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We need to start thinking about more than essential amino acid requirements.

Dan Columbus, PhD,
Prairie Swine Centre

An increased understanding of essential amino acid requirements has led to the ability to reduce dietary protein content while maintaining animal performance. However, it is possible that non-essential amino acids/dietary nitrogen may become limiting in low protein diets. A further understanding of how dietary protein/non-essential amino acid content influences amino acid utilization and growth is key to maximizing animal performance while reducing the cost and environmental impact of animal agriculture.

In general, retention of dietary nitrogen in pigs ranges from 30% to 60% of intake (Dubeau et al., 2011; NRC, 2012) with much of this inefficiency the result of catabolism of excess or unbalanced amino acids (AA) intake (Moughan, 1999). This catabolism represents an energetic cost to the animal, reducing performance, and results in an increase in nitrogen excretion into the environment. Advances in our understanding of nutrient requirements (i.e., AA) in pigs and characterization of nutrient content of ingredients have led to significant improvements in

performance and reduction in nutrient excretion and feed costs in pig production. While previous diets were formulated with high crude protein (CP) to meet lysine requirements, resulting in excess levels of other AA (Wang et al., 2018), use of crystalline AA and the introduction of the 'ideal protein concept' has

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Enrich Your Pigs, Enrich Your Profits

Swine Innovation Porc

Geoff Geddes,
for Swine Innovation Porc

If "sow enrichment" sparks images of pigs by the pool sipping Mai Tais, you've been badly misinformed. As it turns out, enriching a sow's environment is easy, inexpensive and offers a range of benefits. This was made clear by the project "From Innovation to Adoption: On-farm demonstration of Swine Research", which was led by Ken Engele at Prairie Swine Centre and Geneviève Berthiaume at CDPQ. One aspect of the project examined environmental enrichment and strategies to improve laying areas for gestating sows.

What's news in the nursery?

Based on audits at 18 nursery facilities, the project found good news and bad news. On the plus side, pork producers are doing well at adopting best management practices in their barns. Unfortunately, enrichment in the nursery could use some work, with only 11% of audited farms employing it for their animals. While the numbers were better for enrichment in finishing facilities (65%), there is room for improvement, especially with the updated "Code of Practice for the Care and Handling of Pigs" requiring multiple forms of enrichment on farm.

Boosting those numbers was a key focus of this project as it gathered producer experiences in using three types of enrichment: a chain suspended from the ceiling, a piece of wood suspended by a chain, and a Porcichew toy (ring of aromatic plastic), also suspended by a chain.

Chain reactions

Uptake by the animals varied somewhat depending on the form of enrichment. Though interest was highest right after the object appeared, with sows often lining up for a turn with it, producers reported that animals remained engaged – to a lesser degree – in the days that followed.

Among the benefits of enrichment cited by participants, several noted a reduction in pen aggression. As one producer put it: "I'd rather see them chewing on wood than chewing on each other." Given the prevalence of tail biting and ear chewing in many pens, anything that minimizes aggression is worth exploring.

> "Enrichment must be carefully thought out and designed with the pigs and facility in mind."

Popularity contest

Though it's not a popular plaything for humans, the chain garnered the most interest among pigs on the project. One person even noted that his animals played more with the chain than with the chew toy attached to it, though he stressed that the toy got its share of attention as well. While the chain also proved the most durable of the enrichment options, some farms

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allowed for more precise formulation of swine rations while reducing CP content. The current trend in swine nutrition is to formulate lower protein diets supplemented with essential AA (EAA), which have been shown to increase utilization efficiency and reduce nitrogen excretion into the environment (Gloaguen et al., 2014).

The benefits of reducing dietary protein content can be significant. Every 1 percentage point reduction in dietary protein results in a 3% reduction in protein ingredient utilization, reducing feed costs (Wang et al., 2018). Moreover, for the same reduction in dietary protein there is also an 8-10% reduction in ammonia emissions from feces and urine (NRC, 2012) and reduced odour emissions (Hayes et al., 2004), improving environmental impact and animal and worker well-being. Reductions in dietary protein have also been used to reduce the incidence of post-weaning diarrhea (Heo et al., 2009; Jha and Berrocoso, 2016). However, these benefits may quickly be lost if pig performance is not maintained (e.g., reduced growth performance, increased carcass fatness). It is now fairly well accepted that a reduction in dietary protein of 3% from NRC (1998) recommendations while supplementing with crystalline AA can maintain pig performance. Further reductions (> 3%) in dietary protein content have provided conflicting results (Wang et al., 2018) and generally result in significantly decreased growth performance despite supplementation with EAA (Guay et al., 2006; Yue et al., 2008; Roux et al., 2011; Gloaguen et al., 2014). Increased carcass fatness has also been observed at current NRC (2012) recommendations for dietary protein (Tuitoek et al., 1997; Kerr et al., 2003).

A major assumption behind these low protein diets is that pigs are capable of producing sufficient amounts of non-essential AA (NEAA) to meet their demands for growth and so only need to be supplied with a source of EAA. However, to date there is insufficient evidence that this is the case (Wu et al., 2014) and may explain why growth performance is improved in low protein, supplemented diets but still tends to be lower than in animals receiving a normal protein diet. For example, Guay et al. (2006), Gloaguen et al. (2014), and Jansman et al. (2016) observed reduced growth performance in grower and nursery pigs fed low protein diets (< 15% CP) even though a sufficient amount of EAA had been added. This suggests that NEAA may become essential when dietary protein is below a critical level (Wang et al., 2018). For instance, Jansman et al. (2016) concluded that protein can be reduced in post-weaned to approximately 16% CP before performance is negatively affected.

The reduction in performance regardless of EAA supplementation suggests that a minimum amount of NEAA (or total dietary nitrogen) is required in diets in order to maximize nitrogen retention (i.e., growth; Heger et al., 1998; Wu, 2014). This reduced performance regardless of EAA supplementation may also be the result of EAA being catabolized as a source of nitrogen for endogenous production of NEAA. Indeed, current estimates of EAA requirements are largely the result of studies in which a traditional level of dietary protein was used. These recommendations, therefore, may not reflect requirements in low protein, crystalline AA supplemented diets. This concept was demonstrated in multiple studies in which Heger et al. (1998) determined the optimal dietary nitrogen (i.e., crude protein) content that is required to maximize AA utilization using the EAA to total nitrogen ratio (EAA:TN). In multiple species, it was determined that an EAA:TN of approximately 0.50 is required to maximize utilization. Reduced performance in diets with a lower ratio having insufficient EAA to meet requirements, and a greater ratio indicating insufficient NEAA.

> "Ensuring both AA and nitrogen/protein requirements are met ensure maximum efficiency and growth performance"

While EAA requirements need to be met through inclusion of those specific AA in the diet, the source of nitrogen to meet dietary NEAA/nitrogen needs may not be as critical. The ability of pigs to utilize non-specific forms of nitrogen, as well as reiterating the importance of nitrogen specifically, has been demonstrated in a series of studies examining the use of non-protein nitrogen and NEAA supplementation of low protein diets (i.e., >0.50 EAA:TN). Mansilla et al. (2015) initially demonstrated that nitrogen absorbed from the hindgut can be utilized to improve whole-body nitrogen retention in pigs fed a diet deficient in NEAA. They further showed that nitrogen from ammonia (as ammonium chloride) was as efficient as free AA or intact protein for improving growth in pigs fed diets deficient in NEAA (Mansilla et al., 2017) and that ammonia-nitrogen improves the endogenous production of NEAA (Mansilla et al., 2018).

The nutrition research group at the Prairie Swine Centre has received funding from the Government of Saskatchewan through the Agriculture Development Fund to further investigate the importance of dietary nitrogen. The objectives of this series of studies will be to investigate the impact of dietary nitrogen content on essential amino acid requirements and amino acid utilization efficiency and to evaluate the effectiveness of alternative source of nitrogen to improve growth performance of pigs. The information gained from these studies will be used to provide recommendations to refine diet formulations to optimize nitrogen retention and lean gain in growing pigs.

Conclusions

While our understanding of requirements for EAA is very well established, the requirement of pigs for NEAA and nitrogen has largely been ignored. An insufficient supply of nitrogen/dietary protein will likely reduce the efficiency with which EAA are used for lean gain. Failure to account for this will lead to subsequent negative effects on growth performance, feed costs, days to market, and carcass value. By ensuring both AA and nitrogen/protein requirements are met, producers will be able to maximize efficiency and growth performance while reducing environmental impact and feed costs.

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Investigation of enhanced sanitization and disinfection measures applicable for antibiotic-free pig production system.

Bernardo Predicala, Ph.D.
Prairie Swine Centre

This project aims to develop enhanced biosecurity measures that can eliminate or reduce the proliferation of disease-causing pathogens in antibiotic-free pig production as well as in conventional barns for all-inclusive disease prevention. Specifically investigating alternative sanitization and disinfection measures that are effective for control of potentially antibiotic-resistant pathogens, and those measures that might prevent or reduce further development of antimicrobial resistance in the pig production environment.

A comprehensive literature review gathered information on existing and potential sanitization and disinfection technologies available in other jurisdictions, similar industries or applications requiring stringent pathogen control. Sanitization technologies identified from the initial literature search, including use of alternative chemical-based disinfectants, selected nanoparticles, thermal and irradiation technologies was subjected to screening to evaluate their potential applicability in Saskatchewan production units. Results will provide valuable tools for pathogen control not only to pig producers implementing antibiotic-free production but also for disease prevention in conventional livestock production in general.

Overuse of antibiotics can contribute to the development of antimicrobial resistance to (medically important) antibiotics. In recent years, some pig producers have shifted to raising pigs without the use of any antibiotics, with processors offering premiums for pigs raised completely without antibiotics - as consumer demand for such products increased.

Producers developed strategies such as feeding prebiotics and enhanced vaccination programs to offset the reduced availability or the total absence of antibiotics in their operations. However past studies (Desrosiers, 2013) have shown high herd health also helps reduce the reliance on antibiotics. Therefore strong biosecurity and sanitization protocols are essential to ensure that exposure to pathogens is either eliminated or reduced significantly.

Currently, the most commonly used method for controlling pathogens in barns is the use of disinfectants such as quaternary ammonium compound (QAC) and peroxygen, which are more commonly known by their respective trade names. Repeated use of QAC-based disinfectants can lead to the disinfectant being no longer effective for gram-negative bacteria, especially to Escherichia coli (E. coli) and Salmonella sp. Therefore, there is a need for alternative sanitization and disinfection technologies that producers can reliably employ to control the growth and transmission of disease–causing microorganisms, particularly those that may have potentially acquired resistance to current conventional disinfectants and the antibiotics used in the farms.

> "Identifying sanitation and disinfection alternatives are an important component in maintaining long term biosecurity."

Phase 1: Evaluation of potential sanitization and disinfection techniques applicable to swine production facilities

A comprehensive literature review was conducted compiling various sanitization and disinfection procedures and technologies that have been developed and applied in other industries and applications (such as water treatment facilities, hospitals, care home institutions, food processing and manufacturing facilities) to determine their possible application in swine barns. Potential measures include the application of technologies such as ultraviolet germicidal irradiation, non-thermal plasma, ozonation, thermo-assisted drying and decontamination, and the use of slightly acidic electrolyzed water, among others. Aside from the use of new technologies and equipment, the use of nanoparticles (zinc oxide, silver nanoparticle, and titanium dioxide) as potential antimicrobial agents was also considered, together with the use of various chemical-based disinfectants with different active ingredients (peracetic acid, hydrogen peroxide, chlorine dioxide, sodium hypochlorite).

Assessment criteria that considered cost, applicability, potential effectiveness against antimicrobial-resistant pathogenic strains, among others, was developed and then applied to identify the top three to four potential sanitization and disinfection alternatives for consideration in the next stage of evaluation.

Phase 2: In-barn testing of the selected most promising sanitization techniques

Efficacy of the top two potential sanitization and disinfection techniques identified in the previous phase for controlling the growth of disease-causing microorganisms will be evaluated in nursery and grower-finisher rooms at the Prairie Swine Centre (PSC) barn. After each room turn, selected rooms will be pressure-washed following standard cleaning practices, except the sanitizing/disinfecting step; this last step will be carried out as part of this experiment.

Phase 3: Feasibility analysis and development of recommendations and application guidelines

Following the in-barn experiments, a feasibility analysis will be conducted to determine the costs and requirements for the proper implementation of the top treatments in a typical swine production facility.

Results and Discussions

A preliminary evaluation of the various sanitization and disinfection measures is available in Table 1. To reinforce the screening process, an information survey is being conducted to supplement and verify the information gathered on each potential measure, by contacting additional information sources and experts such as swine veterinarians, animal scientists, health researchers, microbiologists, equipment and disinfectant suppliers, and pig producers with on-farm experience on the use of these measures, among others.

Initial results from the literature search also indicate that currently, the most common method for controlling pathogens in livestock facilities is the use of chemical disinfectants. The potential alternative and experimental measures identified from the literature search included ultraviolet (UV) germicidal irradiation, ozonation, thermo-assisted drying, non-thermal plasma, and the use of slightly acidified water spray, among others, with varying degrees of efficacy in inactivating pathogens.

Implications

Based on the initial screening and evaluation of identified sanitization and disinfection alternatives, the following measures i.e., use of peracetic acid, calcium oxide, slightly acidic electrolyzed water, and use of silver nanoparticles, were initially identified for consideration for testing and evaluation in subsequent phases of the project.

Table 1a. Evaluation of conventional disinfectants.

DISINFECTANTS	COST	Applicability to Swine Barn	PROPERTIES					SAFETY	
			Antimicrobial Spectrum	Development of AMR	Effectiveness against AMR	Reactivity		Health Aspect	Toxicity to environment
A. LIQUID									
1. Alcohols	Moderate (requires high volume)	Applicable	Low Level	Low		Fast acting		Low	Low
2. Formaldehydes	Low	Applicable	High level	Low	Low (selective)	Slow acting		Harmful	Intermediate
3. Glutaraldehyde	Moderate	Highly Applicable	High level	Low	Low (selective)	Fast acting		Harmful	Intermediate
4. Iodine	Low	Applicable	Low	High risk (S. suis, B. hyodysenteriae, ascaris suum eggs)	Low (selective)	Fast acting		Low	Intermediate
5. Sodium hypochlorite	Low	Applicable	High level	High Risk (Rotavirus and PCV virus) (S. aureus) (S. enteritis)	Moderate	Medium		Low	Low
6. Hydrogen peroxide	Moderate	Highly Applicable	High level	Low (S. suis, S. typhimurium are resistant under high organic matter conditions)	Moderate	Fast acting		Low	Low
7. Peracetic acid	Moderate	Highly Applicable	High level	Low (S. suis, S. typhimurium are resistant under high organic matter conditions)	High	Fast acting		Low	Low
8. Phenols and Phenolic derivatives	Low	Applicable	Low level	Low Risk (rotavirus)	Moderate	Medium		Harmful	Harmful
9. Quaternary Ammonium Compound (QAC)	Moderate	Highly Applicable	Intermediate (Low)	High risk (S. typhimurium, Salmonella and Bacillus sp.)	High	Slow acting		Low	Low
B. POWDER									
1. Calcium Oxide	Low	Highly Applicable	Intermediate	Low	High	Slow acting		Intermediate	Intermediate
2. Sodium hydroxide	Low	Applicable	Intermediate	Low	Moderate	Slow acting		Harmful	Harmful
C. TECHNOLOGY									
1. Thermo-Assisted Drying and Decontamination	Extremely High	Applicable (material of construction should be considered)	High level		Moderate	Slow acting		Harmful	Intermediate

See Table 1b on page 7

Increased adaptation time improves pig response to functional amino acid supplementation.

Lucas A. Rodrigues
University of Saskatchewan

Dan Columbus, PhD,
Prairie Swine Centre

Highlights

- Average daily gain and feed efficiency were improved by feeding functional amino acids above requirements for growth for 2 weeks before Salmonella infection.
- Inflammatory reaction due to Salmonella was attenuated by a longer adaptation period to functional amino acids.
- Salmonella shedding and intestinal presence were reduced in pigs fed functional amino acids for 2 weeks before infection.
- Positive effects of adaptation period to functional amino acids above requirements for growth may be related to improved gut health in pigs.

A previous study conducted at the Prairie Swine Centre and the University of Saskatchewan revealed improved performance of pigs under Salmonella infection when fed functional amino acids (FAA) above requirements for growth. The positive effects were mainly associated with enhanced gut health and improved immune status. Here, researchers attempted to assess whether a longer adaptation period to FAA supplementation would further enhance the previously reported benefits. To achieve this, weanling pigs were fed a basal amino acid profile (AA-) throughout the trial period (FAA-) or a functional amino acid profile only in the post-inoculation (FAA+0), for 1 week pre- and post-inoculation (FAA+1), or throughout the trial period (FAA+2). The functional amino acid profile contained threonine, methionine, and tryptophan at 120% of requirements. Diets contained no animal products or antibiotics, and all the pigs were inoculated with Salmonella after a 2-week pre-inoculation period.

Pigs fed functional amino acids for a longer period showed improved gut health and had lower counts of Salmonella in feces and colon digesta.

Researchers also measured the activity of an enzyme called my-eloperoxidase (MPO) in fecal and digesta samples. This enzyme has increased activity during situations of gut inflammatory reaction and has been recognized as an important diagnostic and prognostic tool in assessing enteric disease status. Fecal

Table 1. Pre- and post-inoculation growth performance of Salmonella-inoculated pigs

	Dietary Treatment					
Item	FAA-	FAA+0	FAA+1	FAA+2	SEM	P-value
Initial body weight (day -14), kg	11.74	11.63	11.63	11.73	0.346	NS
Inoculation body weight (d 0), kg	16.85	16.34	16.74	17.40	0.701	NS
Final body weight (day 7), kg	18.33	18.62	19.55	20.59	1.093	NS
Pre-inoculation period (day -14 to -7)						
Average daily gain, kg	0.290	0.248	0.289	0.281	0.032	NS
Average daily feed intake, kg	0.446	0.381	0.405	0.407	0.049	NS
Gain:Feed, kg/kg	0.65	0.65	0.71	0.69	0.089	NS
Pre-inoculation period (day -7 to 0)						
Average daily gain, kg	0.440	0.424	0.441	0.529	0.061	NS
Average daily feed intake, kg	0.778	0.750	0.740	0.801	0.042	NS
Gain:Feed, kg/kg	0.57	0.57	0.60	0.66	0.088	NS
Post-inoculation period (day 0 to 7)						
Average daily gain, kg	0.211b	0.326ab	0.401ab	0.456a	0.059	0.01
Average daily feed intake, kg	0.720	0.705	0.763	0.727	0.052	NS
Gain:Feed, kg/kg	0.29b	0.46ab	0.53ab	0.63a	0.099	0.02

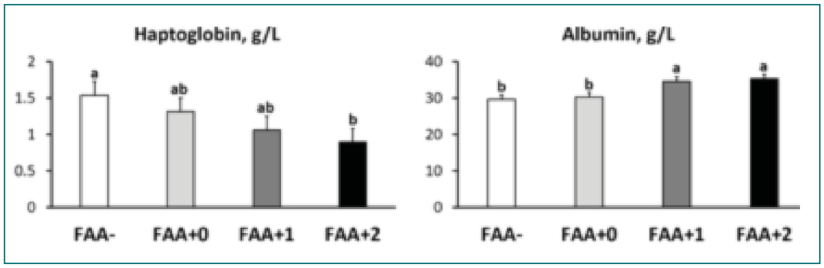

Figure 1. Haptoglobin was increased and albumin was decreased post-Salmonella inoculation. Overall haptoglobin was lower in FAA+2 compared to FAA- pigs while FAA+2 and FAA+1 pigs had higher albumin compared to FAA- and FAA+0 (P < 0.05).

MPO was increased post-inoculation, which confirms the negative effects of Salmonella in the gut. Interestingly, MPO content measured in fecal and colonic digesta samples were lower in FAA+2 and FAA+1 pigs compared to FAA-, indicating decreased intestinal inflammation with longer adaptation period to FAA supplementation. An improved gut health led to a reduced Salmonella shedding in feces in FAA+2 pigs compared to FAA- and FAA+0. Also, Salmonella presence in colon digesta was increased in FAA- and FAA+0 pigs compared to FAA+2.

The researchers measured the content of two blood proteins, haptoglobin and albumin. These proteins are directly related to the overall health status of pigs, with haptoglobin being increased and albumin being decreased during situations of trauma, infection, or inflammation. As expected, Salmonella increased haptoglobin and decreased albumin. However, these trends were counteracted by supplementation of FAA for a longer period, where overall haptoglobin was lower in FAA+2 compared to FAA- pigs while FAA+2 and FAA+1 pigs had higher albumin compared to FAA- and FAA+0 (Figure 1). These findings are in line with the reduced shedding and intestinal counts of Salmonella in pigs fed FAA-fortified diets for a longer period before infection.

Post-infection growth performance was improved in pigs fed functional amino acids for a longer period

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(Investigation of enhanced sanitization... cont'd from page 7)

Table 1b. Evaluation of non-conventional disinfectants.

DISINFECTANTS	COST	Applicability to Swine Barn	PROPERTIES				SAFETY	
			Antimicrobial Spectrum	Development of AMR	Effectiveness against AMR	Reactivity	Health Aspect	Toxicity to environment
A. GAS								
1. Carbon dioxide contact cleaning	Extremely High	Not applicable (Inside access problematic)	Low level		Low	Fast acting	Low	Intermediate
2. Chlorine dioxide	Extremely High	Applicable	High level	High risk (S. aureus)	Moderate	Medium	Intermediate	Low
3. Slightly Acidic Electrolyzed Water	Extremely High	Highly applicable	Extremely high level		High	Fast acting	Low	Low
4. Ozone	Extremely High	Highly applicable	Extremely High	Low risk	High	Fast acting	Harmful	Intermediate
B. NANOPARTICLES								
1. Silver Nanoparticles	High	Highly applicable	Extremely High	No risk	High	Fast acting	Low	Low
2. Titanium oxide	Moderate	Applicable (limited, focuses on its photocatalytic property)	High level		High	Medium	Intermediate	Low
3. Zinc Oxide	Moderate	Highly applicable	High level	No risk	High	Medium	Low	Low
C. TECHNOLOGY								
1. HYDROVAC	Moderate	Not applicable (Not a sanitation procedure)	Low		Low	Slow acting	Low	Low
2. NON-THERMAL PLASMA	Extremely High	Applicable (mostly in vitro studies)	Extremely High level	High Risk (S. enterica, B. cereus, B.subtilis, G stearothermophilus, some yeast and molds	High	Fast acting	Low	Low
3. Ultraviolet Germicidal Irradiation	Extremely High	Highly applicable	Extremely High level	Low risk (for some fungi)[15] (E. coli is resistant after 80 cycles)	High	Fast acting[1]	Harmful	Intermediate
4. Steam wash	Moderate	Applicable (inside access problematic)	Low		Low	Slow acting	Low	Low
5. Soda Blast	Moderate	Not applicable (disinfection is still required)	Low		Low	Fast acting	Intermediate	Harmful (leaves high level of residue)

Impacting Greenhouse Gas Emissions Through Diet Change

Denise Beaulieu, PhD.
University of Saskatchewan

Western Canada, wheat millrun, a co-product of wheat milling is commonly added to swine diets, reducing diet cost and competition with humans for cereals. The inclusion of wheat millrun in swine rations is limited by the high non-starch polysaccharide (NSP; dietary fibre content), Fibre is not digested by pigs, and thus nutrient availability is limited. Carbohydrase enzymes can be added to possibly improve the digestibility of wheat millrun by breaking down the fibre more effectively. This would increase the feeds' energy value and reduce undigested matter in the feces, allowing for low-quality raw materials to be included in swine diets.

Animal protein demand is increasing which will raise greenhouse gas (GHG) production/emissions, exacerbating environmental problems including climate change, unless mitigation steps are implemented. Although pork production accounts for less than 10% of GHG emissions from the livestock sector, the predicted growth in global pork consumption makes mitigation efforts essential. Understanding the impact of non-conventional ingredients in swine diets on the environment is important; specifically how they may alter manure output and GHG emissions. Increasing dietary fibre may increase hindgut fermentation and the production of GHG emissions, but might not affect performance of the pigs when a multi-carbohydrase enzyme is supplemented.

This study focused on how to further reduce the GHG emissions by pigs without negatively impacting efficiency or productivity.

Specific objectives were:
- To determine the response of growing pigs to wheat millrun inclusion in diets, with or without, a multi-carbohydrase enzyme.
- To determine the impact of wheat millrun inclusion supplemented with a multi-carbohydrase in swine diets fed to grow-finishing pigs on GHG production from the pigs and manure.

What We Did

Performance and digestibility

Forty-eight barrows with an initial body weight of 60±2.2 kg were used for the digestibility study. Pigs were randomly assigned to one of six dietary treatments with 8 pigs per treatment. Treatments included wheat millrun (none, low, high; 0, 15 or 30 % respectively) with or without the multi-carbohydrase enzyme. The feed was divided into two equal meals and presented at 0830 and 1500 hrs. Pigs were allowed free access to water throughout the experiment. Urine and feces were collected for analysis.

One hundred and eighty pigs with an initial body weight of 60.2 ± 2.2kg were randomly assigned to one of the four experimental treatments which included a control diet (no millrun), and 30 % wheat millrun inclusion with and without carbohydrase enzymes, with five pigs per pen and nine pens per treatment. Pigs were provided a common diet for at least five days prior to the start of the experiment. Weight was recorded along with feed disappearance throughout the experiment. Pigs were sent to an abattoir once a minimum of 128 kg was achieved and slaughter characteristics were analyzed.

Greenhouse gas measurements

Ninety-six pigs with an initial body weight of 60±2.2 kg were assigned to one of four dietary treatments (described above). There were four replicates (six pigs per replicate) for each treatment. Gases were sampled and analyzed and manure was stored to measure volume and emissions.

What We Found

Apparent total tract digestibility

The apparent total-tract digestibility (ATTD) of dry matter (DM), energy, nitrogen and phosphorus were linearly reduced with increasing wheat millrun inclusion in the diets, while enzyme supplementation reduced the ATTD of DM and energy. Further, increasing the inclusion of wheat millrun in the diets linearly reduced the digestible energy (DE) and net energy (NE) contents of the diets while enzyme supplementation tended to reduce dietary DE and NE contents. Enzyme supplementation, however, did not affect the ATTD of nitrogen and phosphorus total tract digestibility.

Growth performance

The effects of 30% wheat millrun and carbohydrase supplementation on performance of growing pigs are presented in Table 2. Including wheat millrun in the diets tended to reduce the body weight for day 42 and the final body weight resulting from reduced average daily gain (ADG) on days 29 to 42 and overall. Similarly, for days 29 to 42 of the experiment, the gain to feed ratio (G:F) was reduced in pigs receiving wheat millrun. There was a reduction in the overall G:F (Table 2) when pigs were fed diets

(Greenhouse Gas Production... cont'd on page 10)

Table 1: Effect of wheat millrun inclusion and multi carbohydrase supplementation on apparent total tract digestibility of energy and minerals of diets fed to grower pigs (60kg) in Exp1a

	Millrun, %				Enzyme		P- value		
Item	0	15	30	SEM	No	Yes	SEM (Millrun)	Enzyme	Linear
Total tract digestibility									
DM, %	86.5	84.7	83.9	0.28	87.3	82.8	0.22	<0.01	<0.01
Energy,%	87.3	84.9	81.5	0.01	85.0	84.2	0.01	0.05	<0.01
DE, Mcal kg-1	3.50	3.47	3.34	0.01	3.45	3.42	0.01	0.08	<0.01
NE, Mcal kg-1	2.46	2.44	2.34	0.01	2.43	2.40	0.01	0.06	<0.01
Total tract digestibility, %									
N	86.4	85.3	83.5	0.53	85.1	85.0	0.44	0.89	<0.01
P	52.6	43.5	41.1	0.60	46.2	45.2	0.52	0.33	0.02

SEM; standard error of means
No interaction between millrun and enzyme (P > 0.10)
aValues are means of eight individually housed pigs

Table 2: Effect of dietary wheat millrun and multi carbohydrase supplementation on performance of growing pigs over time in Exp2 (60 kg)a

	Millrun, %		Enzyme		Pooled	P- value	
Item	0	30	No	Yes	SEM	Millrun	Enzyme
BW, kg							
Initial	60.1	60.3	59.8	60.6	1.27	0.63	0.10
d 14	76.0	75.8	76.1	75.6	1.12	0.92	0.62
d 28	92.1	91.6	91.9	91.8	0.71	0.50	0.88
d 42	107.3	105.8	106.6	106.4	1.03	0.10	0.84
Final	120.6	118.9	119.6	120.0	0.72	0.10	0.69
ADG, kg d-1							
d 7 to 14	1.13	1.10	1.16	1.08	0.07	0.68	0.14
d 15 to 28	1.16	1.13	1.13	1.15	0.04	0.28	0.42
d 29 to 42	1.09	1.02	1.05	1.05	0.04	0.03	0.90
d 43 to 56	0.94	0.95	0.91	0.98	0.04	0.91	0.11
d 0 to 56	1.10	1.07	1.09	1.08	0.02	<0.05	0.65
ADFI, kg d-1							
d 7 to 14	2.47	2.47	2.47	2.47	0.12	0.98	0.98
d 15 to 28	2.84	2.88	2.87	2.86	0.06	0.60	0.91
d 29 to 42	2.88	2.94	2.87	2.95	0.07	0.58	0.42
d 43 to 56	3.19	3.31	3.20	3.30	0.26	0.24	0.32
d 0 to 56	2.85	2.90	2.85	2.90	0.05	0.41	0.51
G:F							
d 7 to 14	0.45	0.45	0.47	0.43	0.02	0.74	<0.05
d 15 to 28	0.41	0.39	0.40	0.40	0.02	0.19	0.68
d 29 to 42	0.38	0.35	0.37	0.36	0.01	<0.01	0.38
d 43 to 56	0.32	0.30	0.31	0.30	0.01	0.34	0.91
d 0 to 56	0.39	0.37	0.38	0.37	0.01	0.01	0.20

No interaction between millrun and enzyme (P > 0.10)
aData are means of 9 replicate pens with 5 pigs per pen.
SEM; standard error of mean

(Greenhouse Gas Production... cont'd from page 8)
with 30% millrun inclusion. However, wheat millrun inclusion had no effect on average daily feed intake (ADFI). Enzyme supplementation on the other hand reduced G:F during the initial 14 days of the experiment, but had no effect on the overall G:F, body weight, ADG or ADFI.

Carcass traits
Wheat millrun inclusion or multi-carbohydrase supplementation did not affect days to market, market weight, slaughter weight, loin depth or dressing percentage (Table 5). Backfat depth was reduced by 7% while carcass yield increased with the inclusion of 30% wheat millrun. Enzyme supplementation tended to increase backfat depth but had no effect on days to market, market weight, slaughter weight, loin depth, carcass yield and dressing percentage (Table 3).

Greenhouse gas measurement
Emission rates are presented in Table 4. Feeding pigs with 30% wheat millrun included in their diets had no effect on the three GHG's measured in this experiment. The highest concentration of gas emitted was CO2 at 1162 and 1336 μg m-3s-1, without or with wheat millrun inclusion respectively, followed by methane (9.1 vs 11.0) and nitrous oxide (0.34 vs 0.40).

Pigs fed 30% wheat millrun diets consumed around 18% more water than pigs fed the zero wheat millrun diets. Total manure output was increased by about 1.2 L pig-1 day-1 when pigs consumed the 30% wheat millrun diets.

Discussion
Most of the fibre constituents in wheat millrun are insoluble xylose and arabinose. These NSPs comprise the cell wall and act as a "physical barrier" that "traps" nutrients and prevents them from being utilized. The function of the carbohydrase enzyme is to breakdown this barrier, releasing the trapped nutrients for utilization by the pig.

The amount of fibre and type of fibre in diets also may affect the efficacy of enzymes. In the hindgut, soluble dietary fibre is more fermentable than insoluble dietary fibre and this may have contributed to the unaffected DE digestibility results found in the experiment as the wheat millrun contains high insoluble dietary fiber. Energy and DM digestibility were reduced in the multi-carbohydrase supplemented diets. The results were supported by the reduced G:F in the first 14 days with enzyme supplementation in the performance study. The negative impact on nutrient digestibility and growth could be due to the digestive enzyme secretion or activity being affected with the supplementation. These results are likely due to the higher NSP content in the wheat millrun diets compared to the diets containing no wheat millrun.

Table3: Effect of wheat millrun inclusion and multi carbohydrase supplementation on carcass traits in Exp2

	Millrun,		%Enzyme		Pooled	P- value	
Item	0	30	No	Yes	SEM	Millrun	Enzyme
Days to market	68	69	69	68	2.57	0.46	0.31
Final BW, kg	132.25	131.81	132.05	132.01	0.41	0.42	0.94
Slaughter weight, kg	105.84	105.10	105.38	105.56	0.54	0.19	0.75
Backfat depth, mm	16.71	15.54	15.74	16.50	0.75	<0.01	0.07
Loin depth, mm	66.82	68.41	67.97	67.27	1.05	0.28	0.63
Carcass yield, %	61.80	62.42	62.29	61.94	0.36	0.01	0.13
Dressing, %	80.03	79.74	79.80	79.96	0.28	0.35	0.60

SEM; standard error of means
No interaction between millrun and enzyme (P > 0.10)

Table 4: Greenhouse gas emissions as affected by wheat millrun inclusion and multi carbohydrase supplementationa

	Millrun,		%Enzyme		Pooled	P- value	
Item	0	30	No	Yes	SEM	Millrun	Enzyme
Gas, μg m-3s-1							
Methane	9.10	11.00	8.90	11.20	1.10	0.27	0.18
Nitrous oxide	0.34	0.40	0.35	0.39	0.05	0.23	0.44
Carbon dioxide	1162	1336	1254	1244	116	0.15	0.93

No interaction between millrun and enzyme (P > 0.05)
a values are means of 4 replicates (chambers) with 6 pigs per chamber.
SEM; standard error of mean

We expected wheat millrun inclusion to decrease dressing percentage because of its lower digestibility and the subsequent increase in the total empty weight of the gastrointestinal tract. However, dressing percentage was not significantly different. Although the energy content in the wheat millrun diets were lower, they were not low enough to elicit a change in the eating behavior of the pigs; so the pigs had similar feed intake as those with diets containing no wheat millrun. The lower energy intake (6.89 Mcal NE/day vs 7.01 Mcal NE/day) by pigs on the wheat millrun inclusion diets might have been responsible for the 7% reduction in backfat depth since this is mainly influenced by the energy intake in the finishing phase. Carcass yield is mainly influenced by backfat depth and pigs with high backfat depth are penalized; so it is not surprising that carcass yield increased with wheat millrun inclusion diets, as the pigs fed those diets had lower backfat.

The high fibre content and low digestibility of the 30% wheat millrun inclusion diets resulted in a higher manure output. Due to the limited activity of endogenous enzymes in the large intestine, most of the fibre in high fibre diets are not completely fermented and are excreted in the feces. The source of CO_2 is mainly from animal respiration. The CO_2 from the pig is more likely to be influenced by pig activity and less from the manipulation of the diets. Methane emissions from pigs are known to be just 50% of what is produced from manure. Methane emissions (production) from the manure are supported by several factors such as the temperature, organic matter content and pH. The 30% wheat millrun inclusion diets did not affect N_2O emissions. Research has shown that N_2O emissions are mainly influenced by the age of the manure. Also N_2O emissions are related to the excretion of nitrogen, so a reduction of nitrogen in the manure could result in a potential reduction of N_2O during the storage of manure.

Conclusions

Supplementing the multi-carbohydrase enzyme apparently reduced energy digestibility but did not change the growth performance of growing-finishing pigs. Up to 30% inclusion of wheat millrun reduced both nutrient digestibility and growth performance. However, days to market was not affected by having 30% wheat millrun inclusions in the diets. Backfat depth had a decrease and carcass yield increased with wheat millrun inclusion. There were no interactions found between wheat millrun inclusion and multi-carbohydrase supplementation on nutrient digestibility, growth performance and carcass quality characteristics.

The 30% inclusion of wheat millrun in swine diets did not affect GHG emissions from swine barns. Even though wheat millrun inclusion increases the fibre content in swine diets, addition of up to 30% of wheat millrun will not significantly increase the GHG produced by the pigs in swine barns.

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(Enrich Your Pigs, Enrich Your profits... cont'd from page 2)

were pleasantly surprised by the lifespan of the wood, which survived for several months despite vigorous attention.

It can be hard to find consensus on issues in the pork industry; however, producers involved in this survey were quick to recommend the installation of enrichments in sow group housing.

Of course, as this project demonstrated, enrichment must be carefully thought out and designed with the pigs in mind. Above all, material should be stimulating and possess a number of other traits in order to gain and hold the user's interest: destructible, edible, deformable, chewable, odorous and clean.

Producers involved in the study found pigs were attracted by the newness of items, and they stressed that rotating enrichment material regularly is essential to keep it novel and engaging.

Knowing what to use for enrichment is critical, but knowing what to avoid is equally important. In a flooring system with slats, small organic material may slip between the slats and clog liquid ma- nure removal systems. Before introducing a new item, scrutinize it like a toy for your grandchild to rule out any health hazards like choking or poisoning.

Location, location, location

Once you've chosen the object, note the importance of location. Research reveals that items hung at eye level garner more interest from pigs than ones that sit on the floor. If you must use the floor, keep them in boxes so they stay clean and hold their appeal.

One comment from a project participant was that enrichment pieces tend to be cheap to buy and quick to install. Though the cost and time involved will vary from farm to farm, enhancing your pigs' environment is an investment that can pay big dividends in the long run: improved animal performance in areas like feed intake, average daily gain (ADG) and feed conversion ratio (FCR); fewer incidents of abnormal behavior such as biting, tail-biting and aggression; broader range of behaviors; reduced animal stress.

There's a lot to consider when it comes to pig enrichment. Fortunately, one of the main benefits of these on-farm demonstrations is the chance to test real world applications and get the producer's perspective on the issue. At least one of those producers felt overanalyzing enrichment might not be necessary:

"If you just have to hang a chain and it works well, and gets the aggression out of the sows, why not?"

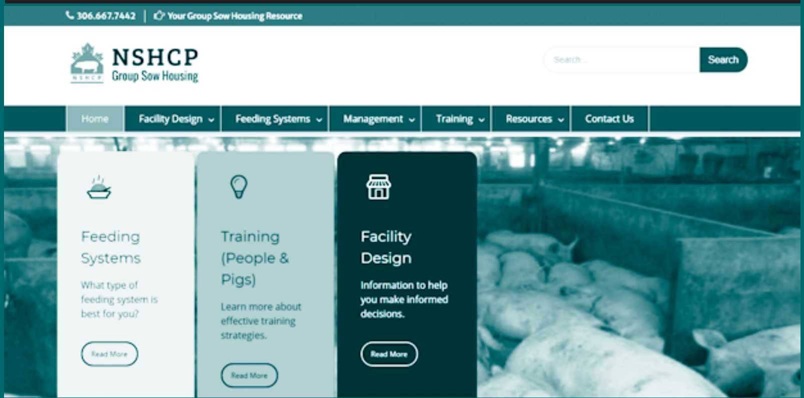
Personal Profile

Miranda Smit,

Miranda Smit has joined the Prairie Swine Centre as assistant manager – knowledge transfer. As such, she will be helping Ken and the PSC with their extension/KTT efforts. Miranda's background allows her to tackle the different research and extension projects head on.

Miranda was born and raised in the Netherlands, where she studied Animal Science (B.Sc. and M.Sc.) at the Wageningen University. She also spent a year in France, where she obtained a second M.Sc. degree in Agriculture. Miranda's story of how she ended up in Canada and in the pork industry are connected to each other. While working on her Master's degree in The Netherlands, she asked her supervisor to find an exchange student opportunity for her in Canada, as she had always dreamed of going there. Her supervisor, being a swine researcher himself, got her in touch with George Foxcroft at the University of Alberta and in 2006 she spent 4 months in Edmonton studying fetal programming. After finishing her Master's degree, she returned in 2007 to the UofA to work as research technician at the Swine Research and Technology Centre (SRTC) for 5 months. This is when Miranda fell in love with pigs and Canada. She returned in 2008 to start her PhD in pig reproduction under supervision of George Foxcroft. Her thesis looked at feeding omega-3 fatty acids to sows, as well as effects of low litter birth weight on postnatal growth performance. After 4.5 years, she defended her thesis in March 2013 and shortly after started a job at Alberta Agriculture to work with Eduardo Beltranena for the Monogastric Feed Research Group. She worked there for 7.5 years, in which time she wrote numerous magazine and journal articles on feeding alternative ingredients or low energy diets to nursery and grow-finish pigs. She also produced lots of posters, abstracts, factsheets etc, and gave radio interviews and oral presentations about her work.

In her off-time, Miranda enjoys hiking in the mountains, riding horses, dancing, traveling near and far, and learning new languages (currently working on Spanish).



Coming Events

Events for this summer and fall are currently being scheduled. Check prairieswine.com at a later date for more information. Dates will be posted when they become available.

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Prairie Swine Centre Inc.
P.O. Box 21057, 2105 - 8th St. E.
Saskatoon, SK S7H 5N9 Canada

Tel:(306) 373-9922
Fax:(306) 955-2510
www.prairieswine.com

Prairie Swine Centre is an affiliate of University of Saskatchewan