Overview

Feed cost is by far the greatest cost of pig production (65-70%) and growing-finishing pigs account for about 80% of feed consumed. The continued high cost of feed demonstrates the need to develop cost-effective feeding strategies for growing-finishing pigs to ensure the long-term competitiveness of the Canadian pork industry. Researchers are working on four strategic areas to address this issue:

1) Novel feedstuffs and enhanced nutritional values
2) Precision feeding of individual pigs
3) Validation of feeding strategies
4) Optimizing feeding strategies for groups of pigs

This report highlights activities from three of these strategic areas.

Highlights

1 Novel feedstuffs and enhanced nutritional values

The nutrient content of emerging ingredients is being characterized in detail to develop unique Canadian databases. Researchers have also been exploring different means to maximize nutrient utilization from such ingredients and dietary inclusion levels.

- Characterize the nutritive value of emerging feedstuffs (M. Nyachoti and J. Squires)

Low-fat corn Dried Distillers Grains with Solubles (DDGS)

Digestibility trials with growing pigs were conducted to compare standard DDGS with low-fat DDGS. As presented in Table 1, low-fat corn DDGS has a higher concentration of digestible amino acids and energy than regular DDGS. Low-fat DDGS samples had also greater standardized ileal digestibility content of indispensable protein and crude protein than the regular DDGS.

Table 1: Digestible energy (DE), crude protein and standardized ileal digestibility of lysine, methionine and threonine of standard DDGS and of low-fat DDGS (2 samples)

<table>
<thead>
<tr>
<th></th>
<th>Standard DDGS</th>
<th>Low-fat DDGS</th>
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<tbody>
<tr>
<td>DE (Kcal/kg)</td>
<td>3614</td>
<td>4494 Sample 1</td>
</tr>
<tr>
<td></td>
<td>30.1</td>
<td>42.3 Sample 1</td>
</tr>
<tr>
<td>Crude protein (%)</td>
<td>4555</td>
<td>43.1 Sample 2</td>
</tr>
<tr>
<td>Lysine (g/kg)</td>
<td>4.9</td>
<td>6.1</td>
</tr>
<tr>
<td>Methionine (g/kg)</td>
<td>4.6</td>
<td>6.8</td>
</tr>
<tr>
<td>Threonine (g/kg)</td>
<td>6.8</td>
<td>9.5</td>
</tr>
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Providing an adequate supply of energy in swine diets is not only the most expensive component of feed but it is the greatest contributor to the growth and efficiency of pork production. These data suggest low-fat DDGS could replace a significant amount of corn and soybean meal compared to regular DDGS. The next logical piece of research is to investigate and determine the most economic and optimal amount to include in pig diets in order to replace corn and soybean meal.

**Hemp co-products**

The net energy (NE) content of the hemp co-products outlined in Table 2 were determined.

<table>
<thead>
<tr>
<th>NE (Kcal/kg)</th>
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<tbody>
<tr>
<td>Hemp hulls</td>
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<tr>
<td>Extruded hemp hulls</td>
</tr>
<tr>
<td>Blended hemp hulls &amp; peas</td>
</tr>
<tr>
<td>2375</td>
</tr>
<tr>
<td>2320</td>
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<tr>
<td>2399</td>
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The relatively high NE content of hemp hull and processed hemp hull products may be attributed to the high levels of residual oil in these ingredients.

**Camelina cake**

Trials were conducted with growing pigs to characterise camelina cake. Results are presented in the following table (table 3)

<table>
<thead>
<tr>
<th>Camellina cake</th>
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<tbody>
<tr>
<td>DE (Kcal/kg)</td>
</tr>
<tr>
<td>ME (Kcal/kg)</td>
</tr>
<tr>
<td>NE (Kcal/kg)</td>
</tr>
<tr>
<td>Lysine (g/kg)</td>
</tr>
<tr>
<td>Methionine (g/kg)</td>
</tr>
<tr>
<td>Threonine (g/kg)</td>
</tr>
<tr>
<td>3755</td>
</tr>
<tr>
<td>3465</td>
</tr>
<tr>
<td>2383</td>
</tr>
<tr>
<td>10.0</td>
</tr>
<tr>
<td>1.6</td>
</tr>
<tr>
<td>8.9</td>
</tr>
</tbody>
</table>

The average standard ileal digestibility of indispensable amino acids in camelina cake fed to growing pigs was 67.2%, while the digestibility of dispensable amino acids was 58.8%.

- **Means to enhance nutrient utilization and maximum inclusion rates** (R. Zijlstra, M-P Létourneau-Montminy, J. Squires, J. Li)

**Nutrient digestibility of mash, steam pelleted and extruded barley and faba bean**

Researchers carried out a digestibility trial with growing pigs to evaluate the nutritional quality of barley and faba bean in mash, steam pelleted and extruded forms. Results have showed that steam pelleting and extrusion enhances the nutritional quality of both faba bean and barley, with a greater increase for faba bean. These two processing methods increase the digestibility of amino acid and energy of faba bean and the digestibility of energy of barley in growing pigs. Steam pelleting and extrusion is more efficient in faba bean because its protein and starch matrix is more resistant to digestion than barley.

**Digestibility of starch, energy, and amino acids, and characterization of undigested starch of pulse and cereal grains**

Researchers carried out a digestibility trial with growing pigs to 1) determine the digestibility of starch, energy, and amino acids and 2) characterize undigested starch using confocal laser scanning of pulse and cereal grains. Results have shown that the accuracy of formulating pig diets containing pulse and cereal grains based on net energy values can be enhanced if starch is defined in two fractions:

- fraction digested by enzymes, and
- fermentable fraction.

More specifically, results have shown that the apparent ileal digestibility of starch in cereals is greater than in pulses. However, for both feedstuffs, the apparent total tract digestibility of starch was 99%, which means that starch was almost completely degraded.
Fermentation of soybean meal

Researchers have further improved the fermentation procedure of feed stuff (soybean meal) to allow larger scale-, and less energy required-fermentation to make it more production applicable and environmental friendly. Fermentation procedures were optimized to allow at least 2 kg of soybean to be fermented at 50% moisture levels, which resulted in eliminating allergen proteins. In addition, fermentation also decreased oligosaccharides in soybean meal. Results of the animal trial, which will examine if fermented soybean meal improves digestibility for growing pigs, will be available in 2018.

Addition of the enzyme xylanase in high-fibre diets

Trials have been conducted with finishing pigs to compare two high-fibre diets to a classic, low-fibre corn and soybean meal diet. All three diets were tested with and without the addition of the enzyme xylanase. The impacts of these diets on the ileal digestibility of nutrients, growth performance, and carcass quality were studied.

Preliminary results showed that the high-fibre diets improved the apparent ileal digestibility of acid-detergent fibres and lipids, without the addition of xylanase. In fact, xylanase increased the digestibility of neutral-detergent fibres only in a non-starch polysaccharides (NSP) soluble diet. Neither the diet nor the xylanase influenced the digestibility of crude protein, calcium, phosphorus, NSP soluble, NSP insoluble, energy or ash. Therefore, these results demonstrate that it is possible to feed pigs with high-fibre diets without modifying nutrient digestibility.

Results of the growth trial showed that high-fibre diets reduces feed intake and average daily gain over the first 14 days of the trial, but did not affect feed efficiency. Knowing that fibre may reduce feed intake, high-fibre finishing diets should therefore include enough essential nutrients to maintain weight gain. Finally, measurements taken on the carcasses indicated that carcasses of pigs fed a high-fibre diet contained more unsaturated fat, but at a level that is still acceptable for the slaughterhouse.

2 Precision feeding of individual pigs

- Improving phosphorus efficiency in sustainable pig precision farming systems (C. Pomar)

Researchers developed mathematical models representing the metabolism of phosphorus and calcium in order to estimate individual pig requirements. It has been found that using phosphorus and calcium depletion-repletion sequences is a good strategy for reducing calcium and phosphorus intake. However, before using this kind of dietary strategy, which increases dietary phosphorus and calcium efficiency without affecting pig growth performance and bone mineralization, more work needs to be done to better understand the digestive and metabolic adaptations that develop.

- Amino acids and formulating low protein diets to reduce feed cost and improve farm sustainability (C. Pomar)

Researchers have reviewed certain nutritional concepts in order to develop precision feeding strategies. Researchers therefore confirmed that:

- Precision-fed pigs use amino acids more efficiently than pigs fed with conventional diets, partly due to the fact that nutrient efficiency is not constant across animals and is affected by production conditions.

- The content of amino acids found in the feed has an impact on the composition of the protein in the pig’s body.

- Restricting amino acids in feed affects body proteins differently depending on the type of body protein.

The high-fibre diets that were tested in this trial included by-product feedstuffs containing either soluble non starch polysaccharides (wheat middling, bakery meal and canola meal) or insoluble non starch polysaccharides (DDGS and canola meal).
As a result, the ‘ideal protein’ concept used to formulate feeds in conventional systems does not apply to precision feeding.

Also, revising these concepts in the model estimating real-time nutrient requirements of pigs will further improve the efficiency of precision feeding. Precision feeding, at this time, already reduces feeding costs by more than 8%, protein intake by more than 25% and nitrogen excretion by more than 38%, and all of this without affecting animal performance.

**Optimal management of farm resources**
(F. Dubeau)

Recently, the most interesting model for precision feeding was obtained when blending two feeds during the growing-finishing phase in order to meet each individual pig needs. This mathematical model reduced feed costs by 4.1%, phosphorus excretion by 3.3 %, and nitrogen excretion by 14.8 %.

Researchers also developed a novel feeding system called the Hybrid Feeding System. This new model combines phase-feeding with a precision feeding system using two feeds. In the Hybrid Feeding System, for instance, if three phases are used, two feeds will be blended during each phase. Between two consecutive phases, one feed would stay the same and one would change. Therefore, four different feeds would be used when using three phases. This new mathematical model reduced feed costs by 5.2 %, phosphorus excretion by 2.2 %, and nitrogen excretion by 17.8 %.

### 3 Validation of feeding strategies

- **Model validation and intact males**
  (I. Mandell and J. Squires)

An initial evaluation was carried out on the potential of certain feed additives to control boar taint, and therefore improve the quality of meat produced by intact male pigs. *In vitro* results have showed that diatomaceous earth, bentonite, spent filter aids, and a hydrated sodium- calcium aluminosilicate (Jumpstart 360) were the most effective feed additives for binding androstenone and skatole, two compounds responsible for boar taint in intact male pigs.

Three feeding trials took place after this evaluation. None of the binding agents were able to decrease levels of androstenone. In the second trial, the binding agents were added to the diets when boars reached either 70 or 90 kg body weight and were fed up to slaughter. Feeding the pigs with hydrated sodium-calcium aluminosilicate decreased the levels of androstenone in plasma and had no impact on growth and meat quality characteristics. A third trial was then conducted to evaluate using wood charcoal, a new binding agent which is a feed ingredient approved by the Canadian Food Inspection Agency. Binding agents had no effect on concentrations of androstenone and skatole and reduced weight gains.

Hybrid Feeding System.
Source: University of Sherbrooke.
- **Nutrition and gut health** (R. Friendship)

Two of the most important pathogens affecting growth performance in the grower-finisher barn are known to be *Brachyspira* and *Salmonella*. In this study, researchers investigated the prevalence of *Salmonella* on 12 farms, and could recover *Salmonella* on all studied farms. Further, the increased amount of antibodies against *Salmonella* found in pigs at the end of the nursery phase (>50%) demonstrates how widespread *Salmonella* is in the Ontario swine population and the importance of the nursery stage in the epidemiology of this disease.

- **Low energy feeds** (E. Beltranena)

The objective of this experiment is to compare growth performance, dressing percentage and carcass characteristics of growing-finishing pigs. These pigs were fed low or high feed energy levels, had either two or three feeder spaces per pen, and were housed at two different stocking densities.

Researchers have previously shown that feeding low, constant net energy (2.1 Mcal net energy) diets to growing-finishing pigs resulted in more than $10 profit per pig (gross revenue after subtracting feed costs) than feeding higher energy levels (2.2, 2.3, 2.4 Mcal). However, pigs must be able to increase feed intake to make up for the lower energy density. In crowded pens, there may not be enough access to feeders for pigs to take advantage of low energy diets. Additional feeders and higher energy diets may compensate for the detrimental effects of pen crowding. Results will be available in 2018.

### Implications for the swine industry

New feeding strategies are being developed for growing-finishing pigs. The following has been learned so far:

- Low-fat DDGS could eventually replace significant amounts of corn and soybean meal in growing-finishing diets. More research is needed to investigate the optimal and economical inclusion levels.
- Steam pelleting and extrusion can enhance nutritional quality of both faba bean and barley.
- Formulating pig diets containing pulse and cereal grains based on net energy values can be done with more accuracy if starch is defined by its enzymatically-digestible and fermentable fractions.
- Fermentation of soybean meal can eliminate allergens and decrease oligosaccharides.
- High-fibre finishing diets can be fed to pigs without modifying nutrient digestibility. Knowing that fibre may reduce feed intake, high-fibre diets should therefore include enough essential nutrients to maintain weight gain.
- Researchers have developed a novel precision feeding system: the Hybrid Feeding System. This allows feed costs to be reduced by 5.2 %, phosphorus excretion by 2.2 %, and nitrogen excretion by 17.8 %.
- The net energy (NE) content of camelina cake, hemp hull, extruded hemp hull, and a blended hemp hull/pea product is now known.
- The digestibility of the crude protein and amino acids in camelina cake is now known.

### Collaborators

<table>
<thead>
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<td>Xun Zhou</td>
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Farmscape Interviews:

- **Formulating Diets for Individual Pigs Reduces Feed Costs and Environmental Impacts**
  - February 5, 2018
- **Precision Feeding Technology Offers Opportunity to Maximise Use of Co-Products**
  - October 7, 2016
- **Precision Feeding Promises Reduced Environmental Impact**
  - September 15, 2016
- **Customising Rations for Each Pig Improves Feed Nutrient Utilization**
  - September 1, 2016
- **Use of Alternative Feed Ingredients Can Dramatically Improve Profits**
  - January 15, 2016
- **Formulating Rations for Pigs Individually Cuts Overall Costs**
  - December 14, 2015
- **National Research Effort Focuses on Improved Feeding Programs to Improve Competitiveness**
  - July 28, 2015
- **Commercial Trials on New Precision Feeder Expected to Start in Early 2016**
  - June 1, 2015
- **Swine Nutritionists Strive to Improve Nutritional Value of Feed**
  - January 21, 2015

Peer-reviewed articles and abstracts:

2017


2016

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2016

  DOI: https://doi.org/10.2527/af.2016-0031

  DOI: https://doi.org/10.1139/cjas-2016-0167


  DOI: https://doi.org/10.2527/jam2016-0479

  DOI: https://doi.org/10.1371/journal.pone.0167624

2015


  DOI: https://doi.org/10.2527/jas.2014-7910


  Retrieved from: https://www.jtmtg.org/
2014


  DOI: https://doi.org/10.2527/jas.2013-7169

  DOI: https://doi.org/10.2527/jas.2013-6555

Additional reading:

2017


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2016


  Retrieved from: https://ovc.uoguelph.ca/conference/cavepm


  Retrieved from: https://www.uoguelph.ca/osrn/swine-research-day/proceedings-archives

  DOI: https://doi.org/10.2527/msasas2016-108

  DOI: https://doi.org/10.2527/msasas2016-269

2015


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2014


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