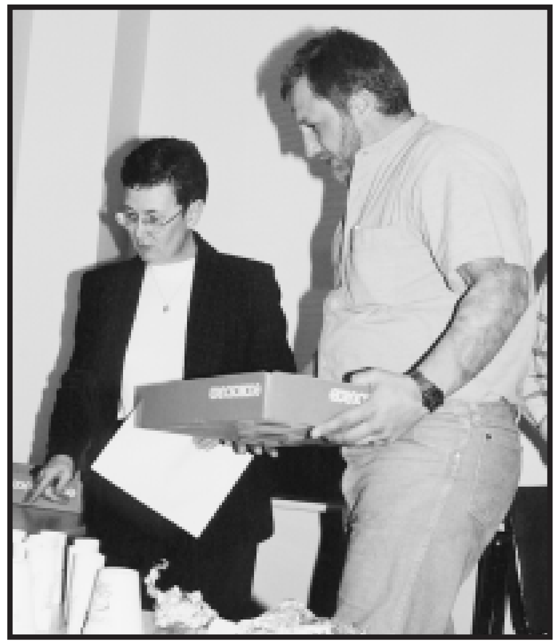
Courses are being delivered in both Saskatchewan and Alberta in a face-to-face delivery format. Participants agree that people who share common challenges need to share these experiences with their peers and learn from each other's mistakes and successes. This networking allows participants to create their own support system. Most courses are 15 hours in length, delivered over a two-day period. An over night stay is encouraged, which allows participants time to socialize and expand their peer network.

The following graphics show the largest percentage of managers in the hog industry seeking training are between the ages of 20 and 30 years of age and that 53 per cent of these managers have less than five years of experience.

Advisory committees have been formed in both Alberta and Saskatchewan consisting of representatives of the funding agencies, producers and managers. These groups provide excellent advice on course content, potential course developers, instructors, delivery schedules and locations. Saskatchewan advisory committee members are: Marilyn Jonas (Pork Central), Nancy Fetch (Big Sky Farms), Andrew Ramsay (Heartland), Raymond Parent (Producer) and Janet Englot (Genex). Alberta committee members are: Michelle Follensbee (Alberta Agriculture, Food and Rural Development), Paul Hodgman (Alberta Pork), Bryan Perkins (Producer), William Wildeboer (Producer) and Marvin Oudshoorn (Manager).







Being an Effective Manager - Oct./98, Olds, AB
Mary Petersen, Frank Hofer

Managing Human Resources - Nov./98, Watrous SK
BR: Kim Meger, Ken Bate, Brian LeNouail, Tim Bray, Jeremy Ottenbreit, Rodney Voldeng, Roy Craske
CR: Sylvia Meszaros, Karen Wartz, Garry Zubot
Sitting: Mary Cawley (instructor)

THE DE CONTENT OF HULL-LESS BARLEY

Ruurd T. Zijlstra, Dave D. Maenz [1]
John F. Patience

The DE content of clean hull-less barley is comparable to wheat.

Summary

Hull-less barley is used as a source of energy and amino acids in swine rations in Western Canada but is characterized poorly in terms of DE content. Our objective was to determine the DE content of cleaned hull-less barley in relation to barley, wheat, and triticale. Chemical characteristics were analyzed to enable subsequent calculation of prediction equations

The DE content of cleaned hull-less barley was equal to that of wheat. We were able to predict the DE content of hull-less barley accurately by using starch, neutral-detergent insoluble nitrogen (NDIN) and neutral-detergent fiber (NDF) analyses.

Introduction

Hull-less barley is an increasingly important energy and amino acid source for grower-finisher pigs in Western Canada, but its nutritional value has been characterized poorly. The DE content has been determined in samples that were not cleaned properly or in samples of which hull content in the sample was not reported.
For this study, five varieties of hull-less barley were grown on two separate experimental fields in Saskatchewan. The objective was to relate DE content of hull-less barley to other cereal grains and with chemical characteristics to enable subsequent calculation of prediction equations.

Experimental Procedures

As a component of a collaborative project with the Prairie Feed Resource Centre, hull-less barley was cleaned and analyzed for crude protein (CP), acid-detergent fiber (ADF), NDF, ash, ether extract (EE), NDIN, starch, and DE content. Regression analysis was used to develop relations between DE content and chemical composition.

Results and Discussion

The DE content of cleaned hull-less barley was equal to that of wheat (Figure 1). The difference between the DE content of hull-less barley and barley was around 400 kcal/kg on a DM basis, suggesting that for each 25 per cent additional hulls in the sample the DE content of hull-less barley might be reduced by 100 kcal DE/kg DM. Using starch, NDIN, and NDF (all three on DM-basis), an accurate ($R^2 = 0.88$) prediction equation could be developed: DE (kcal/ kg DM) = 2231 + 22*per cent starch + 636*per cent NDIN – 42*per cent NDF. Equations using CP with ADF, NDF, CF, or EE did not results in accurate predictions of DE content.

Implications

Results indicate that the DE content of cleaned hull-less barley is equal to that of wheat. This also means that un-cleaned hull-less barley will have a lesser value than wheat and that the amount of hulls remaining in the sample should be taken into consideration on a weight basis for diet formulation or price paid. The DE content of hull-less barley could be predicted accurately; however, the prediction will be expensive to perform.

Acknowledgements

Strategic funding was provided by Sask Pork, Alberta Pork, Manitoba Pork and Saskatchewan Agriculture and Food Development Fund. The presented work was supported financially by College of Agriculture First and Best Funds provided by the Saskatchewan Wheat Pool.

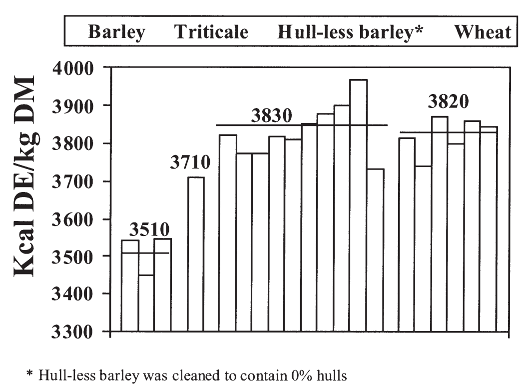


Figure 1. The DE content of cleaned hull-less barley in contrast to wheat, barley, and triticale.

[1] Prairie Feed Resource Centre, University of Saskatchewan

FIELD PEA DE CONTENT AND CHEMICAL CHARACTERISTICS

Ruurd T. Zijlstra, Dave D. Maenz [1]
John F. Patience

Summary

Field peas are used increasingly as a source of energy and amino acids in swine rations in Western Canada. The DE content in 11 field pea samples ranged from 3098 to 3739 kcal/kg (*1997 PSCI Annual Research Report*).

The objective of this study was to relate DE content of field pea samples with chemical and physical characteristics to enable subsequent calculation of prediction equations. Overall, ether extract was the only characteristic with a statistical significant relationship with DE content. We were unable to predict the DE content of the field pea samples accurately with the chemical or physical characteristics included in the study.

Introduction

Research results indicate that western Canadian feed ingredients vary substantially in DE content. Measurements to estimate quality or nutritional value of a specific field pea sample are not available. The objective of the present study was to relate field pea DE content to chemical and physical characteristics to develop prediction equations.

Experimental Procedures

As a component of a collaborative project with the Prairie Feed Resource Centre, field pea samples were analyzed for chemical characteristics including crude protein (CP), acid-detergent fiber (ADF), neutral detergent fiber (NDF), ash, ether extract (EE), gross energy (GE), and starch. Physical characteristics included diameter, kernel weight, and density. The assay results were related to DE content using regression analysis.

Results and Discussion

Similar to some French research, most chemical and physical characteristics were not related to DE content (Table 1) with the exception of EE. However, the range in EE concentration was small, so even EE is probably not a useful analysis. Multiple regression equations improved the accuracy of the prediction, but did not result in logical relationships of chemical characteristics with DE content.

Implications

Results indicate that DE content could not be predicted accurately with the sample set and measured characteristics. Further research is required to understand the relationship between DE content and chemical composition.

Acknowledgements

Strategic funding was provided by Sask Pork, Alberta Pork, Manitoba Pork and Saskatchewan Agriculture and Food Development Fund. Mr. Leon Lueke in Humboldt, SK donated the 11 field pea samples. Mr. S.Y. (John)Randa, Cenderawasih University, Manokwari, Indonesia visited PSCI on a short-term training attachment and measured the physical characteristics. The project was supported financially by Saskatchewan and Alberta Pulse Growers and the SPI Marketing Group.

Table 1. Chemical (in DM), physical (as is), and nutritional characteristics of field peas and their relationship with DE content.

Characteristic	Mean	Minimum	Maximum	CV	R^2 with DE
Chemical (%)					
Crude protein	21.64	19.54	22.94	4.3	**0.16**
Acid-detergent fibre	7.96	7.27	9.41	9.0	**0.03**
Neutral-detergent fibre	16.24	14.64	17.98	6.1	**0.01**
Ash	3.16	2.91	3.55	6.7	**0.16**
Ether extract	1.27	0.96	1.60	15.0	**0.49***
Gross energy (kcal/kg)	4412	4374	4440	0.5	**0.00**
Starch	45.21	43.11	46.92	2.5	**0.12**
Physical					
Diameter (cm)	0.66	0.60	0.74	6.5	**0.04**
Kernel weight (g/200)	0.227	0.156	0.274	17.9	**0.05**
Unclean density (lb/bu)	65.49	64.00	67.3	1.6	**0.01**
Clean density (lb/bu)	64.24	63.4	65.6	1.2	**0.00**
Nutritional					
DE (kcal/kg; DM)	3862	3442	4154	5.9	--
DE (kcal/kg; 90% DM)	3476	3098	3739	5.9	--

*P<0.05. Ether extract was the only characteristic with a statisically significant relation with DE content

Prairie Feed Resource Centre, University of Saskatchewan [1].

THE THREONINE REQUIREMENT OF THE SOW IN LACTATION

Dana Cooper, John Patience
Meike Rademacher

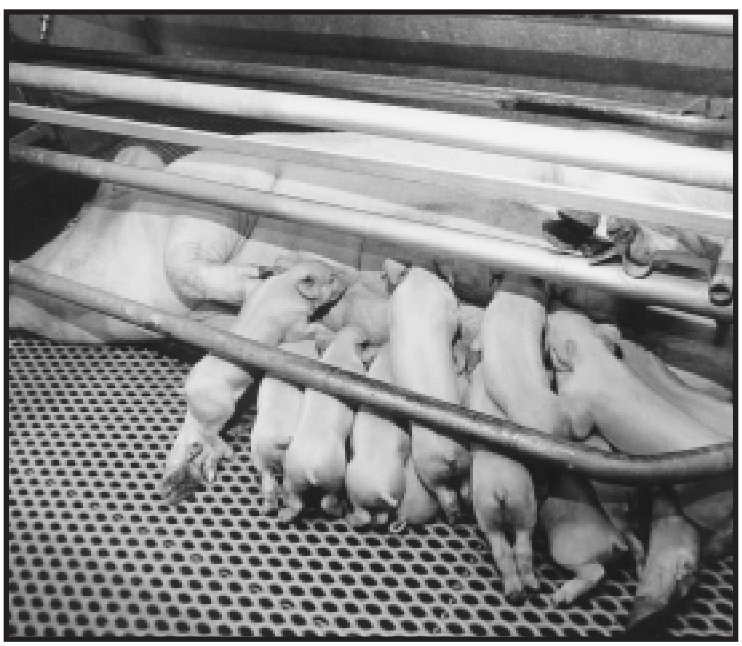
Summary

Threonine is often the second limiting amino acid in most practical swine diets. Therefore, the threonine requirement of the high producing sow in lactation was determined in this study.

Using a total of 419 C-15 PIC sows, the threonine requirement to minimize sow tissue breakdown was found to be 37.3, 40.0 and 38.9 g total threonine/d (28.7, 30.8 and 30.0 g digestible threonine/d) for parity 1, 2 and 3+ sows, respectively. To maximize litter growth, the threonine requirement was found to be 36.6, 39.2 and 38.2 g total threonine/d (28.2, 30.2 and 29.5 g digestible threonine/d) for parity 1, 2 and 3+ sows, respectively.

Introduction

Threonine is often the second limiting amino acid in swine diets; however, limited research has been conducted on the threonine requirement of the sow. Our objective was to determine the threonine requirement for the high-producing sow in lactation.



Materials and Methods

Lactation diets were formulated to contain 0.80 or 1.06 per cent total lysine with threonine set at 37.5 per cent of lysine and added in increments of 0.05 per cent to maximum total threonine levels of 0.65 and 0.70 per cent for the 0.80 and 1.06 per cent lysine diets, respectively. Sow body weight was measured at days 1, 10, 18 and weaning (mean lactation length = 20.1 days). Average daily feed intake (ADFI) was measured for days 0-7, 8-11, 12-15, 16-19 and 20-weaning. Litter size was adjusted to a minimum of 11 piglets and the litters were weighed at birth, days 7, 11, 15, 19 and weaning. Blood was collected on days 10 and 18 of lactation for plasma urea nitrogen analysis. The weaning to estrus interval and subsequent litter size were recorded.

Results and Discussion

Sow ADFI exceeded expectations, averaging 6.9, 7.4 and 7.2 kg/d for parity 1, 2 and 3+ sows, respectively. Sows gained an average of 4.8 kg in lactation and body weight gain was maximized at 0.54 per cent total threonine (Figure 1; $P < 0.05$). Plasma urea nitrogen levels were minimized at 0.54 per cent total threonine (Figure 2; $P < 0.05$).

Average piglet weight at weaning (5.6, 6.2 and 5.8 kg for parity 1, 2 and 3+, respectively) and litter weight gain (2.49, 2.53 and 2.44 kg/d for parity 1, 2 and 3+, respectively) were maximized at 0.53 per cent total threonine (Figure 3; $P < 0.05$). The subsequent total number of piglets born (mean = 11.3) was not affected by threonine ($P > 0.10$).

Implications

The maintenance requirement for threonine in the sow is 41 mg total threonine/kg $BW^{0.75}$. The threonine requirement for litter growth is 14.3 g total threonine/kg litter growth. From these requirements, pork producers can calculate the threonine requirement of lactating sows on their farms.

Acknowledgements

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

The authors gratefully acknowledge Degussa-Huels AG for project funding, donation of amino acids and amino acid assays.

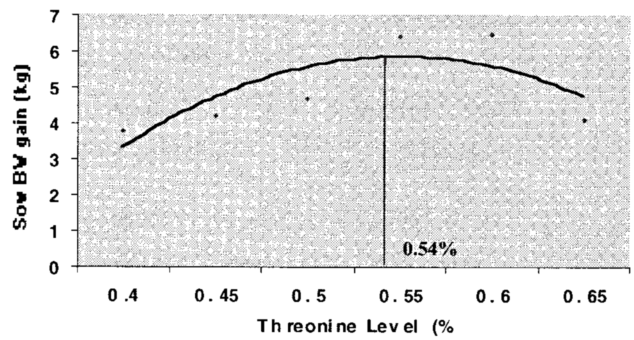


Figure 1. Effect of dietary total threonine level (%) on sow BW changes in lactation (kg).

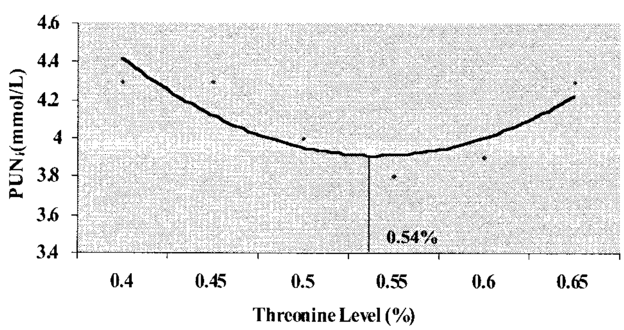


Figure 2. Effect of dietary total threonine level (%) on plasma urea nitrogen levels (mmol/L) in lactation.

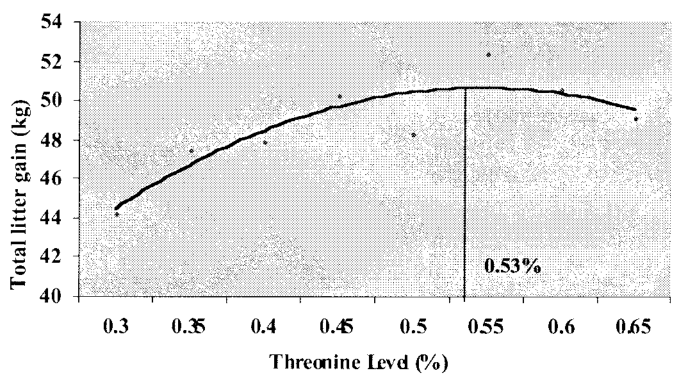


Figure 3. Effect of dietary total threonine level (%) on total litter gain (kg) in lactation.

FACTORS THAT INFLUENCE VOLUNTARY FEED INTAKE

Ruurd T. Zijlstra, C. Martin Nyachoti [1],
Tom A. Scott [2], D. Lee Whittington,
Harold W. Gonyou, John F. Patience

Stress reduces voluntary feed intake of pigs.

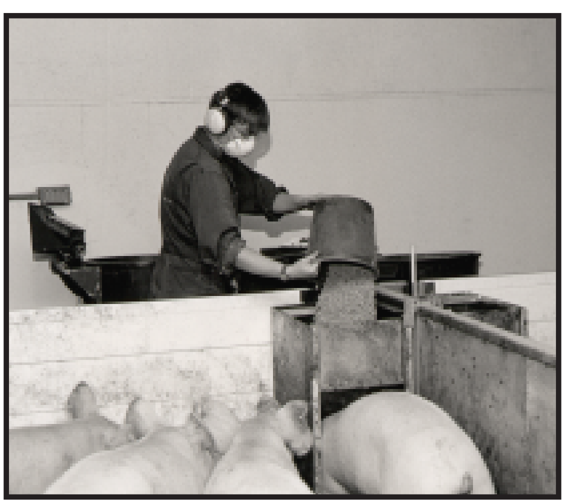
Introduction

Voluntary feed intake of pigs determines nutrient intake levels and thus has a great impact on efficiency of pork production. The intensive selection programs for pig genotypes with better feed efficiency and carcass leanness has inadvertently selected pigs with reduced voluntary feed intake (Webb, 1989).

Adequate feed intake is hard to maintain on many farms, and is an important factor limiting productivity. Surveys show that feed intake varies by at least 25 per cent among commercial farms. Stressors such as hot temperature, increased stocking density and reduced health status, together with genotype, influence feed intake and growth.

Dietary factors, including energy density, deficiencies or excesses of nutrients, antibiotics, flavours, feed processing, and availability of water all influence feed intake (NRC, 1998). In contrast to poultry, differences in intake of pigs fed different batches of ingredients have rarely been described.

The spectrum of factors that affect voluntary feed intake is very broad. The purpose of this paper is to highlight some of these factors. A clear understanding of the key factors involved in determining voluntary feed intake in pigs is an important prerequisite for designing diets to ensure adequate nutrient intake under different production systems.



Voluntary Feed Intake and Stressors

Various stress factors affect how much pigs eat. These factors can be grouped into environmental (temperature, humidity, air circulation, etc), social (space allocation, group size, re-grouping, etc.), and immunological (disease, pathogen concentration, etc.) factors.

The impact of ambient temperature on feed intake has been studied broadly. Cold temperatures increase feed intake, while hot temperatures reduce feed intake when compared to temperatures in the comfort or thermal-neutral zone (Revell and Williams, 1993). When the room temperature is too hot, grower-finisher pigs eat about 40 g per day less for each 1°C above the comfort zone. Under cold temperatures, pigs eat about 30 g more per day for each 1°C below the comfort zone.

Effects of other environmental factors on feed intake are not as well defined, and are usually explained within the context of zone of thermal comfort. It should be noted that the temperature as the pigs feel it is more important than temperature as measured by a thermometer. This will be affected by factors like bedding and ventilation rate.

As for social factors, space restriction reduces feed intake, although the response varies across studies. For example, a 37 per cent reduction in space allowance from 0.55 to 0.35 m^2/pig for grower pigs reduced feed intake by 11 per cent (Edmonds et al., 1998), whereas 55 per cent reduction from 0.56 to 0.25 m^2/pig reduced feed intake by eight per cent Hyun et al., 1998).

Mixing unfamiliar pigs reduces feed intake, suggesting that resorting pigs by weight throughout the grower-finisher phase might be counterproductive. Group size defined as number of pigs in a single pen alters the feed intake pattern of pigs, and these changes might alter overall daily feed intake. Increased group size does not reduce feed intake consistently across studies. Other factors such as space allocation might play a role if a reduction of feed intake indeed occurs.

Immunological stress or activation of the immune system results in reduced feed intake of grower-finisher pigs. The immune system responds to the presence of pathogenic agents by synthesising and releasing cytokines. These in

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turn activate cellular and humoral components of the immune system. The pigs will use physiological and behavioural strategies initiated by the activated immune system to attempt to overcome an episode of clinical or sub-clinical disease (Johnson, 1997).

The reduced feed intake of pigs exposed to space restriction or pathogens could not be overcome by increasing dietary lysine content (Brumm and Miller, 1996; Williams et al., 1997). This indicates that the lysine requirement of socially- or immunologically-stressed pigs was lower because of a reduced protein deposition rate. Diseased animals exhibit a shift in the partitioning of dietary nutrients away from lean tissue accretion towards metabolic responses that support the immune system and also accelerate the breakdown of muscle proteins.

Voluntary Feed Intake and Feed

Feed composition in terms of nutrient content and nutrient balance is an important determinant of feed intake. In general, pigs try to eat to meet the requirement of the most-limiting nutrient, which in most cases is energy. Therefore, the current assumption is that dietary energy content mainly determines voluntary feed intake of grower-finisher pigs from 15 to 110 kg (NRC, 1998).

Thus, as DE content is reduced, pigs attempt to maintain energy intake by eating more dry matter. However, even during the 1960s when pigs were less lean and this assumption was developed, grower pigs had greater difficulty dealing with a reduced dietary energy content than finisher pigs (Owen and Ridgman, 1968). This is likely because gut-size is a limiting factor for grower but not finisher pigs.

The emphasis on selecting for increased leanness or reduced backfat has reduced the amount that pigs eat. (Revell and Williams, 1993). This means present-day grower pigs may have even less leeway to deal with feed of a lower than expected energy content. Within the overall management of voluntary feed intake, a correct prediction of dietary energy content might be essential.

The energy content of complete diets can be predicted reasonably accurately from chemical characteristics (Noblet and Perez, 1993). Apart from energy, controlling balances for specific nutrient groups (carbohydrates, fat, and protein) might influence voluntary feed intake as well (Revell and Williams, 1993). Finally, a few specific dietary nutrients, e.g., content of tryptophan relative to large neutral amino acids, are known to impact brain functions directly and thereby affect voluntary feed intake.

The presentation of feed can influence voluntary feed intake. Two items of concern are presentation as a mash or pellet and wet versus dry presentation. Generally, pelleting of feed reduces feed intake but results in an improved growth performance due to improved nutrient digestibility of the feed (Hancock, 1999). Presentation of mash in a wet versus a dry form increased voluntary feed intake 5 per cent (Gonyou and Lou, 2000).

Voluntary Feed Intake and Ingredients

For pigs, information is limited about variation in voluntary feed intake among batches of ingredients. Because dietary energy content affects feed intake, attention should be paid toward the variation in DE content of ingredients. The DE content range was 16 per cent for barley, nine per cent for wheat, and 18 per cent for field peas (Fairbairn et al., 1999; Zijlstra et al., 1998 & 1999a).

Selecting for increased leanness has reduced the amount that pigs eat

The range in DE content of barley could be predicted accurately with chemical characteristics or near infrared reflectance spectroscopy (NIRS), but not with physical characteristics or available metabolisable energy (AME) content for poultry (Zijlstra et al., 1999b). Using the measured DE content of 11 field pea samples to reformulate diets to an equal DE content resulted in similar voluntary feed intake of grower pigs for 10 out of 11 samples (Zijlstra and Patience, 1998). For wheat, inclusion of selected samples into diets for weaned pigs resulted in large differences in voluntary feed intake (R.G. Campbell, personal communication). Ingredient factors other than DE content might influence voluntary feed intake, for example increased water-holding capacity was linked to reduced feed intake (Kyriazakis and Emmans, 1995).

For poultry, a wealth of information is available describing differences in voluntary feed intake among batches of cereal grains. In the standard test to measure DE content in pigs, feed allowance is maintained at 2.5 to 3 times DE intake required for maintenance.

In contrast, a broiler chick bioassay was developed to measure voluntary feed intake together with AME content of ingredient samples (Scott et al., 1998a). Subsequently, differences in voluntary feed intake of up to 20 per cent for wheat and up to 30 per cent for barley have been described in diets fed to broiler chickens (Scott et al., 1998b). The observed differences in feed intake among ingredient samples were not related strongly to measured AME values. Moreover, voluntary feed intake was a better predictor for performance than AME content of ingredient samples, indicating that factors other than AME content determine voluntary feed intake of broiler chicks.

Finally, the AME content of wheat and barley, voluntary feed intake and subsequent performance among ingredient batches could not be predicted accurately by chemical characteristics (Classen et al., 1995), but were highly predictable by NIRS (Swift et al., 1998ab). The factors that determine voluntary feed intake of broiler chicks might play an important role in swine nutrition as well, and should perhaps be considered to enable predictable performance of grower-finisher pigs.

Summary

Environmental, social, and immunological stressors affect voluntary intake of pigs. The DE content of feed appears to determine feed intake of grower-finisher pigs within limits. In poultry, factors other than dietary energy content predict feed intake and subsequent performance better.

Acknowledgements

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EFFECT OF INCREASING GROUP SIZE ON GROWER-FINISHER PIGS

Stephanie A. Schmolke
Harold W. Gonyou

Introduction

There is growing interest in the swine industry to house grower-finisher pigs in larger pens, increasing group size. Research on management and productivitiy of grower-finisher pigs has generally focussed on small group sizes. As a result, there is a need to understand the effects of increasing group size to ensure this industry trend is beneficial to producers.

The objective of this study was to determine the effects of 10, 20, 40 and 80 pigs per pen on the production and health of grower-finisher pigs.

Experimental Procedure

Four 12-week trials of two groups of 10, and one group each of 20, 40, and 80 pigs per pen were evaluated. An equal number of males and females were used in each pen. Initial body weight was 23.2 ± 0.2 kg. On wet/dry ad libitum feeder was provided for every 10 pigs. Space per pig was constant between group sizes. Injury scores were measured at 48-hour post-regrouping on four body zones, average daily gain (ADG), average daily feed intake (ADFI) and percentage of pigs removed from trial were recorded.

Results

Injury scores were similar among groups but flank injuries were more severe for females than for males. Ear injuries were not significantly different between group sizes and sexes.

ADG throughout the entire study was similar among group sizes (Figure 1). Significant differences in gain were only observed during the first six weeks without any consistent pattern.

ADFI over the 12 weeks was similar among the group sizes (Figure 2). As a result, feed efficiency for the entire period was similar for the group sizes of 10, 20, 40 and 80 pigs per pen.

The percentage of pigs removed did not significantly differ among group sizes (Figure 3).

Implications

If adequate amounts of space are provided for grower finisher pigs, the use of larger group sizes does not appear to either be detrimental to the productivity of health of the pigs, or significantly different compared to smaller group sizes.

Acknowledgements

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Figure 1. Effect of group size on ADG for the entire study

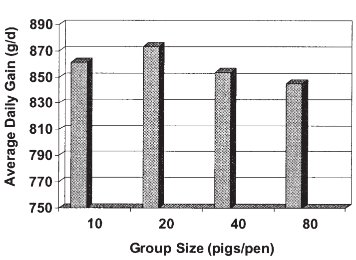


Figure 2. Effect of group size on the overall ADFI

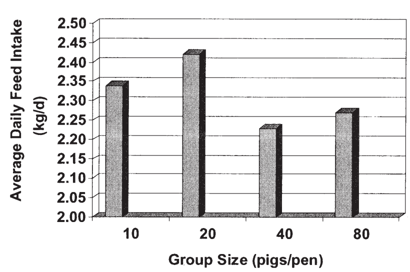
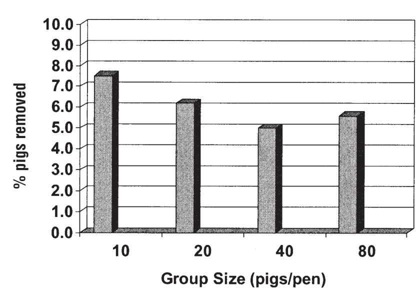


Figure 3. Effect of group size on the percentage of pigs removed



FARROWING AND SAVAGING IN WILD BOAR SOWS

Moira Harris
Renée Bergeron [1]
Harold Gonyou

Summary

Unwanted behaviours such as savaging are sometimes attributed to the process of domestication. Videotaping of farmed wild boar sows during farrowing revealed that 33 per cent were aggressive towards their piglets. Aggression varied with genetic line and was associated with long farrowings involving numerous posture changes. Savaging does not appear to be caused by domestication. Factors associated with piglet-directed aggression in wild boar may also be implicated in savaging in domestic sows.

Savaging does not appear to be caused by domestication

Introduction

The farming of 'alternative' species, such as wild boar, has increased in popularity over recent years. However, almost nothing is known about the maternal behaviour of wild boar kept in captivity.

Piglet-directed aggression (savaging) which occurs in domestic sows has not previously been reported in captive wild boar. In this study, the farrowing behaviour of three lines of captive wild boar sows was videotaped to find out whether sows were aggressive towards their piglets during the farrowing period, and if so, how often this occurred and what factors were associated with this behaviour.

Methods

Twenty-four first parity farmed wild boar sows were housed in individual, straw-bedded farrowing pens measuring 1.52 x 3.05 m. Sows were of three genetic lines: San Diego (SD); Peter Kalden (PK); and Scandinavian (S).

The sows were videotaped during farrowing. These tapes were used to measure the duration of farrowing and number of posture changes during farrowing, and to score the degree of piglet-directed aggression (0 = none; 1 = moderate; 2 = severe). In addition, sows were weighed before farrowing; after birth, litters were weighed and piglet sex ratios recorded.

Results

Eight sows (33 per cent) scored either 1 or 2, indicating some degree of piglet-directed aggression during farrowing. SD sows were significantly more aggressive than either PK or S. Sows with an aggression score of 2 took significantly longer to farrow, and made significantly more posture changes during farrowing, than those scoring 0 or 1. Litters of sows who scored 1 for aggression were more male-biased than those of sows scoring either 0 or 2.

Conclusions

One-third of captive wild boar sows showed some degree of aggression towards their piglets. Thus, savaging deos not appear to be a product of domestication. Savaging in wild boar varied with genetic line, and was associated with long farrowings involving multiple posture changes. The same factors may be associated in savaging in domestic sows.

Acknowledgements

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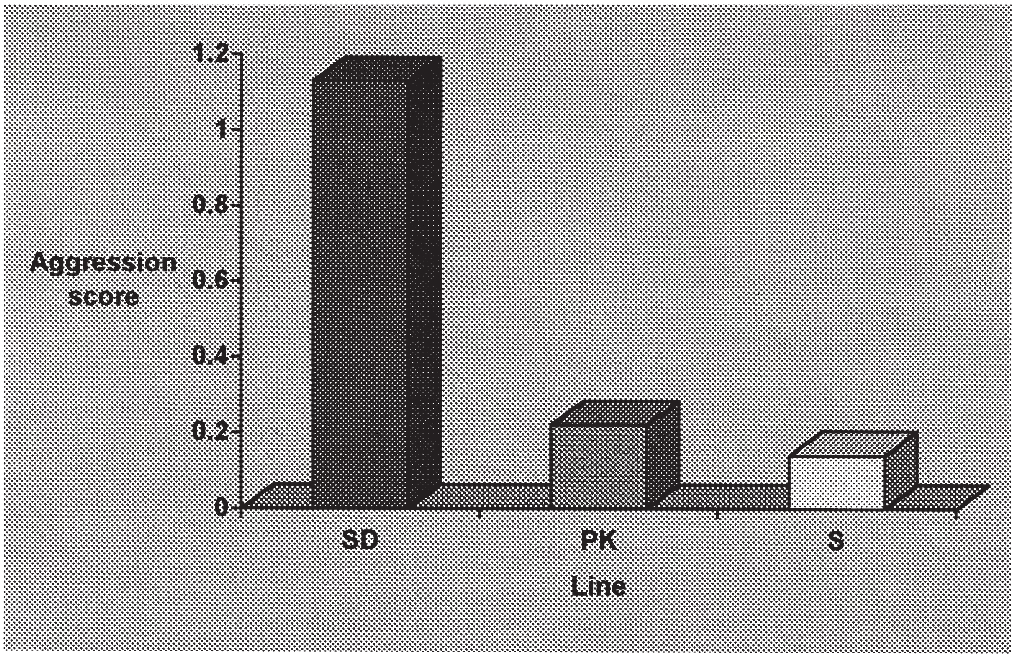

Figure 1. Aggression scores at farrowing of San Diego (SD), Peter Kalden (PK) and Scandinavian (S) sows. San Diego sows were significantly more aggressive towards their piglets.

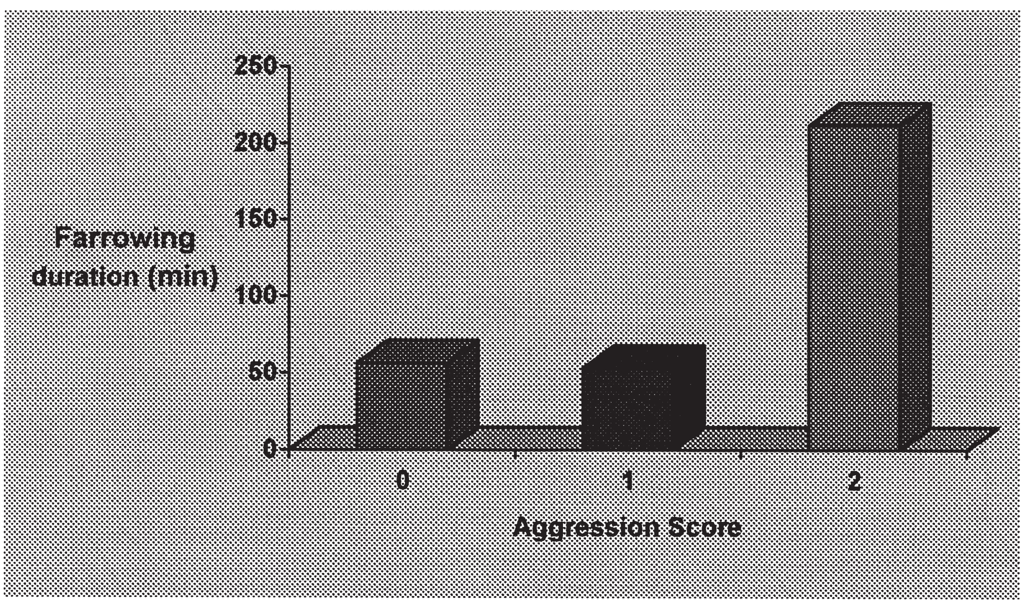

Figure 2. Duration of farrowing (min) of sows with aggression scores of 0, 1 and 2. Farrowing took significantly longer in the most aggressive sows.

INCIDENCE OF BELLY NOSING IN SEGREGATED EARLY WEANING PIGS

Clover Bench, Stephanie Hayne,
Clarence Froese[1], Harold Gonyou

Summary

Segregated early weaning (SEW) was initially employed as a means of eradicating disease in swine operations. However, little is known about how management factors affect the incidence of belly nosing and belly sucking in early weaned pigs. A study was designed to investigate the effects of line difference, diet form and pen enrichment on the incidence of these behaviours in piglets weaned at seven days of age. Results indicate that line difference affects the incidence of nosing and sucking behaviours in early weaned pigs.

Example of pen enrichment through use of air-filled inner tube.

Introduction

Previous studies have shown that as weaning age in piglets decreases, the frequency of belly nosing and belly sucking increases. By studying how breed differences (Duroc versus Yorkshire) affect the amount of time spent nosing and sucking, the possibility of selecting lines better suited to the SEW environment arises. In addition, other factors such as number of days spent on a liquid diet post weaning, gender and pen enrichment (nippled troughs, inner-tubes, and control) may affect the incidence of these behaviours.

Experimental procedure

The incidence of nosing and sucking behaviours were studied in 291 piglets, housed in 19 pens, weaned at 7 days of age. Piglets were fed a liquid diet for either seven (L7) or 14 (L14) days following weaning, at which time they were switched to a dry pelleted diet. Pen environment was modified by providing either an air-filled inner-tube (Tube), rubber nipples (Nipples) in the feed trough, or neither (Control).

Pens were segregated by sex. Within pens, there were both Duroc and Yorkshire lines Observations were made between 8:30 a.m. and 4:30 p.m. on two consecutive days when pigs were 10 to 23 days post weaning. Live observations, at five minute intervals, were made to determine the number of piglets belly nosing, belly sucking, and nosing and sucking on other parts of the body.

Results

Neither diet nor sex affected any of the behaviours. Nipples reduced the percentage of time spent belly sucking (1.10 per cent) compared to Tube (3.12 per cent) and Control (4.12 per cent) treatments. Nipples also reduced the total amount of sucking (1.57 per cent) compared to Tube (3.46 per cent) and Control (4.75 per cent). The Yorkshire line engaged in more belly sucking (3.97 vs. 1.58 per cent), total sucking (4.30 vs. 2.21 per cent), and belly directed (9.22 vs. 6.21 per cent) behaviour than did the Duroc line. Significant line and environmental treatment interactions were present in several variables. In general, nipples reduced the level of sucking and belly directed behaviours in the Yorkshire line, but not in the Duroc line.

Conclusion

Line differences affects the incidence of nosing and sucking behaviours in early weaned pigs. Environmental treatments intended to reduce such behaviours may not be effective in all lines of pigs.

Acknowledgements

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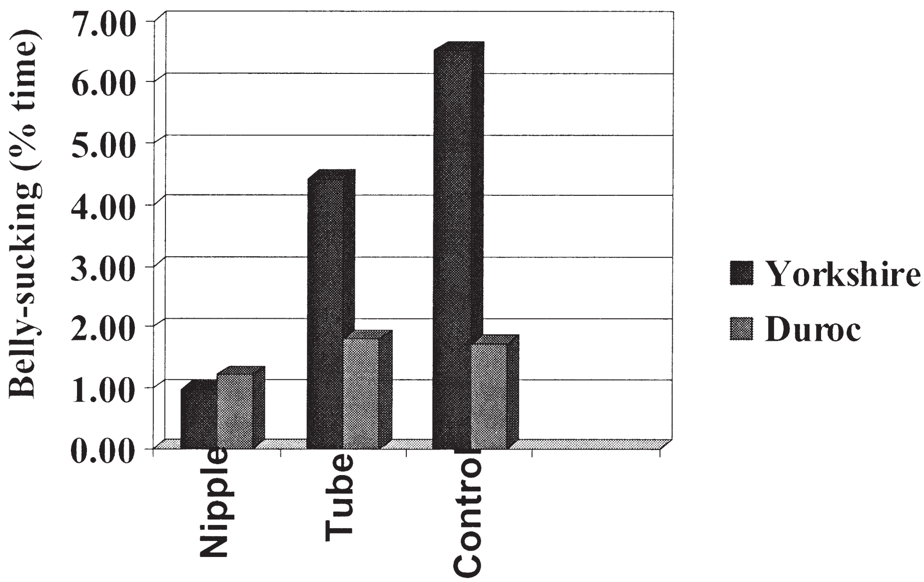
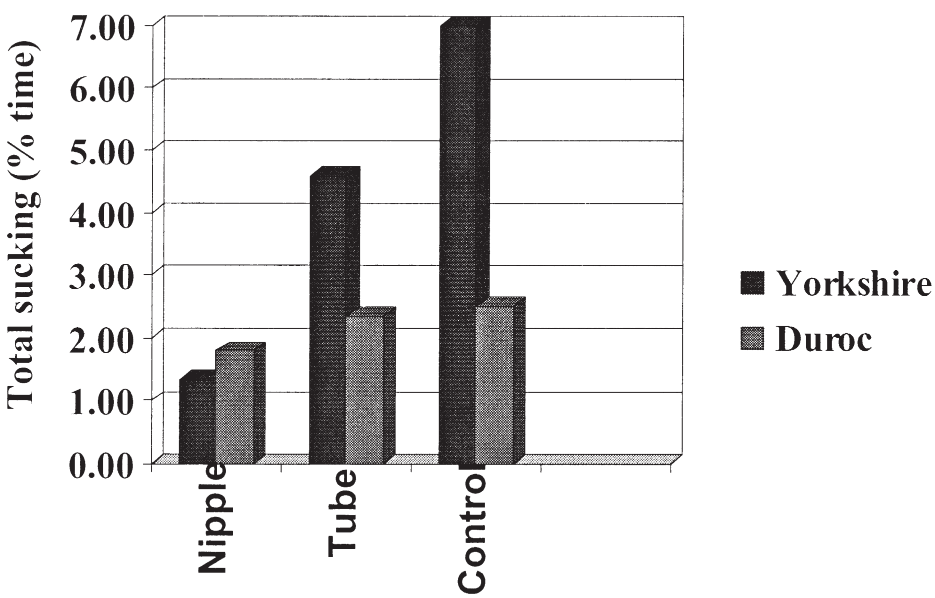

Belly-sucking (% time)
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Nipple
Tube
Control
Yorkshire
Duroc


Total sucking (% time)
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Nipple
Tube
Control
Yorkshire
Duroc

AN OIL SPRINKLING SYSTEM FOR DUST CONTROL IN PIG BUILDINGS

Stéphane P. Lemay, Ernest M. Barber [1],
Myles Bantle [2], Dominic Marcotte

Background

Swine producers are exposed to high dust levels in pig barns, and different dust control methods have been tested over the last decade. Until now, oil sprinkling seemed to be the most promising technique providing dust reduction from 50 to 80 per cent. In previous experiments, the oil was manually applied once or twice a day.

The swine industry has not easily adopted oil application technology because of the very intensive labour needed for manual oil sprinkling. Therefore, the next logical step was to develop and build a low cost automatic system able to provide recommended oil application rates for dust control. The system had to operate at a low pressure with pure canola oil, considering that a high pressure system can produce an oil mist that would likely be a greater risk for workers than the dust itself.

Nozzle selection

Six different types of agricultural nozzles were tested in a laboratory experiment to identify a suitable nozzle for the system. Nozzle flow rate and application patterns were measured under controlled temperature and pressure conditions. Based on those measurements, the most suitable nozzle was selected for the oil sprinkling system.

Oil sprinkling system. This semi-portable prototype designed and built at Praire Swine Centre consists of pump, reservoir, pressure gauges and control valves. Initial testing with the unit showed a 79 per cent reduction in dust mass concentration.

The system

The system tested in the barn consisted of an hydraulic pump, an oil reservoir, two pressure gauges and two control valves modulating the oil flow rate between the main line heading to the nozzles and a recirculation loop which brings the oil overflow back to the reservoir. All components were mounted on a cart and a flexible hose was used to connect to the room pipeline.

The oil pipeline was installed in a rectangular grower-finisher room (14.4 m x 5.4 m x 2.9 m high, 6 pens of 12 pigs). The pipeline, which included nine nozzles in total, was suspended 0.3 m below the ceiling and in line with the front of the pens. Six nozzles, one in front of each pen, were directed to distribute oil within the pens, and three nozzles were oriented to sprinkle oil on the floor of the operator walkway.

Dust reduction

The oil sprinkling system was tested over a two week period in January 1999. The dust concentration of two rooms (one without oil and the one provided with the system) was measured over the experimental period. Each room housed 68 pigs of 89 kg in average. Oil application was done using recommended rates for dust control (40 ml of oil/m^2-day for the two first days, 20 ml of oil/m^2-day for the next two days, and 5 ml of oil/m^2-day for the next ten days).

The sprinkling system provided a dust mass concentration reduction of 79 per cent compared with the control room over the two week period as shown in Fig. 1. Respirable (0.5 to 5.0 µm) and inhalable (>0.5 µm) dust particle counts were reduced by 73 and 80 per cent respectively as indicated in Fig. 2 and Table I. The system was effective in replicating previous dust reduction data obtained with manual equipment and can be used to control dust levels in swine buildings with undiluted canola oil.

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Cost of application and future research

Considering that the same system (cart) would be used for 10 grower-finisher rooms, the cost of oil application would be less than a $1.00 per pig sold. Future projects will look at optimising oil usage (application rate and walkway sprinkling) and at long term effects of oil sprinkling.

Acknowledgements

Strategic funding was provided by SaskPork, Alberta Pork, Manitoba Pork, and Saskatchewan Agriculture and Food Development Fund. The authors also thank Mr. Robert Fengler, Research Technician–Engineering at PSCI, for his technical assistance during the project.

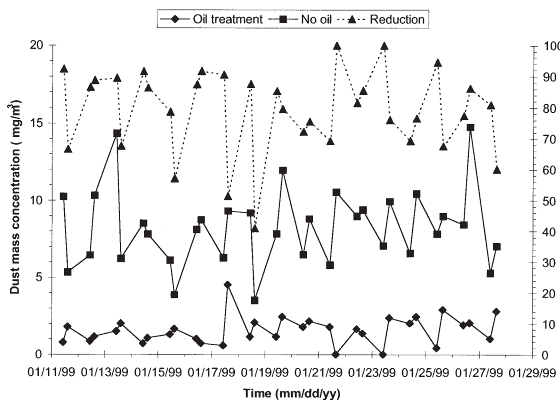

Figure 1 Dust mass concentration in both control and oil sprinkled rooms from January 11th to 27th, 1999.

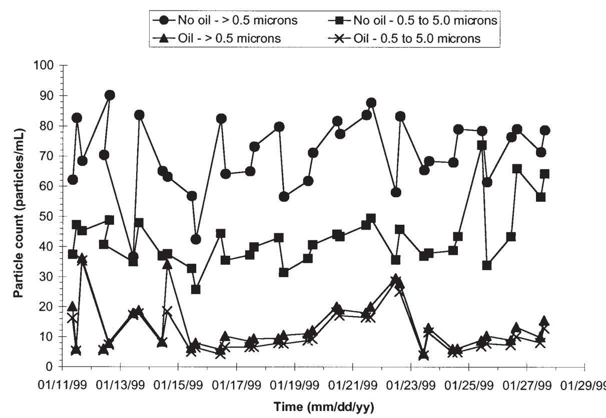

Figure 2 Dust particle counts in both control and oil sprinkled rooms from January 11th to 27th, 1999.

Table I Average dust reduction from January 11th to 27th, 1999.

Measurement technique	Dust reduction (%)
Dust mass concentration	79
Particle counts	
Respirable dust (0.5 to 5.0 µm)	73
Inhalable dust (≥ 0.5 µm)	80

PERFORMANCE AND CARCASS QUALITY OF GROWING-FINISHING PIGS SUBMITTED TO REDUCED NOCTURNAL TEMPERATURE

Stéphane P. Lemay, Huiqing Guo [1], Ernest M. Barber [2]

Reduced temperature set point would yield a net return of 80¢ per pig during summer time.

Background

During summer months, elevated barn temperature reduces pig growth rate by decreasing feed intake. This negative impact on pig performance lengthens the growth period and reduces the productivity level of a swine barn. On the Canadian Prairies, summer days can be very hot but nights are generally cool. Based on previous experiment results, it was suggested that a reduced temperature setpoint during the summer could sustain pig performance by perhaps modifying pig eating behavior and stimulating the average daily feed intake.

The trials

Two trials, a pilot study and a large scale experiment, were conducted over two summers to evaluate the impact of a reduced nocturnal temperature strategy on the performance and carcass quality of growing-finishing pigs over summer months. Typical rooms had a temperature setpoint that is generally used in commercial barns while the temperature setpoint for reduced nocturnal temperature (RNT) rooms was lowered by 6°C.

The results

In Saskatchewan, a reduced temperature setpoint resulted in a lower nocturnal room temperature (1.6°C cooler at night over eight weeks). No influence on room daytime temperature could be measured. The average daily temperature fluctuation in RNT rooms was increased by 2.1°C. The temperature pattern in typical and RNT rooms for three days of experiment is presented on Fig. 1. The lower nocturnal temperature also resulted in a higher relative humidity (+3 per cent) and lower carbon dioxide and ammonia concentrations.

During trial 1, pig average daily gain (ADG) in the RNT room was increased by 5.2 per cent as showed in Table I. For trial 2, feed intake was 3.2 per cent higher in RNT rooms which increased ADG by 2.1 per cent in average over eight weeks as presented in table II. The ADG increase averaged 3.6 per cent during the last four weeks of trial 2. However, pig performance was not statistically increased by the RNT ($P>0.05$). No statistical difference was found in terms of feed conversion and back fat thickness ($P>0.05$).

The benefits

The results suggest that even without statistical significance, the reduced temperature setpoint strategy would provide a net return of 0.80 CAN$/pig sold for pigs raised over the summer period in Saskatchewan. Both trials showed that healthy growing-finishing pigs are not negatively affected by a large daily temperature fluctuation (up to 13°C) as long as this fluctuation is progressively achieved through the day-night outside temperature fluctuation. Based on this research, it is also suggested that summer temperature setpoints for growing-finishing pigs should not be increased to reduce daily temperature fluctuations.

Acknowledgments

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Table I Pig performance and carcass quality for the pilot study (July 11th to September 4th, 1997)

Sex	ADG* (kg/day)		TFI* (kg)		FC* (kg/kg)		Carcass lean (RT Ultra sound, %)	
	Typical	RNT	Typical	RNT	Typical	RNT	Typical	RNT
Male	0.905	0.953	10330	10753	2.950	2.981	40.1	39.2
Female	0.855	0.898	9059	9714	2.834	2.771	40.7	40.5
Average	0.880	0.926	9695	10234	2.892	2.876	40.4	39.9

***ADG: average daily gain, TFI: total feed intake, FC: feed conversion, RT Ultra sound: real time ultra sound.**

Table II Pig performance and carcass quality from the large scale experiment (July 24th to September 17th, 1998)

Sex	ADG (kg/day)		ADFI* (kg/day)		FC (kg/kg)		BF Thickness* (mm)	
	Typical	RNT	Typical	RNT	Typical	RNT	Typical	RNT
Male	0.874	0.900	2.301	2.366	2.692	2.682	11.4	11.7
Female	0.833	0.844	2.136	2.212	2.628	2.668	10.5	11.2
Average	0.854	0.872	2.219	2.289	2.660	2.675	11.0a	11.5a

***ADFI: average daily feed intake, BF thickness: back fat thickness.**
†Males were statistically different than females (P<0.05)
Averages followed by the same letter on a same row are not statistically different (P>0.05).

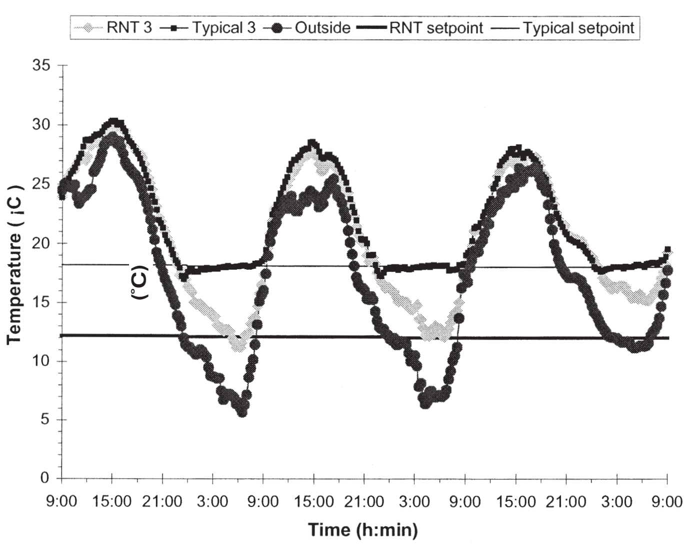

Figure 1. Temperature pattern in typical and RNT rooms from September 4th to 7th, 1998.

HUMIDITY CONTROL STRATEGIES FOR WINTER CONDITIONS

Marina Lambert, Stéphane P. Lemay,
Liliane Chénard, Ernest M. Barber [1],
Trever Crowe [2]

Background

Most control systems used in swine facilities are temperature controlled, relying on a constant minimum ventilation rate (MVR) for relative humidity (RH) and contaminant controls during the cold season.

A survey conducted with 15 grower-finisher farms of the Prairies confirmed that conventional control systems are used and less than half the farms surveyed used recommended MVR settings. In more than half the farms, MVR adjustments were done to keep it to its minimum or to adjust it when the barn operator felt that the humidity was too high.

Underestimating MVR results in high RH and contaminant concentrations. Overestimating MVR results in higher energy cost for ventilation and supplemental heating. A system that could automatically adjust the ventilation according to the room humidity could improve the overall conditions in the building and optimize energy requirements.

Modelling

A computer model has been developed to evaluate the benefits of temperature-humidity control (THC) systems that take into account the room RH over a more conventional temperature control (TC) system. A full-scale grower-finisher room supplied with commercial equipment and control systems was simulated under Prairie winter conditions and under different control strategies.

Simulations

The comparison of heating and ventilating systems was based on average temperature, energy demand and respective fluctuations of humidity and carbon dioxide concentrations. For THC systems, Proportional (P) and Proportional-Integral-Derivative (PID) controls were simulated from November through March under Saskatchewan winter conditions. Based on simulations, a TC system provides effective humidity control considering that the minimum ventilation rate is adequately set and adjusted throughout the growth period. Figure 1 presents the RH obtained with three specific strategies: TC; THC with a PID control and a RH setpoint of 77 per cent; and THC with a P control with a 75 per cent setpoint and a 5 per cent P-Band.

As shown on Fig. 1, THC strategies keep the RH at the setpoint approximately 30 per cent of the time. A much wider variability is obtained with TC strategy. Furthermore, THC strategies are more appropriate as the ventilation is being adjusted to the room moisture production that can fluctuate within a day or as a result of sporadic water wastage.

In THC control, decreasing the setpoint from 80 to 70 per cent increases energy requirements by a factor of two. For a given RH setpoint, PID control requires more energy than P control as it keeps the RH at that setpoint or lower. However when equivalent RH conditions are maintained (75 per cent setpoint with P control and 77 per cent setpoint with PID control), energy requirements are similar or lower with PID control as shown in Fig. 2 and Table I.

Ventilation controllers. This Rapid controller system was modelled in computer simulations to find out what settings delivered the best humidity control and energy efficiency. The results were then checked against real world conditions (see "Development and Evaluation of a Temperature-Humidity Controller for Livestock Buildings").

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Optimum strategy

Overall with specific setpoints, PID (77 per cent) compared to P control (75 per cent-5 per cent) provides higher RH and CO_2 concentrations but differences are lower than 2.5 per cent. Considering simulation results, the controller complexity, the expected accuracy of those controller and humidity sensors, the strategy selected as being optimum was THC with P control, a 75 per cent RH setpoint and a proportional band of 5 per cent (THC-P-75 per cent-5 per cent P. Band).

Acknowledgements

The authors wish to acknowledge the funding provided for this project by the Natural Sciences and Engineering Research Council of Canada, Agriculture and Agri-Food Canada, TDK Corporation of America and DelAir Systems Ltd. The project was initiated by Drs. Y. Zhang and A. Tanaka and their foresight in starting the project and getting it funded are appreciated.

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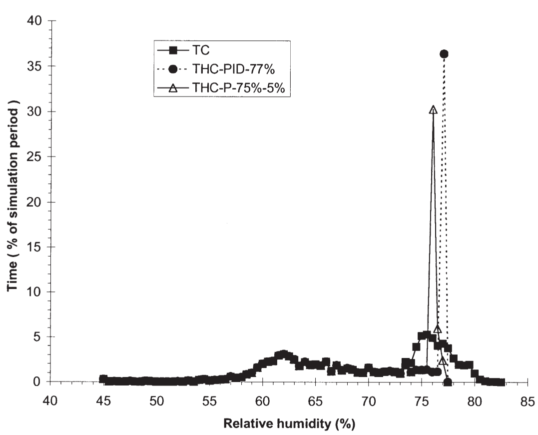

Figure 1 Comparison of the RH level for the different control strategies.

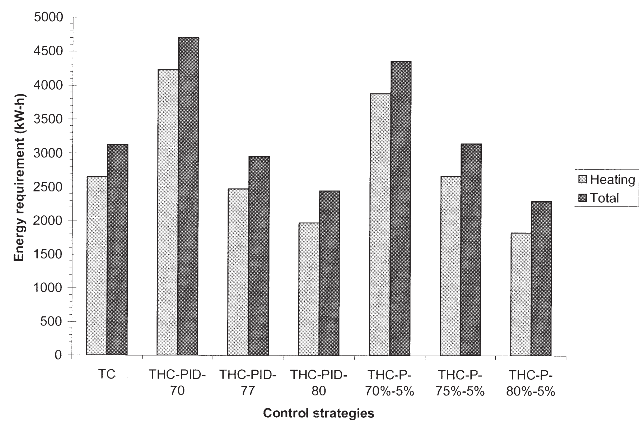

Figure 2 Energy requirement for different control strategies

Table I Comparison of different control strategies for a similar RH control

Control strategy	Energy requirement (kW-h)		Relative humidity (%)		CO_2 concentration (ppm)	
	Heating	Total	Mean	Max	Mean	Max
TC	2649	3127	69.5	81.7	2820	3675
THC-P-75%-5%	2667	3145	69.3	76.8	2809	3737
THC-PID-77%	2474	2951	69.7	77.0	2827	3786

DEVELOPMENT AND EVALUATION OF A TEMPERATURE-HUMIDITY CONTROLLER FOR LIVESTOCK BUILDINGS

Huiqing Guo[1], Stéphane P. Lemay,
Ernest M. Barber [2], Trever Crowe [3]

Temperature control wasn't affected by the temperature humidity control (THC) strategy. Pig performance was not affected.

Background

Previous work at PSCI indicates that a specific protection treatment applied to a TDK relative humidity (RH) sensor could substantially increase the sensor's life expectancy and maintain its accuracy under pig barn conditions. This makes humidity control strategies possible.

Computer simulations demonstrated that the type of RH control and setpoints affect air quality and energy requirements. The objective of this study was to implement the modified TDK RH sensor and the new optimized temperature and humidity control (THC) strategy developed at PSCI in an existing heating and ventilation controller and to evaluate the performance of this new THC controller under commercial barn conditions.

The new controller

The TDK RH sensor and the THC strategy were implemented in the "Rapid Control" controller of DelAir Systems Ltd. (Humboldt, Saskatchewan, Canada) by Critical Control (Saskatoon, Saskatchewan, Canada).

The modified controller regulates the temperature with the ventilation system and a Proportional-Integral-Derivative (PID) algorithm. Humidity control is achieved with a Proportional control loop using the ventilation system. The heater is modulated with an on/off control.

In the THC mode with the experimental THC Rapid controller, the user needs to define the room temperature and relative humidity setpoints, the RH P-band and the values of lower limit and upper limit of the minimum ventilation rate. As it has been done for some commercial controllers, the humidity control (HC) is only allowed within the first stage fan between a lower and an upper limit of its rotation speed. This provision prevents some energy wastage associated with too high RH reading from the sensor that would result in high ventilation rate and excessive heating requirements.

The experimental set up

The controller was evaluated in six identical grower/finisher pig rooms for eight weeks in winter and early spring of 1999. Three rooms were provided with THC controllers using a 70 per cent RH setpoint while the other rooms had conventional temperature-only controllers. Each room housed 68 pigs in six pens and was equipped with the same type of fans and heater.

The performances

The new THC controller provided very good control of room temperature and relative humidity.

In conventionally controlled rooms and over the first three weeks, the time period when RH was higher than 70 per cent occurred 36 to 85 per cent of the day. The highest RH reached 86 per cent as showed in Table I. In THC rooms, the relative humidity was controlled around the setpoint for 33 to 63 per cent of the time. The maximum RH level did not exceed 76 per cent.

On average, temperature control was not affected by the THC strategy implementation. However, temperature fluctuations up to 0.8°C over a 15 minute period were observed on some occasions in THC rooms. Figures 1 and 2 show temperature and RH fluctuations during three days in February. In the THC room, the controller was effectively increasing fan rotation speed to maintain RH at the setpoint. The oversized heater and the setting of time parameters in the controller are likely responsible for those temperature fluctuations. Ammonia concentrations were not different in both room types, but CO_2 concentrations were higher in THC rooms. This indicates a lower average ventilation rate. Pig performance was similar with both control strategies.

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Acknowledgements

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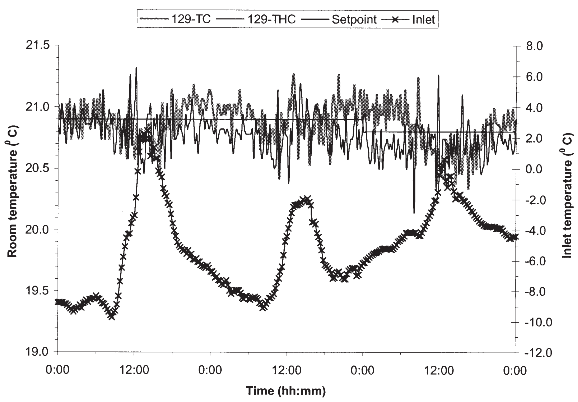

Figure 1 Rooms and inlet temperature in a pair of rooms (129) from February 20th to 23rd, 1999

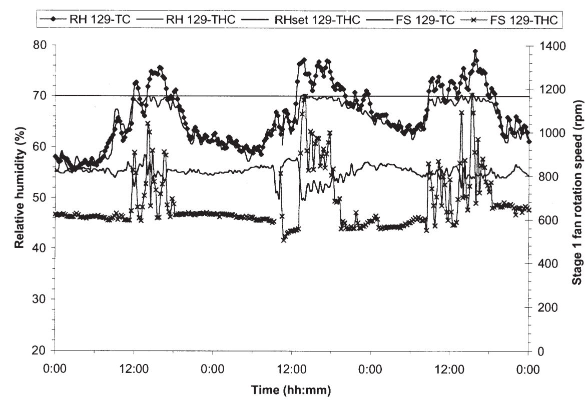

Figure 2 Relative humidity and ventilation rate in a pair of rooms (129) from February 20th to 23rd, 1999

Table I High humidity conditions in a cold weather period (only stage-1 fan enabled) in two specific rooms.

Week	Parameter	TC		THC	
		RH (%)	Period when RH>70% (hh:mm/day)	RH (%)	Period when RH ≥ setpoint (hh:mm/day)
1	Average	72	9:04	70	7:55
	Maximum	79	(37.8%)*	72	(33.0%)
	Minimum	56		55	
2	Average	73	8:40	70	12:37
	Maximum	86	(36.1%)	76	(52.6%)
	Minimum	59		61	
3	Average	74	20:20	70	15:08
	Maximum	84	(84.7%)	75	(63.1%)
	Minimum	62		59	

* Corresponding percentage for one day.

EFFECTIVENESS OF THREE MANURE PIT ADDITIVES

Ryan Stinson, Stéphane P. Lemay
Ernest M. Barber [1], Terry Fonstad [2]

Background

Pit additives are put on the market to offer solutions for the problem of odour nuisance from pig barns. They are also intended to improve manure characteristics such as handling ease, pit gas production, nutrient retention and waste strength.

Most of the scientific testing in this area has been done in laboratory or on a bench scale. To evaluate the effectiveness of such products in conditions duplicating most commercial barn situations, a protocol had to be developed.

The objective of this experiment was to evaluate the effectiveness of three manure pit additives in reducing odour threshold and gas concentrations above the manure surface, in reducing solids and manure strength, and maintaining nutrient and micronutrient content in the manure, for commercial-scale manure pits and simulated lagoons.

The products and the procedure

The additives were American BioCatalysts, Pit Boss and Westbridge (H4-5O2) with respective product costs of \$0.07, \$0.19 and \$0.02 per pig marketed. Two trials were conducted in a commercial room at PSCI. Trial 1 consisted of an indoor phase realized directly in the manure pits under growing-finishing pig pens with manure being treated over a five-week period. An outdoor phase followed where manure was transferred and stored for a four-week period in plastic tubs to simulate storage in lagoon. The second trial (Trial 2) had only the indoor phase of five weeks treatment to provide additional replicates of Trial 1 and allow for statistical analysis of the results. In total, eight replicates of the indoor treatments were obtained.

Sampling setup for odour and gas measurements. The apparatus sits on top of the slats, with sampling tubes going down to just above manure level.

The geometry of the outside tubs (plastic cattle waterers) was selected to simulate a lagoon situation with a high surface exposure compared to manure height. An evaluation of inside phase manure characteristics and odour emissions was completed inside on days 28 (week 4) and 35 (week 5). For the outside phase, measurements were taken after a 4-week storage period (day 63).

The performances

Overall, the performances of the additives were quite mixed compared to manure that had not received any additive treatment.

Odour threshold reductions ranged from zero reduction to 11 per cent reduction during the indoor phase (as showed on Fig. 1) and zero reduction to 66 per cent reduction during the outdoor phase. Hydrogen sulphide concentrations were reduced from 57 to 76 per cent and ammonia concentrations were reduced by 5 to 33 per cent during the experiment (Fig. 2).

All of the additives seemed unable to achieve much solids reduction (Fig. 3) or solubilization during the indoor phase of the experiment, but improving nutrient retention and availability was a strength of all of the additives. Nitrogen content and availability was improved by 7 to 19 per cent and 9 to 25 per cent, respectively during the indoor trial. Similarly, phosphorous availability was increased from 16 to 24 per cent by the additives during the indoor phase.

The additives did not perform very well in reducing chemical oxygen demand, providing no reduction or a minor reduction during the indoor phase. In general, the additives provided some benefits but were unable to improve

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all aspects of the manure.

Future research

The large variability within the results means that it will be difficult to firmly predict how additives will perform. To make progress in pit additive technology, more basic investigations are required to observe and understand the mode of action of additives on emissions from characteristics of pig manure. Such understanding will likely allow for more control in the variability of manure pit additive effectiveness.

Acknowledgements

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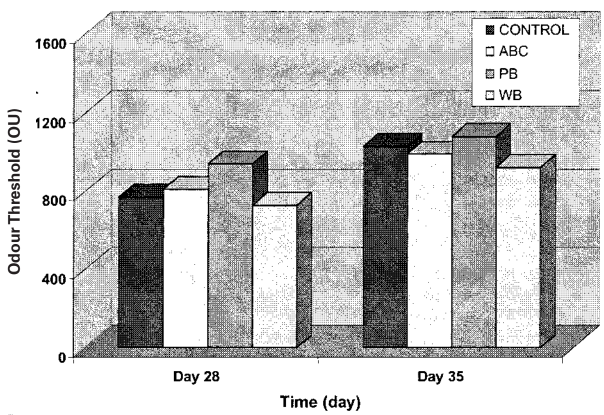

Figure 1 Odour threshold for combined indoor trials

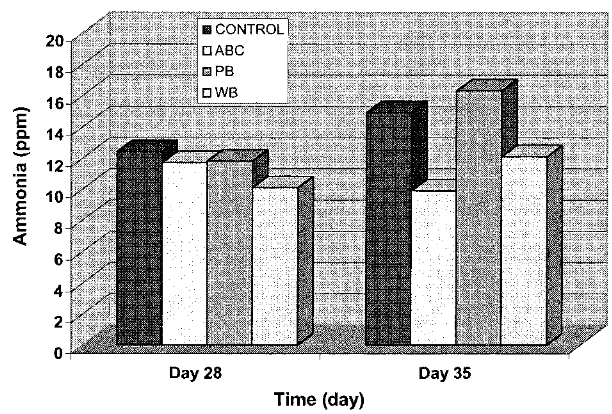

Figure 2 Ammonia concentration for combined indoor trials

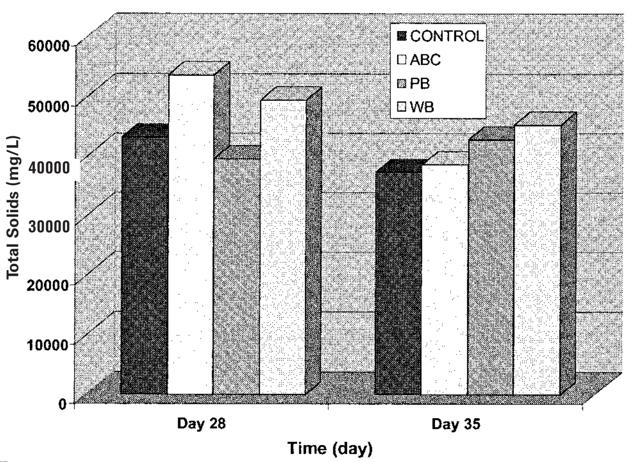

Figure 3 Total solids concentration for combined indoor trials

STRATEGIES TO ALTER NUTRIENT EXCRETION

Matt A. Oryschak, Symeon Zervas, Ruurd T. Zijlstra

Summary

Nutrient management is becoming increasingly important for the swine industry worldwide. However, the situation on the Canadian Prairies cannot be compared to the situation in The Netherlands or North Carolina. That said, sustained attention in the media to nutrient management problems elsewhere supports a proactive approach to study strategies to alter nutrient excretion patterns, and perhaps gain economically in the process. Projects are underway to study nutritional strategies to alter excretion patterns of nitrogen and phosphorus, the two most problematic nutrients in manure.

Introduction

In parts of the world where intensive livestock operations exist, there is growing public concern over the impact that these businesses have on the local ecology. The biggest worry is output of nutrients linked to water or air quality problems, in particular nitrogen and phosphorus.

Technician Tanya Sereda gathering faeces samples for analysis of nutrients not used by the pig.

For the past decade, there has been active research to find ways to reduce nutrient excretion from pigs. This is particularly true in Europe, where application rates of nitrogen and phosphorus onto farmland are restricted by legislation. A reduction in nutrient excretion, without a reduction in pig performance, means pigs retain relatively more nutrients from their feed. This might yield significant economic benefit to the producer. A shift of nitrogen excretion from feces to urine would result in less volatile nitrogen in the manure, and therefore a reduction in ammonia emissions.

Experimental Procedures

In Project 1, processing methods in conjunction with enzyme technology will be used to alter excretion or digestibility of nitrogen and phosphorus. In Project 2, dietary nitrogen content and dietary fiber will be used to reduce or alter excretion patterns of nitrogen. For both projects, barrows will be housed in individual metabolism pens. Feces and urine will be collected separately to quantify nitrogen and phosphorus excretion via each route. In Project 2, an indwelling catheter will be installed to monitor blood concentrations of urea, which is an indicator of excess dietary nitrogen.

Implications

Results from the study will indicate potential benefits of nutritional strategies to alter nitrogen and phosphorus

NITROGEN DYNAMICS IN MANURED SASKATCHEWAN SOILS

J.J. Schoenau [1], P. Mooleki,
P. Qian, G. Wen, J. Charles

Introduction

Manure as a fertilizer is most often considered in its role as a nitrogen source for crop growth, although other nutrients such as phosphorus can also contribute to crop response (Schoenau et al., 1999; Olson and Papworth, 1999). Concerns about manures used as fertilizers include the fate of excess nitrogen lost from the soil through leaching, and gaseous evolution. The objective of this paper is to consider our current state of understanding of the behavior of manure nitrogen added to Saskatchewan soils.

Manure Nitrogen

Knowing the amounts and forms of nitrogen in manure is critical when attempting to predict its behavior in the soil. Both inorganic nitrogen (immediately plant available nitrogen) and organic nitrogen (total minus inorganic) concentrations should be known. They are a key measurement made by laboratories involved in manure testing.

The inorganic nitrogen in manure potentially exists in the forms of ammonium (NH_4+) and nitrate (NO_3–). This inorganic nitrogen is immediately available for plant uptake, similar to commercial inorganic nitrogen fertilizers. Ammonium tends to dominate over nitrate, with little or no detectable nitrate present in the liquid swine effluent and solid cattle manures used in our field trials in Saskatchewan (Schoenau et al., 1998). This is consistent with observations of other researchers (Chang and Entz, 1996; Paul and Beauchamp, 1994).

Dominance of ammonium as the inorganic nitrogen form in manures can be attributed to low rates of conversion of ammonium to nitrate (nitrification) and the instability of nitrate in anaerobic storage conditions. For liquid swine effluents, we have encountered a range of total nitrogen content from about 15 lbs total N per 1000 gallons to upwards of 50 lbs total N per 1000 gallons in some high solids effluents. From 90 per cent to about 30 per cent of this total N is found to be comprised of ammonium, with the lowest proportions in effluents with high solids content (Table 1).

For solid manures such as those from cattle, the proportion of total nitrogen comprised of ammonium tends to be lower, in the range of 10 to 20 per cent of total N (Charles, 1999; Beauchamp, 1986). Therefore for all manures, particularly solid manures, only a portion of the nitrogen is present as the plant available ammonium form.

Table 1. Nitrogen composition of two liquid swine effluents sampled from two earthen storage units during application in spring 1999.

	High Solids	Low Solids
Total N	30 lb / 1000 gal	19 lb / 1000 gal
Ammonium N	18 lb / 1000 gal	15 lb / 1000 gal
Organic N	12 lb / 1000 gal	4 lb / 1000 gal
% of Total N as Ammonium	60 %	79 %

The ammonium present in manure can undergo several fates when added to the soil: 1) be absorbed by plant roots; 2) be absorbed by microorganisms (immobilized); 3) be volatilized by conversion to NH_3 (high pH); 4) be converted to nitrate (nitrification) by microorganisms. Ammonium is rendered immobile in the soil by sorption to soil clays and colloids. However, when ammonium is converted (nitrified) to nitrate, the nitrogen becomes mobile. In Saskatchewan soils, the conversion of ammonium to nitrate is quite rapid (Qian and Schoenau, 2000).

The conversion of the manure organic N is more difficult to predict as it is related to microbial decomposition processes. Owing to the preponderance of organic N forms in some manures, it plays an important role in the overall behavior of manure nitrogen in the soil.

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Decomposition of Manure Organic Nitrogen

Figure 1 depicts the general pathway by which organic nitrogen in manure is ultimately converted into the available forms of ammonium and nitrate. Factors influencing the rate of this conversion include temperature and moisture as they influence microbial activity, with higher decomposition rates associated with higher temperatures and soil moisture contents near field capacity (Schepers and Mosier, 1991).

The composition of the organic matter in the manure will have a great impact on the rate at which organically bound nitrogen is converted into plant available inorganic forms (mineralization).

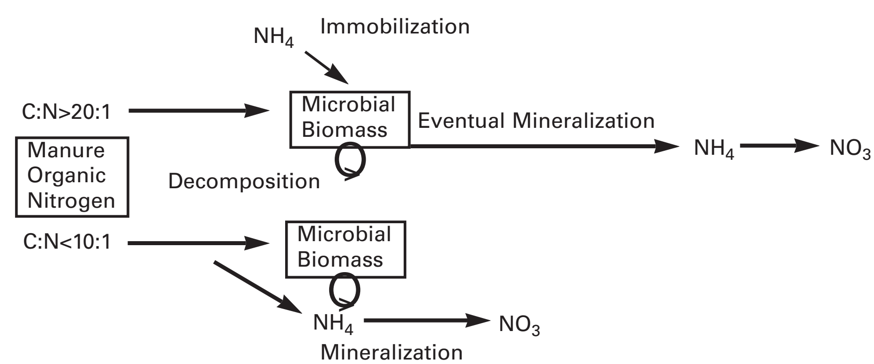

Figure 1. Decomposition pathway of manure organic nitrogen.

A key attribute of the organic matter in the manure influencing nitrogen availability is the carbon to nitrogen (C:N) ratio of the organic matter. When the carbon to nitrogen ratio is high (> 20:1) decomposing microorganisms may initially use all of the nitrogen in the organic matter plus the inorganic nitrogen to construct cell material (immobilization). This can result in little or no increase in available nitrogen observed in the first few weeks or months following application of manures with high C:N ratios, or even a net decrease if the C:N is high enough.

After an initial period of decomposition in which carbon is lost as carbon dioxide, the C:N ratio becomes smaller and eventually inorganic nitrogen in excess of microbial needs is released (mineralization). Consistent with this, Charles (1999) observed limited impact of fresh feedlot pen cattle manure (C:N ~ 20:1) on soil nitrogen availability and crop nitrogen uptake in the year of application at two sites near Humboldt, Sask. However, as decomposition proceeded in the second and third year after application of cattle manure, increases in nitrogen availability became apparent.

The high organic matter content of cattle manure – bedding mixtures contributes to the build-up of a pool of mineralizable humus in the soil which contributes to tilth and available nitrogen supply that is evident even several years after the application ceases (Vitosh et al., 1973).

Paul and Beauchamp (1996) observed that net N mineralization decreases when the C:N ratio is greater than about 9:1. Immobilization of available N has been observed in cattle manures with C:N ratios of about 16:1 (Beauchamp, 1986; Sommerfeldt and MacKay, 1987). It is important to recognize that the C:N ratio of the organic matter in solid manures is variable and should be measured in order to more accurately predict effects on soil available nitrogen in the short-term. For example, manure from feedlots which has much straw bedding (high C:N ratio) incorporated into it will collectively have a have a higher C:N ratio and be less effective as a source of available nitrogen in the year of application than manure which is predominantly fecal material or which has been piled and composted such that carbon has been removed as CO_2 and the C:N ratio decreased.

The C:N ratio of organic matter in liquid swine effluent samples tends to be lower, with values ranging from 5:1 to 10:1 reported for samples collected in Saskatchewan (Charles, 1999). These ratios are low enough such that upon initial decomposition, nitrogen is present in excess of the microbial needs and there is a net release of inorganic N, increasing the supply of available nitrogen (Qian and Schoenau, 2000).

Current estimates of the availability of liquid swine effluent organic nitrogen (net mineralization) in the year of application in Prairie soils is 20-30 per cent. These values, which are incorporated in manure application recommendation systems, appear reasonable. The effects of swine manure on increasing availability of nitrogen in the soil may not always be evident in large increases in

extractable inorganic nitrogen levels in the soil. In forage grasses, significant recycling of applied manure nitrogen appears to take place through mineralization of nitrogen initially sequestered in biomass (microorganisms, roots and exudates) in these systems (Pastl et al., 2000).
The organic matter in liquid swine effluent is more rapidly decomposed than organic matter in solid cattle manure (Charles, 1999). Because of its low C:N, easily decomposed nature and high proportion of ammonium, it is usually observed that liquid swine effluent has a consistent and significant effect on increasing soil available nitrogen and crop nitrogen uptake immediately following application (Schoenau et al., 1999, Qian and Schoenau, 2000). Some workers have suggested that long-term application of liquid swine manure will have relatively little direct impact on increasing soil organic matter as compared to solid manure since the low C:N ratio may stimulate oxidation of native soil organic matter (Eiland, 1980). However, these predicted effects do not take into account the long-term effect of increased crop residue carbon additions associated with stimulation of plant growth from the nitrogen and other nutrients in the manure.

Crop Utilization of Manure Nitrogen and Potential Loss Mechanisms

As expected, because of incomplete mineralization of the manure organic N, the crop recoveries of applied manure N tend to be lower per unit of total N applied as compared to commercial inorganic fertilizer. In trials on a loam soil in the Black soil zone near Humboldt, we found apparent crop recoveries of injected liquid swine manure nitrogen in the year of application to be 60 per cent to 70 per cent of that observed for urea. For cattle manure at this site, we found apparent recoveries of manure N in the crop to be much lower in the year of application , with recoveries for cattle manure N about 7 per cent to 10 per cent of the recovery observed for urea. These findings are consistent with a much higher proportion of the total N in the cattle manure comprised of organic N and a high C:N of this organic matter as compared to the liquid swine effluent.

In the second year following application of the manure, the apparent recovery was still slightly higher for the liquid hog manure than the cattle manure (Wen and Schoenau., 1999). It is clear that in the case of solid manures with much organic matter of high C:N ratio, it may take several years for the nitrogen to be liberated into an inorganic plant available form. However, when the manure nitrogen is retained in the organic form it is much less susceptible to losses by leaching or gaseous escape if not used by the crop.
Potential loss mechanisms for manure nitrogen in Saskatchewan soils include leaching, denitrification and volatilization. Similar to any ammoniacal fertilizer, the inorganic nitrogen added in animal manures as ammonium will be converted to nitrate (nitrified) if not used by plants. If application rates result in available nitrogen amounts in the soil that exceed the crop's nutrient uptake potential, the excess nitrogen is at risk for loss to the environment. The accumulation of nitrate is of concern owing to groundwater contamination risks. Chang et al (1991) observed accumulations of excess nitrate in soils in southern Alberta following annual applications of beef cattle manure at high rates. Similarly, Charles (1999) observed that a high rate of liquid swine effluent (790 kg total N / ha) produced crop injury and excess soil nitrate (> 400 kg NO_3-N / ha 0-60 cm) at the end of the growing season.

Repeated yearly applications of manure at rates which greatly exceed the ability of the crops grown to use the nitrogen will increase the risk of movement of nitrate below the root zone. For a single application of liquid swine effluent made in 1997 at low, medium, and high rates at a research site near Dixon, no elevation in soil nitrate contents below the root zone (60-90cm, 90-120cm) was observed in plots sampled in fall of 1999 as compared to the unfertilized control (Table 2).

For lower annual application rates of liquid swine effluent (~75 - 150 kg total N / ha) there was also no evidence of elevated deep soil nitrate levels above the control at the end of three years (Table 2). However, at the high annual

Unlike many cattle manures, liquid swine effluent has a significant effect on available nitrogen and crop nitrogen uptake right after application.

rates there was some evidence of downward movement of nitrate. At rates of ~300 kg total N / ha each year from 1997 to 1999, in the fall of 1999 the soil nitrate content was significantly increased over the control in the 60-90 cm and 90-120 cm depth.

Urea applied at high rates (200 kg N / ha) every year also showed a similar trend (data not shown).

For the cattle manure treatments, for single application made in 1997 and for annual applications (97,98,99) at all rates (~100 to 400 kg total N / ha), no significant increases in soil nitrate above the unfertilized control were observed in the fall of 1999 in the 30-60 cm, 60-90 cm and 90-120 cm depths. This lack of effect of cattle manure additions on increasing nitrate deeper in the profile after three years is consistent with the slow conversion of organic N to plant available inorganic N with this type of manure. It is important to remember that especially with high organic matter content manure where the nitrogen persists in the ~~organic form, there can be continued release of available N~~ through mineralization for several years after the application ceases.

Liquid Swine Effluent Plots

N Rate (kg total N / ha)			Soil NO3 -N (kg/ha)	
'97	'98	'99	60-90 cm	90-120 cm
0	0	0	1.4 a	2.6 b
75	50	100	2.4 a	6.3 ab
150	100	200	3.5 a	8.2 ab
300	200	400	21.5 b	13.0 a
300	0	0	1.8 a	3.6 b

Solid Cattle Manure Plots

N Rate (kg total N / ha)			Soil NO3 -N (kg/ha)	
'97	'98	'99	60-90 cm	90-120 cm
0	0	0	1.1 a	2.0 a
120	100	70	0.6 a	1.8 a
240	200	140	2.2 a	4.3 a
480	400	280	1.9 a	3.5 a
480	0	0	3.0 a	4.5 a

Table 2. Deep soil profile nitrate contents in samples taken in fall 1999 from manure application research plots at Dixon, Sask.

For a manure type, values in a column followed by the same letter are not sig. different p< 0.05.

The process of denitrification, in which the nitrate is reduced to nitrous oxide and dinitrogen gas (N_2), is another potential loss for manure nitrogen. Microbial denitrification is carried out by soil microorganisms and is favored by poor aeration, abundance of organic carbon, and warm temperatures. Conversion of nitrate to nitrous oxide is of particular concern as nitrous oxide is a greenhouse gas. Manures provide carbon for denitrifying microbes and in the case of liquid manures, much soluble carbon and water, which can create anaerobic microsites where denitrification occurs.

Residual unused nitrate left in the soil is especially susceptible to denitrification losses in fall or spring before the next period of crop nitrogen demand. Potential for denitrification losses are greater in clay soils than sandy soils.

Recent studies of denitrification on field plots in east central Saskatchewan have shown higher potential denitrification activity with injected manure than the equivalent N rate of urea fertilizer (Farrell et al., 1999). As application rates increased, the denitrification potential increased. Denitrification tends to be episodic, with pulses of nitrous oxide gas production observed after application and when the soil is saturated immediately following snowmelt or heavy rainfall. The significance of this process as a loss mechanism deserves continued attention.

Volatilization refers to the loss of manure nitrogen via the escape of ammonia (NH_3) gas. As is the case with ammonia-producing commercial nitrogen fertilizers like urea, placement of manure in the soil through injection or incorporation tends to result in less volatilization loss and greater crop nitrogen recovery than broadcasting. Placement of the manure into the soil gives any ammonia an opportunity to react with the soil, forming ammonium ions which are retained. Broadcasting of liquid manures without incorporation can result in volatilization losses as high as 30 per cent (Beauchamp et al., 1982) while injection (banding) into the mineral soil can reduce volatilization losses to less than two per cent. A similar effect of placement of liquid swine manure was revealed in field plots in east central Saskatchewan where injection has consistently resulted in greater soil available N following application than broadcast and incorporation. For cattle manure we have observed little difference in nitrogen availability between broadcast and immediate incorporation versus broadcast and 24 hour delayed incorporation. It is clear that placement of manure on the soil surface, without incorporation or injection, is less desirable from a nitrogen retention standpoint as well as increasing concerns over odor and contamination from surface runoff.

Conclusion

Good management of the nitrogen in manure involves knowing the amounts and forms of nitrogen present in the manure and accounting for the effects of important processes in the soil nitrogen cycle that will influence the behavior of the manure N as a source of plant nutrients. These are essential factors in the sound management of any fertilizer nitrogen source as this knowledge will enable selection of the best application rate, timing and method of placement to maximize agronomic benefit and minimize nutrient pollution concerns. This knowledge of manure nitrogen behavior in Prairie soils is being integrated into manure application recommendations systems. While ammonium nitrogen contained in animal manures will behave in a similar fashion to ammonium derived from commercial inorganic fertilizers, the content and composition (C:N) of the organic nitrogen will be an important factor governing how the manure behaves as a source of plant available nitrogen in both the short and long-term. As with commercial nitrogen fertilizers, manure application rates that result in available nitrogen in excess of plant needs will create concerns over excess nutrient losses to the environment.

Good management demands knowledge of the amounts and forms of nitrogen present in manures

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POOR IMMUNITY FROM A *STREP. SUIS* AUTOGENOUS BACTERIN

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Immunity

Streptococcus suis is a major cause of death and disease losses, especially among recently weaned pigs. This disease results from bacterial infection. While it may respond to antibiotics or vaccination, *S. suis* is difficult to control since there are many strains (more than 35 serotypes) that can cause sickness.

The disease often strikes quickly and makes pigs quite sick, with bacteria in the brain and joints, before treatment can be started. During a flare-up, the best chance for an infected pig is an injection of antibiotic.

A potential advantage of vaccination is the herd can be protected before disease has flared up and expensive antibiotic treatments may be unnecessary. A successful outcome will depend on antibody level and antibiotic at the site of infection.

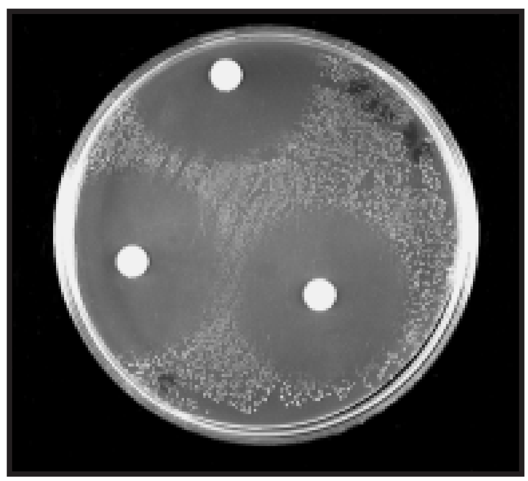
Our objective was to measure the amount and variation in the antibody response

Producers who have to control this disease must make a difficult choice of where to spend limited resources for disease control. Vaccination to prevent disease can be very cost-effective if the vaccine is designed to control the type of bacteria causing disease. This problem can be addressed by having a custom-made vaccine (called an autogenous bacterin) produced from bacteria that are isolated from an untreated sick pig. In this type of situation, the protection from disease depends on the presence of antibody in the serum of vaccinated pigs.

If all vaccinated pigs made a potent immune response, then the choice to get an autogenous bacterin would be economically sound. If there were a large amount of variability or poor response after vaccination, then an alternative disease control strategy might be more effective.

Study herd and trial design

We conducted this study in a Saskatchewan herd of pigs with high quality commercial genetic background. The herd experienced disease loss due to *S. suis,* and there has been on-going treatment for acute and chronic disease. The difficulty and cost of treatment has increased because the *S. suis* now causing disease in this herd are resistant to penicillin.

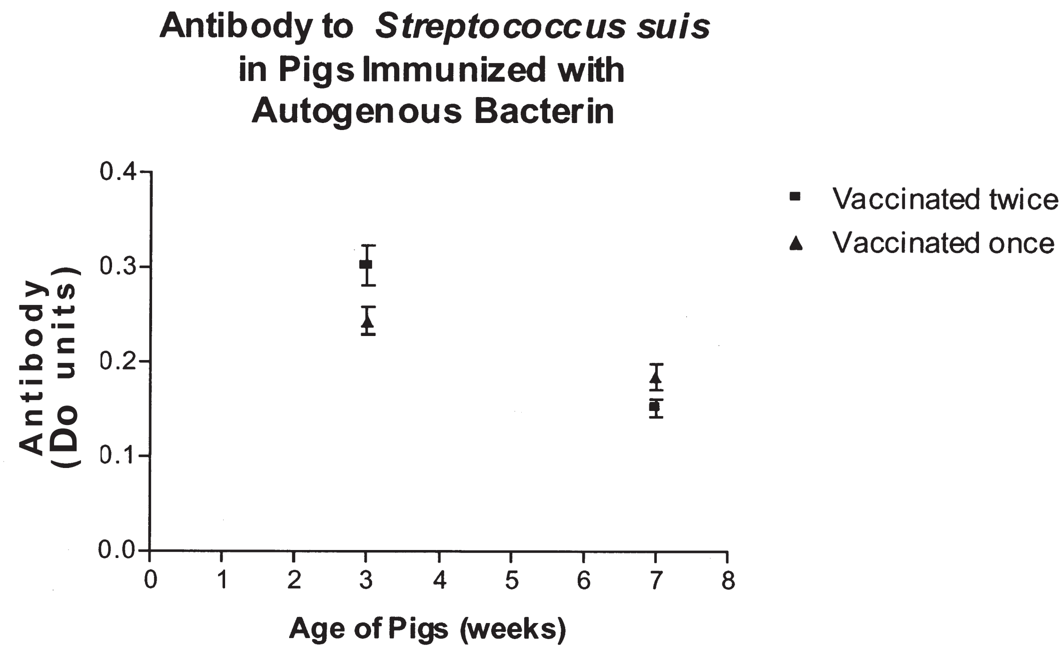


This test of antibiotic susceptibility shows that *Strep. suis* SX-428 is resistant to penicillin and has only intermediate susceptibility to ampicillin and cephalosporin.

A strain of *Streptococcus suis* was isolated from an untreated pig six weeks of age and designated SX-428. This strain was sent to a vaccine manufacturer that prepared an autogenous bacterin. This strain was also used in our laboratory to measure the amount of immune response in vaccinated pigs. The response was measured by using a technique called a “whole-cell ELISA”. A positive control pig immunized with *S. suis* (serotype 2) had antibody level of 0.331 with a coefficient of variation of 15.6 per cent.

Better vaccines or antibiotics are needed to control this pig-killing disease.

Veterinary Infectious Disease Organization, U of S [1].
Warman Veterinary Clinic, Warman, Saskatchewan [2].



Each pig in the trial was given a unique ear tag ID, a "pre-vaccination" blood sample was taken at weaning (three weeks of age) and a "post-vaccination" blood sample was taken at seven weeks of age. The 50 pigs in Group 1 were vaccinated twice (at weaning and 16 days later) in accord with the recommendations of the consulting veterinarian. The 50 pigs in Group 2 were only vaccinated once, at weaning.

Response to Vaccination

The graph above shows the average (and standard deviation) amount of antibody present in the blood of the pigs in this study against the strain of *S. suis*. The effect of number of vaccinations (1 or 2) is considered not significant ($p>0.41$). The effect of time is highly significant ($p<0.01$); however the total amount of specific antibody declined. Environment, disease challenge and host immunity can all affect the occurrence of disease. The vaccine given during this study did not reduce the amount of clinical streptococcal disease in this herd.

Implications

The autogenous bacterin failed to increase antibody levels in vaccinated pigs. The lack of clinical response in the herd following vaccination is consistent with the absence of an increase in specific antibody level. The lower antibody level at seven weeks of age is consistent with normal decline in passive antibody level and is probably not influenced by vaccination in this case.
The autogenous bacterin used in this herd was not economically justified since vaccinated pigs did not have increased immunity to *S. suis.*

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