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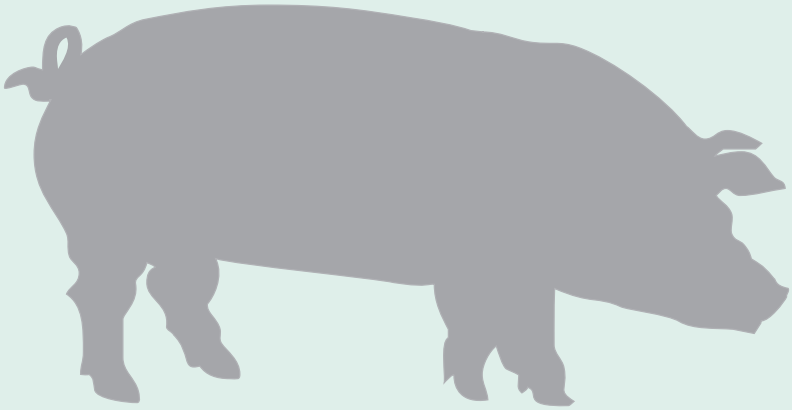

CENTRALIA SWINE RESEARCH UPDATE

January 25th, 2006

CENTRALIA SWINE RESEARCH UPDATE

Kirkton-Woodham Community Centre
January 25, 2006

WRITTEN-ONLY TOPICS

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Ten Years of ODAP – What Have We Learned?

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Background

There are a variety of measures used for benchmarking in the swine industry. Many focus on productivity variables such as pigs/sow, days to market, pork/sow and so on. Other measures reflect expenses per pig such as feed/pig, health costs/pig and labour/pig.

Results from the Ontario Data Analysis Project (ODAP[1]) have been used as the basis of this discussion. ODAP compiles farm level production and financial data from farrow-to-finish producers in Ontario. These participants are considered to be full-time farmers and report little, if any, off-farm income. Most of the farms rely on family labour to fill additional labour needs. This discussion will focus on the swine enterprise and will not take into account other farm activities (i.e. cash cropping). Family labour has not been included in the calculation of expenses.

Results

A comparison of common ODAP benchmarks is provided in Table 1 for 1995 and 2004. Most of the results are not surprising. Increases in productivity are reflected in higher pigs weaned/litter, pork/sow, pigs produced/sow and lower days to market. Higher interest expense reflects increased debt that these larger farms have incurred. Much of the increase in farm assets is attributed to new or expanded buildings, higher inventory numbers and increased land base.

Table 1. Benchmarking 1995 vs 2004.

	1995	2004
Average # Sows	133	217
Weaning Age	25	21.6
Weaned/litter	9.1	9.6
Finishing weight sold (kg live)	104.2	113.6
Days to Market	177	166
Pork/sow	1,420	1,766
Pigs produced/sow[2]	17.1	19.2
Feed exp/pig produced	$85.49	$89.24
Interest exp/pig produced	$6.31	$10.09
Farm assets/sow	$7,555	$12,554
Farm debt/sow	$2,764	$4,174
Farm equity/sow	$4,791	$8,379

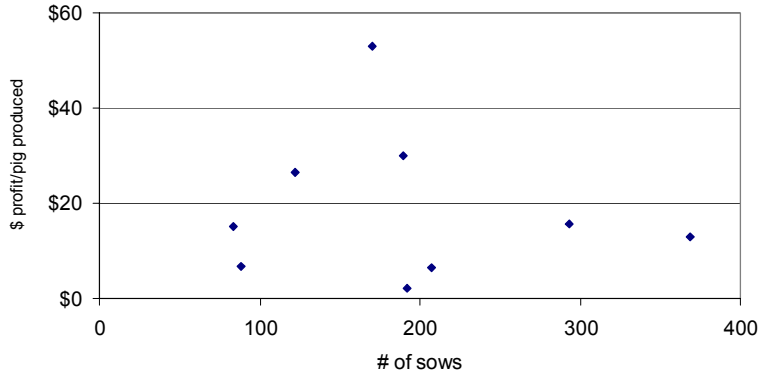
The numbers in Table 1 may be interesting to compare however individual benchmarks do not necessarily suggest profitability at the farm level. They do not answer questions such as: What does it take to be profitable? Is profitability linked to farm size? How important is cost control? and etc.

[1] Participation in ODAP varies each year. Results are for discussion purposes and are not assumed to represent an Ontario average.

[2] Calculated number to convert all pigs produced and sold to market hog equivalents taking into account production and inventory changes. Weaner pigs are converted to market hog equivalents using a factor of forty percent and SEW pigs are given a factor of twenty-five percent.

ODAP data for the years 2000 to 2004 were used to answer some of these questions. With respect to the size of farms, Figure 1 shows that profitability on a per pig basis shows considerable variability between farms. In fact, three farms averaging between 100 and 200 sows reported more than $20/pig profit over the five years. The larger farms, with 300 to 400 sows, averaged about $10 to $20/pig profit during this time. This indicates that larger farms are not always more profitable than smaller farms.

Figure 1. Size versus Profit.



A high profit group and a low profit group based on profit/pig produced were separated out of the 9 producers that participated in ODAP each year from 2000 to 2004. This was done to determine why some farmers are more profitable than others. The results for revenue and expenses per pig for each group are shown in Table 2 below. The high profit group benefits through a combination of higher revenue and lower expenses resulting in a $24.41/pig advantage over the low profit group. Lower depreciation and feed costs were the main reasons for lower total expenses in the high profit group. Although it is not known, it is possible that increased revenue could result from marketing hogs so that they fit into the optimal area of the marketing grid.

Table 2. High Profit vs Low Profit.

	High Profit Group	Low Profit Group	Difference
Revenue/pig produced	$158.77	$148.59	$10.18
Expenses/pig produced	$126.66	$140.89	($14.23)
Profit/pig produced	$32.11	$7.70	$24.41

In summary, benchmarking provides an opportunity for comparison and shows productivity improvements over time. Benchmarking can be used to help show whether farms have been profitable and what it takes to be profitable. It seems to be a combination of factors that affect financial success at the farm level.

Some key learning points are provided below:

- Farms are larger and productivity is higher in 2004 compared to 1995
- Farm size is not an indicator of financial success
- Cost control and revenue optimization are drivers of profitability

Special thanks to Agriculture and Agri-Food Canada for providing funding for ODAP. Recognition and appreciation is extended to the farms that participated.

Greenhouse Gas Emissions From Swine Production

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Background

Greenhouse gases (GHG) are atmospheric gases that absorb and re-emit long-wave radiation released by the earth back to the surface and include carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The concentration of GHG in the air has increased over the last 1000 years, which is at least partly attributed to human activities. Concerns over the effect of this increase on the global climate have led to the Kyoto protocol, an agreement that aims at reducing GHG emissions worldwide. Canada's commitment to climate change mitigation includes an important role for the agricultural sector. In the 2002 "Climate Change Plan for Canada", the federal government proposed that reduction of greenhouse gas emissions due to crop and animal production practices could be used in flexible compliance mechanisms, such as a domestic emission trading system and domestic offsets, to meet reduction targets of Large Final Emitters (LFE).

Emissions from Swine Production

In 2003, agriculture-related GHG emissions totalled 62 Mt CO_2 eq[3], and contributed 8.4%[4] of total national emissions in Canada. Animal-related emissions were estimated to account for nearly 50% of emissions from Canadian agriculture. These emissions were due to: 1) enteric fermentation in ruminants releasing methane (~22 Mt), and 2) microbial processes in animal manure resulting in methane and nitrous oxide emission (~7.8 Mt). In addition, part (~6.6 Mt) of N_2O emissions originating from soils was due to the application of animal manure to crops and excretion of manure on pasture and paddocks by grazing animals. Swine production related GHG emissions were mostly due to methane production during storage of liquid manure (~2 Mt or 3.4%), with a very small fraction coming directly from the animals, and a portion of the N_2O emissions from soils after manure application (~14% or ~1 Mt). Hence, manure storage appears to be the highest source of GHG emissions from swine production. However, some of our recent measurements under Canadian climatic conditions show that the current CH_4 emission estimates for liquid swine manure stored in outdoor tanks may be too high (factor of 1.7).

Mitigation Measures

There are several techniques that have been suggested to reduce gas fluxes from manure storage; composting, anaerobic digestion, diet manipulation, covers and solid-liquid separation. These techniques also are often associated with increases in efficiencies of nutrient (carbon and nitrogen) utilization on the farm. While some studies have demonstrated the effectiveness of treatments in reducing GHG emissions (eg. 30% reduction with aerobic composting of liquid swine manure with wheat straw), there is a lack of quantitative data showing the GHG reduction potential of mitigation measures. In addition, issues of cost and practicality remain for most of these techniques.

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[3] CO_2 equivalent are a way of expressing emissions of all greenhouse gases (CO_2, CH_4 and N_2O) in one type of unit. For this we use a measure of the global warming potential of each gas (GWP), where CO_2 has a GWP = 1, CH_4 has a GWP = 21, and N_2O has a GWP = 310. Hence, the emissions of CH_4 are multiplied by 21 and of N_2O by 310 and all emissions added to give a total GHG emission in CO_2 equivalent.

[4] Note that this amount does not include energy use associated with agriculture.

Alternatives to Dietary Antibiotics: The Potential of Essential Oils

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Background

The emergence of super bugs (drug resistant bacteria) and drug residues in food are the two major food safety and human health concerns associated with drug use in agricultural production. The use of antimicrobials as growth promoters (AGPs) has completely been banned in EU countries starting from January of 2006. Swine and other livestock industries in Canada are also under publics' pressure to reduce or even stop the use of AGPs in livestock production. Consequently, developing alternative products to replace AGPs has become urgent for both the livestock industry and scientific research community.

Essential oils (EOs) are volatile components of plants. Many EOs are generally recognized as safe by the FDA of the United Sates for use as ingredients of perfumes, cosmetic, and food. Some EOs have demonstrated strong antimicrobial activities, against both bacteria and fungi. Previous studies on EOs have mainly focused on seeking natural and safer means for food hygiene or preservation, with limited effort in investigating their potential to control both human and animal pathogens and reduce the use of dietary antibiotics in livestock production. We recently completed a research project on EOs and structurally related compounds and their potentials for being developed into AGPs for swine production. The research showed some positive and promising results. Following is a brief summary of the outcomes from the project.

Experimental Results

To identify effective EOs, a total of sixty-six EOs/compounds were tested for their ability to inhibit the growth of *Salmonella* Typhimurium DT104 and *Escherichia coli* O157:H7. Sixteen out of the sixty-six EOs/compounds tested were found to have strong antimicrobial activity (over 80% inhibition) and nine of them were further studied. The majority of nine EOs/compounds demonstrated high efficacy against *S.* Typhimurium DT104, *E. coli* O157:H7, and *E. coli* K88 (Table 1) with little inhibition towards lactobacilli and bifidobacteria. They were also tolerant to the low pH. When mixed with pig cecal digesta, these EOs/compounds retained their efficacy against *E. coli* O157:H7. In addition, they significantly inhibited *E. coli* and coliform bacteria in the digesta, but had little effect on the total number of lactobacilli and anaerobic bacteria. When mixed with pig diets, all the tested EOs/compounds except for one lost their antimicrobial activity. This EO reduced *Salmonella* counts in the diets by approximately 2-log units (Fig. 1) and required emulsification in hydrocolloid solutions to retain its antimicrobial activity during storage. Pig infection experiments demonstrated a promise of this EO for future application. Further investigation, however, is required to determine the level of treatment, delivery, and other issues regarding its on-farm use.

Take-home Messages

1. Some essential oils can be developed into the substitutes for dietary antibiotics because of their strong antimicrobial activity, tolerance to low pH, and selectivity towards bacterial pathogens over beneficial gut bacteria.

2. Pig diets are a significant factor limiting the antimicrobial activity of essential oils. An effective and practical delivery of essential oils to the animal guts is critical in maximizing their antimicrobial effect.
3. An essential oil has been identified that retained its antimicrobial activity in the presence of diets, in addition to its strong antimicrobial activity, tolerance to low pH, and selectivity towards pathogens. Pig infection experiments have also demonstrated a promise of this EO for future application although further investigation is required.

This research was supported by Ontario Ministry of Agriculture, Food and Rural Affairs through the Food Safety Research Program and by Agriculture and Agri-Food Canada.

Table 1. Minimum Bactericidal Concentrations of essential oils/compounds against *E. coli* and *S.* Typhimurium DT104*

Oil/compound	MBC ($\mu g\ ml^{-1}$)		
	E. coli K88	*E. coli* O157:H7	*S.* Typhimurium DT104
m-Anisaldehyde	700^{a}	933^{a}	933^{a}
Geraniol	300^{b}	283^{bd}	367^{b}
(*DL*)-Mandelonitrile	833^{c}	766^{a}	767^{c}
Clove oil	233^{be}	283^{bd}	300^{bdf}
Carvacrol	100^{d}	283^{bd}	167^{de}
Cinnamon oil	133^{bg}	133^{b}	100^{e}
Eugenol	300^{b}	466^{c}	400^{b}
Thymol	100^{d}	166^{b}	233^{ef}
2-*tert*-Butyl-4-methylphenol	200^{e}	433^{cd}	333^{bf}

* ^{a,b,c,d,e,f}Values in the same column with different superscript letters differ ($p<0.05$); n = 3.

Reference: Si, W. J. Gong, R. Tsao, T. Zhou, H. Yu, C. Poppe, R. Johnson, and Z. Du. 2005. Antimicrobial activity of essential oils and structurally related synthetic food additives towards selected pathogenic and beneficial gut bacteria. J. Appl. Microbiol. (in press).

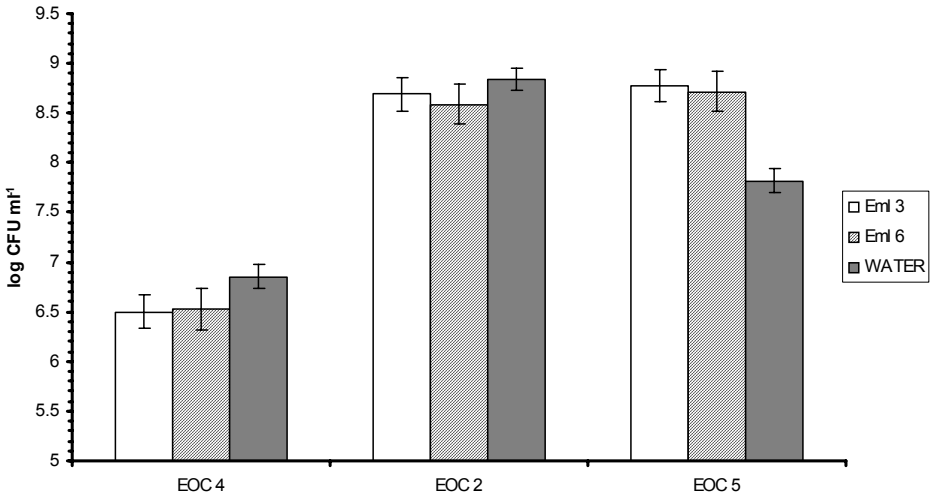

Figure 1. Antimicrobial activity toward *Salmonella* Typhimurium DT104 in the presence of diets of essential oil compounds emulsified or suspended in water. The final concentrations of the emulsifiers and essential oil compounds were 0.1% (1 ml l^{-1} or 1 g l^{-1}). The ration of diets to the solution of essential oil compound was 2:1.

Feeding the Gestating Sow

Mike Tokach, Bob Goodband, Steve Dritz, Joel DeRouchey, and Jim Nelssen
Kansas State University, Manhattan

GESTATING SOWS

When designing a feeding program for gestating sows, we must remember the overall goals for the nutrition program: 1) prepare sows to be in proper body condition at farrowing; 2) maximize reproductive performance (farrowing rate and litter size); and 3) meet the daily nutrient requirements at the lowest cost possible (measured as cost per sow per day).

We are well aware of the problems with overfeeding gestating sows, including the unnecessary expense, potential problems with impaired mammary development, and reduced feed intake in lactation. Over-conditioned sows used to be the main problem on swine farms. In recent years, thin sows have become a more prevalent problem. Too little backfat reserves can reduce reproductive performance and increase sow mortality. Low backfat reserves also can be an animal welfare concern as thin sows have a greater chance of developing shoulder sores.

Management techniques for accurate feeding levels

There is little disagreement on the importance of having sows in the correct body condition at farrowing. Although there is some disagreement on whether the ideal backfat level at farrowing should be 16 to 18 mm or 18 to 21 mm, most people agree that the most important point is to have as few of sows as possible over 24 mm or under 15 mm at farrowing. The big disagreement among nutritionists, veterinarians, and barn managers is the best way to set feeding levels to make sure this happens.

Backfat scanning on commercial farms has convinced us that body condition score is a poor predictor of actual backfat levels. The best correlation that we have found between backfat and condition score on any farm that we have measured is an r^2 of 0.23. Others may argue that body condition score works for their system, but we would challenge you to measure backfat on sows at farrowing to determine the true backfat level of your sows. In reality, if over 75% of the sows are between 15 and 24 mm at farrowing, you are doing a pretty good job of setting feeding levels during gestation. That doesn't sound like a lofty target; however, I would challenge you to audit your farm for backfat levels at farrowing to determine if you are above that mark.

Because of our frustration with condition scoring, we have tested and implemented a method to feed sows based on backfat and body weight estimates using the concepts proposed by Dr. Frank Aherne. The methods that we use are presented in the next section. Whether you feed sows based on body weight and backfat or on body condition score, it is useful to understand the energy requirements of the sows and the energy level of your gestation diet to determine feeding range for your situation.

Regardless of the method used to set the daily feed allowance for each sow, it is useful to get a global picture of gestation feed usage for a swine farm to determine whether any long-term trends towards over or under-feeding is occurring. This can be done relatively simply by dividing the total feed delivery for the period by the number of gestation places in the farm and the number of days in the period (explained in Appendix 1). Certainly, if the sow space is not fully utilized on the farm, this measure will need to be adjusted for actual inventory; however, for most farms simply knowing the number of gestation spaces is adequate. This

calculation is especially useful in production systems with multiple sow farms to determine if one sow farm routinely feeds 2.5 kg/d while another farm routinely feeds 2.1 kg/d when provided the same gestation diet. In reality, most farms should have gestation feed usage of 7.2 to 7.8 Mcal ME per sow per day, which equated to 2.3 to 2.5 kg/d of a gestation diet containing 3.1 Mcal ME/kg or 2.18 to 2.35 kg of a diet containing 3.3 Mcal ME/kg. If feed usage for the farm is outside of these bounds, reasons for the discrepancy should be explored.

Feeding sows based on backfat and estimated weight

The maintenance requirement of the sow accounts for the majority of the feed requirement. The next biggest component is the amount of weight that you want the sow to gain. Thus, an estimate of body weight is extremely important to accurately feed the sow. Because weighing individual sows is not feasible on many farms, we have established weight categories that can be estimated by using a girth or flank measurement. Girth is measured with a cloth tape directly behind the front legs and in front of the first mammary glands. The flank measurement is measured immediately in front of the back legs from the point of one flank over the back of the sow to the point of the other flank. The flank measurement is much easier to obtain, especially when sows are housed in gestation crates. Because of the importance of body weight in determining the daily feed allotment, it is essential that a high percentage of sows are measured for their body weight estimate.

Backfat can be measured with one of several different ultrasound machines. We are using a Renco machine on most farms because of the relatively low cost. Individuals conducting ultrasound measurements must be trained on how to use the machine and where to take the measurement. Sows are scanned at the last rib approximately 10 cm off the midline. We recommend scanning the sow on both sides and averaging the values to determine backfat.

Determining feeding levels

The equations used to set the feeding levels are described in detail in Appendix 2. Using these equations, we can determine the energy requirements for maintenance, maternal gain, and uterine gain. An example of the results of these equations is shown in Table 1. The information is converted to a daily requirement of the sow and a feeding level for sows with various backfat levels in Table 2. Using these calculations in an excel spreadsheet, we develop a chart that can be laminated and placed in the barn for daily use. An example of such a chart, based on a diet with 3.1 Mcal ME/kg is presented in Table 3. Full details on procedures and the spreadsheet can be found at the website: www.asi.ksu.edu under the swine extension sow feeding tools link: (http://www.asi.ksu.edu/DesktopDefault.aspx?tabindex=429&tabid=235)

Table 1. Total gestation energy requirement for a 195 kg sow with a litter birth weight of 15 kg.

Target gain, kg	35	27	20	13
Target backfat gain, mm	9	6	3	0
ME, Mcal				
Maintenance	714	705	696	687
Maternal gain	263	188	113	39
Uterine gain	38	38	38	38
Total	1015	931	847	764

Table 2. Daily gestation energy requirement for a 195 kg sow with a litter birth weight of 15 kg.

Target gain, kg	35	27	20	13
Target backfat gain, mm	9	6	3	0
ME, Mcal				
Maintenance	6.21	6.13	6.05	5.97
Maternal gain	2.29	1.63	0.98	0.34
Uterine gain	.33	.33	.33	.33
Total	8.83	8.09	7.36	6.64
Feeding level, kg/d[a]	2.85	2.61	2.37	2.14

[a] Based on a dietary metabolizable energy level of 3.1 Mcal/kg

Table 3. Feeding levels (kg/d) for gestating sows based on backfat and weight category at breeding [a]

Flank to flank, cm	Estimated weight, kg	Backfat at breeding, mm			
		9 to 11	12 to 14	15 to 17	>18
< 90	< 150	2.3	2.1	1.8	1.6
90 to 97	150 to 180	2.5	2.3	2.1	1.8
97 to 104	180 to 215	2.7	2.5	2.3	2.0
104 to 111	215 to 250	3.0	2.7	2.5	2.3
> 111	>250	3.2	3.0	2.7	2.5

[a] Based on a diet containing 3.1 Mcal ME/kg.
Feeding level should be increased by 1 kg/d on day 101 of gestation.

Procedures to set feeding levels.

Once each week, the person responsible for setting feeding levels scans sows for backfat and determines the weight category. The backfat is written on the sow card and the feeding level is adjusted using a table customized for the farm based on the energy density of their diet and volume of their feed boxes.

At approximately 7 weeks post mating, sows that visibly appear to be very thin are marked and scanned to determine if backfat gains are on target. Approximately 10 to 15% of the sows will have to be scanned at this time. If the sows are not reaching targets, feed intake is increased by .5 kg/d. Sows remain on their feeding level until day 100 of gestation. On day 100, the feeding level is increased by 1 kg/day for the last 2 weeks before farrowing.

The procedure is relatively simple and easy to implement. The three main issues critical for the success of this feeding method are: 1) A person must be trained to scan and estimate weight; 2) you must know the energy level of the gestation diet; and 3) you must know the volume (kg) being dropped at each feed box setting.

Feed Intake Pattern During Gestation

Is the pattern of feed intake important during gestation? High or low feed intake during particular phases during gestation can cause deleterious effects or have specific advantages. In reality, the pattern of feeding isn't nearly as important as keeping sows in the proper body condition. However, a clear understanding of the impact of over- or under-feeding during

each stage of gestation can help explain why negative effects can occur due to improper feeding programs.

Day 0 to 30. Several researchers have reported high intake before day 30 of gestation decreased embryo survival. The increased embryo mortality was attributed to a reduction in plasma progesterone concentration due to increased blood flow and hepatic clearance of progesterone caused by the high feed intake. Further research (Jindal et al., 1996) indicates the critical window to reduce feed intake to prevent embryo mortality may be during the first 48 to 72 hours after mating. The safest recommendation is to limit feed intake from breeding until day 12 after breeding.

The body condition or energy state of the sow also influences the response to high levels of feed intake after mating. Embryo mortality is only increased when high levels of feed are provided to sows in good body condition. Embryo mortality was actually reduced by providing extra feed for the first thirty days after breeding to sows in poor body condition due to low lactation feed intake. Therefore, feeding according to body condition during the first 30 days of gestation is critical for minimizing embryo mortality. Recent unpublished data from Australia also credits high feeding during early gestation with increasing farrowing rate during the summer months when seasonal infertility is a problem.

By following the feeding guidelines listed above, sows that are in good body condition will not be fed high levels immediately after breeding. During the period from breeding until backfat is measured, a safe recommendation is to feed all sows approximately 6.8 Mcal of ME (2 to 2.2 kg/day of gestation diet).

Day 30 to 75. Current understanding of this period during gestation is not complete; however, recent research indicates this is a critical period for muscle differentiation of the developing fetuses. Sterle et al. (1995) found injections of porcine somatotropin (pST) between day 30 and 43 increased placental weight and weight of the lightest fetuses. The authors hypothesized that pST increased nutrient uptake and utilization by the fetuses by increasing nutrient transfer across the placenta. In another trial, pST injections from day 28 to 40 increased embryo survival, embryo weight, and specific gene expression for certain muscles (Kelly et al., 1995). Offspring from the sows injected with pST for the specific window of gestation (day 28 to 40) had reduced backfat and heavier trimmed loin weight at market than pigs from the control sows. Dwyer et al. (1994) observed a similar response by doubling feed intake (2.5 vs. 5.0 kg/day) from day 25 to 80 of gestation. The high feed intake increased the number of secondary muscle fibers and improved growth rate and feed efficiency of the offspring during the growing period (day 70 to 130 of age). We have conducted two experiments to further validate the benefit of high feed intake during mid gestation on fetal muscle fiber development and subsequent body composition at market weight. The results have been conflicting with a benefit to high levels of feed intake in one experiment (Musser et al., 1999) and no response in a second experiment (Musser et al., 2000a). Feeding large quantities of feed has some practical limitations. First, sows can become over conditioned limiting feed intake during lactation. Also, the extra feed intake adds cost and an extra management burden.

The research on high feed intake levels and pST indicates that the goal may be to increase levels of metabolic hormones, such as IGF-1 or IGF-2. In subsequent research, we have found that specific nutrients, such as carnitine, may be beneficial to increase IGF-1 levels in mid gestation without the negative effects of excessive energy intake. We have found that adding L-carnitine to the gestation diet increased circulating IGF-1 concentrations in mid

gestation and carcass leanness of the offspring (Musser et al.; 2000b). In another trial, Musser et al. (2001) found that adding L-carnitine to the diet increased total muscle fiber number in the offspring at birth. Further research is needed to validate these results and determine whether other nutrients may have similar responses.

Day 75 to 100. This period is critical for mammary development. Excessive energy intake during this period increases fat deposits and reduces the number of secretory cells, DNA, and RNA in the mammary gland (Weldon et al., 1991). The result is lower milk production during lactation. Excess feed intake should be avoided during this time.

Day 100 to 112. Feed intake should be increased by 1 to 2 kg (2 to 4 lb) from day 100 to 112 of gestation to prevent sows from losing weight during this period of rapid fetal growth. Failure to increase feed intake during this period results in sows in an extremely catabolic state at farrowing. The catabolic state contributes to gorging and sows "going off feed" during lactation.

Day 112 to 114. Feeding pattern during the last few days of gestation is a controversial area. We prefer to feed 2 kg or more from day 112 to 114. Field experience indicates that extremely low intake of 1 kg or less during this limits the producers' ability to increase feed intake rapidly during early lactation. In extreme cases, ulcers can be created by the extended period of low intake around farrowing. After the long period without feed, sows often overeat if provided free access to feed. The sows will go off feed or have a noticeable dip in feed intake. Many people prescribe limit feeding as a cure for the sows going off feed instead of correcting the problem that originally caused the problem (the extended period of little or no feed intake prior to and immediately after farrowing).

Gestation Summary

Feeding levels in particular stages of gestation have been shown to influence sow productivity and performance of their offspring. However, the periods where excessive feed intake is most detrimental is immediately after breeding (d 0 to 2) for gilts and from day 75 to 90 of gestation. From a practical perspective, feeding pattern is less important than providing a total energy level over the entire gestation period that prevents excessive fat gain or inadequate body reserves at farrowing. Feeding sows based on backfat and weight category at breeding is a method that can help producers reach this goal.

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Appendix 1. Calculating sow feed intake

Gestation intake

The easiest method to determine gestation feed intake is to divide total feed delivery over a period of time by the number of gestation crates in the barn and the number of days in the period. For example, a 3,000 sow farm containing 2,800 gestation crates used 1,210 tons of feed in a 6 month period. The calculations are as follows:

$$\frac{\text{Total Feed}}{\text{Crates X Days}} = \frac{\text{1,109 metric tons x 1,000 kg}}{\text{2,800 crates x 182 days}} = 2.18 \text{ kg/d}$$

The above number can be modified to account for changes in sow inventory; however, the simple use of number of crates is relatively accurate unless the sow farm is undergoing a depopulation or repopulation. A period of 6 months or longer should be used with this method to account for fluctuations in feed deliveries. A 6-month rolling average is a good method to use to track gestation feed usage.

Lactation intake

Two calculations are helpful to determine actual feed intake. The first calculation uses crate days and feed delivery and estimates the lowest amount of feed disappearance per sow per day. The second calculation relies on the number of farrowings and lactation length and estimates the highest amount of disappearance that could have occurred. The average of these two values should be used as the feed intake estimate. Because these calculations rely on feed delivery, which can be sporadic, a period of 4 to 6 months should be the shortest period used for the calculations. A six month rolling average is a good way to view feed intake when using this method.

A 3,000-sow farm with 450 farrowing crates is used as an example. During the 6-month period, 3,615 litters were weaned with an average litter weaning weight of 46 kg at 19 d of age. During this 6-month period, 419 tons of lactation feed was delivered to the farm.

The first method using crate days estimates feed disappearance as:

$$\frac{\text{Total Feed}}{\text{Crates X Days}} = \frac{\text{381 metric tons x 1,000 kg}}{\text{450 crates x 182 days}} = 4.65 \text{ kg/d}$$

The second method using number of lactating days estimates feed disappearance as:

$$\frac{\text{Total Feed}}{\text{Litters X Lactation Length}} = \frac{\text{381 metric tons x 1,000 kg}}{\text{3,615 x 19 d}} = 5.55 \text{ kg/d}$$

The first method should underestimate average lactation feed intake because of days that crates are empty or contain prefarrowed sows that are eating lactation feed. The second number overestimates lactation feed intake because the feed to prefarrowing sows is counted as feed fed to lactating sows. However, the true daily lactation feed intake has to be somewhere between 4.65 and 5.55 kg. An average of the two values (5.1 kg/d) can be used as a good estimate of actual intake.

Appendix 2: Determining gestation energy requirements

The equations listed below allow for the calculation of the daily energy requirement for a gestating sow. To ease calculation, we use an excel spreadsheet, whereby you can change the energy density of the diet and the feed levels are automatically recalculated. In the current example 35 kg of body weight gain is required to get 9 mm of backfat gain.

Body Weight at service, kg	=	195	≡	(430 lb)
Diet ME, Mcal/kg	=	3.1	≡	(1,406 kcal/lb)
Uterine contents per pig, kg	=	1.85	≡	(4.08 lb)
Birth weight per pig, kg	=	1.15	≡	(2.53 lb)
Body Weight (BW) gain, kg	=	35	≡	(77.16 lb)
Backfat (P2) at breeding, mm	=	10	≡	(0.39 in.)
Expected backfat (P2) gain, mm	=	9	≡	(0.35 in.)
Efficiency of ME use for maternal gain	=	0.75		
Efficiency of ME use for fetal gain	=	0.50		
Total born	=	11		

Gestation Uterine and fetal gain, kg = Uterine contents per pig * Total born
= 2.29 * 11
= 25.19

ME for Maternal gain, Mcal = (9.7 * BW gain, kg + 54 * Backfat gain, mm)/Efficiency of ME use for maternal gain
= ((9.7 * 35 + 54 * 9)/0.75)/4.184
= 263.1 (Dourmad et al., 1996, 1997, 1998).

ME for Uterus gain, Mcal = (4.8 * Fetal BW gain, kg)/Efficiency of ME use for fetal gain
= ((4.8 * 11 * 1.50)/0.5)/4.184
= 37.9 (Noblet et al., 1985b).

Total ME for Maternal + Uterine gain, Mcal = 263.1 + 37.9
= 301.0

ME for Maintenance per day, Mcal = 0.45 * $BW^{0.75}$, kg where, BW = BW at service + ½ gestation BW gain + ½ uterine and fetal gain
= (0.45 * (195 + ½ (35) + ½ (25.19))$^{0.75}$/ 4.184
= 6.25 (Noblet and Etienne, 1987b).

Total ME requirement for gestation, Mcal = (ME for Maintenance per day * 115) + ME for Maternal and Uterine gain
= (6.25 * 115) + 301
= 1,020

Daily ME requirement for gestation, Mcal = 1020/115
= 8.87

Daily ME requirement for gestation, kg = 8.87 Mcal/3.1 Mcal/kg
= 2.86

Assessing Strategies to Reduce Variation in Quality Across Ontario Farms

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A three year study has been started in 2005, initially funded by Ontario Pork and latterly with additional contributions from the National Science and Engineering Research Council. The aims of the project are:

1. Identify the scale of variability in pork meat quality produced in Ontario.
2. Systematically evaluate behavioural, nutritional and genetic interactions contributing to this variability.
3. Investigate basic mechanisms whereby these factors impact on quality through proteomics, genomics and the biochemical conversion of muscle to meat.
4. Identify management strategies to improve the quality of pork produced in Ontario.

Twenty-two commercial farms have been identified and contacted with the cooperation of a packing plant, and to date, data have been collected from approximately 50% of these and from two groups produced at a University of Guelph facility.

For each farm, genetic, management, nutrition and behaviour information were collected, and 24 pigs were identified and individually marked for tracking from farm through processing. At the plant, video records were used to quantify behaviour during handling, and blood samples were collected for analyses of stress parameters. Temperature and pH were recorded over the first 48 hours in the ham and loin, and tissue samples were collected at 1.5 hours postmortem and stored at – 70 ^{o}C for analyses of gene expression and biochemistry. Loin and ham samples were also sent to the University of Guelph Meats Lab for subjective evaluation of meat quality (colour, marbling, firmness, wetness) and objective determination of colour (L* a* b* scale), pH, drip loss and Warner-Bratzler shear force (an instrumental measure of tenderness). Shear force measurements were conducted on cooked longissimus chops and smoked ham. From the first set of 312 samples statistical analyses, were conducted to identify outliers based on drip loss and colour of the loins. Individual farm/day effects were accounted for in the model. Samples from the extremes have been extracted for microarray analysis to determine patterns of gene expression peri-mortem in pigs with differing meat quality parameters. These gene expression measurements and biochemical measures of a key enzymic pathway involved in both drip formation and tenderness development are currently underway.

The minimum – maximum range of values from measurements analysed to date are as follows:

	Measurements on Loin (Longissimus muscle)		**Measurements on Ham (Semimembranosus muscle)**	
Parameter	**Minimum**	**Maximum**	**Minimum**	**Maximum**
pH (initial)	5.45	6.60	5.47	6.65
pH (final)	5.29	6.27	5.47	6.58
Colour (L*)	35.47	54.35	40.56	61.58
Drip loss %	2.69	12.54	3.12	12.27
Shear force	2.08	7.66	1.67	5.43

A detailed report on stress response and animal behaviour as related to these variations in meat quality is given by Dr Widowski elsewhere in this 2006 CSRU.

The min-max ranges tabulated above clearly show an extensive range of values. Figure 1 shows the range in two measures often associated with meat quality concerns; Colour L* Value and Drip Loss (%), both measured on the loin eye muscle. The L* value from the Minolta colour meter is a standard measure of the brightness of the meat. Higher L* values are associated with pale pink pork chops. The percentage of drip loss is a direct indicator of the water holding capacity of the post-rigor muscle tissue which has a large impact on the further processing potential as well as the consumer acceptability of the product. Plotting these two components of quality reveals the range of quality in the pigs seen in the sample of pigs we tested. (A drip loss value of 2.5% is the goal established by the US National Pork Board. Similarly, an L* value of less than 50 is desirable, and anything greater than that is considered pale.)

There is extensive variation in the values shown in Fig.1; as with other parameters, the variation between pigs from the same farm is on the same order of magnitude as great as the variation between farms. This indicates that physiological effects in individual animals and their interactions with handling and nutrition may well have a large influence on end product quality. The next step in the project is to interpret gene expression and biochemical analyses of selected samples to explain how these differences come about at the level of individual genes, proteins and enzymes in the meat. The strategic aim of the project as a whole is to suggest nutritional strategies and handling strategies that improve meat quality parameters overall, but also to look at ways to reduce the real outliers.

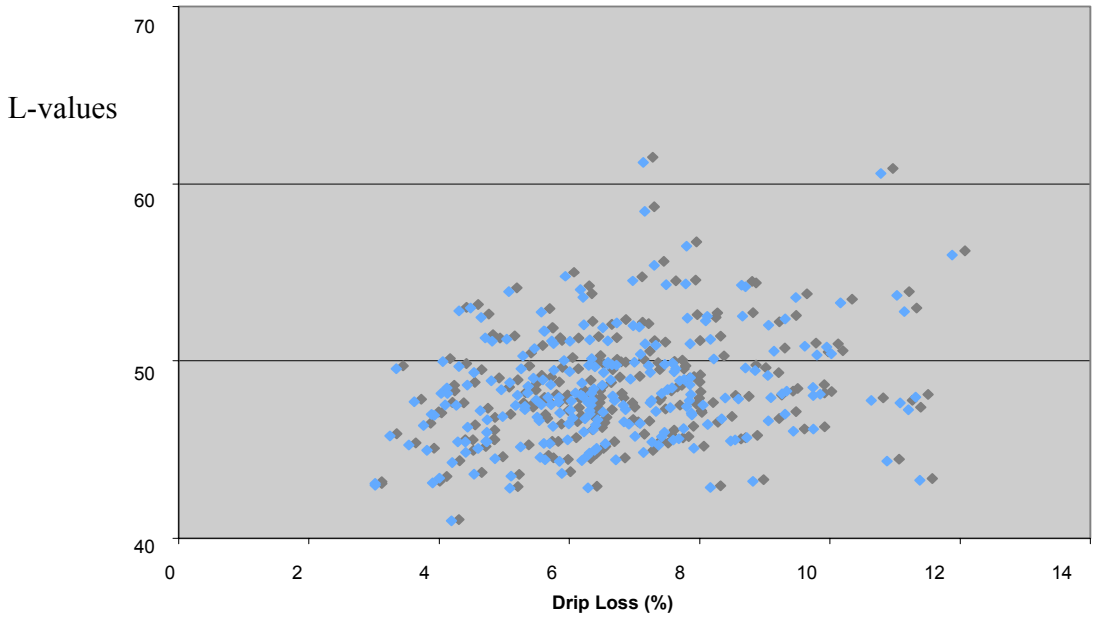

Figure 1. L* values (lightness) versus drip loss (%) values from loin samples only.

Proper Timing for Sow Ovulation

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Artificial insemination (AI) is widely used in the swine industry. For best reproductive performance, there must be adequate quantities of fertile sperm at the site of fertilization when eggs are ovulated from the ovary of the sow. Therefore, timing of insemination is critical to ensuring reproductive success. Optimal sow fertility is achieved by insemination of fresh extended semen during the 24-hour period before ovulation. There is variation in the length of time it takes sows to return to heat after weaning and there is also uncertainty about when ovulation takes place during the period of standing heat. These factors make precise timing of AI more difficult. To overcome the variation and uncertainty producers need to be vigilant in observing for signs of heat and breeding multiple times during estrus. Most weaned sows have a wean-to-estrus interval (WEI) of 4 to 7 days, and are bred at least twice during the period of standing heat. Generally, sows bred later than 7 days after weaning have shorter estrus periods, lower farrowing rates and smaller litter sizes than sows bred within 7 days of weaning. Ideally, sows should be bred before day 7 post-weaning using as few inseminations as possible in order to save time and money.

The use of exogenous pharmaceutical products for the synchronization of estrus and ovulation allow for the application of targeted intensive estrus detection and the determination of the appropriate timing for successful AI. While the use of these products can increase the precision of AI timing, it will not replace or correct other aspects of management required for good reproductive performance.

The most common protocol for the induction of estrus in weaned sows is the injection of 500 to 750 IU of equine chorionic gonadotrophin (eCG) or a combination of 400 IU eCG and 200 IU of human chorionic gonadotrophin (hCG) (PG600). There is a wealth of literature demonstrating the efficacy of this approach for the induction of a fertile estrus after weaning. While efficacious for estrus induction, injection of eCG or PG600 does not permit an accurate timing of ovulation.

Research was conducted at the Ontario Veterinary College to determine the timing of ovulation following a protocol of eCG to induce estrus and porcine luteinizing hormone (pLH) to induce ovulation. In a pilot study sows (n=17) were given 600 IU of eCG on the day of weaning and 5mg pLH 80 hours later. Ultrasound examinations were performed to monitor the ovaries in order to determine the time of ovulation. The time from pLH treatment to ovulation ranged from 34.25 h to 42.5 h, with a mean of 38.2 ± 2.8h. This information was then used to design a reproduction study involving 567 weaned sows. The results of this large study showed that sows could be reliably bred using a single insemination at a fixed time post-weaning, in our case that was Tuesday morning. There was no advantage in using two inseminations. On the farm where the trial was conducted the usual farrowing rate was about 75%. Farrowing rate for sows that were induced to ovulate at a specific time achieved an 85% farrowing rate indicating that the semen and breeding technique were adequate and that the reason for the suboptimal level of reproductive performance in the control group is related to the timing of the insemination. When the protocol was discontinued, pregnancy and farrowing rates fell to previous levels. In this

case the protocol provided diagnostic evidence that timing of AI was likely a problem in this herd.

In another study done in conjuction with researchers at Michigan State University, the same synchronization protocol was used and ovulation times were determined in 32 sows. All sows ovulated between 34 and 42 hours after pLH treatment, with 84.4% ovulating between 36 and 40 hours. The mean time after pLH treatment was 38.2 ± 0.2h. In this study, pregnancy rate with fresh semen was 85% compared to 32% with frozen semen. In this study, precise timing produced acceptable results with fresh semen, but the reduced fertility of the frozen semen compromised pregnancy rate. These researchers were able to remove timing as a factor with the synchronization protocol.

In another OVC study, a reduced number of sperm in the insemination dose (1 billion) produced similar pregnancy rate to normal sperm concentration (3 billion).when the synchronization protocol was utilized. Also pregnancy rate from intra-uterine deposition of semen was comparable to the traditional cervical deposition. These results were obtained using a single insemination. If timing of insemination is precise a lower sperm concentration in the insemination dose may be used in the traditional method of insemination to achieve acceptable results.

Low farrowing rate can be caused by many factors including semen quality, estrus detection, insemination technique and inappropriate timing of insemination. The current research results indicate that estrus synchronization and induced ovulation combined with timed insemination can potentially solve problems associated with timing of insemination and estrus detection. In addition, it can be used as a tool in diagnosing other causes of low fertility by removing timing of insemination and estrus detection as possible causes.

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Composting Swine Manure and Manure Treatment Options: Comparison of Composting to Anaerobic Digestion

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Introduction

Is there a manure management system that is better than storing and spreading on the land? It's hard to beat the economics of that system, but for years, researchers and farmers have been trying to find a better way. The list of possible treatment technologies includes additives, separators and many others, but two that seem to show up near the top of the list are anaerobic digestion and composting. Both rely on bacteria to break down organic matter. Anaerobic digestion relies on bacteria that survive only when oxygen is absent. In contrast, composting relies on bacteria that must have oxygen present (i.e. aerobic).

Ongoing Studies

What are advantages and disadvantages of each? What are the differences? Which is better? Can either system be justified? These are some of the things research efforts have tried to nail down.

Composting studies have gone on at Ridgetown since 1998 and we have learned quite a few things about composting liquid manure.

Anaerobic digestion is used in several European countries but is not common in Canada. We recently installed a pilot-scale unit at Ridgetown mainly to do some "recipe" testing – e.g. look into what combinations of manure and possibly other materials yield the most methane.

Comparison of Main Features

	Anaerobic Digestion	Composting
Inputs	Manure, heat	Manure, carbon material (e.g. straw)
Outputs	Liquid digestate, biogas	Compost (stabilized organic material), heat
Losses	None	Carbon dioxide, water
Typical system	Digester + electrical generation + digestate and gas storage	Composter + storage for compost
Nutrients?	Retained in digestate	Some loss of N to air
Pathogens?	Reduction (how much depends on system)	Reduction (how much depends on system)
Odours?	Reduced	Can be eliminated
Economics?	Critical: price of electricity, value of digestate, off-farm inputs	Critical: cost of carbon substrate, sale of compost vs use on farm, off-farm inputs

Water-Based Growth Promotion

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The use of in-feed antimicrobials in nursery pig diets has long been recognized as a method to improve growth performance and health. But the use of these feed additives poses several challenges to swine production systems. First, changing the type of antimicrobial can be difficult due to feed-processing limitations. Second, handling multiple antibiotics in the mill leads to multiple runs of feed and concerns with cross-contamination with non-medicated feed. Third, pulsing antibiotics can be very difficult with feed application due to the difficulty of timing the delivery of the feed. Replacing in-feed with water-based antimicrobials would simplify feed processing and reduce the risk of feed being contaminated with an inappropriate antimicrobial or antimicrobial residue. Therefore, we conducted a series of experiments to evaluate the effectiveness of water-based antimicrobials as a potential replacement for typical feed delivery of antimicrobials for improving nursery growth performance.

In Exp. 1, 350 pigs (initially 5.9 kg) were allotted to one of five treatments 3 d after weaning: 1) negative control (no antimicrobial in the feed or water); 2) positive control diet containing neomycin sulfate and oxytetracycline (154 ppm neomycin sulfate, 154 ppm oxytetracycline HCl; NEO/OXY); 3) neomycin sulfate in the water (25 mg neomycin sulfate per L); 4) oxytetracycline in the water (25 mg oxytetracycline HCl per L); and 5) combination of treatments 3 and 4. Overall (d 0 to 28), pigs provided water medication had greater ($P<0.02$) ADG and ADFI compared to negative control pigs. Pigs fed diets containing NEO/OXY had greater ($P<0.01$) ADG and ADFI than pigs provided water medication. There were no differences in performance among water medication treatments. We believed the lower ADG for pigs provided with medication via the water may have been due to lower medication intake. Thus, the second experiment was conducted with multiple medication levels.

In Exp. 2, 360 pigs (initially 6.4 kg) were allotted to one of eight treatments 3 d after weaning: 1) negative control (no antibiotic in the feed or water); 2) positive control with NEO/OXY in the feed; 3, 4, and 5) neomycin sulfate in the water (38.0, 75.5, and 113.5 mg neomycin sulfate per L, respectively); 6 and 7) neomycin sulfate in the feed (157 and 314 ppm, respectively); and 8) combination of treatments 2 and 4. Overall (d 0 to 24), pigs fed the positive control diet and pigs provided neomycin sulfate in the water or feed had greater ($P<0.05$) ADG and ADFI compared to negative control pigs. Pigs provided the combination of the positive control diet and medicated water (Treatment 8) had greater ADFI ($P<0.04$) than pigs provided treatment 2 or 4. Increasing neomycin sulfate in the water or feed linearly increased ($P<0.04$) ADG and ADFI. There were no differences in growth performance among pigs provided neomycin sulfate in the water or feed. Growth performance was similarly improved by adding neomycin sulfate to either the feed or water. This experiment proved that growth promotion is similar when similar levels of the medication were consumed via the feed or water.

In Exp 3, 360 weanling pigs (initially 5.2 kg and 18 ± 3 d of age) were used to determine the effects of intermittent use of water-based medication on nursery pig growth

performance. Pigs were blocked by initial weight and randomly allotted 3 d after weaning to one of eight treatments: 1) negative control (no antibiotics in the feed or water); 2) positive control diet containing 154 ppm neomycin sulfate and 154 ppm oxytetracycline HCl; 3) and 4) continuous use of 38.0 and 75.5 mg neomycin sulfate per L of water, respectively; 5) and 6) use of 38.0 and 75.5 mg neomycin sulfate per L of water, respectively, during wk 1 and 3 after placement; and 7) and 8) use of 38.0 and 75.5 mg neomycin sulfate per L of water, respectively, during wk 2 and 4 after placement. Overall (d 0 to 28), pigs provided neomycin sulfate in the water continuously (Treatments 3 and 4), and pigs fed the positive control diet had greater ($P<0.05$) ADG and ADFI compared to pigs provided non-medicated water and feed. There was no difference however, in growth performance and G;F between pigs fed the positive control diet and those provided continuous water-based neomycin sulfate. Numerical increases in ADG and ADFI were observed when pigs were provided water-based neomycin sulfate after drinking non-medicated water as a part of weekly intermittent dosage. However, growth performance returned to the control level immediately after the supply of neomycin sulfate was removed. Pigs provided continuous water medication had greater ADG ($P<0.02$) and ADFI ($P<0.04$) than pigs provided an intermittent supply of water-based neomycin sulfate. These data demonstrate that providing neomycin sulfate in the feed or water results in a growth response; however, there is no carryover effect to support intermittent usage of this type of antimicrobial.

These experiments demonstrate that providing Neomycin sulfate in the water or feed resulted in improved growth performance, compared with that of pigs fed non-medicated feed and water. Similar performance was obtained whether the medication was provided via the feed or the water. This indicates that water-based medication can be used in place of medication in the feed to yield similar growth performance. Providing Neomycin in pulses improved performance when it was in the water; however, there were no carryover effects with performance returning to control levels immediately after the antibiotic was removed from the water. Thus, although medication cost is reduced, ADG and net profit was also reduced by pulsing the medication. At the present time, water based medication is usually still more expensive than providing the medication in the feed for growth promotion; however, using the medication in the water increases flexibility in the feed mill and provides another mode of delivery for growth promotion levels of medication.

PMWS or Porcine Circovirus Disease (PCVD): An Old Virus in a New Environment or a Complete Misnomer?

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Introduction

A wasting syndrome in Western Canadian pigs, first identified in 1991 in high health Specific Pathogen Free (SPF) herds, was reported in 1996 (Clark 1996, Harding 1996). The authors proposed the term "postweaning multisystemic wasting syndrome" (PMWS) to describe the clinical condition. Porcine circovirus (PCV) nucleic acid and antigen were demonstrated in abundance within the lesions of affected pigs and subsequent isolation and characterization of a "new" porcine circovirus (PCV2) virus from diseased pigs was reported (Ellis et al. 1998). PCV genome was also associated with interstitial pneumonia and lymphadenopathy in a 6 week-old pig in California (Daft et al. 1996) and a PCV2 virus was also recovered from this animal (Allan et al., 1998). In 1996/97, a clinical wasting disease associated with PCV2 was described in France (LeCann et al. 1997) and Spain (Segalés et al. 1997). Since these initial reports of PCV2-associated PMWS, the disease has been reported in almost all pig producing countries around the world.

PMWS histological lesions associated with an abundance of PCV2 antigen has now been retrospectively described in archived tissue samples taken in 1986 from pigs in Spain and the United Kingdom (Rodríguez-Arrioja et al. 2003, Grierson et al. 2004) and in 1989 in Japan (Mori et al. 2000). Moreover, evidence of PCV2 infection in pigs has been detected as early as 1969 (Sánchez et al. 2001). It is now recognised that PCV2 is not a "new" virus, but a "newly discovered" virus and PMWS is not a new disease, but the expression of this disease syndrome changed in the early to mid 1990s from occasional clinical diseases in a few pigs to epizootic diseases outbreaks of high mortality in pigs world wide.

It has been estimated that PMWS costs around 600 million Euros per year to the European Union (Armstrong and Bishop, 2004). Common rates of morbitity and lethality associated with PMWS seen in affected farms are 4–30% (with exceptional rates over 50-60%) and 70–80%, respectively, with resulting mortality rates on farms between 4-20% (Segalés and Domingo 2002)

PMWS is now recognized as a disease of pigs where PCV2 infection is needed for expression of the clinical condition, however it is also recognized that PCV2 infection, linked to other co-factors, is necessary for the consistent development of full clinical disease in pigs.

Consistent and repeatable PMWS disease models have been obtained using infectious (Allan et al. 1999, 2003, Krakowka et al. 2000) and non-infectious (Krakowka et al. 2001) co-factors. The reproduction of full clinical disease has been reported in a high percentage of colostrum deprived (CD) and gnotobiotic (germ free) pigs co-inoculated with PCV2 and porcine parvovirus (PPV), porcine respiratory and reproductive syndrome virus (PRRSV), mycoplasma hyopneumonia (Mhy) or inoculated with a potent immunostimulant.

Clinical signs

PMWS most commonly affects pigs of 2 to 4 months of age, although the disease has been described in 1 to 6 month-old pigs and outbreaks of PMWS/PCVD are now being increasingly reported in fattening pigs (J Wadelove, personal communication).

The major clinical sign of PMWS is wasting but it is usually seen concomitantly with other signs such as pallor of the skin, respiratory distress, and diarrhea and, occasionally, icterus (Harding and Clark 1997). A relatively striking feature of pigs in the early clinical phases of PMWS is the increase in size of subcutaneous lymph nodes (mainly inguinal superficial lymph node), although it is not always seen (Segalés et al. 2004).

Other infections or diseases are more commonly found on PMWS-affected farms, when compared to non-affected farms (Ellis et al. 2004) and it has been suggested that the final clinical outcome observed on farms affected with PMWS is the sum of the effects of various management factors and concurrent diseases.

Lesions

The main lesions of PMWS occur in lymphoid tissues, although inflammatory infiltrates associated to PCV2 infection have been detected in a wide range of tissues from affected pigs.

Enlargement of lymph nodes is the most prominent feature of early clinical phases of PMWS (Clark 1997, Rosell et al. 1999). And the microscopic lymphoid lesions observed in PMWS-affected pigs are unique (Clark 1997, Rosell et al. 1999).

Lungs may be enlarged, non-collapsed and rubbery in consistency, following a diffuse or patchy distribution. These findings correspond microscopically to interstitial pneumonia.

In the majority of PMWS affected pigs, liver may appear unchanged or slightly pale but in a few cases, the liver is enlarged, pale, and firm in consistence, with a fine granular surface (Rosell et al. 2000).

Some PMWS-affected pigs show white spots in the kidney cortex (non-purulent interstitial nephritis), a lesion which, at this age, is almost only found in PMWS cases.

Distribution

PCV2 is now considered a ubiquitous virus, both in countries where PMWS has or has not been detected (Allan and Ellis 2000, Segalés et al. 2004) and PMWS has been diagnosed in a wide range of countries. Notable exceptions where PCV2 infection is present and PMWS has not been diagnosed include Australia and Finland. It is also of note that only 1 confirmed outbreak of PMWS has been reported in Norway and very few outbreaks of the disease have been reported in Belgium, when compared to neighboring countries such as France, The Netherlands, Germany and Denmark.

Diagnosis

The diagnostic criteria for PMWS (not PCVD) in single animals are now well established (Sorden 2000; Segalés et al. 2002). Classically, a pig or a group of pigs suffer from PMWS if they fulfill the following criteria (Sorden 2000):

- Clinical signs including growth retardation and wasting, frequently with dyspnea and enlargement of inguinal lymph nodes, and occasionally with jaundice;

- Presence of characteristic histopathological lesions in lymphoid tissues (lymphocyte depletion together with granulomatous inflammation, and presence of inclusion bodies in a proportion of affected pigs; and
- Detection of moderate to high amounts of PCV2 within the lesions in lymphoid and other tissues of affected pigs.

A herd case definition for PMWS should include the occurrence of a clinical process, characterized mainly by wasting and mortality, significantly in excess of the expected and/or historical level for each farm, and the establishment of individual diagnoses of the disease in a number of pigs (Segalés et al. 2003).

Prevention and control

Among PCVD, PMWS is the disease scenario with the major economic impact on swine production. To date, effective control measures to date for PMWS, without the control of PCV2 infection, have focused on the understanding of the co-factors and triggers involved on individual farms and the control or eradication of these triggers.

Prospective studies carried out in France from 1998 (Madec et al., 2000) and more recently in Sweden (Per Wallgren et al., 2005) have clearly shown that management deviations occurred in severely PMWS affected farms. As a result of these studies it was suggested that several environmental conditions might be necessary in association with PCV2 infection to lead to the clinical expression of the disease. The implementation of what is today known as the Madec's 20-point plan significantly decreased the percentage of mortality in severely affected farms (Madec et al., 2001). In studies (Allan et al. 2002, Calsamiglia et al. 2004), reported that PCV2 infection or low serological titres to PCV2 in sows at farrowing had a significant effect on the overall mortality of its offspring due to PMWS. Conversely, more recent studies in Denmark and the United Kingdom have shown that high levels of antibody to PCV2 in sows and gilts does not relate to protection from PMWS in the piglets derived from these animals (Hassing et al. 2004, Allan et al. 2005). However, the protective effect of maternal passive immunity on PMWS development is supported by the fact that disease occurs once these titres have declined (Rodríguez-Arrioja et al., 2002; Larochelle et al., 2003; Sibila et al., 2004). Therefore, measures that increase maternal immunity and decrease sow viremia at farrowing may diminish PMWS impact on piglet mortality.

Partial control of epizootic PMWS has been achieved on some farms in the United Kingdom by changes in the diet of affected pigs (Donadeu et al., 2003). These changes included the increase of nutrient density of young pig diets and addition of commercial feed additives, most of them with anti-oxidant effects. However, these results have not been confirmed by other workers. On the other hand, a recent study has shown that conjugated linoleic acid (CLA) ameliorates PCV2 experimental infection (Bassaganya-Riera et al., 2003). Finally, it has been suggested that the addition of vitamin E and/or selenium in the feed may be of benefit in those farms with PMWS (Boebko et al., 2004). Overall, although some preliminary field and experimental data on nutrition suggest that certain nutritional factors might favour a decrease in PMWS outcome, there is not enough scientific information available to establish the real effect of nutrition in this particular disease.

The use of autogenous vaccine preparations has also been reported as advantageous in the control of PMWS in several countries, including the UK. This procedure involves the homogenization of lymphoid material from diseased pigs on specific farms, followed by

inactivation and ajuventing and administration to sows, gilts and young piglets on the same farm.

An inactivated, ajuvanted commercial PCV2 vaccine for use in sows and gilts is now available in some countries under emergency licience. This vaccine has been shown experimentally and in field trials to reduce the incidence of PMWS on affected farms (Reynaud et al. 2004a,b), presumably due to increased levels of serum antibodies to PCV2 following vaccination and the transfer of these protective antibodies to piglets in colostrum. The efficacy of this vaccine in controlling PMWS under field conditions remains to be fully elucidated, but early reports are very favorable.

Experimental PCV2 vaccine prototypes, including inactivated, recombinant and DNA vaccines have shown a significant protection when evaluated by evolution of body weight and rectal temperatures after PCV2 challenge (Blanchard et al. 2003, Pogranichnyy et al. 2004). A chimeric infectious DNA clone containing the immunogenic ORF2 capsid gene of PCV2 cloned into the non-pathogenic PCV1 genetic backbone induced antibody response to PCV2 capsid when inoculated in pigs and was shown to be attenuated compared to the PCV2 virus (Fenaux et al., 2003). This vaccine also appears to be protective against development of PCV2-associated lesions in an experimental model.

Field observations from farmers and veterinarians have suggested that certain genetic lines of pigs, specifically in relation to boar lines, are more or less susceptible to PMWS. This observation has been supported by recent experimental studies where Landrace pigs were experimentally shown to be more susceptible to develop PMWS lesions than Duroc and Large White pigs (Oppriessnig et al. 2004). Other studies have shown contradictory results with the use of Pietrain boar line; while the use of this genetic line did not seem to have any effect on the offspring in one study (Rose et al. 2003), another study showed lower general postweaning and PMWS associated mortalities (López-Soria et al. 2005).

The role of an unknown agent in causing the expression of PMWS: The New Zealand and Swiss scenario

In New Zealand PMWS was diagnosed for the first time on a farm on the North Island in October 2003. Since this initial diagnosis the Ministry of Agriculture and Forestry has carried out an extensive epidemiological survey in this country to document the incidence of the disease and attempt to identify a new "exotic infectious agent" responsible for PMWS in New Zealand. PMWS in New Zealand has been treated as an "exotic disease" with the relevant movement restrictions etc being put in place. As of 12 August 2004 it appears that there are a total of 16 PMWS-affected farms on the North Island of New Zealand and no PMWS-affected farms have been seen on the South Island. The 16 affected farms are, in general, located in a very limited geographical are of the North Island and are generally hobby or part-time farms. As of August 2004, no main-stream pig farms in New Zealand have been affected by PMWS. The determination of the temporal aspects of the outbreak and spread mechanisms of PMWS in New Zealand has, by the admission of the New Zealand authorities "proven poroblematic". Even though there was a reliance on farmer recall of morbidity and mortality, it appears from the studies carried out to date that, in some places in New Zealand PMWS outbreaks with mortalities in excess of 30% may have occurred as early as 2000, or perhaps even earlier. It is difficult to understand why outbreaks of disease with mortalities in excess of 30% remained unreported and undiagnosed for nearly 4 years in the New Zealand pig industry and, because of this a

complete understanding of the temporal progression of PMWS prior to the initial formal diagnosis in 2003 and the actual means of spread in each case may remain elusive. It has been hypothesised by the New Zealand authorities that an agent X (exotic to New Zealand) entered New Zealand in about 1999 in imported pig meat, which was fed to pigs with insufficient processing. One of the New Zealand herds was infected directly from this source and developed PMWS. Secondary spread has occurred to other like-minded farmers with whom infected herds have had frequent contact. This hypothesis is, to date, unproven date, unproven and is based on farmer interviews, retrospective analysis of farmers' records and kill numbers. A number of important questions regarding the epidemiology of PMWS in New Zealand require further examination. Central to this hypothesis on Agent X and PMWS is whether or not the farms in question 1n 1999 actually developed PMWS. There appears to be no data to support this, except clinical signs of wasting in pigs. It is well documented that ill-thrift and/or wasting in pigs can be caused by a number of conditions. Because of this, and the numerous inaccurate reports from veterinarians of outbreaks of PMWS in pigs based on clinical signs only, the international scientific community has agreed a common standard for laboratory based diagnosis of this condition. This must include clinical condition and typical gross and histological lesions and an abundance of PCV2 antigen associated with these lesions.

It is interesting to note the recent finding by Swiss researchers regarding this topic. In a recent study in Switzerland it has been shown that only 4 of 72 piglets selected from 26 farms with more than 10% clinically wasting piglets were actually diagnosed as having PMWS using the internationally accepted criteria.

PCVD/PMWS and the global pig industry

It is acknowledged that the global pig industry is, in many respects an ever changing environment. The genetics of commercially farmed pigs are continually being “upgraded” to accommodate consumer demand for leaner meat. Indeed, it could be argued that the commercial pig that is farmed today is a genetically diverse animal from the pig that was farmed 10 years ago. In addition husbandry practices have changed, and the contents of pig feed and the vaccines and biologicals used in pig production have also changed extensively. Vaccination of young piglets is a concept introduced in the early to mid 1990s. It is noteworthy that the first outbreak of PMWS in Sweden was on a “test station” set up and managed outside the traditional “welfare friendly” Swedish system and incorporated early weaning and vaccination of piglets and multiple movement and mixing of piglets. To date, all the outbreaks of PMWS in Sweden have been strongly associated with management malfunctions. In a recent review article on this topic (Visscher et al., 2002) the authors state that "disease of the host is not the evolutionary goal of the pathogen. Sub-clinical infections are common, they are the rule, diseases are the exception". This would appear to have been the situation with PMWS/PCVD until recently. In the same article the authors go on to make the following important observation: "the interplay between microbes and host should not necessarily be seen as an ongoing battle but a co evolution of species". Is it possible that accelerated breeding by "natural selection” for leaner traits, increased prolificacy and/or disease resistance in combination with changes in pig farming practices and nutrition has resulted in an unforeseen modulation of the PCV2-host co-evolution?

In conclusion, it would appear that two distinct theories to explain the pathogenesis and epidemiology of PMWS and PCVD are emerging. The initial scientific literature that outlined the importance of PCV2 in this disease scenario and the experimental reproduction of PMWS using PCV2 as inoculum is now being challenged by retrospective epidemiological data from New Zealand, Denmark and the UK that suggests that PCV2 is not the causal agent of PMWS. However, contemporary epidemiological studies in Sweden and Northern Ireland to date, do not support the hypothesis of an "exotic incursion" into the Swedish or Northern Ireland pig herd but do support the hypothesis that changes in the Swedish industry precipitated an explosion of PCV2-associated disease.

Further studies are ongoing in Ireland, other EU countries and New Zealand in an attempt to identify and characterise a "new" common infectious agent that may be responsible for the global explosion of disease. To date no such agent has been reported and the predominance of scientific evidence still supports the hypothesis that PCV2 is the causal agent of PMWS/PCVD and that control of PCV2 infections by vaccination at a herd level will eventually control the global epidemic of PMWS.

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The Effects of Compensatory Growth on Feed Intake and Production Efficiency

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Introduction

There is evidence (Therkildsen et al., 2002) that restrictive feeding (growing phase), can stimulate compensatory gain during the finishing period. The authors also indicated that feed digestibility, efficiency of protein (meat) synthesis and measurements of meat quality were improved when pigs were limit fed during the growing period. They hypothesized that a faster growing pig (compensatory gain) could be conducive to an improved meat tenderness and quality.

This trial was designed to further investigate the performance and economic ramifications of limit feeding during the growing phase. Carcass and meat quality estimates were also measured to determine if limit feeding improves meat tenderness while reducing fat deposition.

Objectives:

The project will evaluate the effects of feeding strategy (full versus limit feeding) and gender (gilt versus barrow) based on growth performance, feed intake, carcass and meat quality and economic returns. The following objectives will be specifically addressed:

1) To determine the effects of feeding strategy (full versus limit feeding) on pig performance, feed intake and efficiency, carcass and meat characteristics and economic returns.
2) To determine the effects of gender (gilt versus barrow) on pig performance, feed intake and efficiency, carcass and meat characteristics and economic returns.
3) To determine if there are interactions between feeding strategy and gender for pig growth rate, feed intake and efficiency, carcass/meat characteristics and economic returns.

Experimental Procedures:

One hundred and eight feeder pigs (30 kg - average weight) were randomly assigned to eighteen pens with six pigs per pen. A specific gender (gilt or barrow) and feeding strategy was assigned to each pen to provide three replications (pens) for each treatment combination.

1) **Control Group (ad lib feeding):** - Grower diet based on corn, SBM, and vitamin/mineral premix (18% crude protein; 0.9%lysine) was fed *ad libitum* until the pigs were marketed. The same diet formulation was used for all 3 feeding strategy groups.
2) **Limit Fed Group (85% of control):** - Feed allocations on a pen basis were limited to 85% of *ad libitum* feed intake (control group) until the pigs weighed 60 kg – pigs were then fed *ad libitum* until they are marketed.
3) **Limit Fed Group (70% of control):** - Feed allocations on a pen basis were limited to 70% of *ad libitum* feed intake until the pigs again weighed 60 kg – pigs were then fed *ad libitum* until they were marketed.

Feed intake and live pig weights were recorded weekly. They were marketed on an individual animal basis when they weighed approximately 110 kilograms (107 to 113 kg

range). Ultrasound measurements of backfat and loin depths were taken at the start, in the middle and before the pigs were marketed. Carcass measurements were recorded at the abattoir with a loin section cut into chops for determination of drip loss, lean colour, intramuscular fat, tenderness (Warner-Bratzler shear force) and pH. Differences in growth rate, feed intake and efficiency (growing and finishing phases and from start of the growing phase to slaughter), carcass and meat quality characteristics are presently being analyzed.

Results to date:

Prelimiary results are summarized in Table 1 for growth rate and feed intake. Carcass and meat quality differences will be available in the near future. Compensatory gain was observed during the finishing period (> 60 kg) when limit feeding was practiced during the growing phase. Compensatory gain resulted in a similar number of days to market and an improved feed efficiency (control versus 70% feed intake).

Table 1. Effects of feeding strategy and gender on pig growth performance and feed intake.

	Feeding Level			Gender	
	Control	**85% Feed Intake**	**70% Feed Intake**	**Barrow**	**Gilt**
Growth Performance and Feed Intake					
Ave. Final Wt. (kg)	108.4	107.9	108.3	109.2	107.3
Days to Market	73.1	74.1	72.3	70.5[d]	75.9[e]
Average Daily Gain (kg)	1.03	1.03	1.05	1.09[d]	0.99[e]
ADG – growing (kg)	1.06[a]	1.00[a]	0.89[b]	1.00	0.97
ADG – finishing (kg)	1.02[a]	1.06[a]	1.16[b]	1.16[d]	1.00[e]
Total Feed Intake (kg)	197.6[a]	197.2[a]	182.8[b]	194.8	190.3
Feed Intake (kg/d)	2.7[a]	2.6[a]	2.5[b]	2.7[c]	2.5[d]
Feed intake growing (kg/d)	2.4[a]	2.1[b]	1.7[c]	2.1	2.1
Feed to Gain (F/G)	2.9[ab]	3.0[a]	2.7[b]	2.9	2.8

[a,b,c] LS means within row for feeding level that do not share a common superscript differ ($p < 0.05$).
[d,e] LS means within row for gender that do not share a common superscript differ ($p < 0.05$).

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Effects of On-Farm Storage Temperature on Stored Semen Quality

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Introduction

Reproductive performance in herds using AI is often not as good as herds that are using natural breeding. One reason for this reduced performance may be due to the improper storage and handling of the semen used for AI. Producers typically store semen on-farm for a number of days prior to use. Boar semen is highly temperature sensitive so maintaining proper storage temperature on the farm is critical in order to achieve good results using AI. The objectives of this research were to determine whether proper semen storage temperatures are being maintained on Ontario farms and to determine what impact on-farm storage temperature has on the quality of stored boar semen.

Materials and Methods

Twenty-seven Ontario sow herds participated in this project. On a day that fresh semen was delivered to or collected on the farm, 1 dose of the fresh semen was obtained from the producers and transported directly to the lab for evaluation. Before leaving the farm, a temperature-logging device was placed inside the farm's semen storage unit. The logger was set to record the air temperature inside the unit at 1-minute intervals. The producers were asked to keep a log of their storage units' use by recording the date, time and reason each time the storage unit door was opened.

Approximately 72 hours after the first visit, the herds were re-visited. The temperature recorder was removed from the storage unit to be downloaded onto a computer for evaluation and the log sheets were also collected. Storage unit temperatures that fell out of the range of 15-20^{0}C or that fluctuated by 2^{0}C or more were considered unacceptable. The log sheets were used to determine if any temperature changes recorded by the logger corresponded with events recorded by the producer. A 2nd dose of semen from the same batch that was initially evaluated was obtained during the 2nd visit and transported to the lab for evaluation in the same manner as the 1st dose. The changes in semen quality from Day 1 (when fresh) to Day 4 (after 72 hours of on-farm storage) were examined for semen stored in both acceptable and unacceptable temperatures.

Results

Unacceptable storage temperatures were recorded in 36% of the storage units examined. In 9 of the 10 storage units producing unacceptable temperatures, the temperature went out of the 15-20^{0}C range: 3 units went above 20^{0}C, 5 units went below 15^{0}C and 1 unit went both above 20^{0}C and below 15^{0}C. In 1/10 of the problem storage units, the temperature fluctuated by >2^{0}C within the 15-20^{0}C range.

In 70% of the problem storage units, the unacceptable temperatures appeared to have been triggered by specific events that had been recorded by the producers. In 3 cases, unacceptably high temperature occurred when warm, fresh semen was put into the storage unit. Other causes of unacceptable storage temperatures included poor maintenance of the storage unit (2 cases), improper setting of the storage unit thermostat (1 case) and adding frozen ice packs to the storage unit (1case).

Several producers had more than 1 batch of semen available on the day of their 1st herd visit. Because of this, 31 separate batches of semen were analyzed from the 27 participating herds. Twenty of the batches were stored in units with acceptable temperatures while 11 batches were stored in units with unacceptable temperatures. The semen analyses showed that on Day 1, there were no differences in any of the semen quality parameters between semen stored in acceptable versus unacceptable conditions (Table 1). However, by Day 4, semen stored in unacceptable temperatures had lower sperm/ml and lower viable sperm/dose than semen stored under acceptable conditions. In semen stored on-farm under unacceptable temperature conditions, there was a decrease in total motility from Day 1 to Day 4 (Table 1). There was also a tendency for progressive motility, sperm/ml and viable sperm/dose to decrease from Day 1 to Day 4 when stored in unacceptable temperatures. For semen stored under acceptable temperatures, there was an increase in total sperm abnormalities from Day 1 to Day 4 while no significant changes in any other quality parameters were observed (Table 1). The percent sperm found in clumps increased from Day 1 to Day 4 in samples stored in both acceptable and unacceptable temperature conditions.

Table 1. Means of semen quality parameters for semen doses stored on-farm under acceptable and unacceptable temperature conditions on Day 1 and Day 4 of storage.

	Acceptable Temperature (n=20)		**Unacceptable Temperature (n=11)**	
Parameter	**Day 1**	**Day 4**	**Day 1**	**Day 4**
Total Abnormalities	10.15%	12.10%*	10.37%	8.04%†
Total Motility	78.06%	76.89%	73.07%	64.21%*
Progressive Motility	63.31%	62.06%	57.39%	48.81%
Sperm/ml	42.47×10^6	38.82×10^6	31.46×10^6	26.34×10^6†
Sperm/Dose	3.32×10^9	3.11×10^9	2.43×10^9	2.03×10^9†
Clumped Sperm	9.59%	13.25%*	11.55%	21.59%*

* $p < 0.05$ within row, within temperature category and between day
† $p < 0.05$ within row, between temperature category and within day

Summary and Implications

- Unacceptable semen storage temperatures are common in Ontario swine herds
- Unacceptable on-farm storage temperatures have negative effects on sperm quality, particularly motility, sperm/ml and viable sperm/dose
- Producers should be aware that their actions can impact the temperatures inside their storage units and that proper semen storage unit maintenance and management are important
- Monitoring temperatures inside semen storage units should be a regular part of sow herd management

Acknowledgements

We appreciate the equipment and time donated by the people at Minitube Canada and the cooperation of the participating producers.

Reducing Stress Response in Pigs to Enhance Meat Quality

Tina Widowski, Jennifer Brown, Kees de Lange, Ira Mandell, Peter Purslow, Andy Robinson, Jim Squires, University of Guelph, and Penny Lawlis, OMAFRA

Research has shown that stress at marketing can reduce meat quality in several ways. The surge in adrenalin that happens as a result of fear or stress can change pH and temperature of the muscle at slaughter, which affects the colour and water-holding capacity of the meat. Prolonged stress from fatigue or fighting can also affect meat quality by depleting the energy stores necessary for the biochemical changes that ensure a good quality product. Stress during loading and transport to the slaughter plant also produces fear in the animal leading to a reduction in animal welfare. Therefore, reducing stress all the way from the farm to the point of slaughter is important for ensuring both good animal welfare and meat quality.

Calm, low stress handling of market hogs depends on a combination of properly designed handling facilities and the technique and experience of the handlers. But even in a well-designed facility skilled handlers often find that some pigs are simply harder to move than others, resulting in more stress for the pigs and the handlers. Sometimes there are large differences in handling and stress response between pigs from different farms – but even on the same farm some pigs are more difficult to handle than others. So what makes some animals more susceptible to handling problems and stress than others? Our research group is using several different approaches to find out.

One approach we are using is to explore management strategies that can be used to improve handling. Pig behavior during handling is thought to depend in large part on their previous experience with humans. One practical recommendation for getting pigs used to moving around people is to "walk the pens" during the growing and finishing phase. In one study, we investigated the effects of walking the pens on fear responses and handling of market hogs at two commercial farms and at a packing plant. Pens on those farms were walked once, twice or three times per week, or not at all, during the last 12 weeks before marketing. When walking the pens, a stockperson simply entered the pens holding a pig board and made one circuit around the pen, spending between 20 and 40 seconds there.

At both farms, walking the pens had a significant effect on pigs' behaviour. All of the pigs showed a reduction in escape behavior over time, but pens of pigs that were walked 2 or 3 times per week were less inclined to try to escape from the handler moving through the home pen than pigs whose pens were walked only once each week. By the end of the trials (weeks 11 & 12) escape behavior was significantly lower in pens walked 2 or 3 times compared to those walked only once per week. At the slaughter plant, pigs were observed as plant workers moved batches of pigs from each of the treatment groups through a crowd pen and into a chute. The frequency of jamming at the entrance to the chute and the time it took to empty the crowd pen were recorded. Handling treatment on the farm significantly reduced the frequency of jamming for pigs from Farm 1, with less jamming occurring for any of the pen walking treatments compared to pigs whose pens had not been walked. Similar results were found for the time it took to empty the crowd pen for the pigs from Farm 2. Pigs whose pens had not been walked on the farm took about twice as long to move out of the crowd pen than pen-walked pigs.

Another approach we are using to study individual pig differences in handling and stress is to measure behaviour on a variety of farms with different management and genetics to determine whether a pig's behaviour at the farm is predictive of its handling and stress at the packing plant and ultimately, of its meat quality (see Purslow this volume). We are currently using standardized tests of reactivity (fearfulness) such as time to approach a novel object or a person entering the home pen. We also assess a pig's temperament by measuring its willingness to exit their home pen when the gate is left open. "Bold" pigs are identified as those that voluntarily exit the home pen within 1 minute, "intermediate" pigs take longer, and "shy "pigs do not leave the pen at all during the test. We then observe behaviour during handling in a crowd pen immediately prior to slaughter, collect blood at slaughter to measure glucose, cortisol, lactate and creatine phosphokinase (CPK) as measures of stress, and take measurements on the hams and loins. Our behaviour data, together with stress hormones will allow us to identify meat quality issues that are associated with stress that occurs immediately before slaughter.

Our results to date indicate that measures of handling problems at the plant such as time spent in the crowd pen, frequency of interactions with the handler and avoidance behaviour of pigs (e.g. balking, jamming, piling) are all positively correlated with one-another. As expected, increases in these behavioral measures are associated with signs of acute stress response – higher blood glucose and reduced initial pH in ham. Different measures of stress are predictive of variation in measures of meat quality. Measures of blood glucose and lactate are positively correlated, and higher levels of blood glucose are associated with lower initial pH values in ham and loin, and higher shear values in ham. High lactate levels are associated with low initial pH in loin, lighter loin colour and higher drip loss levels for both ham and loin, traits which are associated with PSE pork. In contrast, elevated CPK is associated with higher initial and final pH values in ham.

Our preliminary data also indicate that there are relationships between behaviour at the home farm and measures of stress and meat quality at the plant. Significant correlations were found between the time it takes for pigs to approach a novel object and blood creatine phosphokinase (CPK), a measure of physical stress (muscle exertion or physical activity), with faster approach times relating to higher CPK values. High CPK was also associated with elevated pHu (ultimate pH) in ham, suggesting that animals who are quick to approach a novel object are more reactive and tend towards traits associated with DFD pork. Comparison of pig temperament to meat quality measures also shows a significant correlation between temperament and drip loss in ham. Surprisingly, "bold" pigs had the highest drip losses. These data support findings from other studies indicating that individual pigs that seem to be less fearful may actually tend to have more meat quality problems.

The results from both studies indicate that behavioural differences on the farm can translate into differences in handling and stress at the packing plant, which may contribute to variation in meat quality. Behavioural responses of individual pigs and their susceptibility to stress most likely depend on a combination of experience and temperament. Our next step is to determine how pigs with different temperaments respond to different management strategies.

Swine Liquid Feeding: Research Update

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Objectives

A three-year research program is underway to explore the value of swine liquid feeding under Ontario conditions. Over the last year we have explored the use of high moisture corn and corn steep water in liquid feeding of grower-finisher pigs, and the use of condensed whey permeate in starter pig diets.

Introduction

Currently about 20% of grower-finisher pigs in Ontario are raised using computerized liquid feeding systems. As the extent of swine liquid feeding and the use of co-products from the food and fuel industry in swine feeds are likely to increase, more information on swine liquid feeding practices in Ontario is needed. For this reason the Swine Liquid Feeding Association (SLFA) has been formed and a state-of-the art swine liquid feeding system has been installed at the University of Guelph. Further information and previous research findings are posted on the website of the SLFA (www.slfa.ca).

Recent research findings

In a growth performance study, we showed that liquid fed grower-finisher pigs fed high moisture corn and soybean meal based diets, performed just as well as pigs fed dry corn and soybean meal based using conventional dry feeders. In this study we did not observe a clear advantage of liquid feeding of grower-finisher pigs. An area of further study has been **phosphorus (P) availability in high moisture corn**. In dry corn about 70% of P is tied up in phytate, which renders P poorly available to pigs. However, during storage of high moisture corn some fermentation occurs, which may result in degradation of phytate and thus in increased P availability. These changes in P availability have not been well characterized. In our studies, we observed similar levels of total P content in high moisture and dry corn (0.30% in dry matter), but a much high content of soluble phosphorus, indicative of phytate phosphorus degradation, in high moisture corn (50% of total P) than in dry corn (10% of total P). This suggests that the availability of P in high moisture corn is higher (about 50%) than that in dry corn (15%). As a result, the fortification of stored high moisture corn based diets with inorganic P can be reduced, reducing feed costs as well as P excretion with manure. Of interest was also the rapid and substantial release of phytate P when high moisture corn was steeped with phytase. When mixed with water in a 2 to 1 ratio and at a temperature of 21 ^{0}C, close to 50% of phytate P was released within about 2 h; when increasing the temperature and duration of steeping phytate P release was nearly complete. This demonstrates that the use of phytase in liquid swine feeding, and when the feed is allowed to steep, is likely to be more effective than in dry feeding systems. We are currently exploring this further in pig performance studies.

Corn steep water (CSW) is a co-product from the starch and syrup industry. It has a pH of about 4.0. CSW contains about 45% dry matter, and - on a dry matter basis – 50% crude protein, 20% lactic acid, 18.0% ash, 5.1% potassium, 3.3% phosphorus (about 70% of

this is unavailable phytate phosphorus) and 0.08% calcium. The high lactic acid content of CSW can provide benefits to pigs, because of its anti-microbial properties and its stimulatory effects on gut development. Several years ago, attempts to incorporate CSW into liquid swine feeds were not successful. The reason for this is unclear and may be related to corn mycotoxins that will accumulate in CSW. In pilot finisher pig performance studies, we observed no negative effects of feeding CSW, at 5 and 10% of feed dry matter, to finisher pigs. In fact, at the 5% inclusion level we observed slightly positive effects on growth rate (1.17 versus 1.09 kg/d) and feed efficiency (feed/gain: 2.30 versus 2.46). The reason for the slight reductions in growth rate (1.06 kg/d) and feed:gain (2.45) at the 10% dietary inclusion level may be attributed to the high phytate phosphorus and sulfur content in CDS and is being explored further.

In a starter pig study, we compared (1) a conventional dry feeding program, (2) liquid feeding the conventional dry feed, and (3) liquid feeding where all whey was removed from the dry feed and replaced with 20% **condensed liquid whey permeate** on a dry matter basis. Pigs were introduced to the dietary treatments at weaning (17 to 21 days of age; average body weight 5.76 kg) and not fed any in-feed antibiotics in any of the treatments. Liquid feeding was computer controlled and based on 6 feedings per day; no feed was delivered when the previous meal was not consumed completely, monitored by sensors in each individual trough. In this experiment, pigs performed well on all treatments. Best performance was observed for dry feeding, likely because of feed intake restriction in liquid fed pigs. Among the liquid fed groups, body weight gain was improved when whey permeate was included in the diet (375 vs 344 g/d during the first 6 weeks post-weaning). Additional analyses are underway to assess pig behavior, nutrient digestibility and gut health.

Summary and implications

Liquid feeding of swine is gaining in popularity in Ontario as it represents a means to improve various aspects of pork production, and to reduce pork production costs in particular. Current studies indicate that the availability of phosphorus in high moisture corn is higher than that in dry corn, P availability in corn can be enhanced further by steeping with phytase, corn steep water (CSW) has the potential to be an effective pig feed ingredient, and that the inclusion of liquid whey permeate in the diet slightly enhances starter pig performance.

Acknowledgments

This research was initiated in close collaboration with the swine liquid feeding association (www.slfa.ca) and is supported by a number of organizations (www.slfa.ca). A full listing of references is available upon request.

Update on OPIC PRRS Project

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Starting in the fall of 2004, there was a marked increase in the numbers of clinical outbreaks of PRRS in Ontario swine herds. Swine veterinarians recognized this and at their regular meeting in January 2005, formed a committee to look into the disease, with the ultimate goal of working towards eradication. Realizing the enormity of this task, the Ontario Pork Industry Council (OPIC) was approached, and they assumed leadership of this project.

Industry Impact

Porcine Reproductive and Respiratory Syndrome (PRRS) continues to cause major financial losses in the Ontario swine industry and across North America, estimated to cost Canadian producers upwards of $100 million annually. Its impact reaches beyond the production sector, affecting the viability of all sectors of the pork industry from transport to processing, feed to genetics. It is clear that a concentrated and co-ordinated industry effort is required to control, and ultimately eliminate, PRRS virus.

Mandate

OPIC brought together a group of individuals with broad industry representation to form the OPIC Swine Health Advisory Board (OSHAB). The mandate of this committee is to carry out a comprehensive and intensive PRRS Project over approximately three years with the ultimate purpose of:

"understanding how PRRS is moving and changing among herds in Ontario, in order to develop effective control and elimination strategies".

Objectives

- To identify factors associated with the spread of PRRS virus in Ontario
- To recommend strategies that will reduce the spread of PRRS virus among farms and that may be used in a PRRS virus elimination program
- To improve communication within and between sectors of the Ontario pork industry by sharing knowledge and resources
- To develop a template for addressing other industry health issues
- To set up a feedback mechanism to evaluate and adjust the course of action

Activities

- *A study to identify the mechanisms and patterns of spread of the PRRS virus in Ontario* – This study has a timeframe of September 2005 through May 2007 and is being funded by Ontario Pork.
- *A study to identify the impact of maternal PRRS immunity* – This project proposal covers a timeframe of January 2006 through June 2007. This proposal has been submitted to Ontario Pork for consideration.

- *A communications initiative* – A communications project has been submitted to the CanAdvance program for funding consideration. This initiative has several components and a proposed timeframe of three years.
    - *Sector meetings* – Meetings that bring together members of individual industry sectors including, but not limited to, genetics, transport, and AI will be on-going over the entire project timeframe. These meetings seek to identify the needs of the sectors as well as to develop minimum standards and best management practices for PRRS prevention, control, and reporting.
    - *Stakeholder meetings* – These broader industry meetings will focus on updating the industry on current research, OSHAB project findings, available technologies, etc.

Pre-requisites for PRRS Project Success

- A willingness by <u>all</u> sectors to address and support this issue co-operatively and collaboratively

PRRS Project Budget & Funding

The OSHAB PRRS "Project" is, in fact, a series of projects that will collectively seek to achieve the larger goal of PRRS control and elimination in Ontario.

It is anticipated that as the projects listed above proceed, other needs will be identified, and additional projects developed. As new projects and budgets are determined, OSHAB will communicate funding requirements to industry stakeholders.

University of Guelph / OMAFRA Partnership Pork Research Program Projects

Kees de Lange, Pork Research Program Co-ordinator, University of Guelph

The University of Guelph/OMAF Pork Research Program currently supports 47 research projects. These projects are organized by objectives, which are established based on industry wide consultation and under the direction of the Agricultural Research Institute of Ontario (ARIO). New research proposals and research progress are reviewed annually. Current projects and lead researchers for each project are listed below.

For more information on individual projects visit the OMAF website (www.uoguelph.ca/research/omaf/animals/pork.shtml) or contact the lead researcher.

OBJECTIVE 1: STRATEGIES TO ADDRESS ENVIRONMENTAL ISSUES

Goal 1.1. Manure handling, including dead stock disposal

025983 – Emissions from cremation of dead stock – B. van Heyst, School of engineering

Goal 1.2. Reduction of nitrogen and phosphorus excretion

026015 - The Enviropig: from the research lab to the market place - J. Phillips, Department of Molecular Biology and Genetics.

026082 - Modulation of intestinal fermentation and nutrient utilization for reducing detrimental effects on the environment from swine production– M. Fan, Department of Animal and Poultry Science.

026276 - Determining sow performance and mineral requirements with phytase supplementation of the lactating sow ration – P. Luimes, Ridgetown College.

026317 - Quantitative representation of nutrient utilization in the growing pig – C. de Lange, Department of Animal and Poultry Science.

026319 - Determination of dietary true digestible calcium to phosphorus ratio and requirements in weanling piglets (10-20 kg) fed corn and soybean meal-based diets – M. Fan, Department of Animal and Poultry Science.

Goal 1.3. Reducing Odour

026001 - Biofiltration as a means of odour and dust control in animal housing facilities – M. Dixon, Department of Environmental Biology.

026177 - Development of a pork farm odour expert system and studying the feed effects on odour – S.Yang, School of Engineering.

OBJECTIVE 2: PORK QUALITY AND SAFETY

Goal 2.1. Food safety

026207 - The natural transmission of Salmonella typhimurium in swine with and without antimicrobial selective pressure – J. Gray, Department of Pathobiology.

026273 - Evaluating effectiveness of interventions against Salmonella in swine using a novel evidence-based tool – S. McEwen, Department of Population Medicine.

026282 - Effect of bacteriophage on the population dynamics of Salmonella within Ontario pig herds – K.Warriner, Department of Food Science.

Goal 2.2 Reducing antibiotic use

026180 - Molecular analysis of important bacterial pathogens of swine– J. MacInnes, Department of Pathobiology.

026083 - Efficacy of alternative growth promoters for weanling piglets as assessed by visceral organ protein turnover rate – M. Fan, Department of Animal and Poultry Science.

026173 – Dietary means to enhance gut health of newly-weaned piglets – C. de Lange, Department of Animal and Poultry Science.

026272 - Spatial patterns of antimicrobial resistance among pig farms in southern Ontario. – O. Berke, Department of Population Medicine.

026282 - Effect of bacteriophage on the population dynamics of Salmonella within Ontario pig herds – K. Warriner, Department of Food Science.

026291 - Genetic markers of infectious disease resistance in Ontario swine- A. Brooks, Department of Pathobiology.

026316 - Production of transgenic pigs that are more resistant to diseases- J. Li. Department of Animal and Poultry Science.

Goals 2.3 and 2.4. Improving pork quality and uniformity of carcass

025981 - The effects of feeding high protein corn to pigs based on performance and carcass quality – P. McEwen, Ridgetown College.

026038 - Grow-finish pigs - Improving carcass quality through barn-level parameters analyses – C. Dewey, Department of Department of Population Medicine.

026059 - Quantitative and molecular genetic improvement of swine – A. Robinson, Department of Animal and Poultry Science.

026174 - Development of genetic markers for boar taint – J. Squires, Department of Animal and Poultry Science.

026176 - Development of nutritional strategies to improve the processing and eating quality of pork – I. Mandell, Department of Animal and Poultry Science.

026278 - The effects of gender and feeding strategy on pig growth performance and feed digestibility – P. McEwen, Ridgetown College.

026314 - On-farm management strategies to improve handling, reduce stress and enhance meat quality – T. Widowski, Department of Animal and Poultry Science.

OBJECTIVE 3: TO IMPROVE PRODUCTION EFFICIENCY

Goal 3.1. Feeds, feeding and mycotoxins

025997 - Liquid feeding of swine: gut health, food safety, environmental impact and growth performance – C. de Lange, Department of Animal and Poultry Science.

026083 - Efficacy of alternative growth promoters for weanling piglets as assessed by visceral organ protein turnover rate – M. Fan, Department of Animal and Poultry Science.

026171 - The use of byproducts from dry mill ethanol production as a feed ingredient in swine diets – P. McEwen, Ridgetown College.

026276 - Determining sow performance and mineral requirements with phytase supplementation of the lactating sow ration – P. Luimes, Ridgetown College.

026277 - Improving piglet survival by development of a hormone model of lactation – P. Luimes, Ridgetown College.

026278 - The effects of gender and feeding strategy on pig growth performance and feed digestibility - P. McEwen, Ridgetown College.

026317 - Quantitative representation of nutrient utilization in the growing pig- C. de Lange, Department of Animal and Poultry Science.

026323 - Effect of Fusarium mycotoxins on performance and metabolism of gestating and lactating sows – T. Smith, Department of Animal and Poultry Science.

Goal 3.2. Improving pig health

026005 - Enteric disease control in post-weaned pigs – R. Friendship, Department of Population Medicine.

026068 - Modulation of host cell responses by porcine reproductive and respiratory syndrome (PRRS) virus – D. Yoo, Department of Pathobiology.

026170 - Phenotypic immunological imprinting by the neonatal environment in pigs – B. Wilkie, Department of Pathobiology.

026175 - Tetracycline use and selection of virulent enterotoxigenic Escherichiacoli (ETEC) – P. Boerlin, Department of Population Medicine.

026277 - Improving piglet survival by development of a hormone model of lactation – P. Luimes, Ridgetown College.

026291 - Genetic markers of infectious disease resistance in Ontario swine- A. Brooks, Department of Pathobiolgoy.

026316 - Production of transgenic pigs that are more resistant to diseases- J. Li, Department of Animal and Poultry Science.

Goal 3.3. Improving reproductive performance

025670 - PRRS virus: the implications for the breeding herd – C. Dewey, Department of Population Medicine.

026013 - A Study of oxytocin-producing reproductive centres in the hypothalamus of the pig brain – G. Partlow, Department of Biomedical Science.

026179 - Analysis of transient lymphocyte functions in implantation sites during early pregnancy – A. Croy, Department of Biomedical Science.

026277 - Improving piglet survival by development of a hormone model of lactation – P. Luimes, Ridgetown College.

026289 - Improving swine reproductive performance through improved semen quality and better methods of insemination – R. Friendship, Department of Population Medicine.

026294 - Use of soy liposomes for cryopreservation of boar semen – M. Buhr, Department of Animal and Poultry Science.

026318 - Sexing of boar sperm using single stranded DNA aptamers – S. Golovan, Department of Animal and Poultry Science.

026323 - Effect of Fusarium mycotoxins on performance and metabolism of gestating and lactating sows – T. Smith, Department of Animal and Poultry Science.

Goal 3.4. Transgenics

026036 - Artificial Insemination Mediated Modification of Pig Genome – S. Golovan, Department of Animal and Poultry Science.

026316 - Production of transgenic pigs that are more resistant to diseases - J. Li, Department of Animal and Poultry Science.

OBJECTIVE 4: TO IMPROVE ANIMAL WELL-BEING

026069 - Meeting the needs of ill swine to improve well-being and decrease reliance on antimicrobials - S. Millman, Department of Population Medicine.

026081 - Developing a comprehensive framework to assess farm animal welfare – S. Henson, Department of Agriculture Economics & Business.

026181 - Strategies for reducing aggression in loose housed sows – T. Widowski, Department of Animal and Poultry Science.

026182 - Management practices affecting the behaviour and welfare of piglets - T. Widowski, Department of Animal and Poultry Science.

026277 - Improving piglet survival by development of a hormone model of lactation – P. Luimes, Ridgetown College.

026304 - Factors associated with transport losses in market weight finisher pigs- C. Dewey, Department of Population Medicine.

026305 - How to sample pig farms to be confident the results are correct when testing for toxoplasma, salmonella, influenza and yersinia – C. Dewey, Department of Population Medicine.

026314 - On-farm management strategies to improve handling, reduce stress and enhance meat quality – T. Widowski, Department of Animal and Poultry Science.

Ontario Pork Research

Jean Howden, Research Coordinator, Ontario Pork

Ontario Pork is dedicating 20 cents from each hog market towards research and development projects, resulting in more than 1 million dollars allocated to the projects summarized in the following 5 pages. The projects span across a wide variety of areas that will lead to increased knowledge and improvements that will advance the Ontario Industry. A significant amount of funding is targeting herd health, particularly examining Porcine Respiratory and Reproduction Syndrome (PRRS), while also continuing funding pork quality, animal welfare, nutrition and environment projects. The projects range from basic studies on pathogens that may result in knowledge and treatments of swine illness and diseases. Research into feeding and nutrition, is considering benefits of liquid diets and gut health. Continued funding of environmental projects studying manure and deadstock disposal methods are evaluating potential improvements and options for the industry. It is critical that the industry continue to move forward and this requires a strong research base.

These projects are not funded by Ontario Pork alone, but with the assistance of numerous research programs from both the federal and provincial governments, and also other industry partners. Many researchers have doubled their funding, with Ontario Pork contributing only a small portion of the total project funding. A 2004 study estimated the benefit of each public dollar spent on agri-food research as high as 27.5 : 1, and for hogs alone at 9.5 : 1 (Brinkman, G. L., 2004. "Strategic Policy Issues for Agricultural Research in Canada". *Current Agriculture, Food and Resources Issues).* The adoption of research outcomes, into practical application also results in direct and indirect cost efficiencies. The actually actual benefit is very difficult to measure – but we know it is significant.

However, we do know the benefits of research funding lead to an industry that will grow and prosper. Research is a cornerstone of the industry and serves as the building blocks for successes. Ontario Pork continually strives to fund research projects that will benefit this industry and all producers.

Research funded in 2005:

Researcher: Cate Dewey
Title: Developing PRRS control strategies by understanding how the virus is changing and moving in Ontario
Synopsis: Objectives of the research proposal: 1. Create a system to transfer information about the spread of PRRS virus to the industry in a timely and effective manner while maintaining confidentiality. 2. Determine the genetic sequence of all PRRS viruses that are causing overt clinical and sub- clinical problems in herds in Ontario, from September 2004 – August 2006. 3. Compare the genetic sequences of the PRRS viruses among herds in Ontario to other regions of North America that share pig flow with Ontario. 4. Identify factors associated with the spread of the PRRS in Ontario using such potential factors as location of the farm (GPS), source of breeding stock and semen, pig transport used, pig flow (system information), current control methods. 5. Recommended strategies which will reduce the spread of PRRS virus among farms and which may be used in a PRRS virus elimination program.
Brief Description of the Project:
To understand the moving and changing patterns of PRRS in Ontario the researchers will map the PRRS viruses by genotype in Ontario and determine the associations between potential methods of transmission of PRRS and the location of the PRRS viruses in Ontario. With additional funding that is being sought out – further projects will develop appropriate cleaning and disinfecting procedures for nursery facilities and trucks. Then appropriate monitoring protocols will be evaluated. Finally, gilt acclimation procedures identified by the Quebec researchers will be validated on farms in Ontario.
Benefit of the Research to the Ontario Pork

Industry:
The aim of these projects is to understand how PRRS is changing and moving among herds and within herds in Ontario and to use that information to develop control strategies to reduce the losses experienced by the industry due to this virus. The implementation of this research will ensure that Ontario maintains its position as a major exporter of pigs

Researcher: Graeme Hedley

Title: The Economics of Ontario Hog Hauling Fees

Synopsis: The purpose of this project is to provide an economic analysis of hog transportation regulation in Ontario. The objectives of this project are: - to describe hog transportation cost allocation in other jurisdictions relevant to Ontario - to provide a description of the Ontario hog transportation segment - to determine the needs of producers, processors, and transporters in terms of hog transportation services and fees - to determine how alternative hog transportation cost allocation schemes impact base hog prices - to facilitate development of Ontario Pork objectives is establishing hog transportation regulations, and to evaluate existing regulations based on these objectives

Researcher: Peter Purslow

Title: Enhancing the Pork Meat Quality Value Chain

Synopsis: Objectives of the Research
The proposed research project will measure variability in Ontario pork and take a value-chain approach to examine how genetics, on-farm management, packing plant management, and nutrition interact to affect the main mechanisms determining pork meat quality and what these quality variations cost the industry.

Researcher: Phil McEwen

Title: The Effects of Gender and Feeding Strategy on Growth Performance and Pork Quality.

Synopsis: This initiative will investigate performance, carcass characteristics, meat quality and economic ramifications of limit feeding during the growing phase. During the first experiment a control (ad libitum feeding of a grower diet) and two restrictive feeding strategies (feed offered at 70 and 85% of the amounts consumed by pigs fed ad lib) will be evaluated followed by ad libitum feeding of all pigs during the finishing phase. Barrows and gilts will be fed separately to examine gender effects and the presence of gender by feeding strategy interactions. The pigs will be weighed weekly and marketed at 110 kg body weight (BW) to a commercial packing plant. A loin from each pig will be acquired for subsequent carcass and meat quality evaluation at the U of G Meat Laboratory.

Researcher: Kathy Zurbrigg

Title: The effect of noise level in gestation barns on human hearing loss and swine production

Synopsis: This study will provide benchmark information on noise levels in gestation barns and the risk this poses to worker hearing. Loud vocalizations at feeding may indicate increased sow anxiety, which can negatively affect reproduction. Knowledge of this relationship and how barn design and husbandry factors affect sow vocalizations may improve sow reproductive performance on many farms.

Researcher: Harold Gonyou

Title: Gestation Housing for Sows: Studies on Electronic Sow Feeders and Stalls

Synopsis: Final year of a four year study, that examine questions critical to the management of pregnant sows in both group housing and stalls. Four studies are being conducted to improve management of gestating sows in group housing using electronic sow feeders, and to determine the interaction of sow and gestation stall size on productivity and behaviour. These questions are directed at reducing social stress in groups, and issues of crowding in stalled sows.

Researcher: Patrick Boerlin

Title: Molecular epidemiology of resistance to extended-spectrum cephalosporins in Escherichia coli from Pigs in Ontario

Synopsis: The objective of this research is to access if resistance to extended-spectrum cephalosporins (ESC) in E. coli from pigs in Ontario is transferable. To characterize in details the genetic elements associated with this

resistance and to compare them to those from Salmonella enterica. It will look to develop recommendations to avoid the spread of resistance to ESC in bacteria in pigs. The benefit of this research is to assess the real potential for the spread of resistance to ESCs in bacteria from pigs in Ontario. A strong basis for the amendment of prudent use guidelines will be provided. This will increase the confidence of consumers and help safeguard the efficacy of ESC for both the industry and human medicine.

Researcher: Robert Friendship

Title: Control of Salmonella in Ontario Pig Farms

Synopsis: The reseach team will continue to work to develop a better serological test to detect antibodies to Salmonella by including serovars that have been isolated from Ontario farms. They will test essential oils, vaccines, probiotics, phages and other products to determine what are the best methods to reduce or prevent Salmonella infections. This will be tested by using experimental challenge studies and the results will be appied to on-farm studies. They will also examine ways to minimize contamination of carcasses at the packing plant. The main benefit of the work will be to make Ontario pork safer to eat and reduce the risk of Salmonella infection among farm and packing plant workers. Reduced levels of Salmonella may be very important with regard to the export of pork, resulting in increased demand.

Researcher: Dongwan Yoo

Title: Genetically engineered PRRS virus that may not persist in Pigs

Synopsis: This is a two year basic research project set to identify the PRRS virus viral protein responsible for persistence, and develop a genetically modified PRRS virus as a vaccine candidate. PRRS virus persists in infected pigs, which is a major source of transmission. The modified PRRS virus will be made as a potential vaccine candidate that can hopefully be effective in controlling the spread of PRRS.

Researcher: Bruce Wilkie

Title: Immune Response Regulation by Neonatally Administered Cytokines

Synopsis: The research tests the hypothesis that variation in immune response (IR) and consequently in resistance to infectious disease, has a large environmental component that is influenced by immuno-modulating treatments acting on the developing immune system. Potential benefit may be derived from cytokines administered to neonatal pigs, possibly as bacterial or viral recombinant live vehicles acting as designer probiotics. This will be examined using standard immunization regimens to test for induced IR bias. The industry needs alternatives to current health maintenance practices to reduce reliance on exogenous therapeutics in addressing disease, the number one source of loss in productivity. Advantages derived from enhanced innate ability to resist infectious disease may be in the order of $4.00-5.00 per animal. Additional gains due to market access and acceptability of product are also possible.

Researcher: Tony Hayes

Title: Defects in innate disease resistance genes in Ontario Swine

Synopsis: The objective is to identify defects in genes responsible for increased susceptibility of young pigs to various common infectious diseases. Genetic tests will be developed for abnormalities in innate resistance genes that protect young pigs from various infections. These DNA tests will allow the researcher to determine the frequency of these defects, and those that increase susceptibility of young pigs to various common infections. The results from this research could provide new opportunities for the control of some infectious diseases by selective breeding. Tests for these defects could increase value of breeding stock with defined resistance traits.

Researcher: Aiming Wang

Title: Development of a Plant-Based, Low Cost, Orally Administered Vaccine Against PRRSV

Synopsis: This is funding for the first year of a three year project to develop a plant-based, low-cost, orally administered vaccine against PRRS. The results of the three year study could provide the development of a novel, safe, low cost, convenient and uniform, editable vaccine for

clinical use to protect Ontario pigs from PRRS. It could also be a model for the control of other animal infectious diseases.

Researcher: Serguei Golovan

Title: Sexing of boar semen using single stranded DNA aptamers

Synopsis: The objective of this research is to develop aptamers that could selectively bind to X/Y sperm and be used for sperm sexing of pigs. The researcher will use a method of in vitro evolution to perform multiple rounds of selection/amplification to select aptamers which will bind with high affinity and selectibility to X/Y sperms. If successful the method will allow preselection of the sex of piglets at the time of artificial insemination.

Researcher: Lee Whittington

Title: Livestock Issues Resource Centre

Synopsis: This is one year support for a web based resource for producers, to bring order and accessibility to the large and growing body of information available on key issues facing the future of the pork industry. This is accomplished through summarizing of peer reviewed papers, conference proceedings and popular press articles condensed in 250-500 word summaries and available on line through an easy to use searchable database.

Researcher: Julang Li

Title: The feasibility of isolating antimicrobial peptides from slaughtered pig blood and the potential application of these antimicrobial peptides

Synopsis: The objective of this project is to study the feasibility of isolating antimicrobial peptides from pig blood collected from slaughterhouses, and the potential of these peptides to treat infection. Funding is for the first year to evaluate if the necessary components can be collected and purified in vitro.

Researcher: C.F.M. de Lange

Title: Liquid Feeding of Swine

Synopsis: This research will explore and assess beneficial effects of liquid feeding technology (control and flexibility in developing feeding programs, gut health, carcass and pork quality, nutrient excretion, animal well-being, production efficiencies) that may be transferred to dry feeding systems. It will also support development of liquid feeding technology for swine in Ontario.

Researcher: Paul Luimes

Title: Determining sow performance and mineral requirements with phytase supplementation of the lactating sow ration

Synopsis: This research has will compare a typical ration feed during lactation to one supplemented with phytase and reduced calcium, phosphorus and trace mineral supplementation to observe the sow and piglet's performances, and determine the extent of reduction of the sow's fecal and urinary excretions.

Researcher: C.F.M. de Lange

Title: Impact of fermenting high-moisture corn on dynamics of starch and phytate degradation, as well as growth performance, nutrient utilization and gut health in starter pigs

Synopsis: This research will examine (in vitro) the impact of fermentation conditions on starch and phytate degradation in high-moisture corn. It will assess the effects of high-moisture corn in liquid feeding systems on gut structure and function and microbial ecology, with emphasis on the beneficial and pathogenic bacteria present in the gut and in the feed. Further the researchers will examine the production indices and nutrient utilization of starter pigs fed high-moisture corn in liquid feeding systems. The effect of added phytase in liquid feeding systems containing high-moisture corn on nutrient (particular phosphorus) digestion and manure composition will also be assessed.

Researcher: Ming Fan

Title: Dehydrated Chicory Root Powder for Modulating Intestinal Fermentation to Reduce Odour Impact: Study Phase-I with Post-Weaned Pigs

Synopsis: The major objective is to determine a suitable level of dietary supplementation of dehydrated chicory root powder for reducing odor impact in the post-weaned pig. Dietary chicory root powder grown and processed in Ontario can be a functional and cost-effective source of fermentable wate-soluble fiber, which has been shown to reduce odor. The research will also examine the affect of such chicory

root powder addition on key off-flavour compound retention, growth and nutrient utilization efficiency.
Researcher: Ron Ball
Title: Determination of sow amino acid requirements using the indicator amino acid oxidation method
Synopsis: Objectives of Research Proposal: 1. Develop factorial estimate for the gestation lysine and energy requirement considering maintenance requirement, parity, stage of gestation and litter size 2. Determine efficiency of energy utilization as affected by parity and gestation stage 3. Assess the suitability of the indicator amino acid oxidation for lactation 4. Create base-line data for protein metabolism in lactation
Researcher: Bonnie Ball-Coelho
Title: Zone-jection New Conservation Till Manure Nutrient Delivery System
Synopsis: This is the second year of a three year project to develop a system where manure is applied during zone tillage in one operation and evaluated in terms of corn yield and environmental impact. The field experiments are being replicated with treatments to test different methods of zone-jection with and without sidedressing and to isolate physical (ie tillage) from nutrient responses. The researchers are looking for the system which will minimize movement of phosphate, ammonium and soil to surface waters, nitrate to groundwater and reduce or eliminate commercial fertilizer costs. The demonstration of good stewardship, concurrent with elimination of odours will improve public relations and help growers avoid environmentally related litigation.
Researcher: Bill Van Heyst
Title: Environmental Characterization of Selected Dead Animal Disposal Methods
Synopsis: This is the first year of a two year study to assess the environmental impact of on-farm cremation and deadstock composting. The fate of sulfa-based drugs during the composting process will be determined. The project will provide sound scientific results for the environmental impact of on-farm cremation and deadstock composting that can be used for policy decisions by stakeholders
Researcher: John Lauzon
Title: Effectiveness of manure injection and incorporation methods for reducing pathogen and nutrient contamination of water sources
Synopsis: This is the first of a three year trial to assess the losses of nitrogen, phosphorus and E-coli and the agronomic benefit from liquid hog manure applied at three different times of the year and with different application methods (surface application, surface application followed by incorporation, manure injection @75 cm spacing, manure injection @ 37 cm spacing, Aerway system, side dress injection)
Researcher: Claudia Wagner-Riddle
Title: Nitrogen transformations and losses following application of liquid swine manure to agricultural soils as determined by N tracer methods
Synopsis: The objectives of this three year project are: To study transformations of organic and inorganic N in manure following application to agricultural soils with contrasting hydrologic properties; and, to directly quantify the amount of organic and inorganic N in manure recovered in crops, retained in soil and lost through N03 leaching, and gaseous emissions. Findings from this research will be utilized to further improve and verify the Ontario N-index; a regulatory tool under the Nutrient Management Software 'NMAN' which is based on findings from indirect measurements. The proposed approach will provide a direct measure of nitrogen flows and more accurate agronomic balances.
Researcher: George Lazarovits
Title: Evaluation of Pasteurization of Liquid Swine Manure for Use as a Soil-borne Plant Disease Control Product of High-Value Crops
Synopsis: This is the second year funding of a two year study which is evaluating continuous batch thermophylic composter for eradication of potential animal and human pathogens and for ease of use under barn conditions. The pasteurized compost can be reformulated into a saleable product that can be used to control soilborne plant disease of high value crops such as potatoes, and an excellent source of fertilizer.

Canadian Quality Assurance® Program

Christine Orton, Ontario Pork

As of December, 2005, more than 2,500 Ontario farms were registered (approved) under the Canadian Quality Assurance® (CQA) program. The estimated number of hogs shipped annually from these CQA® farms represents about 84% of the market. Currently, all actively shipping producers in Ontario are enrolled in the program.

Question 2b of the Assessment Form has been updated, which previously required that source farms be enrolled in the CQA® program. As of October 1st 2005, all source farms must now be registered on the CQA® program, in other words, they must have completed the validation process and have a valid certificate. What this means is that if a producer is introducing any new stock to their farm, whether for breeding purposes or to feed for further growth, it must be verified that the supplier is a registered CQA® producer. Program validators will verify this when a producer is due for their next scheduled validation by requesting to see proof of who their suppliers are and their CQA® status. With this new requirement, sow and nursery barns have been contacting Ontario Pork to enrol their farms and are now working on becoming CQA® registered.

Quality Meat Packers, Conestoga Meats, and Maple Leaf Pork continue to encourage their contract producers to ensure they are CQA® registered. Ontario Pork provides processors with monthly program reports, and processors follow up with any producers whose CQA® registration has expired. Pool Plus producers must be CQA® registered to join and remain on this contract.

Phase 2 of the CQA® Drug Use Policy was scheduled to be implemented on October 1st, 2005, which would require that all medications on CQA® registered farms carry a Drug Identification Number (DIN). The policy is currently under review and a new policy proposal is being developed with a proposed time of completion targeted for the end of March 2006. Phase 1 was implemented over two years ago and requires that all medications used on CQA® farms be licensed for use in food-producing animals only.

The National CQA® website was launched in 2005 and includes all of the CQA® materials found in the manual. Producers can find information, updates, blank record forms, or use the interactive manual online at www.cqa-aqc.com.

For more information, please contact Christine Orton, CQA® Coordinator for Ontario Pork, at 1-877-668-7675 or christine.orton@ontariopork.on.ca.

Animal Care Assessment Tool

The Canadian Pork Council has recently launched its new Animal Care Assessment (ACA) tool for hog producers. The ACA tool is a proactive, industry led program that was developed to provide producers with a means to evaluate and improve animal care practices on farm. This tool also allows us to demonstrate to our customers that Canadian hog producers are providing excellent care to our hogs and that animal care is important to us. The ACA tool will examine areas of a farm that are critical to the well-being of hogs, including stockmanship, feeding and watering, equipment, and housing.

Developed by a team of hog producers, producer organizations, animal care researchers, and government, the program has been reviewed and supported by the Canadian Federation of Humane Societies, the Canadian Meat Council, the Canadian Council of Grocery Distributors, and the Canadian Veterinary Medical Association.

The ACA tool will begin as a voluntary component of the Canadian Quality Assurance Program (CQA®) and will be available for certification starting in early 2006. As with the pork industry's CQA® on-farm food safety program, the ACA tool requires written records to be kept on animal care practices, has specific program requirements, and can be reviewed on farm by a CQA® program Validator.

An advanced copy of the ACA is available by contacting Ontario Pork or by going to the national CQA® website at www.cqa-aqc.com. In the coming months, Ontario Pork will begin delivering the new ACA tool to all producers currently part of the CQA® program.

For more information on this initiative, please contact Christine Orton, CQA® Coordinator for Ontario Pork, at 1-877-668-7675 or christine.orton@ontariopork.on.ca.

Prevalence of Swine Influenza H3N2 and H1N1 in Ontario Swine

Bob Friendship
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Background

The Ontario swine population has been endemically infected with swine influenza subtype H1N1 for decades. Over the past 5 years the Animal Health Laboratory at the University of Guelph has diagnosed individual cases of other subtypes of influenza but the prevalence of these subtypes has remained very low until recently. This spring outbreaks of swine influenza were reported from over 20 herds in Ontario. The cause of these outbreaks has been determined to be an emerging H3N2 subtype that most closely resembles a virus present in the USA since 1999. The subtype contains genetic material from poultry, swine and human influenza viruses.

The outbreaks of clinical disease and the apparent rapid spread occurred in late spring and early summer. Because H3N2 is new, there is no background immunity in Ontario pig herds and significant disease outbreaks have been observed with pigs showing signs of fever, coughing, and reduced appetite. Influenza can contribute to the respiratory disease complex and trigger outbreaks of other disease conditions such as PMWS. The emergence of new subtypes of influenza and the rapid spread throughout the swine population must be monitored from a public health standpoint because of the possibility of reassortment and antigenic drift. At present there is only anecdotal evidence that the new subtype of influenza virus has spread beyond the twenty or so cases confirmed by the Animal Health Laboratory. The true prevalence and the pattern of spread are unknown.

Objective

The purpose of this study is to determine the prevalence of swine influenza subtype H3N2 and H1N1 in the pig population of Ontario.

Methods

We revisited 50 herds from the "sentinel herd project" in the fall of 2005 and collected 20 blood samples from late stage finisher pigs. We also retrieved 20 samples per farm from our freezer – samples that had been obtained from the same herds in 2004. The blood samples were submitted to the Animal Health Laboratory for testing. An ELISA test for H1N1 and for H3N2 Swine Influenza virus was performed.

Preliminary Results

The presence of antibodies to swine influenza (indicating previous exposure to the virus) was evaluated in the blood of 20 finisher pigs per farm for 2004 and 2005. To date we have the results of 36 herds. For H1N1 (the old strain) 21 out of 36 herds (58%) were positive in the Fall of 2005 compared to 38% of these same herds testing positive in 2004. For H3N2, the same prevalence (58% of herds positive) was reported for samples taken in 2005, but only 8% of these

herds were positive in 2004. Two herds with negative serological results for H3N2 in the fall of 2005 have since reported an outbreak of disease and confirmation of H3N2. This study proves that the new strain of influenza has spread rapidly and has already become widespread in the Ontario pig population. In most cases outbreaks of coughing and clinical signs of moderate respiratory disease were reported in herds where the new strain occurred. In most cases the disease was not severe but in at least a few herds the influenza outbreak coincided with other disease problems. Influenza is regarded as a part of the respiratory disease complex and may be overlooked as a component in serious outbreaks of respiratory disease when PRRS, *Mycoplasma* and porcine circovirus are also present.

Interestingly 12 herds had pigs with antibodies to both viruses. There is a danger when two different influenza strains are continuously cycling in the same herd that the viruses will recombine to create a new strain such as H1N2. From a public health standpoint there does not appear to a danger that humans will become seriously ill from these two strains of influenza and that they will spread from human to human if they do infect a farm worker. The new strain has been circulating in the American pig population for several years. It probably is prudent for all pig farm workers to be vaccinated for influenza to prevent spreading a new strain of human influenza to pigs and thus preventing the possibility of a human virus recombining with the pig viruses which appear to be very common in the Ontario pig population.

Acknowledgements

This work was financially supported by the Ontario Ministry of Health and Long Term Care, the Ontario Ministry of Agriculture Food and Rural Affairs, and Pfizer Animal Health. We are grateful for the pork producers who participated in the study.

Dried Distillers Grains with Solubles (DDGS) Feeding

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Introduction

The inevitable increase in ethanol production in Ontario and the massive expansion in the USA will create a surplus level of (DDGS) which will lower its value. The use of DDGS, as a ration ingredient, has been successfully investigated in the United States. However, very little research has been completed in Ontario using product manufactured by Commercial Alcohols Inc. from their Chatham plant. Since variation in product quality can exist from one plant to the next, feeding trial initiatives were needed to quantify the economic ramifications of feeding DDGS (Chatham) to swine herds in Ontario.

Objective

The project evaluated the effects of feeding Chatham co-product (DDGS) to pigs based on measurements of growth, feed intake, economic returns and carcass quality. The following objectives were specifically addressed:

1) To determine the effects of feeding DDGS (Commercial Alcohols Inc. - Chatham Plant) at a 10 and 20 percent ration inclusion rate based on pig growth rate, feed intake and efficiency.
2) To determine the economic benefits or drawbacks of using DDGS from the Chatham plant in pig grower and finisher diets.
3) To determine if there are significant differences in performance with DDGS from the Chatham plant compared to previous DDGS studies completed in the United States.

Experimental Procedures:

After a three week adjustment period, ninety-six pigs (33.2 ± 5.8 kg) officially began the trial on July 13th, 2004. Each pen (3 barrows and 3 gilts) was randomly assigned to one of the three grower diets until they were 70 kilograms body weight (BW). They were then fed an assigned finisher diet until they were marketed ($\geq$ 110 kg BW) by pen. The following dietary treatments were formulated and fed:

1. Grain corn, SBM and premix. A grower diet (0.83 % lysine) was fed until the pigs were 70 kg (per pen) followed by a finisher diet (0.69 % lysine) until they were marketed.
2. Similar diets and feeding strategy to control group. However a 10 percent inclusion rate of DDGS was added to replace some of the SBM as a protein source. The grower diet was formulated to contain 0.83 percent lysine while the finisher diet contained 0.68 percent. To achieve both levels of lysine an increased protein (CP) percentage was needed in both the grower (19.1%) and finisher (16.8%) diets.
3. Similar diets and feeding strategy to control group. However 20 percent DDGS was added to replace a greater amount of SBM as a protein source. The grower diet contained 0.82 percent lysine while the finisher diet contained 0.67 percent. To achieve desired levels of lysine, an increased protein (CP) percentage was needed in the grower (20.5%) and finisher (18.2%) diets.

The pigs (pens) were fed *ad libitum* with a required feed refusal or weighback taken once weekly. Ultrasound measurements (backfat and loin eye depth) were taken at the start of the trial, five weeks later and before the pigs were marketed by pen. The pigs were weighed weekly and were marketed after achieving an average 110 kg BW. All pigs were slaughtered at one location (Quality Meats) where carcasses were weighed and graded. The data was then entered and analyzed in an appropriate manner using SAS (2001) statistical procedures.

Results:

Table 3. Effects of dietary treatment on pig growth rate, feed intake and carcass quality.

	Control Diet	10% DDGS Diet	20% DDGS Diet
Growth Rate			
Number of pigs	30	36	30
Final Weight (kg)	113.3	114.0	113.6
Days to Market (by pen)	75.7	78.0	77.9
Average Daily Gain (kg)	1.06	1.04	1.04
Feed Intake – per pig (collected by pen)			
Total Feed Intake (kg)	220.5	218.4	215.7
Average feed intake (kg/d)	2.9	2.8	2.8
Feed efficiency (F/G)	2.7	2.7	2.7
Carcass Data			
Hot Carcass weight (kg)	91.8	92.5	91.7
Yield Index (%)	60.4	60.0	60.3
Grade Fat (mm)	19.3	20.4	19.0
Meat depth (mm)	61.7	62.8	62.1

[a] and [b] LS means within row that do not share a common superscript differ significantly ($p < 0.05$).

Conclusions:

- When diets were balanced to a constant lysine level (growing and finishing phase) – similar growth rate, feed intake and efficiency estimates were obtain for diets containing 0, 10 or 20 percent DDGS.
- In this trial, gain costs were similar for each DDGS inclusion rate. However due to similar feed efficiencies, costs of gain were strongly related to ingredient costs. Therefore producers are advised to incorporate DDGS when this co-product is favorably priced relative to corn and soybean meal.

Acknowledgments
The authors would like to thank the Innovation and Risk Management Branch (OMAF), Commercial Alcohols Inc., and OMAF for their financial and technical assistance. Support and technical input from each research team member was also greatly appreciated.

Pilot Scale Treatment of Liquid Hog Manure Using an Electrochemical Reactor

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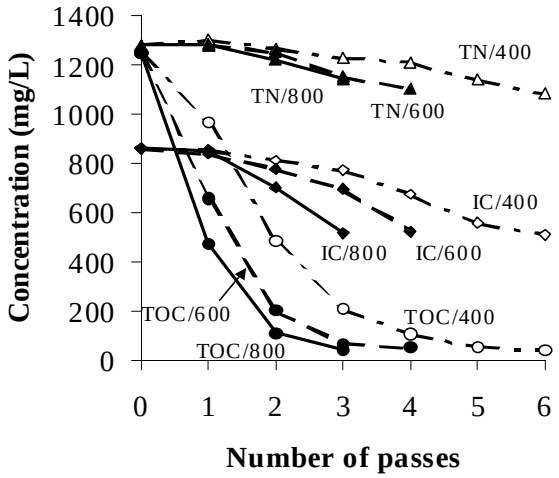
In previous work supported by Ontario Pork we showed that the offensive odour of liquid hog manure could be mitigated by passing an electric current through the solution (electrolysis). Electrolysis is a potentially "green" remediation technology that uses electricity (electrons) rather than added chemicals to drive chemical reactions. Among its advantages are the low cost of electricity compared with chemical remediation agents, although parasitic electrochemical processes such as water electrolysis may lower current efficiency. The success of remediation depended on the material used for the anode (positive pole) of the electrochemical cell; the most successful anodes used materials that promote the formation of reactive hydroxyl radicals at their surfaces.

The concept of odour nuisance is poorly defined, both scientifically and in the regulatory framework. We defined the ***quality*** of smell as follows: **A** = extremely unpleasant (raw hog manure smell); **B** = moderately unpleasant; **C** = slightly unpleasant; **D** = neither pleasant nor unpleasant. The ***intensity*** of smell was determined using the concept of "Threshold Odor Number" (TON), which is the number of times that the sample must be diluted with water before the odour becomes just detectable. In each case members of our research group were used as an "organoleptic panel".

$$TON = (A+B) / A$$

where A = mL of sample and B = mL of odor-free water that must be added to A so that the odour of the solution is just detectable.

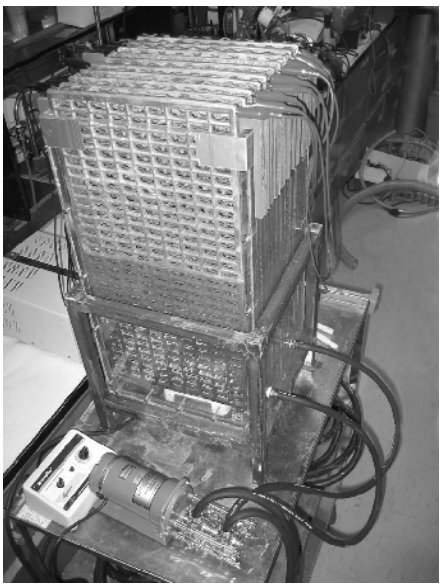


Using stainless steel cathodes and either the novel anode material boron-doped diamond (BDD), which is available commercially (Figure) or Ti/SnO_2 as anode, the progress of electrolysis was followed in terms of changes of total organic carbon (TOC), inorganic carbon (IC), and total dissolved nitrogen (TN) from the solution. The numerical values on the labels in this figure represent the current (mA) through the micro-reactor. With a sufficient number of passes, up to 96% of the TOC was lost, representing mineralization of manure organics to CO_2 and water. Loss of IC was due to stripping of dissolved CO_2 by the gases evolved at the electrodes upon electrolysis of water. The evolution of odor quality correlated with the reduction of TOC, changing from the initial offensive odor of manure to a neutral odour after three passes through the reactor. The odour intensity simultaneously fell from initial TON = 2000 to TON = 100 after one pass through the reactor and TON = 20 after three passes at a current of 600 mA. Unlike the TOC, the TN was not affected by electrolysis, indicating that the deodorized liquid had retained its fertilizer value. We have also examined briefly the influence of the electrolytic process on bacterial counts. This analysis was conducted in order to explain why solutions electrolyzed to a near-odourless state could be stored for several weeks

without redeveloping an off-odour, even though the solutions still contained a substantial residual TOC.

The small scale of the foregoing reactions inevitably left doubt about whether odour remediation could be achieved on a larger, more practical scale. Our first attempt at scale-up involved the construction of a 1 liter Plexiglas reactor, with internal dimensions 4 x 4 x 6 inches. Four anodes and four cathodes were mounted in parallel and supplied in series with current from a Golden Source DC power supply (30V-20A). Stirring was achieved with a magnetic bar, two inches long, using an external magnetic stirrer. The reactor was operated in recirculation mode using a Masterflex peristaltic pump, which pumped a total of 3 L of whole raw manure through the electrochemical unit and back into the reservoir. This system was designed to test indirect-acting (hydroxyl radical forming) anodes using whole, non-centrifuged manure containing solids. The cathodes were grids of mild steel. Although BDD was the most successful anode material at the level of the micro-scale reactor, it was too expensive to use even at a pilot plant scale. We therefore used Ti/SnO_2, which was obtained commercially, and the cheaper Pb/PbO_2, which was prepared in our laboratory from grids of an alloy that was 94% lead and 6% antimony, by making the grids the anode of an electrochemical cell. During 4 h at a current of 1 A, the TON gradually fell from 1000 to 200, while the odour quality changed initial from "A" (extremely unpleasant) to "C" (only slightly unpleasant). Because of the high concentration of solids present in whole manure, no attempt was made to study changes in TOC and related parameters as a result of treatment.

We also constructed a 27 L Plexiglas reactor with internal dimensions 1 x 1 x 2 ft (approx. 0.3 x 0.3 x 0.6 m). Ten anodes (Pb/PbO_2) and ten cathodes (iron grids) were mounted vertically in parallel and supplied in series with current from the Golden Source DC power supply. The active surface area for each electrode was 1 x 1 ft. Stirring was accomplished with a magnetic bar, 5 in (13 cm) long, and an external magnetic stirrer. The reactor was designed to function in both continuous and batch mode. When used in continuous mode the reactor was attached to a Masterflex peristaltic pump with two heads, each of which was capable of a maximal flow rate of 2.9 L/min. These were connected to the two entry ports at the bottom of the reactor. In batch mode, the entrances to the reactor were plugged. The lead/antimony grids were activated to form a layer of lead dioxide as described above.



The reactor was operated in our laboratory in batch mode at 20 A, after charging the unit with 27 L of manure collected from Arkell Research Station. After 3 h of operation during which the voltage difference between the electrodes was 5 V, the quality of the odor changed from A (highly unpleasant, raw manure) to C (mildly unpleasant). The power usage during this period was 20 A × 5 V = 100 W, hence over the course of 3 h, the energy expenditure was 0.3 kWh, corresponding to an electricity cost of about 2¢, equivalent to 74¢ m^{-3}.

A Study Investigating Farm-Level Risk Factors for Variation in Carcass Characteristics in Pigs in Southern Ontario

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Introduction

The three main factors acting on the growing pig are the environment, nutrition and genetics. Disease is an important component of the environment, and if present exerts a negative effect on performance of the growing pig and is detrimental to carcass quality. These factors lead to variation, which occurs both within groups and between groups and is primarily due to inherent biology and individual response to the environment. Genetics is a prime determinant of carcass characteristics and may influence length of carcass, longissimus muscle area, carcass lean[1], backfat and days to 100kg[2].

Carcasses undergo processing within the abattoir. Each carcass has separate measurements such as fat and muscle depths, usually in the back and/or rib area of the pig, and the hot carcass weight. The ideal pig is well muscled with low back fat measurements. This is in response to consumer pressure for ever leaner carcasses, a fact recognised as early as 1936[3]. There is pressure from the meat packer for uniform carcasses to be produced within a narrow weight range with a maximum fat depth and a minimum muscle depth[4]. This 'ideal pig' can be easily handled within the semi-automated processes at the packing plant and results in a consistent product for the end consumer. Producers are now seeking ways of reducing variation in carcass characteristics of market-weight pigs in order to maximise profitability and minimise penalties imposed by the packers for pigs that do not meet the stringent requirements[4].

The objectives of this study were to investigate barn-level factors associated with variation in fat depth and muscle depth of the individual pig, factors associated with barn-level coefficient of variation of carcass fat depth, muscle depth and hot carcass weight and the barn-level factors associated with marketing the maximum proportion of ideal pigs.

Materials and Methods

Data were collected in Microsoft Excel from a single abattoir in Southern Ontario for a two-year period from February 2002 to February 2004. These data included producer information and carcass characteristics for each pig slaughtered at the abattoir within the study period. A telephone survey of producers supplying pigs to the abattoir during the study period was conducted from July to September 2003 (survey available on request). This survey incorporated questions on farm characteristics, nursery-barn management, grower-finisher environment, grower-finisher nutrition and genetic source. These data were coded and entered into Microsoft Excel and then exported to SAS version 8.02[5] for statistical analysis.

Multiple linear regression models were developed using a backwards elimination technique and then Procedure MIXED[5] was used to build mathematical models whose purpose was to

investigate the proportion of variation in the outcome due to a variety of putative causal factors. Models were developed for two pig-level dependent variables: carcass fat depth and carcass muscle; and four barn-level dependent variables: coefficient of variation of fat depth, coefficient of variation of muscle depth; coefficient of variation of hot carcass weight and percentage of ideal pigs marketed per month by the barn.

Results and Discussion

Surveys were completed by 90 out of 173 producers, a return rate of 52%. There was a strong seasonal effect within all models, which suggests that careful management of temperature and humidity within confinement systems is necessary to optimise performance.

Fat and muscle depth at the individual pig-level
Absence of disease in the barn increased fat and muscle depths. The use of all-in-all-out in the nursery barn reduced fat depth and in the grower barn increased muscle depth. Therefore disease control and the use of all-in-all-out pig flow may improve these carcass characteristics and consistency of carcass quality, as well as increase barn income. The use of all-in-all-out pig flow within the nursery was important within both of the models but may have different effects on larger farms compared to smaller farms. This suggests that producers should pay particular attention to pigs within the nursery barn in order to optimise future growth performance of these pigs and minimise variation in the carcass characteristics of these pigs. Increasing space allowance was related to a decrease in fat depth, which is a highly desirable characteristic for the producer and the abattoir.

Coefficient of variation of fat depth, muscle depth and hot carcass weight
Boar and gilt genetics were associated with coefficient of variation of fat depth and coefficient of variation of muscle depth. Barns should consider selection on muscle depth in the carcass when choosing genetics for both boars and gilts. All-in-all-out pig flow within the nursery was important in the coefficient of variation of hot carcass weight. Producers should pay particular attention to pigs within the nursery barn in order to optimise future growth performance of these pigs and minimise variation in their carcass characteristics. An increase in minimum space allowance per pig in the finisher barn was associated with a decrease in the coefficient of variation of hot carcass weight up to a threshold level of space where the coefficient of variation of hot carcass weight plateaued. Provision of appropriate space allowances to finisher pigs allows pigs of the same genotype to more closely reach their potential growth. Absence of clinical mange was associated with lower coefficient of variation of muscle depth therefore control of clinical mange may result in carcasses with consistent muscle depth.

Percentage of ideal pigs marketed per month
The relative importance of the parameters in the model using the inter-quartile range method suggests that coefficient of variation of muscle depth has a stronger association with the percentage of ideal pigs marketed than the coefficient of variation of fat depth or the coefficient of variation of hot carcass weight. Absence of clinical mange was associated with an increase in the percentage of ideal pigs marketed therefore mange control may help in improving carcass characteristics and increase barn income. Nursery barns managed on a continuous flow basis resulted in a lower percentage of ideal pigs marketed compared to all-in-all-out by pen, room or site, which suggests that barns should pay particular attention to pigs within the nursery barn in order to maximise future performance. An increase in space allowance was associated with an

increase in the percentage of ideal pigs marketed, which supports the need to follow published recommendations on space allowances.

Acknowledgements
We greatly appreciate the cooperation of the participating producers and abattoir in addition to help with administering the telephone survey by Karen Richardson and Christa Helmka.

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Update on Needle-Free Vaccination

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Background: There are several reasons why needle-free vaccination of pigs can be a better alternative than using a traditional syringe and needle to deliver vaccine. First, the needle is a "sharps" hazard which requires that workers be trained (perhaps a fairly short, focused training session) in injury avoidance and proper disposal of this biohazard. Most swine veterinarians can assist with developing a proper sharps disposal protocol for their clients. Second, the use of a needle can affect pork product quality. Although the occurrence of broken needles in pork products is quite rare, the consequences for marketing pork can be devastating, so needle use should be minimized. Third, pigs flinch from injections because there is pain and stress that results from the intrusion of the needle into the skin and muscle. Finally, the licensed vaccines have been shown to be effective following conventional injection methods, but immunologists know that there are more effective ways to get protective mucosal immunity.

Effect of injection method on health: We have evaluated the effects of needle-free injection, conventional method of injection, or no injection on piglets. Piglets were provided with nutritional iron (Dexafer) and immunization (Suvaxyn® MH/HPS) by injection at 1 day of age and control piglets were given Dexafer by mouth. Health, blood iron (hematocrit) and serum antibody responses were measured and growth rate was calculated at weaning. Overall herd health was very good, but more disease occurred in pigs that got a regular injection. Pre-weaning disease or death was 2.2 times more likely to occur in piglets injected with a conventional needle and syringe (Group 1) than in piglets given no injection (Group 3). Group 3 received no vaccine and iron dextran by mouth. As expected, both the blood iron (hematocrit) as well as the antibody level for group 3 were significantly lower ($p < 0.05$) than in the other groups, which were not different. No significant differences in daily gain or weaning weight were demonstrated. The needle-free injection method (Fig. 1) resulted in equivalent hematocrit, antibody response and growth and did not result in the increased nonspecific sickness that was observed in the group injected with a conventional needle and syringe.

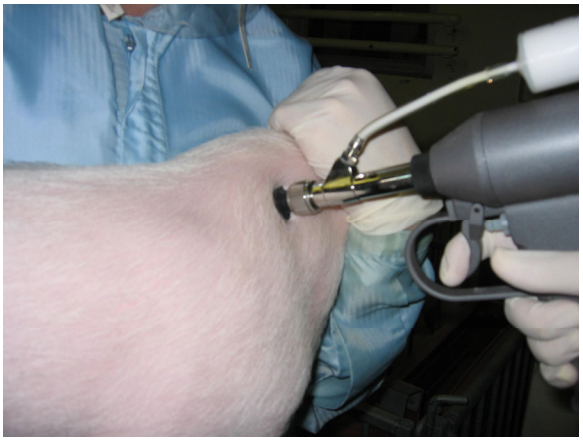

Figure 1. Piglet receiving an experimental vaccination.

Effect of injection method on meat: After this project was funded and begun, other work has been published which demonstrated that needle free administration of vaccine did not result in a difference in meat quality – both methods were acceptable. (Houser, T. A., et al. 2004. Meat Science 68:329-332.) Because this other work addressed the meat quality issue, we focused our remaining time and resources on improved formulation of mucosal vaccines for pigs

Improved formulation of mucosal vaccines for pigs: We evaluated the efficiency of biphasic vesicles (VTAM1 formula) in mucosal vaccine formulations using a combined mucosal/systemic protocol of immunization in pigs. Pigs received 2 i.n. immunizations at days 0 and 30 and 1 s.c. at day 21. Cholera toxin (a potent adjuvant) was included as a positive control for mucosal immunization. Negative control pigs received saline. Antibody responses were assessed after each immunization and compared with responses induced by a biphasic lipid formulation containing antigen and CpG ODNs after 2 s.c. immunizations. The biphasic vesicles (VTAM1 formula) were characterized, and their main properties are described below. The i.n. formulation contained anionic vesicles with trimodal size distribution characteristics. Average size distributions for the 3 particle populations were 23 ± 1 nm (3% of particle population in this size range), 141 ± 18 (55%), and 784 ± 82 (42%) (n = 3). This is consistent with a topical formulation method where the biphasic vesicle components such as the submicron emulsion droplets (mean diameter 141 nm) and phospholipid vesicles trapping submicron emulsion droplets (mean diameter 784 nm) are present. In addition, the small particles with a mean diameter of 23 nm in VTAM1 probably represented surfactant micelles that were not part of the vesicle population. For administration into the nasal cavity, the antigen was mixed with the biphasic vesicles. Binding/association (not entrapment) of the antigen with the vesicles helps increase the residence time of the antigen in the nasal cavity and localizes the antigen in the required regions. The mixture of antigen with the vesicles also improves stability and versatility. It is envisaged that biphasic vesicles could be used as a "universal" adjuvant for many other antigens as well.

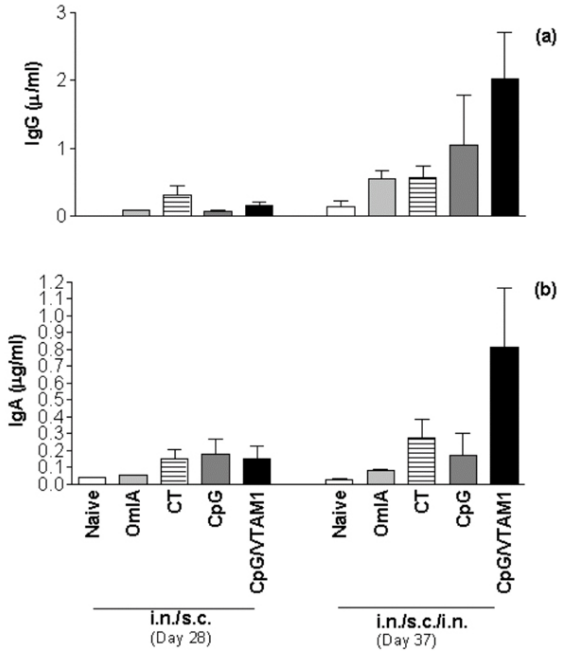

Figure 2. Antibody in nasal secretions after experimental piglet immunization.

The results (Fig. 2) mean that the novel adjuvant and formulation combination that is described here (Alcón V, et al. 2005.AAPS J. 7(3):E566-71.) is as effective as or better than the best previously known material for mucosal immunization in pigs. The novel combination has the additional advantage of avoiding the toxic effects of materials previously used for mucosal immunization.

Financial support provided by Ontario Pork (04/10) and NSERC-CNBPS (225155).

"Homegrown Ontario Fresh Meat": Ontario Red Meat Identity Strategy

Lilian Schaer, Ontario Pork

November 2005

Background

This project is a partnership between Ontario Pork, Ontario Sheep Marketing Agency and Ontario Veal Association to develop a recognizable consumer identity for red meat in Ontario through a comprehensive, multi-year strategy.

This includes the development of a "Homegrown Ontario Fresh Meat" identity, as well as the promotion of that identity to Ontario consumers through media advertising, retail and public relations activities. The other main component of that strategy is market research to pre-test potential messages, test consumer recall of those messages and evaluate the success of the campaign regularly throughout its life span.

Foodland Ontario was initially approached to determine whether they would be willing to expand their well-established and respected program to include red meat. However, there was no interest to undertake such a strategy. So the three partner groups decided to determine the feasibility of working together to develop and launch such a project. Individually, none of the groups have the time, money or staff to execute a project of this magnitude, so it made sense to pool resources into a joint effort.

Research has shown that consumers think of red meat as a collective term, not as veal, sheep, pork etc., so it is important to talk to them in terms that they will understand. As well, all three groups face common issues:

- Export market opportunities far from stable and predictable
- A need to grow and protect domestic consumption in face of import competitors
- A need to continue to defend protein consumption and dispel health-risk myths across entire meat category
- A need to re-emphasize high Ontario standards in face of continuing concerns about food safety
- Previous industry/marketing board identity strategies have proven successful (Milk, Eggs, Maple Leaf's ingredient story, California Raisins, Farm to Fork etc)

The Need for an Ontario Red Meat Identity: Market Research Results

The need for this strategy was clearly demonstrated by the results of consumer focus groups and telephone surveys carried out by Ipsos Reid on behalf of the partner groups.

This research demonstrated a strong opportunity to create an "Ontario" red meat identity in the marketplace, which will be consistent with other branded meats that have high consumer awareness and preference, eg. Alberta Beef, Black Angus Beef and New Zealand Spring Lamb.

It also showed that locally raised and produced products can form the basis of a significant point of differentiation for consumers, and help propel our respective industries forward.

Our individual product offerings are perceived as high quality, safe, and excellent across a number of other measured attributes, and the creation of the "Ontario" brand will help highlight those characteristics to consumers in this province. The notion of an "Ontario Seal of Approval" was well regarded amongst survey participants, presenting an opportunity for the three partner groups to build a full and complete story around the benefits of Ontario standards.

The collective view of the three livestock groups is that an consumer identity strategy would have considerable benefits to Ontario livestock groups, and could become a long term basis for product differentiation and a way of rallying consumers around the notion of choosing Ontario. Homegrown Ontario will offer smaller retailers, processors and abattoirs access to a branded program that they might not otherwise be able to develop, implement and sustain.

Logo Preference

The following concept logos were tested with consumers:

Out of these options, the following logo tested most positively:

Participants thought that the logo was attention getting/eye catching, gave the perception of freshness, and was simple and easy to understand. They also unanimously like the trillium. Respondents strongly preferred "Fresh Meat" to "Red Meat" in all groups, and they also preferred "Homegrown Ontario" to "Ontario's Choice". However, using "Fresh Meat" does restrict labeling to cuts, roasts and ground meats. The majority of respondents did not consider packaged sandwich meat, hot dogs or frozen/boxed meats to be fresh meat.

Project Description

The project will develop an "Ontario" identity for red meat, similar to what Foodland Ontario is to fruits and vegetables, and launch it on the Ontario market place in an effort to influence consumer preference. The aim is to offer consumers the opportunity to buy more Ontario red meat products, which will help grow domestic markets for red meat, a sector that is faced with increasing pressure from global competition and the threat of unstable export markets.

A consumer identity strategy has never been undertaken in Ontario for commodity meat products, only for specific products or programs, ie. Moist & Tender, Sterling Silver etc. However, this program is not intended to compete with or replace existing programs such as Ontario Certified Veal or Ontario Corn Fed Beef. These programs are based on producers fulfilling certain criteria, such as feed requirements or HACCP certification, and are designed to offer a specific marketing opportunity to producers who can meet such criteria. Homegrown Ontario will be developed to serve as an umbrella program for Ontario commodity meat that isn't covered by an existing brand, while at the same time supporting the existing brands.

The following concepts form the backbone of the program's key messages and concepts:

Choose Ontario:

- When you buy red meat products with the Ontario seal, you are not only helping local producers, you are buying the best our province has to offer. Every day local farmers work hard to produce the best for you and your family, so it is important to choose locally raised meat products. When you choose products with the Ontario seal, you are choosing a future for Ontario farmers.

Your Guarantee of the Best:

- When you see this Ontario seal on your meat package or in your butcher's counter, you know you are getting the very best that our local producers have to offer. This seal means that you are choosing locally raised and produced Ontario red meat.

Ontario standards mean the best for you and your family, so look for this seal, to ensure you are choosing only Ontario raised and produced products.

Ontario Goodness Throughout:

- By choosing red meat products with the Ontario seal, you are guaranteeing goodness throughout. From high quality local production standards right to your table, this seal means goodness through and through. If you want the best local producers have to offer, look for the Ontario seal or ask your butcher.

Ontario Standards: World Class For You:

- Today, it is important to choose foods that live up to the highest quality standards of production. That's why when you choose red meats with the Ontario seal, you know you can rest assured that from farm, right to your table, the highest production and safety standards have been followed. The Ontario seal is your guarantee of the best production standards in the world.

Timelines & Funding

The project partners received CORD funding in 2005 to do some consumer research to establish the need for such a program, as well as develop a business plan. This is now in its final stages and the partners will be taking a full program proposal to the Adaptation Council for funding in early 2006. The intent is to develop and launch the program in 2006 for an initial period of three years, although the long term goal is for the program to be self-sustaining with more industry, and hopefully government, partners supporting it.

Engineering Controls to Reduce Hydrogen Sulfide Exposure of Workers in Swine Buildings

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Summary

Three engineering control measures were developed and tested for effectiveness in protecting swine barn workers from exposure to hydrogen sulfide (H_2S) gas during manure handling events. A remote manure pit plug pulling system allowed the worker to pull the manure pit plug from outside the room, thereby significantly reducing risk of worker exposure to H_2S. A water sprinkling apparatus was also devised, which resulted in 79% reduction of H_2S gas concentration under optimal laboratory conditions. However, the use of a similar system on agitated manure showed the opposite effect. A manure scraper system was installed to remove manure daily from the manure pit of a grower-finisher room. Preliminary measurements showed that H_2S levels were 80 to 96% lower in the scraper room than in a similar room with a conventional pull-plug system. However, higher ammonia emissions were observed in the scraper room compared to the conventional grower-finisher room.

Introduction

High levels of H_2S can have detrimental effects on both workers and swine. Previous research by the Prairie Swine Centre Inc. (PSCI) indicated that workers are at risk of exposure to potentially hazardous H_2S levels when performing manure management tasks, such as pulling manure pit plugs. The main goal of this project is to develop practical measures that can prevent or reduce worker exposure to high H_2S concentration in swine buildings. Three different systems were investigated in separate modules.

Module 1 – Improved Design for Pit Plugs

In this module, an improved pit plug concept that allowed for pulling the plugs from a remote location was designed and evaluated. Two undergraduate students, assisted by technical staff at University of Saskatchewan and PSCI, designed and built a prototype system (Fig. 1). The system was installed in two grower-finisher rooms at PSCI and tested by measuring H_2S concentrations using a H_2S monitor (Draeger Pac III monitor with a H_2S sensor, Draeger, Lübeck, Germany) during the plug-pulling operations.

After examining several plug designs, the extended cone plug was selected and installed. Monitoring of H_2S levels during nine plug-pulling events showed that the maximum H_2S concentration in the room over the plug area was 68 ppm, while corresponding concentrations at the alleyway near the winch was 0 ppm. Hence, the system was very effective in protecting the worker from being exposed to H_2S by allowing the worker to perform the task away from the plug area.

Module 2 – H_2S Abatement by Water-based Liquid Spray

Because H_2S is water soluble, it was hypothesized that spraying a water-based liquid over agitated manure would reduce emissions into the air. In this module, a laboratory spray chamber was set up to determine the impact of a water-based spray on H_2S levels in the chamber (Fig. 2). Preliminary tests were done to investigate the reduction in H_2S levels as affected by various parameters such as type of spray nozzle, water pressure, temperature and pH, as well as the use of various chemical additives.

Laboratory tests with various combinations of test parameters consistently reduced the concentration of pure H_2S gas released into the chamber (Fig. 3). Using a hollow cone nozzle at 200 kPa with water at pH = 9 resulted in a 79% reduction of the peak H_2S levels. The treatment was applied to a set of barrels filled

with swine manure. In four control barrels where no spray was applied, manure agitation produced an average of 148 ppm, with a peak reading of 520 ppm measured from the exhaust air. However, application of the water-spray treatment increased the average and maximum H_2S concentrations to 273 and 690 ppm, respectively. Because these were not consistent with the observations in the laboratory study, it was suspected that other gases generated in the manure barrel affected the Draeger Pac III monitor. Additional tests are on-going to investigate the water-spray treatment further.

Module 3 – Manure Scraper System to Reduce H_2S Levels

In this module, a manure pit scraper system (Fig. 4) was installed in a grower-finisher room to remove swine manure on a daily basis. Its effectiveness was evaluated by comparing the air quality in the scraper room and a similar room (Control) with conventional manure pit-plug system.

The scraper system was evaluated over two production cycles; during each trial both rooms were monitored closely over four one-week periods. Table 1 summarises the maximum H_2S concentrations measured at two locations in the rooms. Compared to the control room, the maximum H_2S concentrations were lower in the scraper room by an average of 80% over the plug area and by an average of 96% over the middle pen. Additionally, the maximum H_2S levels in the control room exceeded the 15-ppm ceiling occupational exposure limit (OEL) value on three occasions during the two trials, while no peak H_2S readings were higher than this limit value in the scraper room. The ceiling OEL is the maximum concentration of a biological or chemical agent to which a worker may be exposed, i.e., no worker should be exposed to any levels above this limit at any time.

During the two trials, significant levels of ammonia were measured in the incoming inlet air for both rooms, possibly due to recirculation of air exhausted from the fans into the supply air as well as from possible back draft of ammonia from adjacent rooms into the barn attic. The weekly average ammonia concentrations measured at the exhaust was significantly ($p<0.05$) higher in the scraper room (11.3 ppm, SD = 2.3 ppm) than in the control room (9.8 ppm, SD = 2.1 ppm), although the mean difference was smaller than the indicated accuracy of the ammonia analyser. The calculated ammonia emissions were about 44% higher in the scraper room, which was attributed to the formation of a film of excreta on the pit bottom surface after scraping; this has been previously reported as possibly causing increased ammonia emissions in scraper systems. However, the observed ammonia levels were still lower than the 25-ppm OEL for ammonia, despite the presence of ammonia in the incoming air. Additional tests are on-going to determine the effectiveness of maintaining a layer of standing water at the bottom of the manure channel to control ammonia emissions.

Conclusions

A remote manure plug pulling system was successfully developed. Results showed that the system was effective in preventing worker exposure to H_2S by allowing the pulling of the plugs from the alleyway. A water-spray treatment showed consistent reduction in H_2S levels in a laboratory study. However, application of the treatment on agitated manure showed opposite effect on H_2S. A manure scraper system used for daily manure removal from a swine room was effective in reducing H_2S to levels below the maximum exposure limit for worker's safety. The system generated higher ammonia levels, although peak readings did not exceed the ammonia exposure limit value. Additional tests are being conducted to further investigate both the scraper and the water-spray systems.

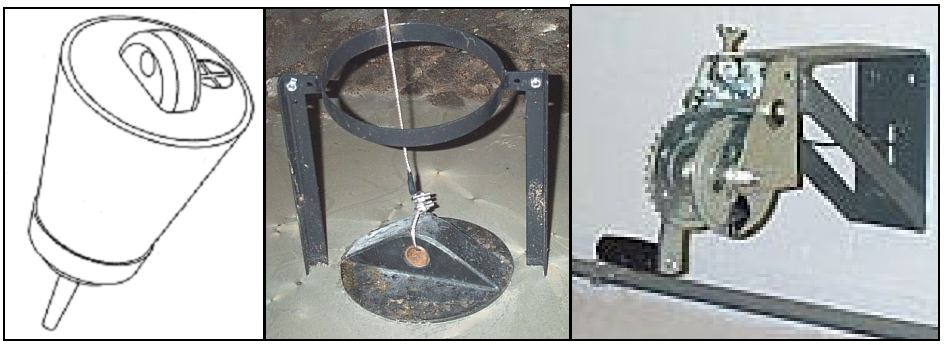
Acknowledgement

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

Table 1. Summary of maximum H_2S concentration (ppm) measured in the scraper and control rooms.

		Control		Scraper	
	Date	Over plug	Middle pen	Over plug	Middle pen
Trial 1	10-Mar-04	4.0	2.0	0.0	0.0
	24-Mar-04	0.0	0.0	0.0	0.0
	7-Apr-04	9.0	0.0	11.0	7.0
	21-Apr-04	12.0	4.0	0.0	0.0
Trial 2	30-Jun-04	12.0	2.0	0.0	0.0
	21-Jul-04	95.0	N/A	6.0	N/A
	11-Aug-04	40.0	30.0	2.0	0.0
	25-Aug-04	30.0	10.0	1.0	2.0
	Average	25.3	6.9	2.5	1.3
	SD	31.2	10.8	4.0	2.6

N/A – data not available, instrument malfunction



(a) (b) (c)

Figure 1. Improved pit-plug design showing the (a) extended cone plug, (b) with cable attached and plug-height stop, and (c) the cable-winch system for remotely pulling the plug from outside the room.

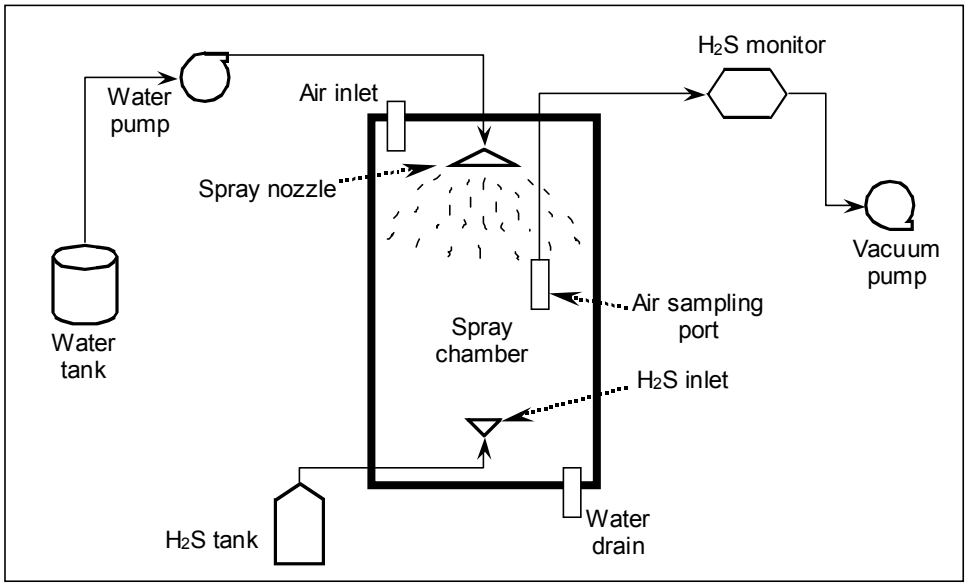


Figure 2. Schematic diagram of laboratory set-up used to determine the effect of water-based spray on H_2S levels in the chamber.

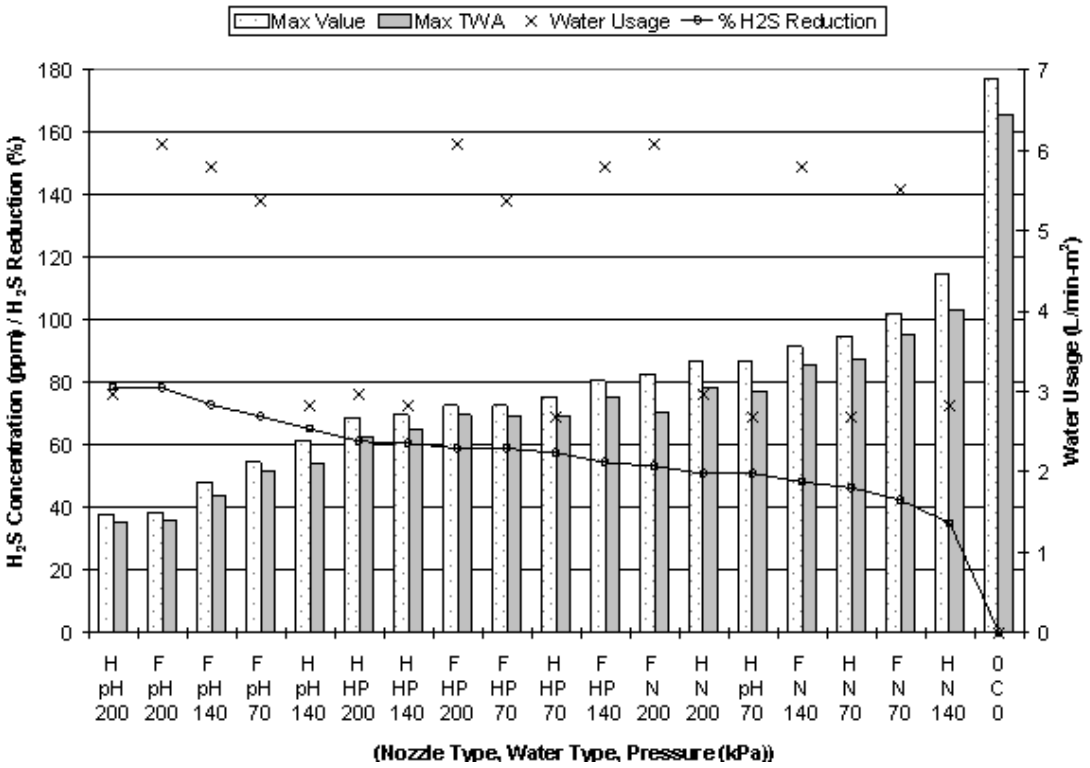


Figure 3. Summary of laboratory test results (Nozzle Types: H (hollow cone) and F (full cone); Water Type: pH (water at pH 9), HP (water with hydrogen peroxide added), and N (normal water); Pressures: 70, 140 and 200 kPa).

Figure 4. Scraper blade used for daily removal of manure from the pit. The manure pit has drains at both ends, through which the scraped manure was emptied to the sewer line.

Effect of Xylanase and (or) Phytase Supplementation on Nutrient Digestibility and Growth Performance of Grower Pigs Fed Wheat-Based Diets Containing Wheat Millrun

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[3]*Danisco Animal Nutrition, Marlborough, UK,* [4]*University of Alberta, Edmonton, AB*

Summary
The nutritional value of wheat millrun with xylanase and (or) phytase supplementation in wheat based diets for growing pigs was evaluated. Wheat millrun inclusion depressed energy and P digestibility and also ADG, but had not effect on ADFI and G:F. Xylanase and phytase reduced ADFI and improved nutrient digestibility. However, the improved nutrient digestibility did not result in improved growth performance which may be indicative of a nutrient imbalance.

Introduction
Feed cost might be reduced or nutrient intake might be enhanced if nutrients bound by the arabinoxylans and phytate of wheat millrun could be released through enzyme supplementation to a higher extent. This would allow for large inclusion rates of wheat millrun into swine diets, while maintaining growth performance. An increased energy and amino acid digestibility in the small intestine is especially beneficial to the pig, but increased energy digestibility in the large intestine will also be beneficial to improve the energy status. Improved utilization of dietary phosphorus will be beneficial economically, but will also reduce the pressure of swine production on the environment.

Results and Discussion
Ileal and total tract energy digestibility was affected by millrun inclusion, xylanase and phytase addition. Millrun addition reduced P digestibility linearly and phytase and xylanase supplementation improved P digestibility. In contrast to digestibility data, performance data were less conclusive. Millrun inclusion reduced ADG linearly, but did not affect ADFI or G:F. Xylanase and phytase reduced ADFI, and phytase tended to reduce ADG . Enzyme supplementation did not affect final BW or G:F.

Conclusions
Overall, millrun inclusion reduced nutrient digestibility and growth performance. Xylanase and phytase improved nutrient digestibility; however, the improved digestibility did not result in improved growth performance which may have been indicative of a nutrient imbalance.

Acknowledgements
Program funding was provided by Sask Pork, Alberta Pork, Manitoba Pork and Saskatchewan Agriculture and Food Development Fund. Danisco Animal Nutrition funded the project.

Table 1. Ingredient and nutrient composition of diets

Ingredient (%)	Wheat	20% Wheat millrun[z]	40% Wheat millrun[z]
Wheat	83.26	61.83	40.26
Wheat millrun	-	20.00	40.00
Soybean meal	12.50	12.50	12.50
Canola oil	-	1.80	3.60
Dicalcium phosphate	1.20	0.70	0.40
Limestone	0.85	1.00	1.10
L-lysine HCl	0.49	0.47	0.45
Vitamin premix[y]	0.50	0.50	0.50
Mineral premix[w]	0.50	0.50	0.50
Sodium bicarbonate	0.29	0.29	0.29
Salt	0.20	0.20	0.20
L-Threonine	0.15	0.14	0.13
DL-Methionine	0.06	0.07	0.07
Calculated nutrient content			
DE (Mcal kg^{-1})	3.34	3.34	3.34
Dig. Lysine (g $Mcal^{-1}$ DE)[v]	2.80	2.80	2.80
Calcium	0.70	0.70	0.70
Total phosphorus	0.60	0.60	0.63

[z] Xylanase was included at a rate of 167 g $Tonne^{-1}$ of finished feed and phytase at a rate of 100 g $Tonne^{-1}$ of finished feed.

[y]Provided per kilogram of premix: vitamin A, 1 650 000 IU; vitamin D_3, 165 000 IU; vitamin E, 8000 IU; niacin, 7 g; D-pantothenic acid, 3 g; riboflavin, 1g; menadione, 800 mg. folic acid, 400 mg; thiamine, 200 mg; D-biotin; 40 mg; vitamin B_{12}, 5 mg

[w]Provided per kilogram of premix: Zn, 20 g; Fe, 16 g; Cu, 10 g; Mn, 5 g; I, 100 mg; Se, 20 mg.

[v]Contained by calculation 2.80 apparent digestible lysine $Mcal^{-1}$ DE (0.94% apparent digestible lysine) and an ideal pattern of digestible amino acids compared to lysine (%); lysine 100; threonine 60; methionine 30 (NRC 1998).

Table 3. Effect of wheat millrun inclusion level and enzyme supplementation on ileal and total-tract energy and DM digestibility and DE content of diets fed to grower pigs

Variable	Millrun (%)									Pooled	Millrun[y]		Millrun diets[z]			
	0	20				40										
	Control	Control	Xyl	Phy	X+P	Control	Xyl	Phy	X+P	SEM[x]	Linear	Quadratic	20 vs 40	Xyl vs Phy	Phy vs non Phy	Xyl x Phy
Ileal																
Energy digestibility (%)	77.5[a]	68.1[bcd]	72.4[b]	71.6[bc]	72.5[b]	62.0[e]	68.1[bcd]	67.4[cd]	66.6[d]	1.21	<0.001	NS	<0.001	0.004	0.035	NS
DE (kcal kg^{-1} DM)	3416[a]	3097[b]	3292[ab]	3262[ab]	3318[ab]	2896[c]	3199[ab]	3141[b]	3129[b]	55.9	<0.001	NS	<0.005	0.001	0.026	NS
DM digestibility (%)	79.4[a]	69.9[c]	73.9[b]	73.8[b]	74.2[b]	63.4[d]	69.2[c]	68.7[c]	67.9[c]	1.09	<0.001	NS	<0.001	0.004	0.012	NS
Total-tract																
Energy digestibility (%)	84.4[a]	77.6[c]	79.8[b]	78.9[bc]	80.7[b]	71.5[f]	75.5[d]	73.4[e]	73.1[e]	0.55	<0.001	NS	<0.001	<0.001	NS	NS
DE (Kcal kg^{-1} DM)	3720[a]	3528[d]	3632[bc]	3596[cd]	3692[ab]	3337[f]	3548[cd]	3424[e]	3433[e]	25.4	<0.001	NS	<0.001	<0.001	NS	NS
DM digestibility (%)	86.7[a]	80.3[c]	82.2[b]	81.7[b]	83.1[b]	74.2[f]	77.9[d]	76.1[e]	75.9[e]	0.45	<0.001	NS	<0.001	<0.001	NS	NS
Total-tract minus ileum																
Energy digestibility (%)	6.9	9.5	7.5	7.3	8.2	9.4	7.6	6.1	6.5	1.27	NS	NS	NS	NS	NS	NS
DE (kcal kg^{-1} DM)	304	430	340	334	374	441	359	282	303	58.9	NS	NS	NS	NS	NS	NS

NS: Not significant
[abcd] Means within the same row with the same letter are not different P>0.05.
[x] SEM:Pooled standard error of the mean.
y:: Linear and quadratic responses were analyzed using 0%, 20%, and 40% control diets.
[z] Source of variation and probability only among diets that contain millrun and/or enzyme.
Xyl: Xylanase.
Phy: Phytase.

Table 5. Effect of millrun and enzymes on performance of grower pigs over time

	Millrun (%)														
	0	20				40				Pooled SEM[x]	Millrun[y]		Millrun diets[z]			
	Control	Control	Xyl	Phy	X+P	Control	Xyl	Phy	X+P		Linear	Quadratic	20 vs 40	Xyl vs Phy	Phy vs non Phy	Xyl x Phy
Average daily feed intake (kg d-1)																
Days																
0-7	1.9[a]	1.9[a]	1.7[a]	1.8[a]	1.8[a]	1.6[a]	1.8[a]	1.7[a]	1.6[a]	0.11						
8-14	2.3[a]	2.2[ab]	2.1[ab]	2.1[ab]	1.9[b]	1.9[b]	1.9[b]	2.3[a]	2.0[ab]	0.11						
15-21	2.7[a]	2.6[ab]	2.6[ab]	2.6[ab]	2.4[b]	2.8[a]	2.4[b]	2.6[ab]	2.4[b]	0.11						
22-28	2.8[a]	2.8[a]	2.8[a]	2.5[b]	2.6[b]	2.9[a]	2.7[ab]	2.5[b]	2.5[b]	0.11						
29-35	3.2[a]	3.2[a]	3.1[a]	2.4[bc]	2.9[ab]	3.2[a]	3.1[a]	2.9[ab]	2.8[b]	0.11						
0-35	2.6[a]	2.6[a]	2.4[bc]	2.4[bc]	2.3[c]	2.5[ab]	2.4[bc]	2.4[bc]	2.3[c]		NS	NS	NS	0.004	0.002	0.043
Average daily gain (kg d-1)																
0-7	0.96[a]	0.88[a]	0.92[a]	0.85[a]	0.88[ab]	0.76[b]	0.81[b]	0.76[b]	0.76[b]	0.05						
8-14	0.90[a]	0.88[a]	0.90[a]	0.85[a]	0.86[a]	0.90[a]	0.77[a]	0.91[a]	0.87[a]	0.05						
15-21	1.23[a]	1.09[ab]	1.14[a]	1.07[b]	1.04[b]	1.02[b]	1.01[b]	1.03[b]	0.99[b]	0.05						
22-28	0.97[a]	0.95[a]	0.91[a]	0.84[a]	0.89[a]	0.89[a]	0.91[a]	0.88[a]	0.93[a]	0.05						
29-35	1.19[a]	1.13[a]	1.08[a]	0.99[b]	1.07[a]	1.10[a]	1.06[ab]	1.08[ab]	1.03[b]	0.05						
0-35	1.05[a]	0.98[a]	0.99[a]	0.92[b]	0.95[b]	0.94[b]	0.91[b]	0.93[b]	0.92[b]		<0.001	NS	0.023	NS	0.09	NS
Feed efficiency																
0-7	0.49	0.45	0.53	0.47	0.48	0.46	0.46	0.44	0.46	0.03						
8-14	0.39[b]	0.39[b]	0.43[b]	0.41[b]	0.43[b]	0.55[a]	0.39[b]	0.41[b]	0.42[b]	0.03						
15-21	0.46[a]	0.41[a]	0.45[a]	0.41[a]	0.44[a]	0.37[b]	0.42[a]	0.40[ab]	0.41[ab]	0.03						
22-28	0.34	0.33	0.32	0.34	0.34	0.31	0.34	0.36	0.37	0.03						
29-35	0.37	0.36	0.35	0.35	0.36	0.34	0.34	0.36	0.37	0.03						
0-35	0.41	0.39	0.42	0.39	0.42	0.41	0.39	0.39	0.41		NS	NS	NS	NS	NS	NS
Final body weight (kg)																
d 7	42.1[a]	41.6[a]	41.9[a]	41.4[a]	41.7[a]	40.8[a]	41.1[a]	40.8[a]	40.8[a]	0.95						
d 14	53.8[a]	47.9[b]	48.2[b]	47.3[b]	47.7[b]	47.2[b]	46.5[b]	47.2[b]	46.9[b]	0.94						
d 21	62.2[a]	55.6[b]	56.2[b]	54.7[b]	54.9[b]	54.4[b]	53.7[b]	54.5[b]	53.9[b]	0.94						
d 28	68.7[a]	62.3[b]	62.5[b]	60.6[b]	61.2[b]	60.7[b]	60.0[b]	60.7[b]	60.4[b]	0.94						
d 35	76.8[a]	70.3[b]	70.1[b]	67.5[c]	68.7[b]	68.5[b]	67.5[c]	68.3[b]	67.7[c]	0.94	<0.001	<0.001	<0.001	NS	NS	NS

NS: Not significant

[abcd] Means within the same row with the same letter are not different P>0.05.

[x] SEM:Pooled standard error of the mean.

y:: Linear and quadratic responses were analyzed using 0%, 20%, and 40% control diets.

[z] Source of variation and probability only among diets that contain millrun and/or enzyme.

Xyl: Xylanase.

Phy: Phytase

Response of Growing and Finishing Pigs to Dietary Energy Concentration

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Summary

The objective of this experiment was to develop an energy response curve for pigs in the growing and finishing phases of production. The diets varied in DE content (3.1, 3.2, 3.3, 3.4 and 3.6 Mcal DE/kg) and were fed from 25 kg to market. Feeding lower energy, lower cost diets, had no effect on ADG or on loin thickness, but did improve feed efficiency and reduced backfat thickness. These results indicate that lower energy diets may be used to increase net income. The applicability of these results amongst a diversity of commercial herds probably depends on feed intake, and the ability of pigs to increase feed intake on the lower energy diets. Nonetheless, the potential for substantially increasing net income warrants careful consideration of dietary energy levels during the growout period. In this experiment, return over feed cost varied by more than $10 per pig across the 5 dietary treatments.

Introduction

The primary objective of pork production is to produce lean meat in a cost effective and sustainable manner. Because energy is considered to be the most important driver of growth in the diet, achieving the full genetic potential for growth in the modern pig requires a clear and definitive understanding of the energy response curve in all phases of production. Despite the importance of energy in the design of commercial feeding programs, and the impact that daily intake has on energy supply, there has been surprisingly little information developed on animal response to energy intake. The little information that is available tends to emphasize whole body growth and reveals little in terms of the partitioning of energy into protein, lipid, water and ash. Establishing responses to nutrient intake levels is particularly critical in defining feeding programs to maximize carcass quality.

The objective of this experiment was to develop an energy response curve for pigs in the growing and finishing phases of production.

Results and Discussion

Energy density of the diet had no effect on ADG during any phase, or when calculated over the entire experimental period (Table 1). Feed intake declined as the energy density of the diet increased and feed efficiency was improved. Increasing the energy density of the diet resulted in a reduced lean yield and reduced backfat thickness (Table 2); surprisingly there was no effect on carcass value or on carcass premiums.

It is important to note that by commercial standards, pigs on this experiment exhibited a high feed intake and this could explain the lack of growth response to increases in dietary energy concentration. If feed intake had been lower, the response of the pigs to dietary energy concentration may have been different. A similar experiment is presently being conducted at a commercial farm to test this hypothesis.

Conclusion

In this trial, feeding lower energy, lower cost diets had no effect on ADG or on loin thickness, but did improve feed efficiency, and reduced backfat thickness. This indicates that lower energy diets

may be used to increase net income. This experiment was conducted in an environment of high feed intake, and different results may accrue under conditions of lower feed intake. At the time of this trial, the lowest energy diet increased return over feed cost by more than $10 per pig sold, as compared to the highest energy diet.

Acknowledgements
Strategic funding provided by Sask Pork, Alberta Pork, Manitoba Pork and Saskatchewan Agriculture and Food Development Fund. Support for this experiment from PIC is greatly appreciated.

Table 1. The effect of dietary energy density on body weight, ADG, ADFI and feed conversion over 3 phases of growth.

	Diet (Measured DE, Mcal/kg)[1]						
Parameter	3.09	3.24	3.34	3.42	3.57	SEM	Regression
Phase 1							
Wt, kg (d0)	31.17	31.06	31.52	31.19	31.08	0.24	ns[2]
ADG, kg/d	0.95	0.97	0.98	0.98	0.99	0.01	ns
ADFI, kg/d	1.95	1.95	1.91	1.88	1.87	0.03	ns
FCE, gain:feed	0.49	0.50	0.52	0.52	0.53	0.01	L
Phase 2							
Wt, kg (d0)	53.15	52.97	53.38	53.39	53.48	0.32	ns
ADG, kg/d	1.04	1.08	1.10	1.07	1.06	0.02	ns
ADFI, kg/d	2.74	2.72	2.74	2.61	2.51	0.04	ns
FCE, gain:feed	0.38	0.40	0.41	0.41	0.43	0.01	L
Phase 3							
Wt, kg (d0)	80.10	79.47	80.30	80.16	80.22	0.44	ns
Wt, kg (end)	115.07	115.51	115.26	115.02	115.58	0.41	ns
ADG, kg/d	1.04	1.08	1.10	1.07	1.06	0.02	ns
ADFI, kg/d	3.29	3.19	3.20	3.05	2.94	0.05	ns
FCE, gain:feed	0.30	0.32	0.32	0.33	0.35	0.01	L
Overall							
ADG, kg/d	1.00	1.02	1.03	1.01	1.05	0.01	ns
ADFI, kg/d	2.76	2.69	2.67	2.59	2.49	0.03	L
FCE, gain:feed	0.36	0.38	0.38	0.39	0.42	0.01	L

[1]Refers to the energy concentration which was determined experimentally at the mid-point of each phase.
[2] ns; the response to dietary energy level was not linear (P>0.05), L; a significant response to dietary energy level was observed (P < 0.05).

Table 2. The effect of dietary energy density, gender and initial bodyweight on carcass value, days on test and feed cost over 3 phases of growth.

	Diet (Measured DE, Mcal/kg)						
Parameter	3.09	3.24	3.34	3.42	3.57	SEM	Regression
Settlement price,	89.91	90.00	90.88	90.72	91.22	0.37	L[1]
Index	113.81	112.91	113.45	111.70	113.24	0.48	Ns
Yield	61.58	61.13	60.88	61.14	60.63	0.18	L
Fat, mm	16.83	17.79	18.33	18.62	19.39	0.34	Ns
Lean, mm	61.65	60.55	62.72	60.25	61.06	1.06	Ns
Price, $	1.10	1.10	1.10	1.10	1.10	0.01	Ns
Value, $	111.36	111.63	111.67	110.20	112.75	1.16	Ns
Premium, $	5.56	5.33	5.53	5.06	5.00	0.18	L
Days on test							
Phase 1	23.3	23.0	22.8	22.9	22.9	0.48	Ns
Phase 2	25.9	24.8	24.6	25.0	25.0	0.49	Ns
Phase 3	35.4	35.8	36.8	34.6	34.0	1.07	Ns
Feed costs, $/pig							
Phase 1	8.36	8.96	9.38	10.39	11.36	0.19	L
Phase 2	12.00	12.70	13.93	14.81	15.46	0.25	L
Phase 3	17.40	19.13	21.85	21.82	22.70	0.55	L
Total	37.76	40.79	45.16	47.03	49.52	0.61	L

[1] ns; the response to dietary energy level was not linear ($P>0.05$), L; a significant response to dietary energy level was observed ($P < 0.05$).

Manure Handling System for Reduction of Air Contaminants in a Swine Barn

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Summary

Two manure-handling systems, a washing gutter and an inclined washed conveyor belt, were tested to determine which system best eliminates all manure contamination from the experimental chambers in an air quality laboratory. Both systems proved efficient at reducing the air contamination from the excreta. However, neither system totally eliminated the release of contaminants to the airspace.

Introduction

Air quality in swine confinement buildings is a growing concern as the impact of poor air quality on the health of pigs and workers becomes better documented. Changes in barn design and management practices in the last 30 years have resulted in many improvements, but the problems associated with poor indoor quality in barns are far from being completely resolved. To understand better the sources of air contamination in an intensive swine operation, this study will look at various factors separately (i.e., feed, manure, and the animals themselves), and attempt to eliminate the effect of each factor on air quality. It is anticipated that once the effect of each factor is reduced to zero, these factors can then be varied individually to find out their effect on overall air quality. The first focus of the study was the manure handling system. Two methods of removing the manure were tested, one was a washing gutter using nozzles and pressurized water to clean the dunging area (Fig. 1), and the other was a washed, inclined conveyor belt (Fig. 2). The objective was to attain zero air contamination from the manure in the room using these manure handling systems.

Results

The average ammonia emissions from the washing gutter and the conveyor belt rooms were 48.7 mg day^{-1} kg_{pig}^{-1} and 57.0 mg day^{-1} kg_{pig}^{-1}, respectively. Even though these emissions were 38% and 47% lower than previous observations from grower-finisher rooms with a conventional pit-plug design in the same swine building, both systems failed to achieve near zero ammonia emissions. There were no differences at a statistically significant level ($P>0.05$) between the ammonia emissions from the two manure handling systems nor among the three frequencies tested (Fig. 3).

Implications

Another manure handling system will have to be found to achieve zero contamination levels for testing of the origin of contaminants. The washing gutter system is recommended for health and productivity testing with a range of contamination levels, as it was simpler and easier to operate than the conveyor belt system.

Acknowledgments

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Figure 1. Water nozzles used to wash the manure from the gutter portion of the pen.

Figure 2. Conveyor belt system used to remove manure from the pen.

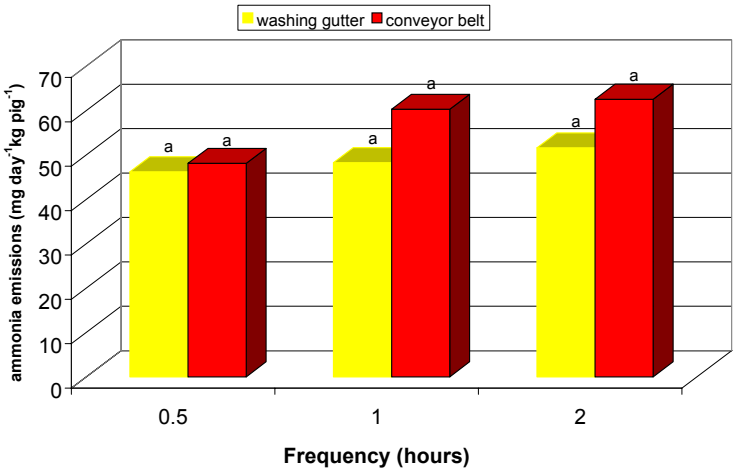

Figure 3. Average ammonia emissions from the experimental chambers over all the trials. Averages followed by the same letter are not significantly different (P>0.05).

The Effects of Crowding on the Performance of Grower and Finisher Pigs on Fully and Partially Slatted Floors

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Summary

Crowding affects the productivity of grow/finish pigs and it is generally believed that floor types differ in required space. This study was designed to determine if there is a significant interaction between the two factors. Crowding resulted in a reduction in ADG, but the type of flooring did not make a difference.

Introduction

Floor space allowance remains one of the more contentious issues in the debate on modern farm practices and animal welfare. It is generally believed that space requirements for maximum growth will vary with housing conditions. The Code of Practice recommends that pigs on partially slatted floors be provided with more total floor area than those on fully slatted floors. However, some research has suggested that there are no differences in the effect of crowding on these two floor types. This study was conducted to gain a better understanding of space required for pigs housed on either fully or partially slatted floors.

Results and Discussion

ADFI was not affected by floor type or floor space allowance in either the grower or finisher phases. ADG tended to be less on partially than on fully slatted floors during the grower phase (1.036 vs. 1.072 ± 0.010 kg/d, P = 0.08), but did not differ in the finisher phase. Pigs on the lowest floor space allowance grew slower than pigs on the other two space allowance treatments (1.013 vs. 1.067 and 1.083 ± 0.010 kg/d, for 0.38, 0.54, and 0.78 m^2/pig, respectively; P = 0.001) during the grower phase (Figure 1). ADG tended to be reduced by crowding during the finisher phase (0.953 vs. 1.001 ± 0.013 kg/d, for 0.54, and 0.78 m^2/pig, respectively; P = 0.06) (Figure 2). There were no significant interactions between floor type and space allowance.

Conclusion

Although crowding to a space allowance coefficient of 0.026 resulted in a reduction in ADG, there was no evidence that this effect differed depending on whether the floor was fully or partially slatted.

Acknowledgements

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

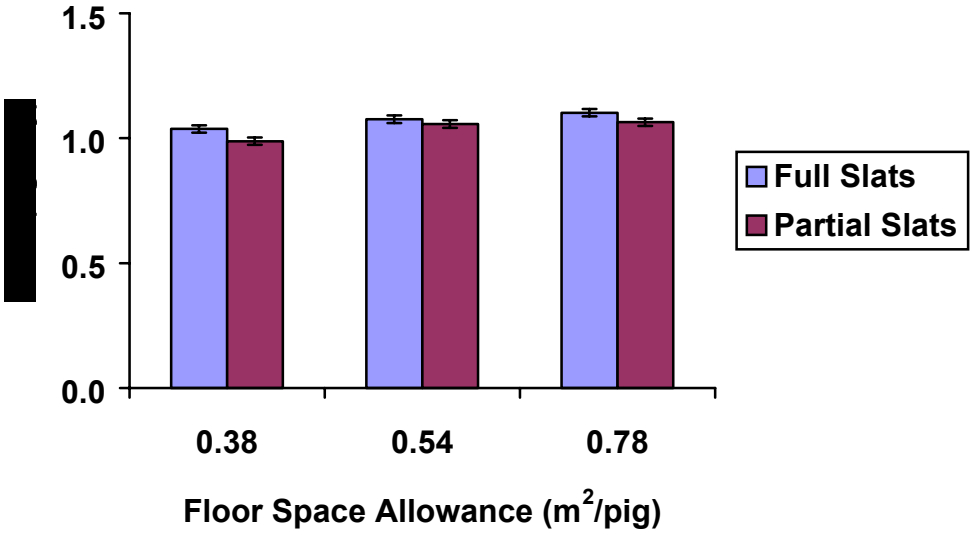

Figure 1. Effect of floor space allowance and floor type on average daily gain (ADG) of pigs during the grower phase.

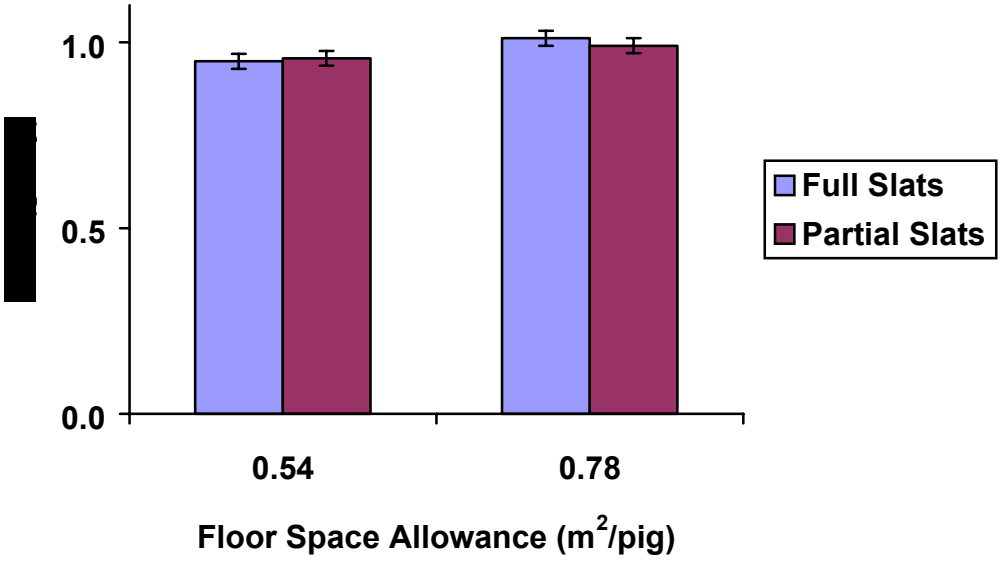

Figure 2. Effect of floor space allowance and floor type on average daily gain (ADG) of pigs during the finisher phase.

Effects of Stall Width and Sow Size on Behaviour of Gestating Sows

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Summary

It is recommended that gestating sows of various weights should be kept in different sizes of stalls. However the proper size of stall has not been well defined. A study was conducted to evaluate stall width by assessing the interaction between stall width and sow size on behaviour. As stall width decreased, sows spent less time standing, more time sitting, and their udders extended into the adjacent stall more frequently. Using udder extension during less than 50% of lateral lying as a criteria for stall width, a 65 cm (26") stall is adequate for gilts and small sows, but a 70 cm (28") stall is required for larger sows if in stalls for the entire gestation period.

Introduction

Gestation stalls are usually uniform in size within a farm in North America despite the wide range in body weights among gestating sows (150 to 350 kg). The adequacy of typical stalls to accommodate large sows is questioned. The Code of Practice suggests producers use different sizes of stalls to accommodate various sized sows. However the proper stall size for sows of different body size is not well defined. As an inadequate stall size is likely to affect the behaviour of the sow, a study was conducted to evaluate stall width by determining the effects of stall width, sows size and the interaction on sow behaviour.

Results and Discussion

At post breeding, average body weights of gilts, small, medium and large sows were 145, 180, 216, and 259 kg, respectively, and the animals gained 60-80 kg during pregnancy (Table 1). At wk 14 of gestation, sows spent more time lying (82.5% vs 77.5% of their total time; $P<0.001$) and less time standing (14.4 vs 19.8%; $P<0.001$) than at wk 4. The proportion of time spent standing increased in wider stalls (Fig 1, $P=0.02$), but sitting decreased ($P=0.001$). Extension of the udder into the adjoining stall was expressed as a proportion of time spent lying laterally. This increased from wk 4 to wk 14 (20.8 vs 60.0%; $P<0.001$), with larger sows (51.0 vs 77.8%, for gilts and large sows during wk 14; $P=0.01$) and in narrower stalls (23.5 vs 91.7%, for 70 and 55 cm stalls during wk 14; $P<0.001$). Extension of the udder into the adjoining stall was significantly affected by the interaction of stall width and sow size ($P<0.05$), indicating that large sows in narrower stalls were quite crowded (Fig 2). Using the criteria that the udder should not extend into the adjoining stall more than 50% of the time that a sow is lying on her side, we suggest that a 55 cm stall is suitable for gilts and small sows, a 60 cm stall for medium sows, and a 65 cm stall for large sows during the early stage of gestation (wk 4), as would be the case if sows were moved into group housing after implantation. But in later stages (wk 14) gilts and small sows should be housed in 65 cm, and medium and larger sows in 70 cm stalls.

Conclusions

Pork producers should use a variety of stall widths to accommodate various sized gestating sows. If stalls are used for the entire gestation period, 65 cm stalls appear to provide adequate space for gilts and small sized sows, and 70 cm stalls for larger sows.

Acknowledgements

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

Table 1. Body weight of animals.

Item	Gilts	Sows		
		Small	Medium	Large
N	39	47	45	53
Ave.parity	0	1.4	2.8	4.8
BW1, kg	145±13	180±14	216±10	259±21
BW2, kg	223±20	250±24	282±21	316±22
ΔBW, kg	78	70	64	57

BW1 = average body weight post breeding
BW2 = average body weight before farrowing
ΔBW = BW2 – BW1

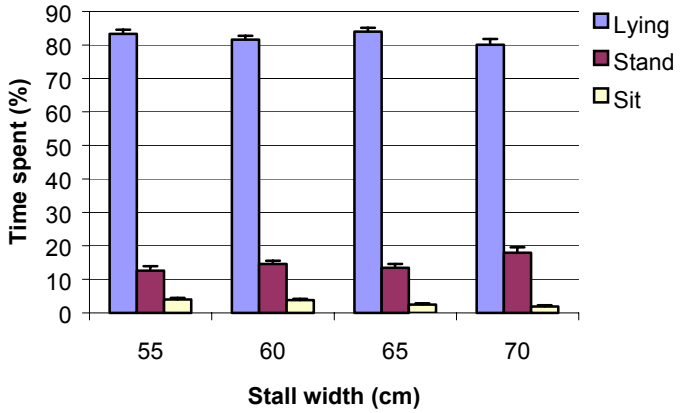

Figure 1. Time budget (as % of total time) for each posture at wk 14 of gestation.

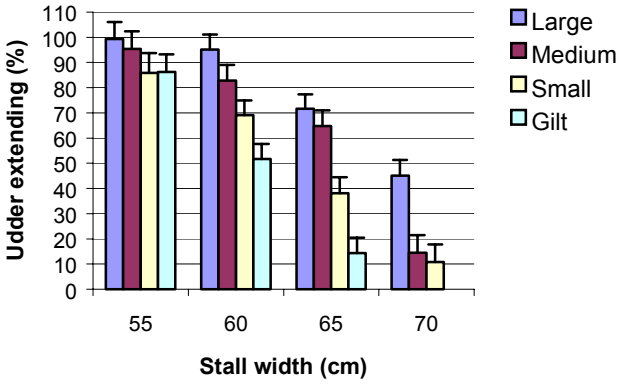

Figure 2. Time spent (as % of lateral lying time) with udder extending into the adjacent stall at wk 14 of gestation.

Dietary Phytase Reduces Phosphorus Excretion by Weanling Pigs*

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Summary

Excessive phosphorus (P) output in the manure is a concern because it can leach into groundwater and/or may limit manure application onto certain lands. The addition of phytase enzyme to the diet of weanling pigs decreased total and water-soluble P output in the manure. This effect was reduced when dietary calcium was high relative to P (Ca:P ratios above 1.7:1). Phytase had only modest effects on performance.

Introduction

The use of phytase in pig diets is rapidly increasing as extensive research has documented its efficacy in improving the digestibility of phosphorus (P) in cereal grains. This allows diets to be formulated with less total P (tP), resulting in decreased P output in the manure and potentially reducing feed costs. It is well known that when diets are formulated with less total P, the dietary calcium:P ratio (Ca:P) becomes extremely important in terms of maximizing the utilization of P. As the industry moves to diets with little or no excess P present, and the use of phytase increases, the need to clarify the Ca:P ratio increases.

It has been suggested that the environmental benefit of reduced phosphorus output in manure is partially dependent upon the solubility of the excreted P. If the use of phytase results in a greater proportion of the P excreted to be water soluble, then the environmental benefits may be reduced.

The objectives of this experiment were to: 1) examine the effect of the dietary Ca:P ratio on phytase efficacy, and 2) determine the effect of the phytase enzyme on the amount and form of the excreted P

Results and Discussion

In experiment 1, there was a modest improvement in growth rate with the added phytase. Phytase had no effect on feed intake and therefore feed efficiency improved. Figure 2 shows the effect of phytase on the amount of phosphorus excreted. Total excreted P ranged from about **4 g/pig/day** when dicalcium phosphate was added to the diet (0(0.31) treatment) to **2.1 g/pig/day** when the diet contained no added dicalcium phosphate and 1000 U/kg phytase enzyme (1000(0.43) treatment). Additionally, the P excreted as soluble inorganic (hatched bars) ranged from 75 to 80% of total P and was not affected by treatment. Therefore, the pattern of excretion of the soluble inorganic P was similar to total P; ie. decreased with the addition of phytase.

The beneficial effect of phytase on the excretion of total and soluble P was repeated in experiment 2 (Figure 3). Moreover, this experiment demonstrated that the effect of phytase is mitigated when the dietary Ca:tP ratio exceeds 1.7:1.

Conclusion

The addition of phytase enzyme to the diet of weanling pigs resulted in approximately 1.4 g/d per pig less P excreted compared to the same diet with the phosphorus provided from an inorganic source (dicalcium phosphorus). The effectiveness of phytase is reduced at Ca:P ratios above 1.7. We saw no effect of phytase on the proportion of P excreted that was water soluble. Phytase allows us to formulate diets containing less total P and effectively reduces the excretion of total and soluble P.

Acknowledgements

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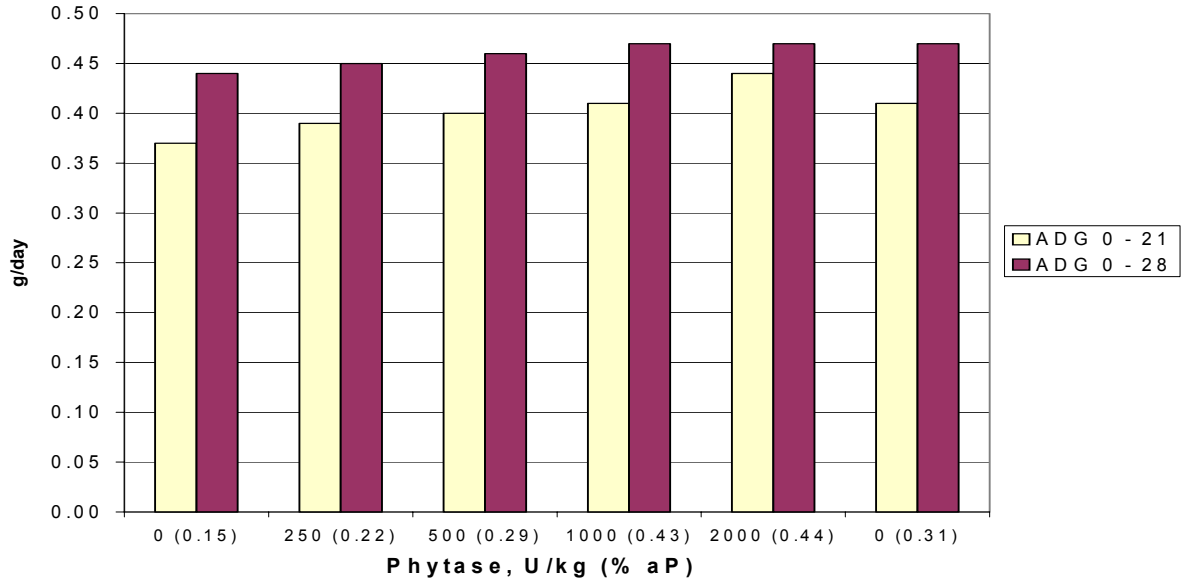

Figure 1. The effect of 0, 250, 500, 1000, or 2000 U/kg phytase on the ADG of weanling pigs (initial weight, 6.52 kg) during the initial 3 weeks of the trial (d0-21) or over the entire experimental period (d0 – 28). Numbers in parentheses refer to the calculated available phosphorus (aP). Dicalcium phosphorus was used to increase the aP concentration in the 0(0.31) treatment.

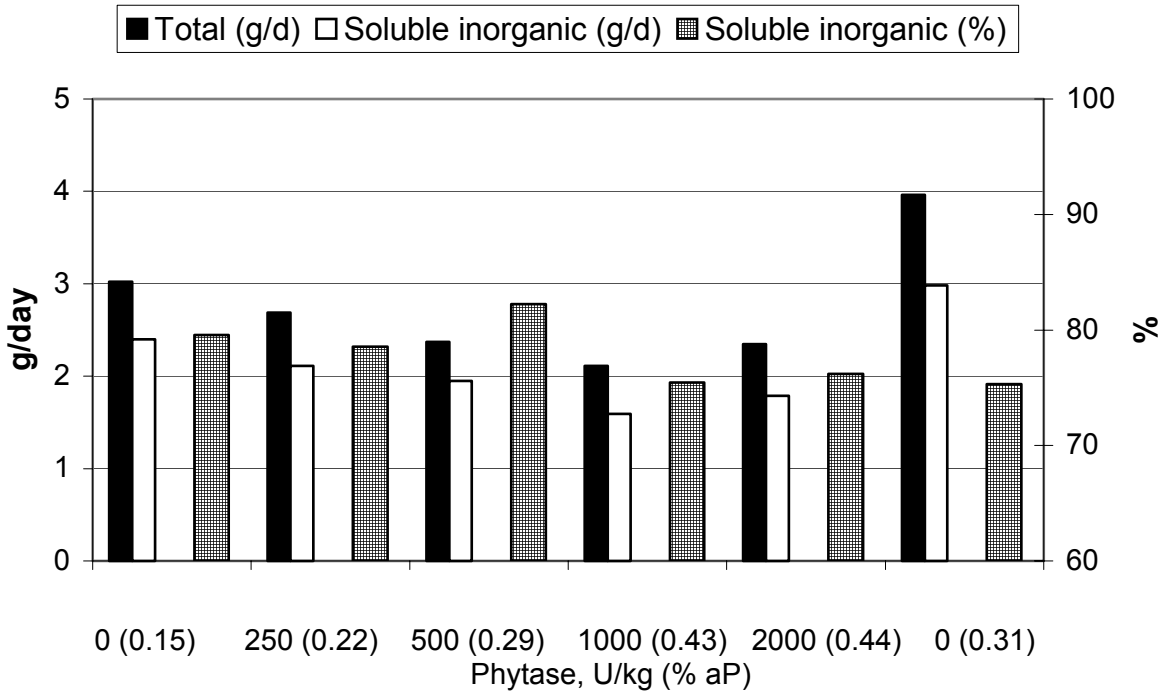

Figure 2. The effect of phytase on the excretion of total (solid bars, left axis) or soluble inorganic phosphorus (open bars, left axis) or soluble inorganic P expressed as a proportion of total P excreted (hatched bars, right axis). Numbers in parentheses refer to the calculated available phosphorus (aP). Dicalcium phosphorus was used to increase the aP concentration in the 0(0.31) treatment. Initial bodyweight averaged 21 kg.

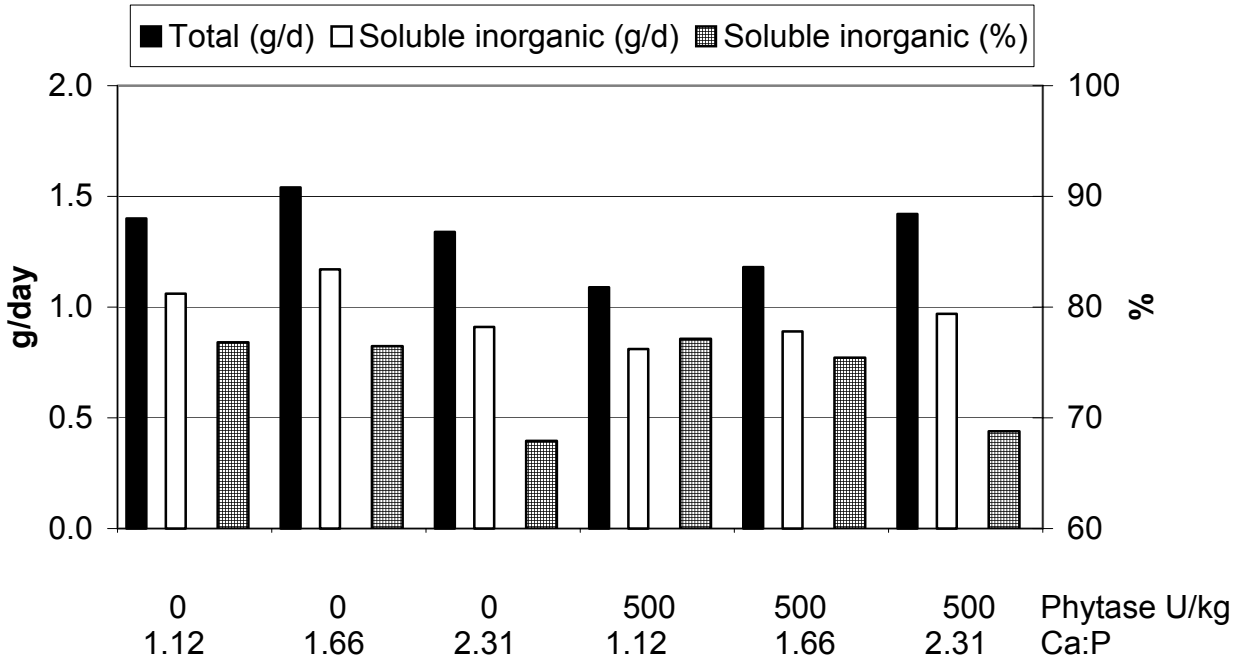

Figure 3. The effect of phytase and the dietary Ca:P ratio on the excretion of total (solid bars, left axis) or soluble inorganic phosphorus (open bars, left axis) or soluble inorganic P expressed as a proportion of total P excreted (hatched bars, right axis). Numbers in parentheses refer to the calculated available phosphorus (aP). Dicalcium phosphorus was used to increase the aP concentration in the 0(0.31) treatment. Initial bodyweight averaged 9.1 kg.