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# Evaluation of methicillin-resistant *Staphylococcus aureus* (MRSA) colonization in pigs and people that work with pigs in Ontario

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## Background and Justification

Methicillin-resistant *S. aureus* (MRSA) is a critically important cause of illness and death in people. Recently, there has been increasing evidence that MRSA may be transmitted between animals and humans, on both directions. Much attention has been paid recently to the potential role of pigs in human MRSA infections, particularly risks for pig farmers, pig veterinarians and their families. Various studies from Europe have identified high rates of MRSA carriage by people that have contact with pigs, and have identified MRSA infections that are linked to pigs. No studies have been carried out in North America.

## Objectives

1) To determine the prevalence of MRSA colonization of pigs and farmers in Ontario.
2) To compare MRSA isolates from pigs with their human contacts (pig farmers) and to compare porcine and pig farmer isolates with MRSA from humans and other animals in North America and Europe.

## Results and Discussion

Nasal and rectal swabs were collected from 285 pigs on 20 farms: 85 (30%) suckling pigs, 95 (33%) weanlings and 105 (37%) grower-finishers. MRSA was isolated from one or more pigs on 45% (9/20) of farms. The prevalence of MRSA colonization in humans was 20% (5/25), with colonized individuals being present on 5/9 (56%) of farms where MRSA was present in pigs. The most common strain in both pigs and humans was *spa* type 539, which is similar to the MRSA found in European pigs. A second type found in a person and pigs was a common Canadian human strain. The reasons for the high prevalence of MRSA colonization in pigs both in Canada and in other countries remain uncertain. The presence of similar strains in pigs and their human contacts, the high prevalence of colonization of pig farmers and the possible emergence of ST398 strains as a cause of clinical infections in humans indicates that MRSA in pigs may pose a public health risk to human contacts.

## Take Home Message

Identifying MRSA in pigs in Ontario has provided an early warning about the potential for MRSA to become a problem in people that work with pigs, and the general public. This may allow for a faster, more proactive approach towards investigating this potential problem.

**Funding Support - Ontario Pork**

# Dietary supplementation of soluble fiber may be effective for reducing cholesterol excretion in pigs and producing healthy pork with a reduced cholesterol content

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## Background

Hypercholesterolemia is well linked to the risk of developing cardiovascular diseases (CVD) in human health (Rideout et al., 2007, *J. Nutr*. 137: 568-572). Reducing dietary cholesterol intake is an important strategy and animal products are one of the sources. Thus, reducing cholesterol content in pork can help improve pork quality.

## Objectives

The objectives were to examine *i)* the effect of dietary supplementation of soluble fiber guar gum on whole body cholesterol homeostasis and related biological mechanisms in growing pigs fed a typical high-fat and high protein "Western" diet for reducing human CVD concerns with the pig model; and *ii)* the feasibility of feeding soluble fibers to pigs for reducing circulatory levels of cholesterol in pigs and pork.

## Methods and Procedures

Fourteen Yorkshire boars (initial body weight of 30 kg) were fed a poultry meal-based high-fat and high protein basal diet supplemented with 10% soluble fiber guar gum for 36 days according to a completely randomized block design (Rideout et al., 2007, *J. Nutr*. 137: 568-572).

## Results

- Compared with the control group, GG consumption significantly reduced circulatory plasma total and low density lipoprotein (LDL) cholesterol concentrations by 27 and 37%, respectively.

- Guar gum consumption significantly increased hepatic LDL receptor gene mRNA (1.8 fold of the control,) and protein (2 fold of the control) expressions in comparison with the control group.

## Take Home Messages

While with pigs as a valid model, we have demonstrated that consuming a suitable level of soluble fiber such as guar gum can effectively reduce blood cholesterol levels by modulating liver gene(s) with implications to human nutrition, dietary supplementation of a suitable level of soluble fiber may be effective to reduce circulatory blood cholesterol levels and producing healthy pork with a significantly reduced cholesterol content beneficial to consumers.

**Financial support from** OMAFRA-University of Guelph Food and Animal Research Programs as well as Ontario Corn's Association is appreciated.

# Enhancing the Pork Meat Quality Value Chain Part 1: Modelling variability and assessing strategies to reduce it

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**Background:**

Perceptions of quality (tenderness, juiciness, flavor, appearance) are a large factor in the purchase of pork meat by consumers, and inconsistent quality is one of the greatest barriers to repeat purchases. The project has previously surveyed the variability in pork meat quality produced in Ontario and collected data on approximately 50 factors that can be contributing to it. The current work has been evaluating the sources of variability and devising trials aimed at minimising undesirable quality.

**Objectives:**

1. Evaluate the major production, behavioral, nutritional and genetic factors contributing to this variability.
2. Identify management strategies to improve the quality of pork produced in Ontario

**Experimental Procedures:**

1. Fifty-six parameters were recorded in a survey of animal behavior, packing plant conditions and subsequent pork meat quality in 672 hogs, from 28 cohorts of animals representing a wide range of commercial operations in Ontario as well as some research farm cohorts. Multivariate statistical analysis (Partial Least Squares) was used to model the factors that had the greatest influence on meat quality.
2. Two behavioral management strategies were implemented to decrease stress in animals by conditioning them to human interaction; "Pen walking" (i.e. humans walking through the animal pens once per day) and practice "crowding" of animals by handlers using boards either into pen corners or through doorways. Three nutritional strategies have also been assessed: Addition of (a) tryptophan; (b) a low glucogenic diet (based on beet pulp); (c) Ractopamine ("Paylean").

**Results to date:**

1. Variations seen in phenotypic measures on meat quality in commercial practice were consistent with the results of a previous US survey (Kauffman et al, 1992; NPPC, Des Moines, Iowa ). Colour ($L^*$value) ranged from 5-62 and drip loss ranged from 2.69 to 12.54% across both loin and ham. Warner-Bratzler (WB) shear force values ranged from 1.67-5.43 Kg in ham samples and from 2.06-7.66 Kg in loin samples. Ultimate pH for loin was negatively correlated with loin color and loin and ham drip loss, and positively correlated with initial and final ham pH. Similarly, the $pH_u$ of ham was negatively correlated with ham shear (tenderness), color (L*) and drip loss, and positively correlated with initial ham pH and initial and final loin pH. From the multivariate analysis, the factor affecting color, toughness and drip loss was the difference between the individual producers and the differences between kill date at the packing plant (these two factors are combined together, and account for 16-33% of overall variability, depending on which quality parameter is examined). There are indications that factors such as the temperature at the packing plant are significant sub-factors within this. Animal temperament was also identified as a linking factor.
2. Both behavioral management strategies are effective in significantly improving water-holding capacity in the pork end-product, so increasing yield, with "pen walking" being the most effective. In trials of nutritional strategies, no significant impact on either growth performance or meat quality was found with tryptophan. The low glucogenic diet showed increased feed efficiency over control diets, tending to produce pork with less marbling and increased tenderness. Ractopamine increased feed efficiency but there are concerns about decreased tenderness at high levels of use.

**Take-home message**

Variations in Ontario pork quality are consistent with those seen elsewhere in North America. There is the potential to improve quality by removing outliers representing extremes of poor quality. Behavioral strategies are effective in improving the water-holding of pork.

**Acknowledgments -** The authors would like to thank Ontario Pork and NSERC for their financial support.

# Enhancing the Pork Meat Quality Value Chain Part 2: Gene expression and biochemical pathways leading to unwanted quality variations

**P.P. Purslow, C.F.M. de Lange, I.B. Mandell, T. Widowski, J. Brown, A. Robinson, E.J. Squires, G. van der Voort and M.C. Cha**

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**Background:**

Perceptions of quality (tenderness, juiciness, flavor, appearance) are a large factor in the purchase of pork meat by consumers, and inconsistent quality is one of the greatest barriers to repeat purchases. Although we understand how individual factors (e.g. breed, handling stress, or post mortem chill temperature) affect meat quality, the interactions between factors and the mechanisms leading to extreme variations in quality are unknown. In this work, gene expression and biochemical analyses aim to show the basic mechanisms leading to unacceptable pork quality.

**Objectives:**

1. Evaluate associations between the proteolytic enzyme activity in pork and its waterholding, tenderness and color
2. Identify changes in gene expression which are associated with extremes of quality.

**Experimental Procedures:**

Ham and loin muscle sample was collected at sticking from the 672 hogs described in Part 1 of the project. Subsets of animals representing extreme highs and lows in shear force, drip loss and colour (L-value) were selected. Calpain activity was assayed by zymography. Gene expression was studied by an Affymetrix porcine gene expression microarray and a human competitive microarray

**Results to date:**

With the Affymetrix gene expression arrays, 281 genes were found to be significantly up regulated and 106 were found to be significantly down regulated relative to pigs with high drip loss A subset of these 387 genes of 30 up and 16 down regulated genes was selected on the basis of biological interest. Using the competitive arrays, 10,089 differentially expressed genes that were detected. Of these, 184 were identified that showed a statistically significant change ($P<0.05$). Gene ontology analysis was used to identify 4 specific gene clusters of interest with genes associated with (1) the ribosome, (2) nucleic acid metabolism, (3) electron transport, or (4) proteolytic activity. Increased proteolytic activity, as measured by calpain activity in the post-mortem muscle, showed a relationship to decreased drip loss in simple correlations on these subsets of samples, but was not a prime factor in a larger multivariate analysis of the entire 672 animals in the main study. .

**Take-home message**

Variations in gene expression are apparent between pork meat with high and low drip loss, shear force and color attributes. We are using this information to identify candidate pathways leading to poor quality pork.

**Acknowledgments -** The authors would like to thank Ontario Pork and NSERC for their financial support.

# Progress in Reducing the Pale, Soft and Exudative (PSE) Problem in Pork and Poultry Meat

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**Background:** Over the past five decades, there has been a substantial amount of work in the pork meat quality area where a number of genetic markers have been identified, and are currently used to remove susceptible animals from the herd. Some of the markers are linked to aberrant calcium regulation in the early postmortem muscle.

**Results and Discussion:** Research findings in the area of the pale, soft and exudative (PSE) pork meat were discussed in a recent review article with an emphasis on genetic, biochemical and metabolic factors contributing to the problem (Barbut et al., 2008). Environmental factors such as ante-mortem stress and early postmortem processing practices (e.g. chilling rate) that can influence the development and severity of the PSE phenomenon were also discussed, since they appear to be critical in the expression and magnitude of the problem. Several of these factors are known to cause protein denaturation at the early stage of postmortem and directly contribute to poor water holding capacity and inferior texture in fresh meat which is later translated into processed products. A newer hypothesis suggesting that variation in protein oxidation, in response to ante-mortem stress and early postmortem tissue environment, can contribute to development of PSE pork is also presented.

**Take Home Message:** Over the years there has been a substantial amount of work in the area of PSE meat, trying to understand and isolate the problem, so it can be reduced in the market place. This has involved the work of geneticists, producers, meat scientists, and marketing people. Estimates of annual losses, around the word, due to poor quality meat and reduced water holding capacity are measured in millions of dollars. Further research to reduce the impact of the PSE problem on meat quality is warranted and areas for further research are suggested.

**Acknowledgments:** the contribution of Genus/P.I.C., Iowa State University, Nicholas, and B.U.T. is greatly appreciated.

**Reference:** Barbut, S.,.A. Sosnicki, S.M. Lonergan, T. Knapp, D.C. Ciobanub, L.J. Gatcliffee, E. Huff-Lonerganc, E.W. Wilson. 2008. Progress in reducing the pale, soft and exudative (PSE) problem in pork and poultry meat. Meat Science 79: 46-63.

# Modelling copper and zinc utilization in growing pigs

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## Background

In order for the pork industry to remain competitive and environmentally sustainable, effective management strategies for growing-finishing pigs are required in which both economic and environmental impacts are considered. Zinc (Zn) and copper (Cu) are essential trace elements, which are usually supplemented due to poor availability from plant sources. However, Zn and Cu are often oversupplied in pig diets because large safety margins are applied or because of their growth promoting effect. Excessive Zn and Cu accumulation in soils occurs in areas of intensive animal production, which may cause phyto-toxicity of cultivated plants. Furthermore, heavy metals accumulate in the top layer, with consequences not only for plant growth but for human health and soil life.

## Objective

To develop Cu and Zn excretion models based on literature data.

## Methods

A database containing Zn balance data for 933 pigs in 10 experiments and Cu balance data for 672 pigs in 6 experiments was constructed from the literature. All datasets were derived from experiments conducted in the United States (Michigan, Iowa and Missouri), Denmark and Finland. The database contained information on diet, dietary Cu and Zn intake, and Cu and Zn excretion. The PROC MIXED procedure in SAS was used for analysis.

## Results

The models show that up to 93% of Cu intake and 90% of Zn intake ends up in manure. For maintenance, growing pigs need to absorb an average of 4.5 and 21 mg/d Cu and Zn, respectively. National requirements for growing pigs for Cu and Zn are 5-6, and 50 ppm in the diet, respectively. The linear models agree with the National Research Council estimate of 70 – 95% excretion for Cu and Zn intake, which contributes significantly to nutrient loading in the soil.

## Take home message

There is a linear relationship between Cu and Zn intake and excretion in manure. Currently up to 300% of heavy metal requirements are applied routinely in swine diets. They need to be reduced significantly to avoid problems with phyto-toxicity, and human and soil health.

**This project was supported by OMAFRA and the OMAFRA-University of Guelph Animal Research Program.**

# Dietary true digestible calcium to phosphorus ratio affects growth performance and phosphorus utilization in post-weaned pigs

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## Background

Swine diets should be formulated on the basis of true digestible phosphorus (P) supply in order to reduce feeding cost associated with supplemental inorganic phosphate and manure P excretion (Shen et al., 2002, *J. Nutr.* 132:1199-1206). Dietary Ca to P ratio is known to affect performance in pigs. However, true digestible dietary Ca to P ratio is not established and little is known about its effect on efficiency of nutrient utilization in pigs.

## Objectives

The objective of this study was to determine the effect of changes in dietary true digestible Ca to true digestible P ratio on growth performance, efficiency of nutrient utilization and manure P excretion and to recommend an optimal dietary true digestible Ca to true digestible P ratio for post-weaned pigs fed corn and soybean meal (SBM)-based diets.

## Methods and Procedures

A total of 48 Yorkshire pigs with an average initial body weight of 11 and 17 kg were fed corn and SBM based diets in two experiments to measure *i)* true Ca and P digestibility by the substitution method (Fang et al., 2007, *Lives. Sci.* 109: 251-254) in experiment-1; and *ii)* the effect of Ca/P ratio (6 levels) in experiment-2 according to a complete randomized block design.

## Results

- Changes in the dietary Ca to P ratio had significant effects on average daily feed intake and average daily gain with optimal responses occurred in true digestible Ca to true digestible P ratio of 0.96:1 to 1.35:1.

- Changes in the dietary Ca to P ratio had a significant effect on the apparent fecal dry matter digestibility. Increases in the dietary Ca to P ratio increased efficiency of digestive and post-absorptive utilization of dietary Ca. Increases in the dietary Ca to P ratio had effects on efficiency of digestive and post-absorptive utilization of dietary P with optimal responses observed for true digestible Ca to true digestible P ratio of 0.96:1 to 1.35:1.

## Take Home Messages

Changes in dietary Ca to P ratio have significant effects on growth performance, efficiency of P utilization and manure P excretions in post-weaned pigs. Dietary true digestible Ca to true digestible P ratio of 0.96:1 to 1.35:1 is the optimal value range and should be used to guide the formulation of diets for the post-weaned pig.

**Financial support from Ontario Pork and OMAFRA-University of Guelph Animal Research Program is appreciated.**

# Dietary supplementation of resistant starch may be effective for reducing the manure key odor compound indole impact from growing pigs

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## Background

Swine odor arising from major volatile smelly compounds such as sulfides, indoles and skatole is a growing environmental concern facing the intensive swine production. Dietary supplementation of soluble fiber has been shown to alter the patterns of microbial fermentation in the large intestine to reduce the biogenesis and excretion of major odor-causing compounds in the pig during feeding (Rideout et al., 2004, *J. Anim. Sci.* 82:1678-1684).

## Objectives

The objectives were to examine the effect of dietary supplementation of three types of resistant starch: granular high amylose cornstarch (GCS), granular potato starch (GPS) retrograded high amylose maize starch (RCS) as well as a conventional soluble fiber guar gum (GG) and a insoluble fiber cellulose (CELL) compared with a normal cornstarch on large intestinal fermentation in growing pigs fed a typical high-fat and high protein "Western" diet for *i)* human gut health with the pig model; and *ii)* pig nutrition focusing on biogenesis of odor compounds.

## Methods and Procedures

Thirty six pigs (initial body weight of 30 kg) were fed poultry meal-based diets supplemented with 10% GCS, GPS, RCS, GG or CELL for 36 days according to a completely randomized block design (Rideout et al., 2008, *Br. J. Nutr.* – in press).

## Results

- Cecal butyrate concentration was significantly increased following consumption of RCS and GG in comparison with the control group.

- Consumption of all three types of resistant starch significantly reduced cecal indole concentration compared with the control.

## Take Home Messages

Dietary supplementation of resistant starch may be effective to reduce manure indole concentration and to promote gut health by producing more butyrate as conventional soluble fibers in growing pigs.

**Financial support from** OMAFRA-University of Guelph Food and Animal Research Programs as well as Ontario Corn's Association is appreciated.

# Is severe porcine circovirus-associated disease (PCVAD) caused by a new strain of porcine circovirus 2?

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## Background and Justification

In 2005 the Animal Health Laboratory at the University of Guelph reported a huge increase in cases diagnosed as Porcine Circovirus type 2 (PCV2)- associated disease. A possible explanation for the outbreak of severe PCVAD in Canada was that the strain of Porcine Circovirus changed. The Animal Health Laboratory showed that the PCR-RFLP type of PCV2 virus previously isolated was mainly type 422 and in late 2004 type 321 appeared. When 4 Ontario RFLP type 321 viruses were sequenced they were all found to have greater than 98% homology with the PCV2 viruses from France and the UK and only 92% homology with the old "strain" 422. It was hypothesized that the more severe clinical signs observed in 2005 and 2006 were a result of the introduction of a new and more virulent strain of PCV2.

## Objective

To determine if the new PCV2 virus (321) was present in herds that had experienced a severe PCVAD outbreak causing greater than 5% mortality in grower-finisher pigs and characterized by wasting and other clinical signs, and absent in herds that had not experienced such a problem.

## Results and Discussion

PCV2 virus with RFLP 321 (the new strain), was the only type of PCV2 isolated except for one farm where the old 422 strain was found. The one farm with the old strain was a case farm that had a very severe form of the disease beginning in early 2005. We were not always able to identify PCV2 from each farm. This was particularly the case in herds using PCV vaccine (which were generally the case farms). When we found PCV2 on control farms it was always the new 321 strain. These farms for the most part were not using a vaccine. Clearly type321 has become the predominant strain of the virus in Ontario, and this shift must have occurred relatively quickly and is now widespread.

## Take Home Message

The finding of PCV2 RFLP 321 on a farm does not necessarily mean that the herd will encounter the severe form of PCVAD characterized by high grower-finisher mortality. There appears to be no diagnostic value in differentiating PCV in this way.

**Funding -** Ontario Pork and the University of Guelph-OMAFRA Sustainable Production Systems Program.

# The effect of coccidiosis on post-weaning performance

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## Background and justification

In 2006, a study was carried out on 50 farms in southwestern Ontario to determine the prevalence and impact of coccidia (*Isospora suis*) in pigs at 7 to 21 days of age. Coccidia were found on 35 (70%) of the farms, and litters that had coccidia were 4-times more likely to have diarrhea than non-infected litters. In addition, coccidia-positive farms had a mean standardized weaning weight that was 400 g lighter compared to non-infected farms. Collectively, these data indicated that coccidia infections occur commonly on Ontario swine farms and are a cause of diarrhea at 7-21 days of age. Whether or not pigs older than 3 weeks of age are affected is not known.

## Objective

To determine the impact of coccidia infections in pigs up to 8 weeks of age.

## Results and Discussion

Weights were obtained from 685 pigs from 72 litters, with 49 litters infected with *I. suis*. Of the 218 pigs that were sampled on 3 separate farms (3 random piglets per litter), 162 were detected positive for coccidia on at least one occasion. Furthermore, infections were detected in weaned pigs up to 5 weeks of age. Analysis of the weight and coccidia data indicated that:

- At 4 weeks of age, pigs that originated from litters that were positive for coccidia at 2 or 3 weeks of age were on average 435 g lighter than pigs that originated from litters that were negative for coccidia ($p=0.065$).

- At 5 weeks of age, pigs that originated from litters that were positive for coccidia at 2 or 3 weeks of age were on average 703 g lighter than pigs that originated from litters that were negative for coccidia ($p=0.007$).

## Take Home Message

Coccidia are a common cause of diarrhea and reduced growth rate in suckling piglets and weaned piglets in Ontario. At present there are no licensed products to treat this disease so control needs to be directed towards sanitation in order to reduce the challenge dose of coccidia from the environment.

## Funding

This project was funded in part through contributions by Canada and the Province of Ontario under the Canada–Ontario Research and Development (CORD) Program, an initiative of the federal-provincial-territorial Agricultural Policy Framework designed to position Canada's agri-food sector as a world leader. The Agricultural Adaptation Council administers the CORD Program on behalf on the province. Ontario Pork also provided financial assistance.

# A field trial to assess the efficacy of an inactivated subunit vaccine (Porcilis ® PCV) against porcine circovirus type 2 (PCV2) in a Canadian pig herd with PCV2-associated disease

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## Background and justification

A similar product to Porcilis® PCV (PCV2 vaccine from Intervet US) has been shown to be safe and effective under controlled (laboratory) conditions and in a Canadian field study. On almost every farm mortality was lower and growth was better in vaccinated animals as compared to historical unvaccinated controls. This trial was carried out to collect field data for product registration, both in Canada and in Europe.

## Objectives

The primary objective of this trial was to assess the efficacy of Porcilis® PCV in reducing mortality and improving growth performance compared to controls receiving water for injection, in a Canadian pig herd where PCV2-associated disease had been diagnosed as a serious problem

## Results

Growth rate was similar between the vaccinated pigs and the control animals as measured by the mean ADG, with vaccinates growing at 749 g per day and controls at 744 g per day from weaning until shipping to market. Growth was better ($P<0.05$) for vaccinated pigs in the grower phase (838g per day vs. 878g per day for control and vaccinates, respectively). Three vaccinated pigs died (1.5%), and PCV2 was not detected from these animals and the post mortem findings were not indicative of a PCVAD infection. Among the control animals 9 pigs died (4.5%) and 4 of these pigs showed lesions consistent with a PCVAD diagnosis with PCV2 identified by PCR. It is possible that vaccinated pigs housed in the same pen as controls reduced the challenge faced by the non-vaccinated animals because mortality in this trial was less than historical levels of >10%. Based on results from an ELISA on serum obtained from control and vaccinated pigs, there was a difference in the proportion of pigs positive to antibodies to PCV2 at 9 weeks of age, with vaccinates demonstrating higher levels of antibodies to PCV2 compared to controls ($P<0.01$). Using Polymerase Chain Reaction (PCR), pigs in the control group were more likely to test positive for PCV2 at end of the finishing stage compared to vaccinated pigs ($P<0.01$). There was no difference between the two groups for the presence or absence of PCV1.

## Take home message

Vaccination of pigs at weaning and 3 weeks later with Porcilis® PCV stimulated immunity as noted by a rise in antibody response and resulted in protection from PCV2 infection based on an absence of PCVAD mortality in the vaccinated pigs.

**This trial was funded by Intervet**

# Evaluation of the completeness of data and data collection tools of a swine veterinary-based surveillance system

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## Background

There is an increasing interest in obtaining farm level data through veterinarians for real-time surveillance, due to the growing concern of emerging and re-emerging diseases in swine populations. Veterinary-based surveillance systems have been implemented in some countries for cattle however information on swine veterinary-based surveillance is limited and to our knowledge there are no studies that have evaluated their performance.

## Objectives and Methods

The objective of this study was to evaluate a swine sentinel surveillance system based on the completeness of the data captured and the usefulness of data collection tools. A pilot study with 13 volunteer swine practitioners from 9 clinics began in the summer of 2007. The veterinarians summarised the number of farm visits and calls according to the type of production, body system affected and in what manner production was affected. Epidemiological data and information on treatment response was also recorded. The data were collected either on carbon paper forms, a personal digital assistant (PDA) Palm®, or by an internet-based form.

## Results

A total of 7/13 (61.5%) veterinarians from 5/9 (66.6%) clinics sent information on a routine basis. A total of 743 records of farm visits and/or calls were received from July to December 2007. Issues related to recording farm location were reported from clinics not sending information. However, master lists with farm location were provided from participating veterinarians. Among participating clinics, major concerns revolved around providing actual estimates like farm size, number of animals affected or estimates of mortality or morbidity. Sections of the form where information was recorded in check boxes were consistently reported. Fields related to production systems, area affected, body systems involved, production parameters affected and treatment efficacy were completed in 80%, 72%, 96.2%, 75.3% and 81.7%, respectively.

Four veterinarians used the PDA to record data and 3 used the paper forms. Data from PDA-users were more likely to be received on a weekly basis whereas those using carbon-forms often mailed forms on a bi-weekly or monthly basis. The internet-based form was never used by any of the clinicians.

## Take Home Message

Data collection forms for a veterinary-based surveillance system should have relevant epidemiological and disease information that can be easily recorded on the farm. The information should be consistent with the type of the disease information routinely collected/observed by veterinarians to increase acceptability. The recording of actual estimates such as number of animals affected may not be practical for swine disease surveillance based on the structure of many farms and the manner in which diseases are diagnosed by swine

practitioners. The PDA (Palm) was cost effective, user friendly, and worked as an incentive for reporting the data.

**Financial support**
Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) and the Food Safety Initiative of the Canadian Food Safety & Quality Program of the Agriculture Policy Framework.

# Evaluating the utility of medication sales information as a data source for veterinary disease surveillance

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## Background

The ability to predict emerging diseases remains a difficult challenge. Many countries have recognized the importance of surveillance systems and have begun to design and implement animal disease surveillance networks. A general deficiency in these systems is finding appropriate aggregates of health information (data) to monitor for the detection of disease outbreaks. A novel health data source for the rapid identification of human disease outbreaks that appears to be useful is the monitoring of medication and retail sales information of pharmaceutical products. Existing veterinary surveillance networks however, have not yet fully evaluated the utility of monitoring medication sales for animal disease surveillance purposes.

## Objectives

This research intends to develop an understanding, and clarify the usefulness, of monitoring veterinary medication sales for the implementation into a swine syndromic surveillance system.

## Methods

This project will be conducted in conjunction with the Ontario Swine Veterinary-based Surveillance (OSVS) Project that is concurrently being conducted by the University of Guelph and The Ontario Ministry of Agriculture, Foods and Rural Affairs (OMAFRA). The overall research plan is to relate the level of swine diseases recorded in Ontario swine herds to the level of medication sales over the same time period and then determine if a spatial correlation exists between the two. Spatial modelling will be developed to adjust for a number of expected confounding factors such as seasonal effects and promotional sales. It will then be determined if a relationship exists between drug sales and the epidemic curves and identified clusters of disease.

## Take Home Message

Understanding the utility of novel data sources for improving the effectiveness of animal disease surveillance is a critical step in the development of timely and effective animal syndromic surveillance systems. When the utility of medication sales information is determined for the Ontario swine industry it can then be tested and applied to other animal health industries and livestock production systems in the province.

**Financial support -** Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) and the Food Safety Initiative of the Canadian Food Safety & Quality Program of the Agriculture Policy Framework.

# Evaluation of practitioner compliance to a veterinary-based surveillance system

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## Background

There is an increasing interest in obtaining farm level data through veterinarians for real-time surveillance, due to the growing concern of emerging and re-emerging diseases in swine populations. Veterinary-based surveillance systems have been implemented in some countries for cattle. However, information on swine veterinary-based surveillance is limited, and to our knowledge there are no studies that have evaluated their performance.

## Objectives and Methods

The objective of this study is to evaluate a swine sentinel surveillance system based on the compliance of participating veterinarians. A pilot study with 13 volunteer swine practitioners from 9 clinics began in the summer of 2007. The data were collected either on carbon paper forms, a personal digital assistant (PDA) Palm®, or by an internet-based form. The Ontario Swine Veterinary-based Surveillance system (OSVS) was compared to submissions by the same veterinarians to the Animal Health Laboratory (AHL), from July to December 2007, as a means to evaluate the level of compliance. A negative difference would reflect poor compliance, since we required that submissions to OSVS include all calls/visits and not only those requiring laboratory diagnostics.

## Results

A total of 7/13 (61.5%) veterinarians from 5/9 (66.6%) clinics sent information on a routine basis. The difference between OSVS submissions and AHL submissions indicated that the quality of compliance was poor for the first three months of the project. However, similar analyses for each veterinarian indicated that periods of poor compliance occurred intermittently throughout the study period.

## Take Home Message

Weekly differences of submissions between the information obtained by a veterinary-based surveillance system and the submissions to an alternative source of swine health data might be a method to measure compliance among veterinarians. We are currently investigating if the ratios of submission to both sources of information could also be an appropriate approach to measure compliance, and if the data collection tools used may be associated with a better compliance.

**Financial support** - Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) and the Food Safety Initiative of the Canadian Food Safety & Quality Program of the Agriculture Policy Framework.

# Development of on-farm temperament tests for market hogs

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## Background

Stress at slaughter is a significant problem in the swine industry as it contributes to increases in bruising and the incidence of PSE pork, as well as being a concern for animal welfare. The stress response depends on both physical and psychological parameters, and varies significantly between animals. If some of this variation is due to differences in individual temperament, then on-farm assessment of behavioural responses may be predictive of the stress response at marketing.

## Objective

To examine behavioural tests of market hogs in group housing, with the goal of validating tests which can be applied in commercial settings.

## Methods

Behavioural responses of pigs to three temperament tests were studied using 118 market hogs at approximately 6 months. Pigs were housed in 8 pens with 7-8 pigs per pen, in two replicate trails. Tests included a human approach test (HAT), novel object test (NOT) and open door test (ODT), and were performed in the home pen on three separate days. Animals were scored on their latency to contact the human or object, or to leave the pen. On each day, the HAT was performed twice by different observers. Repeatability within test was evaluated using a repeated measures mixed model, and agreement between observers and between different tests was evaluated by GLM in SAS.

## Results

- Variation between days in the latency to perform the test was significant ($p<0.05$) with pigs showing reduced latencies over time.
- Variation between pigs was highly significant in the HAT and ODT ($p<0.001$) but not in the NOT ($p=0.182$).
- No significant day by pig interactions were found, indicating consistency within pig over the three days.
- Agreement between the two HAT observers, and between HAT and ODT measures, was significant ($p<0.001$).

## Take Home Message

The results suggest that these methods describe behavioural tendencies (temperament), which may be useful for predicting responses to handling at marketing. The tests could potentially be used for selection of calmer animals, or for assessing methods for reducing stress at marketing.

*We appreciate the financial support from Ontario Pork, NSERC and the OMAF-Animal Research Program at the University of Guelph*

# Dental development and the onset of feeding behaviour in young swine

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## Background

One consequence of early weaning is the frequent inability of piglets to successfully begin eating solid feed at weaning. Failure to consume sufficiently during this critical period can exacerbate other stressors, leading to weight loss and health problems. Currently, no consistent indicators of why piglets begin eating when they do have been identified. One area of research that has not been investigated until now is the role of dental development. Studies on miniature swine show that a lesser stage of dental development results in animals (1) chewing more slowly, and (2) requiring more chew cycles to process food. Also observed is that mastication of solid feed coincides with the eruption of molars.

## Objective

To determine whether various stages of molar eruption are associated with either feeding behaviour or the ingestion of feed in commercial piglets 0 to 4 weeks old.

## Methods

At age 5 days, 80 nursing piglets (8 litters) were offered $Cr_2O$ marked creep feed. Twice weekly, fecal swabs (indicating feed ingestion) and molar eruption were recorded. Weight was recorded weekly. Eruption was based on the proportion of tooth crown emerging through the gingiva while time at the feeder was based on 6 hours of continuous video observations each day after dental exams. Repeated measures ANOVAs (SAS, Proc Mixed) were employed to test the effects of molar development, gender, and growth on both the duration of time at the feeder and feed ingestion.

## Results

- Piglets having more than 1/3 of their mandibular molar4 erupted spent more time at the feeder overall ($p=0.018$) and were more likely to consume feed on day 23 ($p=0.036$).
- Piglets with ½ or more of their maxillary molar3 erupted spent more time at the feeder overall ($p=0.049$).
- Occlusion of both these molars increased time at the feeder overall ($p=0.038$) and increased consumption on days 20 & 23 ($p=0.049$, $p=0.043$).

## Take Home Message

These findings indicate dental development influences feed oriented behaviour and feed intake in young swine. This is the first study to investigate the relationship between tooth development, feeding behaviour and feed consumption, demonstrating the importance of including this aspect of physiology in feed related studies.

*We gratefully acknowledge the financial support offered by NSERC and OMAFRA*

# MONITORING CORE BODY TEMPERATURE IN MARKET SWINE TRANSPORTED TO SLAUGHTER

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## Background

Thermal stress is one of the major causes of mortality and fatigue during transport of market pigs. Therefore, evaluating thermal responses to environmental conditions is important for identifying problem areas and improving the welfare of pigs during commercial transport.

## Objectives

To determine the effect of trailer design and stage of the transport process on core body temperature (CBT) of pigs during transport to a commercial abattoir.

## Methods

Over six weekly trials (June-July 2007), Thermocron iButton temperature data loggers (Dallas Semiconductor, TX, USA) were orally administered to 252 (42/trial) pigs. Pigs were randomly assigned to one of 14 compartments in either a three-deck pot-belly trailer with interrnal ramps (PB) or a double-decked hydraulic trailer without ramps (DD). Data loggers were recovered from gastrointestinal tracts at slaughter. Data were summarized for four time periods during the transport process: Pre-loading (ca. 4 hours), Stationary (ca. 0-1 hour), In-transit (ca. 2 hours), and In-Lairage (ca. 2 hours).

## Results

- There were no overall effects of trailer style or compartment within trailer ($P>0.10$) on mean CBT, but there were significant differences due to period ($P<0.001$), period by trailer ($P<0.01$) and compartment by period within trailer interactions ($P<0.02$).

- When Stationary, PB pigs had a higher mean CBT than those on the DD (40.62 ±0.05°C, 40.15±0.07°C respectively, $P<0.001$). However, pigs on the PB truck were always loaded first and therefore had a longer period of waiting before transit. Within the PB, CBT was higher when Stationary compared to all other periods (Pre-loading: 40.11±0.07°C; In-transit: 40.18±0.07°C; In-Lairage: 39.82 ±0.06°C; $P<0.01$). When Stationary, CBT was significantly higher in two of the top-deck compartments of the PB than for all other compartments in that trailer ($P<0.02$).

## Take Home Message

The results of this study indicate that pigs loaded into the top deck compartments of the PB are at a greater risk for heat stress than pigs in other areas of either truck. This could be due to higher heat load and/or the exertion required to climb to these compartment.

*We gratefully acknowledge the funding support of NSERC, AAFC, Saskatchewan Pork, Alberta Pork, Ontario Pork, Manitoba Pork, Maple Leaf Fresh Foods, F. Menard Inc, Federation of Quebec Pork Producers, The Animal Compassion Foundation*

# Effect of dose of eCG on estrus induction in gilts

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## Background

Gonadotrophin treatment (eg. injection of eCG; or eCG plus hCG combination) is effective for the induction of a fertile estrus in prepubertal gilts. However, the utility of this approach is limited because the initial estrus response and subsequent cyclicity are unpredictable. The ideal gilt estrus synchronization protocol would create a population of gilts with a synchronous first estrus, predictable timing of the second estrus, and good predictability of time of ovulation to allow improved breeding management. A protocol for synchronization of estrus and ovulation in weaned sows using eCG and porcine luteinizing hormone (pLH) has been proven successful, however there is an indication that a higher dosage of eCG would improve performance in parity one sows. The estrus response to the standard dosage of eCG (600 IU) in gilts has been variable.

## Objectives and Methods

The objective of this trial was to evaluate the estrus response to higher dosages of eCG. A total of 112 prepubertal gilts weighing at least 80 kg were randomly assigned to receive 600 IU, 750 IU or 900 IU eCG to induce estrus. A control group was observed for natural estrus. All gilts were exposed to a mature boar for up to 7 days following treatment to observe for estrus behaviour. Blood samples collected on days 0, 3 and 10 will be used to determine progesterone concentrations as a determinant of estrus and ovulation

## Results and Discussion

The percentage of gilts showing estrus was 6%, 55%, 77% and 61% for control, 600 IU, 750 IU or 900 IU eCG, respectively. The progesterone assays on blood samples are not yet complete, but when available, will help to more accurately determine estrus response and ovulation. Even though the sample sizes were relatively small, the partial results seem to indicate a trend towards a greater estrus response to a dose that is higher than the standard 600 IU. When this trial is complete, an appropriate dosage of eCG will be determined and used in a larger study aimed at developing an estrus and ovulation synchronization protocol for gilts.

## Take Home Message

Estrus can be successfully induced in prepubertal gilts with eCG. Treated gilts will show estrus within 7 days but indications are that a better response can be achieved if the dosage is greater than 600 IU.

**Funding Support -** Bioniche Animal Health

# Influence of gonadotrophic stimulation on first and second estrus and fertility in gilts

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## Background

Usually, the largest single component of herd non-productive days (NPD) is the gilt entry-to-service interval. To minimize this, it is necessary to have gilts reach puberty as soon as possible after arrival on the farm, or entry into the breeding herd. The ability to meet the weekly breeding target requires a predictable supply of service-ready gilts (ie. gilts in estrus when required). When gilt availability is limiting, a common method used to stimulate the onset of estrous cycles is the injection of gonadotrophins. Gonadotrophin treatment (eg. injection of eCG; or eCG plus hCG combination) is effective for the induction of a fertile estrus in prepubertal gilts. However, the utility of this approach is limited because the initial estrus response and subsequent cyclicity are unpredictable.

## Objective and Procedures

To develop a management protocol for gilts that will allow improved predictability of breeding and maintenance of fertility. A total of 103 pre-pubertal gilts, weighing at least 85 kg were induced to show estrus and synchronous ovulation using eCG and pLH in a protocol established for weaned sows. Gilts were bred at the first or second natural estrus following the initial induction or following a second induction.

## Results and Discussion

In total, 73% of gilts showed estrus in response to the initial induction. The farrowing rates were similar for gilts bred at the first natural estrus or following the second induction (72% and 79% respectively), but were higher than that of gilts bred at the second natural estrus (54%). There was no difference in litter size for all treatments. The initial estrus response to induction and the fertility of gilts at the subsequent natural estrus was very encouraging. A bigger study is planned.

## Take Home Message

Gilts can be induced to show estrus and synchronous ovulation using eCG and pLH in a protocol established for weaned sows. Breeding can be done at a second induction or at the first natural estrus following the initial induction, but it may be more cost effective to breed at the natural estrus following induction. If these results are repeatable, this protocol could offer a means of having a reliable supply of service-ready gilts as required.

**Funding Support -** Bioniche Animal Health.

# Reactive oxygen species in boar spermatozoa

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**Background:**

Using boar sperm for artificial insemination greatly increases the rate of genetic improvement in swine breeding, and depends on storing the sperm in conditions that keep them fertile. Boar sperm can now be stored for 3-7 days in a liquid extender before quality drops. Although frozen sperm could be stored for an indefinite time, the quality of frozen-thawed sperm is too low to permit widespread usage of this storage method. We want to increase the quality of sperm for artificial insemination, either by improving the current liquid extenders or by developing better frozen storage.

Sperm typically contain very small amounts of compounds called Reactive Oxygen Species (ROS) that can break up parts of a membrane, and ROS can also help conduct messages from one area of the sperm to another. The ROS actions might either damage the sperm or actually support sperm-egg fusion and therefore fertilization. Sperm must undergo small changes in the female tract to be able to penetrate and fertilize the egg, but sperm undergoing these changes at the wrong time when an egg is not available will die. Our research was to examine whether and how ROS help or harm sperm, and how storage affects ROS. Once we know whether these ROS are good or harmful, then we can protect or inactivate the ROS, as appropriate.

**Experimental approach:**

Fresh sperm were extended, frozen and thawed. We measured the number of live sperm, % of sperm swimming, and the amount of ROS present in the sperm both when they were fresh and after they had been frozen and thawed. We introduced fluorescent markers of ROS inside the sperm, so the more ROS was present, the brighter the cells glowed, and we used a flow cytometer to measure the brightness of thousands of sperm from each of 4 boars before and after freezing. Motility was measured with a special computer attached to a microscope.

Of 2 different kinds of ROS in fresh sperm, one was decreased and one was unchanged in live frozen-thawed sperm. However, freezing and thawing killed many sperm and reduced the mobility of the live sperm, and dead sperm showed high levels of ROS-induced damage to sperm membranes. This suggests that only sperm with low or normal ROS levels can survive freezing and thawing.

**Take-home Message:**

Freezing and thawing boar sperm significantly harms their function and promotes deadly ROS-induced damage. We will try to prevent ROS damage to attempt to improve the quality of frozen-thawed boar sperm.

Funding from NSERC and OMAFRA is gratefully acknowledged.

# Effects of post-weaning nutrition on sow reproductive performance

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## Background

The major objectives of sow nutrition after weaning are to shorten the interval from weaning to estrus (WEI), synchronize the onset of estrus and maximize the ovulation and conception rates. It is known that reproductive performance is enhanced in sows that return to estrus by 5 days after weaning, and that bad body condition at weaning is associated with a longer WEI. Bad body condition at weaning is usually associated with younger sows or high-performing sows. If the sow diet can be supplemented adequately during the WEI, there is the potential to improve reproduction parameters such as WEI, ovulation rate, pregnancy rate, farrowing rate and subsequent litter size. Supplementation of the diet would be practical if it can be simply a top-dress of an existing diet. One such product is Litterstart® (Kenpal Farm Products, Centralia, Ontario), which is supposed to help improve reproductive performance, if fed after weaning.

## Objectives and Methods

The objective of the proposed study is to evaluate the effect of adding Litterstart® as a nutritional top dressing during the weaning to breeding period on subsequent reproductive performance of weaned sows. On the day of weaning, 331 sows were individually housed in gestation stalls and randomly assigned to a treatment or control group. The treatment group (n=168) had 0.25 kg of Litterstart Sow Supplement added to their normal daily diet while the control group (n=163) had their normal diet plus an additional 0.25 kg per day. Estrus detection started 2 days post-weaning and sows exhibiting estrus were inseminated that day and once again, 24 hours later.

## Results and Discussion

There was no difference between groups for parameters recorded. Return to estrus by day 5 post weaning was 83% for control sows and 84% for the treated group. Pregnancy rate was 76.2% and 78% while farrowing rate was 73% and 72.5% for control and treated groups, respectively. Total litter size was 11.7 for controls and 11.9 for treated sows. From these results it can be seen that this herd did not have a WEI problem, so it would be difficult to show any improvement. The relatively low pregnancy and farrowing rates could indicate that other issues related to reproduction failure need to be explored. It may be worthwhile to repeat this trial in a younger, higher performing sow-herd where the effects of post weaning nutrition may be more noticeable. A good candidate herd would be one with WEI problems

## Take Home Message

In this particular herd the nutritional top dressing had no effect, but it must be noted that this herd was older than average by industry standards, the level of reproductive performance was moderate and return to estrus was not a problem.

## Acknowledgments

We appreciate the support of the producers who allowed us to do these trials at their facilities. Funding was provided by the University of Guelph-OMAFRA animal research program and Kenpal Farm Products.

# Discoloured bones in pigs at slaughter associated with medication of tetracyclines

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## Background and Justification

In the final quarter of 2005, 524 pigs from 10 producers were identified at slaughter with unacceptable yellowing of their bones. In 2006, over 7000 pigs from a single Ontario packer were identified with discoloured bones. Bone samples analyzed using a HPLC method contained 15-95 ppm of chlortetracycline, and fluoresced when exposed to UV light. It was assumed that the yellow colour was caused by tetracycline residue.

## Objective

To determine whether the yellow discolouration of pig bones is related to; the dosage, timing, or method of administering tetracycline.

## Results and Discussion

Tetracyclines were administered to pigs for various lengths of time and at various dosages and using different routes of administration. The carcass was assessed for yellowing of bones and tetracycline residues in muscle, liver and bone.

**Table 1.** Average levels of tetracyclines (ppm) in bone from pigs in various exposure groups as measured by high-pressure liquid chromatography (HPLC)

| Source | Feed 110ppm/3wks | Feed 660ppm/3wks | Water 1g/8 L | Injectable 300 mg per 45 kg | unknown Discoloured bones |
|---|---|---|---|---|---|
| Tetracycline | 0.5 | 1.4 | 2.5 | 0.3 | 3.2 |
| Chlortetracycline | 2.7 | 16.7 | | | 22.5 |
| Oxytetracycline | | | | 21.4 | 0.9 |

## Take Home Message

Feeding of chlortetracycline at 660ppm for 12 weeks produced a yellow discolouration. Feeding 660ppm for 3 weeks created levels in the bone, which were comparable to levels, found in the discoloured bones from the abattoir. Care needs to be taken regarding the level and duration of tetracycline use to avoid this problem.

Funding - Ontario Pork and the University of Guelph-OMAFRA Sustainable Production Systems Program.

# Effects of protein-restricted versus total feed-restricted dietary regimes up to 65 kg body weight on pig performance, carcass and meat quality

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## Background

Therkildsen et al. (2002; Anim. Sci. 75:367) observed improved feed efficiency, protein synthesis, meat quality and tenderness when pigs were limit fed during the growing period. This trial further investigated growth performance, carcass and meat quality ramifications of limit feeding during the growing period.

## Objectives

The project evaluated the effects of feeding strategy (full feeding, energy restriction, protein restriction, and combined energy and protein restriction) in the growing phase on pig growth performance, feed intake, and carcass and meat quality.

## Experimental Procedures

Ninety-four feeder (37.7 $\pm$ 5.3 kg) pigs were assigned to a 2 x 2 x 2 factorial design trial with 2 dietary protein levels (0.9 versus 0.63% lysine), 2 feeding levels (*ad libitum* vs.70% of *ad libitum*) in the growing period and 2 genders (barrows and gilts) represented. At 65 kg body weight (BW) all pigs were *ad libitum* fed until slaughtered at approximately 115 kg BW.

## Results

- Average daily gains (ADG) for limit fed pigs (both high and low protein diets) during the growing phase were higher ($P<0.01$) during the finishing period (1.3 versus 1.1 kg/d) than for *ad libitum* fed pigs.
- There were no differences ($P>0.60$) in ADG between *ad libitum* fed pigs receiving either the high or low protein diets.
- At slaughter, backfat thickness and marbling scores were similar ($P>0.15$) across dietary treatments.
- Warner-Bratzler shear force (toughness), drip loss, and meat color were not affected ($P>0.35$) by dietary protein level or feeding level.

## Take home message

Feed intake restriction, but not protein intake restriction during the grower phase induced compensatory growth during the finisher phase. Key aspects of meat quality were not influenced feed and protein intake restriction during the grower phase.

## Acknowledgments

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# The effects of compensatory growth during the finisher phase on pig performance, carcass merit and pork quality (Part II)

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## Background

In a previous experiment (McEwen et al. 2006; www.aps.uoguelph.ca/SwineReport2006; Part I) reducing feed intake (70% of *ad libitum* intake) during the growing phase resulted in compensatory growth during the finishing period. Improvements in feed to gain (F/G) and meat tenderness were also observed for limit fed pigs.

## Objectives

The project evaluated the effects of feeding strategy (full versus limit feeding) during the grower phase and gender (gilt versus barrow) on growth performance, feed intake, and carcass and meat quality.

## Experimental Procedures

Feeding strategy and gender effects were examined on 105 market hogs using a 2 x 3 factorial design. Pens of six barrows or gilts (30.3 $\pm$ 2.8 kg BW) were assigned to either full feeding (FF) until pigs attained 110 kg market weight or limit feeding (LF) at 70 percent of FF feed intake until LF pens averaged 60 kg BW. At 60 kg BW, FF pigs and half of the LF pens (LF-LL) were assigned to a low lysine (LL) finishing diet (0.7% lysine) while the remaining LF pens were assigned to a high lysine (HL) finishing diet (1.0% lysine). Full feeding was then followed for all pigs until marketed at 110 kg body weight.

## Results

- Overall (30 to 110 kg BW), BW gain (kg/d) was higher ($P<0.001$) for FF versus LF pigs (kg/d: FF-1.10, LF-LL- 0.96, LF-HL- 0.99; SE=0.01) even though compensatory growth ($P<0.0001$) was observed for limit fed pigs during the finishing period (kg/d: FF-1.19, LF-LL-1.56, LF-HL- 1.64; SE=0.03).
- Overall F/G was lower ($P < 0.01$) for LF versus FF (FF-2.68, LF-LL-2.49, LF-HL-2.51; SE=0.04) primarily due to a lower F/G ($P < 0.02$) during the finishing period (FF-2.98, LF-LL-2.71, LF-HL-2.74; SE=0.06) while lysine level (LF-HL versus LF-LL) in the finishing diet had no effect ($P = 0.75$) on F/G.
- Hot carcass weight, dressing percentage, lean and fat depth (carcass probe), fat depth (ruler) and loin depth (end of growing period) were similar ($P > 0.15$) for all feeding strategies.
- There were no feeding strategy differences ($P > 0.05$) in shear force (tenderness) which is in direct contrast to the first experiment.

## Take home message:

In two experiments (Part I & II) improvements in overall (from 30 to 110 kg BW) feed efficiency (F/G; more than 0.18 kg/kg) was observed when pigs were limit fed (70% of FF) during the growing phase. The impact of feed intake restriction during the grower phase on meat quality was not consistent.

**Acknowledgments**
The authors would like to thank Ontario Pork and the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) for their financial and technical support.

# Cortisol surge induced by handling during intraperitoneal injection of isotopic tracers decreases muscle protein synthesis activity in weanling piglets

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## Background

Poor efficiency of whole body nitrogen (N) utilization between weanling and finishing is responsible for low profit margin and environmental pollution associated with intensive swine production (Fan et al., 2008, *J. Anim. Sci.* supplement 1 – in press). Whole body protein retention is a net balance between protein synthesis, degradation and the endogenous loss with skeletal muscle being the largest body protein pool (Fan et al., 2006, *J. Anim. Sci.* supplement 1 84 supplement 1:E79-E93).

## Objectives

The objectives to this study were to systematically compare protein synthesis rate in organs and tissues measured by the flooding dose technique via intraperitoneal (ip) versus intravenous (iv) routes and to further reveal factors responsible for potential differences in protein synthesis rate associated with these two routes of tracer delivery.

## Methods and Procedures

Five blocks of two littermate gilts, weaned at 16 day of age and fed a commercial starter diet, were surgically implanted with catheters in the jugular vein and carotid artery and were randomly assigned to receive a flooding dose of a stable isotope tracer phenylalanine in saline administered via either ip or iv route. Molar enrichment of tracer phenylalanine in the free and bound pools were measured by gas chromatography–mass spectrometry (Bregendahl et al., 2004, *J.Nutr.*, 134:2722-2728).

## Results

- Administration of the tracer amino acid via ip and iv route induced a significant logarithmical pattern of a surge in cortisol levels in plasma within 30 min.

- Protein synthesis rate measured in plasma, cardiac and skeletal muscles, spleen and stomach were significantly lower in ip than in iv group, and for plasma and skeletal muscles, this was due to the adverse effect of cortisol surge being more dramatic in ip than in iv group.

## Take Home Messages

The process of handling pigs, such as injection of a tracer amino acid solution via ip as demonstrated in this study, induces a surge of the stress hormone cortisol in blood, thus reducing muscle protein synthesis. Therefore, improving animal welfare and well-being may be able to reduce blood circulatory cortisol level and improve whole body nitrogen efficiency.

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# Effects of dietary levels of tylosin on growth performance and efficiency of nutrient utilization in growing pigs

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## Background

Tylosin has been approved and used in disease prevention and disease treatment for the outcomes of safe pork and growth promotion in Canadian swine production by Canadian Food Inspection Agency (CFIA) in 2000. While high doses of tylosin (100-110 ppm) are used for treating infectious diseases such proliferative enteropathy in weanling pigs, lower doses of tylosin (11-44 ppm) are used primarily for the purpose of disease prevention in swine operations.

## Objectives

The objectives of this study were to examine effects of graded dietary levels of lower doses (11-44 ppm) of tylosin on growth performance and efficiency of utilization of dietary nutrients, including crude protein (CP), calcium (Ca), and phosphorus (P) in growing pigs fed a corn and soybean meal (SBM)-based diet.

## Methods and Procedures

Sixty Yorkshire barrows, with an average initial and final body weight of 31 and 48 kg, were fed four diets for 15 blocks according to a randomized complete block design. The four diets were corn and SBM-based and formulated to contain four levels of tylosin at 0, 11, 22, and 44 ppm, respectively. Each experimental block consisted of a 12-day pre-adaptation to the control diet, 9-day adaptation and a 5-day collection of total urine excretion, and fecal samples with efficiency of nutrient utilization measured by the mass balance method (Rideout et al., *J. Sci. Food Agric.* 84:1005-1012).

## Results

- Tylosin supplementation significantly improved average daily gain at 11 ppm but not at the higher levels. However, tylosin did not affect feed intake and feed conversion efficiency.

- Tylosin significantly improved the apparent crude protein digestibility at 11 ppm but not at higher levels, yet did not affect the efficiency of crude protein retention at any of the tested levels. Efficiency of calcium utilization was not improved by tylosin. Dietary supplementation of tylosin had significant cubic effects on the efficiency of phosphorus utilization at the digestive and post-absorptive levels.

**Take Home Messages -** Dietary supplementation of tylosin at 11 ppm may improve growth and efficiency of crude protein and phosphorus utilization in growing pigs.

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# Efficiency of retention and conversion of α-linolenic acid (ALA) to other n-3 fatty acids (FA) in the whole body of growing gilts is reduced over time

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**Background:** Value added pork products may be produced by enriching pork with health benefit providing ω-3 fatty acids, in particular when these ω-3 fatty acids are incorporated into intra-muscular fat and when the contents of most beneficial long chain ω-3 fatty acids (eicosapentaenoic acid [EPA], and docosahexaenoic [DHA]) in pork are maximized. A study was conducted to study the conversion of the ω-3 fatty acid α-linolenic acid (ALA; supplied in the diet from flax seed) to EPA and DHA in different tissues in growing pigs.

**Experimental procedure:** A corn-barley-soybean meal based diet with 10% flaxseed, containing 2.0% ALA, was fed for 30 d to pigs between 27.7 $\pm$ 1.9 and 45.7 $\pm$ 2.2 kg BW. Feed intake was fixed at 70% of ad libitum intake according to NRC (1998). Body composition was determined at initial, intermediate (d 15; 39.2 ± 1.4 kg) and final BW in 4, 6 and 5 pigs, respectively. At slaughter on d 15 and 30 digesta was sampled for measurement of apparent ileal fat digestibility, which was used as an estimate of ALA availability. Disappearance of ALA was calculated as the difference between available ALA intake and the sum of ALA retention and ALA conversion to other ω-3 fatty acids.

**Results:**

- At the initial BW (2516 g of body fat), the content of ALA, C18:4n-3, C20:3n-3, C20:4n-3, EPA, docosapentaenoic acid (DPA) and DHA was 0.79, 0.09, 0.10, 0.02, 0.04, 0.09 and 0.14% of body fat, respectively.
- Whole body content of individual ω-3 fatty acids increased linearly from d 0 to 30 ($P < 0.01$), except for DHA.
- Expressed as a portion of ALA intake, ALA retention declined numerically from 64% (day 0 to 15) to 49.8% (day 15 to 30; $P = 0.11$).
- Conversion of ALA to C20:3n-3 (7.06 vs. 4.29%), C20:4n-3 (0.60 vs. 0.34%), and DHA (1.07 vs. 0.33%) was generally low and reduced over time ($P < 0.05$), while conversion of ALA to EPA (1.14 vs. 1.51%) and DPA (2.36 vs. 2.04%) did not change over time ($P > 0.10$).
- Disappearance of ALA tented to increase over time (3.07 vs. 22.02% of available intake; $P = 0.07$).
- The rate of conversion of ALA to C20:3n-3 was much higher in this experiment than reported in other species and humans and should be explored further.

**Take home message:** In growing pigs, the efficiency of incorporating ingested ω-3 fatty acids into body fat decreases over time, and feeding ALA to growing pigs only leads to modest increases in contents of health benefits providing EPA and DHA in the pig's body. Pigs appear unique in that they store the ω-3 fatty acid C20:3n-3, and intermediate between ALA and EPA, which deserves to be explored further.

**Acknowledgement:** Financial support was provided by Ontario Pork, OMAFRA, and NSERC.

# High dietary potassium levels appears to limit co-products usage in pig diets

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**Background:** With increased demand for corn for bio-fuel production, corn prices are increasing and alternative energy sources for use in pig diets need to be explored. A concern with the use of co-products from the bio-fuel and food industry in pig diets is their high potassium (K) content. A growing-finishing pig performance study was conducted to explore the liquid feeding of large amounts of co-products, and to assess the feeding of high dietary K levels from potassium carbonate ($K_2CO_3$).

**Experimental procedure:** Purebred Yorkshire pigs from the University of Guelph herd were exposed to one of four dietary treatments (5 pens per treatment; 4 gilts and 4 barrows per pen; initial BW 26 kg). Pigs were liquid fed using the *Big Dutchman Hydrojet Liquid Feeding System* at the Arkell Swine Research Station. Pigs on the control treatment, received typical corn and soybean meal based diets. For the moderate co-product treatment, diets contained 10% whey permeate and either 2% corn steep water (CSW) for growing pigs and 3 % CSW for finishing pigs. In the high co-product treatment, diets contained 20% whey permeate and either 4% CSW for growing pigs and 6% CSW for finishing pigs. For the last treatment, $K_2CO_3$ was added to the control diets to achieve dietary K levels similar to those in the high-product diets.

**Results:** Growth performance and carcass quality of growing-finishing pigs.

| | **Dietary co-product level** | | | | SEM |
|---|---|---|---|---|---|
| | Control | Moderate | High | $K_2CO_3$ | |
| Final BW | 111.5 | 109.3 | 106.2 | 109.9 | 2.08 |
| Gain, kg/day | 1.16 | 1.15 | 1.08 | 1.10 | 0.052 |
| Feed intake, kg/day | 2.33[a] | 2.20[ab] | 2.11[b] | 2.20[ab] | 0.109 |
| Feed (dry matter):Gain | 2.02 | 1.91 | 1.95 | 1.99 | 0.108 |
| Carcass lean yield, % | 60.1 | 60.5 | 60.4 | 60.4 | 0.756 |

[a,b] Values followed by different superscripts differ (P<.05).

- Slow growing pigs on the high K and the high co-products usage treatments presented signs of kidney damage, such as discolorations and formation of lumps. Nutrient analysis of the dried powder found in the lumps on the kidney surface and in the urine revealed a high concentration of calcium (35%) and surprisingly low K level (0.74%).

**Take home message:** Increasing dietary levels of co-products reduced BW gain linearly (P = 0.04), but did not impact feed efficiency and carcass lean yield. The numerical reduction in daily gain was only 5% at high co-product usage and could be attributed largely to differences in feed intake. Simple dietary interventions to reduce abnormalities in kidneys should be explored and may allow increased usage of co-products in pig diets.

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# Impact of immune system stimulation on the response of growing pigs to graded levels of and dietary methionine plus cysteine intake

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**Background:** Immune system stimulation (**ISS**) can result in substantial reductions in animal productivity. Previous reports have suggested additional requirements for the sulfur containing amino acids (**SAA**), methionine or cysteine, during ISS for synthesis of metabolites that have important roles in the animal's immune response, such as glutathione (2007 Ontario Swine Research Review). Our objectives were to determine the impact of ISS on the pigs' response to graded levels of SAA intake and to explore whether additional dietary SAA supply can reduce the negative impact of ISS on protein gain in growing pigs.

**Experimental procedure:** Thirty six Yorkshire barrows (23 kg body weight) were fed restricted (850 g/d), and exposed to one of three dietary intake levels of SAA. Diets were formulated to be first limiting in SAA and fed for nine days prior to N-balance measurements. Following a first 5-day N-balance period (**pre ISS**), half of the pigs at each dietary SAA levels were injected intramuscularly with either saline or increasing amounts of *Escherichia coli* lipopolysaccharide (LPS, serotype 55:B5) every 48 h and over at least a 5 day period. A second 6-day N-balance (**during ISS**) was conducted after the start of LPS or saline injections. At the end of the second N-balance period, pigs were weighed and euthanized for sampling of liver tissue and measurement of ileal protein digestibility.

**Results:** Impact of immune system stimulation (ISS) and intake of methionine plus cysteine (SAA) on apparent digestibility of crude protein (CP) and whole body protein deposition (PD).

| ***SAA intake*** | **low** | | **medium** | | **high** | | **SE** | ***P value*[1]** | |
|---|---|---|---|---|---|---|---|---|---|
| ***ISS*** | **-** | **+** | **-** | **+** | **-** | **+** | **M** | **ISS** | **SAA** |
| ***SAA Intake g/d*** | 0.95 | 0.93 | 2.1 | 2.1 | 3.1 | 3.1 | 0.02 | .100 | .001 |
| ***Organ Weight, % of BW*** | | | | | | | | | |
| *Spleen* | 0.2 | 0.3 | 0.2 | 0.3 | 0.2 | 0.3 | 0.01 | .001 | .100 |
| *Liver* | 2.9 | 3.2 | 2.7 | 3.0 | 2.9 | 2.9 | 0.04 | .006 | .050 |
| ***Plasma Protein Levels, g/L*** | | | | | | | | | |
| *Albumin* | 22 | 26 | 34 | 31 | 37 | 34 | 0.76 | .100 | .001 |
| *Haptoglobin* | .1 | .4 | .2 | .4 | .2 | .4 | 0.02 | .001 | .700 |
| *Fibrinogen* | 0.5 | 1.3 | 1.4 | 2.1 | 1.8 | 2.0 | 0.06 | .006 | .001 |
| ***Ileal CP digest., %*** | 60 | 60 | 80 | 78 | 83 | 74 | 6.0 | .448 | .003 |
| ***PD, g/d*** | 29 | 19 | 73 | 65 | 76 | 66 | 1.5 | .001 | .001 |

[1]Interactive effects of immune system stimulation and methionine plus cysteine intake were not significant.

**Take home message:** Immune system stimulation *per se* does not affect apparent ileal digestibility of crude protein in growing pigs. Immune system stimulation increases the pig's requirements for methionine plus cysteine; additional dietary intake of methionine plus cysteine

can reduce the adverse effects of immune system stimulation on whole body protein deposition in growing pigs, and probably accelerates the recovery.

**Acknowledgement:** Financial support was provided by Ontario Pork, OMAFRA, Degussa AG and NSERC.

# Impact of steeping high-moisture corn with phytase on growth performance and phosphorus utilization in liquid-fed starter pigs

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**Background:** The application of phytase in conventional dry pig diets has been studied extensively and improves digestibility of phosphorus (P). The efficacy of phytase may be improved by steeping feedstuffs with phytase prior to feeding. A performance study was conducted to determine the value of steeping high-moisture corn (HMCorn) with phytase for use in P-limited liquid diets.

**Experimental procedure:** Five pens of 16 pigs (weaned at 19 to 23 days of age; 6.7 ± 0.24 kg BW) were assigned to each of five 3-phase feeding programs for 7 weeks (total P was 0.69, 0.48, and 0.45 % in phase I, II and III diets, respectively). The HMCorn based diets were formulated to contain graded levels of added phytase (0, 62.5, or 125 FTU/kg DM HMCorn) which was added either to a mix of HMCorn and water and allowed to steep for a minimum of 24-h or to the dry feed supplement and mixed with the HMCorn at the time of feeding.

**Results:**

- The soluble P content in duodenal digesta was increased with the addition of phytase (63.1 vs. 49.8 % of total P; $P < 0.05$), demonstrating the efficacy of added phytase.
- The addition of phytase had no impact on ADG or G:F ($P > 0.10$).
- Allowing HMCorn to steep with phytase prior to feeding did not increase solubilization of P in digesta (compared to pigs fed diets with phytase added at the time of feeding; 65.0 vs. 61.3%; $P > 0.10$).
- There was no impact of dietary treatment on total tract digestibility of P ($P > 0.05$). However, urinary P excretion was much higher in pigs fed diets with added phytase (241 vs. 29.7 ug/mL; $P < 0.05$), demonstrating again the efficacy of phytase and showing that in excess available P intake is excreted largely via urine.
- Addition of phytase to the diets resulted in greater contents of P in carcass (1.56 vs. 1.31%; $P < 0.001$) and metacarpal bones (5.68 vs. 5. 40 %; $P < 0.05$). Metacarpal breaking strength was higher in pigs fed diets with 125 FTU/kg vs. 62.5 FTU/kg added phytase (32.9 vs. 30.5 kg; $P < 0.05$).

**Take home message:** Added phytase improved retention of P in starter pigs fed P-limited HMCorn based liquid diets, however, there appears to be no benefit to steeping HMCorn with phytase prior to feeding. Responses to both levels of phytase were similar and indicate greater efficacy of phytase in liquid diets than dry diets.

**Acknowledgement:** Financial support was provided by Ontario Pork, OMAFRA, and NSERC.

# It pays to fine-tune feeding programs for individual growing-finishing pig units

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**Background:**

High feed costs and low pork prices provide strong incentives to fine-tune feeding programs, especially for growing-finishing pigs. Based on key measures of pig growth performance and by using pig growth simulation models, feeding programs can be optimized for individual pig units, considering profits as well as nutrient losses into the environment. In 2007 case studies were conducted on two commercial growing-finishing pig units aimed at improving gross margins per pig, while reducing phosphorus and nitrogen losses into the environment.

**Experimental procedure:**

In a preliminary study - conducted to evaluate the pig's (lean tissue) growth potentials - a sub-sample of pigs was ad libitum fed diets that were over-formulated for key essential nutrients. In these pigs, growth rate, carcass quality and whole body nutrient content was monitored and the rate of whole body protein deposition – an objective measure of lean tissue growth – was determined. For two commercial units, average initial body weight, average carcass weight and carcass lean yield, average days in the barn, and feed usage per pig for each of the subsequent diets was monitored. Body weight gain and average daily feed intakes at the various stages of growth were then estimated. This information was used to develop a new feeding program aimed at improving profits and nutrient utilization efficiency, based on adjusting diet nutrient levels, increased usage of phytase and synthetic amino acids, but without altering dietary levels of co-products such as wheat shorts. In both commercial barns direct side-by-side comparisons between the old and the new feeding program were made. On both units, whole body nutrient content was determined in a sub-sample of slaughter pigs to calculate nutrient losses into the environment as the different between nutrient intake and nutrient retention in pigs.

**Results:** Growth performance, margins and nutrient use in growing-finishing pigs.

| | Feeding Program | | SEM | P |
|---|---|---|---|---|
| | Old | New | | |
| Gain (day 1-64)*, g/d | 989 | 968 | 21 | 0.56 |
| Overall feed:gain, kg/kg | 2.79 | 2.82 | 0.04 | 0.42 |
| Carcass lean yield, % | 61.50 | 61.27 | 0.20 | 0.31 |
| Gross margin*, $/pig | 23.11 | 26.36 | 0.22 | <0.001 |
| Phosphorus losses, kg/pig | 1.05 | 0.85 | 0.001 | <0.001 |
| Nitrogen losses, kg/pig | 4.00 | 3.49 | 0.006 | <0.001 |

*Until first pigs were shipped ** Calculated as: carcass value (bid price $1.50 /kg) - feed costs (based on 2008 feed ingredient prices) – feeder pig cost ($50/pig) – variable costs ($15/pig).

**Take home message:**

Based on a systematic analysis of feeding programs on individual growing-finishing pig units, profits can be increased by more than $3.00 per pig, while phosphorus and nitrogen losses into the environment can be reduced by 20 and 13%, respectively.

**Acknowledgement:** Financial support was provided by Ontario Pork, Agriculture and Agri-Food Canada's ETAA program, and OMAFRA.

# Microbial detoxification of deoxynivalenol (DON) demonstrated in a swine feeding trial

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**Background:** Bio-detoxification is an alternative strategy to transform mycotoxins into less or non-toxic metabolites. A bacterial isolate LS-100 from chicken digesta is able to transform deoxynivalenol (DON) into its de-epoxided form, DOM-1. A preliminary starter pig performance was conducted to asses the effect of feeding a diet containing LS-100 fermented DON-contaminated corn.

**Experimental procedure:** Twenty Yorkshire starter pigs, 14 gilts and 14 barrows (average initial BW 16.0 $\pm$ 1.6 kg), were housed individually in floor pens and fed a conventional pig starter diet for a nine day pre-trial period. Pigs were then assigned to one of four dietary treatments: (1) Control (non-contaminated corn and soy bean meal based diet), (2) DON contaminated corn (5 ppm DON in complete feed; same ingredient composition as treatment (1)), (3) fermented DON (equivalent to (2) but DON corn was fermented under closely controlled anaerobic conditions with bacterial isolate LS-100), and (4) fermented control (equivalent to (3) based on non-contaminated corn). Pig growth performance and blood chemistry was monitored for another nine days.

**Results:**

Growth performance of starter pigs fed DON contaminated diets (nine trial period).

| | Control | DON | Fermented DON | Fermented control | SEM |
|---|---|---|---|---|---|
| Gain, g/d | 882[b] | 458[a] | 835[b] | 835[b] | 49.1 |
| Feed intake, g/d | 1,337[b] | 943[a] | 1,367[b] | 1,347[b] | 48.2 |
| Gain:feed | 0.66[b] | 0.47[a] | 0.62[b] | 0.61[ab] | 0.036 |

[a,b] Values followed by different superscripts differ (P<.05).

- No meaningful differences in blood chemistry were observed.

**Take home message:** The large negative effect of feeding DON contaminated corn on pig growth performance was eliminated when the contaminated corn was fermented under closely controlled conditions with bacterial isolate LS-100. Effective means to routinely treat DON contaminated feed ingredients with bacterial isolate LS-100 should be explored further.

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