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Cover Photo
Kaleesi Monk, age 6, wants to be a scientist when she grows up, and she was able to play the part during a recent event at the University of Manitoba.

Precision feeding

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Canadian Hog JOURNAL

Message from the editor

Summer is here, and with it, our annual custom of honouring the people who bring us the swine science that keeps our industry on top. It really has become a tradition, and every year I look forward to sending out the email asking for researchers to submit their best work. I also open the door to researcher biographies, and articles about the institutions where this research takes place.

Inside this issue we also talk to Murray Pettitt, the new CEO of Prairie Swine Centre and we learn how 4-H has shaped young people across Canada to lead in agriculture and beyond. Keeping young people interested in agriculture can be a tough challenge when the business is almost impossible to get into unless you inherit it or win the lottery. But there are other options, and Canada's youth is exploring them. I believe that by celebrating the science behind the industry, we help to recognize that agriculture in this country isn't just in the barn or in the field. We have a lot to be proud of!

The adorable little girl on the front cover is my niece, Kaleesi Monk. My sister had coincidently attended the Manitoba Science Rendezvous at the University of Manitoba in April. I couldn't resist using it when I saw it, especially because right now, at age six, she wants to be a scientist when she grows up. My niece reminds me of my sister, who is nearly 11 years younger than I am. She came to be one time when she was in Grade three, and she told she wanted to be an animal nurse. I asked her, "why not a doctor?" and she had no good answer, so she changed her mind and decided she wanted to be a veterinarian.

Times have really changed since I was a kid. I remember being told that boys were naturally better at math and science than girls were, and looking back, I am stunned that society just accepted this, and even perpetrated the myth. I am so thrilled that today all children are encouraged to pursue their dreams and to live up to their full potential. It's hard to believe that every single researcher represented in this edition was once just a little kid with a dream. ■

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S Monk.

Sheri Monk
Editor, business manager

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4-H clubs help foster a thirst for learning, science

"I pledge my HEAD to clearer thinking, my HEART to greater loyalty, my HANDS to larger service, and my HEALTH to better living, for my club, my community, my country, and my world." That is the pledge that 25,000 young people across Canada take when they join the world of 4-H.

By Sheri Monk

It's a rite of rural passage, a tradition and a hobby. But for many kids, their involvement in 4-H leads to a career in agricultural science.

"4-H offers a lot in the way of career exploration. We have one program, Careers on the Grow, designed entirely to expose youth to careers in the agriculture sector as well as related sectors such as science and technology and the environment and healthy living. This program includes a job matching platform, internship opportunities, mentorship and resources to support career development," said Erin Smith, program director for 4-H Canada. "Many of our other programs also allow members to build networks, develop leadership skills and explore and learn about emerging career paths, information about labour gaps and trends in various sectors, including agri-business and agri-food."

Hilary is dressed in her 4-H costume best at an agriculture club fundraiser for STARS Air Ambulance.

Hilary Baker grew up in Rocky Mountain House, Alberta and joined 4-H when she was 11 years old. She joined a variety of clubs, mostly centered around her passion for horses and riding. She attended the University of Alberta, achieving a Bachelor of Science in Agriculture, and she was part of the University of Alberta Collegiate 4-H.

"My university faculty was Agriculture, Life, and Environmental Sciences which was an incredibly supportive faculty with some amazing clubs, one of which was Collegiate 4-H. I was lucky to connect with 4-H members from all around Canada, continue to work with 4-H youth, develop my leadership skills and take part in some great conferences," Baker said.

Now working as an area rangeland management specialist with the Alberta government and living next to the Rocky Mountains, she is able to reflect on how much her involvement with 4-H shaped her life.

"For anyone considering putting their children in 4-H, I would confidently say that you should unconditionally support them. There are some incredible clubs and projects and the sky is the limit. It is an excellent way to educate and connect youth to agriculture, science and life skills. There are even some really awesome urban bumblebee and gardening projects," she said. "I am thankful for the skills and connections which 4-H gave me throughout my years of involvement because I think I have the best job in the world."

Smith would not be surprised by Baker's story, but she would be proud of it.

CONTINUED ON PAGE 8

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"Through our positive youth development formula and experiential learning approach, we do our best to ensure that all of our programming is relevant, engaging and appealing to our members. Generation Z is globally minded, collaborative, entrepreneurial, tech savvy and savvy in general. These factors all come into the mix when designing and delivering programming for youth."

Alyssa Barbero was raised on a ranch in southwest Alberta, near a tiny town called Beaver Mines. In an area where people from all over Canada, and even the world, come to play, she learned the beef business, joining 4-H at age nine and sticking with it until she was 17.

The ripple effect for young people is that rural communities can be vibrant, innovative places worth investing time in and maybe even worth staying in. ~ Erin Smith

"I joined the new Rocky Mountain 4-H Swine Club in 2007. This club was brought up and organized by my mom, dad and other family members. I began to fall in love with pigs," she said.

Anyone with even a passing introduction to 4-H is usually aware of the public speaking portion of the club, and it is no secret that according to research, many people fear public speaking more than they fear death. Most 4-H kids get over that throughout their participation in the program.

Having been raised on a beef ranch, Alyssa's 4-H experience helped her appreciate the swine industry.

"I loved the community aspect of 4-H and being involved with new people. Public speaking assisted in meeting these new people and communicating with them without being timid," said Barbero.

In the fall, Barbero will finish her Ecosystem Management Bachelor of Applied Science degree and she currently

works as a conservation technician with the Nature Conservancy of Canada.

"We hear over and over through our evaluation and in testimonials from youth members, that they have a sense of belonging through 4-H and within their rural communities. There is a strong sense of pride among 4-H'ers, and I think that means for their achievements and growth through 4-H, but also their contributions and connection to their communities," Smith said.

Jillanna Hammond is from the Pincher Creek, Alberta area, and graduated from Grade 12 in June. While she hasn't chosen to go into an agricultural field – she's taking sociology at the University of Lethbridge – she says 4-H was instrumental in helping her become the person she is today.

"It's a good way to break out of your comfort zone. It teaches you responsibility and commitment. It's a really good way to get kids into the real world before they're actually in the real world and it develops those skills and experiences at a young age," she said.

Alyssa now works as a conservation technician with the Nature Conservancy of Canada.

In a world that draws most young people to large, urban centres, programs that help develop skills and opportunities in agriculture are extremely unique and valuable.

"4-H offers a network of support for rural youth, but it also opens doors and exposes youth to different ways of looking at agriculture or rural Canada. They begin to see that agriculture is also about science, innovation, a healthy planet, technology, communication, etc. The ripple effect for young people is that rural communities can be vibrant, innovative places worth investing time in and maybe even worth staying in. 4-H allows them to make that investment through community engagement, volunteerism and youth-adult partnerships (and) that creates concrete positive change and that matters a lot to Generation Z," Smith said.

For more information on 4-H in Canada, visit www.4-h-canada.ca. ■

New hand at the helm of Prairie Swine Centre

By Sheri Monk

Prairie Swine Centre is a research gem in the diverse sea of agriculture of Canada's Great Plains. Known for its unique relationship with producers and its practical approach to academic research, Prairie Swine Centre has been an integral part of the swine industry for 25 years. It was announced late last year that CEO Lee Whittington was retiring, and the search for a new leader concluded with the appointment of Dr. Murray Pettitt.

Although the position is new to Pettitt, he is no stranger to the Centre, having worked there for 10 years, up until 2009.

"I was very familiar with the Swine Centre and the work it does and their mandate. I have always believed in the Centre and I quite enjoyed my time there back in the day," Pettitt said.

While all research is important, Prairie Swine Centre specializes in the kind of research that is relevant to producers at the time it is conducted, so that the results can be utilized or taken into consideration immediately.

"I'm a researcher who likes practical research," he said. "When I was working at the Swine Centre I was certainly involved in that kind of stuff, on campus at the U of S I was also doing those kinds of research projects, so coming back to the swine centre was very attractive. I truly believe in what it does and its mandate and the fact that it's actually providing value to its producers and other members of the pork value chain."

Pettitt says he feels he is at the right stage in his training and career to tackle the challenging role of CEO.

"The outgoing CEO, Lee Whittington, and I have spent some time together this month and I am just learning the ropes. I've been able to meet everybody and renew friendships and working relationships. Saskatoon is a small town and swine research is even smaller, so many of these folks I have seen around for the last nine years anyway, even though I haven't been working at the centre," he said.

Of course, that doesn't mean the new gig isn't a lot of work, and anyone familiar with the new job jitters can probably relate to how the first few weeks on the job feels.

"So it's been good. Right now I'm in information gathering mode, and I am trying to learn everything I can about the business and how it works. The Swine Centre today isn't exactly the way it was when I left it nine years ago – neither is the industry – so I am coming up to speed to understand the various research projects going on."

Aside from research, the Centre also markets animals, so that's something Pettitt must get a handle on as well.

"I am getting caught up with the production side of things too because part of the income for the Swine Centre is the sale of market animals. I'm just trying to soak it all up," he said.

Pettitt is married, with two cats and an interesting hobby – rocketry.

How does he feel about his future with Prairie Swine Centre?

"It's nice to be home," he said. ■

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NEVER STOP IMPROVING

Ten-year-old field study yields wealth of information on manure management

Submitted by Christine Rawluk, National Centre for Livestock and the Environment, University of Manitoba

Trevor Fraser, soil science technician, shares the latest soil fertility findings during a field day at the NCLE long term field lab.

The NCLE (National Centre for Livestock and the Environment) Long Term Field Laboratory was established in 2007 to initially answer 'what happens to nitrogen availability and soil phosphorus levels over time when manure is applied either annually, at rates to meet crop N requirements, or intermittently, at rates to match crop P removal for several years?'.

After eight years, a couple more questions were asked, including 'what is the capacity of the soil to continue to provide nitrogen if manure applications stop?', and 'how does suspending manure application impact drawdown of soil test phosphorus levels?'

Site experimental design

The 43-acre (17 hectare) field laboratory consists of a total of 96 66' x 66' plots under either an annual cropping system or a perennial forage-based cropping system. Each plot received either annual or intermittent applications of liquid pig, solid pig and solid dairy manures from the University of Manitoba's Glenlea Research Station's swine and dairy production facilities, as well as synthetic fertilizer and control (no fertilizer) treatments for comparisons. In 2015, select plots were split to accommodate additional fertility treatments, resulting in an increase to 144 plots. The site is located at the University of Manitoba's Glenlea Research Station, 18 km south of Winnipeg.

What have we learned?

This long term field study is generating new agronomic and environmental sustainability information pertaining to manure management. The following are key findings to date for the annual crop rotation receiving yearly additions of manure or fertilizer for eight of 10 years. Project leads for this phase of the research were Don Flaten, soil fertility professor (Don.Flaten@umanitoba.ca) and Trevor Fraser, soil science technician.

Nitrogen (N) fertility

- Liquid pig manure was an excellent source of readily available

N for crop growth, generating yields similar to those of plots receiving synthetic fertilizer. Over the entire study, crop yields for plots with a history of solid pig, solid dairy and liquid pig manure were respectively 45%, 74% and 105% of the yield increase under continuous synthetic fertilizer. Yields with yearly applications of solid pig and dairy manure were considerably lower, mainly because Manitoba's traditional formula for calculating manure application rates greatly overestimated the amount of N available in the year of application for these solid manures.

- The eight-year history of annual manure additions created a soil N reserve to provide mineralizable N for future crops. As a result, yields from the solid manure treatments gradually improved over the 10-year period, becoming similar to yields under continuous synthetic fertilizer in the final two years, after annual additions of manure ceased.
- Fall residual soil nitrate N periodically increased during the 10-year study for both manure and synthetic fertilizer treatments, although these levels remained well below Manitoba's regulatory threshold. However, levels might have increased if the mineralization of organic N was not accounted for when determining the rates of fertilizer and manure N application for the subsequent crop. Therefore, annual soil testing for fall residual nitrate-N continues to be recommended for these situations in Manitoba, to minimize the risk of leaching of nitrate N to groundwater and gaseous loss of N to the atmosphere, as well as the cost of excess application of N fertilizer.
- Although gaseous losses of N as ammonia or the greenhouse gas nitrous oxide were not measured as part of these phases of the study, greenhouse gas measurements under select treatments began in 2017 as part of a new study now underway at this site

Phosphorus (P) fertility

- Annually applying manure at rates to meet crop N requirements resulted in a rate of P application that was much greater than P removal by the crops, increasing soil test P levels (STP, measured as Olsen P) over time. However, the extent of build-up in a given year greatly depended on the type of manure that was applied (e.g., annual applications of solid pig manure resulted in higher levels of STP than for liquid pig manure or solid dairy manure), as well as on growing conditions, manure N availability and soil moisture, which affected crop growth and associated P uptake, plus the rate at which the manure P was stabilized in the soil.
- Excess STP poses an increased risk for runoff loss to surface waters, which may contribute to algae growth in water bodies. During the first eight years of the study, annual applications of manure at N-based rates led to build-up of STP that exceeded Manitoba's first and even second P regulatory thresholds at times.

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The NCLE long term field laboratory covers 43 acres at the U of M's Glenlea Research Station.

- Following cessation of annual manure additions, STP decreased faster for sites with higher STP (i.e. solid pig and dairy manures) than for sites with lower STP at the start of the ninth year. However, these decreases were larger than would be expected with crop removal, indicating that the available P is likely being stabilized into less available, more stable forms of soil P.
- Nitrogen fertilization did not accelerate the drawdown of STP in plots where manure application ceased after eight years, because crop yields and P removal in these plots were maintained by the supply of N from historical manure applications.

Getting the information out

Lessons in learnings and knowledge transfer at the NCLE Field Laboratory take many shapes, depending on the audience. Numerous field days, workshops, clinics and tours over the years have attracted producers, agronomists, regulatory and extension specialists, university students and professors, and special interest groups. These sessions cover the latest understandings of manure management practices for optimal crop productivity and minimal environmental risk and are often paired with sessions on other production and sustainability-related topics.

Reaching city and rural students

We have also developed specialized educational programming for high school students to broaden their understanding of the role of livestock as nutrient recyclers in producing food that is both economically and environmentally sustainable. Students get their hands dirty as they learn to think more holistically about our shared food system. We explore how manure management practices developed through science-based research are providing both solutions to environmental challenges as well as environmental benefits in the context of our shared food system, making the connection that protecting our resources is a shared responsibility.

At the end of their half-day program their learning is put to the test to identify manure and land management practices we can use to improve nutrient recycling, soil health, productivity and overall sustainability of farming systems.

Research continues to break new ground

Now in its twelfth year, the focus continues to be around the capacity of the manured soil to continue to release plant-available nitrogen, phosphorus and other essential nutrients and how this affects crop yield. Additionally, we are measuring nitrous oxide emissions from select treatments to gain a better understanding of the role of soil nitrogen transformations in generating this potent greenhouse gas. Project lead for this phase of the long term research is Mario Tenuta, soil ecology professor (Mario.Tenuta@umanitoba.ca).

It is only because of this history of combined investment of research expertise, funding, and most importantly time at this long term site that we are able to answer these questions and to continue to ask new questions.

Acknowledgements

The NCLE Long Term Field Laboratory has received funding support from multiple sources since its establishment in 2007 – Canada Foundation for Innovation, Manitoba Rural Adaptation Council, Agri-Food Research & Development Initiative, Manitoba Livestock Manure Management Initiative under the Canada and Manitoba governments through Growing Forward 1 & 2, a federal-provincial-territorial initiative, Agriculture and Agri-Food Canada Agricultural Greenhouse Gases Program, as well as Manitoba Pork Council and Dairy Farmers of Manitoba. Thank you. ■

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Commercial scale research by Gowans Feed Consulting

Submitted by Gowans Feed Consulting

Research focusing on feeding pigs with different feed ingredients, feed additives, and feeding strategies conducted under commercial conditions provides useful information that producers can apply in their own herds to improve performance, reduce production costs and increase net return. Experiments conducted in university or research institution settings often employ smaller pen group sizes, lower stocking densities, and animals of higher health status compared to commercial conditions. It is often perceived that the credibility and applicability of research results would be greatly improved if such research could be conducted under commercial conditions similar to those in which the results are to be applied. Research efforts conducted "on-farm", however, often lack the facilities to accommodate the statistical design necessary to detect and quantify differences between treatments.

Front view of the Lewisville Nursery Research Barn. The barn is serviced by five smaller (four tonne) and five larger (six tonne) bins with the possibility of testing up to five experimental diets.

Gowans Feed Consulting, a leading Canadian pig, poultry and beef nutrition consulting company, conducts research in two state-of-the-art commercial-scale research barns – one for nursery (Lewisville Nursery Research Barn), and one for grow-finish pigs (Drumloche Research Barn). These barns were designed to conduct applied research from weaning to slaughter weight, using proper experimental design and control. The facilities are located near Irma, Alberta, about one and a half hours east of Edmonton. All trials conducted at these facilities are managed by Gowans Feed Consulting and supervised by its research team.

Lewisville Nursery Research Barn

Built in 2016 by Lewisville Pork Farm, the commercial research nursery barn consists of two rooms with a capacity of 1,400 pigs on test (700 pigs per room). Each of the 50 test pens holds 28 pigs from weaning (six kg initial body weight; 20-21 days of age) up to 25-26 kg of

body weight, providing 0.27 m^2 or 2.9 ft^2 per pig. Pen is the experimental unit and pigs are weighed as pen groups. There are four additional pens for sick/non-test pigs. The feed is dispensed to feeders in both rooms with an electronic automatic computer controlled feeding system (Feed Logic). Water lines are plumbed to allow five different water treatments to be provided to each pen, allowing the testing of water feed additives independently of feed. Lines are equipped with water meters so water usage can be tracked by treatment. Feeders are multi-space dry feeders (Crystal Springs) while water is provided in two bowl drinkers. The Nursery Research Facility also has a viewing area and laboratory where feed, blood or fecal samples can be processed.

Drumloche Grow-Finish Research Barn

The grow-finish research barn was constructed in 2005 by the Burden Family and consists of 2 rooms, each room housing 1,050 grower-finisher pigs in 50 pens (21 pigs/pen). Two remaining pens in each room are used for treated or injured pigs. Pens at the Grower-Finisher barn are equipped with a nose to nose wet/dry stainless steel feeder (Crystal Springs; 2 feeding spaces and one water nipple) and a supplementary water bowl located on each pen partition. Each room at the Drumloche Research Barn is serviced by 6 bins, each with a 7 tonne capacity. Similar to the

Feed Logic system. The automated feed delivery robotic system keeps track of feed delivered to each pen accurately. The robotic system manages multiple diets and can also blend feeds or dispense supplements or additives to specific pens with no cross contamination.

Inside view of one of the rooms at the nursery research facility. Each pen has a multi-space dry feeder and has access to one of 5 different test water lines.

CONTINUED ON PAGE 18

The Drumloche Research Barn. This facility has 2 rooms (1,050 head each) with the capacity to conduct 2 research trials simultaneously.

Pens at the Drumloche Research Barn. Each pen (total space of 158 ft2) is equipped with a nose to nose wet/dry stainless steel feeder and a supplementary water bowl located on the pen partition.

Inside view of one of the rooms at the Drumloche Research Barn. Each room has 52 pens, 50 of them used as test pens and 2 for treated or injured pigs.

nursery, the barn is equipped with a robotic feed delivery system (Feed Logic) for accurate dispensing and tracking of the test diets. Since its construction, a wide array of applied research projects have been conducted at the barn. Some of the projects have focused on evaluating alternative feedstuffs for swine, determining nutrient requirements for pigs, energy response curves, amino acid requirements, feed additive and vaccine evaluations, and terminal sire line trials.

The research data are collected by highly skilled technicians with labor support as required. Dr. Malachy Young is the General Manager of the Nursery and Grower-Finisher Research barns and is involved in experimental design, analysis of results and preparation of final reports. Feed used in the Research barn is prepared at the Sunhaven Farms Feed Mill which manufactures only swine feed and is located 16 km from the barn.

If you require further information please contact Malachy Young at Gowans Feed Consulting (780-842-0780; malachyy@gowansfeedconsulting.ca) ■

Feeding hulled or hull-less barley differing in fermentable starch and fibre to weaned pigs

*Submitted by Lifang Wang[1], Hao Zhang[1], Eduardo Beltranena[1,2], and Ruurd T. Zijlstra1**

[1]Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, AB; [2]Alberta Agriculture and Forestry, Edmonton, AB

Take Home Message

Hulled and hull-less barley are cereal energy sources that may replace wheat grain in feed for weaned pigs to increase profit. They also provide fermentable starch and fibre that can serve as prebiotics to improve gut health in young pigs. We have shown that hulled barley can fully replace wheat grain in nursery feeds without affecting feed intake, growth performance and feed conversion in weaned pigs. But feeding too much fermentable starch and fibre to weaned pigs should be avoided to prevent excess hindgut fermentation that reduces both feed intake and faeces consistency. Because high fermentable starch and fibre reduce energy value, feeds including hulled or hull-less barley should be formulated based on net energy and digestible amino acids to achieve predictable pig growth.

Introduction

Hulled and hull-less barley grain are cereal energy sources for swine. Chemical composition varies among barley grain samples causing changes in nutritional value that may affect pig growth. Among chemical components, fermentable carbohydrates can shift digestion from the small intestine to the large intestine, thereby increasing hindgut fermentation by microbes. Increasing dietary amylose, a less digestible component of starch, or gummy type soluble fibre instead of woody type insoluble fibre (cereal hulls or bran) may alter intestinal and immune function, thereby improving gut health in weaned pigs. But overfeeding amylose or soluble fibre could increase the softness of faeces. Cereal β-glucans, another type of soluble fibre, increases digesta viscosity (water holding capacity) and may also increase softness of faeces in weaned pigs. New cultivars of hull-less barley with increased amylose or β-glucan have been developed. We needed to confirm nutrient digestibility, growth performance and faeces consistency of weaned pigs fed cereal grains differing in these fermentable carbohydrates.

Chemical profile of hull-less, hulled barley and wheat grain

We selected one wheat, one hulled barley and three hull-less barley samples. They differed in chemical composition, especially in fermentable carbohydrates. The moderate fermentable hull-less barley contained moderate amylose (21 per cent of starch) and β-glucan, the high fermentable, high amylose hull-less barley contained the most amylose and elevated levels of β-glucans, whereas the high-fermentable, high-β-glucan hull-less barley contained little amylose but more β-glucan. Compared with hulled and hull-less barley, wheat grain was low in β-glucan and moderate in amylose.

Weaned pig trial set up

We conducted the nursery pig trial over two phases (day 0–14 and 15–35) at the Swine Research and Technology Centre, University of Alberta (Edmonton, Alberta). In total,

240 pigs (Duroc × Large White/Landrace F1; Hypor, Regina, Saskatchewan, weaned at 21 days in three groups) were housed in 60 pens, with four pigs per pen balanced by sex. One week after weaning, pigs (~7.6 kg) were fed the five diets randomized to five pens within area block to achieve 12 pen-replicates per feedstuff. Diets were formulated to include one of five cereal grains (~64 per cent for Phase 1; ~70 per cent for Phase 2): low-fermentable, hard red spring wheat (CDC Utmost), low-fermentable hulled barley (CDC Champion) and three hull-less barley cultivars, namely: 1) CDC Fibar, high-fermentable, high-β-glucan; 2) CDC Hilose, high-fermentable, high-amylose and 3) CDC McGwire, moderate-fermentable. Diets were formulated without antimicrobials or growth promoters to provide equal net energy and digestible amino acids for Phases 1 and 2. Diets were mixed and steam-pelleted at 70°C. Pigs had free access to feed and water. Faeces consistency was evaluated twice daily.

What we found

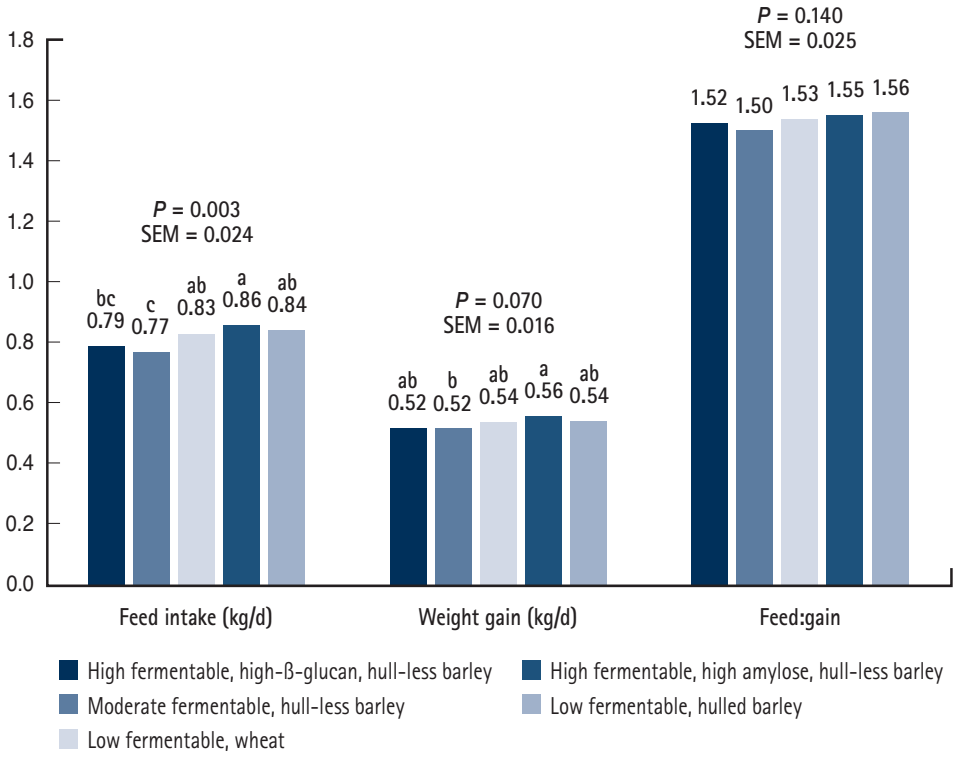
Protein digestibility of barley diets was 5-8%-units lower than the wheat diet, indicating that fibre in barley grain reduced protein digestion. Energy digestibility was lowest for the hulled barley diet (80-83%), intermediate for highly-fermentable hull-less barley (80-85%), and highest for wheat and moderately-fermentable hull-less barley (83-87%). As such, moderately-fermentable hull-less barley and wheat provided more energy to pigs than hulled barley or highly-fermentable hull-less barley. We found that lower energy digestibility was associated with high fibre content, e.g. woody type hull fibre, indicating that fibre in barley is less-digestible.

For the entire trial (day 0–35), there were no differences in feed conversion for pigs fed the 5 diets (Figure 1). Pigs fed the low-fermentable hulled barley or wheat grain had the greatest feed intake, followed by moderate-fermentable hull-less barley, and lowest for highly-fermentable hull-less barley, indicating that fermentation characteristics rather than fibre content had more influence on feed intake. Weight gain of pigs was similar to the order of feed intake, but the gain difference between pigs fed hulled barley or high-amylose hull-less barley was smaller at 43 g/day. As such, pigs fed hulled barley had the greatest final trial weight at 27 kg, followed by wheat grain, moderate-fermentable hull-less barley, and highly-fermentable hull-less barley the lowest at 25.7 kg.

We found pigs fed wheat grain or hulled barley had the best faeces consistency, followed by moderate-fermentable hull-less barley, and the lowest ranking was for highly-fermentable hull-less barley, likely due to excess hindgut fermentation of starch or increased digesta viscosity by abundant β-glucan, and thus increased chance to develop soft faeces.

CONTINUED ON PAGE 22

Figure 1. Growth performance of weaned pigs fed hulled or hull-less barley replacing wheat grain



a, b, c Bars within each growth performance trait without a common lower-case letter differ ($P < 0.05$)
A,B Bars within each growth performance trait without a common upper-case letter tended to differ ($P < 0.10$)

Cost vs. benefit

The following prices were assumed ($ per MT): barley grain (hulled or hull-less), $240; wheat grain, $305; canola oil, $1,100; limestone, $113; mono/di-calcium phosphate, $900; L-lysine HCl, $2,050; L-threonine, $2,630; DL-methionine, $4,050; L-tryptophan, $24,000. Dietary inclusion of hull-less barley or hulled barley to replace wheat reduced feed cost per MT by $36 and $18 for Phase 1, and by $37 and $21 for Phase 2, respectively. Combined, in 2 phases, feeding hull-less barley or hulled barley to replace wheat reduced feed cost per kg of BW gain by 6.58-7.66 cents and 3.57 cents, respectively.

What these results mean?

Considering lower protein digestibility for barley and lower energy digestibility for hulled barley and lower energy utilisation for high fermentable hull-less barley, feed should be formulated based on net energy and digestible amino acids to reach predictable growth performance. We observed reduced feed intake and poor faeces consistency for pigs fed highly fermentable hull-less barley, thus challenging inclusion of highly fermentable hull-less barley in feed for weaned pigs should be avoided. Finally, these results demonstrated that hulled barley is an excellent source of cereal energy for weaned pigs as reflected in both feed intake and growth performance. However, its economic benefit can be influenced by cost of vegetable oil to adjust the energy level in feed.

Thank you

We would like to thank Kim Williams and Zahra Dehghani for caring and feeding these pigs. We also appreciate research funding from Swine Innovation Porc and Alberta Pork. ■

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Optimizing concrete slat and gap widths for group-housed gestating sows

Submitted by Laurie Connor[1], Nicolas Devillers[2] and Qiang Zhang[1]

[1]University of Manitoba, Winnipeg, MB and [2]Agriculture and Agri-Food Canada, Sherbrooke, QC.

Why floor slat and gap widths are important

The transition to sow group housing recommended by the Code of Practice for Care and Handling of Pigs (2014) requires sound information about housing systems options and sow management. One critical area of impact is the type of pen flooring. Concrete slatted floors are commonly used in sow barns for effective drainage of manure to achieve cleaner and more hygienic floors, better in-barn air quality and decrease the total pen space needed; however, considerations must be given to other aspects of sow health and well-being. Slat design can affect the permeability and thermic properties of the floor which, in interaction with ambient temperature, can modify the location of lying, resting and dunging behaviours. Leg and hoof/claw injuries and lameness are major reasons for culling sows, particularly in group housing. Sows housed on slatted floors show more claw injuries than ones housed on solid floors. Moreover, gap width between slats can be responsible for foot injuries in sows and more likely in gilts which have smaller feet. On the other hand, a narrower gap width may decrease manure passage and can increase risks of infection of claw lesions. However, scientific information on the most suitable slatted flooring for sows is lacking. With these factors in mind, we set out to determine the most effective concrete floor slat and gap width combinations for comfort and wellbeing of sows as well as ease of manure management.

Sow outfitted with fluorescent markers and walking the pre-test kinematics corridor on parallel oriented slats.

How the research was done

Before any in-barn tests could be conducted, the slat and gap widths and orientation that caused the least change to sow gait needed to be determined. For this pre-test, slats of three pre-determined widths were cast in concrete (85, 105 and 125 mm). Each slat width was tested with three defined gap widths (19, 22 and 25 mm), in both horizontal and longitudinal orientation in a test corridor where each sows' walking gait could be video recorded. (PIC) Twelve small non-lame sows/gilts and 12 large lame sows were video recorded walking on each of the nine pre-test floor combinations accord-

ing to a Lattice design. Their gait was analysed from video recordings using kinematics.

From this pre-test phase it was determined that, compared to walking on solid concrete, sows' gaits were least affected when slats were 105 mm wide with gaps of 19 mm. Two newly manufactured slatted floors were installed into identical test rooms at the Glenlea Research Station, University of Manitoba. In-barn trials were then conducted by following two groups of 25 nulliparous gilts over two consecutive gestations. One group was housed on concrete slatted test floor (Test; 105 mm slats, 19 mm gaps) and compared to a cohort in an identical room/pen but with conventional concrete slatted flooring (Control; 125 mm slats, 25 mm gaps).

Sows were grouped in the pens with a space allowance of 2.04 m2 per sow, from approximately five to 15 weeks of each gestation and were individually fed with an electronic sow feeder. Each animal was evaluated for lameness (visual gait score, hoof lesions scores for heel overgrowth and erosion, wall cracks, heel cracks and toe length, and limb weight distribution using a force-plate scale), postural behaviour using accelerometers (time budget of standing, lying, sitting and frequency of posture changes), and overall behaviour within the pen (video recordings to assess time budget of activities) during the two successive gestations.

Lameness, hoof lesions, weight distribution and postural behaviour were assessed twice per gestation, and behaviour was video recorded three times per gestation. Performance was recorded in terms of body weight and back fat across gestation and reproductive performance (number of piglets: total born, born alive, stillborn, weaned, and piglets weight at birth and weaning). Performances, lameness and behaviour variables were analysed for the effects of the treatment, time and gestation number.

Assessment of pen cleanliness and air quality were conducted to provide information on floor porosity (slat-gap ratio) for effectiveness of manure removal. Ammonia concentration was measured continuously in each room. Temperature and relative humidity were recorded on data loggers at five minute intervals in three locations in each room. Pen cleanliness was assessed weekly from time lapse photographs taken hourly during the 12 h of 'lights-on' (0700 h -1900 h) on the day preceding floors being scraped to remove any manure build-up. The time-lapse pictures were analyzed using MIPAR image processing software. The floor was divided into four areas for analysis according to the observations of sow activities ¬–sleeping, low traffic, high traffic and dunging areas.

Animal cleanliness (percentage of body stained by manure), which reflects pen cleanliness, air quality, temperature and humidity, was also analyzed from time-lapse photographs using the MIPAR image processing software.

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Force plate scale measures individual limb weight distribution while sow is standing still eating.

Friction of the slat surfaces was measured throughout the test periods to quantify the slipperiness (slip resistance) of the slatted concrete floors. A surface tester was designed and constructed to measure surface friction and roughness.

Outcomes

The pre-test slat-gap assessment in the kinematics corridor offered a unique opportunity to see how slatted flooring dimensions and orientation can influence sow locomotion. Most of the observed effects on sow gait were on the front limbs which bear 60% of the body weight. More gait parameters in small non-lame sows were affected by floor design than in large lame sows; and for perpendicular than in the parallel slat orientation. Therefore, small non-lame sows were more sensitive to the variation of the configuration of the slatted floors and variations in slat or gap width was more likely to be perceived by sows when walking perpendicularly to the slats orientation.

Comparisons between combinations of different slat and gap widths showed that more gait parameters were significantly altered by larger gap widths (stride length, stance time, foot height, joints angles, back angle, walking speed) and the smallest and the largest slat widths (swing time, foot height, joints angles). Comparisons of the different combinations of slat and gap widths revealed that slat width of 105 mm and gap width of 19 mm were the best floor design according to gait characteristics on the solid control floor. These results provide the first evaluation of the impact of slat and gap widths of concrete floor on locomotion of sows. Longer term in-barn tests were needed to fully validate the pre-test results and investigate the impact on postural behaviour, lameness occurrence, foot health and pen environment.

Overall, there were minimal differences between sow groups on the test and control floors in most measures including per-

formance, gait score, lameness and behaviour (Table 1). However, sows on the control floor had higher feet lesion scores and indicators of greater hind-limb discomfort than sows on the narrower slat/gap widths of the Test floor.

Although overt lameness, measured as gait scores, was similar between sows on the control and test floors, the severity of heel overgrowth and erosion and wall cracks was greater for both front and rear (P<0.001) feet in control sows compared to test sows in both gestations.

Sows on test floor during gestation. Coloured markings are individual identification for behaviour assessments from video and time-lapse records.

However, these effects were already evident as soon as one week after sows were moved to the gestation pens, so it is difficult to conclusively discern treatment effects from pre-existing conditions. But, feet lesion scores generally increased during gestation on both slatted floor types and decreased somewhat during lactation when sows were on different flooring. In terms of comfort indicators, analysis of weight distribution showed some effects on several variables measured on hind legs.

For example, control sows spent more time weight shifting in late gestation ((37 vs 32±1.6% of time, P=0.036, control vs test respectively), had a higher variability (SD) of the percentage of weight applied on hind limbs in early (SD = 4.3 vs 3.9±0.10, P=0.006) and late gestation (SD = 3.9 vs 3.4±0.12, P=0.003, for an average of 21% of body weight applied on each hind leg), and a higher amplitude of weight shifting on hind legs in late gestation (P=0.002)).

Higher weight shifting and variability of the weight applied on hind legs are signs of higher discomfort while standing still and possibly lameness in control sows. Therefore, as observed in previous studies, signs of lameness or discomfort

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Table 1. Effects of floor treatment* and gestation number on performances, feet lesions and postural behaviour (least square means)

Measure	Week of gestation	Control floor		Test floor		SEM max	Effects (P-value)		
		1st gestation	2nd gestation	1st gestation	2nd gestation		Floor	Gestation	Interaction
Body weight (kg)	5	181	211	177	216	1.7	0.67	< 0.0001	0.002
	15	216	242	219	242	2.6	0.48	< 0.0001	0.5
Total number of piglets born		14.5	15	13.7	16.3	0.6	0.71	0.01	0.065
Number of piglets born alive		13.6	14.5	12.8	14.9	0.6	0.74	0.017	0.32
Number of piglets weaned		11.5	12.9	11.1	12	0.5	0.092	0.03	0.61
Litter weaning weight (kg)		82.8	86.6	74.8	80	3.1	0.015	0.12	0.81
Heel overgrowth and erosion score									
Front feet	6	1.96	1.86	1.58	1.83	0.12	0.072	0.45	0.081
	14	2.48	2.11	1.97	1.93	0.09	0.0003	0.062	0.19
Rear feet	6	2.22	2.28	1.76	2.13	0.1	0.003	0.007	0.051
	14	2.73	2.52	2.21	2.35	0.09	0.0003	0.73	0.066
Wall cracks score									
Rear feet	6	1.22	1.69	0.98	1.37	0.11	0.003	<0.0001	0.68
	14	1.54	1.68	1.3	1.52	0.12	0.069	0.084	0.65
Postural behaviour (% of time)									
Lying	6	78.3	75	83.3	72.6	1.9	0.47	<0.0001	0.009
	14	77.8	81.1	75.1	77.9	2.1	0.19	0.04	0.88
Sitting	6	5.4	4.9	4.5	5.1	0.8	0.66	0.9	0.42
	14	6.3	2.4	5.2	4.8	1.5	0.63	0.015	0.049
Standing	6	16.3	20	12.2	22.5	1.8	0.62	<0.0001	0.021
	14	15.8	16.3	19.6	17.1	1.9	0.26	0.49	0.29

*Control floor: 125 mm (5 in) slats and 25 mm (1 in) gaps. Test floor: 105 mm (4 in) slats and 19 mm (0.75 in) gaps

are mainly observed on rear limbs and, in the present study, were higher in control sows than test sows.

Observation of how sows' budgeted their time (walking, passive, feeding, social interaction) showed that Control sows spent more time passive (5.7 vs 3.7±0.5%, P=0.006, respectively) and less time walking (3.6 vs 4.6%±0.4, P=0.08, respectively) than Test sows. Looking at postural behaviour, few interactive effects of treatment and gestation number were seen. At week six of first gestation, control sows spent more time standing (16.3 vs 12.2%±1.3, P=0.028, respectively) and less time lying (78.3 vs 83.3%±1.2, P=0.005, respectively) than Test sows. No

major effect of treatment was observed on the frequencies of posture changes. Overall, differences in sow behaviour between test and control were limited and do not reveal a consistent effect on sows' activity.

Evaluation of air quality, sow cleanliness and floor friction showed no significant differences between the test and control floors, thereby demonstrating that manure removal was not compromised by the narrower gaps and slats of the test floor. Specifically, no significant differences ($P>0.05$) were noted between the two test rooms in temperatures, relative humidity and ammonia concentrations during the trials. Floor cleanliness, as a percentage of manured floor area, was similar for both floors. Similarly, the percentage of sow body surface soiled by manure was similar (e.g. 27.1% and 26.9%, gestation 1, test and control, respectively; $P>0.05$). The surface friction, a measure of slip resistance, was similar for both test floors throughout the trial. Notably, the dynamic coefficient of friction (DCOF) decreased markedly within the first week of pig occupancy then remained relatively unchanged for the remainder of the trial. This was likely due to manure on the floor, even though the floors were scraped before friction measurements were taken. All-in-all, the narrower slat and gap widths of the Test floor did not have a detrimental effect on manure accumulation and air quality.

Photographs for lesion scoring of toes, dew claws, underside white line and heel–sole erosions were taken at the beginning and end of each gestation period on the test floors.

The bottom line

As a general conclusion, effects of treatment that were seen do not indicate a marked difference between the two types of floor tested. Nevertheless, Control floor (125/25mm) seems to lead to higher feet lesions scores and a higher discomfort while standing according to the measurements from the force plate. However, these differences did not result in significant differences of gait score and lameness during the two gestation periods. The effects on behaviour and reproductive performance were also limited. However, in terms of feet health and sow comfort, these results indicate a benefit of the narrower concrete slat (105 mm) and gap (19mm) flooring, at least for smaller or early parity sows which then impacts later performance and longevity.

Acknowledgements

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High-fibre diets and immune stimulation increase threonine requirements in growing pigs

Submitted by Dan Columbus, PhD, Research Scientist, Prairie Swine Centre, Inc., and Michael Wellington, MSc, PhD Student, Department of Animal and Poultry Science, University of Saskatchewan

Understanding the interaction between nutrition and pig health

With new legislation eliminating the use of in-feed antibiotics for growth promotion in Canada and increasing consumer pressure to reduce antibiotic use in animal agriculture, it is critical that we develop alternatives to antibiotic use in order to maintain animal performance and health during immune challenge. An increased understanding of the interaction of nutrition and animal robustness (i.e., the ability to cope with an immune challenge), therefore, will be a key component in efforts to replace and/or reduce antibiotic use. Specifically, nutrition-based alternatives to antibiotic use need to be identified.

Pigs are continuously exposed to microbial pathogens and immune-stimulatory antigens that negatively impact animal productivity. Pigs exposed to immune challenge, without exhibiting any clinical signs of disease, show reduced appetite and growth and less efficient use of nutrients compared to healthy animals. Previous studies have estimated a reduction in lean growth of 20-35% and feed efficiency of 10-20% in growing pigs at sub-clinical levels of disease (Williams et al., 1997; Le Floc'h et al., 2009). This decrease in performance can have a substantial impact on profitability of producers. Stimulation of the immune system alters protein and amino acid metabolism and utilization, with amino acids redirected from growth towards supporting the immune response. Of the amino acids, glutamine, arginine, threonine, and aromatic and sulfur amino acids are of particular importance as precursors for synthesis of many critical components of the immune response (Reeds and Jahoor, 2001). It is thought that provision of these amino acids may be important for improving pig response and growth performance during times of stress and disease challenge.

Pork producers have been incorporating increased amounts of co-products from the milling and biofuel industries and other feedstuffs in swine rations. These feedstuffs have higher fibre content and variable protein content and digestibility which may have a detrimental effect on overall pig immune status and robustness. It has already been established that an increased level of threonine is required in high-fibre diets. However, the impact and interaction of factors such as dietary fibre and health status on requirements for specific amino acids that are used for the immune response are not well characterized.

What We Did

A nitrogen-balance study was conducted to determine threonine requirement for maximum protein deposition when dietary fibre and immune system stimulation (**ISS**) were present alone and in combination. Ninety barrows (20.5 ± 0.75 kg initial body weight) were randomly assigned to 1 of 10 wheat and barley-based dietary treatments (n = 9). Diets consisted of a low fibre (12.5% total dietary fibre) or high fibre (18.5%

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What We Found

Feeding pigs high-fibre diets and stimulating the immune system both independently increased the threonine requirement for nitrogen retention when compared to low-fibre and non-stimulated pigs, resulting in an estimate of 0.78 and 0.76% SID threonine, respectively, compared to 0.68% SID threonine. The threonine requirement was also increased when pigs received both high-fibre diets and the immune stimulation (0.72% SID threonine), however, this was not further increased above what was determined for fibre and immune stimulation alone. The exact mechanism behind the interaction of fibre and immune challenge is unknown but may be indicative of a protective effect of fibre. Interestingly, stimulation of the immune system resulted in an increase in the variability of pig response to dietary threonine content, highlighting the difficulty in determining nutrient requirements and development of feeding programs during disease challenge.

Conclusions

This study was the first to confirm an increased threonine requirement during immune challenge in pigs and also the first to determine the interactive effects of both fibre and immune stimulation. This information will be important for the development of feeding programs that decrease feed costs and maintain animal performance while reducing reliance on antibiotics.

Acknowledgements

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Hybrid rye replacing wheat grain for hogs

Submitted by Miranda N. Smit[a], Xun Zhou[b], José L. Landero[b], Malachy G. Young[b], and Eduardo Beltranena[a]

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Take Home Messages

- **In a commercial scale growout trial, hybrid rye completely replaced wheat grain in diets without affecting feed efficiency, carcass traits, feed cost per hog or feed cost per kg of body weight gain, and profit per hog.**
- **Including feed NSP enzymes tended to improve weight gain over the entire trial.**
- **NSP enzyme inclusion improved feed efficiency, but only for hogs fed the all-rye replacing wheat diet.**
- **Assuming 2700 kg greater hybrid fall rye yield than wheat grain, an additional 13 hogs more (30 to 130kg live) could be fed per hectare (five more hogs per acre) at ~200 kg (440 lb) cereal grain intake per hog.**

Why hybrid rye?

Rye is a cereal crop similar to wheat. It is popular in northern and eastern European countries for the production of dark bread and food products. In Canada, rye is best known for the production of whisky and spirits. Its winter hardiness allows efficient use of spring runoff and extends the work season versus spring cereals for grain producers. Of ~324,000 hectares planted to rye in Canada, about 80 per cent grows in the prairie provinces. Rye has other uses in Europe including as grain stock for ethanol production, as forage/silage crop for ruminants and grain for pigs. What's new with rye in Canada is that novel European hybrid cultivars yield >30 per cent more over conventional rye, 15-20 per cent over barley and 20-40 per cent over wheat grain. Modern rye hybrids produce vast amounts of pollen that overwhelm the stigma. With the stigma oversaturated by pollen, mold spores have a lesser

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chance of infecting the ear before the stigma closes. Fall planted rye flowers earlier than spring planted cereals so ergot and fusarium contamination risk is lower. Not much rye is fed to pigs in Canada compared with corn, wheat and barley, or even triticale. But greater grain yield compared with wheat grain (80-120 vs. 40 – 80 bu/acre) was an attractive incentive for us to evaluate feeding hybrid fall rye to hogs even if that resulted in somewhat lower pig performance. Rye is known to have greater fibre content than wheat grain. But the fibre in rye grain is mostly complex gummy sugars, not bulky, woody hulls (bran). These complex soluble sugars could be made more digestible/fermentable to pigs by the inclusion of feed NSP enzymes. Prairie hog producers typically stock two cereal grains (barley, wheat), but not likely three. We decided to evaluate feeding increasing hybrid rye inclusions replacing wheat grain and test whether or not NSP enzymes would make the hybrid rye grain more digestible to hogs.

Commercial scale hog trial setup

We conducted this growout trial at a contract finishing barn located at Lougheed, Alberta that is part of the Sunhaven system. In total, 504 barrows and 504 gilts (Camborough Large White/Landrace ♀ x 380 ♂ (PIC Canada) were involved. As pigs arrived at the barn (~30 kg or 66 lb), they were herded into 48 pens by sex, 21 pigs per pen. Pens with slatted concrete flooring measured 20' × 8' providing 0.7 m^2/pig. Pens were equipped with one wet-dry feeder (Crystal Spring Hog Equipment, St. Agathe, MB, Canada) with two opposing feeding places located halfway along a dividing wall between pens. An additional water bowl drinker was located at the back of the pen. Pigs were initially fed a common Grower 1 diet. At ~44 kg (96 lb), pens were blocked by area of the rectangular room. Within area block, pens of barrows or gilts were randomly allocated to be fed diets with one of three hybrid rye levels replacing soft wheat grain – low rye (1/3rd of wheat replaced), medium rye (2/3rd of wheat replaced), or high rye (all wheat replaced). The fall rye was a hybrid cultivar named Bono (Figure 1) developed by KWS LOCHOW GMBH (Bergen, Germany) grown at Kalco Farms near Gibbons, AB. Diets were fed either with or without NSP enzyme (Endofeed WDC, 200 mg/kg) providing 1400 units/g β-glucanase and 4500 units/g xylanase donated by GNC Bioferm, Bradwell, Saskatchewan. Test diets were fed to slaughter weight (133 kg or 293 lb) over four growth phases (Grower 2 d 0-22, Grower 3 d 23-42, Finisher 1 d 43-63, Finisher 2 d 63 – slaughter). Pigs were slaughtered at Maple Leaf, Brandon, Manitoba.

Figure 1. Field of hybrid fall rye Bono growing in Western Canada. Photo courtesy FPGenetics, Regina, SK.

What we found

Body weight of hogs throughout the trial was not affected by either feeding increasing hybrid rye level replacing wheat grain or enzyme inclusion (Figure 2). For the entire trial (d 0-76), feeding increasing rye level replacing wheat grain reduced hog feed intake and weight gain, but feed efficiency was not affected (Figure 3). Enzyme inclusion did not affect feed intake and feed efficiency, but tended to increase overall weight gain by 20 g/d. Enzyme inclusion improved feed efficiency only for hogs fed the high rye level whereas it did not affect feed efficiency for hogs fed low or medium rye levels. Days on test to 130 kg slaughter weight or carcass traits were also not affected by feeding increasing rye level replacing wheat grain or enzyme inclusion (Figure 4). Feeding increasing rye level replacing wheat grain increased cost per tonne of feed, but did not affect feed cost per hog or per kg of body weight (Figure 5). Feed enzyme inclusion reduced feed cost per hog and per kg of body weight gain by CDN$1.70 and $0.02, respectively.

What these results mean

Because of the decrease in feed intake with increasing rye level replacing wheat grain, we first suspected mycotoxins or ergot alkaloids. Two labs tested both the hybrid rye and wheat grain and confirmed that these were not factors in reducing feed intake. We therefore believe that the decreased feed intake observed was possibly caused by the more complex sugars found in rye. Increasing gummy sugars content made the digesta

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Figure 2. Body weight of hogs on test days throughout the trial fed increasing hybrid rye level replacing wheat grain with or without enzyme.

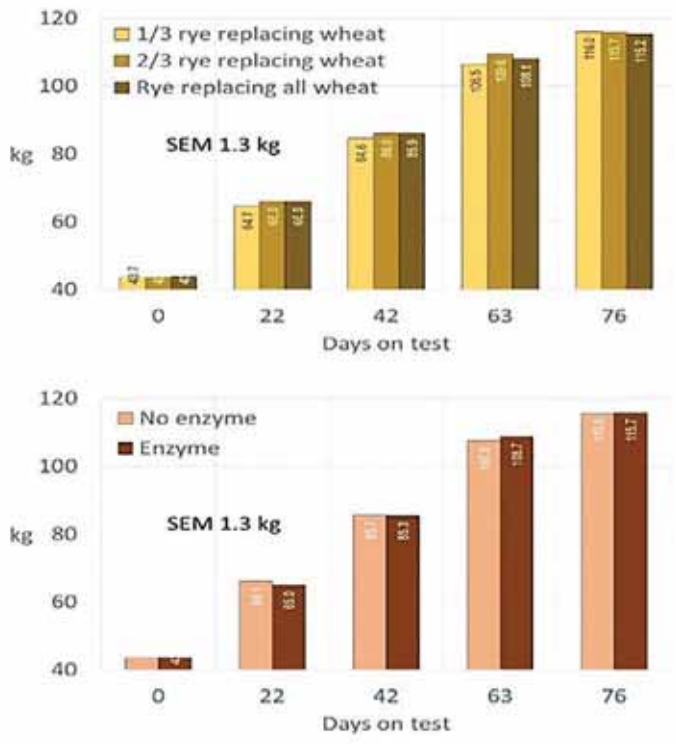
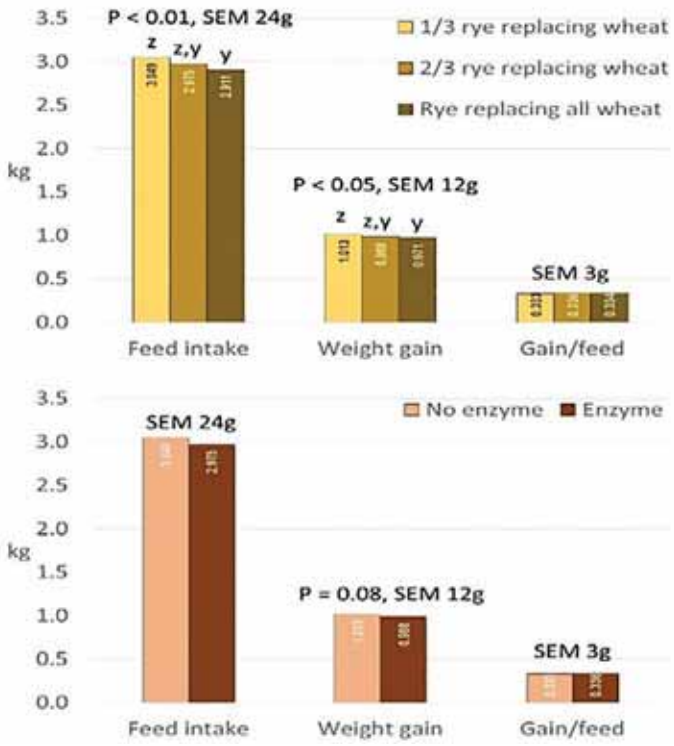


Figure 3. Daily growth performance (0 – 76d) of hogs fed increasing hybrid rye level replacing wheat grain with or without enzyme.



somewhat more viscous (held more water), slowing down passage rate through the gut. Hogs fed these less digestible complex sugars therefore felt more full and satisfied with slightly less feed thus reduced their weight gain. Because both feed intake and weight gain were reduced in parallel, feed efficiency was not affected. Feed NSP enzyme inclusion increased the digestibility/fermentability of the rye complex sugars, but that only showed up at the high rye level replacing wheat grain. The all-rye grain diet likely moved slower along the gut, staying longer and held the most water giving feed enzymes more time to breakdown the rye complex sugars. Carcass dressing was not reduced because the rye complex sugars were mostly soluble instead of bulky, insoluble cereal hulls (bran) so that did not increase gut weight or thickness. Backfat did not increase or decrease because we accounted for the greater rye complex sugars content as a lower net energy value for rye compared with wheat grain. Loin depth was also not affected because we correctly accounted for differences in amino acid (the chain links of protein) digestibility between rye and wheat

Figure 4. Carcass traits of hogs fed increasing hybrid rye level replacing wheat grain with or without enzyme.

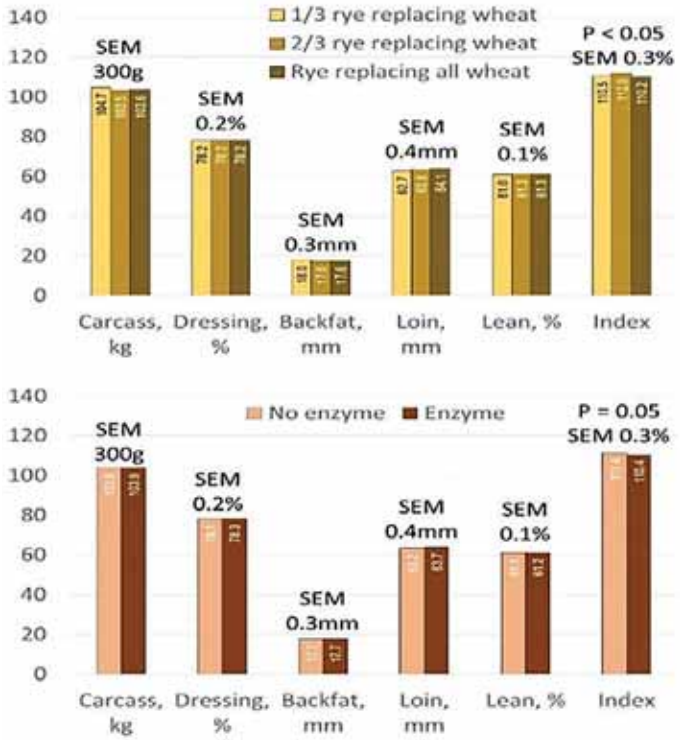
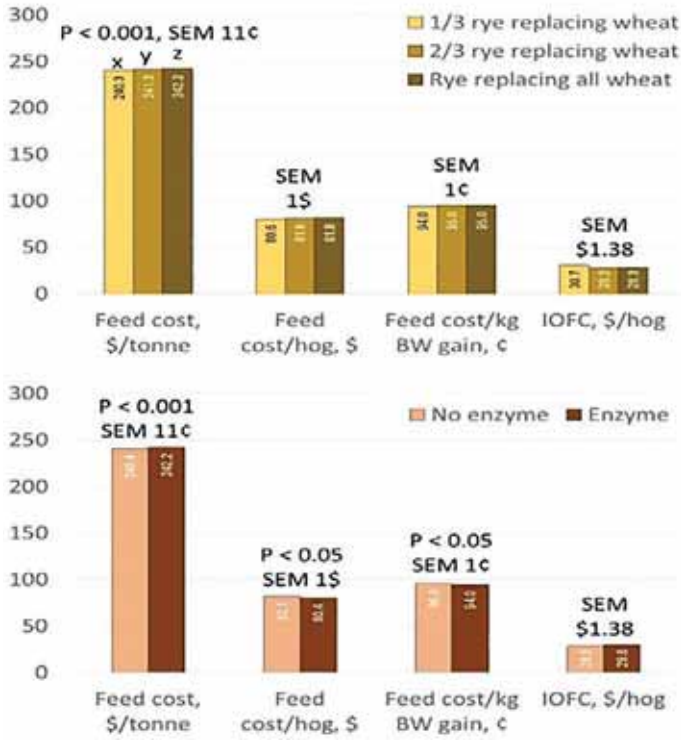


Figure 5. Overall cost vs. benefit of feeding increasing hybrid rye level replacing wheat grain with or without enzyme to hogs. Income over feed cost (IOFC) calculated as gross carcass revenue minus feed cost.



grain at formulating the diets. Diets with increasing rye level were more costly than wheat grain diets because oil was added to compensate for the lower net energy value of rye. Hybrid fall rye was sourced at $170 vs. $180 for wheat grain. Assuming hybrid fall rye yields 2,700 more kg/ha (40 more bu/acre) than wheat grain, using our trial results that would imply 691 more kg of lean pork/ha (617 more lb/acre) feeding 60 per cent rye inclusion replacing wheat grain from 43.7 to 132.7 kg slaughter weight (96 to 292 lb).

In conclusion, hybrid rye can completely replace wheat grain in growout hog diets without affecting feed efficiency, feed cost/hog or feed cost/kg of body weight gain. Inclusion of feed NSP enzymes would be recommended for diets containing high rye inclusion levels (45 – 65 per cent of the diet) to improve feed efficiency and weight gain. Assuming 2,700 kg greater hybrid fall rye yield than wheat grain, an additional 13 hogs more (30 to 130kg live) could be fed per hectare (5 more hogs fed per acre) at ~200 kg (441 lb) cereal grain intake per hog.

Thank you

We thank Tanya Hollinger, Neil and John Burden at the Dumloche test barn for care of the animals and smooth running of the trial. Thanks also to Lewisville Pork Farm for the use of their animals and Sunhaven Farms Milling for mixing and supplying the feed. ■

Development of novel microparticles for effective delivery of an antimicrobial essential oil to pig intestinal tract

Submitted by Faith Adeyinka Omonijo and Chengbo Yang, Department of Animal Science, University of Manitoba*

Faith Omonijo, MSc student with Dr. Chengbo Yang

Young piglets have a high susceptibility to various stressors, including bacterial pathogens, oxidative stress and inflammation, leading to reduced growth performance, high mortality and morbidity rates, and compromised animal welfare. Antibiotic growth promoters (AGP) have been routinely used in pig diets, especially in nursery diets, for decades to reduce incidences of post-weaning diarrhea and improve growth performance. In 2010, total consumption of antimicrobials in food animal production worldwide was estimated at 63,151 tonnes with an increasing trend. The annual consumption of antimicrobials for pigs is 148 mg/kg body weight.

Mounting concern over this increasing use, coupled with the possible role of AGP use in the emergence of antimicrobial resistant bacteria, has coincided with an increasing amount of research to identify possible alternatives to AGP. Essential oils such as thymol are widely recognized as an alternative to AGP due to their antimicrobial, anti-inflammatory and antioxidative properties. However, as thymol is highly volatile, it is not fully effective when used in its natural state. To overcome this limitation, a method of protecting the essential oil until it reaches the lower gut is required.

Project objective

Our aim was to develop a novel microencapsulation technique that is affordable and can easily deliver thymol to the target site. In an *in vitro* experiment, low melting point fat microparticles were developed via a melt-granulation technique. Lauric acid was selected as a good carrier for thymol because of its miscibility at a molten state and at room temperature (23°C). Moreover, lauric acid has significantly reduced the melting point of thymol which provides the convenience of processing thymol at room temperature (23°C) in liquid form. To develop a molten oil mixture, lauric acid and thymol were separately weighed into a closed vial and melted in a water bath, mixed and stirred together with a stirring bar. A starch mixture was prepared using corn starch and pre-gelatinized starch mixed at a ratio of 3:1. Two per cent of the distilled water was calculated to denote the amount of polymer to be weighed. The molten oil mixture was mixed with the starch mixture by hand stirring in a container before adding a polymer solution in distilled water. The solid particles produced were immediately inserted into an ice-water bath and allowed to solidify overnight after which they were granulated. Using gas chromatography, *in vitro* release of thymol from low melting point fat microparticles in simulated salivary fluid (SSF), simulated gastric fluid (SGF) and simulated intestinal fluid (SIF) was determined. The stability of the microparticles was measured by gas chromatography after 12 weeks of storage at 4°C.

Our findings

As shown in Figure 1, our results show that the low melting point fat microparticles with 2 per cent polysaccharide solution exhibited a slow release rate (%) of thymol and lauric acid in the SSF (21.2±2.3; 36 ±1.1), SGF (73.7 ± 6.9; 54.8 ± 1.7) and SIF (99.1±1.2; 99.1±0.6), respectively. The microparticles produced had good stability (> 90%) when stored at 4°C for 12 weeks (Figure 2).

Recommendation

The formula and method developed for encapsulating thymol in this research is simple to practice, affordable and can be potentially used to deliver essential oils effectively to the pig intestinal tract. Also, the method developed can be used by researchers to successfully deliver other essential oils to the pig gut.

CONTINUED ON PAGE 40

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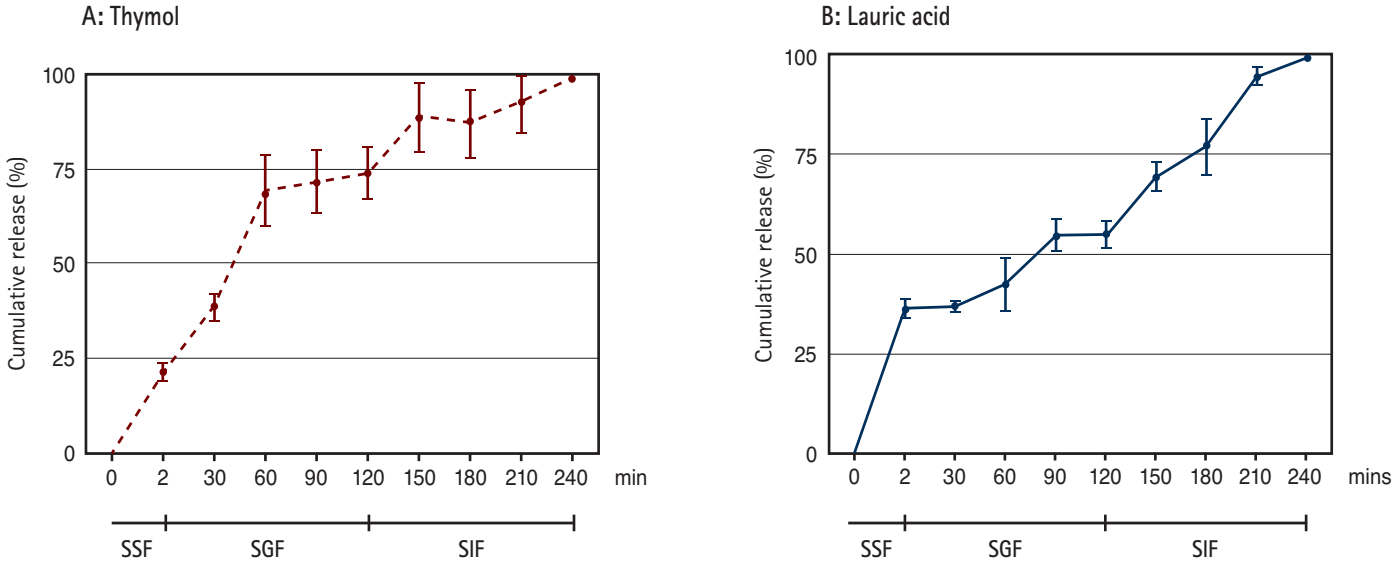
Figure 1. *In vitro* release profile of thymol and lauric acid from microparticles with two per cent polymers using simulated fluids.



In vivo studies will be conducted to verify the effectiveness of the low melting point fat microparticles. This formula and encapsulation method will be further optimized for better controlled release by investigating the physicochemical and molecular property of the low melting point fat microparticles and the retention of encapsulated thymol during feed processing, which will be simulated by steaming for different time periods and validated in a real pelleting process.

Acknowledgements

We acknowledge funding from Natural Sciences and Engineering Council of Canada (NSERC), Manitoba Pork Council, Jefo Nutrition Inc., the University of Manitoba Start-Up Grant, and the University of Manitoba Graduate Enhancement of Tri-Council Stipends (GETS) program. ■

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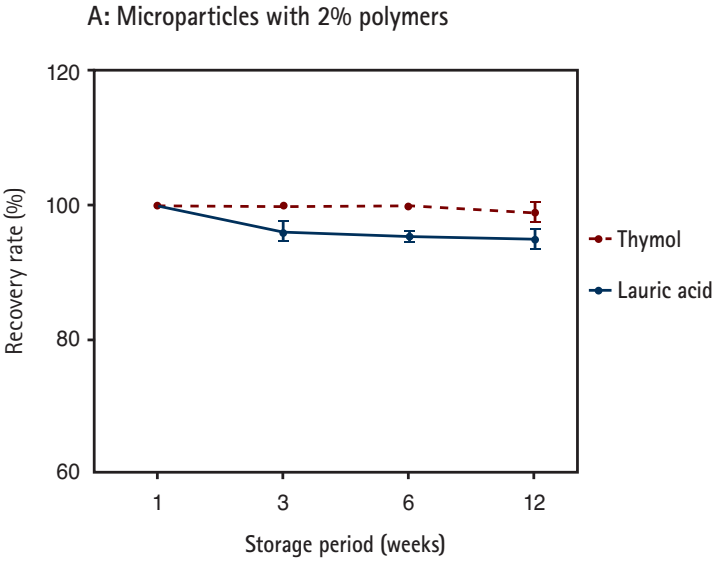
Figure 2. Stability of microparticles of thymol and lauric acid with two per cent polymers stored at 4 °C for 12 weeks.



Precision feeding for gestating sows – results of a commercial trial

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Do you plan on adapting your farm buildings for sow group housing? Do you have questions about which feeding system is the most appropriate? Are you wondering what advantages precision feeding may have? If so, read below to learn about our findings on this subject.

Recap of the results

As a reminder, the first part of the project consisted of simulating the nutritional and economic impacts of precision feeding in gestating sows in a group management context.

The main conclusions drawn about the effects of precision feeding were:

- That it would be beneficial for sows in late gestation and growing gilts, as lysine requirements are important during these periods of the sow's reproductive cycle, when conventional feeding struggles to meet these needs.
- That it would minimize distributed surpluses, particularly for multiparous sows, thus reducing the cost of feeding of around $3/sow per year.

Trial on sows in a commercial setting

The second part of the project was to then validate the effects of precision feeding on growth performance, productivity and cost of feeding sows in a commercial setting. The on-farm trial was conducted at Coop Seigneurie's Ste-Catherine Nord farm and was designed to compare two dietary treatments during gestation, namely conventional feeding (0.53% standardized ileal digestible (SID) lysine (Lys) throughout gestation) and precision feeding (variable SID Lys depending on the day of gestation and the parity of each sow). Sows of four consecutive batches (weeks) were studied over two complete cycles, from breeding to weaning. The experimental period was when the sows were in groups, approximately from day 30 to day 110 of gestation. Data collected included live weight

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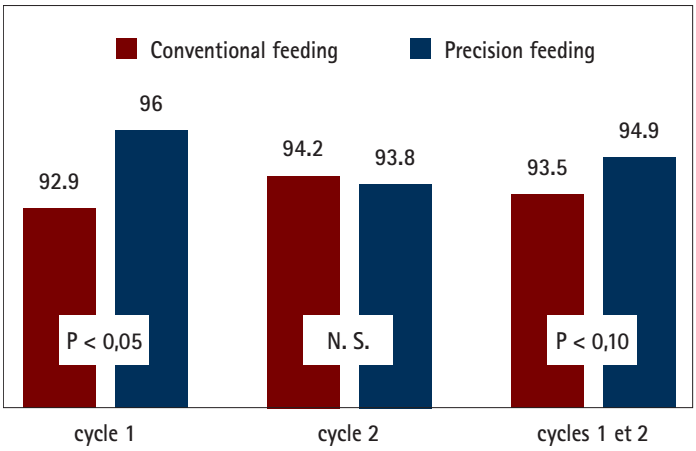
Figure 1: Piglet survival rates at birth in gilts, %



and body condition measurements of sows before farrowing and at weaning, individual piglet birth weights and weaning weights, and finally, all data conventionally taken by pig farms. In total, 295 sows and 523 litters were analyzed.

Effects on multiparous sows

No impact on the condition of the sows or the performance of their piglets was observed. As a result of our simulations during the first part of the project, it was observed that multiparous sows were fairly well fed with conventional feeding, so an improvement in performance was not necessarily expected. This result, however, confirms that it is possible to provide feed with a reduced lysine content to these sows, which reduces the cost of feeding without affecting performance.

Effects on gilts

Little if any impact was officially confirmed during the trial, but some promising effects were observed. Indeed, precision feeding could have a positive impact on the survival rate of piglets at birth because, during the first cycle, the gilts' piglets showed a significantly higher survival rate at birth, but this effect was not observed during the second cycle (Figure 1). Following the simulations, an improvement in gilt performance could be expected since precision feeding more adequately met the gilts' need for lysine than conventional feeding, especially in the last third of gestation. Thus, although no impact was clearly demonstrated during the on-farm trial, some areas for improvement in performance were highlighted. A project specifically targeting gilts should be initiated to validate targeted performance criteria.

Economic impact

From an economic point of view, the confirmed gain from precision feeding is therefore limited, for the moment, to the reduction of the feeding costs which would be of around $3/sow per year since the effect on the survival rate of gilts remains to be validated. However, if this effect is confirmed, it could greatly improve this economic gain.

In a few words

Precision feeding reduces feed costs while not affecting sow performance. However, it is possible that this feeding strategy improves performance of gilts, but this still needs validation.

Financial partners

This project was funded by the Agri-Innovation program by Agriculture and Agri-food Canada, in partnership with La Coop Seigneurie, Jyga Technologies and Les Éleveurs de porcs du Québec. ■

Suckling of a teat for two days in first parity ensures enough milk is produced in second parity

Submitted by Chantal Farmer, Ph.D., Research Scientist, Agriculture and Agri-Food Canada, Sherbrooke R & D Centre, QC, Robert Friendship, D.V.M., M.Sc., Professor, Ontario Veterinary College, University of Guelph, ON, Rocio Amezcua, D.V.M., Ph.D., Research Associate, Ontario Veterinary College, University of Guelph, ON

We know that if a teat is not suckled in first lactation it will produce less milk in second lactation. But for how long must a teat be suckled in first lactation to avoid such a negative effect? Most recent results show that if a teat is suckled for only two days in parity one, its milk yield will not be reduced in parity two. When comparing lactation lengths of two, seven or 21 days in first parity, milk yield of sows in second parity was not affected. There is therefore no advantage to leaving piglets for more than 2 days on a teat in terms of milk yield from that teat in the next parity. This finding is crucial for swine producers because it will impact the management of first-parity sows that have poor body condition. It would indeed be possible to remove some piglets from thin primiparous sows as of day three of lactation in order for these sows to improve their body condition, knowing that milk yield from the less-used teats will not be compromised in the subsequent lactation. This is information that will prove most useful for producers in the decision making relative to management of first-parity sows.

Lactating sows are greatly solicited in terms of milk yield because of the current use of hyperprolific sow lines. It is now customary to have more live piglets at birth than there are teats to feed these piglets. Sows must therefore produce large quantities of milk and will do so at the expense of their body reserves. This leads to the problem of overly thin sows, which is most prevalent in sows nursing their first litter, and which has a serious negative impact on reproductive performance and decreases sow longevity in the herd.

A solution to this problem could be to decrease litter size in primiparous sows with poor body condition but this is problematic because we now know that an unused teat in first lactation will produce less milk in second lactation (see article by Farmer and Devillers in Western Hog Journal – winter 2013, pp. 34-36). Would it however be possible to remove some piglets from the sow after a short period of time in lactation in order to give the dam a chance to replenish her energy reserves? A research project aiming to answer that question was carried out jointly between the Research and Development Centre of Agriculture and Agri-Food Canada in Sherbrooke and Guelph University. It was demonstrated that a teat can be used for only two days in first lactation without hindering its productivity second lactation.

Figure 1. New piglets suckling.

This project was carried out with 61 primiparous sows and compared lactation lengths of two, seven, or 21 days in first lactation. The effects of treatment on piglet growth, milk composition and sow metabolic status in second parity were

CONTINUED ON PAGE 44

determined. In both lactations, litters were uniformized to 12 piglets of average body weight within 12 hours of farrowing and only 12 teats were kept functional. Surplus teats were taped so that there was one teat available per piglet. During the second lactation, the same 12 teats were made available and piglets were weighed at birth, and on days two, seven, 14, 21, 31 and 56 postpartum. Weaning took place on day 21 of lactation and suckling piglets had no access to dry feed so that their growth rate reflected sow milk yield. Representative milk samples were obtained on day 21 of lactation to measure dry matter, fat, protein and lactose contents. On that day, a blood sample was also obtained from all sows to measure concentrations of glucose, urea, and of the growth factor IGF-1, which reflects the energetic status of the animal.

Sows with a 21 day lactation in first parity consumed more feed in the first week of the second lactation (average daily consumption of 4.80, 4.58 and 5.65 kg for sows with lactation lengths of two, seven and 21 days, respectively, in parity one). However, this was not maintained in later lactation and was not associated with a greater piglet growth rate (see Table 1) or with changes in milk composition. Blood data also showed no differences in the metabolic status of second-parity sows related to lactation length in first parity.

In conclusion, new findings show that it could be possible to remove some piglets from the udder of first-parity sows without affecting milk yield from these teats in the next lactation, as long as they have been suckled for a minimum of two days. This would permit to reduce litter size in sows that show poor body condition in order to ensure optimal reproductive performance and longevity in the herd. This information is most important for producers as it will assist them in developing the best management strategies tailored to the individual needs of their primiparous sows according to body condition.

This project was funded by Ontario Pork ■

Table 1. Weight and weight gain of piglets born from second-parity sows that had lactation lengths of 2, 7 or 21 days in first parity.

	2 DAYS	7 DAYS	21 DAYS
Weight, kg:			
Day 2	1.84	1.80	1.87
Day 7	3.03	2.85	3.00
Day 14	5.02	4.79	4.89
Day 21	6.78	6.63	6.66
Day 31	8.72	8.49	8.70
Day 56	23.2	23.1	23.5
Weight gain, kg:			
24-48 h postpartum	0.153	0.152	0.145
Days 2 to 21 (lactation)	5.07	4.98	4.92
Days 21 to 56 (post-weaning)	16.4	16.5	16.8
Days 2 to 56 (total)	21.5	21.5	21.7

Low cost feeding strategies in nursery production – Feeding simplified diets with feed enzymes

Submitted by B. Koo, and C. M. Nyachoti, University of Manitoba *corresponding author: Martin.Nyachoti@umanitoba.ca*

Take Home Message

There was no difference in average daily gain between newly weaned pigs fed a simple diet compared with a conventional complex diet over a four-week experimental period although the conventional diet supported superior growth during the first week of the post-weaning period. Also, pigs fed the simple diet had greater feed efficiency during the four-week observation. Dietary supplementation with a multicarbohydrase (cocktail of enzymes) improved feed efficiency irrespective of nursery diet complexity. Considering the unit cost of the diets used in the study, feeding a simple diet decreased the total feed cost per pig and feed cost per kilogram of body weight gain by approximately $3.02 and $0.20, respectively. Furthermore, the addition of multicarbohydrase into the nursery diet tended to lower feed cost per kilogram of body weight gain by $0.02.

Introduction

In nursery pig production, highly digestible and palatable ingredients are included in the diet to minimize post-weaning challenges such as impaired gut morphology and high incidences of diarrhea. This practice increases the complexity of diet composition which, in turn, leads to increased feed costs. However, significant reductions in cost may be achieved if conventional ingredients can be replaced with various low-quality alternatives while maintaining growth performance. Additionally, including multicarbohydrase (MC) to nursery diets has been shown to increase feed efficiency and nutrient digestibility. In this trial we investigated a series of simplified nursery diets formulated with alternative ingredients with and without MC supplementation to determine the impact on growth performance and feed costs compared with feeding conventional complex diets.

Bonjin Koo, PhD student with Dr. Martin Nyachoti

Swine Innovation Porc

University of Manitoba

The trial

A total of 144 weaned piglets (21 days of age, 6.70 kg of body weight, 1:1 male to female ratio) were assigned to one of six dietary treatments in a 3×2 factorial arrangement based on diet complexity (complex1, complex2, and simple) and MC addition (0 vs 0.1%). Diets were provided in a two-phase feeding program with phase one (day one to 14) and phase two regimes (day 15 to 28). Complex1 was formulated to mimic a conventional weaner diet with blood plasma, fish meal, dried whey, and skim milk powder. Complex2 partially or totally replaced these ingredients with various plant-based alternatives such as barley, DDGS, wheat middlings, canola meal, field peas, and flaxseed meal. The simple diet consisted primarily of corn, wheat and soybean meal. The MC contained cellulase, pectinase, mannanase, galactanase, xylanase, glucanase, amylase, and protease. Within each phase, calculated nutrients

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and metabolizable energy content were similar in all diets and met or exceeded requirements according to NRC (2012).

Results and interpretation

Diet performance: Pigs fed the complex1 diet had greater average daily gain (ADG), average daily feed intake (ADFI), and feed efficiency than those fed with the complex2 or simple diet in the first week after weaning (Table 1). This may be because the highly palatable and digestible ingredients increased feed intake and thus provided sufficient nutrients and energy to support adequate growth performance immediately after weaning. However, no differences in ADG or ADFI were observed between pigs fed the complex1 and simple diets throughout the 28-day period, whereas the complex2 diet led to lower ADG and ADFI compared with the complex1 diet. Furthermore, feed efficiency was greater in pigs fed the simple diet compared with those fed the complex1 diet over the four-week period.

Table 1. Effects of diet complexity and multicarbohydrase (MC) supplementation on growth performance in weaned pigs

Item	Diet complexity			Multicarbohydrase		P-value	
	Complex1	Complex2	Simple	(+)	(-)	Complexity	MC
Average daily gain, g/d							
d 1 to 7	316^{x}	233^{y}	238^{y}	255	270	<0.01	0.344
d 0 to 28	477^{x}	441^{y}	470^{xy}	464	461	<0.05	0.785
Average daily feed intake, g/d							
d 1 to 7	350^{x}	300^{y}	286^{y}	309	315	<0.01	0.635
d 0 to 28	752^{x}	690^{y}	707^{xy}	705	728	<0.05	0.164
Gain to feed ratio, g/g							
d 1 to 7	0.91^{x}	0.77^{y}	0.83^{y}	0.83	0.85	<0.01	0.30
d 0 to 28	0.63^{y}	0.64^{xy}	0.67^{x}	0.66	0.63	<0.05	<0.05

^{x,y,z}Means within the main effect of diet complexity and within row lacking a common superscript letter differ (P <0.05).

In the simple diet, relatively high amounts of soybean meal containing anti-nutritional factors might have elicited a clinical allergic reaction and contributed to poorer performance in the first week compared to the complex1 diet. However, it seems that hypersensitivity to the antigens in soybean meal could be transient, indicating digestive adaptation to the diet.

Economic Analysis: Based on growth performance data and unit costs of the experimental diets, the total feed cost/pig and feed cost/kg of body weight were compared among treatments (Table 2). The total feed cost/pig on the simple diet was 26.4 per cent lower than that fed the complex1, due to the lower unit cost of the simple diet. Better feed efficiency as well as lower feed costs resulted in a $0.21 reduction in the cost/kilogram of body weight gain when pigs were fed the simple rather than the complex1 diet. Our findings indicate that feeding weaned pigs the simple diet rather than a conventional complex diet is economically beneficial by lowering feed costs for the four-week post-weaning period without compromising final body weight.

Multicarbohydrase supplementation: The addition of MC increased feed efficiency throughout the experimental period (Table 1). This suggests that the MC used had feed saving effects in nursery production, mainly due to the improvement of nutrient digestibility. The effect of MC on the simple and complex2 di-

Table 2. Economic analysis for diet complexity and multicarbohydrase (MC) supplementation in weaned pigs

Item	Diet Complexity			MC		P-value	
	Complex1	Complex2	Simple	(+)	(-)	Complexity	MC
Feed cost, $/ton							
Phase I	642	510	502				
Phase II	459	362	365				
Total BW gain, kg	13.36x	12.33y	13.17xy	13.00	12.91	<0.05	0.78
Total feed cost per pig, $/pig	10.87x	7.85y	8.00y	8.82	9.00	<0.01	0.37
Feed cost/kg of BW gain, $/kg/pig	0.82x	0.64y	0.61y	0.68	0.70	<0.01	0.08

[x,y,z]Means within the main effect of diet complexity and within row lacking a common superscript letter differ (P <0.05).

ets was expected to be greater than on the complex1 diet because the former regimes contained higher levels of complex carbohydrates. However, no interaction effects between diet complexity and MC were observed, suggesting that the MC had similar effects irrespective of diet complexity. Due to the relatively inexpensive price of MC (calculated at $5/kg) and its benefits for feed efficiency, MC tended to decrease the feed cost/kg of body weight gain during the 28 days of nursery production.

Limitations and future research

Taken together, the results imply that economic benefits may be achieved by feeding a simple corn-wheat-soybean meal-based diet with MC supplementation in the four weeks of nursery production without compromising growth performance. However, scaling up to commercial production would be necessary to determine the economic and performance benefits in a commercial setting. Further investigation is also needed into whether the nursery regime affects subsequent growth performance and carcass characteristics.

Acknowledgements

Financial support for this research was provided by Swine Innovation Porc through the Canadian Swine Research and Development Cluster. ■

Swine research, education and outreach at the University of Alberta in the Department of Agricultural, Food and Nutritional Science

Submitted by Ruurd T. Zijlstra

In the Department of Agricultural, Food and Nutritional Science (AFNS) research with swine is mostly conducted in partnership with internal or external partners. Swine education includes the teaching of undergraduate students in the Agriculture (Animal Science) and Animal Health programs. Graduate students in their MSc or PhD programs together with their professors drive innovation using an array of facilities and collaborations. Swine outreach is conducted via a range of routes including the Banff Pork Seminar that is organized together with an advisory committee including representatives from industry.

Overall, research is conducted to enhance key value attributes for the pork industry and value chain. Our research is focused on enhancing animal health and welfare, reproduction, pork quality, nutrient efficiency and reducing feed cost, together thereby enhancing the sustainability of the pork industry. The pig is also used as a model for biomedical research.

Livestock Gentec CEO Graham Plastow together with Leluo Guan and Paul Stothard apply genomic-based tools to support the livestock industry. For porcine genomics, scientists study mechanisms in pigs that make them genetically less susceptible to disease or more efficient in the use of nutrients, provide important new diagnostic tools for breeders, and expand our understanding of disease control mechanisms. Other projects in collaboration with the team include pork quality and pig welfare (see below). Such genome projects include our colleague Ellen Goddard from the Department of Resource Economics and Environmental Sociology who provides the GE3LS component linking Genomics with its Ethical, Environmental, Economic, Legal, and Social Aspects.

Swine health and immunity is studied by Dan Barreda and Richard Uwiera. Such research is tied to genomics as described above, to create robust pigs that rely less on antibiotics in research programs led by Michael Dyck. Research conducted by Ben Willing and Michael Gaenzle links gut microbiology and the effect of bacterial communities and microbial metabolites on swine health. As support, equipment was recently established to perform germ-free piglet experiments.

Pork quality and animal welfare are becoming increasingly important for the pork industry. Pork quality is tied to important genomic, nutrition, husbandry and slaughter variables as studied by Heather Bruce. Animal welfare in particular is related to group-housed pigs. Clover Bench studies automated behavior and welfare assessment technology platforms.

Story Ideas? Press release? Comments?

Email the editor!
sherimonk@gmail.com

Finally, feedstuff evaluation research is conducted by Alberta Agriculture and Forestry Scientists Eduardo Beltranena and Ruurd Zijlstra. Such research includes new commodity ingredients but also novel feedstuffs that are created using dry or wet fractionation technologies.

For biomedical research, the pig model is used by AFNS Human Nutrition professor Spencer Proctor who studies heart disease risk, diabetes and the complications of low birth weight swine. Moreover, Pediatrics Associate Professor Justine Turner studies severe intestinal malfunction in young piglets and has been testing pharmacological solutions to this problem that could translate to life-saving therapies for human babies. On North Campus, biomedical researchers also use the pig model.

Facilities are an important component of research and education. AFNS operates the Swine Research and Technology Centre on South Campus (SRTC) as the main animal facility that is managed by Jay Willis. Professors collaborate with scientists from other organizations to provide access to SRTC or gain access to pigs elsewhere to reach better research outcomes and training opportunities. On North Campus, researchers use central laboratories for Genomics and Proteomics, Chromatography, and Proximate analyses. Genomics and associated research is organized under the umbrella of Livestock Gentec. On South Campus, novel feeds or feedstuffs are created at Agri-Food Discovery Place.

The SRTC provides a full range of support for activities including research programs for graduate students, teaching programs for undergraduate students, and training in swine handling. The SRTC has a sow herd providing research animals and animal facilities for researchers in AFNS and biomedical researchers in other departments. Sows are housed in gestation and farrowing rooms. Weaned pigs are housed in nursery rooms until reaching 25 kg body weight, and some pigs can reach slaughter weight in a growout facility. Pigs can be modified using surgery and subsequently be housed individually in the metabolism wing of SRTC.

To enable the described research in the facilities, strong industry and government partners are essential and appreciated. Furthermore, strong ties exist among the researchers mentioned and their external collaborators. The description of the research provides the entry-point information to contact scientists working with swine among several disciplines in our department. ■

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Ad Index

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