The Prairie Swine Centre is pleased to present our 1997 Annual Research Report

HIGHLIGHTS

- **This experiment focuses on the lysine requirements of pigs from 28 to 56 days of age. (p.22)**
- **A large-scale study of the effects of well water high in sulphate and iron on weanling pigs concluded that pigs have the ability to maintain performance, but may show signs of diarrhea. (p.26)**
- **The effect of well water high in sulphate and iron on blood and tissue in weanling pigs is analyzed. (p.30)**
- **Commercial diets can be formulated more accurately if we define the lean tissue and lipid growth curves. (p.33)**
- **Using actual slaughter data and mathematical modeling techniques, the changes in body composition of barrows and gilts are illustrated. (p.37)**
- **The variability in energy content and a practical method to accurately estimate digestible energy and metabolized energy content of barley samples were identified. (p.40)**
- **The range of digestible energy content and economic value in eleven field pea varieties is investigated. (p.45)**
- **Behaviour and age of weaning are linked. The effects of current weaning practices on the behaviour of piglets in the nursery through to the grower/finisher phase in investigated. (p.48)**
- **A calculation of space allowance expressed in terms of body weight allows one to plan, design and manage pig flow and pen sizes precisely regardless of shifting market weights or weight at which pigs are moved from grower to finisher facilities. (p.52)**
- **A well-designed feeder can improve many aspects of pig production. A key to success in feeder design is to accommodate the eating pigs' physical and behavioral requirements. (p.55)**
- **Reducing aggression among pigs at re-grouping can lead to depressed growth, injuries, poor meat quality and stress-induced embryonic loss. The introduction of odours to pigs did not reduce aggression when pigs are mixed. (p.59)**
- **Weight gain and growth performance of intact males, which were immunocastrated, produced weight gain and growth performance similar to boars and superior barrows. (p.63)**
- **Injecting hog manure into soil can result in improved crop yields, soil fertility and soil structure. The inclusion of elemental sulphur can also improve crop productivity on some soils. (p.69)**
- **Temperature variation can result in reduced animal performance. A review of temperature requirements for pigs is conducted. (p.76)**

"The mission of Prairie Swine Centre Inc. is to provide a centre of excellence in research, technology transfer and education, all directed at the enhancement of efficient, sustainable pork production in Canada."

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THE PRAIRIE SWINE CENTRE

The Prairie Swine Centre focuses on issues of efficiency and sustainability. While much of the research program seeks to improve the individual pork producer's net income, through nutrition, management and housing, there is also a need to deal with issues that have less direct economic impact but clearly influence the future success of our industry. Currently, the issues of animal welfare and human health are two important focuses of the Centre's research, technology transfer and teaching programs.

Funding

The Centre must attract funding in order to survive. This is one of the corporation's strengths. It ensures that the Centre is responsive to industry needs and input. This is clearly demonstrated by the make-up of its Board of Directors. In addition, the Centre was established with a view to attracting funds from a wide variety of sources; this reduces dependency on any one source and at the same time reduces the cost to any one participant in the Centre's various programs. About one-third of total revenues are derived from sale of stock; this encourages the Centre to be a good pork producer, which many producers tell us is critical to our being a good research facility. The subject of funding is covered in greater detail in the President's Report.

Staffing

The strength of any organization is its staff. While the Centre is proud of its modern, practical research facilities, its greatest resource is its people. There are a total of 38 people currently employed by the Centre in a variety of professional and support positions.

Graduate Studies

Graduate students bring a new perspective to the Centre. Their intense interest often leads to new questions being asked and traditional ideas being challenged. The Centre currently has three graduate students - two in ethology and one in engineering. Further expansion of graduate training is expected in the future.

Facilities

The Prairie Swine Centre is the largest swine production research facility in Canada. With more than 77,000 ft^2 of barn and office space, it maintains a unique array of research capability on one site.

Original Facilities

The original 250 sow farrow-to-wean unit was built in 1980 by the University of Saskatchewan. It consists of two 100-sow and one 50-sow units, each with its own gestation, farrowing and weanling areas. A small feeder barn was also built at that time consisting of 24 pens capable of holding 10 pigs each.

Grower-Finisher Research Unit

In May of 1992, pigs were first introduced into the new Grower-Finisher Research Unit. This unique facility was designed by a commercial engineer and constructed using the same materials and methods employed by the commercial pig industry. The cost of the new unit, at about $\$35/ft^2$, is only moderately higher than the \$20 to $\$25/ft^2$ experienced by commercial units. Yet, this includes a wide array of specialized research equipment and facilities; this cost also includes office facilities for the expanded research staff. The unit can be divided into 5 functional areas: basic, intensive, semi-intensive, commercial and proprietary.

Basic

The basic research area includes a fully-equipped surgery, related prep areas, two small experimental rooms designed for flexible research use, and a very sizable metabolism room that can accommodate up to 20 metabolism crates for large-scale digestibility studies.

Intensive

The intensive research area includes two rooms of 76 individual pens each. These rooms are designed for use in experiments where individual animals are the focus of research or where only small quantities of test materials are available for nutrition experiments. The pens are designed to be modified, to convert from one pig in a pen up to 5 pigs in a pen, depending on the needs of the experiment.

Semi-intensive

Often, research requires facilities that are mid-way between commercial scale and intensive. The semi-intensive rooms were designed to fulfill this need. Four rooms each contain 20 pens designed for 5 pigs each. Again, the penning is flexible, allowing groupings larger than 5 pigs when desired.

Commercial

The commercial area actually includes two types of facilities. In one area, there are three rooms of partially-slatted floor pens; each room consists of 12 pens housing 12 pigs each. Although somewhat smaller than the typical commercial group size of 20 to 30, the commercial rooms allow research to be conducted in facilities that in most respects resemble recently constructed commercial barns.

A second area of the commercial wing includes two engineering rooms. These consist of 12 pens of 12 pigs each, housed in fully-slatted floor pens. However, the rooms are designed for maximum flexibility so that they can be converted to partially-slatted or even totally-solid floors. The ventilation system can be completely changed to incorporate a wide array of options in both inlet and exhaust design.

Proprietary

The proprietary area includes 4 semi-intensive rooms and one metabolism room, similar to that in the basic area. This provides Prairie Swine Centre with unique facilities to serve the commercial sector; indeed, companies from across the United States and from as far away as Europe have contracted with the Centre to conduct research on their behalf. This not only helps the financial situation of the Centre, but places it firmly in the "big leagues" of swine research worldwide.

Other Facilities

In addition to the above, the Centre maintains an office building complete with offices for the research and administrative staff as well as graduate students. It also has a simple laboratory and reading room. By employing modern communication technology, the Centre is linked through computer networks to researchers on campus and around the world. Prairie Swine Centre Inc. employs research and support staff to ensure that all research and technology transfer objectives are met. Each member of the Executive Management Team brings a wealth of research and practical pork production experience.

BOARD OF DIRECTORS

Left to right seated: Terry Scott, John Patience, Weldon Newton, Jim Smith
Left to right standing: Wayne Vermette, Florian Possberg, Mac Sheppard, Cam Henry, George Lee
(Missing: John Stewart)

Board of Directors

The Centre's Board of Directors has 10 members as of June 30, 1996. They represent the diverse interests of the western Canadian swine industry, including:

Mr. Weldon Newton, Chairman, Prairie Swine Centre Board of Directors, Manitoba pork producer,

Mr. Jim Smith, Alberta pork producer

Mr. Wayne Vermette, Saskatchewan pork producer

Mr. Florian Possberg, Saskatchewan pork producer

Dr. George Lee, Agricultural Research Coordinator, University of Saskatchewan

Dr. John Patience, President Prairie Swine Centre,

Mr. Cam Henry, Manitoba grain producer

Mr. Terry Scott, Deputy Minster of Agriculture Saskatchewan Agriculture and Food

Mr. Mac Sheppard, controller (recently retired), University of Saskatchewan

Dr. John Stewart, Dean of Agriculture,University of Saskatchewan

STAFF AND ASSOCIATES

Executive Management Team

Left to right seated: Dr. Edward Beltranena; Dr. John Patience, President/CEO; Dr. Stéphane Lemay
Left to right standing: Dr. Harold Gonyou; Mr. Brian Andries; Mr. Lee Whittington

President

Dr. John Patience is President and Chief Executive Officer of the Corporation. He brings 13 years of experience in extension, the feed industry and research to the Centre. Raised on a hog and beef farm in southern Ontario, he obtained both his Bachelor and Master degrees from the University of Guelph and his Ph.D. from Cornell University, the latter in 1985.

Research Scientist - Engineering

Dr. Stéphane P. Lemay,is a graduate of Laval University. He completed both his B.Sc. (1989) and M.Sc. (1991) in agricultural engineering and his Ph.D. (1996) in mechanical engineering. Following graduate school, he was employed for six months as a research assistant with Agriculture and AgriFood Canada, and in 1996, joined the staff of Prairie Swine Centre Inc. as Research Scientist - Engineering. He was appointed an Adjunct Professor at the University of Saskatchewan in 1997. He is a member of the Québec Order of Engineers, the Canadian Society of Agricultural Engineering and the American Society of Agricultural Engineering. Dr. Lemay is the author or co-author of 3 refereed journal articles, 1 book chapter and 7 articles in conference proceedings.

Research Scientist - Ethology

Dr. Harold Gonyou is Research Scientist - Ethology (Behaviour). Raised on a farm in southern Ontario, Dr.Gonyou obtained his Bachelors degree from the University of Guelph, his Masters degree from the University of Alberta and his Ph.D. from the University of Saskatchewan. He joined the faculty of the University of Illinois and rose to the position of Professor before leaving to join the Centre. Currently, Dr. Gonyou is President of the International Society of Applied Ethology, the first North American to hold this position. He has also been invited to participate in an international committee focusing on swine equipment design.

Manager - Information Services

Mr. Lee Whittington is Manager - Information Services. Originally from Ontario, he obtained his Bachelors degree from the University of Guelph before joining Shur Gain where he remained for 13 years. Mr. Whittington recently completed his M.B.A. at the University of Saskatchewan. In addition to his animal science background, Mr. Whittington has extensive training and experience in marketing and communication, making him ideally suited to his current responsibilities at the Centre.

Manager - Operations

Mr. Brian Andries is Manager - Operations. He hails from southern Saskatchewan and obtained his Bachelors degree from the University of Saskatchewan. Mr. Andries has over 10 years experience in swine production and has risen through the ranks of the Centre to his current position.

In addition to the staff noted above, the Centre is very well served by support staff in a variety of accounting, clerical, production and technical positions. Their combination of training and experience in pork production as well as research methodologies provides the essential support needed in any successful research program.

Post Doctoral

Dr. Mark Lorschy
Citizenship - Australia
Degree - PhD Nutrition
Last appointment - University of Minnesota
Area of research - Amino acid/energy interaction in growing-finishing pigs

Dr. Zhensheng Lou
Citizenship - Canadian
Degree - PhD Behaviour
Last appointment - University of Guelph
Area of research - animal/equipment interaction

Graduate Students

Ruth Forde
Degree sought:
M.Sc. in Ethology

Dana Ball
Degree sought:
M.Sc. in Nutrition

Moira Harris
Degree earned:
M.Sc. in Ethology
Degree sought:
Ph.D. in Ethology

Shawn Fairbairn
Degree earned:
M.Sc. in Nutrition

Administration Staff
left to right:
Christine Wakabayashi (Financial Manager),
Audrey McFarlane (Secretary).

Proprietary Research Group
left to right: Alison Orr, Research Technician,
Dr. Eduardo Beltranena, Manager-External Research,
Raelene Petracek, Research Technician.

Kelly Sauder,
Farm worker

Production and Technical Staff
Standing left to right: Troy Donauer, Raelene Petracek, Scott Neis, Joe Jobin, Alison Orr, Karen Wurtz
Seated left to right: John Meier, Colin Peterson, Doug Gillis, Marnie Korchinski

FINANCIAL SUPPORT

Pork production research is entering a new phase in Canada, with increasing emphasis on producer driven and funded programs. Prairie Swine Centre Inc. wants to acknowledge the many individuals and agencies that supported the dynamic research and technology transfer programs this past year. This support is essential to the ongoing developments that will keep Canadian pork producers at the forefront of applied technology. In addition to industry and government funding, the University of Saskatchewan contracts the facilities and services of PSCI for research and teaching. This ongoing agreement provides income for the Centre in return for the use of modern production and research facilities.

The following organizations have provided funding or donations in kind to support public research at the Centre for the 1996/1997 year. Their support is greatly appreciated.

Pork Producers of Saskatchewan
SPI Marketing Group
Swine Improvement Services Co-op

Pork Producers of Alberta
Alberta Pork Producers Development Corporation

Pork Producers of Manitoba
Manitoba Pork Est.

Government
Alberta Agricultural Research Institute
Agricultural Development Fund
Canada-Saskatchewan Green Plan Agreement
Industrial Research Assistance Program (IRAP)
Natural Sciences and Engineering Research Council of Canada (NSERC)
Saskatchewan Agriculture and Food
Western Economic Diversification Program

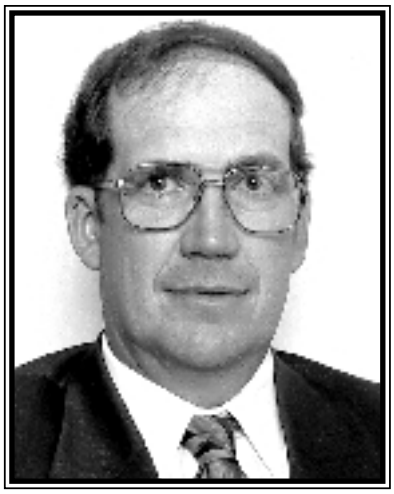
Institutions
Inspiraplex
United States Department of Agriculture (USDA)
University of Maryland
University of Saskatchewan

Industry Donations
ADM Bioproducts
B.C. Hog Marketing Commission
Canadian Feed Industry Association
Canodev Research
Canola Council of Canada
Canodev Research
Central Water Conditioning
Degussa Corporation
Feed Flavors Incorporated
Feed Rite Ltd.
Hillcrest Farms Ltd.
Hoffman - LaRoche
Kenpal Farm Products, Inc.
Master Feeds
Pig Improvement (Canada) Ltd.
Ralston - Purina Canada Inc.
Shamrock Feed Ltd.
TDK Corporation of America

Many corporations provide funding in support of technology transfer programs conducted by the Centre. We wish to acknowledge their contribution for assisting the Centre in encouraging the adoption of new technologies by Canadian Pork Producers.

Bank of Montreal
Better Feeders Ltd.
Calmar Feed Mill
Canadian Bio-Systems
Co op Feeds, division of FCL
Cotswold Western Canada Ltd.
Dalland Value Added Pork Inc.Degussa Canada Ltd.
Degussa Canada Ltd.
East-Man Feeds Ltd.
Elanco Animal Health
Feed-Rite Ltd.
Heartland Livestock Services
Heartland Lysine
Kenpal Farm Products Inc.
Managro Harvestore Systems (1977) Ltd.
Merck AgVet
Minitube Canada
National Pig Development (Canada) Ltd.
Pharmacia & Upjohn Animal Health
Phason, Division of Wintech Inc.
Pig Improvement (Canada) Ltd.
Prairie Pride Enterprises
Pro-AgProducts
Puratone Corporation
R.R. Western Feed Mill Ltd.
SaskTel
ScotiaBank
Sheridan & Heuser Swine Health Services
Stirdon Systems
UniPork

CHAIRMAN'S REPORT



Weldon Newton
Chairman of the Board

CHAIRMAN'S REPORT - WELDON NEWTON

The prairie swine industry has embarked on a period of unprecedented expansion. As the industry expands our every move is being watched like never before. It is essential that we are able to answer our critics with well-substantiated answers based on good research and documentation that is relevant and valid for the Canadian prairies. Unfortunately, even this may not always appear to enable us to carry forward our case in the court of public opinion in the short term. However, over the long term we will emerge with our reputation intact and a much larger, responsible and well-managed industry. The Prairie Swine Centre looks forward to being an integral part of this dynamic industry.

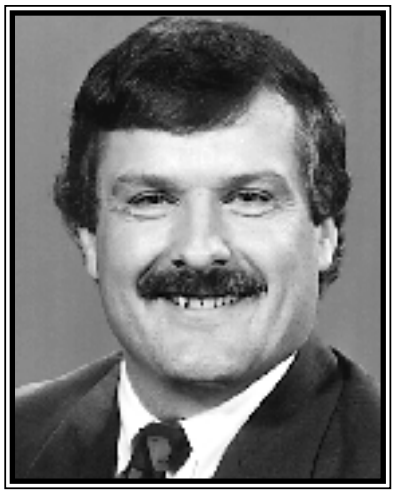
During the past year the Prairie Swine Centre has attempted to look at itself and determine how we can continue to be relevant to the industry of tomorrow. We will continue to assist industry growth by providing some of the answers that will be required. The adoption of our second five-year strategic plan sets out the framework for our activities for the next five years. It builds on the original mission set forth in 1991 "to be a centre of excellence in research, education and technology transfer, all directed at efficient, sustainable pork production". It will take our technology transfer program a step farther by placing more emphasis on technology adoption. Another expanded area of activity will be the Centre's role in education and training. While already involved in Post Graduate training and introductory there is an opportunity to develop education and training opportunities for management and production staff already involved in the industry.

We have enjoyed a good year financially and this will help to maintain the resources necessary to continue an excellent research program into the future. The renewal of the financial commitments by the producers in Saskatchewan, Alberta, and Manitoba is a welcome endorsement of the research program. This core funding is essential to enable the Prairie Swine Centre to develop and maintain a research program that continues to meet the broad needs of producers.

The development and maintenance of the research program is only possible because of the commitment of all members of our research team. The dedication and energy exhibited by all staff members is recognized and appreciated. It is certainly encouraging to hear that at a time when the centre has the largest herd ever, one of the limiting factors for research projects is the availability of animals. This is the case because a very large portion of the herd is being utilized for research purposes.

This will be my last report as a member of the board of directors and it certainly has been a privilege to be associated with this dynamic and growing research institution for the past six years. I am sure that the Prairie Swine Centre will continue to play a large role in the Canadian and world swine research community and it will continue to be an invaluable asset for our industry.

PRESIDENT'S REPORT



Dr. John Patience
President

The year 1997 represented the 5th anniversary of Prairie Swine Centre Inc. It has been a very exciting and rewarding five years, in particular because the Advisory Board's vision as defined in 1989 moved from the drawing board to reality. The vision… "a research centre that would focus on the needs of pork producers, emphasize technology transfer, operate in a sound business-like manner and embrace the concept of excellence in everything it did".

As Prairie Swine Centre Inc. enters its second five years of existence, we continue to ensure that these guiding principles are sustained. We look to the future with enthusiasm, as the need for new technology to remain competitive in an increasingly competitive global market has never been stronger. This is amply demonstrated by the emphasis placed on technology development and application practised by Canada's main trading competitors.

Prairie Swine Centre Inc.'s role will become increasingly valuable as access to new technology by individual producers is becoming more difficult. The 1960's, 1970's and 1980's saw a ready exchange of information and ideas on a global scale. As we move towards the next millennium, the free movement of information between Europe and North America is diminishing, as global competitiveness becomes more acute. Within North America even, this same trend is clearly evident.

"Prairie Swine Centre Inc.'s role will become increasingly valuable as access to new technology by individual producers is becoming more difficult."

This is called the Information Age and the value of knowledge as a competitive advantage is being increasingly recognized. As a public research institution, Prairie Swine Centre Inc. takes its role as a provider of new ideas and information very seriously. Every trend in the industry suggests this role will be more important in the future than ever before.

The Advisory Board vision... "a research centre that would focus on the needs of pork producers, emphasize technology transfer, operate in a sound business-like manner and embrace the concept of excellence...."

The financial support of pork producers is key to our success. It allows the Centre to build on this core funding with grants from public agencies, such as the Saskatchewan Agriculture Development Fund, the Alberta Agriculture Research Institute and the federal Natural Sciences and Engineering Research Council of Canada. In 1996-97, the $410,000 received from the pork producers of Saskatchewan, Manitoba and Alberta supported a total research budget in excess of $1.5 million, a multiplier effect of almost 4:1. I would like to take this opportunity to thank the pork producers for their support, because it is so important to our success. We were particularly pleased by the fact that all three provinces renewed their funding of the Centre this year.

In addition to the pork producers and public agencies listed above, the Centre attracted research funding from no less than 17 other agencies and corporations. Companies like ADM Bioproducts, TDK Corporation, Pig Improvement Canada, the BC Hog Marketing Commission, SISCO, the Canola Council of Canada,

the Canada Saskatchewan Green Plan Agreement and the United States Department of Agriculture, all continued their funding of our work from previous years.

We also welcomed new partners as well, including Hoffman LaRoche, Ralston Purina Canada, Degussa Corporation, Central Water Conditioning, Feed-Rite and the Canadian Feed Industry Association.

The sale of pigs also helps to support our research activities. Because of strong market prices, combined with staff efforts to elevate herd productivity to a record 25.1 pigs/mated sow/year, profits from animal sales subsidized our research and technology transfer program to the tune of more than $200,000.

"Students bring a level of enthusiasm and commitment to their research programs that elevates the aspirations of us all."

A number of new staff joined the Centre this year. Dr. Ruurd Zijlstra was appointed Research Associate - Nutrition in October; Ruurd will provide leadership to our nutrition research program, particularly in the areas of ingredient evaluation and weanling management. Dana Ball and Marina Lambert began their graduate studies in nutrition and engineering, respectively, while Ryan Stinson is working as a summer student in the slurry treatment/management area.

Andrew Mencarelli resigned from our staff to enter the Western College of Veterinary Medicine, Nadine Possberg returned to her studies at the University of Saskatchewan, while Larry Tittle and Richard Schmidt moved on to other employment.

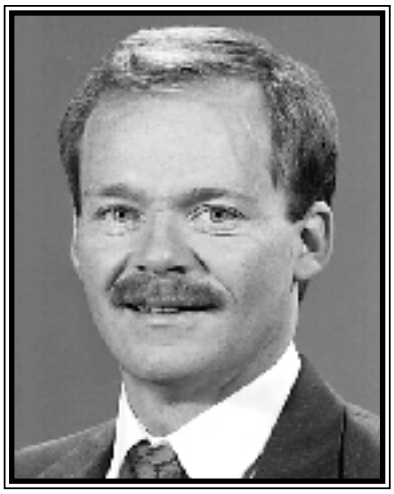
I would like to recognize all of the staff and students at the Centre who work very hard at contributing in their own area to achieving the Centre's goals. Production staff maintain a high level of animal productivity, to ensure our research is conducted on animals producing at levels considered relevant by pork producers. Research support staff are responsible for carrying out research protocols in a precise manner, to ensure confidence in the data. Administrative support staff keep the business operating in a professional manner and research scientists recruit funding and oversee a research program that grows in both size and international stature every year. Technology transfer staff have the important role of ensuring that research results are communicated to the industry as quickly and effectively as possible, and students bring a level of enthusiasm and commitment to their research programs that elevates the aspirations of us all.

Finally, I would like to acknowledge the important role of the Board of Directors, under the Chairmanship of Weldon Newton. Each Director is very busy in his own right, and yet they give of their time freely and without compensation. Their special responsibility is pointing the ship on the correct course and creating an environment that encourages all of the staff to contribute to the Centre's goals and principles to the best of their abilities.

Joe Jobin adjusting feeders in one of the all-in all-out nurseries at PSC

Dr. Lemay conducting air quality analysis in a fully slatted grow-finish room at the centre

INFORMATION MANAGER'S REPORT



Lee Whittington
Manager-Information Services

Technology transfer becomes technology adoption. The original vision of Prairie Swine Centre included a mandate for technology transfer. It was agreed that any investment in research should include a significant investment in the mechanism which would move new research results into the hands of the commercial pork industry. Over the course of the last five years this commitment by researchers and staff at the Centre to provide information on the new developments has continued to grow. From the date the new technology transfer service opened the volume of requests has grown. From simple ration balancing to complex implementation of customized feedings programs, the Centre has sought to fill a void for specific, timely information that can improve efficiency or sustainability of the production unit.

Now serving Manitoba and Alberta in addition to Saskatchewan, the activities of the technology transfer program are in a state of continual review and improvement. For three years a Satellite program has linked viewers in western Canada for a half day discussion on timely topics and recent research. This 'flag ship' event is a tremendous opportunity to draw the national industry's attention to a short list of common issues. The conference begins with a general topic such as personnel, economics, or the environment. The program builds on these common issues to discuss new research developments taking place at Prairie Swine Centre or elsewhere. The uses of new communications technology, including video conferencing links to the studio, have contributed to the speed, accuracy and appeal of the technologies discussed. It has been said that most of us require seven exposures to new information before we change our behaviour. It is our intent to try and shorten that chain of events from first exposure to adoption.

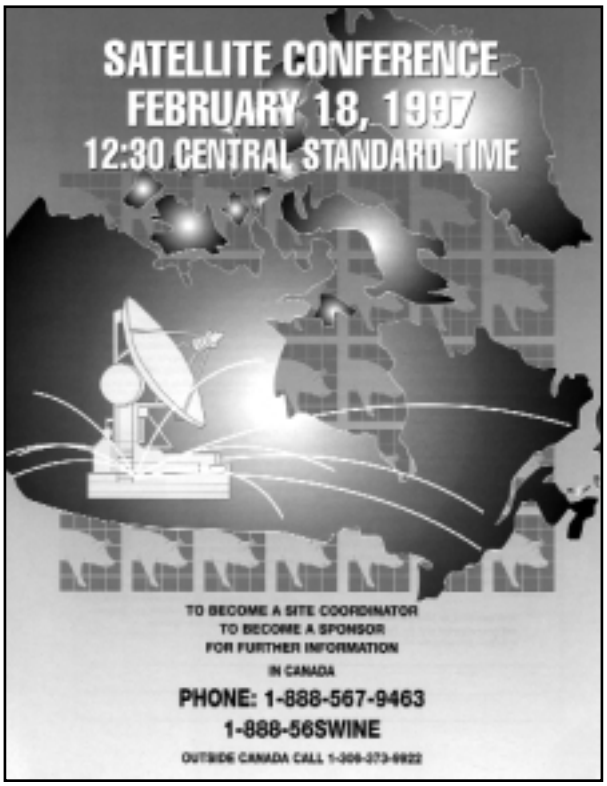
Through adoption of new information we can improve not only the efficiency of pork produced in Canada but also the acceptability of our production. Sustainability of the industry over the long term is dependent on our ability to coexist with all of society. This means issues such as the environment, animal welfare and worker health and safety must be acted upon in a timely manner. Using new research described in this and previous reports pork producers could reduce respirable dust within the barn by 80%, reduce odours emanating from concrete manure storage tanks by 90% and identify that widening the farrowing crate does not contribute to improved sow comfort prior to farrowing.

We will continue to take a multi-media approach to distributing this information in an effort to speed the adoption of this new information. The use of quarterly newsletters, factsheets, web site and email continue to supplement the personal contact between the industry and the Centre. In addition, the coming year will see the introduction of the research monograph for those seeking detailed information on our work and a planned introduction of audio tape presentations. An expanded role for technology transfer in the area of pork producer training is also to be introduced in the coming year.

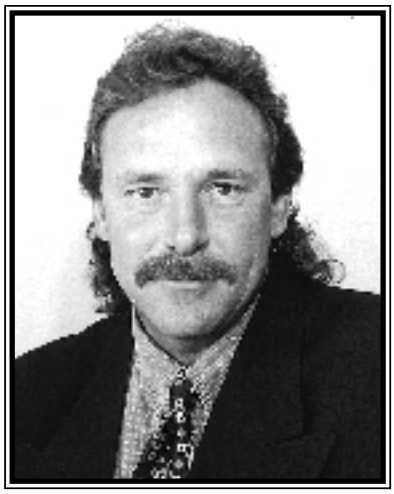
Thanks to the Following Cooperators and Volunteers

British Columbia Ministry of Agriculture, Fisheries and Food
British Columbia Hog Commission
Alberta Agriculture, Food and Rural Development
University of Alberta
Alberta Pork Producers Development Corporation
Saskatchewan Department of Agriculture and Food
Pork Implementation Team
SPI Marketing Group (Saskatchewan)
Manitoba Pork Est.
Manitoba Department of Agriculture
Ontario Pork Producers Marketing Board
Ontario Ministry of Agriculture, Food and Rural Affairs
Université Laval, Québec
Centre de Developpement du Porc du Québec Inc.
P.E.I. Department of Agriculture
P.E.I. Hog Commodity Marketing Board
Nova Scotia Department of Agriculture

We would also like to thank all the individuals and businesses that helped to organize a local site.



OPERATION MANAGER'S REPORT



Brian Andries
Operation Manager

The continued success of production staff has resulted in animal inventory levels remaining at a consistently high level to the end of this fiscal year. The strong, stable markets over the last year have financially benefited all producers throughout the Prairie Provinces, including Prairie Swine Centre Inc.

Again this year I am pleased to report increases in the major productivity measures. We are particularly pleased to have reached the important milestone of 25 pigs weaned per inventoried female. Few measures of reproductive efficiency of the herd are as important as pigs per inventoried female. This number demonstrates key tasks such as breeding, pregnancy checking and attention to farrowing are all being completed, all of the time. It is our goal to continue to strive for productivity that is comparable with the top herds in western Canada. Good production provides not only a more economical source of pigs for research but more importantly demonstrates that current research work being conducted at the Centre is relevant to our commercial industry.

In association with a high level of production, we were able to optimize the utilization of animals and research facilities in completing 58 experiments during 1996. In total 6,434 animals were utilized for piglet, nursery, growing - finishing and sow trials over the past year.

Extensive renovations started January 1st in the gestation rooms of both 100-sow barns. One-foot extensions were added to the existing 6-foot stalls that originally were utilized in a group-housing configuration. Replacement gilts, before breeding, are the only animals now housed in group pens. Two rows of dry sow stalls in each barn were relocated to incorporate a larger area of slatted flooring under each sow, resulting in a cleaner, drier environment. An additional 9 stalls per barn were added to accommodate the slightly increasing sow herd numbers.

At the end of this fiscal year, we discovered that PRRS (Porcine Reproductive and Respiratory Syndrome) had entered the herd. The disease came into the herd through piglets obtained from cesarean section. The virus has been shown in other commercial herds to have widely varying health effects. Some herds experience little more than a slight rise in stillbirths and an increase in weak piglets. Some herds report serious reproductive losses and related respiratory ailments in nursery and growing pigs. Fortunately, our experience to date has been the milder version. The effect that the virus has on the herd is being recorded in detail in an attempt to provide a detailed documentation of the disease progress for future industry reference. In consultation with Dr. Chuck Rhodes, our Herd Health Veterinarian, and Dr. Townsend, an epidemiologist with the Department of Internal Medicine at WCVM, a plan was developed to determine a management strategy for disease control. A series of blood sampling were carried out and analyzed to determine the spread of the infection through the facility. Records are being kept to track mortality and treatment pre- and post weaning of animals.

Farrowing and nursery management procedures were reexamined after the outbreak of PRRS, to ensure that production staff were doing everything possible to reduce pre- and post-weaning mortality. This included tube feeding weaker, nonviable piglets, using electrolytes and milk replacer in farrowing rooms, and ensuring that all-in all-out practices were being adhered to throughout the facility. Again, staff have pulled together to ensure that losses from this outbreak are kept as low as possible, as we did with our struggle with T.G.E several years ago. It is our hope that we can again assist producers to further understand how this virus affects commercial operations, and in this way, help to reduce production losses.

Improvements in production over the last fiscal year is summarized in the following table (Table 1):

Table 1. Production parameters for the 1995/1996 and 1996/1997 fiscal years

	1995/1996	1996/1997
Sows farrowed, #	712	688
Farrowing rate, %	89.7	90.1
Pigs born alive/litter	11	11.4
Litters weaned	702	687
Pigs weaned	7060	7142
Weaned/female inventory	24	25

A modified school bus is used to transport finished pigs to market

Marnie Korchinski weighing feed for a gestation sow study.

FIVE YEAR OBJECTIVES

The five year research program of Prairie Swine Centre Inc. has five main objectives, and broadly covers the areas of nutrition, engineering and behaviour. In detail the objectives are as follows:

Objective 1:

To define optimum feeding and management procedures to reduce the cost of feeding out grower-finisher pigs (20 kg to market) by at least $2.00 per head.
Feed is the single largest expense in commercial pork production; there is tremendous opportunity to significantly reduce the cost of production by defining cost-effective feeding strategies that focus on the biology of the pig. Optimum nutrition at the least cost occurs when we are neither overformulating nor underformulating diets. Projects in this area include investigation into phase feeding, split sex feeding and defining requirements based on lean tissue growth rates (genetics).

The underlying objective here is the development of feeding programs that focus on maximizing net profit as opposed to maximizing average daily gain or achieving the best index.

Objective 2:

To increase the value and use of opportunity feeds in swine diets.
In order to increase the use of locally grown commodities as ingredients in practical swine diets, the feeding value or the levels of available nutrients in these opportunity ingredients will be determined in digestibility studies. The maximum inclusion rate of opportunity ingredients in swine diets will be determined using feed intake and animal performance studies. Again, the objective is to maximize net income. The central question will be "how can these ingredients be used effectively to reduce the overall cost of production?" rather than "how much can be added to the diet without affecting performance?"

Objective 3:

To develop animal care guidelines through consideration of animal behaviour.
The evolving science of animal behaviour is used to determine how the physical and social environment affects the productivity and well-being of the pig. The underlying objective is to define management procedures that are good for both pigs and people.

Objective 4:

To develop systems for improving air quality inside hog barns, for health and productivity of pigs and people, and to reduce external odour emmissions.
Air quality affects performance of livestock and stockpersons. Research in this area deals with all aspects of air quality including temperature, humidity, gases and dust. Research into new methodologies for reducing odour from inside the barn and from manure storage areas is a growing aspect of the engineering research program.

Objective 5:

To reduce the costs of production by optimizing the physical environment in commercial barns.
Currently, pork producers spend large amounts of money to build and operate facilities in order to achieve a certain interior barn environment. Optimizing this physical environment will avoid the cost of over-building while at the same time identifying weaknesses in our current designs. These studies will help to bring together the true needs of the pig (e.g. temperature, humidity, space, etc.) and the construction and operating specifications of the barn.

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BIOLOGICAL VARIABILITY & CHANCES OF ERROR

Variability among animals in an experiment leads to problems in interpreting the results. Animals on treatment X may have higher average daily gains than those on treatment Y, but variability within treatments may indicate that the differences in production between X and Y were not the result of the treatment alone. Statistical analysis allows us to calculate the probability that such differences are from treatment rather than chance.

In some of the articles herein, you will see the notation "P,.05." That means the probability of the differences resulting from chance is less than "1 chance in 20" or 5%. If two averages are said to be "significantly different", the probability is less than "1 chance in 20" (5%) that the difference is from chance, or the probability exceeds 95% that the difference resulted from the treatments applied.

Some papers contain correlations or measures of the relationship between traits. The relationship may be positive (both traits tend to get larger or smaller together) or negative (as one trait gets larger the other gets smaller). A perfect correlation is one (+1 or -1). If there is no correlation the relationship is zero.

In other papers you may see an average given as 2.5+- .1. The 2.5 is the average; .1 is the "standard error". The standard error is calculated to be 68% certain that the real average (with unlimited number of animals) would fall within one standard error from the average, in this case between 2.4 and 2.6.

Many animals per treatment, replicating treatments several times, and using uniform animals increase the probability of finding real differences when they exist. Statistical analysis allows more valid interpretation of the results, regardless of the number of animals. In all the research reported herein, statistical analyses are included to increase the confidence you can place in the results.

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Allison Orr completing statistical calculations on an experiment

LYSINE FOR EARLY WEANED PIGLETS

DEFINING THE RESPONSE OF EARLY WEANED PIGLETS TO DIETARY LYSINE:ENERGY RATIOS

Eduardo Beltranena, John F. Patience, Alison Orr and Claire Jardine

SUMMARY

The rapid changes occurring in the management of the weaned pig, concurrent with rapidly increasing expectations of animal performance, suggest that diet formulations acceptable in the past may no longer suffice. This experiment focused on the lysine requirement of pigs from 28 to 56 days of age. A total of 240 pigs were randomly allotted from within weight groups to pens and one of six dietary treatments, representing total lysine:Digestable Energy (DE) ratios of 2.7, 3.0, 3.3, 3.6, 3.9 and 4.2 g/Mcal. A significant linear but not quadratic response to dietary lysine was observed for both rate and efficiency of weight gain. The lack of a quadratic response indicated that the level of lysine at which animal performance would be maximized, must be either at or above the highest lysine level evaluated. We conclude that the lysine requirement for maximum performance in the rapidly growing early-weaned pig may be above currently accepted levels and require further review.

INTRODUCTION

The changing nature of piglet management, combined with higher expectations of animal performance, emphasizes the need to carefully scrutinize existing feeding and management programs to ensure they are, in fact, optimal. From a nutritional perspective, the possible alteration in immune function, combined with increased lean growth rate, suggests that nutrient requirements defined previously, under different management systems, may no longer apply. In addition, under commercial conditions, a wide range in nursery pig performance is observed, again suggesting a need to revisit amino acid requirements.

The lysine requirement of the weanling pig has evolved considerably over the past two decades. For example, the NRC (National Research Council's 1988 Nutrient Requirements of Swine) 1988 recommended 1.15% total lysine (3.3 g/Mcal DE) for piglets over 5 kg and 0.95% (2.7 g/Mcal DE) for piglets over 10 kg bodyweight. More recent estimates are generally higher, but surprisingly consistent. For example, the 1994 Kansas Swine Nutrition Guide recommended 1.25% total lysine for pigs weighing more than 7.5 kg. Texas A&M University also recommended total dietary lysine levels of 1.25%, equivalent to 3.6 g lysine/Mcal DE, for pigs of the same body weight. Our 1995 Swine Nutrition Guide recommended 3.2 g lysine/Mcal DE.

A complete review of the amino acid requirements of the early-weaned piglet must clearly start with lysine, the first limiting amino acid in most practical diets. From this basis, information on other amino acids can be defined, leading ultimately to the development of optimum feeding programs, i.e. those which maximize producer net income while taking into account a differing array of economic, environmental and genetic circumstances. The objective of this experiment was to define the response of the early weaned piglet to varying lysine:energy ratios in the Phase III nursery diet.

EXPERIMENTAL PROCEDURE

Two hundred and forty pigs, weaned at 14 days of age were housed in three on-site nursery rooms which were managed in an all-in all-out basis. Although no sex effect was expected, males and females were housed in separate pens. Animals were randomly allotted from within weight groups to pens.

At the time of weaning, all pigs were offered an "SEW Diet" for a period of five days, followed by a "Transition Diet" for the next eight days. Pens of same sex pigs were then randomly allocated to receive one of the six treatment diets starting on Day 13 postweaning when they were 28 days of age and remained on test until they were 56 days of age. Pigs had free access to water from nipple drinkers and the diets from pen self-feeders.

A total of six dietary treatments, representing total lysine:DE ratios of 2.7, 3.0, 3.3, 3.6, 3.9 and 4.2 g total lysine/Mcal were formulated (Table 1). Diets contained 3.5 Mcal DE/kg and were based on wheat, lactose, fishmeal, wheat gluten meal and soybean meal. The elevated lysine levels were achieved by

adding lysine as lysine hydrochloride. Other crystalline amino acids were supplemented as required to maintain appropriate levels relative to lysine, according to the principles of ideal protein.

The diets were submitted for amino acid assay confirming that actual lysine levels were consistent with calculated values (Table 2). The assays also confirmed that appropriate ratios of other amino acids to lysine were maintained as well. The diet containing the second highest level of lysine assayed low in methionine and threonine. Because no crystalline methionine was added to this diet, and the mix sheets confirmed the appropriate addition of threonine, we suspect an error in sampling or analysis is the most likely explanation for this discrepancy.

Pigs were weighed on the day of weaning (Day 0), on Day 5 when the pigs were changed to the Transition Diet, on Day 13, when the pigs were started on the test diets, and every seven days thereafter.

RESULTS AND DISCUSSION

Average age (14.4 ± 0.2 days) and weaning weight (5.00 ± 0.12 kg) were constant across treatments (Table 3). All pens received common diets for the first thirteen days after weaning, so their weights were not different across treatments before the start of the test period.

There was a significant linear response ($P < 0.05$) but not a significant quadratic response ($P > 0.05$) to lysine in terms of body weight and average daily weight gain (Table 3). This applied to each week of the experimental period and overall. Weekly body weights and weight gain were analyzed using both individual pig and average pen data. Statistical analysis of both data sets revealed that the same interpretation would have been drawn in both cases (Tables 3 and 4).

There was no effect of lysine level on average daily feed (Table 4), except during the final week of the experimental period ($P < 0.05$). With no effect of lysine on feed intake, but a significant effect on average daily gain, it was therefore not surprising to observe that feed efficiency responded linearly to dietary lysine concentration ($P < 0.05$).

It is clear from these data that pigs growing at a rapid rate, with an excellent appetite, require more lysine than is currently recommended in order to maximize rate and efficiency of weight gain. Because only the linear effect was significant, and the quadratic effect was not, we can conclude that the highest level of lysine supplementation was inadequate to maximize performance. It is also interesting to note that increasing lysine resulted in increased growth rate during each week of the experiment, i.e. until the pigs were 56 days of age.

CONCLUSIONS

We conclude that the current standards applied by the industry with respect to dietary lysine levels are not adequate to maximize the performance of the early-weaned pigs. Currently, it is unusual for commercial nursery diets offered during this period to contain more than 1.3% total lysine. The fact that a linear response was observed to 1.47% indicates that diet formulation should be reconsidered. Further studies are required to characterize the true lysine requirement. The level of lysine which maximizes growth rate and feed efficiency, was unfortunately not defined in the present trial.

Further studies are also needed in the area of dietary energy response; this is the subject of other study at the Prairie Swine Centre.

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Table 1. Ingredient specifications of experimental diets.

	Total lysine %					
	0.95	1.05	1.16	1.26	1.37	1.47
Ingredients %						
Wheat	62.270	61.109	59.662	58.056	56.720	55.318
Lactose	10.000	10.000	10.000	10.000	10.000	10.000
Menhaden meal	7.400	7.900	8.400	9.000	9.500	10.000
Wheat gluten meal	5.200	5.500	5.900	6.300	6.600	7.000
Soybean meal	8.900	9.500	10.100	10.800	11.400	12.000
L-lysine HCI	-	0.071	0.158	0.224	0.315	0.382
L-threonine	-	0.010	0.060	0.100	0.160	0.200
DL-methionine	-	-	-	-	-	0.040
L-tryptophan	-	-	-	-	0.005	0.010
Limestone/glass rock	0.930	0.900	0.850	0.820	0.800	0.750
Mono/dical. phosphate	1.000	0.910	0.870	0.800	0.700	0.650
Salt	0.500	0.500	0.500	0.500	0.500	0.500
Canola oil	2.300	2.100	2.000	1.900	1.800	1.650
Vitamin premix	0.400	0.400	0.400	0.400	0.400	0.400
Trace mineral premix	0.400	0.400	0.400	0.400	0.400	0.400
ASP-250	0.700	0.700	0.700	0.700	0.700	0.700

Table 2. Amino acid analysis on test diets

	Dietary treatments					
Calculated						
Lysine %	0.95	1.05	1.16	1.26	1.37	1.47
g lysine/Mcal DE	2.7	3.0	3.3	3.6	3.9	4.2
Assayed						
Crude protein, %	22.4	23.4	23.8	24.8	25.2	26.8
%Lysine	0.97	1.06	1.17	1.31	1.36	1.47
Methionine	0.38	0.40	0.41	0.42	0.38	0.47
Methionine + cysteine	0.79	0.81	0.81	0.84	0.74	0.90
Threonine	0.69	0.73	0.79	0.86	0.80	0.98
Tryptophan	0.25	0.23	0.27	0.32	0.28	0.32
Isoleucine	0.85	0.87	0.88	0.91	0.94	0.99
Leucine	1.52	1.59	1.63	1.71	1.74	1.82
Valine	1.00	1.03	1.05	1.10	1.12	1.17
Calculated ratios						
Methionine:lysine	39	38	35	32	28	32
Total sulphur:lysine	81	76	69	64	54	61
Threonine:lysine	71	69	68	66	59	67
Tryptophan:lysine	26	22	23	24	21	22
Isoleucine:lysine	88	82	75	69	69	67
Leucine:lysine	157	150	139	131	128	124
Valine:lysine	103	97	90	84	82	80

Table 3. Means for the effect of the level of total lysine on weekly body weights and average daily weight gain based on individual pig data.

	Total lysine, %							
	0.95	1.05	1.16	1.26	1.37	1.47	SE	P value
No. pigs	38	39	40	38	40	40		
Initial age, d	14.42	14.75	14.43	14.16	14.18	14.30	0.16	0.44
0 d	5.07	4.95	4.93	5.02	4.94	5.06	0.12	0.99
13 d	7.38	7.33	7.17	7.47	7.45	7.40	0.18	0.56
20 d	8.75	8.71	8.78	9.04	9.37	9.18	0.22	0.04
27 d	11.20	10.93	11.69	11.97	12.51	12.65	0.31	0.01
34 d	14.62	14.33	15.61	15.92	16.59	16.95	0.37	0.01
41 d	18.89	18.32	20.14	20.19	21.15	21.76	0.45	0.01
13 - 20 d	0.191	0.189	0.211	0.216	0.254	0.253	0.01	0.01
20 - 27 d	0.358	0.338	0.416	0.401	0.459	0.505	0.02	0.01
27 - 34 d	0.489	0.485	0.560	0.564	0.582	0.612	0.02	0.01
34 - 41 d	0.609	0.570	0.648	0.611	0.652	0.687	0.02	0.01

Table 4. Means for the effect of the level of lysine on pen average daily weight gain, feed disappearance and gain:feed ratios.

	Total lysine, %							
	0.95	1.05	1.16	1.26	1.37	1.47	SE	P value
No. pens		10	10	10	10	10	10	
Weight gain, kg								
13 - 20 d	0.193	0.184	0.211	0.211	0.255	0.253	0.01	0.01
20 - 27 d	0.361	0.329	0.146	0.395	0.459	0.505	0.03	0.01
27 - 34 d	0.488	0.487	0.560	0.559	0.582	0.613	0.02	0.01
34 - 41 d	0.613	0.572	0.648	0.607	0.652	0.687	0.02	0.01
13 - 41 d	0.413	0.393	0.463	0.451	0.489	0.513	0.01	0.01
Feed disappearance, kg								
13 - 20 d	0.406	0.425	0.405	0.411	0.415	0.446	0.02	0.45
20 - 27 d	0.622	0.626	0.626	0.645	0.620	0.653	0.03	0.64
27 - 34 d	0.830	0.820	0.877	0.843	0.814	0.851	0.03	0.87
34 - 41 d	1.071	1.058	1.039	1.021	0.994	1.009	0.03	0.03
13 - 41 d	0.775	0.755	0.781	0.760	0.741	0.768	0.03	0.61
Gain:feed, kg:kg								
13 - 20 d	0.479	0.430	0.521	0.517	0.609	0.572	0.02	0.01
20 - 27 d	0.581	0.523	0.665	0.633	0.740	0.771	0.02	0.01
27 - 34 d	0.590	0.596	0.640	0.687	0.717	0.719	0.02	0.01
34 - 41 d	0.571	0.543	0.622	0.596	0.656	0.683	0.02	0.01
13 - 41 d	0.540	0.524	0.600	0.609	0.664	0.672	0.01	0.01

WATER QUALITY AND WEANLING PIG PERFORMANCE

EFFECT OF WELL WATER HIGH IN SULPHATE AND IRON ON WEANLING PIGS: PERFORMANCE

John Patience, Nadine Possberg and Doug Gillis

SUMMARY

Few well-controlled studies have investigated the impact of poor quality water on pig performance; most suggest the pig is capable of handling relatively high concentrations of sulphates and other mineral contaminants without apparent effect. However, claims from field workers suggest that under farm conditions, water quality is an important issue that has not yet been adequately addressed.

Two experiments were conducted to determine how pigs react to poor quality water under commercial farm conditions. They were carried out on a commercial farm, where the well water was high in sulphates, total dissolved solids and iron; an on-site reverse osmosis unit provided high quality water for comparison.

Although diarrhea was observed, water quality had no impact on weanling pig performance or nutrient digestibility. Based on these results, along with previous research, it can be concluded that pigs weaned at three weeks of age have the ability to handle relatively high quantities of sulphate in their drinking water and maintain overall growth performance. It can further be concluded that the presence of diarrhea alone, associated with high sulphate water, cannot necessarily be linked to poor animal performance.

INTRODUCTION

Water quality remains a controversial topic. Controlled studies suggest that the pig can perform very well when the drinking water contains 1,000 ppm or more of sulphates. Yet, claims from field workers suggest that under farm conditions, water quality is a serious problem. The suggestion is that conditions on farms are sufficiently different that institutional research results are not reflective of what is happening commercially.

We were very fortunate to be presented with the opportunity to conduct a large scale study on a commercial farm, where the well water was very high in sulphates, total dissolved solids and iron. An on-site reverse osmosis unit allowed us to compare the untreated well water to the same water with the minerals removed. The objective of the experiment was to determine if water high in mineral contaminants would affect the health, performance and nutrient utilization of pigs weaned at about three weeks of age.

MATERIALS AND METHODS

Two experiments were conducted on a 1,200 sow farrow-to-finish commercial farm. There was excellent co-operation on the part of both the owner and the staff of the farm.

Water was obtained either directly from a deep well (control) or treated first by reverse osmosis (treated) prior to delivery to the pig herd (Table 1). Alternate pairs of pens were assigned to water source. In the first experiment, within each water source, approximately half of each pair of pens were assigned to Balpi dish-type drinkers and half to nipple-type drinkers. In the second experiment, half of the pens within each water treatment were assigned to a control starter diet, while the other half received the same starter diet with zinc oxide removed.

Both experiments consisted of all male pigs from one week's weaning. The pigs remained in the nursery for five weeks following weaning at about 21 days of age. All pigs were weighed individually on the day of weaning and on Days 18 and 35 thereafter. Feed intake and feed conversion were also recorded. Nutrient digestibility was determined by using a special batch of starter diet into which chromic oxide was added at the rate of 0.4%. Feces were collected on Days 6 through 9 inclusive following introduction of the marker into the diet.

RESULTS AND DISCUSSION

Animal performance (Table 2) was unaffected by water source in experiment 1 ($P > 0.10$). However, there was a tendency for the dish-type drinker to improve feed conversion ($P < 0.10$) in the last half of the nursery period. Although the data are not presented in the tables, there was no effect of water quality on pig performance in the early grower period ($P > 0.10$).

Dish-type drinkers offered a clear benefit over the nipple drinkers in terms of water disappearance (Table 3). Pigs using the nipple-type drinkers used approximately 67% more water than those on the dish-type drinkers. Water disappearance differs from water intake, in that it represents the sum of intake and wastage. The reduction in disappearance with the dish-type drinkers is assumed to reflect reduced wastage, not reduced intake. The fact that dish-type drinkers supported performance at least equal to the nipple-type drinkers tends to validate this conclusion.

Reduced water disappearance represents large savings to the pork producer, not only in water usage, but also in slurry production.

All of the diets used in the first experiment contained zinc oxide at 3,000 ppm. In the second experiment, the impact of removing zinc oxide on the response of the pigs to poor quality water was examined. The pigs receiving the control water in combination with the zinc oxide in the diet had the lowest final weight overall. However, the difference was not statistically significant. The pigs receiving the control water with no zinc oxide had final weights equal to those of the pigs receiving the treated water (Table 4). The addition of zinc at the rate of 3,000 ppm depressed growth rate and feed intake ($P < 0.05$); the effect was more pronounced on the control water.

It is quite clear that water quality had no impact on the pigs' ability to digest dry matter, energy, nitrogen or fibre (Table 5).

IMPLICATIONS

Two experiments conducted under commercial farm conditions failed to show any adverse effect of high sulphate levels in the drinking water. These results are heartening to the pig industry, as it suggests that high sulphate levels in the drinking water need not necessarily lead to insurmountable problems with young pigs.

While high sulphate water results in diarrhea, one must be careful in concluding that scouring pigs are poor performing pigs. As demonstrated in these two experiments, which involved more than 500 pigs, newly weaned pigs can grow very well in the face of high sulphates in their drinking water and with varying degrees of diarrhea induced by these high sulphate levels. The study was not conducted beyond the nursery, as early measurements taken in the grower barn revealed no effect of water source on animal performance.

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The authors thank Stomp Pork Farms, Leroy, Saskatchewan and its staff for kindly allowing the use of their facilities and for their excellent co-operation. Financial support from PAWBED, the Canadian Feed Industry Association (Saskatchewan Division), Hillcrest Farms Ltd., Kenpal Farm Products, King Lee Technologies, Central Water Conditioning, Hydranautics Inc., Masterfeeds and Shamrock Feeds was greatly appreciated. Analytical assistance by the Saskatchewan Research Council is gratefully acknowledged. The authors also acknowledge the pork producers of Saskatchewan, Manitoba and Alberta for their strategic funding to Prairie Swine Centre Inc.

Table 1. Average water composition used in the experiment.

Analyte	Units	Control Water	Treated Water
Total Dissolved Solids	mg/L	3086	193
Sulphate	mg/L	1634	15
Sodium	mg/L	163	45
Magnesium	mg/L	186	8
Total hardness	mg/L	1795	80
Nitrate nitrogen	mg/L	0.03	0.32
Nitrite nitrogen	mg/L	BDL	0.07
pH		7.56	6.93
Iron	mg/L	7.24	0.43

BDL: Below detectable limits. All assays conducted by the Saskatchewan Research Council
"Control" water was delivered directly to the pigs without treatment; "Treated" water was passed through a reverse osmosis unit prior to delivery to the pig.

Table 2. Impact of water quality and drinker type on pig performance: Exp. 1.

	Control Water		Treated Water	
	Nipple	Dish	Nipple	Dish
Initial wt.; kg	5.97	5.85	5.73	6.06
Final wt.; kg	21.25	21.39	20.18	21.77
No. pigs	62	53	63	54
No. pens	7	6	7	6
Ave. gain/d, kg	0.437	0.444	0.413	0.449
Ave. feed/d, kg	0.675	0.665	0.637	0.668
Gain:feed	1.54	1.49	1.54	1.49

Table 3. Impact of water quality and drinker type on water disappearance (mL/day): Exp. 1.

	Control Water		Treated Water	
	Nipple	Dish	Nipple	Dish
0 to 3 days	1331	1496	2207	1448
0 to 7 days	1401	1065	1632	1273
0 to 21 days[1]	2145	1209	2073	1245
0 to 35 days[1]	2972	1666	2636	1679

[1] Effect of drinker significant, $P < .01$.

Table 4. Impact of water quality and zinc oxide supplementation on weanling pig performance: Exp. 2.

	Control Water		Treated Water	
	No Zinc Oxide	Zinc oxide	No Zinc oxide	Zinc Oxide
Initial wt.; kg	5.84	5.85	5.85	5.89
Final wt.; kg	19.36	18.54	19.37	19.33
No. pens	6	6	6	6
Ave. gain/d, kg[1]	0.410	0.385	0.410	0.407
Ave. feed/d, kg[1]	0.674	0.607	0.656	0.642
Gain:feed	0.611	0.635	0.628	0.635

[1] Effect of diet significant, $P < 0.05$
[2] Diet x water interaction significant, $P < 0.05$

Table 5. Impact of water quality on nutrient digestibility (%).

Nutrient	Control Water	Treated Water
Dry matter	82.0	82.5
Energy	82.4	82.2
Nitrogen	80.5	80.0
Acid detergent fibre	24.9	25.5
Neutral detergent fibre	55.9	56.2

Figure 1: Early weaned pigs in a commercial sew nursery

WATER QUALITY AND EFFECTS ON BLOOD AND TISSUE

EFFECT OF WELL WATER HIGH IN SULPHATE AND IRON ON WEANLING PIGS: BLOOD AND TISSUE ANALYSIS

John Patience, Nadine Possberg and Doug Gillis

SUMMARY

Few well-controlled studies have investigated the impact of poor quality water on pig performance; fewer still have been conducted on commercial farms. While published research suggests pigs are capable of handling relatively high concentrations of sulphates and other mineral contaminants without apparent effect, field workers suggest that under farm conditions, the situation is different.

Two experiments were conducted to determine how pigs react to poor quality water under commercial farm conditions. The animal performance results are presented in another paper in this Annual Report. However, blood and tissue samples were also collected and analysed to determine if the high sulphate and iron were affecting the pig in ways not revealed in performance studies.

Similar to the performance data, the assay of blood and various organs failed to show any consistent changes due to water quality which could be associated with ill health or which could lead to production problems. These data confirm the ability of the pig to tolerate quite high levels of sulphate and iron in their drinking water without apparent problems at least within the time frame of this study. The modest changes in certain serum and tissue mineral levels, while not problematic, raise the question regarding the long term effects of exposure to high mineral levels in the drinking water.

INTRODUCTION

Water is clearly an essential part of any pork production unit. While quantity and consistency of supply is important, water quality is also a topic of considerable interest. The results of two performance trials completed on a commercial farm in central Saskatchewan are presented in a companion paper.

This report addresses the results of blood analyses completed on the same pigs. The objective was to determine if these tests would provide insight into the issue of water quality, beyond that obtained from measuring only weanling pig performance.

MATERIALS AND METHODS

The procedures for handling the pigs were identical to those presented in the companion paper. In addition, blood samples were collected from 20 pigs per treatment on Days 3, 7, 14, 21, and 28 following weaning in Experiments 1 and 2. Blood serum was collected and submitted to the clinical pathology laboratory at the Western College of Veterinary Medicine for assay.

A total of 28 pigs were sacrificed for the collection of muscle, kidney, brain and liver samples: eight piglets (four per treatment) on the day of weaning to provide baseline data, 12 pigs (six per treatment) seven days after weaning, and 12 pigs (six per treatment) were sacrificed 21 days after weaning.

RESULTS AND DISCUSSION

Water source had little effect on any blood parameter. However, the treated water decreased serum bicarbonate levels, and tended to result in higher serum magnesium levels ($P < 0.10$), water source had no effect on any other mineral element (Table 1). None of these differences are considered problematic as all values were well within normal tolerances.

The treated water also increased the level of albumen in the blood ($P < 0.01$), as well as the albumen:globulin ratio ($P < 0.05$), but had no effect on total protein (Table 2). Similarly, the treated water resulted in higher serum creatinine levels ($P < 0.05$).

Blood samples collected in the second experiment and assayed for the same parameters gave similar results (Tables 3 and 4). While a few parameters varied by water source, the differences were few and of relatively small magnitude. It is difficult to predict the biological significance of these changes, but since all blood measurements fell within the normal range

for pigs, it would be dangerous to read too much into these changes. For example, the only parameters to be affected by treatment were serum magnesium and phosphorus, as well as total protein. Taken in the context of the total blood profile, these results do not reflect any major pathologies. However, by the same token, one cannot totally rule out possible biological or metabolic implications.

Although not presented in the tables, zinc oxide depressed both haematocrit and haemoglobin levels. Samples of brain, liver, kidney and muscle were submitted for mineral assay. For the most part, there was no effect of water source on mineral accumulation in the selected tissue. However, calcium levels in all tissues, except muscle, were increased in pigs given the treated as opposed to untreated well water. Numerically, the differences were small, but the consistency across tissues is striking. No effect of water source was observed for chlorine, nitrogen, sodium or potassium.

Table 1. Impact of water quality and drinker type on serum mineral levels: Exp. 1.

		Control Water		Treated Water	
Item	**Units**	**Nipple**	**Dish**	**Nipple**	**Dish**
Calcium	mmol/L	2.91	3.00	2.87	2.82
Chloride	mmol/L	106	106	107	105
Magnesium	mmol/L	1.26	1.29	1.32	1.41
Phosphorus	mmol/L	2.92	2.86	3.04	3.20
Potassium	mmol/L	7.1	6.8	7.0	6.7
Sodium	mmol/L	143	142	144	142
Anion Gap	mmol/L	17	16	17	20
Bicarbonate[1]	mmol/L	27	28	26	24

[1]Effect of water source significant ($P < .05$)

Table 2. Impact of water quality and drinker type on blood chemistry: Expt. 1.

		Control Water		Treated Water	
Item	**Units**	**Nipple**	**Dish**	**Nipple**	**Dish**
Albumin1	g/L	28	29	31	30
Albumen/Globulin2		1.43	1.49	1.83	1.61
Total Protein	g/L	49	49	49	50
Glucose	mmol/L	5.5	6.1	5.9	6.2
Urea	mmol/L	4.5	4.1	4.2	4.3
Creatine Kinase	U/L	934	1214	899	564
Creatinine[1]	umol/L	101	104	114	126
Anion Gap	mmol/L	17	16	17	20

[1] Effect of water source significant, $P < .01$.
[2] Effect of drinker source significant, $P < .01$.

IMPLICATIONS

Similar to the performance data, the assay of blood and tissues failed to show any consistent changes due to water quality. The only possible exception was calcium, which was lower in the pigs drinking untreated water. Further study would be required to determine the exact nature of changes in tissue calcium levels; however, the differences were very small. Changes in certain mineral levels in the blood (eg. phosphorus, magnesium) and brain (eg. calcium) raise questions about the long-term effect of drinking water high in minerals.

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Table 3. Impact of water quality and zinc oxide supplementation on serum minerals: Exp. 2.

		Control Water		Treated Water	
	Units	No zinc	Zinc added	No zinc	Zinc added
Calcium	mmol/L	2.87	2.93	2.96	2.87
Chloride	mmol/L	106	105	105	106
Magnesium[1]	mmol/L	1.23	1.16	1.37	1.23
Phosphorous [1,2]	mmol/L	3.03	3.42	3.32	3.03
Potassium	mmol/L	6.3	6.6	6.6	6.3
Sodium	mmol/L	146	146	144	146
Anion Gap	mmol/L	19	21	21	19
Bicarbonate	mmol/L	27	26	25	27

[1] Effect of water source significant, $P < .01$.
[2] Effect of diet significant, $P < .05$.

Table 4. Impact of water quality and zinc oxide supplementation on blood chemistry: Exp. 2.

		Control Water		Treated Water	
	Units	No zinc	Zinc added	No zinc	Zinc added
Albumin1	g/L	29	29	33	29
Albumen:globulin[1]		1.88	1.87	2.08	1.88
Tot Protein1	g/L	45	42	50	45
Urea[2]	mmol/L	4.6	3.7	4.6	4.6
Glucose	mmol/L	6.3	6.3	6.0	6.3
Creatine kinase	U/L	1319	1118	2031	1319
Glucose	mmol/L	6.3	6.3	6.0	6.3
Creatinine	umol/L	88	93	89	88

[1] Effect of water source significant, $P < .01$.

PROTEIN DEPOSITION IN GROWING AND FINISHING PIGS

DEVELOPMENT OF WHOLE BODY PROTEIN AND LIPID DEPOSITION CURVES

Mark L. Lorschy, John F. Patience and Doug A. Gillis

SUMMARY

Commercial diets could be formulated more accurately if, first, we knew the rate at which the pig deposits protein and energy in the carcass and second, we linked energy and amino acid levels in the diet to requirements based on lean and lipid rates of gain. This would result in the most efficient feeding programs, producing pork of high quality at the lowest possible price. This experiment was carried out to define the lean tissue and lipid growth curves of a common commercial genotype.

Peak protein deposition was found in barrows to be 150 g/d and occurred when the pig was between 43 and 52 kg bodyweight. In gilts, maximum protein deposition of 133 g/d occurred between 68 and 74 kg bodyweight. Barrows deposited protein at a greater rate than gilts until 87 kg bodyweight.

Observed differences in protein and lipid deposition between genders explain differences in amino acid and energy requirements. These findings reinforce the need for split sex and multiple phase feeding programs, to maximize production efficiency and carcass quality. Most critically, these results provide information on a subject of limited information - what is the rate of protein deposition of commercial pigs.

INTRODUCTION

Pigs that have been intensively selected for body weight gain or lean tissue deposition have a higher maximum protein retention than pigs of unimproved strains. Defining the amino acid requirements for these improved strains requires accurate estimates of whole body protein deposition from birth to market weight. The rate of maximal protein deposition determines the pig's nutrient requirements for growth and its likely response to nutrition or management changes.

The objectives of this study were to characterize the upper limit to protein deposition, lipid growth curves and feed intake and feed efficiency curves for barrows and gilts grown from 24 to 120 kg bodyweight.

EXPERIMENTAL PROCEDURE

All animals were the F_1 hybrid cross from PIC Camborough 15 gilts X Canabrid boars. At about 18 kg bodyweight, 29 gilts and 29 barrows were selected for the experiment. The pigs had ad libitum access to a grower diet from 24 to 65 kg, and to a finisher diet from 65 to 120 kg (Table 1). These diets contained essential amino acids, minerals and vitamins at levels deemed to not limit lean tissue growth when consumed at or above 90% of the NRC feed intake predicted curve.

Pigs were sacrificed as follows: four barrows and four gilts at 24 (± 2) kg bodyweight, and five barrows and five gilts at each of the following weights (± 2 kg): 56, 72, 88, 104 or 120 kg bodyweight.

Individual bodyweight and feed disappearance data were recorded weekly and prior to slaughter. Upon reaching its target slaughter weight, each pig was euthanized. The contents of its stomach, small and large intestines, gall bladder and urinary bladder were emptied. Empty whole body composition was then defined as the weight of the carcass and viscera after the contents of the latter were emptied.

Each frozen carcass and viscera were ground together in a meat grinder and mixed thoroughly. Sub-samples of each carcass and viscera mix were then freeze-dried to estimate moisture content. Dried samples were analyzed for nitrogen, ether extract, ash and moisture content.

Protein and lipid deposition rates were predicted for barrows and gilts, separately, using a variety of statistical curve-fitting techniques. Comparisons for average daily weight gain, feed intake and feed efficiency between each slaughter weigh group, gender and their interaction were made using a statistical software package (SAS, 1987).

RESULTS AND DISCUSSION

Feed intake for pigs grown between 24 and 56 kg bodyweight was lower than expected. Feed intake was considered adequate to support the targeted levels of growth for pigs grown above 56 kg bodyweight. Interestingly, there was no difference *(P* > 0.10) in average daily feed intake and feed/gain ratio between gilts and barrows (Table 2).

The form of the protein deposition curves was different for barrows and gilts (Figure 1). At 24 kg bodyweight, the protein deposition rate was 137 and 98 g/d for barrows and gilts, respectively. Protein deposition rate increased after 24 kg bodyweight, reached a peak, and proceeded to decline towards 120 kg bodyweight when the rate of protein deposition was 100 and 137 g/d for barrows and gilts, respectively.

Peak protein deposition was calculated as 150 g/d between 43 and 52 kg bodyweight and 133 g/d bodyweight between 68 and 74 kg bodyweight, for barrows and gilts, respectively. Protein deposition for barrows was less than for gilts after about 87 kg bodyweight because of a continual increase in their rate of lipid deposition towards 120 kg bodyweight (Figure 2).

IMPLICATIONS

These results reinforce the need for split sex and multiply phase feeding systems for pigs grown to market. As a consequence of the different patterns and rates of protein and lipid deposition for gilts and barrows, different nutritional recommendations, particularly for essential amino acids and energy, are necessary to minimize feed costs and maximize carcass quality.

This study has provided information concerning how protein deposition changes as pigs of this genotype grow. As protein deposition is the major determinate of the essential amino acid requirement, recommendations for these amino acids may be made to meet these levels of protein deposition.

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The authors would also like to thank the numerous people who were involved during the experimentation and processing of carcasses. We are grateful to Dr. C.F.M. de Lange, University of Guelph, for his insight and contribution to the experiment during planning and while it was being conducted. We would like to thank Ms. Alison Orr and Mr. Joe Jobin for their technical assistance. We also thank Dr. Sonke Mohn, also of the University of Guelph, who ground and freeze-dried the carcasses reported in this study.

Dr. Ruurd Zijlstra and Technician Doug Gillis are shown using real-time ultrasound to determine body composition of live pigs.

Table 1. Experimental growing and finishing diets (as fed, %).

Item	Grower	Finisher
Ingredient		
Barley	10.000	10.000
Wheat	61.292	71.634
Soybean meal - 47%	14.078	6.698
Select menhaden fishmeal	4.000	3.000
Whey powder	4.000	3.000
L-lysine HCl	0.397	0.378
DL-methionine	0.130	0.052
L-tryptophan	0.071	0.046
L-threonine	0.288	0.215
Dicalcium phosphate	1.059	1.285
Limestone	0.752	0.854
Salt	0.500	0.350
Mineral premix a	0.500	0.500
Vitamin premix b	0.500	0.500
Canola oil	2.584	1.488
Calculated analysis		
Digestible energy, kcal/kg	3426	3349
Crude protein, %	20.00	17.00
Available lysine, %	1.10	0.87
Available total sulfur amino acids, %	0.72	0.57
Available threonine, %	0.77	0.61
Available tryptophan, %	0.24	0.19
Calcium, %	0.85	0.85
Phosphorus, %	0.70	0.70
Sodium, %	0.24	0.22

[a] Provided the following per kg of diet: vitamin A, 3,250 IU, vitamin D 825 IU, vitamin E 40 IU, menadione 4 mg, thiamine 1 mg, riboflavin 5 mg, niacin 35 mg, d-pantothenic acid 15 mg, vitamin B12 .025 mg, biotin 0.2 mg and folic acid 2 mg

[b] Provided the following per kg of feed: copper 0.05 g, iron 0.08 g, manganese 0.025 g, zinc 0.1 g, iodine 0.5 mg, selenium 0.1 mg

Table 2. Average daily rates of weight gain for whole body carcass, feed intake and feed:gain ratio for gilts and barrows at six consecutive bodyweights between 24 and 120 kg.

		Body weight, kg						
Variable	**Gender**	**24 to 56**	**56 to 72**	**72 to 88**	**88 to 104**	**104 to 120**	**Effect**	**SEM**
Weight gain	Gilts	779^{Aa}	871^{Ab}	933^{Ac}	974^{Bd}	991^{Bd}	L,Q	3.19
(g/d)[x,y,z]	Barrows	931^{Bb}	969^{Bc}	954^{Bc}	930^{Ab}	888^{Aa}	L,Q	2.67
Feed intake	Gilts	1565^{a}	2569^{b}	2927^{b}	3110^{b}	3234^{b}	L	136.00
(g/d)[y]	Barrows	1601^{a}	2584^{b}	3018^{bc}	3086^{bc}	3360^{bc}	L,Q	84.90
Feed intake	Gilts	81	99	97	96	98	-	4.80
(as % of NRC)	Barrows	84	98	100	97	101	-	3.30
Feed:gain ratio[y]	Gilts	2.01^{a}	2.96^{b}	3.13^{b}	3.19^{b}	3.27^{b}	L	0.15
	Barrows	1.72^{a}	2.67^{b}	3.16^{b}	3.32^{b}	3.79^{b}	L	0.093

Lowest superscripts i.e. a, corresponds to lowest value for each variable

[a,b,c] Differences ($P < 0.05$) between means between body weight groups given by a different lower case letter

[A,B,C] Differences ($P < 0.05$) between means comparing barrow and gilts for a specific body weight range given by a different upper case letter

[x] Differences ($P < 0.01$) between means between barrows and gilts

[y] Differences ($P < 0.01$) between means between slaughter weights group

[z] Differences ($P < 0.01$) between gender x slaughter weight group interaction

L, Q significant linear and quadratic response ($P < 0.05$), respectively, to an increase in slaughter weight groups

Figure 1. Protein deposition rate curves of barrows (- - -) and gilts (-) grown from 24 to 120 kg bodyweight.

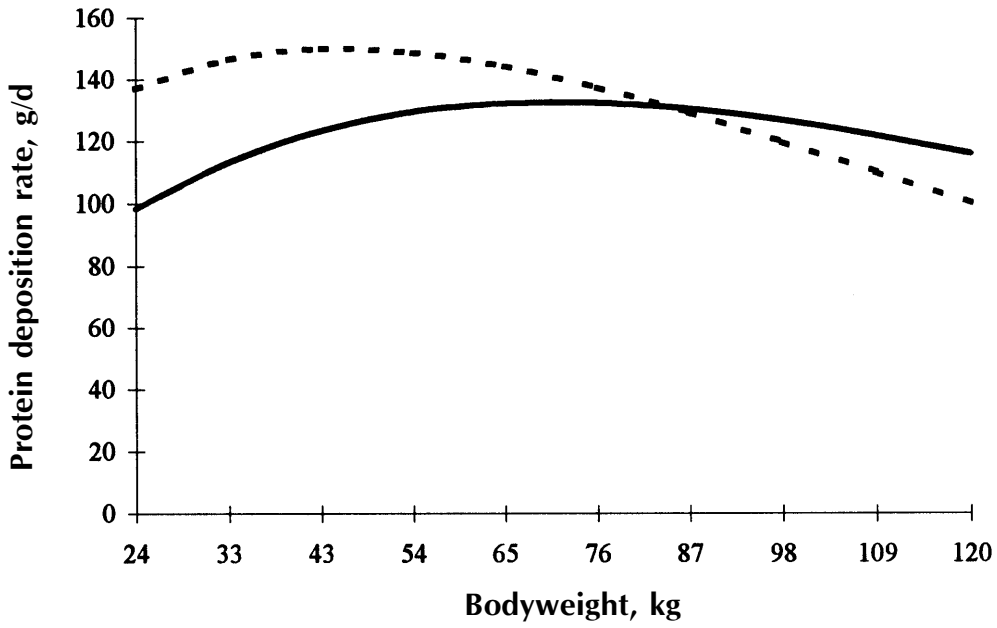
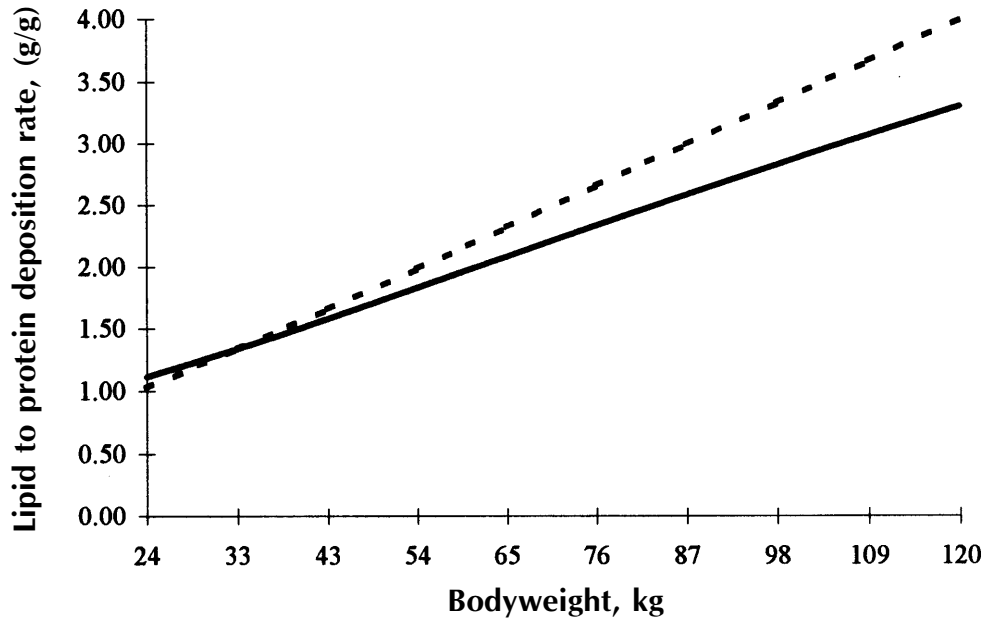


Figure 2. Lipid to protein deposition ratio curves of barrows (- - -) and gilts (———) grown from 24 to 120 kg bodyweight.



BODY COMPOSITION IN GROWING AND FINISHING PIGS

CHANGES IN BODY COMPOSITION IN GROWING AND FINISHING PIGS

Mark L. Lorschy, John F. Patience and Doug A. Gillis

SUMMARY

The assessment of changes in body protein content over time allows us to estimate amino acid requirements much more precisely. Assessment of energy requirements similarly will be based on carcass lipid and muscle content. The body is not composed solely of protein and lipid, but also includes the gain of water and ash, as well as gut fill. The objective of this study was to determine the changing proportions of body weight composition as the pigs grew from 24 to 120 kg.

A series of mathematical models were developed which allowed us to characterize the deposition of protein, lipid, water, ash and gut fill. The portion of body lipid (fat) almost tripled, increasing from 10% at 24 kg to 28% at 120 kg. Over the same weight range, protein was much more constant,17% at 24 kg and 15% at 120 kg.

Increased information on body composition will form the basis for diet formulation in the future. Basic knowledge of how modern commercial genotypes grow will be essential, as diet formulation becomes more precise, allowing for maximum carcass quality at the lowest possible cost.

INTRODUCTION

The pork industry is demanding improved information on swine nutrition, in order to define more economical feeding programs while at the same time ensuring the best possible product for the consumer. In order to provide this information, it is necessary to understand the basis for nutrient needs by the pig. For example, amino acid requirements will be closely linked to the rate of protein accretion in the body. Thus, understanding protein deposition curves is particularly important. However, body gain is more than just protein, and represents the sum of protein, water, minerals (ash) and fat. In addition, when live hogs are measured, adjustment must be made for gut fill (primarily undigested feed resident in the intestinal tract plus urine in the bladder).
The objective of this paper was to illustrate the changes in body composition of barrows and gilts from 24 to 120 kg bodyweight, using actual slaughter data and mathematical modeling techniques.

EXPERIMENTAL PROCEDURE

All animals were the progeny from the cross of PIC Camborough 15 gilts X Canabrid boars. At weaning, the pigs were given ad libitum access to a commercial starter containing 1.5% apparent digestible lysine. At approximately 18 kg, 29 gilts and 29 barrows were selected for the experiment on the basis of bodyweight. This was the same group of pigs employed for the companion study reported in "Protein Deposition in Growing and Finishing Pigs."

Pigs were then given ad libitum access to a grower diet to 65 kg, and a finisher diet from 65 to 120 kg. These diets contained essential amino acids, minerals and vitamins at levels deemed to not limit lean tissue growth when consumed at or above 90% of the NRC feed intake prediction curve. All procedures with respect to carcass measurements were identical to those described in the companion paper.

For barrows and gilts, separately, protein and lipid deposition rates were predicted using various statistical procedures. Richards function characterized the association between bodyweight and age, and an allometric function characterized the association between body protein content and bodyweight. Predictions for water and ash deposition rate were derived from their relationship with protein deposition rate. For barrows and gilts, separately, a simple linear equation characterized the association between gut fill and bodyweight.

RESULTS AND DISCUSSION

As shown in Table 1, the rate of lipid gain increased as the pigs approached market weight, while that of protein rose and then fell over the same period. Indeed, the portion of bodyweight that was lipid at 24 kg (10%) almost tripled by the time the pig reached

120 kg (28%). Conversely, the portion of the body that was protein was relatively constant (17% at 24 kg and 15% at 120 kg).
The curves characterizing the proportion of bodyweight as lipid for barrows and gilts, separately, are shown in Figure 1. The fit of the curves to the raw data was accurate; when expressed as a coefficient of determination, the values were 99.9 and 99.7% for barrows and gilts, respectively.

By means of a verification against the same data set, bodyweight gain was compared with the sum of its components (Table 1); in other words, the predicted composition of each component of the carcass, when added together, was very close to the actual weight of the carcass. The prediction equations adequately predicted bodyweight gain, particularly when gut fill was accounted for. Values for gut fill were similar to the average value of 5% accepted by several researchers by pigs fed common fibre containing diets.

This study was also used to confirm that lipid content of barrows and gilts could be predicted from P2 backfat thickness and bodyweight. Together with rates of protein deposition derived either from direct carcass slaughter or estimated using real-time ultrasound, energy requirements and the distribution of energy intake to body protein and lipid can be assessed.

IMPLICATIONS

Increased knowledge of body composition of the pig, and in particular, changes in that body composition as the pig grows from birth to market, will allow nutritionists to formulate diets much more effectively, resulting in lower feed costs and presumably, more uniform carcass quality. This experiment provides further information on the changes in body composition over time. Lipid, as a portion of the total body, almost tripled from 23 kg to market, while protein was much more constant.

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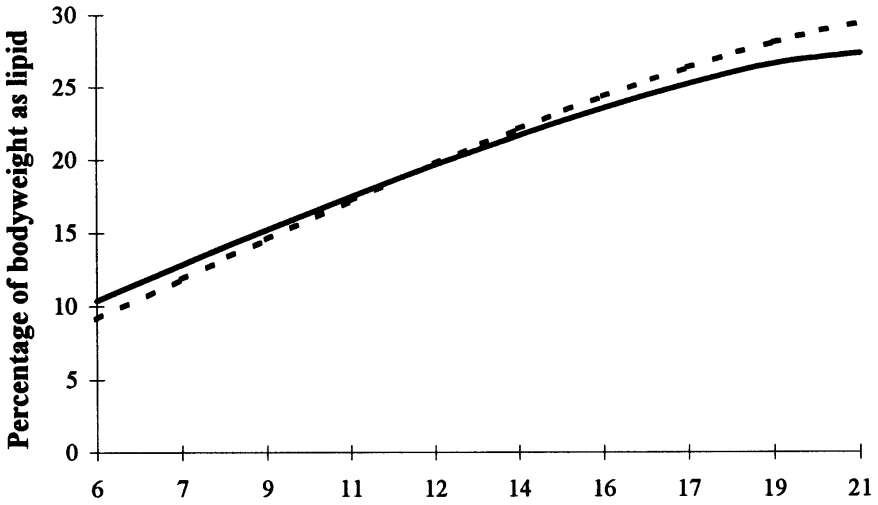
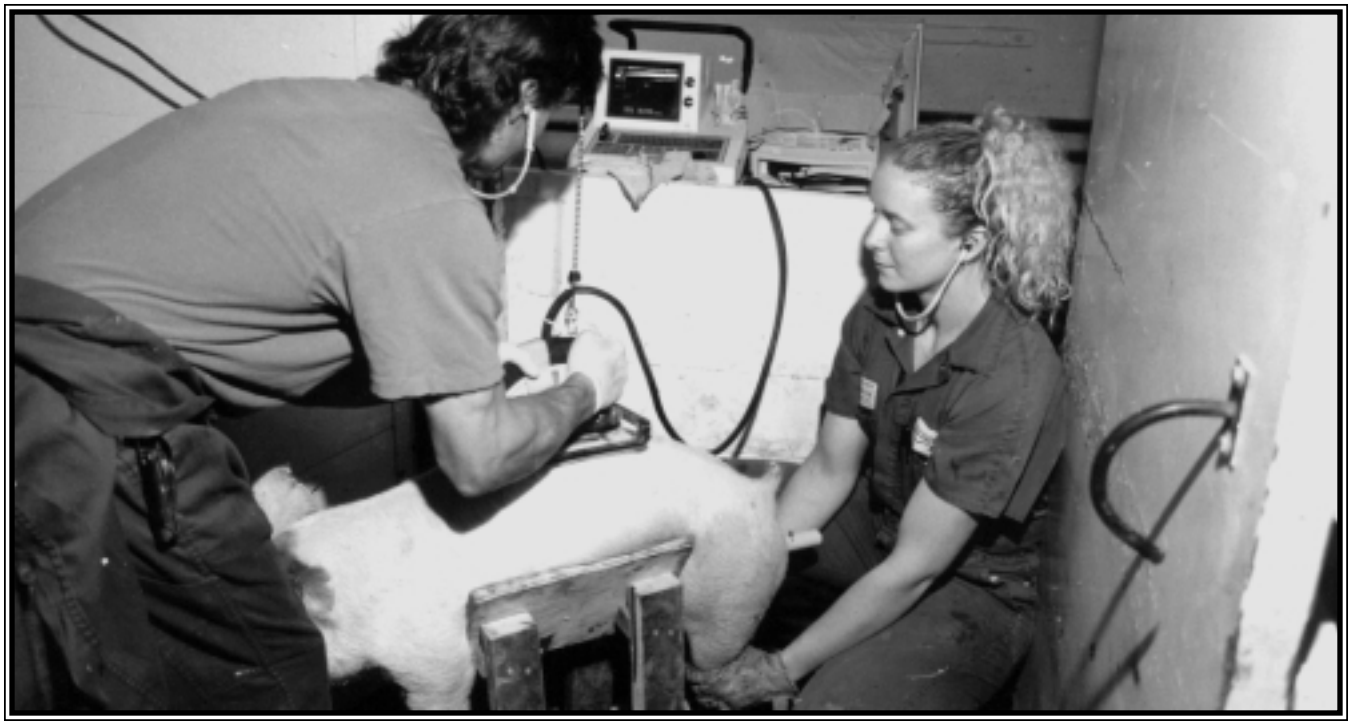


Figure 1. Predicting the percentage of bodyweight as lipid in barrows (- - -) and gilts (æ) grown from 24 to 120 kg bodyweight.

Table 1. Verification of model. All values derived using body weight, and contents of protein, lipid and ash as driving variables.

Variable	Gender	Body weight, kg					
		24	56	72	88	104	120
days of age	gilt	58	94	109	132	150	156
	barrow	61	90	108	126	140	156
bodyweight, kg	gilt	25	55	72	87	103	120
	barrow	27	55	72	87	104	119
protein, kg	gilt	4.1	8.5	11.1	14.3	16.4	17.8
	barrow	4.7	8.8	11.4	13.8	14.5	17.4
protein, g/d	gilt	108	128	131	137	128	111
	barrow	141	147	144	135	110	103
lipid, kg	gilt	2.5	8.9	15.9	18.4	25.7	33.4
	barrow	2.7	8.5	15.5	22.4	28.5	34.6
lipid, g/d	gilt	116	243	299	336	366	382
	barrow	155	290	347	382	400	400
ash, g/d	gilt	19	23	23	24	22	19
	barrow	27	33	34	34	28	28
water, g/d	gilt	362	387	380	385	350	301
	barrow	468	475	460	429	349	324
bodyweight, g/d	gilt	696	881	912	910	885	841
	barrow	839	984	985	952	891	816
gut fill, g/d	gilt	35	28	25	22	20	17
	barrow	30	21	17	15	12	10
unaccounted, % body weight gain	gilt	8	8	6	1	0	1
	barrow	2	2	-2	-5	-1	-6

Technician Doug Gillis and Alison Orr using real-time ultrasound to determine body composition of growing pig.



ENERGY CONTENT OF BARLEY

VARIATION IN THE DIETARY ENERGY CONTENT OF BARLEY

Shawn Fairbairn, John Patience, Hank Classen and Ruurd Zijlstra

SUMMARY

Formulation of commercial pig diets requires an increasing degree of precision, in order to minimize the cost of production, optimize performance and achieve the highest quality of carcass possible. Such precision, while necessary, is difficult to achieve, given the high degree of variation in common feed ingredients. For example, the level of digestible energy in barley can vary by as much as 8 - 12% or 250 - 370 kcal. Given that nutritionists attempt to formulate diets to within a tolerance of 50 kcal/kg, the problem is apparent. This study was conducted to identify the factors, which cause energy variation in barley and establish a system to estimate the digestible (DE) and metabolizable energy (ME) levels in barley samples.

Four samples of each of five hulled barley varieties were collected across the three Prairie provinces and fed to growing barrows to determine the apparent digestibility of energy and several other nutrients. The mean DE and ME values were 2,934 and 2,857 kcal/kg (as fed basis), respectively, with a range in the order of 15%. Acid detergent fibre (ADF) was the single most important variable, explaining 85% of the observed variation in DE. Prediction equations were developed to estimate the DE and ME levels in barley. Economic analysis determined the market value of the 20 barley samples varied by more than $60/tonne, compared with an average price of $110/tonne at the time of the study.

INTRODUCTION

Barley is a major ingredient in commercial swine diets in many parts of the world. Currently, barley is traded as a commodity, with little effort to differentiate samples based on actual nutrient content. However, the economic value of barley could be increased if the actual energy content of individual samples could be accurately estimated or predicted. This would include overcoming the uncertainty associated with a variation in DE and ME that has been observed to be as high as 20% (ca. 600 kcal/kg). Given that nutritionists seek to formulate diets to within a tolerance of 50 kcal/kg (ca. 1.5%), the magnitude of the problem is apparent. The problem is certainly not restricted to barley, as similar variation is observed in most of basal ingredients. This lack of precision raises feed costs, lowers production performance, reduces carcass uniformity and decreases the economic potential of any livestock operation. A better understanding of the variation in energy content of barley will improve the accuracy of diet formulation, improve the profitability of feeding pigs and enhance the economic value of barley to the pig industry. Benefits will accrue to both the grains and livestock industries.

The objectives of this study were to characterize the sources of variability in energy content and to develop a practical method to accurately estimate the digestible (DE) and metabolizable (ME) energy content in individual barley samples.

EXPERIMENTAL PROCEDURE

A feed industry survey was used to select hulled varieties of barley to include in this experiment. Differences in feed vs. malt, two- vs. six-row, and importance to the swine industry across the Prairies, were all considered. Four samples of each of the five varieties (AC Lacombe, B-1602, Bedford, Harrington, and Manley) were obtained from Alberta, Manitoba and Saskatchewan. The 20 samples were thus selected to obtain nutritional and regional diversity. Fifty 35-kg barrows were placed in special metabolism crates to permit collection of urine and faeces, and thus determine the actual DE and ME content of each barley sample.

Feed, faecal, and urine samples were collected in order to determine DE and ME. Feed and faecal samples were also used to determine apparent digestibility of protein (CP), lipids (EE), acid detergent fibre (ADF) and neutral detergent fibre (NDF). The barley samples were also analyzed for a wide range of chemical constituents such as starch, glucans, amino acids, and several different types of fibre. Statistical analyses were conducted to derive prediction equations which related the energy content

in the barley to other more easily measured quality characteristics.

RESULTS AND DISCUSSION

There was large variation among the twenty barley samples in physical characteristics (Table 1), nutrient digestibility (Table 2) and chemical constituents (Table 3).

The mean DE for the all barley samples included in this experiment was 2,934 kcal/kg (Table 2). The DE ranged from 2,686 to 3,133 kcal/kg, a difference of 447 kcal or 15.3%. Bushel weight ranged from 43.5 to 55.9 lb/bu. However, that bushel weight alone was not an accurate measure of energy content. For example, two barley samples which had a similar bushel weight (51 lb/bu) had DE values which differed by 310 kcal (2,803 - 3,113 kcal/kg).

Acid detergent fibre proved to be the single most accurate predictor of DE content, explaining 85% of the total variation in the energy content (Figure 1). For every 1% increase in ADF, DE declined by about 90 kcal/kg.

Prediction equations to estimate DE or ME levels are presented in Table 4. These equations were developed to achieve a desired level of accuracy, but were also created to be practical and economical. The analysis required for these equations are not overly expensive and can usually be done quickly in most commercial laboratories. For example in Equation 1 of Table 4, if ADF, CP, and 1000 kernel weight analyses were conducted on a particular barley sample and if those values were substituted into the equation, the resulting estimate of DE would be 88% accurate. This would allow for a more precise diet formulation once the energy level was estimated compared with assuming the barley contained the “average DE book value”.

The economic value of the twenty barley samples for a industry typical grower diet were calculated with July, 1997 prices for ingredients with the feed formulation software Brill, and are reported in Table 5. Value of the barley samples ranged from 78.12 to 139.39 $/1000 kg in a grower diet, a difference of $61.27 or 56%.

IMPLICATIONS

An improved understanding of, and ability to estimate the energy variability in barley, makes it possible to more precisely formulate pig diets, avoiding costly over-formulation while at the same time ensuring minimum requirements are met. A practical method to accurately estimate energy content in barley will result in a reduction in feed costs, improved carcass uniformity, ability to market barley on a nutritional value basis, and decreased amounts of wasted nutrients in the slurry.

ACKNOWLEDGMENTS

The authors acknowledge the pork producers of Saskatchewan, Manitoba and Alberta for their strategic funding to Prairie Swine Centre Inc. The researchers would also like to kindly thank Degussa Corporation for amino acid analysis and Kansas State University for particle size analysis.

Figure 1. Relationship between digestible energy (90% DM) and acid detergent fibre (90% DM).

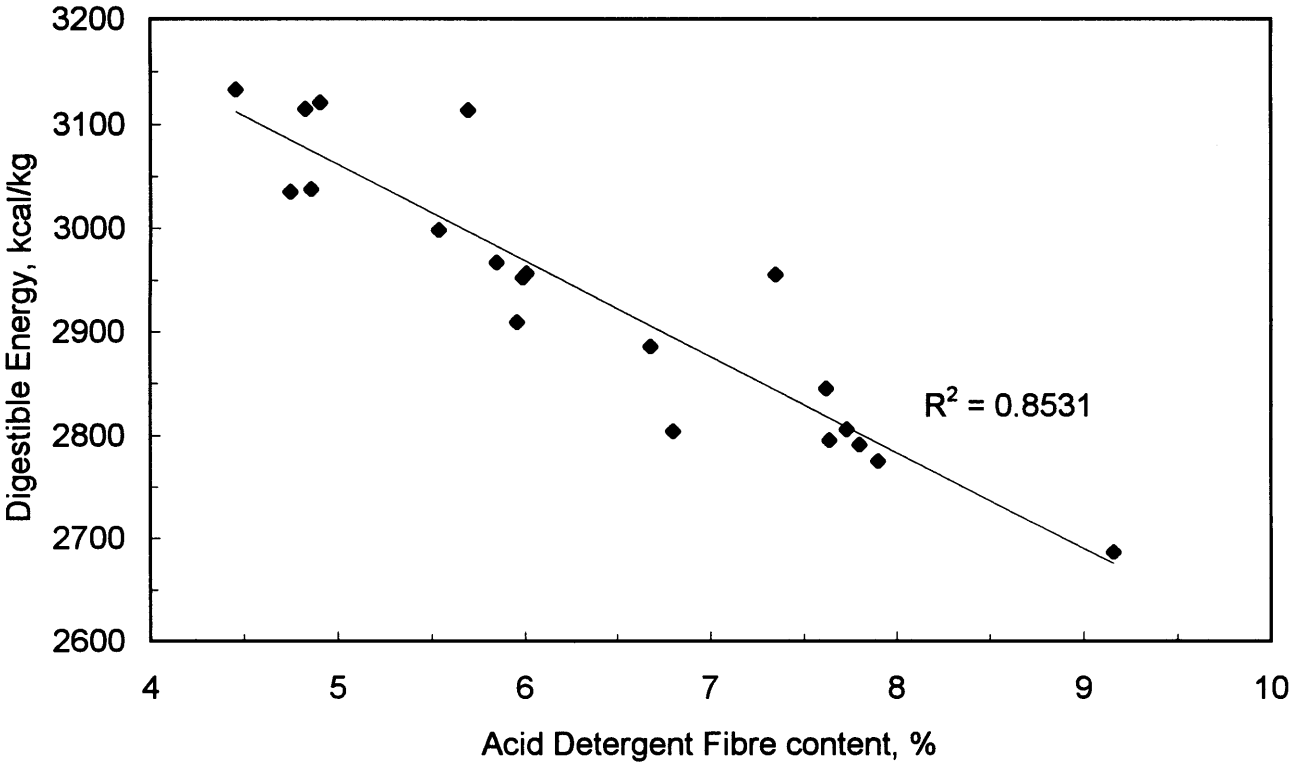


Table 1. Physical characteristics of the barley samples.

Item	Variety					Mean	Total SD[a]	Avg. SD within variety[b]	SD among varieties[c]
	AC-Lacombe	B-1602	Bedford	Harrington	Manley				
Bushel weight, lb/bu	48.5	50.5	48.9	49.8	51.6	49.9	3.44	3.561.24	
Unclean bushel weight, lb/bu	47.2	48.9	48.8	48.0	49.5	48.5	4.35	4.64	0.86
Test weight, kg/hL	60.5	63.0	61.0	62.2	64.4	62.2	4.30	4.46	1.55
1000 Kernel weight, g	41.36	35.63	33.22	40.00	43.82	38.81	6.97	6.28	4.31
Dockage, %	0.5	0.8	0.9	2.8	1.5	1.3	1.52	1.18	0.92
1000 kernel volume, mL	35.0	29.6	30.1	33.2	37.2	33.0	4.80	4.16	3.25
Particle size, μm	1330.93[d]	982.92[e]	1168.73[df]	1064.71[ef]	1025.07[ef]	1114.5	167.17	102.93	139.26
n	4	4	4	4	4	20	—	—	—

[a] Total standard deviation (SD) of all 20 observations; [b] Average of the 5 SD's calculated for each variety; [c]SD among the 5 varieties. These three values provide an estimate of the variation among the 20 samples, within each variety and among the 5 varieties, respectively.

[d,e,f]Means within a row with different superscripts differ, $P < 0.05$

Table 2. Digestibility coefficients and energy values of the barley samples.

Item	Variety					Mean	Total SD	Avg. SD within variety	SD among varieties
	AC-Lacombe	B-1602	Bedford	Harrington	Manley				
Digestibility coefficient, %									
Dry matter	76.48	79.81	75.61	77.95	79.53	77.88	3.39	3.11	1.84
Crude protein	66.39	73.50	66.72	68.01	71.21	69.16	4.29	3.48	3.08
Ether extract	58.27	68.98	61.20	66.46	65.53	64.09	6.96	5.83	4.30
Acid detergent fibre	13.68	8.31	5.72	10.90	6.29	8.98	9.32	9.40	3.32
Neutral detergent fibre	55.55	56.80	47.59	56.59	55.45	54.39	6.21	5.34	3.85
Energy	74.57	78.09	73.60	75.87	77.99	76.02	3.45	3.09	2.01
Energy values, Mcal/kg[a]									
Digestible energy	2.872	3.019	2.849	2.931	3.000	2.934	133.10	120.56	75.25
Metabolizable energy	2.798	2.934	2.777	2.853	2.924	2.857	128.78	117.35	71.60
Net energy[b]	2.092	2.204	2.083	2.156	2.208	2.149	112.25	104.38	59.68

[a]90% DM basis; bNE calculated as NE = .700 x DE + 1.61 x EE + .48 x ST - .91 x CP - .87 x ADF (Noblet et al., 1994)

Table 3. Chemical components of the barley samples[a].

Item	Barley variety					Mean	Total SD	Avg. SD within variety	SD among varieties
	AC-Lacombe	B-1602	Bedford	Harrington	Manley				
Ash, %	2.59	2.50	2.56	2.54	2.92	2.62	0.39	0.36	0.17
Ether extract, %	1.58[c]	2.06[d]	2.13[de]	2.36[e]	2.09[d]	2.05	0.30	0.15	0.28
Crude Protein, %	11.80	13.57	12.86	12.23	12.73	12.64	1.20	1.07	0.67
Starch, %	47.11	48.13	47.97	48.80	49.93	48.38	2.99	2.95	1.05
Gross energy, Mcal/kg	3.852	3.866	3.870	3.863	3.847	3.860	22.64	21.78	9.92
Crude fibre, %	6.24	5.69	6.02	5.63	5.51	5.82	1.02	1.08	0.30
Acid detergent fibre, %	7.24	5.71	6.77	6.46	5.71	6.38	1.32	1.25	0.67
Neutral detergent fibre, %	25.59	23.87	24.13	24.83	22.34	24.15	2.60	2.56	1.21
Acid detergent lignin, %	1.14	1.07	1.23	1.11	1.15	1.14	0.14	0.13	0.06
Total NSP[b]	19.35[c]	18.25c	17.56[ce]	15.20[d]	15.78[de]	16.29	2.07	1.35	1.72
Insoluble NSP[b]	13.89	12.83	12.80	11.42	11.04	12.40	1.65	1.37	1.16
Soluble NSP[b]	5.46	5.41	4.76	3.78	4.74	4.83	0.94	0.77	0.68
Cellulose, %	4.44	3.60	3.90	3.14	3.12	3.64	0.87	0.74	0.55
Total arabinoxylans, %	8.94[c]	8.50[ce]	7.92cd	6.83d	7.29[de]	7.89	1.17	0.87	0.86
Insoluble arabinoxylans, %	7.44	7.14	6.84	6.30	6.18	6.78	0.92	0.82	0.54
Soluble arabinoxylans, %	1.50[c]	1.35c	1.08[c]	0.52[d]	1.11c	1.11	0.46	0.33	0.37
Total ß-glucans, %	3.48	3.71	3.78	3.52	3.29	3.56	0.48	0.48	0.19
Insoluble ß-glucans, %	2.79	2.93	3.01	2.68	2.35	2.75	0.43	0.39	0.26
Calcium, %	0.06	0.07	0.06	0.06	0.06	0.06	0.01	0.01	0.001
Phosphorus, %	0.35	0.36	0.39	0.35	0.39	0.37	0.04	0.04	0.02
n	4	4	4	4	4	20	—	—	—

[a]All chemical components are reported on a 90% DM basis; [b]Non-starch polysaccharides; [c,d,e]Means in a row with different superscript letters differ at $P < 0.05$

Table 4. Prediction equations of DE (kcal/kg; 90% DM) [a].

No.	Equation	Coefficient of determination	Residual standard deviation
1	DE = 3039 - 74.4 x ADF + 4.4 x KW + 15.8 x CP	.88	50
2	DE = 3357 - 83.1 x ADF + 2.8 x KW	.86	52
3	DE = 3526 - 92.8 x ADF	.85	52
4	DE = 1902 - 17.3 x NDF + 21.0 x BW + 31.6 x CP	.79	67
5	DE = 1489 - 29.7 x CF + 32.5 x CP + 24.2 x BW	.77	70
6	DE = 838 + 32.3 x BW + 38.6 X CP	.76	69
7	ME = 3276 - 81.4 x ADF + 2.6 x KW	.88	48
8	ME = 3435 - 90.4 x ADF	.87	49
9	ME = 1976 - 18.1 x NDF + 19.5 x BW + 27.2 x CP	.78	65
10	ME = 862 + 31.3 x BW + 34.5 x CP	.75	68
11	ME = 1380 - 23.7 x CF + 24.9 x BW + 29.7 x CP	.75	70

[a]Abbreviations for the variables are as follows: BW = bushel weight, CF = crude fibre, CP = crude protein, EE = ether extract, KW = 1000 kernel weight

Table 5. Value of barley samples when variability in DE was incorporated into a typical grower diet[a,b].

Barley variety	Sample #	Barley DE Level (kcal/kg; 90% DM)	Economic value ($/1000 kg)
AC Lacombe	1	2,955	113.10
AC Lacombe	2	2,806	87.47
AC Lacombe	3	2,953	112.80
AC Lacombe	4	2,775	78.08
B 1602	1	3,038	125.35
B 1602	2	3,114	136.58
B 1602	3	3,133	139.39
B 1602	4	2,791	81.08
Bedford	1	2,804	86.78
Bedford	2	2,909	106.30
Bedford	3	2,886	102.91
Bedford	4	2,795	83.14
Harrington	1	3,114	136.58
Harrington	2	2,967	114.87
Harrington	3	2,686	78.12
Harrington	4	2,957	113.39
Manley	1	3,035	124.92
Manley	2	3,121	137.62
Manley	3	2,846	96.98
Manley	4	2,998	119.46
Mean		2,934	108.75

[a]The price of barley was $110.00/tonne as of July 25, 1997, Saskatoon, SK.; [b]The value of each barley sample was estimated as follows: a basal grower diet was costed using "average" barley energy (2,934 kcal/kg) content and price ($110/tonne). The diet was then reformulated to the same nutrient composition using the actual DE content of each barley sample. The value of each barley was set at the price which resulted in a cost of the diet equal to that of the basal formulation ($ 214.07). The diet had to contain a minimum of 45% barley.

NUTRITIONAL VALUE OF FIELD PEAS

RANGE OF DIGESTIBLE ENERGY CONTENT IN 11 FIELD PEA VARIETIES

Ruurd T. Zijlstra, Shawn L. Fairbairn, Doug A. Gillis, D. Lee Whittington, and John F. Patience

SUMMARY

Field peas are used increasingly as a source for protein and energy in swine diets in Western Canada. The variability for the energy value of field peas has been described poorly. Yet, effective diet formulation requires a clear understanding of not only average nutritional value, but also its variability. The objective of the present study was to determine the range of digestible energy (DE) content in samples of 11 field pea varieties grown on a single quarter section of land.

The DE ranged from 3098 to 3739 kcal/kg; thus, the difference in DE between the highest and lowest value was 20%. Despite being grown under similar conditions, energy value for sample differed greatly among samples and variation in DE was greater than expected. Due to the fact nutritionists try to formulate diets within an accuracy of 1.5%, the issue of ingredient variability represents an area of significant economic opportunity.

INTRODUCTION

Recent research results indicate that locally grown feed ingredients express a high variability in nutritional value for growing - finishing pigs. The highest and lowest DE value differed 20% within twenty samples of barley collected from Alberta, Saskatchewan and Manitoba (see article by Shawn Fairbairn in this Annual Report issue). Field peas are becoming an increasingly important protein and energy source for growing - finishing pigs in Western Canada. The range in nutritional value of field peas has been poorly assessed. Therefore, the objective of the present study was to characterize the DE content in samples of 11 field pea varieties.

EXPERIMENTAL PROCEDURES

Eleven different field pea varieties were grown on a single quarter of land in central Saskatchewan by an interested pork producer. Twelve diets were tested: eleven diets containing 40% field pea of a specific variety and 55% wheat. One diet containing 95% wheat served as control. The diets also contained chromic oxide as indigestible marker and were fortified with vitamins and minerals. Each field pea diet was fed to four grower pigs and the control diet was fed to six pigs for a total of 50 observations. Pigs were housed in metabolism crates for 27 days. After a seven-day adaptation period to the crates, the pigs completed two 10-day experimental periods: five days of acclimation to a specific diet followed by five days of feces collection.

Presently, diets and feces have been analyzed for dry matter, energy and chromic oxide content. The DE content has been calculated for individual samples.

RESULTS AND DISCUSSION

The physical characteristics of the 11 field pea variety samples are presented in Table 1. The range in bushel weight was narrow, which might suggest that growing conditions were indeed similar for all varieties.

The mean DE for the field pea varieties used in the experiment (3476 kcal/kg; Table 2) was close to the DE suggested for peas in PSCI's Swine Nutrition Guide (3400). In the samples, DE ranged from 3098 to 3739 kcal/kg. The difference in DE between the highest and lowest value was 20%. The highest DE was 10% more than the standard, which would result in excess of energy in diets after formulation. Likewise, the lowest DE was 9% less than the standard, which would result in diets being deficient in energy.

The economic values of the field pea samples was calculated using July 1997 ingredient prices. Using a commercial feed formulation software (Brill), a grower diet containing 25% field peas was formulated. The cost of the grower diet was kept constant at $189.23, which was the price calculated with the mean DE for field peas. The value of the field peas then ranged from 167.58 to 256.37 $/tonne. These results are summarized in Table 2.

No correlation existed between volume weight and DE within the 11 field pea samples (Figure 1). Volume weight was an extremely poor indicator of nutritional value of field peas.

IMPLICATIONS

The results of the present study indicate that nutritional value of field peas can differ 20%, even when field peas are subjected to equal growing and harvesting conditions. The study was not a comparison between field pea varieties, because just one sample was collected per variety. However, the results strongly suggest that the nutritional and economic value differ tremendously between field pea varieties grown in Western Canada.

ACKNOWLEDGEMENTS

The project was initiated by Mr. Leon Lueke in Humboldt, SK. Mr. Lueke grew and harvested the 11 field pea varieties and donated samples to PSCI for research purposes. Funding for this project was provided by the SPI Marketing Group and the Agriculture Development Fund of the Saskatchewan Department of Agriculture and Food.

Figure 1. Plot of digestible energy (DE) versus bushel weight for 11 field pea samples (r^2 = 0.2%). There was no correlation between volume weight and DE; therefore, volume weight was an extremely poor indicator of nutritional value.

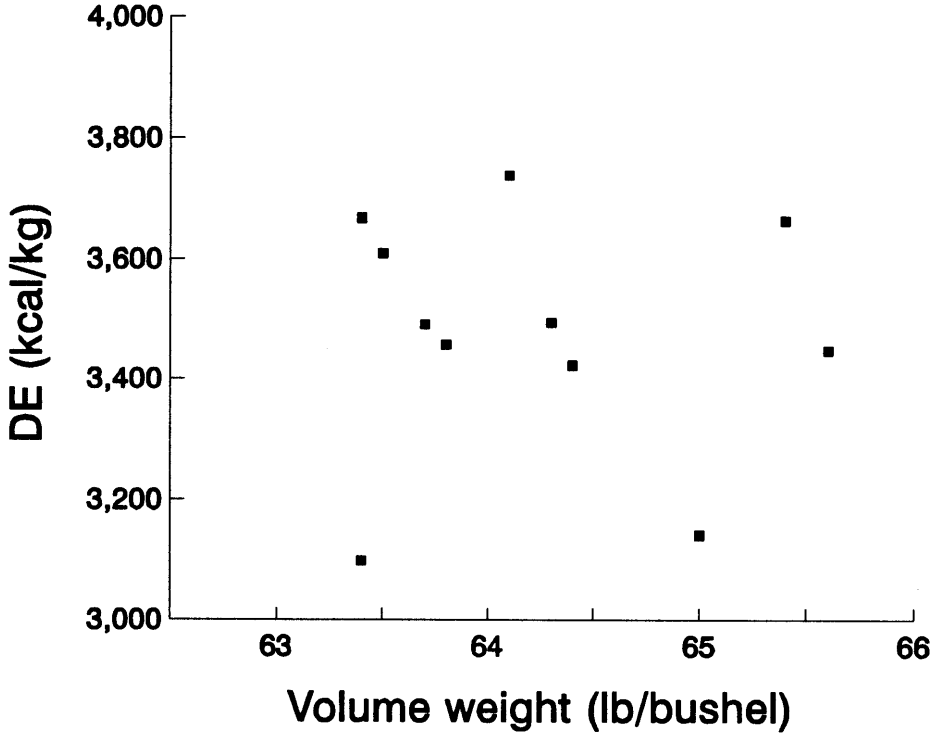


Table 1. Brief description of the 11 field pea variety.

Variety	Colour / Grade	Bushel weight[a]	
		Unclean	Official
Bohatyr	Yellow / # 3 Extra Large	65.5	63.7
Carneval	Yellow / # 2	64.7	63.8
Danto	Green / Bleached	65.8	64.3
Emerald	Green / Bleached	64.5	63.4
Highlight	Yellow / # 1	66.2	65.0
Majoret	Green / Bleached	66.2	64.4
Mustang	Yellow / # 2 Large	65.3	64.1
Orb	Green / Bleached	64.2	63.5
Spring	Yellow / # 2	67.3	65.6
Victoria	Yellow / # 1	64.0	63.4
Voyageur	Yellow / # 3	66.7	65.4
Mean		65.5	64.2

[a]Unclean bushel weight is with dockage, official bushel weight is without dockage.

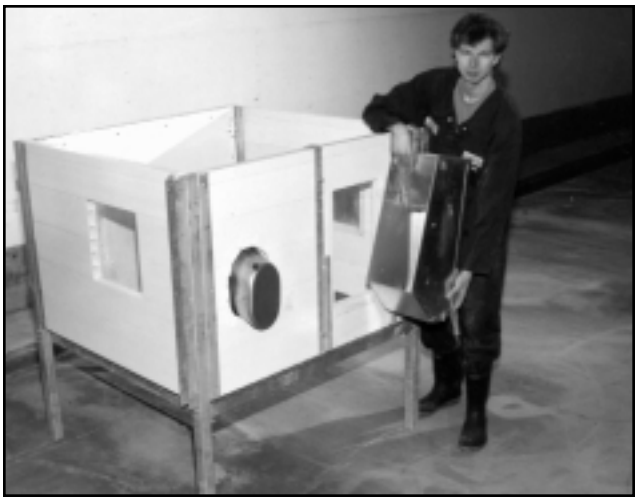
Table 2. Digestible energy and calculated economic value of 11 field pea variety samples.

Variety	Digestible energy[a] (kcal/kg; 90% DM)	Economic value[b] ($/tonne)
Bohatyr	3492[b,c]	222.21
Carneval	3458[b,c]	217.51
Danto	3495[b,c]	222.63
Emerald	3098[d]	167.58
Highlight	3141[d]	173.67
Majoret	3423[c]	212.67
Mustang	3739[a]	256.37
Orb	3610[a,b,c]	238.53
Spring	3448[b,c]	216.13
Victoria	3668[a,b]	246.55
Voyageur	3664[a,b]	246.00
Mean	3476	220.00

[a] Means within a column with the same superscript letter are not significantly different.

[b] Calculated with the feed formulation software Brill using 25% field peas in a diet for grower pigs, with July 1997-prices for ingredients. Cost for the grower diet was kept constant at $189.23, which was the price calculated with the mean DE for field peas.

Dr. Ruurd T. Zijlstra with metabolism crates used in evaluating feedstuffs.



BEHAVIOUR OF EARLY WEANED PIGS

BEHAVIOUR OF EARLY WEANED PIGS IN THE NURSERY AND GROWER/FINISHER BARN

Harold W. Gonyou, Eduardo Beltranena, Lee Whittington and John F. Patience

SUMMARY

An experiment was conducted to investigate the effects of current early weaning practices on the behaviour of piglets in the nursery and through the grower/finisher phase. Two treatments were compared: weaning at 21or weaning at 12 days of age. Treatments were housed in separate but identical on-site nursery rooms, and within the same grower/finisher rooms. Pigs weaned at 12 days of age were found to be slower to develop normal levels of eating behaviour than those weaned at 21 days of age, but did so by 48 h after weaning. During the subsequent 5 - 6 weeks, early-weaned pigs spent more time eating, drinking, nosing other pigs and chewing on objects. The higher levels of nosing and chewing activity persisted into the growout period, substantiating concerns that early weaning may have a lasting effect on animal behaviour.

INTRODUCTION

Early weaning of pigs has been associated with an increased incidence of behavioural vices, most notably that of belly nosing. The high incidence of such behaviour has led to restrictions on weaning age in several countries. Previous studies have not determined if these vices continue into the growing - finishing period. Early weaned pigs must also adapt to eating solid feed prior to the time they would normally begin to consume it if still suckling. It is also possible that current diets could affect the development of behavioural vices as well. The present study investigated the effects of early weaning on behaviour throughout the nursery and the growing - finishing periods.

EXPERIMENTAL PROCEDURE

The control group consisted of litters weaned at 21 ± 3 days post-farrowing, with the piglets placed in an on-site nursery room operated on an all-in-all-out basis. The treatment consisted of litters weaned at 12 ± 2 days, with the piglets placed in an identical room adjacent to that used for the control litters on-site. Additional details of the management of the pigs during the nursery phase are provided in the production report elsewhere in this volume. Piglets were transferred to the growout facilities at approximately 56 days of age, and their performance was monitored through to market.

Eating During 48 h Post-weaning
During each of four replicates, 3 pens from each treatment were videotaped from directly overhead for 48 hours immediately after weaning. The number of pigs eating in each pen was recorded at regular times during this period. Data were summarized into four 12 h periods (0 - 12, 12 - 24, 24 - 36, and 36 - 48 h).

Behavioural Time Budgets During the Nursery Phase
Beginning 3 - 5 days after weaning, pigs were observed to determine time budgets for eating, drinking, lying, standing, belly nosing, chewing on other pigs, and chewing on objects. Observations were made on 3 days per week in both the morning (approx. 10:00 - 12:00) and afternoon (approx. 13:00 - 15:00), at 8 minute intervals. During each observation, the behaviour of each pig in the pen was recorded as lying, eating, drinking or standing. It was also recorded if each pig was nosing another pig, chewing on another pig, chewing on an object, being nosed by another pig or being chewed upon by another pig. Data were summarized by pen for each week prior to analysis.

Behavioural Time Budgets During Growing - Finishing Phase
Beginning the week after pigs were moved to the grow/finish facilities, pigs were observed to determine time budgets as in the nursery phase. Pigs were maintained in the same nursery groups, either as a single group or half of a group per pen, during this period

Correlation Among Behaviour and Production Variables
Data for each pig were summarized to include mean values for each behaviour variable for both the nursery and growing - finishing period, as well as the

average daily weight gain for the nursery and growing - finishing periods. Partial correlations among these variables were determined after controlling for group effects. The results represent within group correlations to determine if pigs within a group, which performed certain behaviours consistently, performed other behaviours or grew faster or slower than others within that group.

RESULTS AND DISCUSSION

During the initial 48 hours after weaning, pigs weaned at 21 days of age spent more time eating than did those weaned at 12 days of age (6.39 vs. 3.74%), respectively ($P < 0.01$). Eating increased over the 2 d period for both weaning age groups ($P < 0.01$). The pattern of eating over time differed between the two age groups (Figure 1; $P < 0.01$). Pigs weaned at 21 days of age increased eating gradually over each 12 h period following weaning. Pigs weaned at 12 days of age did very little eating before 36 h post-weaning. However, during the final 12 h of observations, time spent eating was similar for the two age groups. The level of eating between 37 and 48 h post-weaning was similar to the average over the next 6 weeks (Table 1). Our pigs were on full feed within 48 h, slightly earlier than those studied in earlier reports. The results demonstrate that learning to eat solid feed is more difficult for very young pigs, and suggest that management at this point must not be compromised.

During the 5 - 6 weeks following weaning, pigs weaned at 12 days of age spent more time eating, drinking, nosing other pigs and chewing on objects (Table 2). Drinking and chewing on objects peaked at weeks 3 and 4 post-weaning. Nosing other pigs peaked during weeks 2 and 3 post-weaning. The time course of these behaviours differed between age at weaning groups. Although pigs weaned at 12 days of age generally nosed other pigs more than those weaned at 21 days of age, the increase during the second and third weeks after weaning was particularly marked in the younger pigs (Figure 2b). The increase in drinking during weeks 3 and 4 after weaning was almost entirely due to the younger pigs (Figure 2a).

Excessive drinking sometimes occurs as a result of limited feed access or as a stereotypy. Neither of these should have been a factor in these young pigs. Nosing of other pigs is sometimes attributed to hunger, but in this study as in previous reports, it did not develop until after pigs were eating well. It is possible that nosing relates to an aspect of eating behaviour that is not directly related to hunger, but is thwarted by the feeding system imposed on weaned pigs. Motivation for those particular elements of eating behaviour could accumulate and eventually be shown in non-feeding behaviour. The importance of nosing to performance and welfare requires further study, but the differences between the age groups raise questions about the different motivations of the animals.

Time budgets for general maintenance behaviours, eating, drinking and standing, did not differ between pigs weaned at 12 and 21 days of age during the growing - finishing period. Nosing and chewing other pigs continued to occupy approximately 1.8 and 1.3% of observations for pigs weaned at 12 and 21 days of age, respectively. However, unlike during the nursery phase, the predominant inter-pig activity during the growing-finishing period was chewing rather than nosing. Both of these activities were greater among pigs weaned at 12 than at 21 days-of-age.

Although producers have suggested that flank and tail biting are more common among early-weaned pigs, this is the first data to support such claims. It is not clear if the increased nosing and chewing results in more frequent removal of pigs due to injuries. However these results support concerns about the effects of early weaning on anomalous behaviours through to market.

Approximately 28% (54 of 90) of the partial correlations among behaviours and gain were significant. Pigs, which were observed lying frequently, were less likely to be observed eating, drinking or standing. Within rearing periods, environment-directed behaviours were correlated with each other (10 of 20). Pigs, which were nosed or chewed, by other pigs, were less likely to nose or chew on others. Active pigs (lower levels of lying) engaged in nosing and chewing behaviours more than inactive pigs, but there was little relationship between general activity and being the recipient of environment-directed behaviours. Average daily gain between periods was positively correlated, but the primary relationship between behaviour and growth

was related to general activity; inactive pigs grew faster.

The behavioural correlations reveal the relationships among various classes of behaviours. In general, active animals engage in nosing and chewing activity. All of these behaviours have been associated with anxiety or lack of comfort in previous studies, or they could represent distinctive temperaments. It is noteworthy that pigs, which nose or chew on other pigs, are rarely nosed or chewed themselves. This supports the division of active and inactive pigs, and their associated availability for environment-directed behaviours. Although nosing and chewing are considered to be anomalous behaviours, perhaps indicative of welfare status, performance of these behaviours was not related to average daily gain.

The fact that the higher levels of nosing and chewing persist into the grow/finish period for early weaned pigs substantiates concerns that early rearing environment may have a lasting effect on animal behaviour. However no definitive effect of these behaviours on productivity were found.

IMPLICATIONS

Pigs weaned at 12 days of age are slower to develop normal levels of eating behaviour than those weaned at 21 days of age, but do so by 48 h after weaning. Even with the use of feeding pans and highly palatable diets, management at this time must not be compromised or feed intake will suffer. During the subsequent 5-6 weeks, early-weaned pigs spend more time eating, drinking, nosing other pigs and chewing on objects. The differences in these oral activities appear to be greatest 2-4 weeks after weaning. In particular, nosing of other pigs is markedly greater in those weaned at 12 days of age, and reaches its peak 2-3 weeks after weaning.

The fact that the higher levels of nosing and chewing persist into the grow/finish period for early weaned pigs substantiates concerns that early rearing environment may have a lasting effect on animal behaviour. However no definitive effect of these behaviours on productivity were found. Advances in SEW technology and management, such as the inclusion of plasma protein in the diets, have not eliminated the behaviour-related concerns related to early weaning.

Figure 1. Eating behaviour during the 48 h following weaning of pigs weaned at either 12 or 21 days of age. Time x Age interaction was significant ($P < 0.01$).

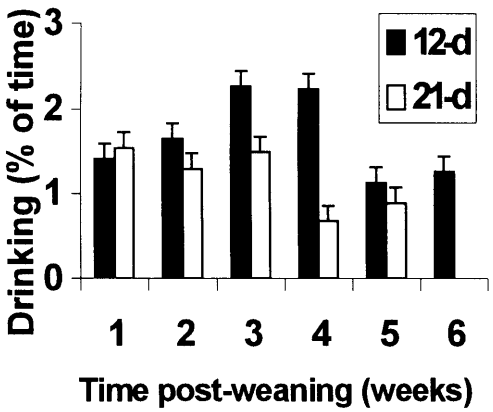
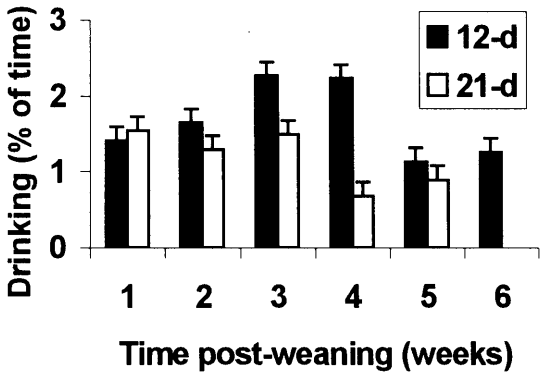


Figure 2. Drinking (2a) and nosing of other pigs (2b) by pigs weaned at 12 or 21 days of age during 5 weeks following weaning.



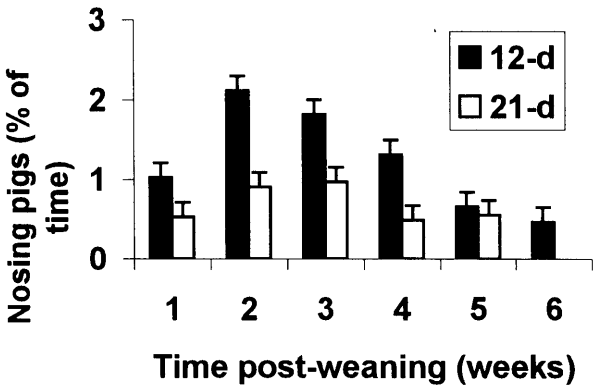


Table 1. Effects of weaning age on behaviour of pigs weaned into on-site nurseries.

	Weaning age, days			
	12	21	S.E.M.	Prob.
	- % of time -			
Eating	1.56	10.46	0.450	0.05
Drinking	1.65	1.22	0.100	0.01
Standing idle	22.50	21.60	0.93	Ns
Nosing other pigs	1.23	0.74	0.094	0.01
Chewing on other pigs	0.57	0.63	0.047	Ns
Chewing on objects	2.48	2.33	0.065	0.01

[a]Observed between 0900 and 1500h for 6 wk following weaning.

Table 2: Effect of time post-weaning on behaviour of pigsa weaned into on-site nurseries.

	Weeks post weaning						
	1	2	3	4	5	6	S.E.M.
				- % of time -			
Eating	13.26[b]	11.84[bc]	12.44[b]	10.45[c]	8.22[d]	8.72[d]	0.699
Drinking	1.47[bc]	1.47[bc]	1.88[b]	1.46[c]	1.01[d]	1.26[cd]	0.149
Standing idle	25.15	23.11	22.54	18.60	19.72	24.3	1.459
Nosing other pigs	0.77[cd]	1.51[b]	1.39[b]	0.90[c]	0.61[cd]	0.47[d]	0.130
Chewing on other pigs	0.39	0.47	0.87	0.80	0.49	0.51	0.071
Chewing on objects	2.06[bc]	2.01[c]	3.62[b]	3.62[b]	1.87[c]	0.15[d]	0.570

[a] Observed between 0900 and 1500h. Pigs weaned at 12 or 21 days of age.
[b, c, d] Means sharing a common superscript do not differ ($P > 0.05$).

ACKNOWLEDGMENTS

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EFFECTS OF FLOOR AREA ALLOWANCE AND GROUP SIZE ON THE PRODUCTIVITY OF GROWING-FINISHING PIGS

Harold W. Gonyou and W. Ray Stricklin

SUMMARY

Six groups sizes and three levels of floor area allowance were studied in a 6 x 3 factorial arrangement. Group sizes were 3, 5, 6, 7, 10 and 15 pigs per pen. Floor area allowances were 0.030, 0.039 and 0.048 m^2 x $BW^{0.667}$(body weight to the power of $^2/_3$). Initial weights averaged 25.0 kg, and pigs remained on test for 12 wk. Pigs were weighed, feed intake determined, and size of pens increased at 2-wk intervals. Pen average daily weight gain (ADG) was reduced with increasing group size (899, 851, 868, 872, 857 and 821 g, for 3, 5, 6, 7, 10 and 15 pigs, respectively, $P < 0.05$). Pen average daily feed disappearance (ADF) also decreased with increasing group size (2.49, 2.34, 2.32, 2.28, 2.28 and 2.21 kg, for 3, 5, 6, 7, 10 and 15 pigs, respectively; $P < 0.05$). ADG and ADF (832 g and 2.25 kg, respectively) for the most crowded space allowance were reduced compared with more spacious allowances (ADG and ADF of 875 and 877 g, and 2.35 and 2.36 kg, for 0.039 and 0.048 m^2 x $BW^{0.667}$, respectively; $P < 0.05$). These results demonstrate that group size and space allowance act independently upon productivity.

INTRODUCTION

Space allowance is a critical factor in designing barns and accommodating the movement of pigs through the various phases of production (pig flow). Most studies have investigated space allowance relative to a specific end point, such as market weight, but this approach limits the usefulness of the findings. For example, when industry demands a shift in market weight, the research data are no longer applicable. A calculation of space allowance expressed in terms of body weight would allow one to plan, design and manage pig flow and pen sizes more precisely regardless of shifting market weights or the weight at which pigs are moved from grower to finisher facilities. Previous investigators have proposed that space allowance should be based on body surface area, which is proportional to $BW^{0.667}$.

Group size is also an important determinant of barn design. Some studies have demonstrated a decrease in performance as group size increases, but others have not. In addition, it has been suggested that space allowance and group size may interact in their effects on performance.

The objectives of this study were:

1. To determine the relationship of space allowance, based on $BW^{0.667}$, on productivity and the consistency of this effect over a range of body weights;
2. To determine the effect of group size on productivity over a range typical of experimental and small commercial pens.

EXPERIMENTAL PROCEDURE

Six group sizes and three floor area allowances were evaluated in a 6 x 3 factorial arrangement, with two replicates over time. Group sizes studied were 3, 5, 6, 7, 10 and 15 pigs per pen. Using the biological relationship between body weight and surface area, floor area allowances were calculated as k * $BW^{0.667}$, where BW is in kg, and floor area allowance is in m^2. The values for k used in the study were 0.030, 0.039 and 0.048. Pen sizes were adjusted at 2-wk intervals to reflect the requirements of the pigs at the mid-point of the subsequent 2-wk period, based on their expected body weights. Floor area allowances for the first and final 2-wk periods averaged 0.295, 0.382, and 0.467, and 0.578, 0.761, and 0.942 m2/pig for k values of 0.030, 0.039 and 0.048, respectively.

The pigs averaged 25.0 and 96.9 kg at the beginning and end of the 12-wk study. All pens were square and constructed of solid walls. Each pen was equipped with one single space dry self-feeder and one nipple drinker. The pigs had ad libitum access to the pelleted complete diets based on wheat, barley, soybean meal and canola meal.

Pigs were individually weighed on Day 0 and at 2-wk intervals thereafter. Pen sizes were adjusted on the same day. Feed disappearance (intake) was summarized at 2-wk intervals using standard weigh-in and weigh-back methods. Pen average daily weight gain (ADG), daily feed disappearance (ADF) and efficiency (gain/intake) were analyzed for the periods 0 - 4, 4 - 8, 8 - 12 and 0 - 12 wk.

RESULTS AND DISCUSSION

Decreasing the floor area allowance from a coefficient of 0.048 to 0.039 did not affect ADG, ADF or feed efficiency over 12 wk (Table 1). The additional decrease in floor area allowance to a coefficient of 0.030 resulted in a reduction of both ADG (5%) and ADF (4%), but had no effect on efficiency during this same period. This pattern of reduced weight gain and feed intake at the lowest floor area allowance was numerically true in each 4-wk period of the study, and was significant for ADG between wk 4 and wk 8 and for ADF during every period. Again, efficiency did not differ among floor area allowances during any 4-wk period. The coefficient of variation (CV) for weight within a pen did not differ among floor area allowances, with a mean of 9.0%.

Commonly, studies on floor area allowance are designed such that pigs are provided a specific area throughout the experiment rather than adjusting the pens as the animals grow. Although this common experimental practice reflects commercial production, it results in the animals having abundant floor area early in the trial and only being crowded during the final few weeks of the study. As a consequence, traditional studies reveal the effects of the final few weeks of crowding, but do not necessarily indicate at what point crowding begins or the effect of restricted floor area allowance early in the study. The results of this study indicate that when floor area allowance is expressed on an allometric basis (related to body size), the effects of restriction are consistent throughout the growing period. Thus, we believe it is possible to extrapolate these results to market pigs of larger weights. It also provides a basis for managing floor area and pig flow based on actual requirements rather than published ranges. Under the conditions of this experiment, productivity was affected by crowding at a floor area allowance between coefficients of 0.030 and 0.039. Guidelines for floor area allowance should strike a balance between animal well-being, as indicated by ADG, and efficiency of space use (gain per unit of floor area). The level for optimal efficiency of floor area use may be considerably lower than that for maximal individual weight gain.

Group size

During every 4-wk period, the ADG and ADF of pigs in groups of 3 exceeded that of pigs in larger groups, and that of pigs in groups of 15 was reduced compared with that of pigs in smaller groups (Table 2). Overall, ADG of pigs in groups of 3 exceeded that of pigs in groups of 5, 6, 7, or 10 by 4.3%, which in turn exceeded those in groups of 15 by 4.9%. This reduction in ADG averaged 1.1 and 0.6% per pig increase in group sizes between groups of 3 and the mid-sized groups (5 - 10 pigs/pen) and between the mid-sized groups and groups of 15, respectively. ADF was 8% greater in groups of 3 than in the mid-sized groups, and 4.3% greater in mid-sized groups than in groups of 15. Efficiency peaked for groups of 7 or 10 and was poorest for groups of 3 and 5 ($P < 0.05$).

With both ADF and ADG decreasing as group size increases, it is usually hypothesized that the decrease in gain is due to the reduction in intake. In the current study the use of a single space feeder would be expected to magnify this problem. However, the greatest effect of increasing group size occurred between very small groups (3 pigs/pen) and middle sized groups (5-10 pigs/pen), neither of which should have been greatly restricted by access to the feeder. Associated with increasing group size is increasing pen size which results in greater distances between resources (feed, water, dunging and resting areas) within the pen, and the greater cost of moving to resources may reduce their use. An alternative hypothesis is that stress within larger groups reduces lean growth potential, and hence ADG, which in turn reduces appetite and ADF. Stress within the group could come from physical restrictions as discussed above, or from the social stress of interacting with more pigs.

IMPLICATIONS

Although the use of $BW^{0.667}$ as the basis for determining floor area allowances has been suggested for some time, we demonstrated for the first time that the application of this method results in consistent effects on productivity of pigs across a range of weights. The application of this methodology for determining floor area allowances should improve barn design and pig flow by better estimating space needs whenever pigs are moved to new pens or when preferred market weights change. The effect of increased group size on productivity should be

considered when comparing results from experimental studies using small (<10 pigs) or large (>10 pigs) groups, but appears to be of less importance for larger commercial sized groups.

ACKNOWLEDGMENTS

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Table 1. Effects of floor area allowance on production traits of growing/finishing pigs.

Production trait	Period (wk)	Floor area allowance (m^2 * BW(kg)$^{0.667}$) 0.030	0.039	0.048	SEM
ADG (g/d)	0 - 4	729	755	764	13.3
	4 - 8 *	857[a]	911[b]	899[b]	12.7
	8 - 12	916	958	967	15.8
	0 - 12 **	833[a]	875[b]	877[b]	8.0
ADF (kg/d)	0 - 4 *	1.65[a]	1.68[ab]	1.73[b]	0.022
	4 - 8 **	2.18[a]	2.32[b]	2.32[b]	0.024
	8 - 12*	2.94[a]	3.04[b]	3.05[b]	0.030
	0 - 12 **	2.25[a]	2.35[b]	2.36[b]	0.017
Feed conversion efficiency	0 - 4	0.444	0.450	0.453	0.0112
(ADG/ADFI)	4 - 8	0.394	0.392	0.388	0.0048
	8 - 12	0.316	0.316	0.318	0.0046
	0 - 12	0.372	0.373	0.371	0.0031

*P <0.05; **P < 0.01.

[ab]Means with common superscripts do not differ ($P < 0.05$).

Table 2. Effects of group size on production traits of growing/finishing pigs.

Production trait	Period (wk)	Group size (pigs/pen) 3	5	6	7	10	15	SEM
ADG (g/d)	0 - 4 **	786[a]	784[a]	753[ab]	775[a]	691[c]	711[bc]	18.8
	4 - 8	916	865	892	886	913	861	17.9
	8 - 12 *	994[a]	904b[c]	959[abc]	956[abc]	967[ab]	893[c]	22.3
	0 - 12 **	899a	851b[c]	868[b]	872[ab]	857[b]	822[c]	11.3
ADF (kg/d)	0 - 4 **	1.84[a]	1.78[a]	1.66[b]	1.64[b]	1.59[b]	1.59[b]	0.031
	4 - 8 *	2.41[a]	2.25[b]	2.25[b]	2.25[b]	2.24[b]	2.23[b]	0.034
	8 - 12 **	3.21[a]	2.99[b]	3.06[b]	2.94[b]	3.01[b]	2.81[c]	0.042
	0 - 12 **	2.49a	2.34[b]	2.32[b]	2.28[bc]	2.28[bc]	2.21[c]	0.024
Feed conversion	0 - 4	0.429	0.440	0.454	0.469	0.436	0.448	0.0159
efficiency	4 - 8	0.380	0.385	0.397	0.394	0.405	0.387	0.0067
(ADG/ADFI)	8 - 12	0.310	0.304	0.314	0.325	0.328	0.318	0.0065
	0 - 12 *	0.362b	0.364[b]	0.374[ab]	0.383[a]	0.378[a]	0.372[ab]	0.0044

*P < 0.05; **P < 0.01.

[abc]Means with common superscripts do not differ ($P < 0.05$).

ERGONOMIC EVALUATION OF FEEDER DESIGN

AN ERGONOMIC EVALUATION OF FEEDER DESIGN

Zhensheng Lou and Harold W. Gonyou

SUMMARY

Five ergonomic studies were conducted using a feeder on which the lip height, feeder depth (front to back), width, and feeding shelf height could be adjusted. Pigs were tested at various weights from 22 to 96 kg. Stepping-into the feeder was more common as feeder depth was increased, but was also dependent upon the size of pig. Grower pigs stepped into a feeder with a depth of 20 cm, but large pigs did not do so until the depth was 30 cm or more. Lip height had only a minor influence of stepping-in. The appropriate feeder depth for each weight group of pig could be approximated by the distance from the toe of the pig to its snout when eating without a feeder lip. The feeder lip restricts access to the front of the feeding zone, particularly for small pigs. Pigs prefer to stand at an angle of approximately 30° to the feed access, but in restrictive feeders will turn their heads to obtain an angled approach. Pigs also rotate their heads approximately 45 - 55° while eating to improve access to the feed.

***ergonomic**:* is the study of the interaction of animals (or humans) with equipment.

INTRODUCTION

Expansion or renovation of pork operations requires a heavy investment in self-feeders for growing/finishing pigs. A well-designed feeder can improve many aspects of pig production such as feed wastage, hygiene, ease of management, and space use. A key to success in feeder design is to accommodate the eating pigs' physical and behavioural requirements. Interviews with both local and international manufacturers have indicated that equipment is often developed with little specific knowledge of pig behaviour, and marketed before extensive testing. Producers have little information available upon which to base their selection of equipment and are often disappointed with their decision. The specific objectives of this study were to:

1. To determine ergonomic measures of the interaction among feeder dimensions and pig body postures.
2. To determine dimensional criteria which limit pigs from stepping into the feeder, but facilitate reaching the feed access point and cleaning of the feeder.

EXPERIMENTAL PROCEDURE

An experimental feeder was constructed to facilitate the frequent adjustments required in this study (Figure 1). The feeder measured 45 (width) x 45 (depth, front to back) x 90 (height) cm in its outside dimensions. A side panel, the feeder lip and the feed shelf were detachable and adjustable. Portions of the feeder were constructed of transparent plexiglass to allow behavioural observations.

Eleven pigs were used in a total of five studies. Tests were conducted at four body weight ranges, when pigs averaged 22.6, 48.4, 71.7, and 95.7 kg. Pigs were deprived of feed for 4 h to ensure that sufficient motivation to eat was present during each test.

Stepping Into the Feeder

This test investigated the effects of feeder depth (feeder lip to feed access point), lip height, and body weight on the occurrence of pigs stepping into the feeder (stepping-in). The test was designed as a 4 x 5 x 4 factorial using four depths of 10, 20, 30 and 40 cm; five lip heights of 0, 5, 10, 15 and 20 cm; and the four body weights of pigs. Feeder width (inside dimension between side panels) was set at 19.4, 25.1, 28.7, and 31.6 cm (110% of shoulder width), at the four body weights studied. Each pig was allowed to eat for 30 seconds, during which time it was recorded if the pig did or did not step into the feeder. The number of pigs with step-ins at each depth/lip height/body weight combination was analyzed using Chi-square procedures.

Normal Reach

This test was conducted at all four body weights using the same feeder widths as in the 'step-in' test, but the feeder lip was removed. While the pig was eating the distance from the tip of its most forward toe to the feed access point was measured.

Eating Zone

Lip height and feeder width were standardized at 10 and 45 cm, respectively. Prior to this test, the bottom of the feeder was overlaid with a thin layer of feed. Each pig was allowed to clean the feeding surface as thoroughly as it could. The portion of the feeding zone, which was made difficult to access due to the feeder lip, was determined by observations. Once the pig was finished eating, the area of residual feed on the feeding surface was measured and the shape of the area drafted.

Position of Pig's Head

The study was organized as a 7 x 4 factorial with seven shelf heights of 0, 10, 20, 30, 40, 50 and 60 cm and the four body weights previously mentioned. Smaller pigs could not reach the higher shelf heights. Feeder widths were set according to body weight as in the step-in test. Head yaw angle and head entrance angle (Figure 2a) were measured while the pig was eating from the feed shelf. Pigs were allowed to eat for 30 sec, during which time the maximum yaw and head entrance angles were recorded.

Body Angle

This test examined the natural body position of pigs when they were not restricted by a feeder. Pigs were tested at all four body weights. Feed was provided from a gap at floor level, with no restrictions to the sides of the pigs, allowing them to turn their bodies freely at any angle toward the wall. The angle between the feed gap (wall) and the body of the pig while it was eating was measured.

RESULTS AND DISCUSSION

Lip Height and Feeder Depth

The incidence of stepping-in the feeder decreased as the weight of the pigs increased, from 66% of the time for 22.6 kg pigs to only 30% for 95.7 kg pigs ($P < 0.01$). Effects of lip height and feeder depth were examined for each weight class, and in all cases feeder depth significantly affected stepping-in ($P < 0.01$). For 22.6 kg pigs, all pigs stepped-in at feeder depths of 30 and 40 cm. Less than 10% of pigs stepped-in when feeder depth was 10 cm. Stepping-in when the feeder depth was set at 20 cm was affected by lip height ($P < 0.01$), with the lowest frequency occurring when lip heights were 5 and 10 cm. For the three heavier test weights, fewer than 10% of the pigs stepped-in at feeder depths of 10 or 20 cm, and all pigs stepped-in at the 40 cm depth, regardless of lip height. Lip heights of 20 cm for 48.4 kg pigs, and 15 or 20 cm for 74.3 kg pigs reduced the frequency of stepping-in at feeder depths of 30 cm.

The normal reach (toe to snout) of the pigs increased with body weight, with mean values of 14.3, 22.4, 27.7, and 32.0 cm, for weights of 22.6, 48.4, 71.7 and 95.7, respectively. The relationship between normal reach and body weight can be expressed as the allometric equation: Normal Reach (cm) = -14.5 + body weight$^{0.333}$(kg). During the analysis of the eating zone, when lip height was set at 10 cm, the zone behind the lip which could only be reached with the throat in contact with the feeder increased in depth from 10.0 to 20.0 cm, for 22.6 and 95.7 kg pigs, respectively.

No combination of lip height and feeder depth is entirely suitable for the wide range of pig sizes considered. The normal reach determined for each weight class would appear to be an appropriate feeder depth in each case. At these depths, the back third of the eating space would be beyond the point at which a 10 cm lip would interfere with eating. Lip heights would have little effect on stepping-in at these feeder depths. However, a 32.0 cm feeder depth, as suggested for large pigs, would result in small pigs regularly stepping into the feeder. Conversely, a depth of 14.0 cm may be ideal for small pigs but would restrict eating by large pigs. It would seem that the best compromise would be a feeder depth between 20 and 30 cm, and a lip height of 10 to 15 cm. A sloping surface from the top of the feeder lip to a point 15 to 20 cm in front of the lip should prevent feed from accumulating in this location.

Head and Body Position

The average yaw angle of the pigs' heads while eating from a shelf was 46.7°. Even when the shelf was at floor level, pigs rotated their heads an average of 42.6°. The smallest pigs (22.6 kg) could not eat from

the shelf when it was 40 cm above the floor, and only the largest pigs (95.7 kg) could reach the shelf at heights of 50 cm. It would appear that shelf height does not become a limiting factor at up to 75% of shoulder height.

During the head yaw and angle test, when they were restricted by the sides of the feeding space, pigs held their heads at angles between 50° and 55° from the feed access point. During the body angle test, when no restrictions were made to side movement, pigs positioned their bodies at angles of approximately 30° to the feed source. In a typical feeder, with side restrictions, head yaw appears to be limited by head entrance angle, which appears to be limited by body angle. The use of side panels to reduce aggression at the feeder may restrict body position such that an unusual eating posture is assumed. Pigs eating from feeders without side panels often approach the feeder from an angle. Rather than forcing pigs to enter a feeder at a 90° angle to the feed access point, perhaps an angled approach should be considered.

When selecting a grow/finish feeder three dimensions are key to selecting a feeder appropriate to your pigs. The width of a feeder space should be about 10% greater than the shoulder width of your largest pig. For pigs marketed at 110 kg, this is approximately 33 cm (13inches).

Cleaning of the Feeding Space

As expected, residual feed was found in the corners and edges of the feeding area. The side edges were virtually clean for all sizes of pigs, but the back edge was most effectively cleaned by the two smaller sizes. This may be due to their small snout, or a more efficient turning of the head. In contrast, larger pigs were better able to access feed near the lip of the feeder. In general, large pigs tended to leave more feed in the corners and along the back edge of the feeding area, while small pigs left feed at the front.

We believe wastage will be minimized throughout the grow/finish period with a depth of 25 cm (10 inch). If feeders are only used in the grow or finish phase, depths of 20cm and 30cm are recommended, respectively. Lip height is probably the least important dimension of the three, a height of 10cm to 15cm can appear to be effective.

CONCLUSIONS

To reduce the incidence of stepping-in the feeder, feeder depth should be kept to a minimum. This minimum can be approximated by the normal reach (toe to mouth) of the pig while eating without a feeder lip. This distance is sufficient to provide the pig an eating zone well beyond the area that is difficult to access in front of the feeder lip. Ideal feeder depth is dependent upon the size of the pig, and varies from 14 to 32 cm for 22 to 95 kg pigs, respectively. Feeders intended for use by pigs throughout this range of weights should be 20 to 30 cm in depth, and have lip heights of 10 to 15 cm to minimize stepping-in.

Unrestricted pigs stand at a 30° angle to the feed, and even when their body position is restricted, will turn their heads to a 45° angle. Pigs also rotate their head as they eat, approximately 50° from vertical. Protective side panels may better define an eating space and provide protection to the pig while eating, but they may also force pigs to stand at awkward angles while eating.

IMPLICATIONS

The ergonomic evaluation of the pig feeder in this study suggests specific dimensions for different weight pigs. Producers and feeder manufacturers should be aware that a single feeder will not be properly dimensioned for pigs throughout the entire grower/finisher period. Manufacturers should also consider feeder designs which allow pigs to orient themselves at an angle to the feed access point. Such designs may facilitate eating by the pigs, but need to be evaluated before being accepted by the industry.

ACKNOWLEDGMENTS

This research was funded by grants from the Alberta Agricultural Research Institute, the Alberta Pork Producers Development Corporation, and the Agricultural Development Fund of Saskatchewan. Commercial feeders used in the studies were donated by manufacturers and distributors. Appreciation is expressed to Curtis Cathcart and Colin Peterson who conducted the trials.

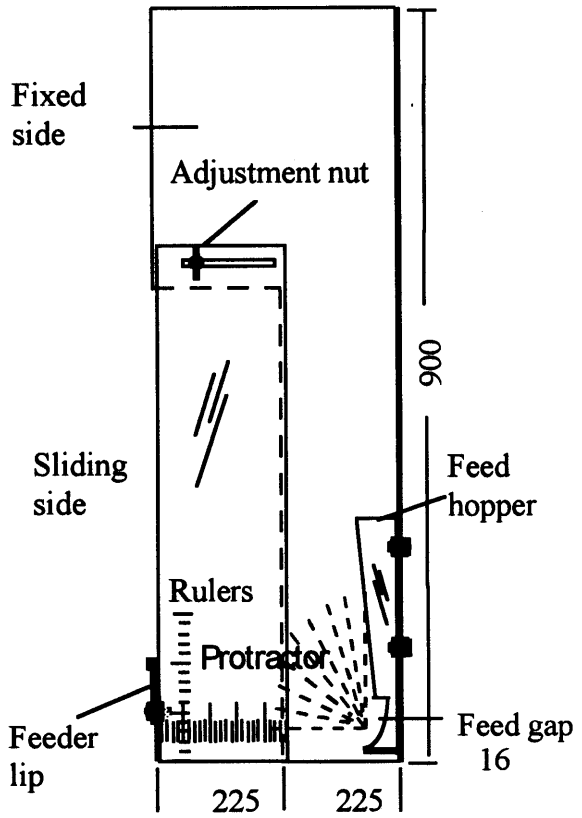


Figure 1. Experimental feeder (measurements in mm)

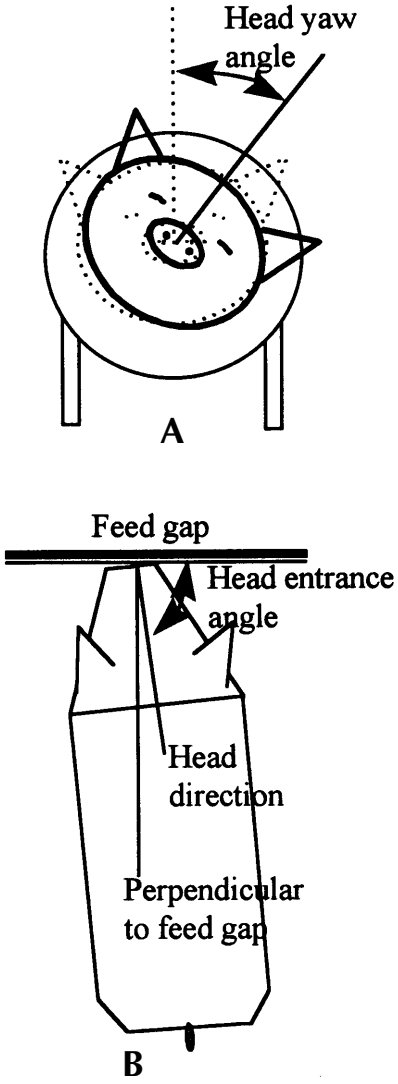


Figure 2. Illustration of head yaw angle (A) and head entrance angle (B)

The feeder evaluations included dry and wet/dry feeder designs

The feeder evaluations included single and multiple space feeders

CAN ODOURS BE USED TO REDUCE AGGRESSION IN PIGS

USING ODOURS TO FAMILIARIZE PIGS PRIOR TO RE-GROUPING

Harold W. Gonyou

SUMMARY

Two studies were conducted with growing - finishing pigs to determine if group odours are involved in the regulation of aggression following re-grouping. In the first study, neatsfoot oil was used as a common odourant. Pigs were exposed to the oil for several days before re-grouping (familiarized), on the day of re-grouping (masked), or not at all (control). None of the oil treatments affected aggression among previously acquainted pigs. Both types of oil applications increased aggression among unacquainted pigs, although the familiarized pigs fought less than the animals which were only masked. In the second study, pigs were exposed to the odours of other pigs by exchanging pens for 3 days prior to re-grouping. Exposure to the odours of other pigs did not affect the aggression which occurred following re-grouping. It is concluded that group odours are unlikely to be involved in modifying aggression among unfamiliar pigs. Aggression is likely related to individual recognition, rather than recognition of the group.

INTRODUCTION

Re-grouping of pigs at weaning, when entering the grow/finish barn, or in breeding pens, leads to aggression which may result in depressed growth, injuries, poor meat quality and stress-induced embryonic loss. Because of these deleterious outcomes, alternative practices may be used (eg. stall housing of sows) or losses are accepted as part of the system. If a means were devised to eliminate this aggression, production losses could be reduced, meat quality could be improved, and group housing of sows would be more feasible.

Recognition among pigs is based on familiarity, that is, prior exposure to each other. The primary sensory modality involved is olfaction (smell). The odour of an individual may convey two types of identifying information. The first is a group odour, indicating that the animal belongs to a specific group, such as a litter. The second is individual identity, identifying the specific individual. If group odours exist in pigs, it may be possible to reduce aggression among pigs by making them familiar with the odour of strangers prior to re-grouping.

The overall objective of this project was to reduce aggression among pigs at re-grouping by exposing them to odours in such a way that they become familiar with each other prior to actually meeting. In the first study, pigs were exposed to a non-pig odour that could be applied to pigs at the time of re-grouping. In the second study, pigs were exposed to the actual odour of unfamiliar pigs prior to their re-grouping.

EXPERIMENTAL PROCEDURE

Growing - finishing pigs were used as the experimental subjects. Pigs in each social group at the time of treatment application had not encountered any pigs from the other groups since prior to weaning, at least 9 weeks previously. Groups of pigs were maintained in pens equipped with solid pen partitions in order to further minimize sensory contact.

Studies 1 and 2 consisted of 7 and 6 replicates over time, respectively. One to three days prior to treatment application, pigs were moved to a semi-intensive room equipped with 20 pens (2.4 x 1.7 m). Pens had fully slatted concrete floors and solid polycarbonate walls. During the treatment application phase pigs were kept in familiar groups of 5-7. The treatment application phase lasted 4 days.

On the day of testing, pigs were allocated to one of 10 test groups. The composition of each resulting test group was such to achieve the desired combinations of familiarity and odour treatment within each replicate, and similar weights within each group. Pigs were marked with a paint crayon to identify individuals within a test group. Once identified, pigs were moved to 10 test pens at which point the test groups were actually formed. Observations began within 30 min of re-grouping.

Observations were accomplished by a team of 5 trained observers. Each pen was observed for four 10-min periods by each observer, for a total of 200 min

within 5 h of re-grouping. Observers recorded the duration of each fight as well as the individuals involved. The beginning of a fight was defined as the time of open-mouthed contact between two pigs. A fight ended when the pigs separated, provided that separation lasted more than 5 sec. Fights were timed with a stopwatch. Data for each test group were summarized to obtain the frequency and total duration of fighting between each pair of pigs.

In Study 1, pigs were exposed to one of three oil treatments: familiarization (F), masking (M), and control (C). Pigs were familiarized to oil by the application of 25 ml of neatsfoot oil applied to their head and neck on each of 3 days prior to, and on the day of testing. The odour of pigs was masked by applying oil to their head and shoulders on the day of testing only. Control pigs were never treated with oil. Test groups were formed in order to create different combinations of acquainted (Acq.) and unacquainted (Unacq.) pigs, within and between oil treatments.

In Study 2, the treatments involved exposing pigs to the odours of other (unacquainted) pigs in one of three ways: exchanged (Exc.), exposed (Exp.), and control (Con.). Odours between two groups of pigs were exchanged by placing each group in the other group's pen, while they were absent, for 6 h on each of 3 days. These pigs subsequently encountered each other on the test day. Pigs were exposed to unfamiliar odours by placing them in the pen of other pigs, while they were absent, for 6 h on each of 3 days, but these pigs did not encounter each other on the test day. Finally, control pigs were moved to a clean pen for 6 h on each of 3 days. Test groups were designed to include various combinations of acquainted and unacquainted pigs, within and between odour treatments.

Each study was analysed using a number of within and between pen comparisons. For between pen comparisons, contrasts were conducted using the GLM procedure of SAS after blocking by replicate. For within group comparisons, relevant groups were selected and analyzed using a two-factor analysis of variance model for degree of acquaintance and oil or odour treatment, after blocking by replicate.

RESULTS AND DISCUSSION

The results of Study 1 are presented in Tables 1 and 2. Previously acquainted pigs fought much less than unacquainted pigs. This was evident in both between and within pen comparisons. Oil treatment had no effect on aggression among acquainted pigs. Among unacquainted animals, the use of either oil treatment resulted in increased aggression, compared with no oil. However, there was evidence in the between pen comparisons that Familiarization reduced aggression compared to Masking. There were no differences among oil treatments for within pen comparisons.

Among unacquainted pigs, previous familiarization with oil reduced aggression compared with exposure to oil without previous exposure. Thus pigs did achieve some degree of recognition through the use of oil. However, use of oil in any fashion increased aggression among unfamiliar pigs. It may be that oil inhibits the development of individual recognition once individuals meet. This could happen if the oil prevented individual odours from being detected. However, among familiar animals, oil did not significantly increase aggression. In this case, sufficient recognition cues were still available to allow identification of the individual.

Degree of acquaintance was also the dominant factor affecting aggression in Study 2. Acquainted pigs fought less than unacquainted pigs in both between pen and within pen analyses (Tables 1 and 3). Prior exposure to the odours of other pigs did not reduce aggression when those pigs were grouped together, or with other unacquainted pigs. In fact, although the results are not statistically significant, the numerical differences would suggest that prior exposure to the odours of other pigs may increase aggression toward those pigs when re-grouped.

Pigs in the exchanged treatment were definitely exposed to the odours of their future penmates. Although it was hoped that this would facilitate their integration upon re-grouping, the pigs clearly recognized the unacquainted pigs as strangers. Exposure to the group odour, or even individual odour, of unacquainted pigs failed to reduce aggression.

Considering the results of both studies, odours intended to instill group recognition failed to reduce

aggression when pigs were re-grouped. These results suggest that group odour is not important, at least in situations in which pigs have not actually encountered the pigs. It may be that aggression is only affected if individual information has been obtained in previous encounters. The results do not support the hypothesis that group odours are involved in reducing aggression. The alternative hypothesis, that individual odours, probably associated with prior experience, are primarily involved with modifying aggression, must be given stronger consideration.

CONCLUSIONS

1. Aggression is greater among strangers than among previously acquainted pigs, regardless of odour manipulation.
2. Exposure to a common odour, or to the odour of each other's group, did not reduce aggression upon later re-grouping of unacquainted pigs.
3. Group odours do not appear to be involved in recognition which would reduce aggression.

IMPLICATIONS

It appears unlikely that any odour familiarization treatment will be effective in reducing aggression among re-grouped pigs. Previous exposure to neither a common odourant nor the odour of unfamiliar pigs reduced aggression when re-grouping subsequently took place. Other means of aggression control will have to be developed in order to reduce injuries, improve meat quality and facilitate social manipulations during pig production.

ACKNOWLEDGMENTS

This research was funded by grants from the Alberta Pork Producers Development Corporation and the Alberta Agricultural Research Institute, under its Matching Grant Program. Appreciation is expressed to Curtis Cathcart and Colin Peterson who cared for the animals, applied the treatments, and organized the trials. Appreciation is also expressed to the numerous observers involved in the trials, and to Dr. Zhengseng Lou who analyzed the data.

Table 1. Between pen comparisons of the effects of level of acquaintance and oil treatment on aggression in pigs (Study 1).

	Comparison		Duration (sec)		Frequency (no.)	
	I	II	I	II	I	II
Study 1:	Acq.	Unacq.	6.5[a]	112.5[b]	0.97[a]	4.71[b]
	Unacq.C	Unacq. F&M	66.7[a]	135.4[b]	4.01	5.07
	Unacq.F	Unacq.M	112.2[a]	158.5[b]	4.14[a]	5.99[b]
	Acq.C	Acq. F&M	12.3	3.6	1.17	0.88
Study 2:	Acq.F	Acq.M	4.0	3.2	0.69	1.07
	Acq.	Unacq.	13.1[a]	134.0[b]	0.85[a]	4.31[b]
	Acq. (E)	Acq. (C)	7.4	18.8	0.72	0.9

[a,b] Means with dissimilar superscripts differ ($P < 0.05$) Acq.= acquainted, Unacq.=unacquainted F=familiarized; M=masked; C=control; E=exposed

Table 2. Within pen comparisons of the effects of level of acquaintance and oil treatment on aggression in pigs (Study 1).

Combinations	Parameter	Oil treatment			Level of acquaintance	
		F	M	C	Acq.	Unacq.
F & C	Duration (sec)	65.50		39.70	24.80[a]	80.40[b]
	Frequency (no.)	4.33		3.03	1.79[a]	5.57[b]
F,M. & C	Duration (sec)	70.30	119.60	90.40		
	Frequency (no.)	2.86	4.36	3.00		

[a,b] Means with different superscripts differ ($P < 0.05$)
Acq.=acquainted; Unacq.=unacquainted; F=familiarized; M=masked; C=control

Table 3. Within pen comparisons of the effects of level of acquaintance and odour exposure on aggression in pigs (Study 2).

Comparison		Duration (sec)		Frequency (no.)	
I	II	I	II	I	II
Acq.	Unacq.	12.1a	79.5[b]	1.08[a]	3.82[b]
Unacq. (Exc.)	Unacq. (Exp. & Con.)	204.8	133.5	4.94	3.51
Unacq. (Exc.)	Unacq. (Con.)	293.2	129.8	3.33	2.33
Unacq. (Exp.)	Unacq. (Con.)	158.2	105.0	4.50	3.67

[a,b] Means with dissimilar superscripts differ ($P < 0.05$)
Exc.=exchange; Exp.=exposed; Con.=control. Acq.=acquainted; Unacq.=unacquainted

GnRH VACCINATION OF INTACT MALE PIGS

THE EFFECT OF GnRH VACCINATION ON FAT ANDROSTENONE CONCENTRATIONS AND CARCASS CHARACTERISTICS OF INTACT MALE PIGS

Sarah R. Robbins and Jack Manns

SUMMARY

The objective of this trial was to determine the pattern of decline of fat androstenone, the main causative chemical of boar taint, in intact male pigs after vaccination with a recombinant GnRH protein.

Four groups of pigs were used. The primary vaccination was given at weaning (21 days of age). The second vaccination was given as the pigs reached 100 kg. Weight gain, fat androstenone and blood samples assayed for testosterone and anti-GnRH antibodies were collected pre-second immunization and weekly thereafter until slaughter. All pigs were slaughtered 42 days after the second immunization and testicular weight, bulbourethral gland length, carcass weight and back fat depth were measured.

There was no difference in carcass weights although live weights prior to slaughter were different between treatment groups. The immunocastrates, late castrates and boars had less backfat than barrows. As expected, mean testicular weight and bulbourethral glands length of boars at slaughter were greater than those of immunocastrates. GnRH titres were detected in all immunized animals 28 days after primary immunization. Within seven days after the second immunization or surgical castration, the mean serum testosterone concentrations of both the immunocastrates and the late castrates were significantly lower than those of boars. By Day 14, there was no difference between immunocastrates, late castrates and barrows. Serum testosterone concentrations remained suppressed until slaughter.

Within seven days after surgical castration, mean fat androstenone concentrations in late castrates had dropped below the olfactory detection level for boar taint (0.5 μg/g). Within 14 days after the second immunization, mean fat androstenone concentrations in immunocastrates had dropped below the detection level. Fat androstenone concentration in immunocastrates remained depressed until slaughter.

These results indicate that immunization with 40 μg GnRH protein in VSA-3 adjuvant in two doses resulted in decrease in serum testosterone and fat androstenone 42 days after the second immunization. Weight gain and growth performance were similar to boars and better than those of barrows at the end of the finishing period.

INTRODUCTION

Except in countries such as England, Australia and Spain, male pigs are castrated surgically shortly after birth. This is done despite the fact that intact males utilize feed more efficiently and have a superior carcass. Boars are not raised for meat production because at typical market weights (>80 kg), some boars achieve sexual maturity. Consequently, androstenone, a volatile, unpleasant smelling steroid produced by the maturing testes, may be present in significant quantities in the edible tissues of some animals. This condition is called boar taint. A certain percentage of pork consumers can detect androstenone at tissue concentration of approximately 0.5 μg/g.

Androstenone secretion by the testes is regulated primarily by luteinizing hormone (LH), a pituitary hormone that is controlled by hypothalamic gonadotrophin releasing hormone (GnRH). Therefore, it should be possible to block testicular androstenone production by eliminating or neutralizing GnRH production. One possible strategy would be to immunize animals against GnRH, thereby interrupting the GnRH-LH pathway and resulting in decreased androstenone secretion by the testes.

The objectives of this trial were: a) to test the effectiveness of GnRH vaccination to immunocastrate intact male pigs and b) to determine the pattern of decline of fat androstenone in intact male pigs after vaccination with GnRH fusion protein at 100 kg live weight compared with animals which had been castrated surgically after such animals had become sufficiently mature to have readily detectable levels of androstenone in their fat.

EXPERIMENTAL PROCEDURE

The trial was conducted in an all-in all-out nursery room and continued in a growing - finishing room at Prairie Swine Centre Inc. The pigs were obtained from one farrowing group and were weaned at approximately 21 days of age. The pigs were blocked by weight and litter of origin and assigned randomly to one of four treatment groups (Table 1).

All pigs received 1 mL of vaccine or placebo intramuscularly in the neck at weaning and when they were approximately 100 kg. Blood samples for testosterone concentration and anti-GnRH antibody titres were obtained by jugular vein puncture at Day 0 (immediately prior to the primary immunization) and at 28 day intervals until the time of the second immunization. At this time the frequency of sampling was increased to every seven days until slaughter. In addition, pigs in Group 1, were sampled four days after the second immunization. Blood was allowed to clot at room temperature, centrifuged and the serum was then frozen within 24 hours after sampling.

All animals were weighed monthly from weaning until the second immunization at which time they were weighed weekly until slaughter. Individual weight gains were calculated.

Subcutaneous fat samples (5 g) were obtained at the time of the second immunization and subsequently at weekly intervals until slaughter (42 days). The samples were obtained from alternating sides of the neck. Fat samples were chilled immediately and frozen within 4 hours after biopsy.

Pigs were slaughtered 42 days after the second immunization. Measurements included carcass weight, backfat depth at the level of the 10th rib, testicular weight and bulbo-urethral glands length.

Anti-GnRH antibody titres and serum testosterone concentrations were determined by radioimmunoassay procedures. Fat androstenone concentrations were assayed by Dr. Jim Squires at the University of Guelph with a colorimetric assay.

RESULTS

PERFORMANCE

There was no difference in weight gain between treatment groups until two weeks prior to slaughter (Figure 1). At such time the growth curve of the barrows leveled off while the immunocastrates, boars and late castrates continued to gain weight at similar rates. The difference in weight was statistically significant one week prior to and at slaughter (live weight).

SLAUGHTER CHARACTERISTICS

Carcass weight: There was no significant difference in carcass weights between treatment groups, although there was a significant difference in live weight prior to slaughter.

Carcass backfat: There was a significant difference in backfat depth between treatment groups. The immunocastrates (24.5 mm), late castrates (24.2) and boars (18.3) had significantly less backfat than barrows (28.0 mm; Figure 2). There was no statistical difference between the backfat depths of immunocastrates and late castrates.

Testicular weight: Boars had significantly greater mean testicular weight than immunocastrates (Figure 3). Mean testicular weight of the boars at slaughter was 641 g and the mean testicular weight of the immunocastrates was 291 g.

Bulbourethral glands length: Boars had significantly larger bulbourethral glands than the immunocastrates and late castrates (Figure 4). Mean bulbourethral glands length of the boars at slaughter was 14.2 cm compared with 9.6 cm for immunocastrates. There was no statistical difference between bulbourethral glands length in the late castrates and immunocastrates. There was no overlap in individual bulbourethral glands length between the boars and the immunocastrates.

SEROLOGY

Anti-GnRH antibody titres: GnRH titres were detected in all immunized animals at a 1:100 dilution at 28 days after the primary immunization. Within seven days after the second immunization, the mean titre had increased to 48% binding at 1:5000 dilution. All of the immunized animals had responded immunologically to the second immunization. All of

the animals in Group 1 had titres within seven days after second immunization at a level which previous work had suggested resulted in effective castration. None of the unvaccinated animals had significant levels of anti-GnRH antibody production (i.e. greater than 10% binding at 1:5000 dilution). The titres in Group 1, peaked at Day 21 after the second immunization and slowly declined until Day 42 after the second immunization (Figure 5). Despite the decline in mean titre, the individual titres remained above effective immunocastrate titres.

SERUM TESTOSTERONE CONCENTRATION:
Within seven days after second immunization or castration, mean serum testosterone concentrations of both the immunocastrates and the late castrates were significantly lower than those of boars. By Day 14, there was no difference between immunocastrates, late castrates and barrows (Figure 6). The barrows had very low concentrations of testosterone throughout the trial. The serum testosterone concentrations remained suppressed until the end of the trial, 42 days after second immunization. There did not appear to be any effect of the primary immunization on serum testosterone concentrations in the immunized pigs.

FAT ANDROSTENONE CONCENTRATION
Due to the small tissue sample sizes (fat biopsy samples < 5 g), which prevented duplicate analysis in a number of samples, there was marked variation in fat androstenone concentrations between serial samples within the same animal and between different animals. Fat samples obtained at slaughter were larger and thus the results were much more accurate. Within 14 days after second immunization, mean fat androstenone concentrations in immunocastrates had dropped below the olfactory detection level for boar taint. Within seven days after surgical castration, mean fat androstenone concentrations in late castrates had dropped below the olfactory detection level for boar taint. This reduction in fat androstenone concentration was significantly different from that of boars seven days after immunological or surgical castration. By Day 14, there was no statistical difference in fat androstenone concentrations between immunocastrates, late castrates and barrows. The fat androstenone concentration in immunocastrates remained below detectable levels of boar taint 42 days after the second immunization.

CONCLUSIONS

Immunization with 40 μg GnRH vaccine in VSA-3 adjuvant in two doses resulted in decreased serum testosterone and fat androstenone concentrations. Immunocastrate titres, based on a decrease in serum testosterone, appeared to occur at titres >18 - 20% binding at 1:5000 dilution (RIA assay). Serum testosterone concentrations drop rapidly to essentially castrate levels within 14 days after the second immunization. Fat androstenone levels decreased to below boar taint detection levels by 21 days after second immunization. Both serum testosterone and fat androstenone levels remain low 42 days after second immunization. Weight gain and growth performance was similar to boars and significantly better than barrows especially at the end of the finishing period. Although the carcasses of immunocastrates were not as lean as those of boars, these had less backfat than those of barrows. A shorter period between the second immunization and slaughter (21 to 28 days as opposed to 42 days) may result in immunocastrates with less barrow-like qualities and leaner carcasses.

IMPLICATIONS

GnRH vaccination at the time of weaning and boosting at no less than 21 days prior to slaughter should result in no detectable boar taint and a leaner carcass at slaughter. Weight gain compared with barrows should also be improved in the late finishing period. Other potential benefits to GnRH vaccination should be the ability to take intact males to a heavier slaughter weight without the risk of boar taint in males.

ACKNOWLEDGEMENT

This trial was conducted at the Prairie Swine Centre and financed by BIOSTAR Inc, Saskatoon.

Table 1. Treatment groups

Group	Description	Number of pigs	Vaccine or Placebo	Time of castration
1	Immunocastrates	11	Vaccine	None
2	Late castrates	6	Placebo	At 110 kg
3	Boars	7	Placebo	None
4	Barrows	6	Placebo	Five days of age

Figure 1. Effect of GnRH immunization on weight gain in pigs during the time period from second immunization to slaughter (42 days after second immunization).

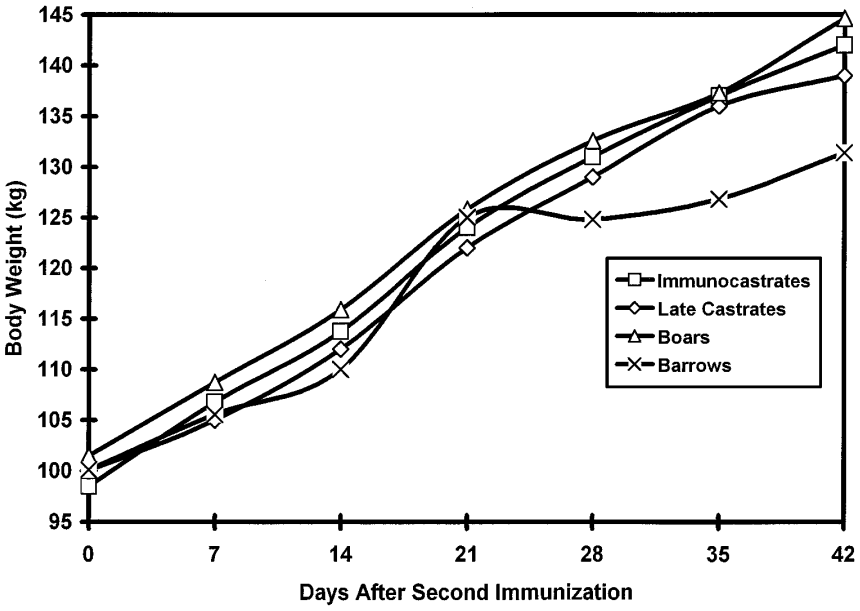


Figure 2. Effect of GnRH immunization on backfat depth at the time of slaughter at 172 days of age (42 days after second immunization(mean +/- SEM). Immunocastrates, late castrates and boars are significantly less

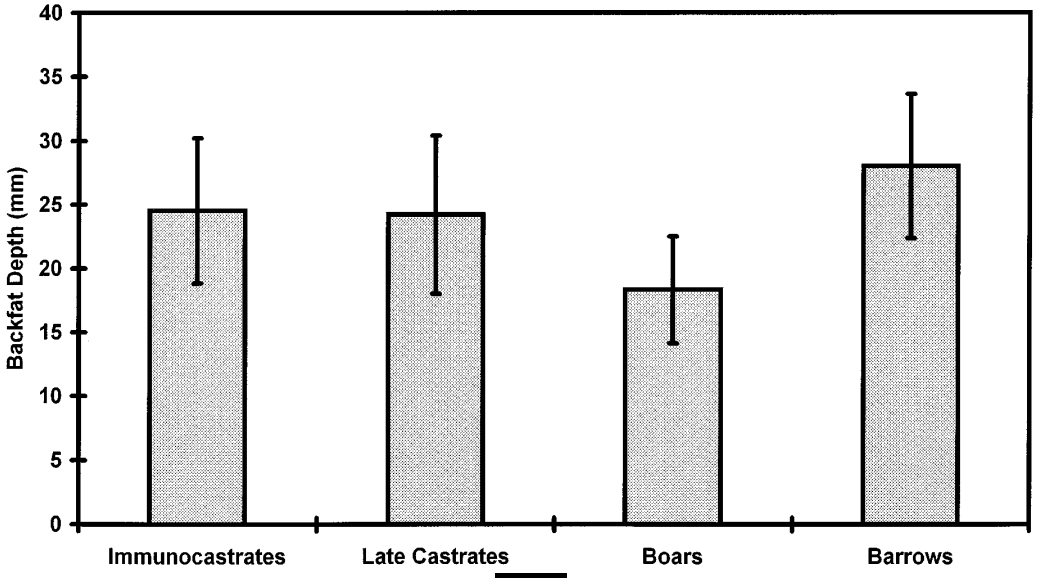


Figure 3. Effect of immunization on testicular weight at the time of slaughter at 172 days of age (42 days after second immunization) (mean +/- SEM).

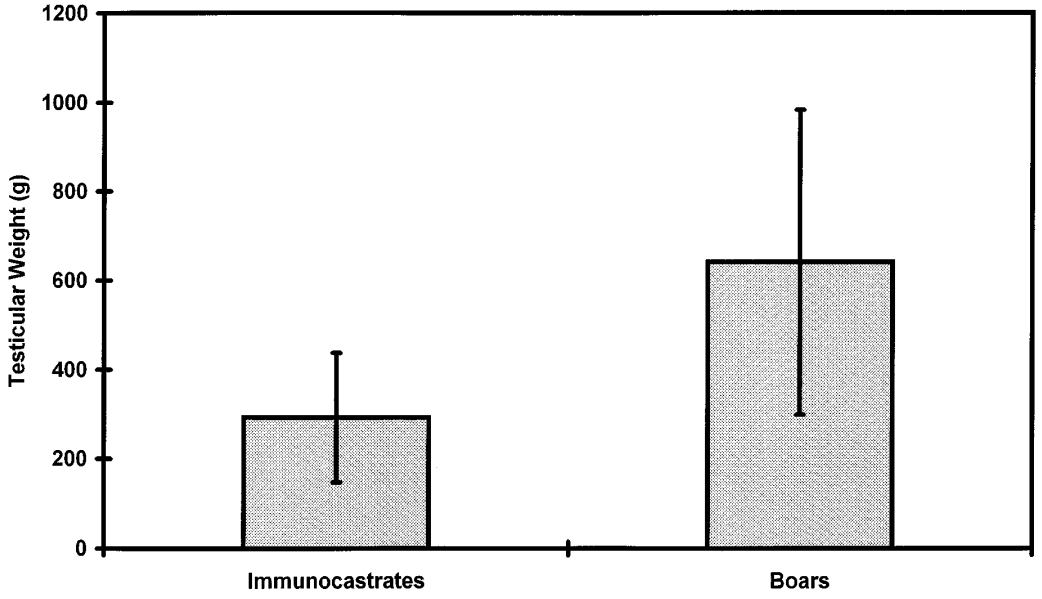


Figure 4. Effect of GnRH Immunization on bulbourethral gland length at the same time of slaughter at 172 days of age (42 days after second immunization) (mean +/- SEM).

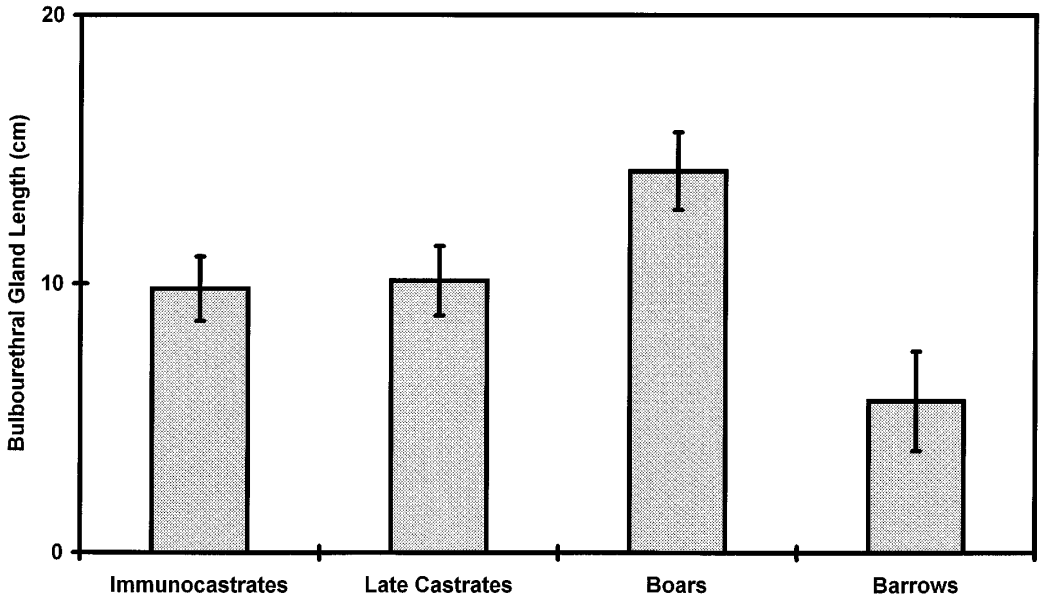


Figure 5. Effect of GnRH immunization on serum GnRH antibody titres in male pigs (mean +/- SD). Arrows represent time of primary and secondary Immunization. Antibody titres are measured at % bound at 1:5000 dilution of serum in Immunocastrates.

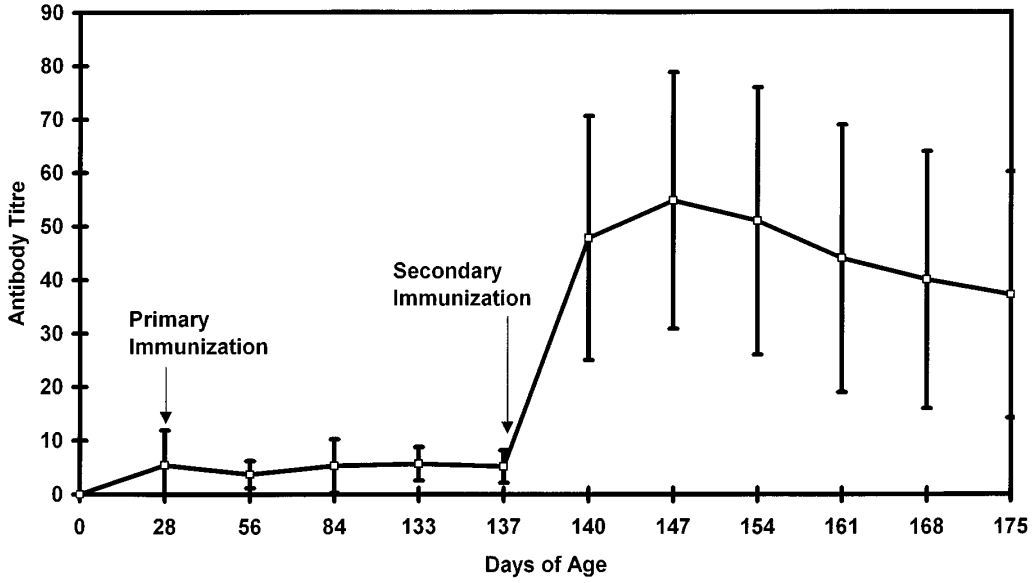
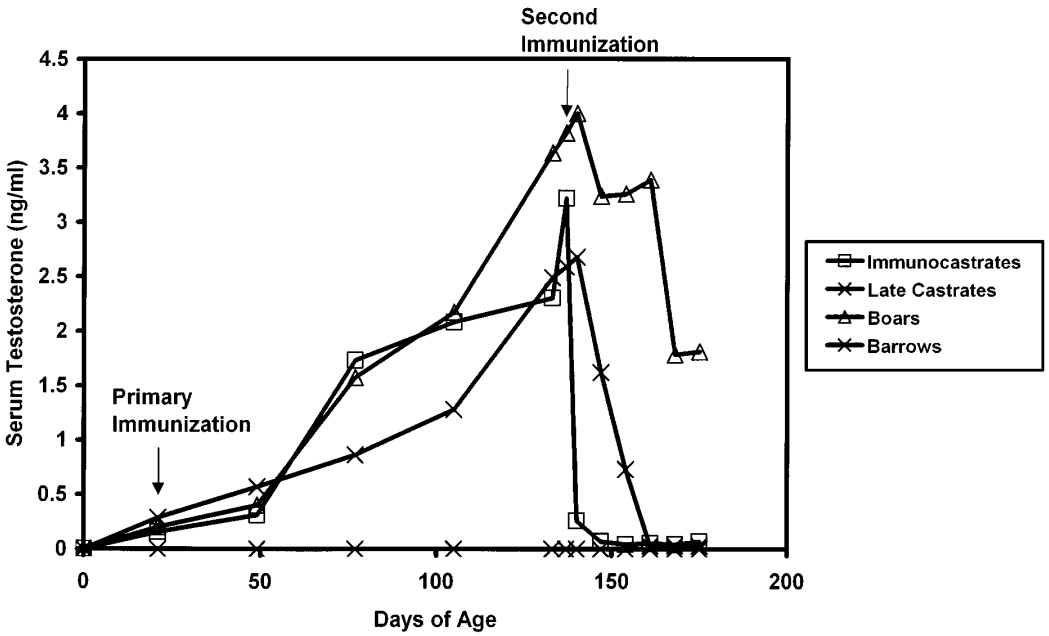


Figure 6. Effect of GnRH Immunization in Male Pigs: Serum testosterone from birth to slaughter.



INJECTING LIQUID HOG MANURE FOR IMPROVING CROP YIELDS

IMPROVING SOIL QUALITY BY SOIL INJECTING LIQUID HOG MANURE AND ELEMENTAL SULPHUR

Mike Grevers and Jeff Schoenau

SUMMARY

The application of hog manure resulted in significant increases in soil fertility, soil structure and crop production; and when applied at a rate of 8,000 gallons per acre, these effects lasted into the second year. The inclusion of elemental sulphur resulted in the greatest increase in crop production on a sulfur-deficient soil at Star City. However, at the other sites the sulphur appeared to decrease the effectiveness of the hog manure. Our research indicates that the acidification process of S-mineralization may negatively affect N-mineralization.

INTRODUCTION

Manure has been recognized as a valuable source of plant nutrients, for its positive effect on soil tilth and for improving crop production in general. However, manure contains a number of ingredients, some of which are harmful to the environment at high concentrations. Manure applied to soil increases the content of various plant macronutrients such as nitrogen and phosphorus, micronutrients such as zinc and copper, and other elements such as cadmium.

Odour problems from manure-applied soils can be addressed by using application methods that incorporate the manure into the soil. A soil-injection system allows for the minimum amount of odours to escape into the atmosphere. The injection of liquid manure into the soil can be achieved by using a ripper-type system, where a flexible hose immediately behind the ripping shank allows the manure to be injected into the slot of soil opened by the ripper.

Hard-pan or Solonetzic soils are well suited for soil injection of liquid hog manure, as these soils are poorly drained and the risk of groundwater contamination by leaching would therefore be minimal. There are 4.5 million acres of Solonetzic soils (hardpan soils) in Saskatchewan.

Elemental sulphur (a virtual waste product from the oil and gas industry) added to the hog manure should further improve the productivity of Solonetzic soils. Injecting sulphur/hog manure mixtures into the soil has the potential for increasing crop production on Solonetzic soils and on soils with crusting problems. This practice would substantially reduce odour problems and because of the poor drainage, characteristics of Solonetzic soils would be an environmentally friendly method for manure disposal.

The objectives of this research were to evaluate soil-injected liquid hog manure for improving crop production on poorly structured soils (hardpan soils and soil with crusting problems, and to determine if the addition of elemental sulfur to soil-injected hog manure increases soil productivity.

EXPERIMENTAL PROCEDURE

Four sites were established in the vicinity of large hog operations. The sites were surveyed extensively to determine the suitability for applying manure. The sites were located at:

1. Central Butte, Echo Clay Loam,
2. Birsay, Kindersley Clay Loam
3. Star City, Waitville Loam
4. Tisdale, Tisdale Clay to Clay Loam

Soils #1 and #2 have soil structure problems involving hardpan layers and poorly structured topsoil. Soil #3 has soil crusting problems and low soil fertility. Soil #4 has less severe soil structure and soil fertility problems; however, farmer experience with similar soils in the area suggests that it required considerable inputs to be productive.

The supply of liquid hog manure was obtained from local hog producers. The manure in the lagoons was first agitated for a two-hour period before it was pumped into the manure applicator tank. The manure was then injected using a deep ripper hooked up to a flexible hose system connected to a pump and supply (holding tank) of liquid hog manure. The depth of soil injection was around 20 cm. The broadcast treatment was carried out by setting the injection system to a depth of 5 cm. The elemental sulfur/hog manure mixtures were prepared separately by incorporating

the sulfur with the hog manure in the holding tank before field application. The treatments were as follows:

- BC: broadcast hog manure @ 4,000 gallons per acre
- RIP: the injector shanks ripped through the soil without adding manure
- HM: soil inject hog manure @ 4,000 gallons per acre
- HM2: soil inject hog manure @ 8,000 gallons per acre
- CNTL: no hog manure applied
- BC+S: broadcast hog manure @ 4,000 gallons per acre + elemental sulfur
- HM+S: soil inject hog manure @ 4,000 gallons per acre + elemental sulfur
- HM2+S: soil inject hog manure @ 8,000 gallons per acre + elemental sulfur

The chemical characteristics of the hog manure and the concentration of nutrients etc. applied with the hog manure are shown in Table 1. At rates of 4,000 and 8,000 gallons per acre, the actual field application rates of N, P, K and other nutrients are shown in Table 2.

Soil samples were collected and analyzed in the subsequent spring from each of the plots to a depth of 60 cm in increments of 0 - 15, 15 - 30, and 30 - 60 cm.

Crop yield was determined by using square meter frames to harvest crop samples just prior to swathing. A total of six replicate samples were taken for each treatment in each of the replicate blocks (6 reps for each treatment for each replicate block). The crop samples were taken to the Crop Development Centre at the University of Saskatchewan where they were allowed to dry and subsequently threshed. Total weight and grain weights were determined.

1. Soil chemical properties

The acidity (pH), salinity (EC), and and sodicity (SAR) measured in May of 1995 are shown in Table 3. The pH values indicate near neutral to alkaline condition for three of the sites, while the pH values for the Tisdale site indicate slightly acidic conditions. The highest pH values were associated with high SAR values. Sodic soil layers typically have pH values at or greater than 8.5. The low pH values found at the Tisdale site are in line with those for Luvisolic soils.

The salinity values (EC) indicate non-saline conditions (< 4 dS/m) for all the soils. The lowest salinity values were found in the irrigated (Birsay site) and Luvisolic soils (Tisdale and Star City). The highest salinity values were found in the dryland Solonetzic soil (Central Butte).

2. The effect of the treatments on soil fertility at the start of the 1995 growing season

The hog manure treatments increased plant available nitrogen by up to 64 lb./acre when applied at 8,000 gallons per acre. Most of the increase in plant available nitrogen was in the form of nitrate.

The relative concentration of ammonium- vs. nitrate-nitrogen was markedly different between the plots. At Central Butte and at Birsay (data not shown), most of the plant available nitrogen was in the nitrate form (88% and 90% of plant available N, respectively), whereas at Star City and at Tisdale the percentage of nitrate nitrogen was considerable smaller (only 45% and 33% of plant available N, respectively).

There was no effect of adding elemental sulphur on plant available nitrogen levels. However, there was a trend in the data for the Central Butte and the Tisdale sites showing a negative effect of S on soil nitrate nitrogen levels. The oxidation process of elemental S to sulphate is an acidifying process which effects nitrification, and lower soil nitrate-nitrogen levels may therefore be expected when sulphur is added to hog manure.

3. Soil structure and soil-water content

The injection of liquid hog manure reduced the bulk density of the surface 10 cm at the Central Butte and at the Tisdale sites (data not shown); there were no significant differences in soil density at the other sites. The hog manure application did not effect soil crust formation or soil strength. There were no differences in soil-water content.

Hog manure application had a significant effect on soil aggregation (aggregate size) (Table 4). The average diameter of soil aggregates was increased by 38%. There was no effect on soil aggregation regarding the rate of hog manure applied (4,000 versus 8,000 gallons per acre), the incorporation of S with the manure, or the method of manure application (broadcast versus injected).

4. Crop production and grain quality

The 1995 yield results (the first year since manure application) show two sites with a substantial response to hog manure, especially at the high rate (8,000 gallons per acre), and one site with a strong response to sulphur but not to hog manure; the remaining site showed little response (Table 5). The low rate of hog manure increased total dry matter production between 9% and 15%, while the high rate of hog manure increased total dry matter production between 33% and 36%. Hog manure increased the average grain yield by 30%; however, there was little difference between the hog manure rates. There was no effect of the treatments on the % carbon in the grain, nor on the % nitrogen (or protein content) of the grain.

Crop production in the second year since application (Table 5) increased dry matter yields by 9.5% at the Birsay, Star City and Tisdale sites, and by 136% at the Central Butte site. There was no significant increase in grain yield for the Birsay, Star City and Tisdale sites; however, at the Central Butte site grain yields were increased by 128%.

DISCUSSION

The application of hog manure resulted in significant increases in soil fertility, soil aggregation and crop production; and when applied at a rate of 8,000 gallons per acre, these effects lasted into the second year. The most important aspect of the treatments was the hog manure itself, regardless of the application method (broadcast vs. injected) or of the application rate (4,000 versus 8,000 gallons per acre). The inclusion of elemental sulphur resulted in the greatest increase in crop production on a sulfur-deficent Gray Luvisol (Star City). However, at the other sites the sulphur appeared to decrease the effectiveness of the hog manure. Lower available nitrogen levels in the HMS treatments compared to that of the HM treatments suggests an inhibitory effect of S on plant available N. Our research indicates that the acidification process of S-mineralization may negatively affect N-mineralization. The Tisdale soil has the lowest surface soil pH of the sites (the pH of the top 30 cm varied between 6.0 and 6.1, whereas the pH at the Central Butte site varied between 7.3 and 7.8), and N-mineralization may therefore be the more affected by elemental S application.

Table 1. Analysis of hog manure.

	Star City Hog Manure[Y]		Birsay Hog Manure[Z]	
	HM	HM+S	HM	HM+S
pH	8.8	8.8	8.6	8.5
EC (dS/m)	12.2	12.0	16.1	14.0
SAR	12.8	11.7	14.1	9.9
Water contents (%)	95.2	95.2	95.1	95.4
Total N (mg/L)	1461	1500	2270	1528
$N0_3^-$ (mg/L)	<0.4	<0.4	<0.4	<0.4
NH_4^+ (mg/L)	1180	1125	1800	1205
Organic N (mg/L)	281	375	470	323
Total S (mg/L)	117	837	607	4876
$S0_4$= (mb/L)	26	171	84	1315
P (mg/L)	267	256	444	345
K (mg/L)	1175	1207	1414	1230
Na (mg/L)	390	378	384	406
Ca (mg/L)	60	69	51	96
Mg (mg/L)	6	6	<1	18
C1 (mg/L)	766	735	726	812
$HC0_3$ (mg/L)	3100	2817	3469	2054
Total Cu (mg/L)	11	10	4	12
Total Zn (mg/L)	15	13	17	17

[Y,Z] denote the manure source used for Sites 3 and 4 and Sites 1 and 2, respectively.
HM=hog manure
HM+S, hog manure with elemental sulfur

Table 2. Amounts of nutrients added to the soil in the hog manure.

	Star City Hog Manure[Y]				Birsay Hog Manure[Z]			
	HM	HM+S	HM2	HM2+S	HM	HM+S	HM2	HM2+S
	Lb/acre							
Total N	58.4	60.0	116.8	120.0	90.8	61.1	181.6	122.2
NH_4+	47.2	45.0	94.4	90.0	72.0	48.2	144.0	96.4
P_2O_5	10.7	10.2	21.4	20.4	17.8	13.8	35.6	27.6
K_2O	56.4	58.0	113.8	116.0	67.9	59.0	135.8	118.0
Total S	4.7	33.5	9.4	67.0	24.3	195.0	48.6	390.0
SO_4^-	1.0	6.8	2.0	13.6	3.4	52.6	6.8	105.2
Ca	2.4	2.8	4.8	5.6	2.0	3.8	4.0	7.6
Mg	0.2	0.2	0.4	0.4	<0.1	0.7	<0.1	1.4
Na	15.6	15.1	31.2	31.2	15.4	16.2	30.8	32.4
C_1	30.6	29.4	61.2	58.8	29.0	32.5	58.0	65.0
Cu	0.4	0.4	0.8	0.8	0.0	0.5	0.4	1.0
Zn	0.6	0.5	1.2	1.0	0.7	0.7	1.4	1.4

[Y,Z] denote the manure source used for Sites 3 and 4 and Sites 1 and 2, respectively.
HM = 4,000 gallons per acre of hog manure, respectively.
HM2 =8,000 gallons per acre of hog manure, respectively.
HM+S =4,000 gallons per acre of hog manure plus elemental S
HM2+S =8,000 gallons per acre of hog manure plus elemental S

Table 3. Soil chemical and mechanical characteristics of the four sites.

				Soil Mechanical Properties				
Depth (cm)	Site	pH	EC (dS/m)	SAR	Sand	Silt %	Clay	Texture
0-10	C. Butte	7.34	1.84	7.71	45.3	23.9	15.4	L
10-30		7.77	2.46	11.52	42.7	27.4	18.3	L
30-60		8.24	3.16	ND	40.8	28.2	19.7	L
0-15	Birsay	7.40	0.68	1.35	32.7	28.5	38.8	CL
15-30		8.18	0.56	2.55	24.4	25.9	49.6	C
30-60		8.65	0.58	5.06	23.5	29.8	46.8	C
0-15	S. City	7.20	0.17	0.56	74.3	15.7	10.0	SL
15-30		7.75	0.18	0.63	64.6	21.4	14.1	SL
30-60		8.16	0.19	0.54	62.7	22.6	14.9	SL
0-15	Tisdale	6.07	0.32	1.16	16.9	38.4	44.7	C
15-30		6.01	0.22	1.63	14.7	36.4	48.9	C
30-60		6.97	0.37	3.55	10.9	31.6	57.5	C

Table 4. The Effect of Hog Manure on Soil Aggregation.

	Birsay	Star City	Tisdale	Central Butte	Relative size
	Aggregate size (MWD in mm)				
Manure	14.7	8.1	14.7	23.7	138[b]
Control	8.5	5.8	10.6	19.5	100[a]

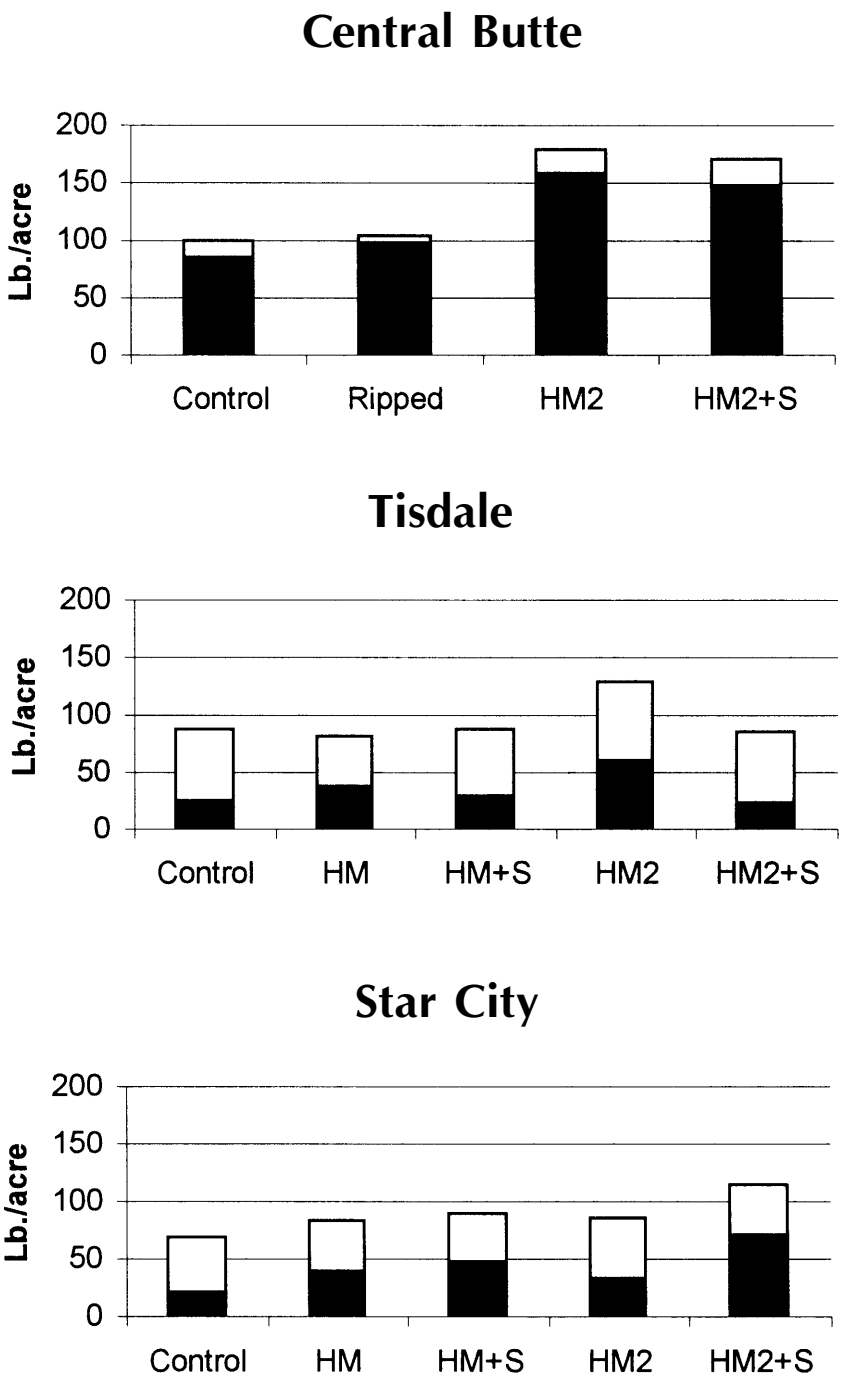
Totals with different superscripts within the same column denote significant differences at 95%

Table 5. The effect of different hog manure treatments on crop production.

	Central Butte	Birsay	Star City	Tisdale
1995 Growing Season				
		Dry Matter Production in t/ha		
Ripped	6.13[a]			
Control	5.27[a]	6.38[a]	3.45[a]	6.01
HM		8.31[b]	3.89[ac]	5.55
HM+S		7.81[ab]	5.06[bc]	5.34
HM2	9.55[b]	8.18[b]	3.89[ac]	6.48
HM2+S	8.87[b]	8.56[b]	5.37[b]	5.81
Grain Production in t/ha				
Ripped	2.37[a]			
Control	2.08[a]	2.31[ac]	1.82[a]	3.33
HM		2.14[c]	1.79[a]	3.12
HM+S		3.01[a]	2.60[bc]	2.92
HM2	3.33[b]	3.25[b]	2.03[ac]	3.69
HM2+S	3.36[b]	3.27[b]	2.69[bc]	3.22
1996 Growing Season				
		Dry Matter Production in t/ha		
Ripped	1.30[a]			
Control	0.74[a]	6.31[a]	5.38	4.21[a]
BC		6.86[ab]	5.57	4.50[a]
BC+S		7.61[ab]	5.47	4.23[a]
HM		7.10[ab]	5.48	4.65[ab]
HM+S		7.35[ab]	5.80	4.16[a]
HM2	1.92[a]	7.92[b]	5.45	5.07[c]
HM2+S	2.89[b]	7.83[b]	5.34	4.07[a]
		Grain Production in t/ha		
Ripped	0.67[a]			
Control	0.34[a]	3.07	2.29	1.23[a]
BC		3.18	2.22	1.31[a]
BC+S		3.61	2.13	1.24[a]
HM		3.16	2.17	1.36[ab]
HM+S		3.56	2.06	1.27[a]
HM2	0.95[a]	3.55	2.32	1.52[b]
HM2+S	1.35[b]	3.59	1.86	1.27[a]

HM+S and HM2+S = 4,000 and 8,000 gallons per acre of hog manure, respectively.
HM+S and HM2+S = 4,000 and 8,000 gallons per acre of hog manure plus elemental S, respectively
a-c: different letters following means for each year indicate significant difference at 95%

Figure 1. Spring available nitrogen in the form of ammonium (top) and nitrates (bottom) in the top 60 cm of the thee sites.



HM = 4,000 gallons per acre of hog manure
HM2 = 8,000 gallons per acre of hog manure
HM+S = 4,000 gallons per acre of hog manure plus elemental S
HM2+S = 8,000 gallons per acre of hog manure plus elemental S

TEMPERATURE REQUIREMENTS FOR PIGS

DEFINITIONS OF AMBIENT TEMPERATURE REQUIREMENTS FOR PIGS: A REVIEW

Mark L. Lorschy

SUMMARY

Pigs, like all animals, have an ability to live in a variety of thermal environments. Although pigs can adapt to some degree to different thermal environments, there is a cost to production associated with keeping them outside their comfort zone.

During cold stress, pigs consume more feed to maintain their core body temperature (the temperature of their vital internal organs). The extra feed consumed is not used for body weight gain. On the other end of the scale, heat stress will reduce feed intake in the pig; production is reduced in the case of the lactating sow because of the reduction in milk production. It is also observed that pigs heat stressed in the growing phase are fatter.

There are many factors, which influence the thermal environment of the pig. Some of the more obvious are the temperature outside the barn and artificial heating in the barn. Others that are less obvious include stocking density in the pen, type of flooring and feed intake; however, there are many more. Most of these factors can be manipulated in some way by the producer or by the pig itself to reduce the effects of thermal stress.

Although there are values in books, which indicate the optimal temperature ranges for pigs of different body weights and production phases, being able to recognize signs of cold or heat stress in your pigs is the best way to adjust the set point temperature and ventilation rate in your barn rooms.

THE PIG CONTROLLING ITS OWN BODY TEMPERATURE

Throughout the pig's life, it attempts to control its body temperature within a narrow range (39 ± 0.5°C). This is, of course, essential for life processes. The control of body temperature, called thermoregulation, is a balancing act between the control of those components which contribute to heat production and those associated with heat exchange (including heat gain and heat loss) between the animal and its environment.

The pig is able to regulate both heat production and heat exchange to the environment over a wide range of climatic conditions. This is a good thing, because the thermal environment in which the pig is maintained may not always be ideal. The pig's perception of the thermal environment is through changes in core body temperature.

Regulation of heat production by the pig is achieved by various mechanisms including (Figure 1):

* Alterations in food intake -food digestion produces body heat
* Alterations in activity -body movement creates body heat
* Shivering -muscle shaking generates body heat-
* Non-shivering thermogenesis -special body processes generate body heat

Regulation of heat exchange between the pig and the environment is achieved by various mechanisms including (Figure 1):

* Altering the rate of blood flow to the skin
* Changing posture
* Huddling
* Regulating evaporative heat loss from the lungs and skin

There are other factors, which will change the magnitude of heat production and heat exchange with the environment:

* The productive state of the pig
* Growing versus maintenance
* Pregnant versus lactating
* The composition of the diet
* Stocking density
* Bedding and floor type
* Tissue insulation
* Area of wet skin
* Rate of air movement
* Vapour pressure of air
* Radiant heat
* Ambient temperature

THE COMFORT ZONE

The comfort zone, or zone of thermal comfort, is simply the range of temperatures with which the pig is not cold or hot (Figure 1). The lower end of the thermal comfort zone is called the lower critical temperature (LCT). Pigs housed at or below their LCT will increase their heat production by shivering and by attempting to increase feed intake.

There is a limit to how much cold a pig may be able to cope with. The lower limit is determined by how much the pig can increase its heat production. Of course this is constrained by how much the pig can eat and by the energy density of the diet. If heat loss continues to exceed summit metabolism the animal will die from chilling.

When the ambient temperature rises above LCT, the animal will regulate heat production and heat exchange to the environment by mechanisms that require a minimal expenditure of energy. Within the zone of thermal comfort the animal may change the rate of heat lost:

* Through the skin by altering skin blood flow wetting its skin
* By a change in huddling behavioural so that the pig alters contact with other pigs
* By altering posture to vary skin contact with the floor when the floor temperature is different from skin temperature, or
* By seeking an alternative floor type

HOW TO RECOGNIZE A PIG IN COLD STRESS

A pig housed in a cold barn will of course eat more feed. It would be no surprise to any producer, that if the extra energy provided by the increased food intake does not keep the pig warm, then the pig will huddle with its pen mates, and may shiver.

Generally, the LCT declines with an increase in bodyweight. Some rough guidelines for the comfort zone are given in Table 1.

HEAT STRESS

As ambient temperature continues to increase to the upper range of the zone of thermal comfort, the control of body temperature can be achieved through substantial increases in heat loss. This loss of heat is from the evaporation of water from the lungs and the skin. The major component of the increased heat loss is through increases in breathing rate as heat loss via sweating in the pig, compared to other mammalian species, is ineffective.

The ambient temperature at which evaporative heat loss increases markedly is termed the evaporative critical temperature (ECT).

As the ambient temperature continues to exceed ECT, the body temperature may rise from 39.0 to 40.5°C. The rise in body temperature will increase the temperature difference between the body core and skin, allowing an increase in the rate of heat loss from the animal to the environment.

The upper critical temperature (UCT) is the temperature at which the animal's maximum rate of heat loss coincides with the maximum rate of evaporative heat loss through respiration.

At UCT, food intake is minimal and further rises in ambient temperature cannot be compensated for. Body temperature will increase uncontrollably and death may follow.

CONFUSION ABOUT THE TEMPERATURE ABOVE WHICH THE PIG IS HEAT STRESSED?

There is confusion in the literature about where pigs become heat stressed. The 'old school of thought' used to define heat stress where ambient temperature exceeded the upper critical temperature (UCT). But how can it? The pig reduces feed intake and level of activity to reduce heat production above UCT. However, there is still an unavoidable increase in heat produced, because of the increase in respiration.

How to Recognize a Heat Stressed Pig

Information in the literature regarding ECT for all physiological states of the pig is scarce. The reason for this is because of the lack of research in the area and the complexity of factors involved in determining ECT. Table 1 gives a guide to values of ECT for pigs of different productive stages.

Typically pigs breath at a rate between 20 and 30 breaths per minute. One of the first signs of heat stress is that the pig will pant. The higher the panting rate, the higher the temperature above ECT.

Of course, in combination with the increase in panting, you'll see that the pig will reduce its feed intake. Again, the higher the temperature above ECT, the larger the impact on feed intake.

Heat stressed pigs may also spread out on the pen floor, dung throughout the pen, and/or will use water (either urine or from the nipple drinker) to wet their skin.

COST OF PRODUCTION DURING HEAT STRESS

Assuming that the only effect of heat stress on the growing pig is that on feed intake (assuming no effect on feed conversion efficiency), we can examine what effect this decline in feed intake has on the cost of production.

I will use a simplified example of a growth curve for market pigs, averaging 890 g/d with feed intake equal to 95% of NRC. For convenience, I will assume one diet is fed (3349 kcal DE/kg) from weaning (21 d) to market (105 kg bodyweight).

If pigs were housed at a temperature that was above their comfort zone, such that feed intake declined by 20%, these pigs would take a further 29 days to reach market weight (155 vs. 184 days). An additional 30 kg of feed is required to bring a pig to market. If feed costs are $175 per tonne (1000 kg), then the additional feed alone would cost $5.25 per pig.

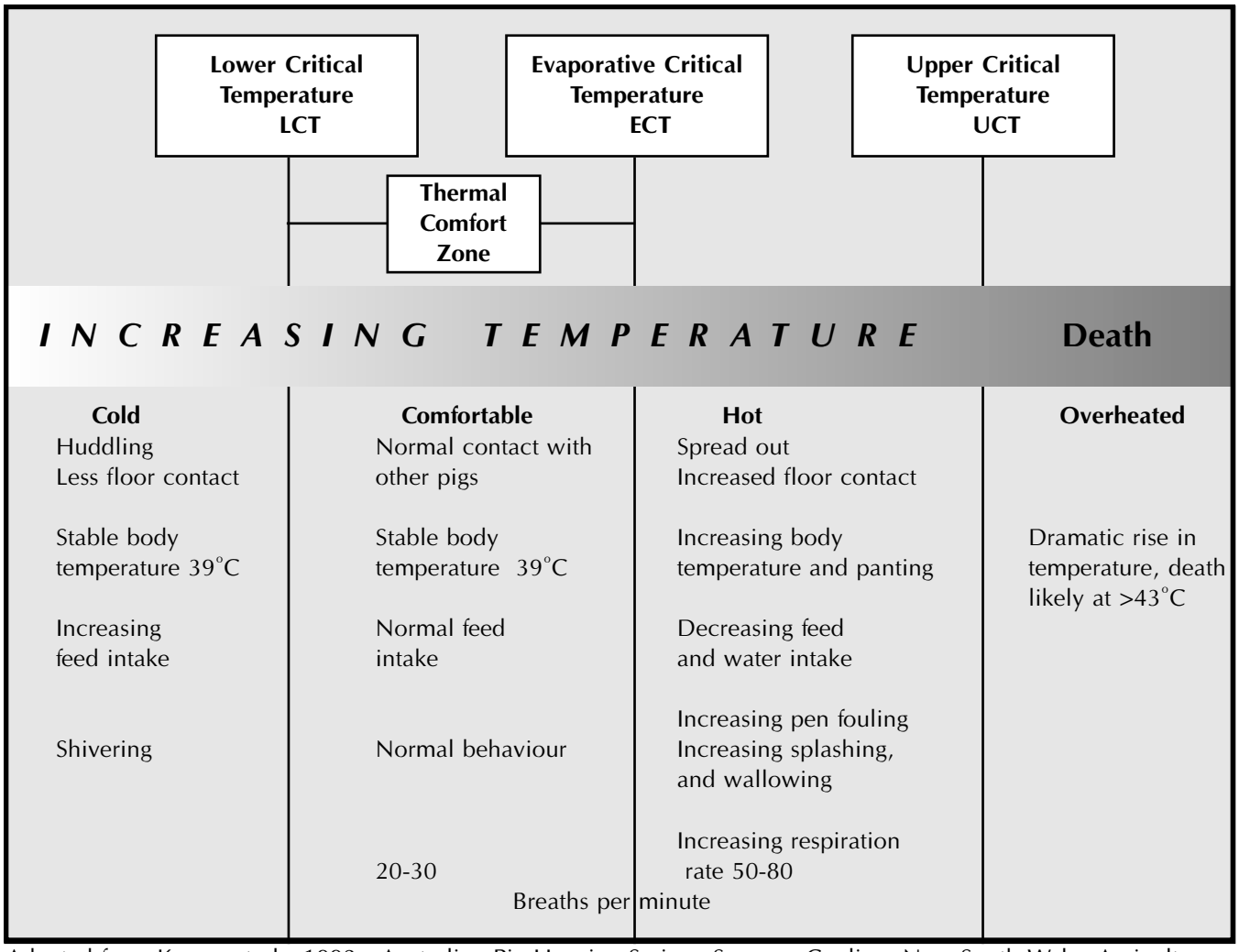
There is an additional loss in productivity, as it takes longer for heat stressed pigs to reach market. In the situation where pigs are not heat stressed throughout the year, the barn or room throughput (i.e. 500 pigs x 365 days per year / 155 days to market) is 1177 pigs per year. If one barn cycle is heat stressed from weaning to market, it is only possible to grow-out 1084 pigs/year (i.e. loss of 94 pigs/year). With a gross market after feed and other variable costs of $65 per pig, this represents an additional loss of $5.14 per pig.

This example illustrates the potential benefits of using spray and ventilation cooling and other means to minimize the effect of the high effective temperature from pigs.

WHAT TEMPERATURES KEEP PIGS IN COMFORT ZONE?

Recommended set point temperatures for use under typical commercial conditions are presented in Table 2. These recommended set points therefore serve only as guidelines. Remember though, that they are only guidelines. Again, many factors besides ambient temperature affect the animal's perception of its thermal environment, and these have already been identified in this article.

Figure 1. Pig's response to temperature.



Adapted from Kruger et al., 1992. Australian Pig Housing Series - Summer Cooling, New South Wales Agriculture, Tamworth, Australia

Table 1. Examples of critical air temperatures.

STOCK	AGE (wk)	WT (kg)	FLOOR TYPE	AIR SPEED	ENERGY INTAKE (Mcal DE/d)	SKIN WETNESS (%)	TEMP. (°C) LCT	ECT	UCT
Piglets	1	2	mesh	still	ad lib	15	26	35	41
	4	5					24	33	39
Weaners	5	7	mesh	still	ad lib	15	26	35	41
	6	10					24	33	39
	8	16					22	30	37
	5	7	concrete	still	ad lib	15	27	36	42
	6	10					25	34	40
	8	16					23	31	38
Growers	9	20	concrete	still		15	16	30	38
	15	50				15	12	28	36
	21	90					9	27	36
	9	20	concrete	draughty		15	18	32	39
	15	50					15	30	37
	21	90					14	29	36
	9	20	concrete	draughty		60	20	34	42
	15	50		+ spray			17	32	40
	21	90					16	31	39
Dry sows		150	concrete (one sow)	still	6.5	15	15	27	36
				draughty	6.5	15	18	27	36
				D+spray	6.5	60	20	33	40
			concrete (group of 5 sows)	still	6.5	15	12	26	35
				draughty	6.5	15	15	28	38
				D+spray	6.5	60	18	32	40
Lactating sows		150	mesh	still	ad lib	15	8	22	32
				still+drip		30	9	26	33
			concrete	still	ad lib	15	10	23	33
				still+drip		30	11	25	34

Adapted from Kruger et al., 1992. Australian Pig Housing Series - Summer Cooling, New South Wales Agriculture, Tamworth, Australia

This table is not a set of recommendations. It gives examples of critical temperatures for the various conditions shown.

SKIN WETNESS: 15%, normal due to drinkers; 30%, during drip cooling; 60% average for spray cooling

Table. 2. Recommended setpoint temperatures.

	Heating season[2]		Setpoint 1 temperature (°C)	Cooling season[3]		
Room and body Mass (kg)	Solid floor	Slatted floor	Solid floor with straw	Solid floor	Slatted floor	Slatted floor with straw
Dry sows	17	19	15	19	21	18
Farrowing*	16	18	14	18	20	17
Weanling 7 kg*	26	28	25	27	29	26
20 kg	23	24	22	24	26	22
Grower/finisher (continuous)						
25-60 kg	18	20	16	19	21	18
60-100 kg	14	16	12	16	17	15
25-100 kg (all-in-all-out)	18	19	17	19	21	18
25 kg*	21	23	20	22	24	22
30 kg	20	22	18	21	22	20
35 kg	19	20	17	19	21	18
40 kg	17	19	16	18	20	17
45 kg	16	17	15	17	18	16
50 kg	15	16	14	16	17	15
55 kg	14	15	13	16	17	15
60 kg	14	15	12	16	17	15
70 kg	14	15	11	16	17	15
80 kg	14	15	10	16	17	15
90 kg +	14	15	10	16	17	15

Source: Zhang, 1994. Swine Building Ventilation: A Guide for Confinement Swine Housing in Cold Climates, Prairie Swine Centre Inc., Saskatoon, Canada.
These set point temperatures are recommendations only. Variations in ideal set point temperatures will differ among farms due to the factors described in the above article.

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