PRAIRIE SWINE CENTRE INC.

2001 Annual Research Report

Our Mission

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

PRAIRIE
SWINE
CENTRE INC.

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Nutrition

Environment

Glossary

a guide to some of the terms used in this publication

ADF – a fibre fraction used to identify characteristics of feed stuff.

ADFI – average daily feed intake.

ADG – average daily gain.

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

ammonium – NH_4, a nitrogen compound found in commercial fertilizers and manure.

ANOVA – analysis of variance. A statistical tool used to compare independent variables.

anthropogenic – caused or produced by human activity.

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

BW – Body weight.

caecum – the cul-de-sac where the large intestine begins.

cannulated – to insert a small flexible tube into the small intestine to measure ingredient absorption.

chromic oxide – Cr_2O_3, a stable compound that doesn't dissolve in water and is largely unaffected by digestive acids.

CP – crude protein.

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

DE – dietary energy.

DM – dry matter.

digesta – digested feed.

endotoxin – poison produced by certain bacteria and released upon destruction of bacteria cell.

glucosinolates – naturally produced antinutritional chemicals that can hamper growth rate and cause thyroid problems in animals.

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

H_2S – hydrogen sulfide. A colourless, poisonous gas that produces a "rotten egg" odour. In pig barns it is produced by the breakdown of manure and is extremely hazardous if not managed properly.

hedonic tone – subjective measure to the pleasantness or unpleasantness of odour.

ileal – pertaining to the latter part of the small intestine, or ileum. Nutrients from feed are absorbed in this area.

ileum – the lowest portion of the small intestine.

K – potassium.

kcal – kilocalorie, or one thousand calories. A calorie is the amount of energy required to raise one gram of water one degree.

lysine – an amino acid essential for growth. Cereal grains are generally poor in lysine.

nitrate – NO_3, a nitrogen compound found in manure.

N – nitrogen (N_2), a major component of the atmosphere and an essential plant nutrient.

NDF – neutral detergent fibre. One fraction of total fibre found in a feedstuff.

operant conditioning – a process of changing behavior by rewarding or punishing a subject each time an action is performed until the the action is associated with pleasure or distress.

P – phosphorus.

proximate analysis – a testing protocol used to determine the makeup of a foodstuff, e.g. fats, proteins, carbohydrates.

psychrometer – an instrument used for measuring water vapor content or relative humidity using a pair of moist and dry thermometers.

regression analysis – a standard statistical tool for comparing the relative behaviour of two or more variables.

SEM – standard error of the mean. A way of stating how accurate data are.

sonicating – mixing or homogenizing a liquid using sound waves.

spectrophotometry – using different wavelengths of light to analyze materials.

plasma urea – urea contained in blood plasma. Urea is the principal end product of nitrogen metabolism in mammals.

xylanase – an enzyme which breaks down xylans, a type of carbohydrate.

Chairman's Report:

Growth of the Hog Industry Depends on Public Awareness and Support

As Prairie Swine Centre Inc. completes its 10th year of operation as a non-profit corporation, I can't help but reflect on the struggles the previous unincorporated Prairie Swine Centre endured. I thank the industry leaders of the day for their foresight and perseverance.

Without this major step forward, the Centre would not be the world class research facility it is today. In fact it may be questionable whether it would have survived.

We have not only survived, but made major strides ahead, with the addition of the 600 sow farrowing & finishing facility known as PSC Elstow Inc. Completed in 2001, Elstow has now begun full scale marketing. Research began the day the site planning commenced and has expanded to include the sow herd and most animals going to slaughter. Research varies from monitoring air quality, odor concentration, effects on ground water quality and the impact of effluent on applied soils. Animal research ranges from housing alternatives for the 600 sows, to feeding and behavioral studies of the numerous pigs going to market.

PSC Elstow's Viewing Gallery will allow the public to see a modern pig production facility without compromising biosecurity.

Biosecurity shuts the public out of pig production facilities, raising suspicions in the process.

Research programs between Prairie Swine Centre's two facilities – Floral and Elstow – involve a combined annual volume of pigs in excess of 12,700. This makes the Centre the largest public research facility of its kind in North America.

Public awareness has been a concern for the hog industry for the past 20 years. As the industry has grown in unit size, the risk of disease introduction has increased, or at least the numbers of animal affected in one location has increased. As a result of these real concerns, biosecurity for production units has increased and the doors have been closed to anyone who isn't directly involved with the operation.

This has left the public with a real concern that the production sector is hiding the way in which pork is produced.

During the planning stages of PSC Elstow Inc., attention was paid to this concern. We now have a production unit that has been designed to easily accommodate a renovation to allow the public at large to view each area of production and gain an understanding of our industry.

Wayne Vermette
Chairman of the Board, PSCI
Owner/Operator, Elite Stock Farm Ltd.

A group of industry leaders from Alberta, Saskatchewan, and Manitoba have been assembled to plan and design the interpretive center as well as raise the $1 million needed to complete and operate the facility for three years. At the time of writing this report, we have successfully raised half the capital. I send out a plea to our industry to solidly get behind this project so it can be completed this year. In order for our industry to grow and flourish we need the public – from school age children to the seniors that built this country – to support it. Opening the doors to the public in this way will be a major step towards acceptance and pave the way for growth.

This is my last official duty as a board member of the Prairie Swine Centre Inc. I truly enjoyed the time I've spent as a member on the Board of Directors and working with a truly professional organization. Thank you to John Patience, his staff and fellow members of the board for this opportunity.

President's Report:

Strategic Planning will Yield the Keys to the Future

In May, 1992, a new non-profit corporation, Prairie Swine Centre Inc., started operations, replacing the former unincorporated Prairie Swine Centre. At that time, a new strategic plan for the Centre was being implemented, complete with new facilities, new staff, a modified corporate structure and a clearly defined vision and mission.

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

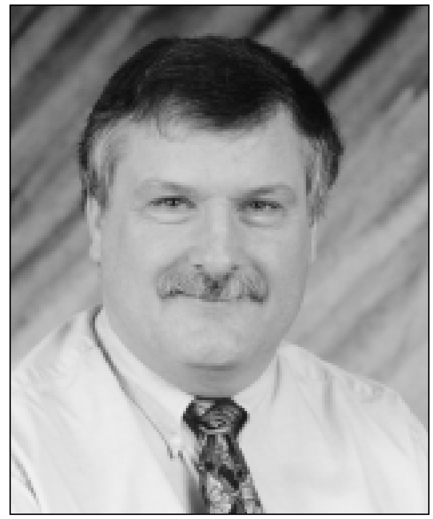
Time seems to have flown past, but here we are, almost 10 years later. Much has happened in the past decade, but our current focus is on the future, not on the past. In an industry that is changing rapidly, strategic planning is an essential management tool. Early in 2002, the Centre will embark on an exciting new strategic planning process, starting with personal interviews of more than 50 pork producers, consultants, government personnel, researchers and people working in the service sector across the Prairie region and beyond. We also anticipate a major symposium with internationally recognized authorities discussing the future of pork production, followed by intensive discussions with industry leaders on how the Prairie Swine Centre can best serve the pork business. A third phase of our strategic planning process will be discussions with our staff to gain their insight into how we can operate more effectively and efficiently. By year's end, we expect to have in place a strategic plan that will guide us boldly into the next decade, with a clear picture of our mission and vision, and strategic and personal action plans ensuring its implementation.

We undertake this process at the Centre following a decade of continuous improvement, increased financial stability, an internationally recognized research and technology transfer program and a committed staff. Thus, our strategic planning can be proactive rather than reactive. Never before has the Centre been more effective in providing practical information to the pork industry, to contribute to the financial success and long-term sustainability of pork producers. Research at the Prairie Swine Centre has helped producers lower their cost of production, use local feed ingredients more effectively, improve their barn environments for the benefit of pigs as well as people and address issues related to the environment and animal welfare. Our students have assumed positions in the feed industry, academia and the public service. In addition to their research and teaching accomplishments, our Research Scientists further serve the pork industry through membership on local, national and international organizations.

I believe we can now legitimately lay claim to international recognition as a leader in applied research for the pork industry. Comments from visitors from across Europe, the United States, Mexico and Asia confirm this fact. Nonetheless, with a rapidly changing industry, and emerging new trends in production, nutrition, housing, the environment and animal welfare, we must

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

greet the future with a clear vision of our role in serving the pork industry in the next decade. The best way to do this is, quite



Dr. John Patience Ph.D
President and C.E.O.

simply, to ask the pork industry, concisely and directly, for its input — then act on this information.

Why has the Centre achieved such success? The "recipe" is simple. Develop a clear plan based on input from the pork industry, hire the best possible staff, implement the plan with a strong sense of excellence and then communicate the results effectively to the industry. By continually interacting with the industry, the plan can be fine-tuned to ensure any necessary adjustments are implemented as quickly as possible.

The keys to success are also simple. The first is people. While I am very proud of the Prairie Swine Centre and its success, my greatest pride is in our staff: Research Scientists who would excel in the best faculties around the world, managers who continually seek a high level of excellence and service to their clients, research support staff that effectively and efficiently carry out the research, production staff that ensure our research facilities operate at a level that is relevant to the commercial pork industry and students who bring a level of enthusiasm and initiative that encourages all of us to do better.

Because we work with finite resources it's critical to have a plan, and stick to it.

The second key to success is our relationship with the pork industry. At the Prairie Swine Centre, this starts with our Board of Directors, a group of 10 which includes pork producers and others from across the Prairies who donate their time to our benefit. They are a body with a strong sense of where the industry is today, and where it is going in the future. Their role in guiding the Centre is absolutely critical to our success. I would like to publicly thank them for the time and effort, as they are all very busy people in their own right. They receive no payment for their time, and could easily reject our nomination to the Board in favour of more time with family, or with their own farm or jobs.

Our relationship with the pork industry does not stop at the Board, however. Through our technology transfer activities, and other interactions with the industry, we continually seek – and receive – input on our research and technology transfer programs. Each of our Research Scientists commit 20% of their time to technology transfer, an activity that we find highly rewarding due to the knowledge that new information from the Centre is being applied by the industry. In the process, we often receive suggestions for new projects, or refinement of existing ones. While we cannot respond directly to all input, in the end, we are confident that we are meeting the needs of the pork industry to the best of our abilities and within the context of the resources with which we have to work.

A third and final key to success has been a commitment to a plan. The resulting focus may have prevented us from pursuing some new ventures, but it has ensured that we have not self-destructed by spreading limited resources too thinly across too many activities. It has meant that we have regrettably had to say no to some requests, but in the end, our adherence to the plan has been critical. This brings me back to the concept of strategic planning, and why we are taking the process so seriously. It represents yet one more way for producers to provide us with guidance on how best to serve them.

At this time, I would like to thank our retiring Chairman, Wayne Vermette, who epitomized all which is good about our industry and was a real pleasure to work with, and who committed wholeheartedly to the Centre. I would also like to thank Dr. Louise Greenberg who also retired from the Board this year and contributed her time and expertise to our benefit.

I save my final thanks to the pork producers of Manitoba, Saskatchewan and Alberta, and to the Saskatchewan Agriculture Development Fund, who fund the Centre and allow us to exist. Your ongoing financial and moral support sustains the Centre and its people, and motivates us to continually try harder to serve your needs to the very best of our abilities.

PSCI BOARD OF DIRECTORS:
Back row (left to right): **Bryan Perkins, Ron Rempel, Mac Sheppard, Dr. Ernie Barber.**
Front row (left to right): **Harvey Wagner, Wayne Vermette, Dr. John Patience, Jim Smith.**
Missing from photo: **Dr. Louise Greenberg**

Report from the Manager-Operations

Maintaining Strong Genetics and Experimental Facilities

Production for this fiscal year, 2000/2001, faltered slightly from the previous year in relation to farrowing rate. Conversion of new genetic lines through PIC Canada Ltd. is well underway and should be complete for both the Floral and Elstow facility within the next fiscal year. Replacement of F1 females with the C-22 line and the use of the Line-65 boar as our terminal sire has improved market performance over the last year as the genetic profile of the herd evolves.

Over the last three fiscal years, index has risen from an average of 106.58 to 109.33. We have also been able to increase average weight from 85.98 to 88.93 kg. in fewer days to market freeing up some much needed finishing space.

Maintenance and repair issues are becoming more relevant as our facilities age. The original barns were constructed in 1979, the grow-finish facility in 1992 and three nursery rooms in 1995. In the upcoming year, we will be focusing on maintenance and repair and will develop budget strategies to ensure research and production doesn't suffer from facility inadequacies. We are in the process of designing and budgeting for three new nurseries tentatively scheduled to be constructed at the start of next fiscal year.

The Canadian Council for Animal Care on their last visit to the Floral facility recommended that the nurseries constructed over 20 years ago be replaced or renovated in the near future. These nurseries would be built similar to and in close proximity to the nurseries constructed in 1995. This will increase nursery research capabilities at the Centre as well as alleviate biosecurity concerns. For example, feed bins will be added for bulk diets, decreasing the number of tonnes of bagged feed delivered to the Centre for experimental purposes. When rooms are not on experiment an automatic feed system will be used to feed production diets.

Another program that has been implemented in an effort to maintain the integrity of our facility as well as preserve our minimal disease status is the complete eradication of rodents from the Floral and Elstow facilities. It is known that rats and mice carry *Heptospirosis, Streptococcus suis*, Swine dysentery and Swine erysipelas. Rats alone carry Bordatellosis and Trichinosis. The barns have a three-foot wide gravel barrier around all perimeters and spilled feed is removed immediately. Grounds are mowed and weeds are sprayed on a regular basis and all garbage is removed daily to disposal bins. Exterior and interior bait stations are monitored on a regular basis as part of our rodent control standard operating procedure.

Brian Andries B.Sc.
Manager, Operations

Table 1. **Production parameters for the 98/99, 99/00, 00/01 fiscal years**

	98/99	99/00	00/01
Sows farrowed, #	784	781	722
Farrowing rate, %	87.4	91.2	87.3
Pigs born alive/litter	11.0	11.2	11.4
Litters weaned	776	797	728
Pigs weaned	7767	8033	7311
Weaned/female inventory	24.2	24.5	24.8

Technology Transfer

It's What You Do with What You Know

The Annual Report is the perfect time to reflect on where you have come from and where you are going to. This year's title comes from an old adage that goes something like this:

"Life is not about education; unrewarded genius is almost a proverb; we are also not interested in action alone since unguided action can be as unproductive as inaction. What we seek, and the world applauds, is: what did you do with what you know?"

After realizing this simple truth we realign our compass and ask "what have we done that speeds the adoption of new technology by the commercial pork industry?" Table 1 is this year's tally of activities. They cover the three critical areas of personal contact, print media and electronic media.

Adopting new technology at the barn level demands clear, well-crafted messages, delivered face-to-face and through media.

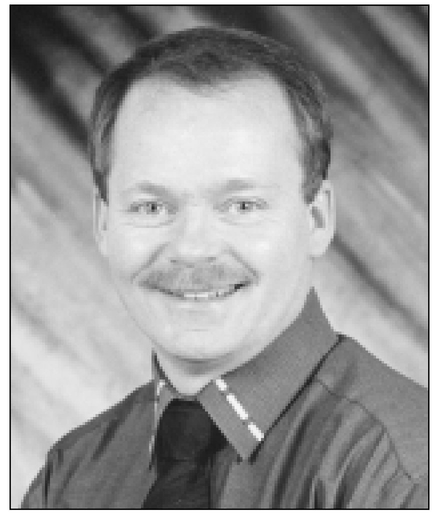
Activity by itself doesn't guarantee the message is being received and acted upon, but it does greatly improve the chances of having the information incorporated into the daily routine of barn management.

Crafting a clear message is important, but repeating it ensures it is seen. For example, most people are aware seatbelts are a good way to reduce injury, but how long was it before you automatically buckled up when you got in the car? How many commercials on radio and TV bombarded us (just as drinking and driving ads do today)? At first we resisted the change with reasoning like "I have gotten along just fine so far without them"; or "besides there is no proof they help, in fact I knew someone in an accident that would never have survived if they had their belt on …" and so on. But after some time, continually exposed to the message, reminders from the alarms installed in the car, a ticket or close encounter with a fine all persuaded us to adopt the technology. Today it is automatic: you don't even know you're are doing it but the belt is on.

Repetition of the message, presenting it in different ways, in different media all contributes to the adoption of new technology. As a professor in agricultural marketing states:

"On average it requires seven exposures to new information to elicit a change in behaviour."[1]

We take this advice seriously at Prairie Swine Centre and look for new opportunities to make the message practical, useful and retrievable. Typically a message will follow a path that looks something like this: Key research findings appear first at the Focus on the Future Conference (held each spring). This is picked up by local radio and one or more agriculture media as a news story. Then it is featured in *Centred on Swine* in greater detail, followed by an article in a pork magazine, and at research update meetings and symposia across the region, in the *Annual Research Report* and on the Web site. In the meantime, results are presented at major scientific conferences, and are published in scientific journals. This process fulfills our requirement for at least seven separate exposures to the information.



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

This year the focus was on increasing the

Table 1. **Listing of Annual Technology Transfer Activities**

Activity	Frequency per year	Distribution per issue/attendance
Annual Research Report	1	2000
Centred on Swine	4	4700
Speaking engagements	60 +	2000 +
Open House (at PSC)	5	100
Factsheets	1-5	5000
Special publications (books, proceedings)	1-2	
Posters at conferences	8-10	
Focus on the Future Conference	1	135
Farm calls	35 – 40	

[1] Downey, Purdue University, 1990 (based on a survey of US farms including both crop and livestock producers).

amount of information retrievable from the Web site. Right this minute the information on selecting a new feeder or evaluating a new pit additive, or considering group housing for sows may not be on the top of your list of priorities. These have been widely published but lie somewhere in back issues of a magazine or *Centred on Swine* that can't be found. So when key questions need answers where do you turn for information? My personal experience is that most people phone someone they trust and respect as their first source, then supplement this with some reading. Today an increasing number of these questions are addressed to Internet Web sites. The advantage is that it is readily accessible when the need arises and in many cases a great deal of detailed documentation can be found. One survey indicated that over 65% of pork producers have Internet access. When all of these factors are considered it only made sense to place additional resources on the development of the Centre's Web site.

Paul Vielfaure addresses the audience at the PSCI Director's Lecture in October.

Today you can find an increasing amount of technical information researched at the Centre and elsewhere all in an easy to navigate one-stop-shop. Back issues of *Centred on Swine* (soon to include a text search function), seven years of *Annual Research Report* summaries, printable (PDF) documents from various papers and presentations, and the most comprehensive database of research information on the pork industry. By going to the Web site and typing in key words such as odour, amino acids, air quality, etc., a group of four databases can be accessed. These include over 1,500 research summaries from around the world in addition to summaries from the Centre's research. There is no charge for accessing this information if you are a pork producer contributing to the annual core program funding provided by Sask Pork, Manitoba Pork and Alberta Pork.

Lastly, making the information relevant also speeds adoption. "How much does it cost and how great are the benefits?" These are fair and legitimate questions. In many instances, where it is possible, a brief economic assessment has been made that helps you to decide on the cost/benefit of a particular technology. This economic assessment is an important part of helping you adopt new technology. We will be increasing the emphasis on providing this type of information in support of applied research.

EXECUTIVE MANAGEMENT TEAM:
Back row (left to right): **Dr. Eduardo Beltranena, Lee Whittington, Dr. Ruurd Zijlstra, Dr. Claude Laguë, Dr. Harold Gonyou**
Front row (left to right): **Brian Andries, Dr. John Patience, Linda Ball, Dr. Stéphane Lemay**

Hydrogen Sulphide Awareness: A Response to Producer Needs

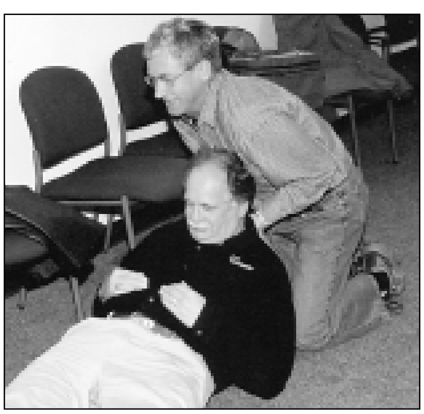
Mary Petersen, B.Ed. Coordinator of Training Programs

The Prairie Swine Centre training program added a new one-day course, Hydrogen Sulphide Awareness, which addresses growing industry concern regarding safety and exposure of hog barn workers to hydrogen sulphide gas (H_2S).

Mary Petersen, Coordinator of Training Programs, worked closely with the University of Saskatchewan Department of Agricultural Medicine and Department of Saskatchewan Occupational Health and Safety to develop the one-day course designed to increase the safety of hog barn workers.

Mary Peterson, instructor, Kelly Bowen and Christina Morassutti at a course in Niverville, MB.

Using an Self-Contained Breathing Apparatus (SCBA) for the first time.



Demonstrating rescue techniques.

Hydrogen Sulphide Awareness begins by giving participants information about the gas, including properties of H_2S, short-term and long term effects on humans, and exposure limits as outlined by Occupational Health and Safety.

Instructor, Petersen strives to make the course fun by keeping lectures to a minimum and encouraging open discussion among producers. This enables participants to learn from each other. Working in small groups, participants analyze and discuss real life incidents from hog barns throughout western Canada. This makes them realize these incidents can happen to anyone who is uninformed and unprepared.

“The concepts behind H_2S, and how fast accidents can happen without proper precautions, was pretty sobering,” according to one course participant.

Participants are also introduced to electronic monitors that measure gas levels, as well as a Self-Contained Breathing Apparatus. Rescue techniques are demonstrated and the importance of protecting yourself in dangerous situations is discussed.

The initial response from the industry was rewarding. The course has been delivered in Saskatchewan, Alberta and Manitoba. To date, over 800 people have been trained through this program.

“Regardless of your farm set up H_2S awareness and safety together with SOPs are essential to any hog operation,” one producer says. “This course was very timely, informative and useful to my operation. My staff will see improvements to our SOPs. Excellent job done by the instructor and by the people who worked on the manual.”

Financial Summary

A Broad Base of Support for Pork Research

Prairie Swine Centre Inc. is a non-profit corporation. We derive our income from three different sources: sale of stock, service and research. Each contributes 28%, 4% and 68% of the total, respectively. In last year's annual report, we presented details on the importance of animal sales to the Centre's financial success. This year, we focus on research funding.

Since its inception in 1992, Prairie Swine Centre Inc. has received funding for our research and technology transfer programs from no less than 70 different organizations, representing both the private and public sectors in six Canadian provinces, eight nations covering the governments of North America, Europe and Asia.

Core funding, provided by SaskPork, Alberta Pork, Manitoba Pork Council and the Saskatchewan Agriculture Development Fund, provides the resources to put in place our core scientific and management staff. These people, in turn, seek out money from public funding agencies, such as the Natural Sciences and Engineering Research Council of Canada and the Alberta Agriculture Research Institute as well as dozens of private agencies associated with the pork, grains, feed, and equipment industries. The result is a diversity of funding that supports an applied research program in nutrition, engineering and applied ethology (behaviour).

The nature of the Centre's funding has changed in the past decade. Figure 1 illustrates how core funding is supplemented by funds recruited from other public and private agencies. In 1993, core funding represented 88% of the total; by 2001, it had fallen to only 31% of the total. Nonetheless, core funding remains critical to the success of the Centre, as it puts in place the staff who can then recruit additional funding from various other private and public sources. Figure 1 clearly shows how successful these staff have been in building on core funding.

Pork producer funding represents a significant portion of the total. In addition to core funding earned from Sask Pork, Manitoba Pork Council and Alberta Pork, significant grants for various projects have been received over the years from the (U.S.) National Pork Producers Council, the B.C. Hog Marketing Commission and the Ontario Pork Producers Marketing Board. In 1993, 29% of total funding of research and technology transfer came directly from pork producers, compared to 26% in 1997 and 24% in 2001 (Figure 2). Overall, for every $1 received from pork producers, the Centre has conducted about $4 worth of research.

Finally, the Centre is increasingly recognized as a significant participant in global applied research. Whereas in 1993, only 10% of total research and technology transfer funding was earned outside the Prairie region, by 1997, this proportion had risen to 34%. By 2001, more than 45% of the total research and technology transfer funding was derived from outside the Prairie region (Figure 3).

Increasing levels of funding earned outside the Prairie region reflects the Centre's growing reputation for world-class applied research.

It makes sense for the Centre to broaden its base of support as widely as possible. However, this must all be accomplished with a clear vision and goal. Without a clear focus, limited resources would be spread over too wide an array of activities, and in the end, we would have little to show for it. For this reason, the Prairie Swine Centre is embarking on a major strategic planning initiative. The details are presented in the President's Report elsewhere in this Annual Report.

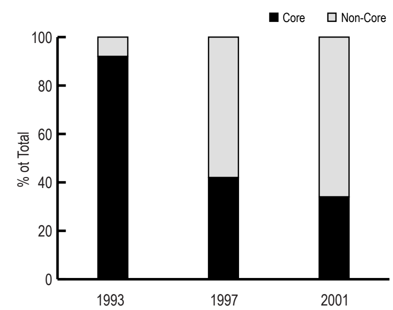


Figure 1 **Proportion of total research funding which is "core".**

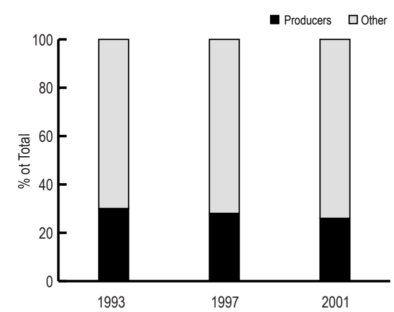


Figure 2 **Proportion of total research funding contributed by pork producers**

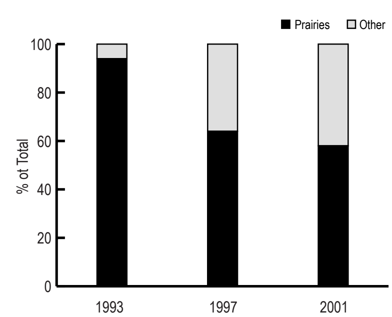


Figure 3 **Proportion of total research funding earned outside the prairie region**

Research Objectives

1. To reduce the cost of production in western Canada by at least $2.00 per pig sold, by defining cost-effective feeding strategies for the growout phase.

2. To provide greater economy and flexibility in swine diet formulation, and to increase the use of locally grown commodities, by developing recommendations for use of "opportunity" feeds in hog production.

3. To develop animal care guidelines and management procedures consistent with the needs of the swine industry, but derived through the consideration of swine behaviour.

4. To develop systems for improving air quality inside hog barns, to enhance human and animal health and comfort, and to reduce external odour emissions.

5. To reduce hog production costs by optimizing the physical environment in hog barns.

6. To develop new information on operating systems and management procedures which ensure the long-term environmental sustainability of pork production.

PRAIRIE SWINE CENTRE INC.

The Impact of Feeder Adjustment and Group Size / Density on Weanling Pig Performance

Laura Smith, A. Denise Beaulieu *Ph.D.*, John, F. Patience *Ph.D.*, Harold W. Gonyou *Ph.D.*, and R. Dean Boyd[1] *Ph.D.*

Summary

An experiment was conducted to examine the impact of group size / density and feeder adjustment on the performance of weanling pigs. Providing more floor space resulted in increased body weight at 10 weeks of age. Performance was maximized when the feeder gap allowed for 40% of the trough to be covered with feed. Moreover, proper adjustment of the feeder reduced the time spent eating and thus increased feeder capacity.

Figure 1 **Feeder trough coverage with a gap adjustment providing a gap opening of 9.2 mm.**

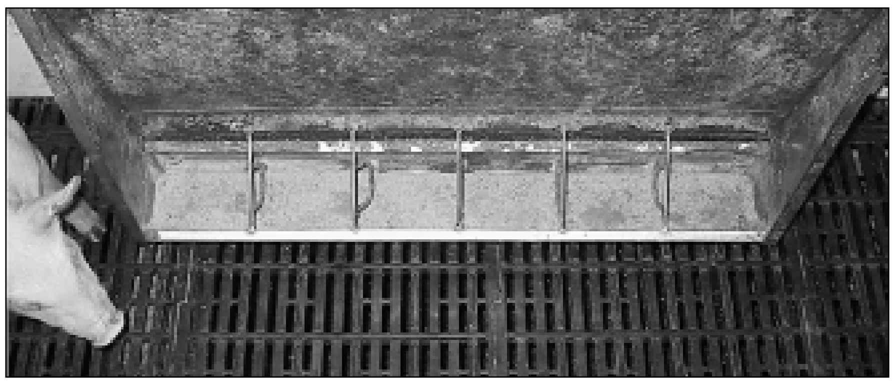


Figure 2 **Feeder trough coverage with a gap adjustment providing a gap opening of 17.9 mm.**

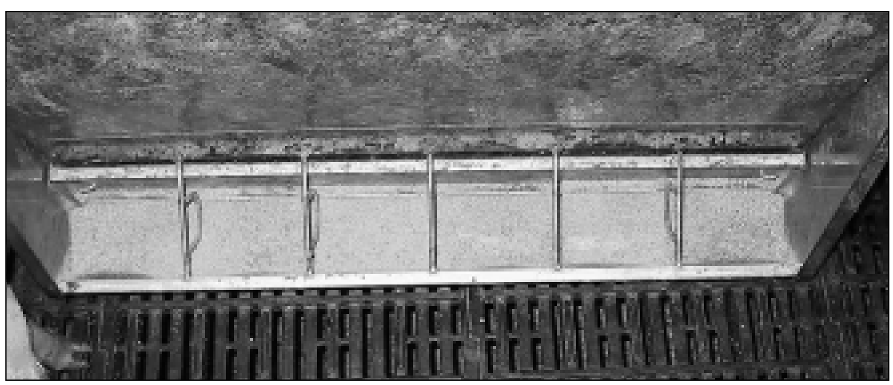


Figure 3 **Feeder trough coverage with a gap adjustment providing a gap opening of 31.5 mm.**

Introduction

Crowding and /or reduced floor space allowance negatively affects nursery performance and exacerbates social vices such as tail-biting, side-nudging and ear chewing. Feeder adjustment impacts feed intake and can alter feeder capacity. Since some of the detrimental effects of crowding are due to decreased feed intake, adequate floor space and proper feeder adjustment may act in a synergistic fashion to improve pig performance.

Experimental Procedures

Seven hundred and sixteen pigs weaned at an average of 18.2 days of age were assigned to: 1) 24 pigs per pen, 2.5 ft^2 per pig; 2) 20 pigs per pen, 3.0 ft^2 per pig [approximates commercial conditions]; and 3) 16 pigs per pen, 3.75 ft^2 per pig [approximates the Canadian Code of Practice] for a 42 day trial. A commercial, 6 space feeder with an overall width of __. Eight days later (d0 of exp.) feeders were adjusted to provide gap openings of 9.2, 11.8, 17.9, 24.8 and 31.5 mm (see Figures 1 to 3). Only a small bead of feed was available with an opening of 9.2 mm while the entire trough was covered with an opening of 31.5 mm. Feeding behaviour was videotaped on days 3 to 6

[1] Pig Improvement Company, Franklin, KY

and on days 39 to 42. On day 42, each pig was scored for incidence and severity of tail biting, side nudging and ear chewing.

Results and Discussion

The effect of treatment on body weight and feed intake were not apparent until the second half of the experiment. Body weight, daily gain and feed intake were maximized with a minimum feeder gap size of 18 mm ($P < 0.05$) or when at least 40% of the feeder trough was covered with feed ($P < 0.05$; Table 1). Younger pigs spent more time eating with a reduced feeder gap; however feed intake and daily gain were lower ($P < 0.05$; Table 1). Assuming feeder capacity is achieved when it is being used 90% of the time, the maximum capacity of a nursery feeder space would be nine pigs when adjusted to a 9 mm gap, but 11 pigs when adjusted to a 25 mm gap. The optimal feeder gap would change with different feed particle size and form; however it is achieved when at least 40% of the trough is covered with feed. Feeders with smaller gaps also required frequent unclogging (data not shown).

Less crowding and 40% coverage in the feeder tray offers the best economic return.

Decreasing group size and providing more floor space per pig resulted in increased final weight, daily gain, and feed intake (Table 1). When expressed on pork produced per square foot of floor space, the results favour crowding. However, previous research at PSC Elstow revealed that for every kilogram increase in body weight at 11 weeks of age, body weight at 17 weeks of age increased by 1.5 to 1.8 kg. The economics favour reduced crowding when considering the increased growth rate.

The effects of density/group size on final weight was more dramatic with a reduced feeder gap opening (feeder adjustment and group size/density interaction, $P < 0.05$; Figure 4). Neither floor space allowance or feeder adjustment affected the incidents of aggression, measured by skin lesion scores.

Implications

Body weight at 10 weeks of age was greater with increased floor space allowance, however, the kg of pork produced per square foot of floor space was increased with crowding. Nonetheless, when considering the increased net income due to the increase in nursery exit weight, the present results favour reduced crowding.

Optimal feeder gap is obtained when at least 40% of the feeder is covered with feed. Proper feeder gap adjustment reduced the time spent eating and thus increased feeder capacity. Assuming that feeder capacity is achieved when it is being used 90% of the time, the maximum capacity of a nursery feeder space would be nine pigs when adjusted to a 9 mm gap, but 11 pigs when adjusted to a 25 or 32 mm gap

Acknowledgements

Strategic program funding provided by Sask Pork, Alberta Pork, the Manitoba Pork council, and the Sask. Ag. Dev. Fund. Direct funding from the Pig Improvement Co. of Franklin, KY is greatly appreciated.

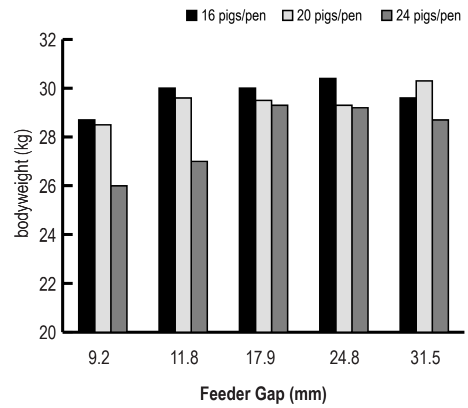


Figure 4 **The impact of treatment on final (d42) weight of pigs. There was an interaction of feeder adjustment and group size/density (P < 0.05). 16 pigs per pen provided 3.75 square feet per pig; 20 pigs per pen provided 3.0 square feet per pig and 24 pigs per pen provided 2.5 square feet per pig.**

Table 1 **The impact of feeder gap and group size/density on pig performance, feeder characteristics, time spent eating and lesion scores.**

	Feeder Gap, mm					Pig Density, ft^2/pig				Significant
	9.2	11.8	17.9	24.8	31.5	2.5	3.0	3.75	SEM	Effects[1]
Weight, kg										
Initial	6.96	7.10	7.12	7.18	7.03	7.03	7.10	7.09	0.044	ns
Final	27.9	28.9	29.5	29.5	29.56	28.0	29.3	29.6	0.093	F, D
	1	7	5	0		3	9	9		FxD
Daily Gain, kg/d	0.48	0.52	0.53	0.52	0.53	0.50	0.52	0.53	0.002	F, D
Feed Intake, kg/d	0.72	0.75	0.78	0.77	0.78	0.74	0.77	0.79	0.005	F, D
Gain: Feed	0.66	0.69	0.68	0.67	0.68	0.67	0.68	0.68	0.004	ns
Feeder										
Area Clear, %	94.1	88.0	62.6	31.8	8.8	51.9	53.8	59.0	2.28	F
Feed Depth, cm	0.06	0.04	0.30	0.69	1.27	0.48	0.50	0.44	0.028	F
Total Duration of eating, min/pig d[1]										
Days 3-6	142	118	125	116	116	122	127	121	5.99	F, FxD
Days 39-42	97	90	85	79	75	82	85	88	8.93	ns
Skin lesion score[2]	0.06	0.04	0.04	0.05	0.05	0.05	0.05	0.03	0.001	ns

[1] Effect of F (feeder adjustment), D (group size/density), or F x D, significant if $P < 0.05$.

[2] The mean score for belly, ears, body and tail. A score of 0 indicated no lesion, 2 indicated severe lesions.

Current Engineering Projects at Prairie Swine Centre Inc.

Stéphane P. Lemay *Ph.D.* and Liliane Chénard *M.Sc.*

Summary

New engineering projects have begun in 2001 and many ongoing studies will come to completion over the course of 2002. Considering the stage of those experiments, no final analysis can be discussed yet. This paper presents an overview of current engineering research activities at PSCI by providing a brief description of each project.

Current Projects

Establishing and comparing the water inputs and outputs in grower-finisher rooms using dry and wet/dry feeders

(S.K. Christianson, S.P. Lemay, H.W. Gonyou, J.F. Patience and L. Chénard; funded by the Natural Sciences and Engineering Research Council of Canada (NSERC))

Intensive swine operations require large amounts of water. Any wasted water increases demand on the water source, manure storage requirement and handling costs. The objective of this study is to establish and compare water balance between two grower-finisher rooms, one room equipped with dry feeders and the other with wet/dry feeders. Sources of water identified in this study include water disappearance from the drinker, feed moisture, metabolic water produced by the pig, water content of the pig and moisture of the incoming ventilation air. The sinks of water include the manure water content, water content of the pig and moisture in the outgoing ventilation air. Two rooms with identical features have been used with feeder type as the variable. Three grower and three finisher cycles have been studied over an 11-month period. At the grower phase (up to 60 kg BW) there is little difference between wet/dry and dry feeders for total water disappearances or manure product. For finisher pigs wet/dry feed reduced water usage and manure production by up to 45%. An accurate description of room water inputs and outputs constitutes a valuable tool in guiding water conservation initiatives.

Comparing water use of pigs on dry feeders with those on wet-dry systems.

A low protein diet combined with oil sprinkling for reducing odour and gas emissions of pig barns

(M. Payeur, S.P. Lemay, R.T. Zijlstra, S. Godbout, L. Chénard and E.M. Barber; funded by the Canadian Pork Council and the Livestock Environmental Initiative)

Odours and gases produced from the ventilation system of a hog barn can be an nuisance for the local environment and the neighbourhood. This study, the second phase of a larger project, was done to determine the combined impact of canola oil sprinkling with a low protein diet on odour and gas emissions of grower-finisher rooms. Four commercial rooms at PSCI were used to measure the effects of two oil application rates and two feed formulations over three different grower-finisher cycles of 10 weeks each. Room ventilation rate, temperature, relative humidity, ammonia, carbon dioxide, odour and dust concentrations were monitored in the four rooms. Trends obtained in the first phase of the project were observed in the second phase as well. Preliminary analysis of the data shows that a low protein diet, including fermentable carbohydrates, can reduce the ammonia concentration at the exhaust fan by up to 50%. Canola oil application reduced total dust concentration by 50 to 80%.

Preliminary results show a low protein diet and canola oil can reduce barn ammonia and dust emissions.

Modelling of ammonia emissions from swine buildings

(S.P. Lemay, E.M. Barber, H.W. Gonyou, J.F. Patience and S. Godbout; funded by NSERC)

Ammonia production from livestock operations can contribute to environmental acidification and pollution of ground and surface water by nitrogen enrichment. Excessive ammonia within the barn also affects air quality for animals and stock persons. The ultimate goal of this research is to develop a computer model to simulate ammonia production from a pig barn, factoring in the impact of diet formulation. As this modelling work is being developed, experimental measurements have been performed to understand how ammonia emission varies on a daily basis and how it is related to pig behaviour. Those measurements will be used to calibrate and verify the precision of the computer model. Modelling the emission process helps us understand how ammonia is produced and how its production rate can be reduced. This research will lead toward reduction of the ammonia concentration in barns and of emissions.

Hydrogen sulphide risks assessment for the Saskatchewan swine industry

(S.P. Lemay, C. Laguë and L. Chénard; funded by SaskPork)

Hydrogen sulphide (H_2S) is a life threatening gas produced by the anaerobic degradation of swine liquid manure. It is released when manure is agitated (e.g. while pulling the pit plugs, at the lift station, when the manure storage is agitated prior to emptying). Since this gas is heavier than air, it can be trapped inside pits and buildings where it can present a real hazard for human and pigs. Even though the H_2S concentration in a production room is generally very low, certain incidents lead us to believe that manure management tasks can result in high H_2S concentration. Swine workers may be assigned to specific tasks related to manure management that can significantly increase their exposure to H_2S (e.g. manure application contractors, workers assigned to manure management and maintenance of equipment in the barn, crews assigned to power washing). Up to now, those exposures have not been well evaluated and documented in the swine industry.

The main objective of this project is to monitor H_2S concentrations at the worker level, related to specific manure management tasks. These include emptying manure pits, power washing, working around the lift station, agitating manure before land application and pumping manure from the storage facility. The H_2S concentration associated with in-barn tasks is being measured at six different farms, in all four sections of the buildings (farrowing, gestation, nursery and finisher rooms) and during two seasons (summer and winter conditions). It is very important to fully characterize this exposure to ensure barn workers can complete their daily duties safely.

H_2S: Examining the risk to producers, and evaluating a tool for detecting this deadly gas.

Evaluation of the Dräger microPac performance for hydrogen sulphide monitoring in pig barns

(S.P. Lemay and L. Chénard; funded by Dräger)

Hydrogen sulphide monitors are available on the market but most have not been used continuously in swine buildings, so their long-term performance under these conditions is not well known. Instruments in swine building environments are submitted to a harsh environment of dust, humidity and gases. In addition, monitors worn by workers may be subjected to accidental falls on the concrete or in the manure during normal barn procedures. Also, with pig barns operating under strict biosecurity rules, monitors would have to be fumigated if moved between different farms or production sites. Thus, swine production conditions are likely to challenge the H_2S monitor and its sensor. A systematic testing procedure carried out under real barn conditions will provide valuable information on the monitor's reliability and durability when submitted to a typical pig barn environment.

The objective of this project is to evaluate the performance of the Drager microPAC unit for H_2S monitoring under pig barn conditions for a period of one year. This experiment will define the microPAC performance under real working conditions and will provide essential information to pork producers in selecting a good H_2S monitor for themselves or their employees.

Feasibility study for concrete swine buildings in western Canada

(S.P. Lemay, C. Laguë and L. Chénard; funded by the Cement Association of Canada)

Traditionally, swine buildings in Western Canada consist of a wood structure built over a concrete foundation. These have an average lifetime of 20 to 25 years. However, the industry is changing. Most of the expansion taking place in the Prairies is being done by companies of sufficient size to be interested in building more efficient and durable facilities that need less maintenance. The objective of this study is to evaluate the potential of concrete swine buildings with or without incorporating in-barn manure storage. General building concepts will be developed for each section of the barn (gestation, farrowing, nursery, and grow-finish) and they will be compared in terms of total volume of concrete used for construction, advantages/disadvantages of the design and life cycle cost.

Finding out if concrete buildings make economic sense.

Project Completion

Except for the ammonia modelling project which will be pursued over the following year, all studies previously described will be completed in 2002. Results of these experiments will be included in next year's edition of the *Annual Research Report*.

Acknowledgements

Strategic program funding is provided by SaskPork, Alberta Pork, Manitoba Pork and Saskatchewan Agriculture and Development Fund.

Thermoregulation of the Nursery by Early Weaned Piglets Through Operant Condition

Clover J. Bench[1] *M.Sc.* and Harold W. Gonyou *Ph.D.*

Summary

A study was designed to determine the optimal temperature preferred by early weaned piglets in a standard nursery environment through the use of operant conditioning (pig controlled environment - see definition on page 3).

Introduction

Thermal environment has a large effect on the health and productivity of growing swine. This is especially critical in the case of newly weaned piglets, which require warmer temperatures in the nursery environment. Today's confined pigs are often prevented from selecting their optimal temperature. Instead, the farm manager selects the temperature setpoint. During the colder months, nursery temperatures are often kept relatively uniform over space and constant over time. This deprives young pigs of the chance to select an environment more comfortable than the one the barn manager chooses. Previous studies on thermal preference in swine have concentrated on pigs four weeks of age and older, and have not investigated the ideal temperature for early weaned pigs. Through the use of operant conditioning in these previous studies, pigs have demonstrated the ability to respond to heat rewards and successfully control their thermal environment.

Piglets choose warmer days, cooler nights.

Experimental Procedure

Temperature preference was studied in piglets early weaned at 12-14 days of age in five consecutive replications during the winter of 2000. Each replication of the study lasted 21 days and took place in a single nursery room of six pens with eight piglets per pen.

Through the use of operant conditioning, in which an infrared heat lamp was used as a heat reward, one pen of eight pigs controlled the gas heater in the nursery room. Within the controlling (C) pen, a box was mounted which had both an operating (O) and non-operating (NO) lever. The infrared heat lamp was positioned over the O lever. The position of the O and NO1 levers were switched between replications. A second pen within the room was also equipped with a box mounted with a N02 lever.

Temperature data was collected every five minutes by means of thermocouples positioned throughout the nursery room connected to a datalogger. All hits to the O, NO1, and NO2 levers were recorded via the datalogger as they occurred. Relative humidity readings were taken daily with a psychrometer. Pigs were weighed at weaning and at 21 days post-wean.

Results and Discussion

The results demonstrate that piglets early weaned at 12-14 days are aware to a degree that allows them to learn to control their thermal environment successfully through the use of operant conditioning.

As age increased, the average preferred temperature for the early weaned piglets decreased by approximately 1.0°C per week ($P = 0.29$; Figure 1). Average temperature preferences were 26.33°C, 25.71°C, and 25.24°C for days 3-5, 10-12, and 17-19, respectively. While the average maximum temperature each week did not differ significantly ($P = 0.67$; Figure 1), the average minimum temperature was highest days 3-5 post-wean ($P < 0.05$; Figure 1). Furthermore,

Piglets enjoying the warmth of the infrared heat lamp.

[1] PSCI and Department of Animal and Poultry Science, University of Saskatchewan

minimum temperature in the room did not drop below 19°C (lower temperature safety setting), which kept average minimum temperatures between 22-23°C. Thermal preferences consistently ranged between 22-29°C each week post-weaning.

Thermal preferences reflected a circadian sinusoidal pattern in which the piglets preferred the highest temperatures during the day and the lowest temperatures during the night ($P < 0.0001$; Figure 2). These results agree with trends found in studies done in grow/finish hogs.

Implications

While it is known that early weaned piglets need warmer temperatures in the nursery, these data suggest that keeping the thermal environment uniform over space and constant over time is not preferred by piglets. Temperature settings for the nursery should be based on size and age of the animal as well as time of day. This challenges hog producers to consider more fuel efficient (and welfare friendly!) ways of managing the thermal environment of the early weaned piglet.

Acknowledgements

Funding provided by NSERC along with strategic funding provided by Sask Pork, Alberta Pork, Manitoba Pork and Saskatchewan Agriculture and Food Development Fund.

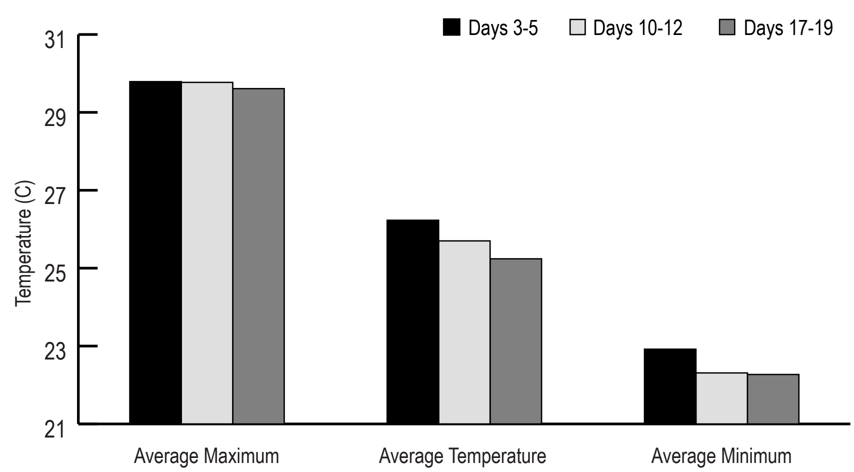


Figure 1 **Average preferred temperature with minimum and maximums for days 3-5, 10-12, and 17-19 days post-weaning.**

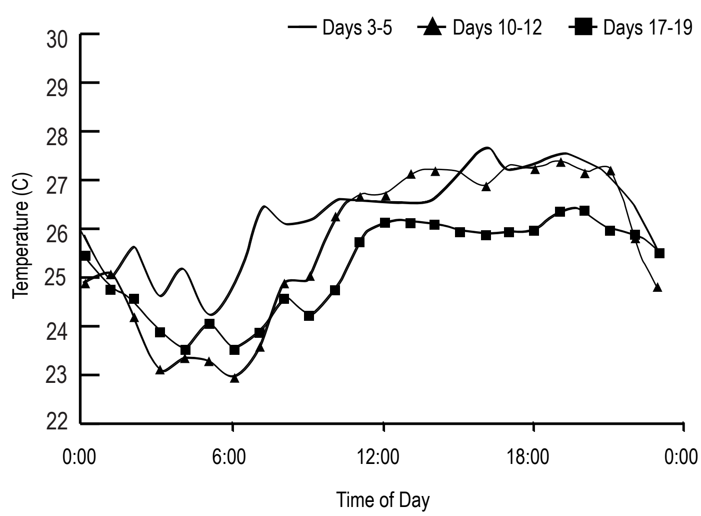


Figure 2 **Sinusoidal pattern for average temperatures preferred over a 24 hour (circadian) cycle. Temperatures averaged for days 3-5, 10-12, and 17-19 days post-weaning.**

Effect of Group Size on Aggression of Grower-Finisher Pigs

Stephanie A. Schmolke[1] ***M.Sc.*****, Yuzhi Li** ***Ph.D.*** **and Harold W. Gonyou** ***Ph.D.***

Introduction

Research on management and performance of grower-finisher pigs has generally been conducted with small group sizes, while the swine industry has shifted towards larger group sizes. Our previous study shows that productivity of pigs was not affected by group size up to 80 pigs/pen. However, there are still concerns about aggression and injuries among pigs in a large group. The objective of this study was to determine effects of group size on aggression and injuries of pigs.

Group size has no effect on aggression, and most fighting occurs two hours post-mixing

Materials and Methods

Each of two replicates was comprised of two pens of 10 pigs, and one pen each of 20, 40 and 80 pigs. Each pen contained an equal number of males and females with initial body weight of 23.2kg. One wet/dry feeder was provided for every 10 pigs. Space per pig was constant among group sizes. Aggression was observed for the initial eight hour post-regrouping. The number and duration of fights were recorded by continuous observation. Injury scores were collected 48 hours post-regrouping on four body zones. Time spent on lying, standing, eating, and sitting was determined at week three and week 10 during the study period.

Results and discussion

Pigs in large groups did not show more aggressive behaviours than those in small groups. Total duration of aggression was similar among group sizes (Fig.1). Fighting time was longer during the initial two hours post regrouping and declined thereafter. About 95% of pigs fought during the first two hours post-regrouping, and there were no differences among group sizes. Injury scores were similar among group sizes (Table 1). Injury was closely related to aggression. There were no differences in time spent on lying, standing, eating, and sitting among group sizes. After three weeks of regrouping, pigs spent 75 ~ 80% and 7% of total time on lying and eating, respectively.

Conclusion

Large group size did not cause higher aggression or more severe injury in pigs. At regrouping, most aggression and related injuries occurred during the first two hours post-mixing. Pigs in large groups behaved similarly to those in small groups.

Acknowledgements

Strategic funding provided by Sask. Pork, Alberta Pork, Manitoba Pork and Saskatchewan Agriculture and Food Development Fund. Additional funding for this project was provided by NSERC.

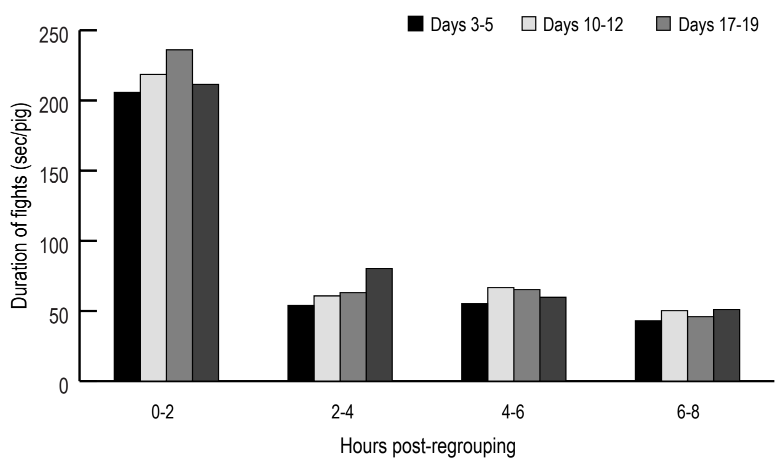


Figure 1. **Total duration of fights post-regrouping.**

Table 1. **Effect of group size on 48 hr post-regrouping injury scores***

	Group Size			
	10 pigs/pen	20 pigs/pen	40 pigs/pen	80 pigs /pen
Number of pigs scored	41	38	78	168
Average ear score	3.19	3.27	3.60	3.29
Average shoulder score	2.20	2.33	2.66	2.59
Total score	5.39	5.60	6.26	5.88

Injury scores: 0 = no wounds, 1 = 1 ~ 3 wounds, 2 = 4 ~ 6 wounds, 3 = > 6 wounds.

[1] PSCI and Department of Animal and Poultry Science, University of Saskatchewan

Effect of Gender and Crowding on Variation in Days to Market

Dana R. Cooper *M.Sc.*, John F. Patience *Ph.D.*, Harold W. Gonyou *Ph.D.* and Ruurd T. Zijlstra *Ph.D.*

Summary

Marketing strategies are affected by variation in days to market within groups of pigs. This study determined effects of gender and crowding on variation in body weight (BW) gain and days to market. Pigs were marketed individually at an identical market weight resulting in uniform carcass characteristics. Crowding did not increase variation; however, pigs marketed first were the heaviest pigs when traced back to farrowing. Thus, raising the growth curve of all pigs may be more practical than reducing variation. The latter appears very difficult on most farms.

Introduction

Managing variation in the production chain is receiving increasing attention. The economic impact of variation when marketing groups of pigs is enormous, yet few research programs focus on this issue. Uniformity of pigs reaching market weight may be affected by variation in growth caused by gender or crowding during the entire grower-finisher phase.

Experimental Procedures

At weaning, 493 pigs were assigned randomly within gender to a pen containing either 16 pigs/pen (0.35 m^2/pig; Control) or 21 pigs/pen (0.26 m^2/pig; Crowded). In the grow-finish room, pigs were allowed 0.88 m^2/pig (Control) or 0.67 m^2/pig (Crowded). Pigs were weighed at birth, days 21, 56, 77, 112, and 140 of age, and at market (~ 115 kg).

Results and Discussion

Crowding did not affect BW until day 77 when Control pigs were 1.6 kg heavier than Crowded pigs (Table 1). Gender did not affect BW until day 56 when barrows were 2.7 kg heavier than gilts. Coefficient of variation (CV) for BW at day 140 or days to market was not affected by gender or crowding. Together, results indicate that crowding reduced mean BW gain, but not variation around the mean. Marketing individual pigs at a specific BW resulted in similar carcasses between Control and Crowded pigs (Table 1). Overall, for an extra kg BW at weaning, 1.9 kg extra was gained at day 56 (8 wk), 2.4 kg extra at day 77 (10 wk), and 4.2 kg extra at day 140 (20 wk; Figure 1), indicating the importance of increasing weaning weight.

Implications

Marketing strategies should be developed based on variation within groups of pigs. Holding gilts longer than barrows may improve market value of a group. Less crowding reduced days to market (115 kg) by four days. Barrows reached market weight six days earlier than gilts.

Acknowledgements

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

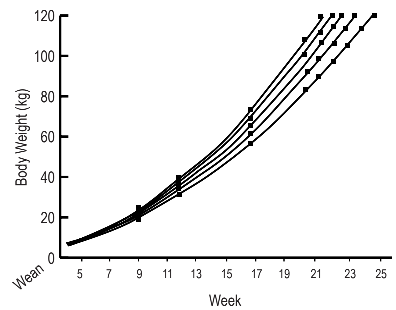


***Figure 1.* Growth curves of pigs marketed at 21, 22, 23, 24, and 25 weeks of age.**

Table 1. Effect of gender and crowding on performance variables

	Barrows		Gilts	
Item	**Control**	**Crowded**	**Control**	**Crowded**
BW, kg				
day 0	1.5	1.5	1.4	1.4
day 21	5.4	5.3	5.3	5.3
day 56	19.9	18.7	19.7	19.5
day 77[b]	30.6	28.9	30.7	29.2
day 112[ab]	61.0	60.4	59.1	56.9
day 140[ab]	96.4	93.1	90.9	89.2
CV	8.0	8.9	10.8	9.3
Days to market[a]	156.9	160.1	161.0	165.1
CV	5.1	5.0	12.5	4.8
Carcass characteristics				
Dressing %	90.4	89.9	91.0	90.6
Fat, mm[a]	23.7	21.8	18.0	18.7
Lean, mm[a]	52.3	52.5	58.0	56.8
Index[a]	107.4	108.3	113.4	112.9

[a]Gender effect [b]Crowding effect

Response to Dietary Energy Concentration and Stocking Density in Weaned Pigs

Crystal L. Levesque [1] *M.Sc.*, John. F. Patience *Ph.D.*, Eduardo Beltranena *Ph.D.*, Ruurd T. Zijlstra *Ph.D.*

Summary

Understanding the effect of energy intake on growth performance and body composition of pigs is critical for the development of economical feeding strategies. However, knowledge is limited on the influence of varying amounts of DE content on growth and body composition according to the growth potential of the pig. A study was conducted to examine the effect of increasing dietary digestible energy (DE) concentration on weaned pig performance at the farm level. Results indicate that higher dietary DE concentration may not improve weaned pig performance.

Introduction

Gut capacity is assumed to be the primary limitation to growth in the young pig because it limits their daily energy intake. Thus, concentrating dietary DE has been assumed to be an effective way to overcome this limitation in gut size. However, increasing dietary DE concentration increases the cost of the diet. In a previous study, increasing DE concentration did not result in improved pig performance. This lack of response to increased dietary DE may have been due to the absence of external stressors. Commercial groups of pigs are under additional stressors such as crowding. Crowding is known to negatively affect pig performance. Concentrating dietary DE may have a greater impact on weaned pig performance in the presence of external stressors.

Experimental procedure

Piglet response to dietary DE concentration and stocking density was studied in 600 pigs weaned at 19 days of age. Pigs were assigned to a low (3.75 ft^2/pig) or a high (2.50 ft^2/pig) stocking density and one of five dietary DE concentrations (3.19, 3.33, 3.47, 3.61, 3.75 Mcal DE/kg). Pigs received commercial starter diets from 19 to 25 days of age and experimental diets from 25 to 53 days of age. Body weight and feed disappearance were measured weekly. Cost per kg of gain was calculated using overall gain and feed intake.

Results

Final pig body weight (20.25 kg ± 0.06 SEM) was not affected by diet or stocking density. However, from 46 to 53 days of age, pigs at the low stocking density had higher feed intake (0.93 vs. 0.88 kg/d) and higher daily gain (0.67 vs. 0.62 kg/d) than crowded pigs. Feed intake decreased (0.64, 0.64, 0.63, 0.63, 0.59 kg/d) and feed efficiency (0.74, 0.75, 0.78, 0.79, 0.80) improved with increasing dietary DE concentration. Overall, piglet gain did not improve with increased dietary DE concentration, regardless of stocking density. Cost per kg of gain was greatest for the highest DE diet (0.48, 0.50, 0.50, 0.50, 0.51 $/kg gain).

Conclusions

A high stocking density can negatively impact piglet performance. In this study, crowded pigs had a 9.2% slower growth rate than the uncrowded pigs during the last week of the experiment. The weanling pig was able to compensate for reduced dietary DE through increased feed intake. Growth limitations in the weanling pig are not overcome simply be increasing dietary DE concentration. The increased cost of the high DE diets and hence increased cost per kg of gain may not justify the use of higher DE diets in weaner pigs.

Acknowledgements

Strategic program funding provided by Sask Pork, Alberta Pork, Manitoba Pork and Saskatchewan Agriculture and food Development Fund. Specific funding for this project was provided by NSERC/AAFC.

***Table 1.* Pig performance and cost of gain from 25 to 53 d of age**

DE level, Mcal DE/kg	3.19	3.33	3.46	3.61	3.75
ADG, kg/d	0.47	0.47	0.48	0.49	0.47
ADFI, kg/d*	0.64	0.64	0.63	0.63	0.59
Feed efficiency**	0.75	0.76	0.78	0.79	0.80
$/tonne[a]	352.15	368.51	380.27	391.49	404.41
$/kg gain[a]	0.48	0.50	0.50	0.50	0.51

[a]Cost in $/tonne and $/kg gain was calculated using the following ingredient prices – wheat: $110.00; barley: $85.00; Soybean meal: $328.00

* $P < 0.05$, ** $P < 0.001$

[1] PSCI and Department of Animal and Poultry Science, University of Saskatchewan

Feeding Level Affects Barley DE Measurements in Grower Pigs

Miladel N. Casano[1] *M.Sc.* and Ruurd T. Zijlstra *Ph.D.*

Summary

Feeding level and nutrient content of diets used in DE content measurement for grains do not reflect practical conditions and prevent measurement of voluntary feed intake. The DE content of three barley samples was analyzed using four combinations of measurements. The measured DE content was 2.5% lower using pigs with free access to feed than pigs with restricted access to feed, while diet composition did not affect barley DE content. Furthermore, voluntary feed intake was indicative of performance and tended to vary among barley samples.

Free access to feed offers a better model to determine nutritional value.

Introduction

Previously, barley DE content and ranking of barley samples depended on method of measurement used (*2000 Annual Research Report*), but separate effects of diet composition and feeding level were not studied. The objectives were to evaluate effect of diet type and feeding level on DE content of three barley samples differing in fibre content, and to determine if voluntary feed intake differences exist among barley samples.

Experimental Procedures

Three barley samples spanning a range of ADF (5.2 to 9.2%), NDF (15.5 to 21.8%) and CP (10.7 to 14.6%) on DM basis were incorporated into 2 diets: standard (96% barley, 2970 kcal DE/kg, 0.8 g dlys/Mcal DE) and complete (71% barley, 22% soybean meal, 2% canola oil; 3200 kcal DE/kg, 2.4 g dlys/Mcal DE). Each diet was offered at three times DE maintenance requirement (restricted access) or without restriction (free access). Barley DE content was calculated directly for standard diet and by difference for complete diet, assuming additive DE content in ingredients in a complete diet.

Results and Discussion

Barley DE content was 2.5% lower using pigs with free access to feed compared to pigs with restricted access to feed (Figure 1). Measured barley DE content did not differ between pigs fed standard or complete diets. However, the measured DE content of the low-fibre barley sample in a complete diet was higher than in a standard diet. This suggests that ingredients or nutrients may interact, for example dietary fibre and fat. Voluntary feed intake varied up to 90 g/day among barley samples (Figure 2) and was in pigs with free access to a complete diet a better predictor of performance (r = 0.82) than DE content (r = 0.28).

Implications

A complete prediction of nutritional value of ingredient samples should perhaps include free access to a complete diet as a model, to reflect practical conditions. Such a method measures voluntary feed intake and provides insight to performance and is therefore key to determine the true nutritional value of feedstuffs.

Acknowledgments

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

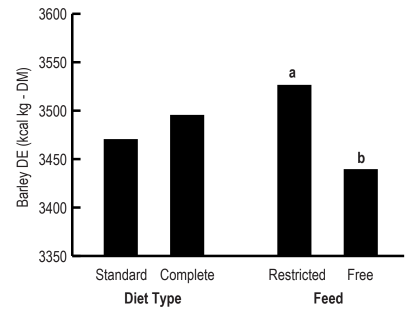


Figure 1 **The effect of diet type and feeding level on DE content of barley.**

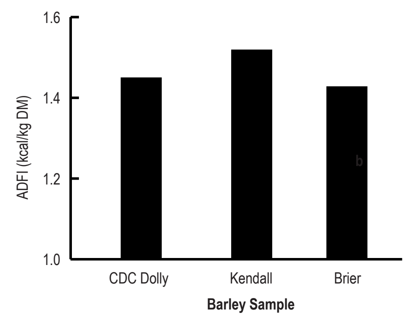


Figure 2 **The voluntary feed intake (ADFI) of pigs fed 3 barley samples differing in fibre content. The ADF content (DM) was 5.2% for CDC Dolly, 7.8% for Kendall, and 9.2% for Brier.**

[1] PSCI and Department of Animal and Poultry Science, University of Saskatchewan

The Effect of Ergot on the Performance of Weanling Pigs

T.F. Oresanya[1] *M.Sc.*, J.F. Patience *Ph.D.*, R.T. Zijlstra *Ph.D.*, A.D. Beaulieu *Ph.D.*, D.M. Middleton[2] *Ph.D.*, B.R. Blakley[3] *Ph.D.*, and D.A. Gillis *M.Sc.*

Summary

Ergot contains numerous poisonous substances (alkaloids), which upon ingestion by animals may lead to poor growth rate, decreased feed consumption and poor feed efficiency. The effect will depend on the age or physiological stage of the animal, and the amount consumed. Results obtained in this study indicate that the consumption of diets containing more than 0.10% high alkaloid ergot by weanling pigs severely reduces growth rate, and feed consumption and efficiency.

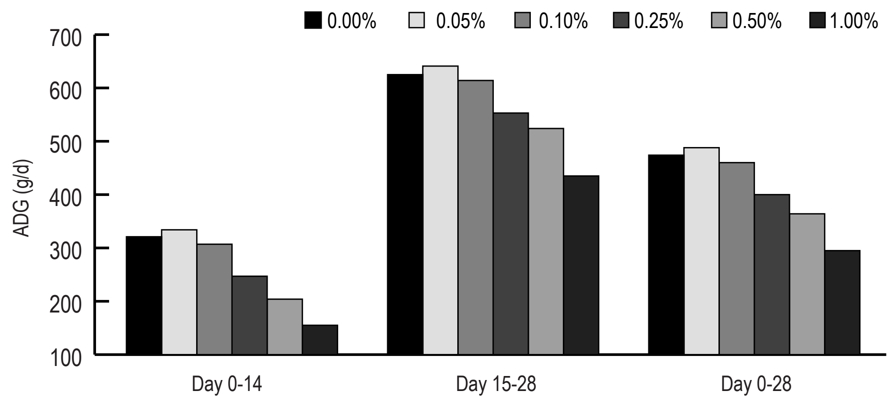


Figure 1 **The effect of level of dietary ergot on ADG of piglets ($P < 0.001$, all periods).**

Introduction

Ergot infection in cereal grains, especially wheat, is of great economic importance. An ergot infection may not result in reduced grain yield but will reduce quality due to the replacement of grain kernels with a number of poisonous alkaloid-containing ergot sclerotia. These grains may end up as feedstuff in swine diets. Ergot ingestion may impair growth and development. Also, the plasma concentration of certain hormones, especially prolactin, may be reduced. Information is lacking on the safe inclusion level of ergot in the diet of the weanling pig. This experiment was conducted to investigate the impact on performance of including ergot-contaminated wheat in the diet of weaned pigs and determine the level that can safely be included in the diet.

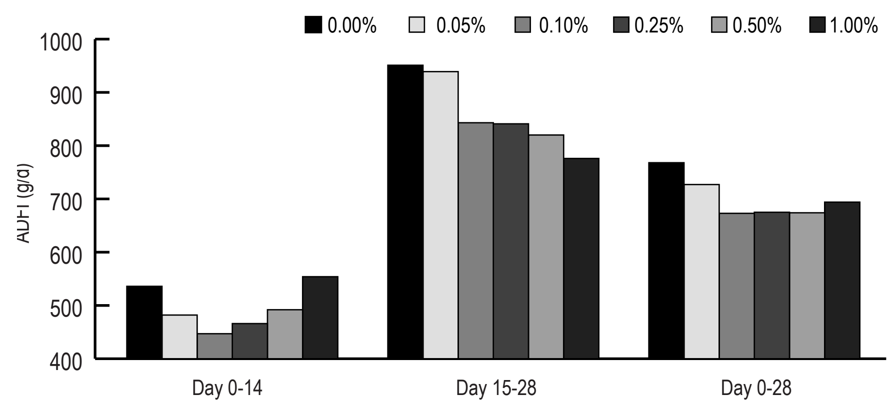


Figure 2 **The effect of level of dietary ergot on ADFI of piglets ($P > 0.05$, d 0-14; $P < 0.05$, d 15-28 and d 0-28).**

Experimental Procedures

Ground ergot sclerotia were added to diets at 0% (control), 0.05%, 0.10%, 0.25%, 0.50%, and 1.00% (weight basis). Ground wheat ergot sclerotia contained 1880 mg alkaloid/kg with ergocristine, ergotamine, ergosine, ergocryptine and ergocornine constituting 40, 36, 11, 7, and 6%,

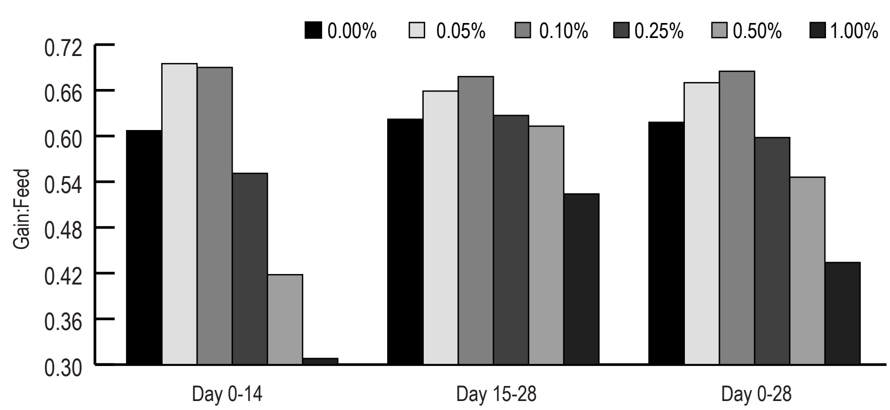


Figure 3 **The effect of level of dietary ergot on feed efficiency of piglets ($P < 0.01$, all periods).**

[1] PSCI and Department of Animal and Poultry Science, University of Saskatchewan
[2] Department of Vet. Pathology, University of Saskatchewan
[3] Department of Vet. Biomedical Sciences and the Toxicology Centre, University of Saskatchewan

respectively. Thus, diets contained 0.00, 1.04, 2.07, 5.21, 10.41, and 20.82 mg alkaloid/kg, respectively. Each diet was fed to 8 pens of four pigs (two barrows and two gilts) for four weeks. Average daily gain and feed efficiency were calculated from the performance data. Prolactin analysis was conducted on serum samples collected from pigs on day 28. Regression analysis was used to determine the effect of ergot level on performance and serum prolactin concentration.

Diets containing up to 0.10% ergot can safely be fed to weanling pigs, provided these pigs are not destined for the breeding herd.

Results and Discussion

Nervous signs or cutaneous lesions associated with ergotoxicity were not observed. Average daily gain was similar for pigs that consumed diets up to 0.10% ergot, but was depressed at higher levels ($P < 0.001$) (Figure 1). The effects were most pronounced in weeks 1 and 2 with pigs fed the 1.00% ergot gaining 82 and 38% less than control (211 vs. 39 g/d, and 432 vs. 269 g/d, week 1 and 2, respectively (Figure 1). Average daily feed intake was decreased over the entire period ($P < 0.05$) but was unaffected by ergot during weeks 1 and 2 ($P > 0.20$) (Figure 2). Feed efficiency (gain:feed ratio) was increased at low levels of ergot inclusion but was reduced with ergot levels above 0.10% (0.685 vs. 0.435, 0.10% vs. 1.00%). Serum prolactin concentration was reduced at all levels of ergot ($P < 0.0001$) (Figure 4). The maximum level of alkaloids that can be included in weanling pig diets without adverse effects on ADG and feed efficiency was 2.31 mg alkaloid/kg. This is based on the alkaloid content and profile of ergot sclerotia used in this study and corresponds to 0.12 g ergot sclerotia per 100 g diet.

Implications

Feeding high levels of ergot alkaloid caused severe reductions in the growth performance of weanling pigs. Prolonged exposure depressed feed intake. Serum prolactin concentration was depressed which indicates that ergot may impair normal mammary gland development in gilts. When the level of ergot in wheat is known, the level that can be used in weanling pig diet can be calculated. For example, wheat contaminated with 1.0% ergot, should not comprise more than 10% of the diet of weanling pigs.

Acknowledgements

Strategic program funding provided by Sask Pork, Alberta Pork, the Manitoba Pork Council, and the Saskatchewan Agriculture and Food Development Fund. Direct funding from the Alberta Agricultural Research Institute (AARI).

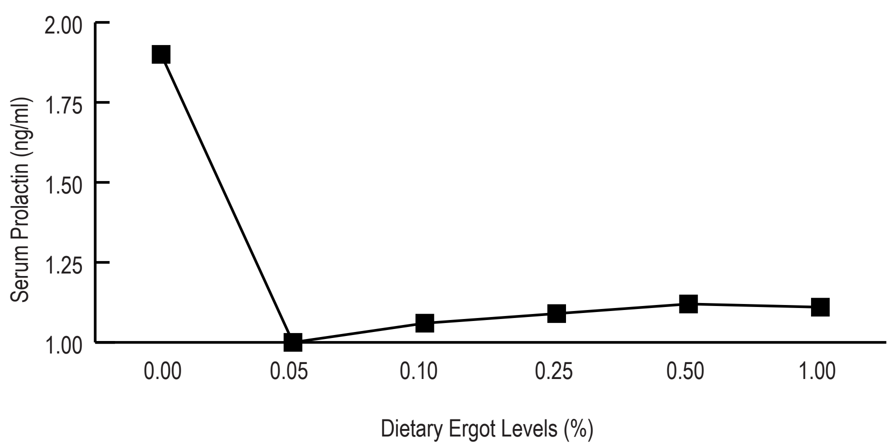


Figure 4 **The effect of level of dietary ergot on serum prolactin concentration of piglets ($P < 0.0001$).**

Nutritional Value of High-Oil Oat Groats

Ruurd T. Zijlstra *Ph.D.*, Brian G. Rossnagel[1] *Ph.D.*, Dave D. Maenz[2,3] *Ph.D.*, John F. Patience *Ph.D.*, and Vern J. Racz[3] *M.Sc.*

Summary

High-oil germplasm should increase the DE content of feed ingredients. The nutritional value of high oil oat groats was analyzed using grower and weaned pigs. Using grower pigs, DE content of high oil oat groats was 5% higher than regular oat groats. A subsequent performance trial with weaned pigs indicated that high oil oat groats resulted in a similar performance as regular oat groats if replaced on an equal weight basis.

High oil groats can be a worth-while alternative for weaned pigs.

Introduction

High oil is a natural variant in oats, similar to high oil corn (*2000 Annual Research Report*). Subsequent dehulling produces high oil oat groats that should have a nutritional value superior to regular oat groats, because of an assumed higher DE content. Regular oat groats are recognized for their palatability and high energy density. The nutritional value of high oil oat groats has not been explored extensively.

Experimental Procedures

High oil and regular oat groats were analyzed by proximate analyses. Diets consisting of 96% high-oil oats or oat groats, plus vitamins, minerals, and chromic oxide as an indigestible marker were fed to grower pigs. Mash diets based on corn, wheat, or regular oat groats (50 or 100% replacement of wheat) were formulated to an equal nutritional value (phase-1, 3,540 kcal DE/kg, 1.4% total lysine; phase-2, 3,430 kcal DE/kg, 1.24% total lysine) and then fed to three-week-old weaned pigs for four weeks (2 wk phase-1, 2 wk phase-2). High oil oat groats replaced regular oat groats on a weight basis to create a total of six dietary treatments.

Results and Discussion

The fat content was higher for high oil oat groats than regular oat groats (10.1 vs. 7.2 % DM); however, protein content was lower (11.3 vs. 12.1% DM). The DE content (DM) was 2,920 kcal/kg for high oil whole oats, 4,341 kcal/kg for high oil oat groats, and 4,149 for regular oat groats (Figure 1). This indicates that the DE content of high oil oat groats is 5% higher than regular oat groats. The DE content of high oil whole oats remained low. Average daily gain was higher for 100% oat groats than wheat diets fed to weaned pigs ($P < 0.05$; Figure 2), indicating that oat groats are a palatable ingredient with a high nutrient density for weaned pigs. Overall, performance of pigs fed high oil oat groat was similar to pigs fed regular oat groats (Figure 2), indicating that the increase in energy intake did not result in improved performance, perhaps due to the lower than expected protein content of the high-oil oat groats.

Implications

The fat content of high-oil oat groats was higher than regular oat groats, and did result in a 5% higher DE content. High oil oat groats did not have any adverse effects on performance and seems a worthwhile product to pursue to increase energy intake of young pigs.

Acknowledgements

Strategic program funding provided by Sask Pork, Alberta Pork, Manitoba Pork, and Saskatchewan Agriculture and Food Development Fund. Project funding was provided by the College of Agriculture/SWP First and Best Campaign Fund.

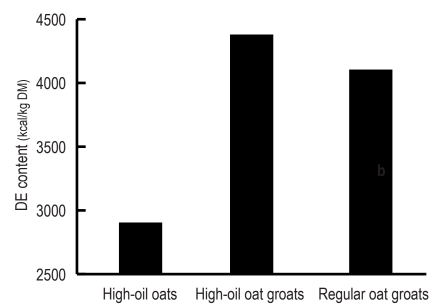


***Figure 1.* The DE content of high-oil whole oats, high-oil oat groats, and regular oat groats as analysed in grower pigs. High-oil oats groats was derived from the high-oil whole oat samples.**

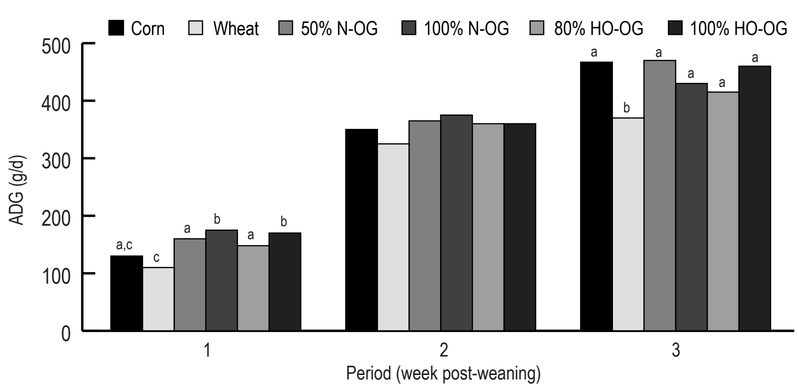


***Figure 2.* Average daily gain over the first 3 weeks for 3-week-old weaned pigs fed diets including corn, wheat, or 50 or 100% of the wheat replaced with normal (N) or high-oil (HO) oat groats (OG; $P < 0.05$).**

[1] Crop Development Centre, University of Saskatchewan

[2] Prairie Feed Resource Centre Inc., University of Saskatchewan

[3] currently MCN Canola Products Inc.

Effects of Pelleting, Expanding Plus Pelleting, and Enzyme Supplementation on Barley Diets with Wheat Millrun on DE Content

Ruurd T. Zijlstra *Ph.D.*, Gary Fitzner[1] *Ph.D.*, and John F. Patience *Ph.D.*

Summary

Individually-housed grower pigs were fed barley or barley-millrun diets with or without supplemental enzyme and processing. The DE content and subsequent performance did not differ between barley and barley-millrun diets indicating grower pigs may be fed high-fibre diets without negative impact on performance. Supplemental enzymes improved DE content of barley but not barley-millrun diets.

Introduction

Feed costs may be reduced if high-fibre ingredients could be included in diets fed to grower-finisher pigs without affecting performance negatively. Successful inclusion of these ingredients (for example, barley and wheat millrun) may be accomplished by treatment of diets with processing or enzyme supplementation.

Experimental Procedures

Barley and barley-25% wheat millrun diets that were formulated to limit in energy (3200 kcal/kg) but not amino acids (3 g dig. Lysine/Mcal DE). Barley diets were mash, pelleted, or pelleted + expanded and barley-millrun diets were pelleted, or pelleted + expanded. Diets were fed with or without enzyme (ß-glucanase + xylanase) to six individually-housed grower pigs.

Results and Discussion

Barley and barley-millrun diets did not differ ($P > 0.10$) in DE content, feed intake, or growth performance, indicating that up to 25% of wheat millrun may be included in diets for grower pigs. Supplemental enzyme increased DE content ($P < 0.10$; Figure 1) and nutrient digestibility of barley diets, but not of barley-millrun diets. Pelleting versus mash improved DE content of barley diets. Supplemental enzyme increased voluntary feed intake across all diets in week 1 ($P < 0.05$; Figure 2) but not week 2; however, improvements in growth performance were not detected.

Millrun can be included in diets without a negative impact on performance.

Implications

Up to 25% wheat millrun may be successfully incorporated in diet formulations for grower pigs without reducing performance, a finding that should be confirmed with group-housed pigs. Supplemental enzymes improved DE content of barley, but not barley-millrun diets, indicating that barley but not millrun contains fibrous fractions that reduce energy digestibility.

Acknowledgements

Strategic program funding provided by Sask Pork, Alberta Pork, Manitoba Pork, and Saskatchewan Agriculture and Food Development Fund. Project funding was provided by Aventis Animal Nutrition. Diets were provided by Heartland Feeds, North Battleford, SK.

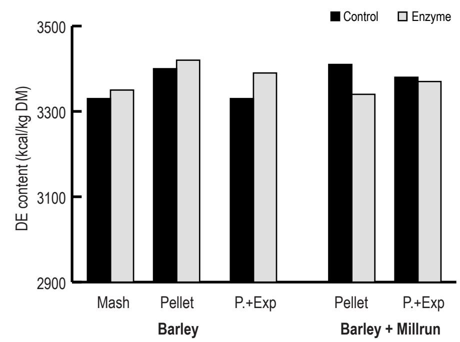


Figure 1 **Effects of supplemental enzyme on DE content of barley or barley-millrun diets that were either mash, pelleted, or pelleted + expanded (P+Exp) and fed to grower pigs.**

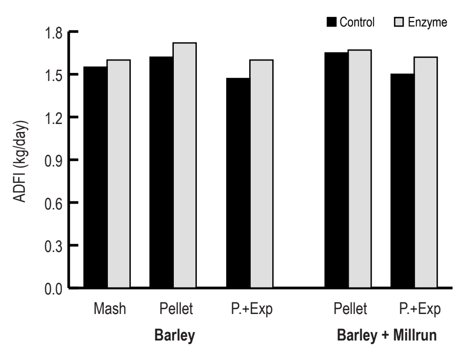


Figure 2 **Effects of supplemental enzyme on voluntary feed intake of grower pigs fed barley or barley-millrun diets that were either mash, pelleted, or pelleted + expanded (P+Exp) for 1 week.**

[1]Aventis Animal Nutrition, Atlanta, GA; currently Purina Mills, St. Louis, MO

Effects of Fibre in Cereal Grains on Performance of Weaned Pigs

E. David Ekpe *Ph.D.*, Ruurd T. Zijlstra *Ph.D.*, John F. Patience *Ph.D.*, Hank L. Classen[1] *Ph.D.*, and P. Howard Simmins[2] *Ph.D.*

Summary

Variation in voluntary feed intake and nutrient digestibility restricts use and efficiency of use of Canadian feed ingredients. The weaned pig was used to characterize differences in voluntary feed intake and nutrient utilization in wheat and barley samples that differed in fibre content. Voluntary feed intake, average daily gain, and energy digestibility differed among wheat and barley diets, and correlated negatively with fibre for wheat diets.

Introduction

Variation in nutritional value of feed ingredients may be related to nutrient content or voluntary feed intake. Fibre content limits digestibility and availability of nutrients, and negatively affects use of Canadian ingredients in the pork industry. An accurate assessment of feed ingredients may lead to a better utilization of nutrients, and lower formulation cost.

Experimental Procedures

Four wheat and four barley diets were each fed to six pens for three weeks to determine performance of weaned pigs. Four corn diets (control + three levels of purified fibre) were used as a benchmark for variation in fibre content. Diets were formulated to 3.16 g digestible lysine/Mcal DE. Differences in digestible nutrient content were compensated for with purified energy and amino acid ingredients. feces were collected and actual DE content was measured (Figure 1). Regression analysis determined relationships between fibre content in feed and pig performance.

Results and Discussion

Diets ranged from 4.2 to 7.6% in ADF and 11.7 to 21.4% in NDF with barley > wheat > corn. The DE content of diets differed ($P < 0.05$) and was consistently overestimated, except for wheat (Figure 1). Overall, voluntary feed intake ranged from 0.67 to 0.96 kg/d, ADG ranged from 0.30 to 0.57 kg/d, and feed efficiency ranged from 0.45 to 0.59. Inclusion of purified fibre in corn diets reduced ADG from 0.47 to 0.30 kg/d, and feed intake from 0.81 to 0.67 kg/d. Pig performance differed among diets and within each of the three diet categories. Performance correlated negatively with fibre for corn and wheat diets, but positively for barley diets (Figure 2). Variation in performance and energy digestibility may be related to changes in fibre content of cereals or differences between actual and formulated DE.

Increased fibre enhances feed intake with barley, but decreases in wheat diets.

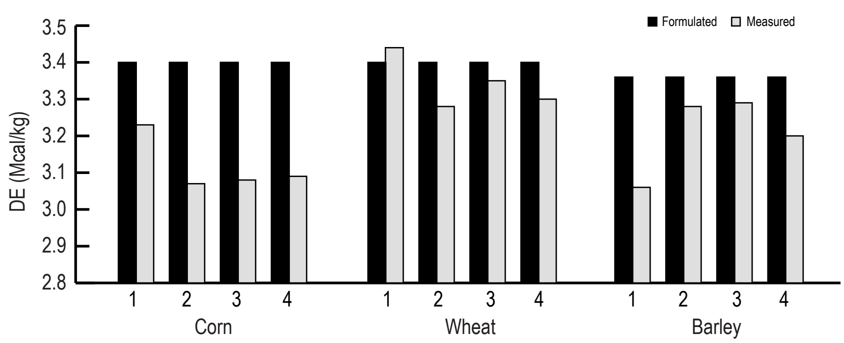


Figure 1 **Formulated and measured DE content of diets fed to weaned pigs.**

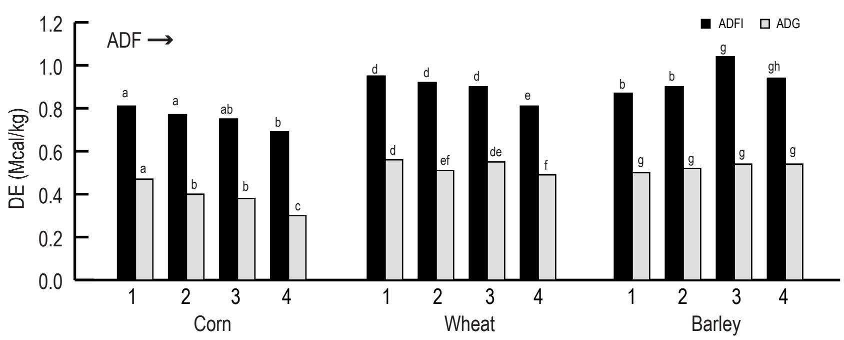


Figure 2 **Effect of increasing ADF content in corn, wheat and barley diets on performance of weaned pigs (different superscripts, $P < 0.05$).**

Implications

Feed ingredients differ in nutritional value. Voluntary feed intake of weaned pigs fed wheat diets decreased while voluntary feed intake of pigs fed barley diets increased with increasing fibre content. A complete description of negative effects of fibre will allow development of specific treatments to improve performance.

Acknowledgements

Strategic funding provided by Sask Pork, Alberta Pork, Manitoba Pork, and Saskatchewan Agriculture and Food Development Fund. Project funding was provided by Finnfeeds International Ltd., Canola Council of Canada, and National Sciences and Engineering Research Council of Canada.

[1] Department of Animal & Poultry Science, University of Saskatchewan
[2] Finnfeeds International Ltd., Marlborough Wiltshire, United Kingdom

Replacement of Soybean Meal with Canola Meal in Weaned Pig Diets

E. David Ekpe *Ph.D.*, Ruurd T. Zijlstra *Ph.D.*, John F. Patience *Ph.D.*, Hank L. Classen[1] *Ph.D.*, and P. Howard Simmins[2] *Ph.D.*

Summary

Fibre content is three times higher in canola meal than soybean meal, and may limit nutrient availability. The present study determined whether canola meal could replace soybean meal in weaned pig diets with a balanced digestible nutrient content. Increasing content of canola meal increased fibre content in diets, and decreased voluntary feed intake, ADG and feed efficiency. Performance correlated negatively with fibre content in diets, and was reduced when canola meal replaced 75% or more soybean meal.

Canola's meal's high fibre content hinders performance in weaned pigs.

Introduction

The lower nutritional value of canola meal compared to soybean meal may be related to high fibre content. Fibre limits digestibility and availability of nutrients, and negatively affects use of canola meal in the pork industry. An accurate assessment of nutritional value may lead to better use of canola meal and reduced nutrient wastes to environment.

Experimental Procedures

Diets with 0, 4, 8, 12, or 16% canola meal were fed to five-week-old weaned pigs for three weeks to determine effects on performance. Canola meal replaced 0, 25, 50, 75, or 100% soybean meal on an equal weight basis. Diets were formulated to equal DE (Figure 1) and 3.15 g digestible lysine/Mcal DE. Differences in digestible nutrient content were compensated for with purified energy and amino acid ingredients. feces were collected to measure actual DE content. Fibre and glucosinolate contents in feed were determined. Regression analysis determined relationships between fibre content in feed and pig performance.

Results and Discussion

Diets ranged from 4.3 to 6.3% in ADF and 11.5 to 15.2% in NDF from low to high canola meal diets. Dietary glucosinolates were below detection limits, but ~0.2 mmoles/g of 3-butenyl or 2-OH-butenyl glucosinolates were measured in 12 and 16%-canola meal diets. The measured DE content of diets differed ($P < 0.05$), and was highest for the 16% canola meal diet. From low to high canola meal diets, voluntary feed intake reduced from 0.92 to 0.81 kg/d, ADG reduced from 0.56 to 0.46 kg/d (Figure 2), and feed efficiency reduced from 60 to 57%. For each per cent increase in canola meal in diet, ADFI, ADG, and feed efficiency decreased by 6.2 g/d, 5.5 g/d, and 2.5, respectively, even though DE was compensated for by addition of canola oil. Performance correlated negatively with fibre content in diets. Reduction in performance may be related to fibre but not glucosinolate content of canola meal.

Implications

Inclusion of canola meal increased fibre content of the diet and reduced performance of weaned pigs. Inclusion of more than 8% canola meal in weaned pig diets may not be economically beneficial to the pork industry, without additional processing to reduce negative effects of fibre content.

Acknowledgements

Strategic funding provided by Sask Pork, Alberta Pork, Manitoba Pork, and Saskatchewan Agriculture and Food Development Fund. Project funding was provided by Finnfeeds International Ltd., Canola Council of Canada, and National Sciences and Engineering Research Council of Canada.

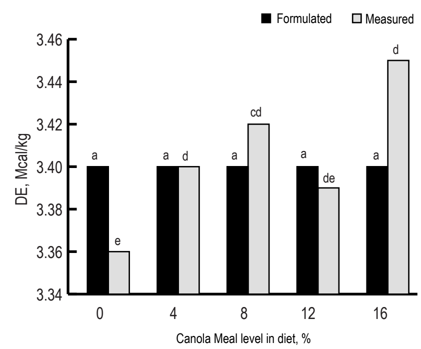


Figure 1 **Formulated and measured DE content of diets fed to weaned pigs (P < 0.05).**

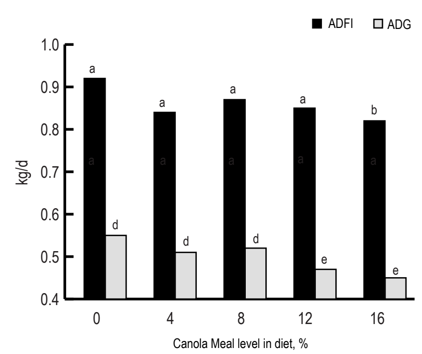


Figure 2 **Relationship between canola meal level in diets and performance of weaned pigs (P < 0.05).**

[1] Department of Animal & Poultry Science, Unversity of Saskatchewan, Saskatoon

[2] Finnfeeds International Ltd., Marlborough Wiltshire, United Kingdom

Dietary Cereal Affects Intestine Bacteria Numbers in Weaned Pigs

Murray D. Drew[1] *Ph.D.*, Alberto E. Estrada[1] *Ph.D.*, Andrew G. van Kessel[1] *Ph.D.*, E. David Ekpe *Ph.D.*, and Ruurd T. Zijlstra *Ph.D.*

Summary

Dietary ingredients may be an important component of control of intestine health. A study was conducted with 45 weaned pigs fed diets based on corn, barley, or wheat. Digesta was collected from the small intestine and caecum. Dietary cereal grain or dietary fibre may affect bacteria populations in the intestine.

Introduction

Intestine health in weaned pigs is presently partly manipulated by dietary antibiotics. Cereal grain may compose up to 70% of diets of weaned pigs, and cereal fibre may impact bacteria populations in the intestine. The objective was to characterize the bacteria populations in the small intestine of weaned pigs fed the three main cereals in western Canada.

Experimental Procedures

Diets containing corn, barley, or wheat as the main cereal but not antibiotics were formulated to a similar nutrient content. Diets were fed for three weeks to weaned pigs. Fifteen pigs per treatment were killed to collect digesta, which was analyzed for bacterial profiles using plating techniques. Performance was measured on a pen basis.

Results and Discussion

Switching dietary cereal caused some changes in profiles of the major bacteria populations at the end of the small intestine (ileum; Figure 1) and in the caecum (Figure 2). Diarrhea was not observed in the experiment. Changes in dietary ADF were correlated to enterobacteria in the ileum (r = -0.30), and lactobacilli and clostridia in the caecum (r = 0.31 and 0.34). Feed efficiency but not body weight gain or feed intake was correlated to lactobacilli in the ileum (r = -.43)

Research is needed to fully explain how diet formulations affect intestine health.

Implications

The fibre composition of ingredients and therefore diets may impact intestinal bacteria populations. The relation between ingredients and intestinal health is presently ignored in diet formulations. Further research is required to characterize this relationship and bacteria populations in further detail, because control of intestine health may become an increasing challenge with ongoing reductions in access to antibiotics.

Acknowledgements

Strategic program funding provided by Sask Pork, Alberta Pork, Manitoba Pork, and Saskatchewan Agriculture and Food Development Fund. Project funding was provided by Finnfeeds International Ltd, Canola Council of Canada, and NSERC.

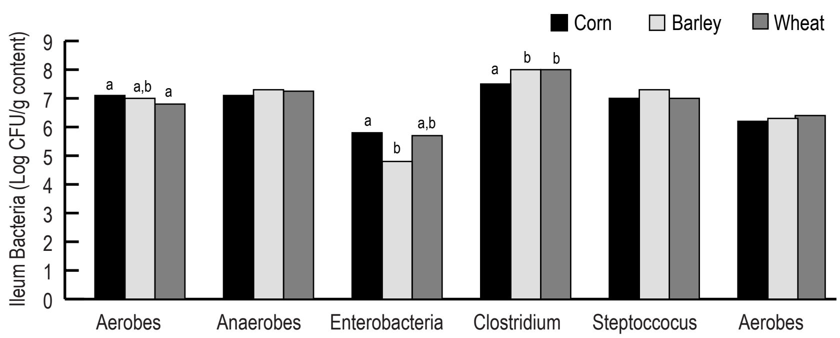


Figure 1 **Effects of main dietary cereal on bacteria populations in the small intestine of weaned pigs.**

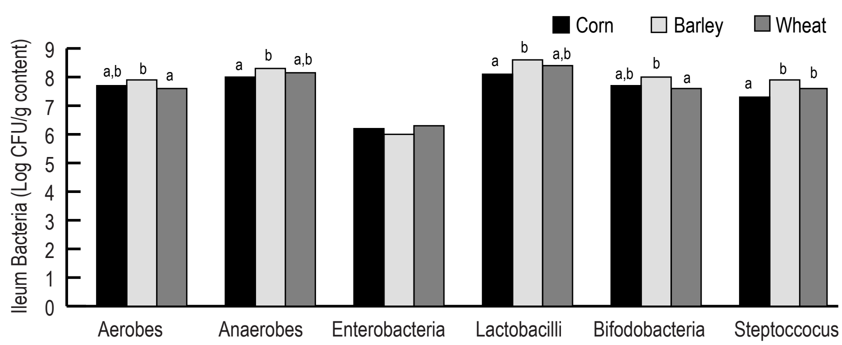


Figure 2 **Effects of main dietary cereal on bacteria populations in the caecum of weaned pigs.**

[1] Animal Biotechnology Centre, Department of Animal and Poultry Science, University of Saskatchewan

Nutritional Value of Debranned Wheat

Ruurd T. Zijlstra *Ph.D.*, Dave D. Maenz [1,2] *Ph.D.*, Dana R. Cooper *M.Sc.*, John F. Patience *Ph.D.*, and Vern J. Racz [1] *M.Sc.*

Summary

Removing bran from wheat produces debranned wheat. The nutritional value of debranned wheat was analyzed using grower and weaned pigs. Using grower pigs, DE content of debranned wheat was 6% higher than the parent wheat. Diets based on 35% debranned wheat, wheat, or oat groats were formulated to an equal nutritional value and fed to weaned pigs. Performance was similar among the three diets, indicating that debranned wheat does not have any adverse effects on voluntary feed intake and is a worthwhile product to include in least-cost diet formulation.

Introduction

Dehulling or debranning of cereal grains results in separation of the hull or bran from the groat. The dehulled or debranned grain or groat should have a nutritional value superior to that of the original grain, because removal of the fibrous hull or bran will reduce the fibre content of the end product. Oat groats are recognized for their palatability and high energy density. The nutritional value of debranned wheat has not been explored to date.

Experimental Procedures

Wheat, debranned wheat, and oat groats were analyzed by proximate analyses. Diets consisting of 96% test product, and vitamins, minerals, and chromic oxide as an indigestible marker were fed to grower pigs. Using estimated nutritional values, mash diets based on 35% debranned wheat, wheat, or oat groats were formulated to an equal nutritional value (3,490 kcal DE/kg; 1.3% total lysine) and then fed to 3-week-old weaned pigs for 4 weeks.

Results and Discussion

The fibre content was lower for debranned wheat than the parent wheat (NDF, 9.3 versus 12.4% DM). The DE content (as is) was 3,407 kcal/kg for debranned wheat, 3,216 kcal/kg for the parent wheat, and 3,736 for the oat groats (Figure 1), indicating that the DE content of debranned wheat may be up to 200 kcal/kg or 6% higher than wheat. Overall, feed intake was similar among diets fed to weaned pigs ($P > 0.10$; Figure 2), indicating that debranned wheat is a palatable ingredient for weaned pigs. Overall, average daily gain for pigs fed debranned wheat was slightly higher than for pigs fed oat groats, and similar to pigs fed wheat (Figure 2), indicating that the nutritional value of debranned wheat may be higher than calculated based on book values.

Debranned wheat can be a worthwhile alternative for weaned pigs.

Implications

The DE content of debranned wheat was higher than the parent wheat, but did not reach the DE content of oat groats. Debranned wheat does not have any adverse effects on voluntary feed intake and is a worthwhile product to consider for least-cost diet formulation. The nutritional value of debranned wheat should be assessed for a range of wheat samples.

Acknowledgements

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

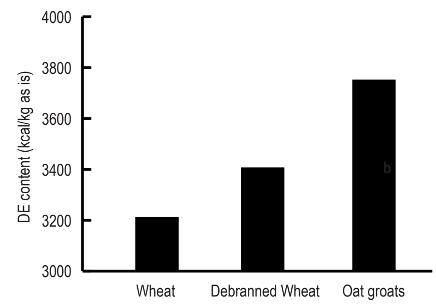


Figure 1 **The DE content of wheat, debranned wheat, and oat groats as analysed in grower pigs. The wheat sample was the parent wheat for the debranned wheat.**

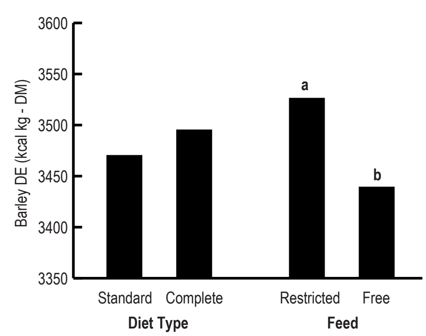


Figure 2 **Average daily gain and feed intake over 4 weeks for 3-week-old weaned pigs fed diets including 35% wheat, debranned wheat, or oat groats, formulated to an equal nutritional value (differences, $P < 0.10$).**

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

[2] currently MCN Canola Products Inc.

Effects of Nipple Drinker Height and Flow Rate on Water Wastage in Grower and Finisher Pigs

Yuzhi Li *Ph.D.* and Harold W. Gonyou *Ph.D.*

Summary

An experiment was conducted to study the effects of height and flow rate of nipple drinkers on water wastage in pigs. Results show water wastage can be reduced by up to 20% by adjusting nipple height. High flow rate resulted in higher water wastage.

Introduction

In our previous study on water wastage, grower/finisher pigs wasted 25% of water from the nipple drinker at standard flow rate (700 ml/min) and height (5 cm higher than the shoulder height of the smallest pig). However, on commercial farms, water wastage from a nipple drinker is reported as high as 40~60%. The difference between these results may partly be attributed to the improper drinker height and flow rate on pig farms. This study focused on effects of drinker height and flow rate on water intake and wastage in grower/finisher pigs.

Materials and Methods

Four pens of eight female pigs were tested during the 12 week study. Water disappearance, water wastage, and feed intake were measured at two stages, i.e. week 1~4 for growers, and week 8~12 for finishers. In each stage, drinkers were set up at two heights, i.e. five cm higher than the shoulders of the smallest pigs in the pen (standard height) or 33 cm (low height). At each drinker height, two flow rates, 500 and 1000 ml/min, were employed. Pigs in each pen were exposed to each treatment combination for one week, and the data were collected during the last four days of the week. Body weight was measured individually at the start of each test and every two weeks thereafter. Feed intake was determined every week on a pen basis.

Results and discussion

Nipple height did not affect feed and water intake in either growers or finishers (Table 1). Water intake was about two times feed intake. The low nipple height increased water wastage by about 10% (from 26% to 35%) in growers and 20% (from 18% to 39%) in finishers. The flow rate of nipple drinkers did not change feed intake and the ratio of water to feed intake (Table 2). Water wastage was increased by about 7% at the higher flow rate in both grower and finisher pigs. The flow rates employed in the study were lower than that usually used on commercial farms. Higher flow rates could result in more water spillage from nipple drinkers. Water wastage at each treatment combination is shown in Table 3.

Conclusion

By adjusting nipple drinker height, water wastage can be reduced by up to 20% in grower/finisher pigs. High flow rate can result in more water spillage from nipple drinkers.

Acknowledgements

Funding for this project was provided by an NSERC/AAFC grant. Strategic funding provided by Sask Pork, Alberta Pork, Manitoba Pork and Saskatchewan Agriculture and Food Development Fund.

Table 1 **Effect of nipple heights on water intake and wastage**

Stage	Growers		Finishers	
Drinker Height	Standard	Low	Standard	Low
BW, kg	23.5	23.3	68.6	68.5
ADFI, kg/d	1.2	1.3	2.4	2.3
Water disap., L/d	3.3	3.8	5.2	7.2
Water intake, L/d	2.5	2.5	4.2	4.3
Water intake/ADFI, L/kg	2.0	2.0	1.8	1.9
Wastage, %	25.9	34.6	17.7	39.0

Table 2 **Effect of flow rate of nipple drinkers on water wastage**

Stage	Growers		Finishers	
Nipple flow rate	1000 ml/min	500 ml/min	1000ml/min	500 ml/min
Body weight, kg	23.5	23.4	68.6	68.4
Feed intake, kg/d	1.3	1.2	2.4	2.4
Water disap., L/d	4.0	3.2	6.6	5.8
Water intake, L/d	2.6	2.3	4.4	4.1
Water intake/ADFI, L/kg	2.1	1.9	1.9	1.8
Wastage, %	34.0	26.5	31.0	25.7

Table 3 **Water wastage as % of water disappearance by pigs at nipple drinkers**

	Growers		Finishers	
	1000 ml/min	500 ml/min	1000ml/min	500 ml/min
Standard nipple height	29.5	22.2	20.3	15.1
Low nipple height	38.4	30.8	41.8	36.3

Dietary Particle Size and Nutrient Supply Affect Nitrogen Excretion

Matt A. Oryschak[1] *M.Sc.*, and Ruurd T. Zijlstra *Ph.D.*

Summary

Diets based on barley and peas ground to two particle sizes and with one of two diet formulations (either limiting in energy or amino acids) were fed to cannulated grower pigs. Energy digestibility was affected by particle size but not diet formulation. Total nitrogen excretion was affected by diet formulation, but not by particle size.

Nitrogen excretion has more to do with feed formulation than particle size.

Introduction

Nutrient management may impact the sustainability of the pork industry. Particle size reduction may reduce fecal nitrogen excretion; however, it may also result in an increase in urinary nitrogen excretion (*2000 Annual Research Report*). In this study, effects of particle size and diet formulation on energy digestibility and nitrogen excretion patterns were investigated.

Experimental Procedures

Diets (barley, peas, soybean meal) with a particle size of 600 or 900 mm were formulated to be either high in amino acids (High AA; 2.8 g dig. Lys/Mcal DE, 3,150 kcal DE/kg) or high in energy (High DE; 1.8 g dig. Lys/Mcal DE, 3,400 Mcal DE/kg). Diets were fed to grower pigs cannulated at the end of the small intestine (ileum). Feces, digesta, and urine samples were collected. Daily feeding rates were adjusted to three times maintenance.

Results and Discussion

Reducing particle size from 900 to 600 mm increased total tract and ileal energy digestibility by 3% and 11%, respectively (Figure 1). Energy digested at the small intestine is more efficiently used than energy digested in the large intestine; thus, particle size reduction may improve energy utilization more than expected from improvements in total tract energy digestibility. Reducing particle size from 900 to 600 mm did not alter urinary or total nitrogen excretion, but reduced fecal nitrogen excretion 11% (Figure 2), indicating that particle size reduction improved nitrogen digestibility but did not reduce total (feces + urine) nitrogen excretion. Pigs fed High AA-diets excreted 29% more nitrogen, but also retained 31% more nitrogen than pigs fed High DE-diets. Total nitrogen excretion and nitrogen retention (as % of nitrogen intake) were not different between diet formulations.

Implications

Particle size reduction may improve overall energy utilization more than explained by improvements in total-tract energy digestibility. Reducing particle size was effective in reducing fecal but not total nitrogen excretion. Diet formulation is more effective in reducing nitrogen excretion.

Acknowledgements

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

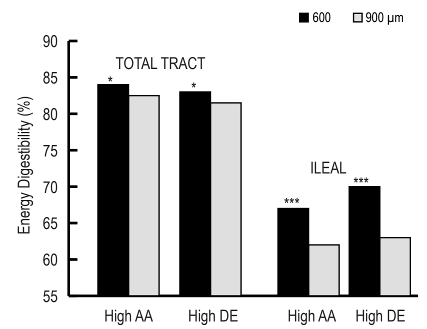


Figure 1 **Apparent energy digestibility at the end of the small intestine and of the total tract for diets with two particle sizes either high in energy or amino acids.**

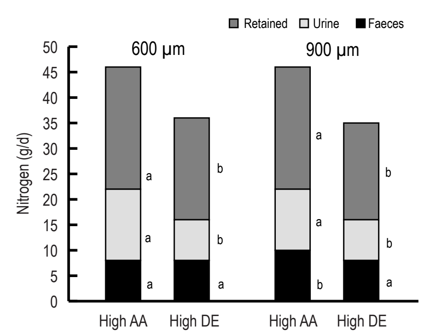


Figure 2 **Nitrogen intake separated into nitrogen excreted in urine and feces and retained for diets with two particle sizes either high in energy or amino acids.**

[1] PSCI and Department of Animal and Poultry Science, University of Saskatchewan

Greenhouse Gas and Odour Emissions from Swine Operations in Québec and Saskatchewan: Benchmark Assessments

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Summary:

It is estimated that agriculture contributes about 10% of the total anthropogenic greenhouse gas (GHG) emissions in Canada. About 40% of the agricultural emissions of GHG originate from livestock production. However, there exists a lot of uncertainty relative to the actual GHG emissions from livestock production systems in Canada since many of those estimates have been based on data collected in other parts of the world. In addition to GHG, odour emissions from production buildings and manure storage facilities often constitute an important source of nuisances in livestock production, especially in the pig industry.

The general objective of this ongoing research project (January 2001 – September 2003) is to evaluate GHG [carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O)] and odour emissions for swine production buildings and manure storage facilities under liquid manure management in two different regions of the country (Québec and Saskatchewan) in order to better assess the relative importance of those two components of swine production systems in terms of GHG and odour emissions. More specifically, the study is targeted at:

1. determining GHG and odour emissions from different types of swine production rooms (gestation, farrowing, nursery and grower-finisher) and for two different types of floor designs (fully and partially slatted floors) in grower-finisher rooms;
2. determining GHG and odour emissions from different types of manure storage facilities (earthern manure storage and concrete tanks; covered and uncovered; treated vs untreated manure), and
3. determining GHG and odour emissions associated with the agitation and emptying of manure storage facilities.

Emission data relative to objectives 1 and 2 above will be collected over a two-year period in order to account for seasonal variations in GHG and odour emissions from barns and manure storage. Research work for objectives 1 and 3 is completed at PSCI and PSC Elstow Research Farm Inc. and manure storage facilities located both in Québec and in Saskatchewan are monitored within the scope of objective 2. In relation with objective 2, GHG and odour emissions associated to two different manure treatment systems (Biofertile and Biosor) are also assessed in Québec.

Developing Canadian benchmarks for greenhouse gas and odour emission will form the base for future research.

All GHG emission data are expressed in terms of mass of gas emitted per unit animal mass per unit time. Similarly, odour emission intensity is evaluated in terms of odour units per unit animal mass per unit time and odour pleasantness is evaluated by hedonic tone on a –5 (very unpleasant) to +5 (very pleasant) scale. This will allow for the evaluation of the relative contribution of the animal housing and manure storage components of swine production systems to the total GHG and odour emissions, thus facilitating the identification of the sub-systems where potential mitigation measures for the reduction of GHG or odour emissions should be implemented. In addition, it will be possible to more precisely assess the relative importance of the Canadian swine production industry to the total GHG emissions of the country, thus determining if this industry should be a priority target for GHG emissions reductions in the future.

[1]University of Saskatchewan
[2]Prairie Swine Centre Inc.
[3]Université Laval
[4]Institut de recherche et de développement en agroenvironnement du Québec inc. (IRDA)

Dietary Protein and Fermentable Fiber Affect Nitrogen Excretion

Symeon Zervas[1] *M.Sc.*, and Ruurd T. Zijlstra *Ph.D.*

Summary

Nitrogen excretion is of concern because of its potential impact on the environment inside and outside the barn. The effects of reducing dietary protein content and inclusion of dietary fermentable fibre sources on reducing urinary nitrogen excretion were additive, together resulting in a 55% reduction. Urinary nitrogen excretion could be predicted from plasma urea (PU) concentration.

Introduction

The intensification of pig production has raised environmental concerns. Urinary nitrogen is emitted easily as ammonia while fecal nitrogen is less volatile because it is bound within proteins. Reduction of dietary protein is a direct way to reduce nitrogen excretion and ammonia emission. Nitrogen excretion can be shifted from urea in urine to bacterial protein in feces with dietary fermentable carbohydrates. Effects of two levels of protein and three fermentable fibre sources on nitrogen excretion patterns were investigated.

Experimental Procedures

Diets (wheat, barley, soybean meal; soybean hulls or sugar beet pulp as fibre source) supplemented with synthetic amino acids were formulated to 3300 kcal DE/kg and 2.40 g Dlys/Mcal. Feces, urine and blood samples were collected. Pigs had free access to feed.

Results and Discussion

For low compared to high protein diets, urinary and total nitrogen were reduced 27% and 16%, respectively, while nitrogen retention was reduced 7% (Figure 1). Urinary nitrogen was reduced 9% – units for soybean hulls – and 10% for sugar beet pulp diets. Fecal nitrogen (as % of nitrogen intake) was increased 5% – units for soybean hulls – and 9% for sugar beet pulp diets, compared to control. Dietary fermentable fibre did not affect nitrogen retention. Urinary and total nitrogen excretion was not affected by a protein and fibre interaction, indicating a cumulative effect. Both soybean hulls and sugar beet pulp are good sources of fermentable fibre for pigs. Comparison of urinary nitrogen excretion to PU by regression analysis indicated that PU could predict urinary N excretion (Figure 2).

Implications

Lower total nitrogen excretion may reduce land base needed to apply manure in a sustainable manner. Lower urinary nitrogen excretion will reduce ammonia emission inside and outside the barn. Models to predict urinary nitrogen excretion may be useful to access nitrogen status on farms. Further studies are required to validate these models under various conditions.

Acknowledgements

Strategic program funding provided by Sask Pork, Alberta Pork, Manitoba Pork, and Saskatchewan Agriculture and Food Development Fund. Project funding was provided by AARI and NSERC.

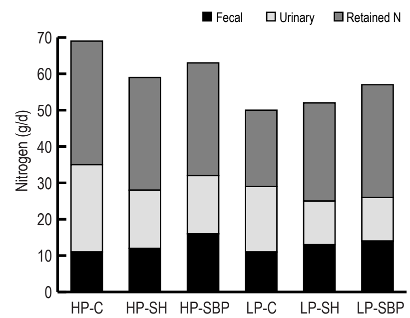


Figure 1 **Effects of dietary protein level (HP = high protein; LP = low protein) and fermentable fiber source (C = Control, SH = soybean hulls; SBP = sugar beet pulp) on nitrogen retention and excretion patterns in grower pigs with free access to feed.**

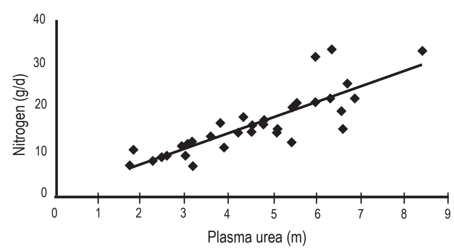


Figure 2 **Relationship of plasma urea to urinary N excretion at 0800 in grower pigs with free access to feed (R^2 = 0.71).**

[1] PSCI and Department of Animal and Poultry Science, University of Saskatchewan

Airborne Endotoxin and Microbial DNA Outside a Swine Barn

Jayda Cleave, Laura Ingram[2], Ernest Barber[3] *Ph.D.*, Philip Willson[1] *Ph.D.*

Introduction

The intensive livestock industry is under continuous scrutiny in relation to potential environmental impacts and health safety issues. Adverse health affects due to dust exposure from intensive livestock facilities have received increasing attention and today are a major concern. There is reason to believe that endotoxins and microbial DNA are present in dust exhausted from swine barns. Endotoxin is a pulmonary irritant contained in the cell wall of Gram-negative bacteria that when inhaled may cause cough, phlegm, wheezing and fever. In severe cases, it may lead to chronic airway inflammation. In addition, a natural property of the immune system is to respond to the stimulus of microbial DNA. In order to determine the impact of barn aerosols, endotoxin and microbial DNA concentrations must be investigated. The objective of this study is to quantify the amount of airborne endotoxin and microbial DNA downwind from a swine facility. It is hypothesized that increased levels of endotoxin and microbial DNA will be detected close to the exhaust fans and that airborne endotoxin and microbial DNA a few hundred meters away will not be different from "fresh air" upwind from the barn.

Materials and Methods

Project Site

The project site was Prairie Swine Centre, Elstow Research Farm Inc. Total dust sampling for the determination of airborne endotoxin and microbial DNA began in April 2001 and was completed in August 2001.

Bacterial DNA and endotoxin downwind of barns is little different from fresh air.

Ambient Air Sampling

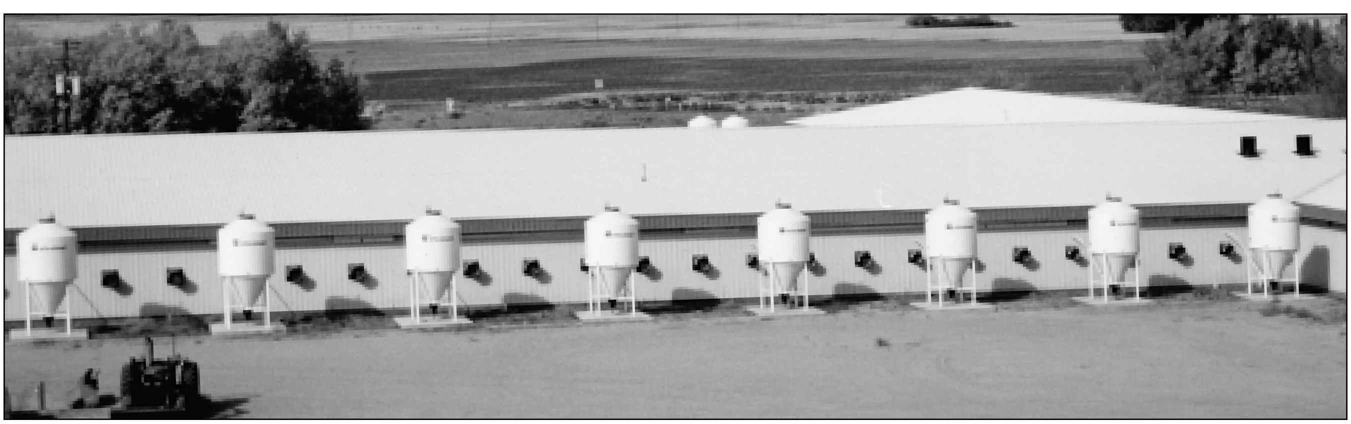
A total suspended solids high volume air sampler was utilized. Three samples were taken at each time point, prior to seeding, during seeding and in mid-summer to incorporate times of high and low dust loading. High volume sampling was performed at 2400m upwind ("fresh air"), 600m downwind from the barn and at an outlet (0.1m). A standard sampling time of 24 hours was used as recommended by Saskatchewan Environment and Resource Management. Total dust was determined by weighing the filters, in triplicate, before and after each sampling event. A weather station that provided continuous data on wind direction, wind speed, air temperature, and relative humidity was established by Dr. Maule to aid in the interpretation of all air samples.

Dust Extraction

The microfibre filters with the collected dust were extracted individually in large Ziplock bags with 50 mL sterile nonpyrogenic water during incubation for one hour at room temperature in a sonicating water bath. The resultant solution was transferred to a centrifuge tube and stored (<24 h) at 4°C until endotoxin analysis.

Endotoxin Analysis

The amount of endotoxin units (EU), in serial dilutions of the dust solution, was determined using a Limulus Amebocyte Lysate (LAL) test kit from BioWhittaker, Inc. The sampling time and flow rate were used to calculate the concentration of endotoxin in air (EU/m3).



Ventilation at the PSC Elstow research barn features both sidewall and chimney outlets.

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[3]Dean, College of Agriculture, University of Saskatchewan

Microbial DNA Analysis

Total microbial DNA was extracted from 9 mL of the dust solution, following the endotoxin assay, using a standard phenol:chloroform extraction and ethanol precipitation technique. Quantity and purity of the microbial DNA was determined spectrophotometrically. The sampling time and flow rate were used to calculate the concentration of microbial DNA in air (mg/m3).

Statistical Method

A two-way ANOVA was used to compare the data. A value of $P < 0.05$ was considered statistically significant.

Results and Discussion

The concentrations of total dust (Figure 1; $P < 0.05$), endotoxin (Figure 2; $P < 0.05$) and microbial DNA (Figure 3; $P < 0.05$) 600m downwind from the barn were not statistically different from the concentrations at 2400m upwind ("fresh air"). As expected, the concentrations at the outlet were elevated however, at 600m downwind these levels had become diluted to that of "fresh air". Time of the year did prove to have an impact on total dust and microbial DNA concentrations ($P < 0.05$) at the outlet. During periods of marked soil disturbances, high dust loading was demonstrated. This in turn leads to elevated levels of endotoxin and microbial DNA in the air. Microorganisms are ubiquitous therefore more detailed research is required to attribute the endotoxin and microbial DNA found in the air downwind from the barn to the swine operation. The significantly low microbial DNA concentration demonstrated at the outlet during seeding was unexpected and requires further study.

Conclusion

The results support the hypothesis that the The results support the hypothesis that the concentration of endotoxin and microbial DNA 600m downwind from the barn is not statistically different from the "fresh air" upwind from the barn. This suggests that there is modest environmental concern downwind from the barn, which may be managed with low impact controls such as landscaping. These results are applicable to modern confinement livestock operations that interact with neighbours or the general public.

Acknowledgments

Strategic funding provided by Sask Pork, Alberta Pork, Manitoba Pork, and Saskatchewan Agriculture and Food Development Fund. The authors wish to acknowledge the funding provided for this project by Saskatchewan ADF, Livestock Environmental Initiative and Sask Pork.

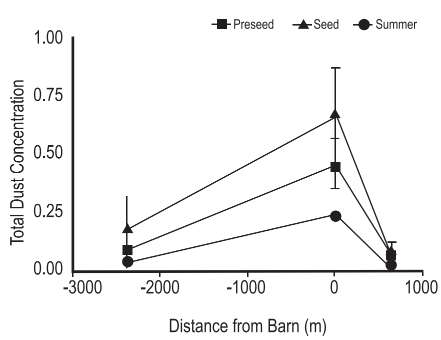

Figure 1 **Total dust concentration (mg/m³) upwind 2400m, at the outlet (0.1m) and 600m downwind from the barn prior to seeding, during seeding and in the summer (mean ± SD).**

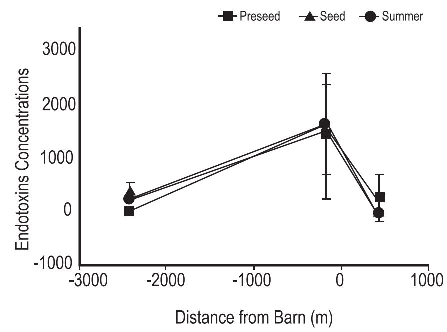

Figure 2 **Endotoxin concentrations (EU/m³) upwind 2400m, at the outlet (0.1m) and 600m downwind from the barn prior to seeding, during seeding and in the summer (mean ± SD).**

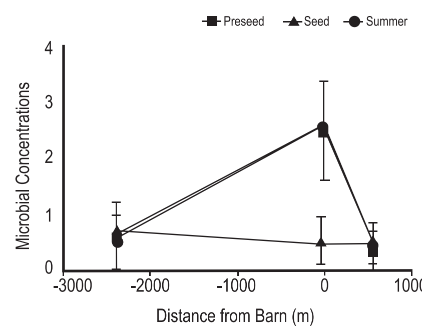

Figure 3 **Microbial DNA concentrations (mg/m³) upwind 2400m, at the outlet (0.1m) and 600m downwind from the barn prior to seeding, during seeding and in the summer (mean ± SD).**

Manure Management in Zero Till Systems

J.J. Schoenau[1] *Ph.D.*, G. Hultgreen[2] and P. Mooleki

Presented at Manitoba-North Dakota Zero Tillage Farmers Association 24th Annual Workshop, Minot, North Dakota, January 29,2002

Role of Manure as a Source of Plant Nutrients

Types

Manure is a rather complex and variable by-product of livestock production systems. It is comprised of excreta (feces and urine), bedding materials, wasted feed, and water. Animal manure can be solid, semi-solid or liquid, depending on moisture content. A feature of solid and semi-solid manure is a higher organic matter content than liquid manure.

Liquid swine manure and solid cattle penning manure are two forms commonly land applied in Western Canadian cropping systems. Composting of solid manure may also be done in order to reduce volume, increase product uniformity and handling ease, and reduce or eliminate weed seed and pathogen viability.

Composition

The value of land-applied animal manure lies primarily in its role as a source of plant nutrients in crop nutrition and a source of organic matter to condition the soil and improve tilth. A common denominator in most all manure sources is a low and variable nutrient content per unit weight or volume compared to commercial fertilizers. For example, liquid swine manure typically has a total nitrogen (N) content ranging from 0.1 to 0.5%N by weight and fresh cattle penning manure may range from 0.5 to 1.5%N. This is in contrast to a commercial nitrogen fertilizer like UAN solution with 28% N by weight or urea with 46% N by weight.

Manure fertilizer can offer a broader range of nutrients than inorganic products.

Low nutrient content of manures makes transportation costs a major factor in dictating how far the manure can be economically moved from its point of production to the field, with economic hauling distances of fresh manure typically being only a few km from the source. However, it is important to account for all the potential benefits of the manure when assigning a value to it. These benefits include the other nutrients: phosphorus, potassium, sulfur, micronutrients that are added in manure in addition to nitrogen, as well as potential longer term benefits to soil tilth from the added organic matter. This is why the “value” of manure is best thought of as the value of the overall crop yield increase over several years associated with the manure addition rather than simply multiplying the nutrients in the manure by the price per pound paid for commercial inorganic fertilizer.

Nutrient Forms and Behavior

As indicated above, manure is not an “off-the-shelf” fertilizer. To properly use it, the nutrient content and forms must be known through a manure analysis. It is important to know the relative amounts of nitrogen, phosphorus and other nutrients contained in the manure, since application according to a requirement for one nutrient may result in over or under application of another nutrient. Therefore, to achieve the desired balance of nutrients in the soil and not overload the soil with any one nutrient, it may be necessary to supplement manure with additions of commercial fertilizer.

Knowing the nutrient forms (organic versus inorganic) in the manure is important in predicting manure behavior. Liquid manures such as liquid swine effluent contain and add relatively low amounts of organic matter to soil in comparison to solid manures. Reflecting this, in a liquid manure a higher proportion of the nutrient is found in immediately plant available inorganic forms as compared to a solid manure in which much of the nutrient is contained in organic forms which are only slowly rendered available in the soil via microbial decomposition. As an example, it is has been observed that 50% to 90% of the nitrogen applied as liquid swine manure is available for crop use in the year of application, while in the case of solid cattle penning manure with straw bedding, only 10% of the nitrogen was available. Manures that include a high content of carbonaceous materials such as straw or wood chips may release their nitrogen into available forms only very slowly, such that it may take more than one year following application before one sees significant benefits in increased nitrogen availability in the soil.

Using manure effectively demands nutrient and soil analyses.

Crop Responses

Field trials conducted across the soil-climatic zones of Saskatchewan over the past five years have shown large and significant yield increases from applied manure nutrients at rates of manure nutrient application, which match the crops predicted nutrient demand according to soil test. Owing to the high plant availability of nutrients contained in liquid swine manure, crop responses to injected liquid swine manure were often

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[2]Prairie Agriculture Machinery Institute, Humboldt, SK.

similar in magnitude to that observed for commercial inorganic nitrogen fertilizers at similar rates of application. Although the plant availability of any individual nutrient in the liquid manure is typically lower than for a commercial inorganic form in the year of application, the combined effect of adding several nutrients (macro and micronutrients) at once in manure was likely responsible for near equivalent yields in comparison to nitrogen fertilizer alone, especially in soils that were deficient in other nutrients such as P and K which the manure supplied. On the other hand, our research showed relatively low yield responses in the year of application from cattle penning manure that contained lots of straw bedding. The low crop response to cattle penning manure in the year of application was attributed to restricted nitrogen availability due to initial tie-up of nitrogen when straw contained in the manure was decomposed. The carbon: nitrogen ratio was identified as an important parameter influencing the pattern of available nitrogen release from solid manures. As the carbon: nitrogen ratio decreased with prolonged decomposition, available nitrogen was eventually released and we observed good yield responses to cattle penning manure in the second and subsequent years after application.

Nutrients in cattle manure are released in the second and subsequent years after application.

In our field trials, we also observed several problems when manure nutrients were over-applied. Repeated yearly applications of manure at rates, which greatly exceeded the crop nutrient requirements, were observed to result in excessive accumulations of nitrate in the soil profile as well as gaseous denitrification losses to the atmosphere. The accumulation and potential escape of nutrients to ground or surface water as well as emissions to the atmosphere are significant environmental concerns associated with over-applications of manure. There are agronomic concerns as well, as application of manure nutrients at rates two to three times that required by the crop also sometimes caused problems with germination, emergence and lodging. As well, high rates of manure application in dry years sometimes produced a "haying off" of cereal crops, in which heavy vegetative growth early in the season could not be sustained when it turned dry later in the season, resulting in disappointing grain fill and grain yield relative to straw yield.

Manure Management Practices

A sound manure nutrient management plan requires: 1) knowing what is in the manure (manure nutrient analyses), 2) availability of nutrients in soil (soil testing), 3) manure nutrients and fertilizer to be applied to meet crop nutrient demand (rate recommendations), 4) strategy for application, and 5) record-keeping and monitoring.

Rates

A sound long-term approach to efficient, economic and environmentally friendly use of manure nutrients is to apply at rates which balance with crop demand and use over time. In the short-term, rates of manure appropriate for next year's crop may be calculated based on analysis of the manure nutrient content and predicted availability of the manure nutrients to be applied along with soil test and required rates for individual nutrients as used for application of commercial fertilizer. Manure software recommendation packages have been developed by commercial soil testing laboratories as well as government agencies which simplify these calculations and in some instances, allow record keeping and provide calibration information.

Timing

With a source of manure such as liquid swine manure in which much of nitrogen is contained in the form of immediately plant available ammonium, similar to commercial fertilizer the application in late fall or spring is most desirable in order to reduce opportunity for conversion of the ammonium to the nitrate form which is more susceptible to losses such as leaching and denitrification. To reduce potential losses, these manures should be applied as close to the time of plant nutrient demand as possible. For solid manures such as cattle penning manure, low availability of nitrogen in the year of application due to the straw in the manure may necessitate a supplemental application of commercial N fertilizer or perhaps a pulse crop in the first year to optimize production, as a lead time is necessary to give the organic nitrogen opportunity to be released into the plant available inorganic forms.

For best results, fertilize with manure when the crop needs it.

Method of Application

Owing to the dilute nutrient concentration in manure, large volumes must be applied to satisfy the nutrient recommendations. Therefore, application rates of liquid swine manure in the order of a few thousand gallons per acre or cattle manure applications of a few tons per acre are needed in comparison to a few pounds of commercial fertilizer. This has made effective application strategies challenging. A consistent finding in research trials in Saskatchewan has been that liquid manure that is placed into the soil (injected) provides better crop recovery of nutrients and greater yield response than surface applications, as well as reducing odor.

Strategies for Using Liquid Manure in Zero-Till

Low Disturbance Injection of Liquid Manures

Considerable advances have been made in technology for injection of liquid manure over the past few years. Injection technology has progressed from crude shanks on a wide spacing that simply directed the liquid manure into large channels or trenches, to the development of manifold systems and tool bars to distribute the manure to narrow row spacing shanks with sweep or spike openers that provide closure of the furrow and retention of the manure in place. Most recently, equipment has been developed for low disturbance injection of liquid manure into forage stands and no-till fields. In field research trials in Saskatchewan, large increases in biomass yield have been observed from the low disturbance injection of liquid swine effluent into forage grass stands such as crested wheat and brome grass. The low disturbance injection technology in these trials uses coulters or discs to open a narrow channel into which the liquid manure is injected. Other approaches to low disturbance in-soil placement include the use of a rotating drum to make indentations in the soil into which the manure flows. These techniques are now being used by several commercial applicators and provide an effective link between the desire to effectively recycle manure nutrients and the expansion in direct seeded and forage acres.

Post-Emergent Injection to Boost Yield and Protein of Cereals

Low disturbance, post-emergent injection of liquid swine effluent at low rates to boost yield and protein content of cereal crops is currently being evaluated in a three year research project (2000, 2001, 2002). In this study, low disturbance coulters are used to inject liquid manure in-crop at around the tillering stage. In 2000 in east-central Saskatchewan under good moisture conditions, this approach worked well. At one site the post-emergent injection of liquid swine effluent into a hard red spring wheat crop on June 30 at 2000 gallons per acre ($\sim$60 lb total N / acre) increased the yield over the check by 6 bushels per acre and raised the protein content from 14.4% to 15.9%. In 2001, under poorer moisture conditions, some yield reduction from the disturbance during later applications was evident and only protein content was increased. Post-emergent injection methods show promise in opening up the application window for liquid manure application, and are compatible with no-till systems.

Figure 1 **Low disturbance coulter system for injecting liquid manure into forage stands and no-till fields.**

Challenges

Some challenges we still face regarding use of manure as fertilizers and soil amendments include the inherent variability in manure, its low nutrient content and constrictions in transportation and application technology. In the case of solid manure, we still lack good technology to uniformly distribute the solid manure across the field area during application. This poses problems in effective use of solid manures in zero till systems, as considerable soil disturbance is often associated with attempts to distribute and incorporate the solid manure following application. The goal would be to have equipment that allows solid manure to be placed below the surface of the soil during application with minimum soil disturbance. Composted manures and processed manure products fortified with commercial fertilizers to obtain the desired nutrient content, balance and physical properties may allow more effective utilization of solid manures in the future. For liquid manures, further development and refinement of technology for “on-the-go” sensing of manure nutrients should allow for more precise application of manure nutrients in the field and help to account for the potentially high variability in nutrient content from load to load.

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