

# **University of Guelph Swine Research Day**

Thursday May 9, 2019

## **Program & Proceedings**



# 2019 University of Guelph Swine Research Day

The organizing committee is pleased to announce the 4th annual  
**University of Guelph Swine Research Day**

In 2016, the Centralia Swine Research Update (CSRU) and the Mike Wilson Swine Research Day (MWSRD) merged into one day meeting.

The program highlights University of Guelph swine research and carries on with the tradition of both the CSRU and MWSRD with high profile guest speakers, short updates on current swine research, written proceedings, and opportunities for networking.

## **The program includes the:**

Kees de Lange Memorial Lecture  
Mike Wilson Keynote Presentation  
CSRU Graduate Student Competition  
And  
Faculty Research Presentations

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## 2019 University of Guelph Swine Research Day

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## Keynote Speaker Bios

### 2019 Dr. Kees de Lange Memorial Lecture – Dr. Martin Nyachoti

The Dr. Kees de Lange Memorial Lecture will be given by: **Dr. Martin Nyachoti**, Director of the T.K. Cheung Centre for Animal Science Research, Department of Animal Science, University of Manitoba.

#### ***“Dietary manipulation to support gut health and function in piglets”***

Dr. Nyachoti is a Professor and Head of the Department of Animal Science at the University of Manitoba. He holds a B.Sc. (Agric) from the University of Nairobi and M.Sc. and Ph.D. degrees in animal nutrition (majoring in poultry and pig nutrition) from the University of Guelph. Dr. Nyachoti’s current research focuses on nutrition and gut health in the non-ruminant, energy and nutrient (mainly nitrogen and phosphorus) utilization, and feed ingredient evaluation. He has served on Editorial Boards of several journals including Journal of Animal Science and British Journal of Nutrition. His current publication record includes 240 peer-reviewed journal articles and he has given 76 invited presentations in 19 countries. In 2005 and 2013, Dr. Nyachoti won the Canadian Society of Animal Science Pfizer Young Scientist Award and Award for Excellence in Nutrition and Meat Sciences, respectively, as well as Merit Awards for Research excellence from the University of Manitoba in 2006, 2010 and 2013.

### 2019 Dr. Mike Wilson Keynote Presentation – Dr. Marcelo Gottschalk

In tribute to the MWSRD the “Mike Wilson Keynote Presentation” will be given by **Dr. Marcelo Gottschalk**, Professor, Faculty of Veterinary Medicine, University of Montreal.

#### ***“Streptococcus suis: Struggling to control disease”***

Dr. Gottschalk was born and raised in Buenos Aires, Argentina, where he obtained a DVM (1982). He then came to Canada and obtained his PhD in microbiology and immunology from the Faculty of Veterinary Medicine, University of Montreal (1991). Since 2002 he has been a full professor in the department of Pathology and Microbiology, Faculty of Veterinary Medicine of the University of Montreal. Dr. Gottschalk was the first director of the Swine Infectious Disease Research Centre (Quebec, Canada) and is the director of the international reference laboratory for swine pleuropneumonia and the international laboratory for the serotyping of *Streptococcus suis*. In addition, he was granted with a Doctor Honoris Causa by the University of Ghent (Belgium) in 2018 as a recognition for his career. Dr. Gottschalk has published more than 350 papers in peer-reviewed journals, over 300 papers in professional journals and has been an author for Diseases of Swine, The Pig Site, and the Merck Veterinary Manual. He has been an invited speaker at over 250 conferences in more than 35 countries around the world.

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## **Dietary manipulation to support gut health and function in piglets**

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### **Abstract**

Piglets are highly susceptible to enteric disorders during the immediate period after weaning. Thus, post-weaning diarrhea (PWD) is a major challenge in the nutritional management of weaned piglets and a cause of significant economic losses to the swine industry. Various studies and a large number of published reviews have demonstrated that diet is a major factor in determining gut health and function outcomes in weaned pigs. Consequently, there has been a considerable focus on nutritional interventions as possible tools to mitigate PWD. With respect to diet composition, two components that have been shown to impact digestive physiology with significant implications on gut health and function are protein and dietary fibre contents. Use of low crude protein diets supplemented with crystalline amino acids are known to 1) reduce the proliferation of pathogenic bacteria in the gut and to favor those with potential gut health benefits; 2) minimize the attachment of enterotoxigenic *Escherichia coli* to the intestinal mucosa, thus preventing it from causing disease; and 3) minimize production of toxic metabolites which may damage intestinal mucosa. Dietary fibre has profound effects on intestinal physiology and depending on its physico-chemical properties, can confer gut health and function-promoting effects. Taken together, available evidence suggests that manipulation of dietary crude protein and fibre contents (and composition) can be effective in designing diets to support gut health and function in piglets.

### **Introduction**

The immediate post-weaning period poses major challenges in the nutritional management of the piglet that has direct consequences on growth performance in the nursery through to market weight. Furthermore, this period is characterized by poor feed intake which, in concert with immature digestive and immune systems, predisposes the piglet to intestinal disturbances, especially proliferation of enteric pathogens such as enterotoxigenic *Escherichia coli* (ETEC) K88 (Pluske et al., 1997). In the advent of antibiotic-free feeding, weaned piglets are likely to experience higher incidences of intestinal health problems and prolonged period of an immunological challenge. Therefore, it is critical to formulate starter diets that primarily fit the digestive capacity of weaned piglets, maintain gut health and promote growth.

Of the many nutritional strategies to support gut health and function, the use of low-crude protein (LCP) diets supplemented with crystalline amino acids (AA) has been suggested (de Lange et al., 2010; Heo et al., 2013). This is based on the fact that feeding started diets with high protein content may encourage proliferation of pathogenic bacteria, which preferentially ferment the proteins (Rist et al., 2013), in the gastrointestinal tract thus leading to increased incidences of PWD in weaned pigs and poor performance (Ball and Aherne, 1987). Another dietary component that has profound influence on gut physiology is dietary fibre (Agyekum and Nyachoti, 2017). Depending on its physico-chemical properties, dietary fibre influences the gut microbiome and the ability of pathogenic bacteria to cause disease (Molist et al., 2010, 2012, 2014). Thus, there has been considerable interest in the use of fibre to modulate gut health and function in weaned pigs and the potential synergies among different nutritional interventions.

The lecture will examine the concept of using LCP diets as a nutritional means of preventing incidences of PWD in newly weaned pigs and the potential interactions with dietary fibre. The proposed modes of action of how these components act to influence gut physiology and the major challenge with their practical application in commercial pork production will be discussed.

### **Low-crude protein diets**

Weaned piglets are fed high CP diets because of their low capacity for feed intake and a high potential for protein accretion. However, due to incomplete digestibility, a large proportion of undigested dietary

protein enters the large intestine and is subject to bacterial fermentation. To minimize the amount of fermentable protein that enters the lower gut and the associated enteric problems, the use of low crude protein AA supplemented diets has been proposed (Nyachoti et al., 2006; Wellock et al., 2006; Heo et al., 2008). Generally, this means a reduction by 4 percentage units coupled with fortification with the most limiting AA (Lys, Thr, Met and Trp) (Nyachoti et al., 2006).

The mechanisms by which dietary protein content modulates gut health outcomes in weaned pigs is related to the reduction in the amount of substrate available for the proliferation of pathogenic bacteria, thus minimizing proteolytic fermentation and the production of associated toxic metabolites (Opapeju et al., 2008). When nursery piglets are fed LCP diets, there is a reduction in intestinal concentrations of ammonia N, branched chain volatile fatty acids, putrescine and cadaverine (Prohaszka and Baron, 1980; Bikker et al., 2006; Nyachoti et al., 2006). These metabolites of proteolytic fermentation are considered to be toxic to intestinal cells and might predispose piglets to post-weaning diarrhea. Furthermore, feeding LCP diets to weaned pigs has been reported to reduce incidences of diarrhea compared with diet containing high CP content to weaned pigs (Heo et al., 2008; Garcia et al., 2014) while supporting adequate performance.

Feeding a LCP diet supports several indices of gut health, including those that relate to gut structure and function, microbial population, incidences of diarrhea. For example, Opapeju et al. (2009, 2010) and Bhandari et al. (2010) demonstrated that feeding a LCP diet to weaned piglets that challenged with *E. coli* K88 significantly reduced the population of *E. coli* K88 in the jejunal and ileal digesta and mucosa-associated ETEC compared with those fed the high CP diets. These observations suggest that dietary protein content not only influences ETEC population but also affects its ability to cause diarrhea. Also, LCP diets may improve gut health outcomes by suppressing the proliferation of pathogenic bacteria while promoting those with beneficial effects (Rist et al., 2013), although this observation is not universal (Bikker et al., 2006, 2007; Pieper et al., 2012; Jeaurond et al., 2008).

The impact of feeding a LCP diet on gut structure (e.g. intestinal morphology) and function (e.g. enzyme development and absorptive capacity) is less well defined. However, existing evidence collectively indicate that feeding a LCP diet has not negative effect on the development of intestinal brush boarder enzymes and gut maturation (Yue and Qiao, 2008) and can modulate inflammatory responses in piglets subjected to disease challenge (Opapeju et al., 2010).

### **Practical considerations for using LCP diets to control piglet diarrhea**

Reducing dietary crude protein content inevitably leads to a reduction in dietary amino acid supply, which can compromise animal performance, hence the need to fortify LCP diets with crystalline amino acids. Often in such diets AA deficiencies not only involve essential AA but also non-essential AA. Results of many studies have shown clearly that it is critically important to carefully formulate LCP diets to ensure that adequate levels of all amino acids are provided in the diet in appropriate proportions so as to assure acceptable performance. Also, it is of interest to determine how a LCP diet can be utilized along with the available interventions to manage diarrhea in piglets. In this regard, few studies have examined synergistic effects of a LCP diet with other feed additives or formulation strategies and some of this work has shown that a LCP diet could act synergistically with probiotics to support growth performance in piglets similar to that piglets fed a control diet containing an AGP (Bhandari et al., 2010).

### **Manipulation of dietary fibre**

From the perspectives of gut health, the fibre component of the diet is believed to play an important role primarily through its influence on the gut microbiome or by simply providing alternate attachment site for pathogenic bacteria, which prevents infection. Addition of fermentable fibre to swine diets has been shown to reduce protein fermentation in the gut, beneficially shift the gut microbiome and produce volatile fatty acids (Konstantinov et al., 2004; Pieper et al., 2012; Rist et al., 2013). Supplementing coarsely ground



wheat bran as a source of insoluble fibre to nursery pig diets was shown to prevent the adhesion of *E. coli* to the intestinal mucosa and the incidence of diarrhea in ETEC-challenged pigs (Molist et al., 2010, 2012). These observations suggest that manipulating dietary fibre content in addition to feeding a LCP diet may further enhance gut health outcomes in piglets. Although the independent effects of dietary crude protein and fibre are well established, the benefits of using them in concert needs to be explored further.

### Conclusions

Diet has a profound impact on gut physiology in swine, which if managed carefully can lead to positive outcomes in terms of maintaining a healthy gut and supporting adequate performance. In this regard, manipulating the dietary contents of protein and fibre has been shown to have significant influences on gut health and function in weaned pigs. Because high dietary protein is an important predisposing factor for the occurrence of diarrhea in piglets because it encourages the proliferation of pathogenic bacteria, feeding a low-crude protein diet (i.e. a minimum reduction of 4 percentage units) has been suggested a strategy to mitigate diarrhea disease in weaned piglets. However, as feeding a low-protein diet may lead to reduced performance due to inadequate supply of amino acids, thus such a diet must be carefully fortified with crystalline amino acids (i.e. those that are likely to be most limiting) to meet requirements. As dietary fibre has significant impact on intestinal physiology and the gut microbiome, there is interest to understand how it can be used in concert with other strategies as use of a LCP diet to better support gut health and function. However, these concepts need to be developed further before they can be effectively and routinely applied in managing diarrhea in piglets as existing evidence for synergistic/interactive effects between crude protein content and dietary fibre is less convincing.

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## **Streptococcus suis: Struggling to control disease**

Dr. Marcelo Gottschalk

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According to the Canadian Swine Health Information Network, *Streptococcus suis* (*S. suis*) related diseases are the most common infectious problem reported on Canadian swine farms. Outbreaks of *S. suis* disease result in decreased performance and increased mortality which have a significant economic impact on swine production in our country. Clinical features associated with *S. suis* infection in pigs are meningitis, arthritis, endocarditis, polyserositis and septicemia with sudden death. There are 35 serotypes that have been described, although some of them have been now re-classified as non-*S. suis*. Although a few virulent serotypes are recovered from diseased animals in Europe (mostly serotypes 2 and 9), the situation is much complicated in Canada and USA, where a relatively large number of serotypes are routinely isolated from diseased pigs, with no clear predominance of a given serotype. Recent data from Quebec, Canada and USA indicate that serotypes 1, 1/2, 2, 3, 5 and 7 (depending the region) may be the most important, but these will count all together for less than 60% of the isolates recovered from diseased pigs. Multilocus sequence typing (MLST) may give some indication of the virulence of such isolates: those included in the clonal complex 1 (mostly sequence type or ST 1) are considered highly virulent. In USA and Canada (at least in Quebec), between 10 and 20% of recovered isolates (serotypes 1, 2 and 14) belong to this ST. Although ST28 serotype 2 strains have been traditionally considered as low virulent in experimental infection in animal models, most field strains of serotype 1/2 (predominant serotype in USA and Canada) as well as those of serotype 2 (all recovered from ill animals) belong to this ST. This may indicate that results obtained in experimental infections do not always reflect the reality of the field.

Control of *S. suis* disease is frustrating. Antibiotics can prevent clinical outbreaks, but those that have efficacy are mainly in categories 1 and 2, so products that the industry is trying to use as little as possible, given their importance in both human and veterinary medicine. Hence, prevention of *S. suis* disease should be concentrated on management of predisposal factors and, mainly, vaccines. Being a well-encapsulated pathogen -which makes it low immunogenic: animals produce low antibody response - and presenting high number of serotypes (with no protection one against each other), universal efficacious commercial vaccines could not be developed so far. Indeed, only bacterins (whole cell killed bacteria) have been used in the field, with contradictory results. The limited protective response obtained with bacterins has been attributed to failure of the whole-bacterial antigens to elicit an immune response due to loss of antigenicity caused by the killing procedure, production of antibodies to antigens not associated with protection, and/or the use of inappropriate adjuvants.

The reduction in the use of antimicrobials, largely employed to control *S. suis* infections and the presence of a high variety of serotypes, led to an increased popularity of autogenous vaccines in many countries, including Canada. Autogenous vaccines are bacterins based on the predominant strain(s) recovered from diseased pigs in the affected farm and produced by accredited laboratories. However, there are few published scientific studies demonstrating whether the use of such vaccines is correlated with a clear reduction in both mortality and curative antibiotic use and if this practice, as presently used, is economically profitable for producers. In fact, there are no studies on the capacity of autogenous vaccines produced by licensed laboratories to induce antibodies. In addition, there are no clear data when and how these vaccines should be applied. In the field, and without any scientific data, autogenous vaccines are used in sows or piglets. Our results showed that piglets vaccinated twice with a licensed autogenous vaccine do not induce any detectable antibody response measured by ELISA. In addition, sera from vaccinated animals did not possess high titers of opsonophagocytic antibodies (no differences with control non-vaccinated animals).

Vaccination of sows before farrowing might elicit passive maternal immunity, being less costly, and thus representing an economical alternative to piglet vaccination. Our studies showed that vaccination of sows slightly increase antibody titers (which were already very high) in adult animals. However, maternal

immunity transferred to piglets was similar in animals from vaccinated and non-vaccinated sows and disappeared from piglet sera after 3 weeks of age.

More complete and scientific studies are needed on the use of such autogenous vaccines. In addition, diagnosis of *S. suis* as a primary pathogen when different serotypes are recovered from the same affected farm is still a challenge. This may also influence the effectiveness of such vaccines.

## **Defining pig sort loss with a simulation of various marketing options of pigs with the assumption that marketing cuts improve variation in carcass weight and leanness**

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**Introduction:** The study offers clarification on pig sort loss and associated marketing strategies using a simulated pig marketing system. The objective was to investigate the economic variability associated with marketing strategies using the simulated pig marketing models. Typically, individual pigs are assessed by measuring carcass weight and predicted leanness, which is then incorporated into a two-factor grid for producer payment, providing incentives for producers who consistently produce desirable carcasses and discounts for producers who produce inconsistent or undesirable carcasses.

**Methods:** The simulation considered six producers with the presumption that each had a maximum capacity for 4,800 grow-finish pigs, in order to imitate commercial finishing barns with 48 pens of roughly 100 pigs per pen. It was assumed that all of the pigs enter at a standard weight of 24kgs, which would be a representative weight of pigs entering the grow-finish period. For each individual producer, the number of marketing group and marketing days differed, however, the days of marketing was chosen so that each producer would have an equal number of total days of production for pigs and each marketing group would be a representative of a standardized truckload of pigs. The simulation dataset was created using a random number generator with the inverse of the cumulative normal distribution function on Microsoft Excel (Microsoft Inc., USA) with a targeted carcass weight (102.86 kg) and average predicted lean (60%) based on industry averages and previous research studies. Under the assumption that variability in carcass weight and predicted leanness decreased with the addition of each marketing cut, the simulation incorporated a standard deviation reduction of 20% per increase of one marketing cut for both carcass weight and predicted leanness of the population of pigs marketed on a given day. Premiums were then estimated using an example marketing grid that used predicted lean and hot carcass weight.

**Results:** As a result of the values and marketing grid used in this study, there was an increase in profitability; as well as, a decrease in pig sort loss (defined with both carcass weight and predicted leanness) with each marketing cut. It was understood that overall profitability was the result of the subtraction of the total production from the total amount of revenue. With that, there was a 95.44% improvement in market premiums for a producer marketing 2 cuts of pigs compared with 1 marketing cut (\$36,863.41 vs. \$18,861.79), a 37.22% improvement in market premiums for a producer marketing 3 cuts of pigs compared with 2 marketing cuts (\$50,585.31 vs. \$36,863.41), a 17.21% improvement in market premiums for a producer marketing 4 cuts of pigs compared with 3 marketing cuts (\$59,291.84 vs. \$50,585.31), a 12.90% improvement in market premiums for a producer marketing 5 cuts of pigs compared with 4 marketing cuts (\$66,943.06 vs. \$59,291.84), and a 2.23% improvement in market premiums for a producer marketing 6 cuts of pigs compared with 5 marketing cuts (\$68,435.91 vs. \$66,943.91). While, profitability improvements diminished (as a percentage improvement) with each additional marketing cut, each additional marketing cut did provide improvements in profitability. However, the greater advantage with additional marketing cuts may be the improvement of consistency for the processor.

**Conclusion:** This simulation provides an appropriate framework and the necessary equations to allow repetition of the different parameters and marketing grid specifically related to an individual producer and processing facility. Limitations of this work include the amount of variation used throughout the industry with marketing grid premiums/discounts, and the general assumption that sort loss is improved to a specific level with increased number of marketing groups.

**Industry Implications:** This project hopes to help the industry gain a better understanding of how market cuts can decrease variation and consequently improve profitability.

**Acknowledgements:** Funding for this project was provided by Ontario Pork.

## Precision feeding of gestating first parity sows improves sow body weight gain in late gestation

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**Introduction:** Gestating sows experience varying nutrient and energy requirements throughout gestation. Failing to adequately meet these changing requirements can lead to sub-optimal body condition, reduced reproductive performance, and diminished sow longevity. The objective was to determine the effects of precisely meeting estimated (daily) energy and Lys requirements for first parity gestating sows on sow body weight and back fat thickness changes throughout gestation.

**Methods:** Ninety, first parity sows were randomly assigned to a precision (PF; n=49) or control (CON; n=41) feeding program between day 2 and 9 of gestation and housed in group-pens equipped with electronic sow feeders (ESF) capable of blending 2 diets. The PF sows received unique daily blends of two isocaloric diets (2518 kcal/kg NE; 0.80 and 0.20% SID Lys, respectively) while the CON sows received 2.2 kg of a static blend of the diets to achieve 0.56% SID Lys. Sow body weights were measured weekly, back fat thickness was determined via ultrasound in early (~d5), mid (~d60), and late (~d110) gestation, and litter characteristics (e.g. born alive, birth weight) were recorded after farrowing.

**Results:** The PF sows had greater body weight gains in late gestation (i.e. when nutrient requirements are greatest; between day 60 and 110) versus CON sows (859 vs 484 g/d;  $P < 0.05$ ). Back fat thickness increased continuously for PF sows but decreased between day 60 and 110 of gestation for CON sows. The total amount of body weight gain during gestation and number of piglets born alive did not differ, but PF sows tended to have fewer stillbirths (0.24 vs 0.53;  $P = 0.058$ ) and lower litter birth weights (15.0 vs 16.5 kg;  $P = 0.09$ ) than CON sows.

**Conclusions:** Energy, and likely amino acids, were limiting for the CON sows by late gestation as they sacrificed both back fat and body weight gain in order to support litter growth. The long-term consequences for both the sow and her offspring remain to be elucidated.

**Industry Implications:** By precisely meeting estimated nutrient requirements on each day of gestation, nutrient losses to the environment will be reduced and sows will have improved longevity within the herd and produce larger litters of uniformly sized and robust piglets. Improving annual sow production by even 0.1 pig weaned (\$30/pig; value - feed cost) represents \$750,000/year for Ontario.

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## **Growth performance in antibiotic-free and conventional nursery herds in Ontario**

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**Introduction:** The nursery period presents a unique set of stressors for pigs. In the nursery barn, piglets that are just weaned off their dams and are thus losing passive immunity are mixed together in an environment where common endemic diseases seem to linger. This stressful transition may result in reduced growth rate and increase susceptibility to disease. Being able to control disease and optimize growth in the nursery stage can improve the productivity of an entire herd. Feeding low levels of antibiotics in feed is a common practice that has been shown to improve nursery pig growth rate. However, due to public concern of antibiotic usage, pigs being raised without antibiotics is a growing niche market in Ontario. These systems include pigs from organic and raised without antibiotic (RWA) farms. The objective of this study is to compare growth rates of antibiotic-free nursery pigs to those of conventionally raised nursery pigs. It is hypothesized that antibiotic-free pigs will have reduced growth rates compared to conventional pigs.

**Methods:** A pre-existing dataset containing data from 27 conventional nurseries and 523 pigs was used. Samples were also collected from 391 pigs in 20 antibiotic-free nurseries, 10 of which were classified as organic with the other 10 being RWA. Each barn was visited twice, shortly after pigs entered the nursery and again shortly before they left. At the initial barn visit, producers answered a survey describing their type of production system and basic management practices. Twenty pigs at each farm were randomly selected and tagged. The selected pigs were weighed at both visits. Weight gain and average daily gain (ADG) were calculated for each animal and used to determine the average production parameters for each farm. Management practices will be analyzed in a linear regression with ADG as the outcome, production system type as the explanatory variable and farm included as a random effect.

**Results:** The conventional nursery pigs had a mean ADG value of 466 g/day, with a minimum value of 114 g/day, a maximum of 850 g/day and a standard deviation of 108 g/day. The 196 RWA pigs had a mean ADG value of 446 g/day, with a minimum value of 176 g/day, a maximum of 734 g/day and a standard deviation of 108 g/day. Lastly, the 195 organic nursery pigs sampled had a mean ADG value of 402 g/day, with a minimum value of 75 g/day, a maximum of 764 g/day and a standard deviation of 146 g/day.

**Conclusions:** These preliminary results indicate that there may be no difference in growth rates of RWA and conventional nursery pigs, while organic nursery pigs may have slower growth rates than conventional. This may be due to the specific management practices used in organic production that differ from RWA and conventional production. However, the statistical significance of these results as well as how specific management practices affect growth rates, and the variation between farms of the same system type, needs to be further analysed using regression analysis.

**Industry Implications:** This research can provide relevant information about how pigs in antibiotic-free programs grow compared to conventionally raised pigs and whether certain management practices can be used to optimize production. The results of this study can also provide benchmarking data about nursery pig production for Ontario hog producers.

**Acknowledgements:** We would like to thank OMAFRA New Directions Research Program Ontario Agri-Food Innovation Alliance, and Ontario Pork for their financial support.

## **The synthesis of sulfated 16-androstene steroids by porcine Leydig cells and their potential involvement in the development of boar taint**

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**Introduction:** Boar taint is a meat quality issue characterized by an off-odour or off-flavour in pork from entire male pigs, which is currently prevented by castrating males early in life. The development of boar taint is caused primarily by the accumulation of androstenone in the fat, but sensory estimates of boar taint do not always correlate with fat androstenone concentrations (1). However, these evaluations examine the sensory qualities of both the fat and lean tissue of heated pork products. Sulfated metabolites of androstenone are polar compounds that are abundantly produced by the Leydig cells of the testes, which may accumulate in more hydrophilic lean tissue. Therefore, the purpose of this study was to investigate the testicular metabolism of androstenone to further characterize important pathways involved in the development of boar taint.

**Methods:** Leydig cells were isolated from the testes of 7-month-old Yorkshire, Duroc and terminal cross [Duroc x (Landrace x Yorkshire)] boars and incubated with radiolabeled androstenone for 8 hours. The sulfated metabolites were identified using liquid chromatography-mass spectrometry (LC-MS/MS), and the proportion of sulfated androstenone metabolites produced was then quantified by reverse phase high performance liquid chromatography (HPLC) and radioisotope detection.

**Results:** Following isolation and analysis with LC-MS/MS, several sulfated metabolites of androstenone were identified including androstenol-3-sulfate and two major sulfated forms of androstenone, which we have tentatively identified as androstenone-4-sulfate and androst-3-enol-3-sulfate. Additionally, removal of the sulfate group from these two sulfated forms of androstenone returned the parent compound androstenone, and not a hydroxylated metabolite. The average production of androstenol sulfate produced across all boars was  $52.1 \pm 8.6\%$ , which was not significantly different ( $P=0.7$ ) from the average production of sulfated androstenone ( $47.9 \pm 8.6\%$ ).

**Conclusions:** The results of this study indicated that androstenone is directly sulfated as the removal of the sulfate group returned the parent compound and not a hydroxylated metabolite. Therefore, sulfated metabolites of androstenone may function as steroid reservoirs that can enzymatically regenerate free androstenone within hydrophilic lean tissue. Alternatively, these metabolites may accumulate in the lean tissue, which we are proposing as a novel mechanism that contributes to the development of boar taint.

**Industry Implications:** This study has provided new insight on the metabolic pathways regulating the development of boar taint, which can be used to design alternatives to castration. Castration has been recognized as an animal welfare concern, which has put pressure on pork producers to cease this procedure. Controlling boar taint without castration would also improve growth, increase lean yield, improve feed utilization and decrease feed consumption, which would improve profitability and enhance sustainability of swine production.

**Acknowledgments:** Funding provided by OMAFRA and NSERC.

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## **Non-antibiotic approaches to reduce the need for antibiotics in nursery pig production: A scoping review**

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**Introduction:** Swine producers aim to reduce their use of antibiotics belonging to classes of medical importance to humans. These antibiotics have been used in nursery pigs to prevent diarrhea and other causes of morbidity and mortality. Our objectives were to systematically describe the research literature published in English since 2000 evaluating non-antibiotic approaches that may improve health in nursery pigs raised under typical North American systems, identify specific topics with sufficient literature for systematic reviews, and identify knowledge gaps.

**Methods:** Multiple databases and conference proceedings were searched for relevant articles.

**Results:** There were 422 relevant studies. The majority of studies were conducted in Western Europe (59%). The research literature from the USA was dominated by conference proceedings (55%) whereas the literature from Western Europe, Canada, and Australia/New Zealand was dominated by journal articles. Among the 422 studies, 98% and 2% were clinical trials and observational studies respectively. The two most frequent categories of interventions were feed additives (31%) and vaccinations in piglets (30%). The three most frequently measured outcomes were diarrhea (26%), mortality (22%), and vaccine immunity (19%). Comparison groups included a different form or level of the intervention (49%), a no treatment control group (33%), a placebo group (12%), a preventive antibiotic group (4%), and a zinc oxide group (2%). Sixteen potential specific topic areas which may share enough commonality for systemic reviews were identified.

**Conclusions:** Future primary research of interventions could include preventive antibiotic use comparison groups where appropriate to enhance the knowledge of antibiotic alternatives.

**Industry Implications:** There is considerable volume, breadth, and depth of research on non-antibiotic approaches in nursery pig production. However, direct comparisons to preventive antibiotic groups are lacking.

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## **Assessment of the analgesic efficacy of ketoprofen and meloxicam when compounded with iron dextran and administered to piglets at the time of castration using chute navigation**

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**Introduction:** Castration of neonatal piglets is a painful procedure, creating both acute and ongoing pain (1,2). Control of post-procedural pain is required by The Canadian Code of Practice for Care and Handling of Piglets. Iron dextran (ID), already given to piglets to prevent anemia, and there is interest in combining this practice with non-steroidal anti-inflammatory drugs (NSAIDs) at the time of processing. This has the potential to decrease piglet handling, reduce injections that piglets receive, and reduce labour and costs of associated with piglet castration overall. The study objectives are to determine if the analgesic efficacies of the NSAIDs meloxicam (M) and ketoprofen (K) are altered after mixing with ID and administered at the time of castration.

**Methods:** Piglets (n=175) from 25 litters were assigned to 1 of 7 treatment groups: M or K alone, compounded M+ID, compounded K+ID, or 1 of 3 control groups; sham handled (SH), ID+castration (ID+C), ID and no castration (ID-C). Piglets navigated a chute at 7 time-points ranging from 15-minutes prior to castration, to 30-hours post-castration. Chute navigation times (seconds) were recorded and compared, using linear regression (StataIC 14.2, StataCorp LLC).

**Results:** After controlling for the effect of time-point, all treatments groups had faster chute navigation times versus the ID+C group ( $P < 0.01$ ). There was no decrease in chute navigation time for NSAIDs compounded with iron dextran, as compared to NSAIDs administered alone ( $P > 0.05$ ).

**Conclusions:** Piglets treated with NSAIDs (given alone or compounded with iron dextran), had shorter chute navigation times supporting that they were less painful following castration than piglets castrated without NSAID administration. The practice of compounding meloxicam and ketoprofen with iron dextran does not appear to reduce the efficacy of these drugs for the control of post-procedural pain.

**Industry Implications:** This method of compounding NSAIDs with iron dextran could improve overall early piglet experiences, optimize labour input for barn staff, while increasing compliance with the recommended Code of Practice regarding analgesic control of painful processing procedures. Future work examining tissue drug depletion for compounded formulations is required, in order to ensure food safety.

**Acknowledgments:** Funding provided by Ontario Pork, Ontario Ministry of Agriculture, Food and Rural Affairs, and the Ontario Veterinary College scholarship program.

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## **Investigation into the serotypes of *Streptococcus suis* isolates in nursery pigs in Ontario, Canada**

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**Introduction:** *Streptococcus suis* naturally inhabits the nasal cavities and tonsils of pigs. Some strains can cause systemic infection leading to a wide range of disease conditions. This study describes *S. suis* serotypes isolated from sick pigs and investigates whether serotypes found in systemic sites (blood, meninges, spleen) are also found in their upper respiratory sites. In addition, this study examined whether the same serotypes are found in upper respiratory sites of sick pigs and healthy pigs.

**Methods:** A case control study involving 4-8-week-old nursery pigs from Ontario farms was conducted. Cases showing clinical signs of *S. suis* infection were selected and matched with an equal number of healthy controls based on herd, time of visit and pen. Nasal, tonsil and rectal swabs, as well as blood samples were collected from each case and control. In addition, cases were euthanized to collect meningeal swabs and tissue samples from spleen, ileum and tonsil. Samples were cultured on phenylethyl alcohol blood agar and incubated for 48 h at 35°C with 5% CO<sub>2</sub>. *S. suis* isolates were tested for presence of glutamate dehydrogenase and recombination protein N genes by PCR. Confirmation of *S. suis* was concluded if both genes were present. The isolates were then serotyped using a two step-multiplex PCR.

**Results:** Twelve Ontario farms were visited, and 698 samples were collected from 128 pigs (451 from 64 cases and 247 from 64 controls). Serotypes commonly detected in both sick and healthy pigs included 29 (8 farms), 16 (7 farms), 15 (6 farms) and 9 (6 farms). Serotypes commonly detected in systemic sites included 29 (3 farms) and (2,1/2), 7 and 9 (2 farms each), as well as untypable (4 farms). In individual confirmed cases, serotypes 9, (2,1/2) and untypable were most commonly detected. Cluster analysis suggested existence of four major groups of confirmed cases: i) serotype 9, ii) untypable, iii) mixed serotype and iv) serotype (2,1/2). Detection of serotypes 9 (p=0.03) or (2,1/2) (p=0.08) in upper respiratory sites were positively associated with detection of the same serotypes in systemic sites of case animals; whilst there was no association in these sites between untypable isolates; however, the isolation of these serotypes was very low. There was also no association between presence of specific serotypes in upper respiratory sites between case and control animals.

**Conclusions:** This study provides a good understanding of which *S. suis* serotypes are most commonly found in these clinical cases. Further molecular analysis may help to better understand which serotypes are able to reach systemic sites and cause clinical illness.

**Industry Implications:** The knowledge of which serotypes most frequently found on each farm may help to implement better autogenous vaccines and lead to reduced mortality and improved welfare of pigs.

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## Effects of individual vs. group housing system post-weaning on reproductive performance of sows

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**Introduction:** Selection of appropriate housing conditions for breeding sows is critical for their long-term reproductive success and physical health. There is an ongoing debate as to whether the individual-stall (IS) or group-pen (GP) housing system is more beneficial for the reproductive productivity of sows. The primary goal of the present study was to determine and compare the relative utility of the IS and GP systems of post-weaning sows in commercial settings for their reproductive parameters.

**Methods:** This study was conducted on a large commercial facility housing 850 cross-bred sows. Animals were fed a dry fodder mix that increased in energy and nutrition content with time. During the study period, 3,053 sows were weaned at a rate of roughly 20-30 animals per week at median age of 4 weeks. 1474 sows were moved into group pens of 7-8 animals each, while 1579 were placed in individual stalls. After weaning, the sows were randomly allocated to either individual stalls (IS) or group pens (GP). Two days post-weaning, animals were checked for the onset of estrus with a teaser boar.

**Results:** Generally, the number of sows showing the signs of standing heat 6 days post-weaning was significantly greater ( $P < 0.05$ ) for sows moved to GP compared to sows moved to IS. This difference manifested specifically in second parity sows weaned in the summer and fall. Conception and farrowing rates were significantly higher in GP compared to IS sows in every season but autumn. The weaning-to-estrus interval was significantly longer in IS than GP sows. Mean litter size was lower in IS groups in summer, autumn, and winter. Total number of live-borns was greater for GP sows in summer and fall ( $P < 0.001$ ).

**Conclusions:** While both housing systems have their pros and cons, the data collected in this study are supportive of the long-term reproductive advantages of GP over IS housing system. There was a significantly greater proportion of sows returning to estrus post-weaning “on time” (i.e.,  $\leq 7$  days) in group housing compared to single stalls (healthier WEI). This was congruent with existing studies that measured WEI as one parameter of reproductive health when comparing housing systems (1). Group housing improved nearly all reproductive parameters with the exception of conception/farrowing rates in the fall. These results suggest a seasonal aspect to sow fertility worthy of investigation. Beneficial effects of group housing on piglet productivity manifested up until the seventh consecutive farrowing and then began to wane.

**Implications for industry:** While the single-stall system can prevent fighting, reduce physical stress, and enable easier medical care, it may restrict natural socialization and exercise. Data suggest that single stalls may have more negative consequences on the sow's reproductive viability. Although group housing systems of post-weaning sows typically make specialized care difficult, they mimic “natural” conditions, appear to have benefits for reproductive efficiency and are typically favoured in economic evaluations (2).

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## Standardized ileal digestible amino acids in black soldier fly larvae meal (*Hermatia illucens*) fed to growing pigs

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**Introduction:** As the world population increases, greater stress is being placed on livestock producers to keep up with the demand for animal products to prevent global food insecurity. Presently, most livestock diets rely on soybean meal (**SBM**), a coproduct of soybean oil extraction, as a high-quality protein source with 85% of the world's soybean supply being processed into SBM (and oil) and nearly 97% of that being used to feed livestock. This is unsustainable long-term as it increases competition with humans for a preferable food source and can contribute further to global food insecurity. Black soldier fly larvae (**BSFL**) are a great feed alternative as they require less water, land, and resources to produce versus other conventional plant-based feed ingredients and they can reduce the competition between humans and animals for preferable food sources. Further, BSFL can efficiently consume a variety of substrates such as food waste, kitchen waste, and distillers' grains, among others, while maintaining an optimal amino acid (**AA**) profile; the AA profile of BSFL is comparable to SBM, making it an ideal substitute. BSFL meal is also enriched with both chitin and medium chain fatty acids. Chitin acts as a prebiotic to support a balanced and diverse population of gut microbes while medium chain fatty acids exhibit anti-inflammatory and antimicrobial properties, which make it a promising alternative to in-feed antibiotics. Our objective is to determine the standardized ileal digestible (**SID**) AA contents of two different BSFL meal sources (full fat and defatted). We hypothesize that overall BSFL meal will have a comparable SID AA contents to SBM.

**Methods:** Test diets were formulated to contain 50 and 36.5% of full fat and defatted BSFL meal from two different sources, respectively, as the sole protein source in each and to achieve similar dietary protein concentrations. A total of 8 barrows ( $25.1 \pm 0.41$  kg BW) were surgically fitted with simple T-cannulas in the terminal ileum. After 7 days of recovery, barrows were assigned to 1 of 2 test diets in a replicated 2 x 2 Latin square design ( $n = 8$  over 2 experimental periods). Pigs were fed at 2.8 x maintenance energy requirements based on the body weight at the beginning of each period. In each period, pigs were fed the test diet in two meals for 5 d followed by 2 d of continuous ileal digesta collection for 8 h after the morning meal. Total AA contents of the diet and digesta were determined via liquid chromatography (UPLC) and SID of AA were calculated using basal endogenous losses for pigs fed a nitrogen-free diet.

**Results:** The crude protein (**CP**) concentration of full fat BSFL meal was 4% greater than defatted BSFL meal (as-fed; 42.46 vs. 40.80%), which were approximately 15% lower than that of SBM (47.73%; NRC, 2012). The SID of essential AA (**EAA**) for the full fat BSFL meal were typically not different from the defatted BSFL meal (e.g., 85 and 88% SID Lys for full fat and defatted BSFL meal, respectively), which were also comparable to those of SBM (e.g., 89% SID Lys). The exception was for Met whose SID was approximately 13% less for the defatted BSFL meal than full fat BSFL meal or SBM (80, 88, 90% SID Met for defatted BSFL meal, full fat BSFL meal, and SBM, respectively).

**Conclusions:** There were no differences in CP concentration nor SID of EAA between the two BSFL meals. Compared to SBM, BSFL meals provided 15% less CP and similar EAA SID. Therefore, both full fat and defatted BSFL meals are possible substitutes for SBM but provide less digestible AA overall.

**Industry Implications:** Due to the high price point of these BSFL meal, and the relatively lower CP concentration versus SBM, it may be appropriate to explore other functional benefits of BSFL meals versus using them as a complete replacement for SBM in swine diets.

**Acknowledgments:** Funding provided by the Ontario Ministry of Food, Agriculture and Rural Affairs. Oreka Solutions kindly donated the full fat BSFL meal. We acknowledge technical support from undergraduate and graduate student volunteers for their help during the animal studies.

## The relationship between tonsil microbiota and clinical *Streptococcus suis* infection in nursery pigs

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**Introduction:** *Streptococcus suis* is a Gram-positive bacterium that naturally resides in the upper respiratory tract of swine (1). *S. suis* has been shown to be present in 98% of pigs in Ontario; however, only around 5% develop clinical signs of infection (2,3). The most clinical cases occur in weanling pigs, with clinical signs including meningitis, septicemia, arthritis, and endocarditis (3). *S. suis* causes major economic losses in the swine industry throughout the world and is recognized as an emerging zoonotic pathogen (2). Human cases have been reported across Europe, North America, Asia and South America (2). It is currently unknown why some pigs with *S. suis* remain healthy while others develop the infection. The tonsils are secondary lymphoid organs that survey, detect and initiate the immune system. The tonsils of the soft palate are also an important site of bacterial colonization in the upper respiratory tract (4), and they have a large number of crypts that can be the portal of entry for *S. suis* and other pathogens (4, 5). The objective of this study was to determine whether the tonsil microbiome is altered in nursery pigs with clinical signs of *S. suis* disease compared to healthy pigs.

**Methods:** Animals were classified into 3 categories: confirmed cases (with clinical signs of infection and presence of *S. suis* in systemic sites), probable cases (with clinical signs but absence of *S. suis* in systemic sites), and controls (without clinical signs and absence of *S. suis* in systemic sites). In total, 62 (19 confirmed, 23 probable, and 20 controls) pigs were obtained from 7 farms. DNA was extracted from the tonsils of the soft palate of these animals. Illumina MiSeq sequencing of the 16S V3-V4 hypervariable region was done to assess the composition of the microbiota and the mothur pipeline was used for clustering and taxonomy assignment.

**Results:** Using a linear regression method, the confirmed cases had higher taxonomic diversity than the probable cases and controls ( $P < 0.001$ ). However, the probable cases had a higher taxonomic diversity than the control group ( $P < 0.001$ ). The top 5 phyla identified in all groups were *Proteobacteria*, *Firmicutes*, *Fusobacteria*, *Bacteroidetes* and *Tenericutes*. The relative abundance of *Streptococcus* spp. was lower in confirmed cases than controls but it was borderline significant ( $P = 0.05$ ).

**Conclusions:** These findings indicate that there may be a difference in tonsil microbiota between healthy pigs and those with *S. suis* disease. This change in microbiota could be influencing the growth of *S. suis*, allowing this opportunistic pathogen to reach systemic sites. Currently, statistical analysis with farm and other pig level variables are being implemented to understand the clinical status and microbiota relationship.

**Industry Implications:** It is currently unknown why some pigs develop clinical signs of *S. suis*, while others remain healthy. The observation that tonsillar microbiome differed in *S. suis* diseased pigs in this study, may help to identify the pigs that are more prone to disease development. Furthering our understanding of this opportunistic pathogen, we can use this knowledge to prevent infection using probiotics and/or antibiotics to promote the establishment of a healthy microbiota.

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## **The risk factors of tail-biting in swine: a scoping review**

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**Introduction:** Tail biting in pigs is a broad research topic in which many articles, both peer reviewed and grey literature, have been published. It can be time consuming and may be difficult to get a thorough picture of all literature through a simple literature review and difficult to determine if conclusions have any relevance for industry and producer knowledge. Scoping reviews focus on transferring knowledge on a specific research topic through a systematic analysis of the literature allowing an examination of gaps, theories and concepts (1). The objective of this scoping review is to identify risk factors associated with tail-biting in pigs.

**Methods:** This scoping review follows the Joanna Briggs Institute steps. Two reviewers have decided upon a protocol, including the main objective, keywords to use in database searches, exclusion and inclusion criteria, and which databases to utilize. Three databases were agreed upon for the published literature; CABI, Web of Science and AGRICOLA. The American Association of Swine Veterinarians library was selected to use as the grey literature database. An independent, initial search of the 3 databases by each reviewer found 212 total articles for published literature, while the grey literature database produced 253 results. A level one screening of all titles and abstracts in both published and grey literature is being completed, and the appropriate articles will then undergo level two screening: full text revision. When both screening levels are completed, the chosen articles will be broken down using the charting program DistillerSR. Conclusions will then be determined from the charted data.

**Results:** The scoping review is in the level one screening process and no results are currently available.

**Conclusions:** The scoping review is in the level one screening process and no conclusions are currently available.

**Industry Implications:** Despite extensive research, tail biting remains a difficult and costly problem to prevent in commercial swine operations. A scoping review can be helpful in thoroughly identifying current research and organizing this information. Through analysis of this charted data, knowledge, as well as gaps in the current literature will be identified, which may lead to future research opportunities. The industry will benefit from this work by having a single document to identify the known risk factors of tail-biting. In addition, knowledge gained from this work may be sufficient for implementing procedures and policies. Through this resource, possible interventions may come to light that others are applying, which may help swine producers and the industry alike.

**Acknowledgments:** Funding provided by the Ontario Agri-Food Innovation Alliance, Grand Valley Fortifiers and OVC Departmental Graduate Growth Support

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## Digestive and post-absorptive utilization of dietary crude protein was not affected by feed antibiotics in weanling pigs

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**Introduction:** For the past several decades, one of the most economical and effective ways to maintain the health condition and feed efficiency in swine production was the application of feed antibiotics supplementation. Improved understanding mode of actions of feed antibiotics in promoting growth performances in weanling pigs may contribute to the development of effective alternative dietary strategies.

**Methods:** A total of 72 crossbred (Duroc×Yorkshire×Landrace) barrows, weaned on d 19 with an average initial body weight of 7.1 kg, were randomly assigned to two corn and soybean meal-based diets for 21 d according to a randomized complete block design. The antibiotic diet was supplemented with 550 mg aureomycin/kg. N balance was performed on d 15 for 7 d with 9 pigs from each diet being housed in individual metabolic crates for the collection of total urinary excretion and fecal samples for the last 5 d (1). The enzyme kinetics of the jejunal and ileal aminopeptidase N (APN) activities were determined with collected jejunal and ileal samples by using L-alanine-p-nitroanilide (0-16 mM). Abundances of APN protein and mRNA were examined by Western blotting and quantitative real-time RT-PCR with  $\beta$ -actin as a house-keeping control, respectively.

**Results:** There were no differences ( $P>0.05$ ) in the apparent ileal CP digestibility (control,  $67.7\pm 3.7$  vs. antibiotic,  $76.3\pm 1.8\%$ ) and the apparent N retention (control,  $64.8\pm 0.9$  vs. antibiotic,  $65.5\pm 2.4\%$ ) between the two the diets. There were also no differences ( $P>0.05$ ) in the APN enzyme kinetics between the two diets. Although we had identified 14 potential N-glycosylation sites within the porcine gut APN protein catalytic pocket, the gut APN functionality was unlikely affected by N-glycosylation because of the dietary antibiotic treatment. Moreover, there were no differences ( $P>0.05$ ) in the jejunal and ileal APN protein and mRNA abundances between the two diets.

**Conclusions:** Our results suggest that feed antibiotic use did not significantly improve efficiency of the digestive and post-absorptive utilization of dietary CP in promoting growth performances in the weanling pigs.

**Industry Implications:** This study helps us to better understand about the effectiveness of supplemental feed antibiotics on utilization of dietary CP in weanling pigs. Therefore, alternatives to antibiotics should be developed to tackle the problem of antibiotic resistance and misuse of feed antibiotics in the pig production industry.

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## **Impact of a high-fibre feeding regimen for developing gilts on subsequent lactation performance and incidence of lameness**

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**Introduction:** Milk is the main source of nutrients and energy for the piglet and the production of large quantities of milk is helpful to improve piglet growth pre-and post-weaning. Therefore, maximizing mammary development in reproductive females is necessary. Mammary development begins between 90 days of age until puberty, other spikes in development occur in the last third of gestation and in lactation. Restricted feeding levels during these important developmental stages can reduce mammary development and therefore ad libitum feeding levels are suggested for optimal mammary gland development. High feeding levels however, causes fast growth and can lead to potential issues for body condition, conformation, and lameness in gilts and increase the risk of premature culling; early culling can be harmful for both the profitability of the farmer and the potential well-being of the animals. Slower growth reduces fat to protein deposition in the mammary glands, increasing milk secreting parenchymal tissue instead of the fatty extraparenchymal tissue. The study hypothesis is that diluting the dietary energy content with fibre will slow down the growth rate of developing gilts thus, reducing the incidence of locomotion issues, while still supporting maximal mammary development. The objective of the study is to determine the impact of fibre addition to diets for developing gilts on the incidence of lameness and subsequent lactation performance.

**Methods:** A total of 110 gilts will be recruited at 90 days of age and fed one of four dietary treatments. The dietary treatments are as follows: [1] a commercial diet with standard ad libitum feeding, commercial diet fed at [2] 10% or [3] 20% of ad libitum, and [4] a high fibre diet, formulated with 25% more fiber than the commercial diet to reduce energy density by approximately 5%, fed ad libitum. Gilts will be selected in blocks of 12 (3 gilts per treatment per block) based on body weight and litter of origin to allow for equal distribution among the 4 treatment groups. Gilts will be housed in individual pens throughout the treatment period [~90 days of age until breeding at ~190 days of age]. After breeding, gilts will be housed in a group stall feeding system and fed 2.0 kg of a commercial gestation diet until day 110 of gestation. Subsequently, gilts will be moved to a farrowing room where they will receive 2.0 kg of a standard lactation diet until farrowing and ad libitum feed access thereafter. Litters will be standardized to  $11 \pm 1$  before 24 hours postpartum. Piglets will not be provided creep feed so piglet growth rates will reflect the sow's milk yield; weaning will occur ~ 21 days after farrowing. Gilts body weights and feed intake will be determined weekly. Blood samples will be collected from 12 gilts per treatment on days 90, 160, and 180 of age, day 110 of gestation, and day 21 of lactation for analysis of reproductive hormones, growth factors, and bone quality markers. Lameness scores and ultrasounds (to assess back fat thickness) will be conducted on days 90, 145, and 160 of age, at breeding, on day 110 of gestation, and at weaning. A sample of milk will be collected on day 20 of lactation to determine milk composition. Piglets weights will be collected 12 hours after birth and on days 2, 7, 14, and 21 (weaning) of lactation, and days 35 and 56 of age after receiving standard nursery diets for 14 and 35 days, respectively.

**Industry Implications:** It is expected that the high fibre, ad libitum feeding regimen will slow gilt growth rate, without impairing the amount of mammary gland tissue and subsequent milk yield, and will reduce the incidence of lameness compared to control gilts. Thus, this feeding regimen would help to improve the longevity of replacement gilts by reducing premature culling and ensuring maximal milk production during lactation. Furthermore, the addition of fibre to developing gilt feeding program will limit feed intake without necessitating individual housing during gilt development.

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## Relationship between carcass weight, muscle, fat, and predicted lean yield for commercial pigs in Ontario

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**Introduction:** Greater knowledge of variance and relationships of pork carcass parameters could be used to improve performance, efficiency, and profitability of the pork industry. Previous research has investigated the correlation between pork carcass parameters; however, there are still many misunderstandings, particularly in commercially representative pigs. Thus, the purpose of this study was to examine the correlation and variance of carcass weight, fat depth, muscle depth, and predicted lean yield in commercial pigs.

**Methods:** The second largest commercial pig slaughter facility in Ontario slaughtered approximately 1.5 million pigs in 2018. Carcass data (hot carcass weight, fat depth, muscle depth, and predicted lean yield) from 1,025,572 pigs was used for this study with pigs slaughtered on each production day of 2018 (between January 2, 2018 and December 31, 2018). Hot carcass weight was reported immediately following slaughter as a head-on weight, and fat depth and muscle depth were measured with a Destron PG-100 probe (International Destron Technologies, Markham, Ontario). The equation used for predicted lean yield was the Canadian Lean Yield equation (CLY (%) =  $68.1863 - (0.7833 \times \text{fat depth}) + (0.0689 \times \text{muscle depth}) + (0.0080 \times \text{fat depth}^2) - (0.0002 \times \text{muscle depth}^2) + (0.0006 \times \text{fat depth} \times \text{muscle depth})$ ). Pearson product moment correlation coefficients were calculated among all parameters using RStudio version 1.1.456 and R version 3.5.1 statistical software. Correlation coefficients were considered significantly different from 0 at  $P < 0.05$ . Correlations were considered weak (in absolute value) for  $r < 0.35$ , moderate for  $0.36 \leq r \leq 0.67$ , and strong for  $r \geq 0.68$ . Linear regression models were created between parameters that had meaningful relationships using the RStudio statistical software. Gnuplot version 5.2 was used to create scatter plots to allow for better visualization of the correlation between meaningful parameters.

**Results:** The mean  $\pm$  standard deviation for fat depth, muscle depth, hot carcass weight, and predicted lean yield were  $18.27 \pm 4.12$  mm,  $65.69 \pm 9.06$  mm,  $105.93 \pm 8.39$  kg, and  $61.03 \pm 1.91$  %, respectively. We observed weak positive correlations between fat depth and hot carcass weight ( $r = 0.27$ ;  $P < 0.0001$ ), and between muscle depth and hot carcass weight ( $r = 0.17$ ;  $P < 0.0001$ ). We obtained a weak negative correlation between predicted lean yield and hot carcass weight ( $r = -0.21$ ;  $P < 0.0001$ ). The predicted lean yield equation used for this set of pigs included measurements for fat depth and muscle depth, so strong correlation between these parameters was expected. We obtained a moderate positive correlation between muscle depth and predicted lean yield ( $r = 0.39$ ;  $P < 0.0001$ ) and a strong negative correlation between fat depth and predicted lean yield ( $r = -0.96$ ;  $P < 0.0001$ ).

**Conclusions:** Results from this dataset revealed that hot carcass weight was generally not correlated with fat depth, muscle depth, or predicted lean yield. The conclusion is based on the current dataset is that pigs do not reach a weight threshold where they consistently become fatter or heavier muscled.

**Industry Implications:** This information can be used to help the industry gain a greater understanding and appreciation for current genetics, nutrition, and management strategies used in commercial pork.

**Acknowledgments:** The authors would like to acknowledge Conestoga Meat Packers for their assistance with the data used in this study.

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## **Welfare friendly alternative to piglet castration**

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**Introduction:** Castration is a highly invasive procedure performed on male pigs within the first few days after birth. Castration reduces aggressive and sexual behaviours and, more importantly, removes the incidence of a meat quality issue called boar taint. Androstenedione, one of the compounds which contributes to the development of boar taint, is a 16-androstene steroid produced during sexual development of the boar (1). An increase in testicular secretion of 16-androstene steroids is also seen in pigs at about 4 weeks of age. Despite boar taint occurring in the range 10-75% of pigs, all pigs are castrated to remove any testicular steroid secretion (2). Studies have shown that androstenedione has moderate to high heritability, thus it may be possible to eliminate boar taint through selective breeding programs (3). Raising intact boars, however, brings about a different welfare issue, as boars typically display more aggressive and sexual behaviours than castrates or gilts (4). The goal of this upcoming research aims to characterize aggressive behaviours in genetically low and high boar taint pigs to assess the feasibility of raising entire males for pork production.

**Methods:** 112 male piglets [(Yorkshire x Landrace) x Duroc] will be selected. Half of the piglets will be castrated to serve as controls for intact males. At 4 weeks of age, 16-androstene steroids will be measured from plasma and used to characterize pigs as either high or low boar taint potential, resulting in a 2x2 factorial arrangement. Piglets will be randomly assigned experimental pens in pairs and mixed with 2 females. During the nursery phase, pigs will be submitted to additional behaviour tests and observations to better characterize aggression, tendency to explore, reaction to a stressful situation, fear of humans, ease of handling, and sexual behaviour. Performance, stress physiology, and meat quality will be assessed. Boar taint compounds will be measured from fat samples at slaughter and genotypes will be assessed to validate genetic markers of high and low boar taint with the boar taint phenotypes. Levels of androstenedione in plasma at 4 weeks of age will be compared to boar taint levels at slaughter to assess if this can be an early indicator for potential boar taint development.

**Expected Results:** The live trial will begin May 2019 to characterize behavior and physiology of low and high boar taint pigs. We expect to demonstrate that low boar taint pigs show less aggressive and sexual behaviours than high boar taint pigs, and do not need changes in management practice. It is anticipated that estimates of androstenedione from plasma samples at 4 weeks will be predictors for boar taint levels at slaughter.

**Industry Implications:** Raising intact male pigs has many benefits, including faster growth (+13%), leaner meat (+20%), more efficient feed conversion (+14%), and less feed consumed (-9.5%) compared to barrows (5). These benefits will also have a positive environmental impact from reduced energy costs and less waste excreted with more efficient feed conversion, increasing sustainability of the swine industry. The ability to predict the development of boar taint from plasma androstenedione at 4 weeks of age could be used as a potential tool in industry to identify individuals that will not develop boar taint, reducing the number of animals subjected to castration.

**Acknowledgments:** Funding provided by the Organic Science Cluster and OMAFRA.

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## **Cytogenetic screening of Canadian swine herds: the prevalence of chromosome abnormalities**

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**Introduction:** Two types of chromosome abnormalities are known to occur in swine, constitutional, which affects all cells in the body, and mosaic, which only occur in a subset of cells. Constitutional chromosome rearrangements are well studied and represent one of the major etiological factors affecting reproductive efficiency in the domestic pig. These rearrangements occur spontaneously in 1/200 live births (1, 2). Carriers of constitutional rearrangements produce litters containing up to 40% fewer piglets due to embryonic mortality, and pass on their rearrangement to half of liveborn offspring. Mosaic chromosome rearrangements often go undetected, and their impact on fertility is unknown as a result. Mosaic rearrangements represent an understudied area of cytogenetics, even though they are suggested to play a role in genome diversity and development of disease. The aim of this study is to investigate the occurrence of chromosome abnormalities in Canadian swine.

**Materials and Methods:** The King Lab at the University of Guelph has conducted North America's largest swine cytogenetic screening program, involving 5534 young reproductively unproven boars, since 2015. Peripheral blood samples were routinely collected from reproductively unproven boars across Canada. Blood samples were cultured for 72 hours, and harvested using standard cytogenetic procedures, and GTG-banding. Metaphase chromosomes were imaged under a light microscope, and the resulting images were karyotyped using SmartType software, allowing for the detection of chromosome rearrangements.

**Results:** Since the initiation of this screening program in 2015, 90 carriers of chromosome rearrangements have been identified. This includes 27 unique constitutional rearrangements amongst in 54 total carriers, and 15 unique mosaic rearrangements in 36 carriers of mosaic rearrangements. The prevalence of constitutional rearrangements was 0.98%, while the prevalence of mosaic rearrangements was 0.65%. The total prevalence of chromosome rearrangements was 1.63%. A noticeable decrease in the prevalence of constitutional rearrangements was observed in successive generations, while an increase in the prevalence of mosaic chromosome rearrangements was observed. Constitutional rearrangements appeared to be unique to families, while three mosaic rearrangements were observed to appear recurrently across swine herds.

**Conclusion:** Chromosome rearrangements are prevalent throughout Canadian swine herds. We report a higher prevalence of constitutional rearrangements than other cytogenetic programs, with this number expected to fall as screening efforts are conducted over successive generations (2). The observation of 36 mosaic rearrangement carriers is an unexpected result, and marks the largest such observation of mosaic carriers recorded in the domestic pig. The recurrent nature of some mosaic rearrangements, and the impact on the fertility of carriers has yet to be fully explained and will be the subject of future investigations.

**Industry Significance:** Chromosome rearrangements are prevalent throughout Canadian swine herds, appearing in 1.63% of all pigs examined. Cytogenetic screening is currently the only effective method of identifying and removing carriers from breeding eligibility, thus maintaining herd reproductive efficiency.

**Acknowledgements:** The University of Guelph, the Ontario Veterinary College, and OMAFRA

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## Supplemental tryptophan and its effect on growth, feed intake and aberrant behaviour in grower pigs

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**Introduction:** In growing pigs, aggression and aberrant behaviour such as tail- and ear-biting can result in decreased growth, diminished health and welfare, increased morbidity and mortality and increased labour on the part of the producer. Tryptophan (TRP), an essential amino acid in the pig's diet, has been shown to produce calming effects in both rats and humans (1) through its role in the serotonergic system. The objective of this study was to determine the effect of varying inclusion rates of dietary TRP on growth, aberrant behaviour and feed intake in grower pigs.

**Methods:** This study examined the effects of 3 feed treatments on a total of 90 grower pigs (over 2 trials) divided equally across the three diet treatments in a completely randomized block design. Sex, weight and litter origin were balanced across pens in each trial. There were 5 pigs/pen and 3 pens/treatment. This feeding trial lasted a total of 29 days, with feed and water being fed ad libitum. A single diet was formulated based on providing all nutrients at or above their estimated NRC requirements. Amino acid mixtures were then added to the base diet to provide: 1) Control diet (TRP at 100% of its standard ileal digestible (SID) requirement), 2) TRP at 175% of its SID requirement, and 3) TRP at 250% of its SID requirement. All feed was weighed and feed intake was measured for the duration of the trials. All pigs were weighed weekly. All pens had continuous behaviour recordings done for 12 hours (06:00-18:00) 3 days/week. An ethogram was used to examine 13 mutually exclusive behaviours and to evaluate the severity and duration of aggressive interactions taking place; the number of bites and head-knocks, as well as the duration of time spent fighting; ear- and tail-biting were also recorded at this time using 10 minute scan sampling. Plasma and serum samples were taken from 3 pigs/pen (N=27/trial) at four different time points (day 8, 15, 22 and 29) with TRP and serotonin levels being measured respectively, using ELISA.

**Results:** No differences were observed in behaviour, growth rate or feed intake, regardless of diet treatment ( $P>0.05$ ). Plasma and serotonin data continue to be analyzed.

**Conclusions:** All pigs grew well and did not exhibit aberrant behaviour for the duration of the trials. Supplemental TRP supplied above NRC requirements did not have a beneficial effect on aberrant behaviour, feed intake or growth in growing pigs.

**Industry Implications:** The use of therapeutic TRP in pig diets could positively impact the entire pork industry if the producers could benefit from reduced labour costs in treating injured and ill animals, higher growth rates and better carcass quality; the industry could benefit from an improved public perception of how pigs are raised commercially; and the growing pigs could have increased health and welfare due to decreased levels of aggression.

**Acknowledgements:** Funding provided by the Ontario Agri-Food Innovation Alliance, Grand Valley Fortifiers and OVC Departmental Graduate Growth Support.

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**A metagenomic case-control study to identify new risk factors associated  
with *Streptococcus suis* infections of nursery piglets**

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**Introduction:** *Streptococcus suis* can be found in almost all swine herds. Piglets acquire *S. suis* through vertical transmission from the sow and environmental contamination at birth, but only some piglets are colonized, and only a few develop bacteremia and meningitis (1). Colonized pigs have been found to carry *S. suis* in their tonsils and/or genital tracts and infections are common in all types of production systems (1). Outbreaks of *S. suis* in nursery piglets may be suggestive of an underlying viral pathogen such as porcine reproductive and respiratory syndrome virus (PRRSV) or circovirus (1). Nursery pigs coinfecting with PRRSV and *S. suis* experience severe CNS disease, bacteremia and higher mortality than those infected with *S. suis* alone (1). Some of these interactions could be tracked using high-throughput technology, such as next generation sequencing (NGS). The primary objective of this study is to compare the respiratory virome of nursery pigs clinically affected with *S. suis* with healthy pigs from the same group using NGS technology in order to explore whether viral-bacterial interaction is associated with *S. suis* clinical disease.

**Methods:** This study involved collecting tonsillar swabs from cases and age-matched controls from nurseries with outbreaks of *S. suis*. Cases were selected based on clinical signs including ataxia, incoordination, convulsions, paralysis, nystagmus and controls based on health, appropriate body condition and exhibition of normal behavior. Tonsillar swabs of 28 cases and 30 controls were spiked with 1 mL of a DNA and RNA internal control virus and sequenced via next generation sequencing.

**Results:** Preliminary analysis of the viral metagenome showed that the DNA and RNA spiked internal control viruses were correctly identified as Feline Herpesvirus-1 and Feline Calicivirus, respectively. Overall, the sequencing depth of spiked RNA target for all samples ranged from 0 – 120000 reads, and so samples with <1000 reads for spiked RNA target were excluded as not sequencing properly. There was a total of 120 different RNA viral families identified. Sequence results of tonsillar swabs showed that 26% of the viral reads were from bacteriophage families such as Myoviridae and Siphoviridae. Approximately 10% of samples were positive for viral families of known swine pathogens, such as Orthomyxoviridae.

**Conclusion:** Our understanding of *S. suis* etiology is limited and complex bacterial-viral interactions may be contributing to infections in the nursery. At this stage of our investigation, we are formally analyzing the association between viral families, functional groupings and measures of diversity and health status.

**Industry Implications:** Studying the interaction between viruses and *S. suis* infection may help prevent *S. suis* related outbreaks more effectively. Creating a profile of the nursery pig respiratory virome may provide the swine industry with baseline information for evaluating emerging viruses.

**Acknowledgments:** Funding provided by Canada First Research Excellence Fund.

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## Identification of genetic markers for stress responsiveness and meat quality in Canadian Yorkshire pigs

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**Introduction:** Behavioural and neuroendocrine responses to stress as well as meat quality are highly variable among pigs and can be attributed to prior experiences and genetic background (1). However, the genetic basis for stress-responsiveness and meat quality in pigs is still unclear. *Luman* is a stress regulatory gene that affects activity of the hypothalamic-pituitary-adrenal (HPA) axis in mice (2) and therefore presents a promising avenue for exploring genetics underlying variable stress-responsiveness in pigs. Pigs that have similar characteristics to *Luman*-deficient mice including greater resilience to stress and greater receptivity to human handling (2) would be valuable in the pork industry.

**Methods:** A candidate-gene high density single nucleotide polymorphism (SNP) scanning approach was utilized to survey the swine *Luman* locus for the presence of polymorphisms in 30 Yorkshire and 29 Meishan pigs. A similar survey was subsequently performed on 202 purebred Ontario Yorkshire pigs and a generalized linear mixed model was used to assess the association between identified variants with behavioural stress response measured during four behaviour tests (back test, open field, test, novel object test, and human approach test), physiological stress-responsiveness (cortisol levels analyzed by ELISA), as well as carcass and meat quality measurements (including loin pH, colour, wetness, marbling, drip loss, and cooking loss).

**Results:** In our survey of 30 Yorkshire pigs, we identified 8 genetic variations (3 coding and 5 non-coding) and detected 2 haplotype blocks (550bp and ~4kb in length) that each consisted of 3 SNPs and were in high linkage disequilibrium (LD) with each other. In Meishan pigs, we identified 6 SNPs (2 coding and 4 non-coding) and detected one haplotype block comprised of 5 SNPs that was ~3kb in length. Within 202 Yorkshire pigs, the same 8 Yorkshire variants were identified and comprised 4 haplotypes. Genotypes featuring haplotype A were associated with lower basal cortisol, decreased activity levels and exploratory behaviours in response to fear/anxiety to novelty and humans as well as improved meat quality characteristics including reddish-pink colouring of meat, increased loin marbling (2.0 on NPPC scale), and lower cooking loss (15.5-19.3%). In contrast, genotypes featuring haplotype C were associated with higher basal cortisol as well as greater activity levels and exploratory behaviour in response to fear/anxiety to novelty and humans. Genotypes featuring haplotype B were associated with poorer meat quality characteristics, including higher loin cooking loss (22.5%) and drip loss (5.5%) as well as lower marbling (1.3 on NPPC scale) and paler colouring of meat on all subjective scales.

**Conclusions:** In this study we characterized differences in the extent and pattern of genetic diversity within the *Luman* locus between Yorkshire and Meishan breeds, as well as intra-breed differences in genetic variation. This study provides evidence that genetic variation in *Luman* is associated with individual differences in behavioural coping styles for stress, basal physiological stress levels, and meat quality characteristics among pigs.

**Industry Implications:** Improving the adaptability of animals to their environment will improve animal well-being and reduce undesirable effects of stress on pigs. Selection for haplotype A in breeding programs may result in pigs that have lower reactivity to novelty/humans as well as improved meat quality. These pigs may be easier to tend for, which may be beneficial for farm management, improve animal welfare, and yield higher quality pork products. In contrast, haplotype B and C genotypes should potentially be avoided in breeding programs.

**Acknowledgments:** Participating organizations and funding sources for this project include AGC (Alliance Genetics Canada), OMAFRA, NSERC, CFREF, and Swine Innovation Porc.

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## **Synchronized ovulation and advanced semen catheter design to increase sow productivity and reduce breeding costs**

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**Introduction:** Optimal timing of semen delivery is one of the most influential elements affecting swine reproductive performance. Sows exhibit a great deal of variation in the duration of estrus, wean-to-estrus interval and estrus-to-ovulation interval (1). Hormones can be used to induce ovulation and allow a single fixed-time insemination protocol to be used (1). This, combined with using a superior semen catheter design may aid in decreasing the number of inseminations and the number of sperm per insemination (2). The objective of this study is to determine if the use of single fixed-time insemination and improved insemination catheter design will result in optimal reproductive performance while using substantially smaller dosages of semen.

**Methods:** The research is being conducted at Arkeil Swine Research Centre, University of Guelph. From July 2017 through June 2018, 432 mixed parity sows will be randomly assigned to one control and three treatment groups of 108 sows per group. **Group 1 (Control):** estrus detection performed twice per day beginning on day 3 post-weaning. Sows exhibiting estrus will be bred by AI (3 billion sperm, conventional catheter) when first discovered in strong standing heat and rebred 24 hours later. **Group 2:** sows will be injected with eCG at weaning and 72 hours later with pLH to induce ovulation. Sows will be inseminated with a single dose of approximately 3 billion sperm 36 hours after pLH using 3 billion sperm and conventional catheter. **Group 3:** sows will be injected with eCG at weaning and 72 hours later with pLH to induce ovulation. Sows will be inseminated with a single dose of approximately 3 billion sperm using a Gedis® catheter. **Group 4:** sows will be injected with eCG at weaning and 72 hours later with pLH to induce ovulation. Sows will be inseminated with a single dose of approximately 1 billion sperm using a Gedis® catheter. Farrowing rate and litter size are being recorded.

**Results:** 508 sows were bred in total, of which 6 were excluded from the trial due to culling or death before farrowing. Conception rate for the treatment groups are as follows: Group 1 (90.3%), Group 2 (82.3 %), Group 3 (75.8%), and Group 4 (70.0%).

**Conclusions:** Findings show that the use of the Gedis® catheter appears to be associated with a lower conception rate than the conventional catheter, with substantial breeding and farrowing data. Synchronizing ovulation and single AI using a conventional catheter resulted in a good conception rate, yet was somewhat less than the control group. Although reproductive performance appears to be compromised in the Gedis® treatment groups, we expect that this could change with a more refined trial design.

**Industry Implications:** Our aim is to assess the effect of single fixed-time insemination via the Gedis® catheter, in hopes of increasing reproductive efficiency. This would further result in economic benefits associated with reduced labour and lower semen costs.

**Acknowledgments:** Funding and in-kind contribution provided by UofG-OMAFRA Research Partnership, Eastgen, Gene Diffusion, Ontario Swine Improvement and Ontario Pork. The assistance of the staff at Arkeil Swine Research Centre is greatly appreciated.

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## Tracking Porcine Reproductive and Respiratory Syndrome Virus (PRRSV) incidence and clinical impact in Ontario sow herds

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**Introduction:** PRRSV is the etiological agent of Porcine Reproductive and Respiratory Syndrome (PRRS). The virus is endemic within North America and has high genetic variability. Some genotypes spread rapidly between herds, with highly variable clinical outcomes and impact. The goals of this study were to: 1) describe PRRS incidence and the clinical impact using three population-level health measures, and 2) investigate the association between viral strain groupings and clinical impact in sow herds.

**Methods:** A questionnaire was used to gather herd-level production data. This included data related to the initial farm case, along with quantitative and qualitative production measures for up to 8 weeks after the start of the clinical signs. The production measures gathered were, pre-weaning mortality, sow mortality, and number of abortions. Cluster analysis was utilized to investigate possible case groupings based the three production measures.

**Results:** To date, data from 64 participating sow farms have been gathered. Results demonstrated a higher incidence of PRRS in 2018 than in 2017 (RR= 1.6, Fisher's Exact  $p=0.02$ ). As of February 2019, there has been a higher incidence of PRRS when compared to 2017, however lower than 2018 at the same comparable time. Additionally, farm cases can be classified into a high or low severity category based on clinical impact. Utilizing the three performance measures, the results of cluster analysis suggested that these clinical impact categories were mostly influenced by sow related performance parameters, such as abortions and sow mortality. Further investigation noted that these clinical impact groupings were not associated with previous PRRS herd status (OR=1, Fischer's exact,  $p>0.05$ ).

**Conclusions:** In conclusion, preliminary results suggest that there are two clinical impact groupings among cases. In addition, contrary to current clinical perceptions, previous herd status was not found to be a significant predictor of current case clinical impact.

**Industry Implications:** Results from this study will help to design a system which aims to track incidence of clinical cases in the future. The results gathered from this work may also aid in a new classification system with regards to PRRSV clinical impact.

**Acknowledgments:** Thank you to OMAFRA for funding this project, and to Swine Health Ontario, the participating clinics, and the swine producers for providing the data.

## Comparing the Pezzaioli trailer vs commercial North American trailers in Canadian conditions

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**Introduction:** The transportation process, loading, transit, and unloading has been reported to be one of the most stressful events in a pig's life. Transportation in commercial North American trailers can be exceedingly stressful from extremely fatigued pigs to the point of death. Although transportation loss and fatigue are multifactorial in nature, North American studies indicate that vehicle design is the primary cause (Dewey *et al.*, 2009; Correa *et al.*, 2013). Conventional North American pot-belly trailers have been shown to reduce handling ease and induce stress in pigs due to the presence of multiple ramps and bends, increase in electrical prod usage, and have a high internal compartment temperature, due to poor trailer ventilation especially when the vehicle is stationary, that results in heat stress and dehydration (Brown *et al.*, 2011; Fox *et al.*, 2014; Torrey *et al.*, 2013; Weschenfelder *et al.*, 2012, 2013). Another vehicle design is a flat deck trailer, referred to as a modified trailer, that is equipped with a hydraulic deck and is considered an alternative to the pot-belly trailer since it can maintain similar loading densities whilst reducing stress placed on the transported pigs. However, handling difficulties during loading and unloading remain and heat stress during transit is still a concern (Weschenfelder *et al.*, 2012, 2013). Recently, an Italian trailer company, Pezzaioli, manufactured a relatively new triple decked trailer that is equipped with fully hydraulic upper and middle decks to hypothetically reduce loading and unloading stress, and comes with fan-assisted ventilation, water misters, adjustable rooftop compartment, and water drinkers to hypothetically improve ventilation and decrease heat stress and dehydration. Therefore, the objective of this study is to examine whether the Pezzaioli design improves swine welfare during the transportation process in comparison to commercial pot-belly and modified trailers in Canadian summer and winter conditions during short (1 hour) and long (12 hour) distances.

**Methods:** 72 loads of pigs (three trailers, six trails per season, two seasons, two years) with 50 sentinel pigs per load, where pigs are randomly allocated to short or long distance and further distributed into either pot-belly, modified, or Pezzaioli trailer during the summer or winter season. Trailers will be bedded with wood shavings in both summer and winter and will have side panels 100% open in summer and 10% in winter. Temperature and relative humidity of trailer compartments will be measured using Ibutton data loggers at one-minute intervals and GI tract temperature in the pigs will be monitored with the Ibutton logger at the same interval. Behaviour, such as latency to enter the truck, slipping, falling, during loading and unloading will be recorded by a trained observer, and cameras will be used to monitor pigs during transit at 2.5-minute intervals for standing, sitting, lying. Blood samples will be collected at the abattoir and analyzed for stress indicators, such as cortisol and lactate. Lastly, carcass and meat quality will be examined on the *Longissimus dorsi*, *Semimembranosus*, and *Adductor muscles* for quality, carcass percent yield, skin bruises, and damage.

**Expected Results:** The summer trials will begin either in June or July of 2019, and will examine swine behaviour, blood stress levels, and carcass meat quality in Canadian summer conditions, to examine if the Pezzaioli outperforms commercial North American trailers. It is expected that pigs shipped to the abattoir via the Pezzaioli will show less fearful or stressful behaviour, lower levels of blood stress indicators such as cortisol, and improved meat carcass quality in comparison to the commercial North American trailers.

**Industry Implications:** The implication to the industry is reduced economical losses due to pigs death or stress during transport, production of carcasses, and poor meat quality to allow for economic growth of Canadian pork sector both in the domestic and export market.

**Acknowledgments:** Funding provided by Canadian Agricultural Partnership (CAP)-Agriscience Program

## **Effect of flavophospholipol on the fecal microbiota of weaned pigs challenged with *Salmonella***

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**Introduction:** The increased presence of multi-drug resistant *Salmonella* Typhimurium on Ontario swine farms presents a public health and food safety concern. Research suggests flavophospholipol, an antibiotic, may have the ability to alter the gut microbiota equilibrium in favour of beneficial bacteria while inhibiting the colonization of pathogenic bacteria (e.g. *Salmonella*) (1,2). Thus, the objective of this study was to evaluate the changes in the fecal microbiota of weaned pigs treated with flavophospholipol and challenged with *S. Typhimurium*.

**Methods:** Twenty-one weaned pigs were fed either a diet containing 4 ppm of flavophospholipol (Flavomycin<sup>®</sup>, Huvepharma) or a non-medicated feed (control group) for 36 days post-weaning (Day 1 to Day 36). On Day 7 and 8 of the trial, pigs were orally challenged with a 2 mL dose of 10<sup>8</sup> CFU/mL of *S. Typhimurium* DT 104. Community bacterial DNA was extracted from fecal samples collected at Day 6 and Day 36 were used to assess the fecal microbiota using the V4 region of the 16S rRNA gene with Illumina MiSeq next-generation sequencing. Sequencing data were visualized using mothur, and analyzed in JMP and R.

**Results:** After challenge with *Salmonella*, the fecal microbiota of pigs that received flavophospholipol had significant differences in abundance of phyla (Firmicutes, Proteobacteria) and genera (*Lactobacillus*, *Roseburia*, *Treponema*, unclassified Ruminococcaceae, *Blautia*, *Streptococcus*, *Megasphaera*, *Dorea*, *Sporobacter*, *Peptococcus*, unclassified Firmicutes, *Clostridium* IV and *Campylobacter*) compared to pigs that received non-medicated feed ( $P < 0.05$ ). Specifically, results demonstrated a significant increase in phylum Proteobacteria ( $P = 0.001$ ) and decrease in Firmicutes ( $P = 0.012$ ) and genus *Roseburia* ( $P = 0.003$ ) in the flavophospholipol treated pigs suggestive of possible microbial dysbiosis. In comparison to the control group, an increased abundance of genera *Treponema* ( $P = 0.012$ ) and *Lactobacillus* ( $P = 0.012$ ) was also noted in the treated group.

**Conclusions:** The changes found in the fecal microbiota of weaned pigs treated with 4 ppm of flavophospholipol and challenged with *S. Typhimurium* DT 104 are consistent with dysbiosis found in other species. Based on these findings, it is difficult to conclude whether treatment with 4 ppm of in-feed flavophospholipol is aiding in reducing *Salmonella* and promoting favorable indigenous bacteria in the pig microbiota. Further research using a larger sample size will help to draw conclusions on the impact of flavophospholipol on the porcine fecal microbiota.

**Industry Implications:** This research allows producers and industry partners to assess whether treatment with flavophospholipol is beneficial in improving the gut microbiota composition as well as inhibiting the colonization of *Salmonella* in swine.

**Acknowledgments:** OMAFRA-FSRP, OMAFRA-UofG Research Partnership and Huvepharma

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## Antibody responses to *Mycoplasma hyopneumoniae* from weaning up to marketing in 14 groups of pigs in Ontario

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**Introduction:** Respiratory diseases on swine farms can contribute to poor growth rate, impaired animal health, and loss of producer profits. One of the most prevalent respiratory diseases affecting swine farm productivity in Canada is enzootic pneumonia, a relatively mild disease in uncomplicated cases caused by *Mycoplasma hyopneumoniae* (*M. hyopneumoniae*). However, *M. hyopneumoniae* suppresses pulmonary immunity which often contributes to more complicated secondary infections. Monitoring for the prevalence of *M. hyopneumoniae* may help develop improved control strategies and minimize the impact of enzootic pneumonia on swine farms. The present study investigated antibody responses to *M. hyopneumoniae* in pigs from weaning to the end of the finisher stage and also assessed the impact of a low complexity nursery diet on antibody responses to *M. hyopneumoniae*.

**Methods:** Fourteen groups of pigs from eight farrowing sources (n=618) were followed from birth to the end of the finisher stage. Pigs were fed either a conventional high complexity (HC) or experimental low complexity (LC) diet during the nursery stage (1,2). Blood samples were collected at weaning and at the end of the nursery, grower, and finisher stages and sera were analyzed by ELISA for the presence of *M. hyopneumoniae* antibodies. Multilevel mixed-effects regression methods were used to analyze the data.

**Results:** Seven of the fourteen groups sampled were classified as high seropositivity, in which at least 25% of pigs were seropositive for *M. hyopneumoniae* at least once over the course of production, while in the remaining groups, <10% of pigs were seropositive. Across the high seropositivity groups, 56.0% of pigs at weaning, 41.1% at the end of nursery, 40.6% at the end of grower, and 63.4% at the end of finisher were seropositive for *M. hyopneumoniae*. Nursery diet complexity had no effect on seropositivity ( $p=0.3$ ). In the high seropositivity groups, pigs born between October and January were more likely to be seropositive at the end of the grower ( $p<0.001$ ) and finisher ( $p=0.001$ ) stages compared to weaning, while pigs born between May and August were more likely to be seropositive at the end of the nursery ( $p<0.001$ ) and grower ( $p=0.001$ ) stages compared to weaning. Pigs were also more likely to be seropositive for *M. hyopneumoniae* in the fall ( $p=0.015$ ) and winter ( $p<0.001$ ) than in the summer.

**Conclusions:** These findings suggest that antibody responses to *M. hyopneumoniae* may vary significantly between different stages of production in commercial swine herds. In addition, the high proportion of seropositive pigs at weaning indicates the presence of maternal antibodies that decline towards the end of nursery. Although this study was unable to differentiate between antibody responses to natural infections and vaccination, it may help to encourage vaccination in post-weaning pigs, a time in which the interaction between maternal antibodies and vaccine antigens is minimized.

**Industry Implications:** Monitoring for *M. hyopneumoniae* at different stages of production may allow for the implementation of improved control strategies at specific stages of increased vulnerability on farm. Farms with minimal disease pressures may also benefit from implementing a cost-effective low complexity nursery diet, although further research is required to determine the impact of this diet on susceptibility to other bacterial and viral pathogens.

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## **Impact of steeping corn DDGS over 72 hours without or with fiber degrading enzymes and protease alone or in combination on concentration of sugars and organic acids and pH in the liquid medium**

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**Introduction:** Fiber in diets has been known to have beneficial effects on gut health as it can stimulate regular physiological function of the gut, increase satiety, improve gut health, and growth performance and reduce diarrhea of piglets (1). Therefore, inclusion of fibrous ingredients in swine diet such as distillers dried grains with solubles (DDGS) has been increasing. However, fiber in diet negatively influences other nutrient and energy digestibility (2). Therefore, the use of exogenous carbohydrase has received great interest as it can improve growth performance and digestibility. The objective of this study was to investigate the impact of steeping corn DDGS over 72-h with or without fiber degrading enzymes (**FDE**) and/or protease (**PRO**) on the concentration of sugar, acetic and lactic acid, and pH.

**Methods:** Four tested treatments were: 1) DDGS steeped without enzymes (**Control**) 2) DDGS steeped with FDE (**FDE**), 3) DDGS steeped with protease (**PRO**), 4) DDGS steeped with combination (**FDEPRO**). Enzymes were added at 1% of DDGS. Briefly, 50g of DDGS was mixed with 500-mL water with or without enzymes in sterile plastic bottles and was steeped for 0, 12, 24, 48 and 72-h at 37°C with continuous agitation. Samples were aliquoted to individual bottle for each timepoint. At each time point, bottles were pulled out from the incubator for pH measurements and liquid medium supernatant for sugars and organic acid analyses.

**Results:** Highest arabinose, xylose and glucose was observed at 12 and 24-h followed by decrease at 48 and 72-h. At 12-h, arabinose was higher ( $P<0.05$ ) for FDE and FDEPRO than control. The highest xylose and glucose were seen at 12-h for PRO, FDE and FDEPRO while control was highest at 24-h. Acetic acid and lactic acid increased over time. At 72-h, FDEPRO had highest acetic acid compared to control and PRO while lactic acid was highest for FDE and FDEPRO compared to ( $P<0.0001$ ) control and PRO. The pH decreased ( $P<0.05$ ) over time for all treatments. At 72-h, FDE had lowest pH followed by FDEPRO, PRO and control ( $P<0.0001$ ). Overall, arabinose, xylose and glucose increased to a certain timepoint and decreased while lactic and acetic acid increased over time subsequently leading to lowest pH at 72-h.

**Conclusions:** In conclusion, FDE increased concentration of sugars and acids in steeped DDGS whereas PRO had no effect.

**Industry Implications:** Applying FDE to fibrous ingredients may improve pigs gut health without compromising growth performance and digestibility.

**Acknowledgments:** Canadian Bio-Systems, Ontario Agri-Food Innovation Alliance, Natural Sciences and Engineering Research Council of Canada

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## Comparative characterization of intestinal alkaline phosphatase kinetics in young piglets and human Caco-2 cells

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**Introduction:** Alkaline phosphatases (EC 3.1.3.1) belong to a family of dimeric metalloenzymes that catalyse the hydrolysis of a wide range of phosphoesters with the reaction optimum at alkaline pH conditions (1). Intestinal alkaline phosphatases (IAP) play a critical role in maintaining gut health through detoxifying luminal pro-inflammatory molecules including endotoxin lipopolysaccharides (LPS) and other emblematic members of pathogen-associated-molecular patterns (PAMPs) such as ATP (2).

**Methods:** A total of 4 crossbred (York × Landrace × Duroc) 10-d suckling piglets were obtained from the University of Guelph Arkenl Swine Research Station were used for jejunal tissue collection. Caco-2 cells were grown in DMEM medium with 20% fetal bovine serum and incubated at 37 °C in 5% CO<sub>2</sub> into confluency and differentiation. The enzyme kinetics of IAPs in the porcine jejunal and the homogenized Caco-2 cells were determined using the synthetic substrate of *p*-nitrophenyl phosphate (*p*NPP), as well as physiological substrates of ATP and LPS (2) at physiological conditions (pH = 7.4; at 37 °C). The Kinetic parameters were calculated using the Michaelis-Menten equation by GraphPad Prism 5.0.

**Results:** The 10-day suckling young porcine jejunal IAP displayed the  $K_m$  values of 1.26±0.50 mM, 1.35±0.64 mg/mL and 0.290±0.072 mM for the hydrolyses of ATP, LPS and *p*NPP, respectively; while the respective  $K_m$  values were 0.030±0.007 mM, 0.66±0.22 mg/mL and 0.033±0.006 mM for the IAP in the Caco-2 cells towards the same set of substrates. In comparison, the  $K_m$  values of the young porcine jejunal IAP were 2-40 times higher than those of IAP from human Caco-2 cells. The  $K_m$  values of the IAP from the human Caco-2 cells in this study were close to previously reported  $K_m$  values of human IAP (1). In addition, Pearson correlation analyses showed tight positive correlations ( $P<0.001$ ) between IAP activities towards *p*NPP, ATP and LPS in the piglet and the Caco-2 cells, suggesting that the IAP activity towards *p*NPP could be used to predict the IAP activities on the physiological substrates of ATP and LPS. Lastly, four AP genes were identified in the genome of *Sus scrofa*. Three of these porcine AP genes are annotated as intestinal-type alkaline phosphatase genes and clustered at the distal end of chromosome 15, namely *IAPX1*, *IAPX2*, and *IAPX3*. The genomic context of APs in the pig genome is highly similar to those in the human genome. We predict that pig *IAPX3* (XP\_003133777) is likely an IAP gene for pigs. Further comparisons in post-translational modification and protein 3-D structure homology model were performed, indicating that the observed differences in kinetic affinity between the young porcine jejunal IAP and the human Caco-2 cell IAP in hydrolyzing ATP, LPS and *p*NPP might relate to their differences in the coding sequences and/or N-glycosylation of the IAP proteins.

**Conclusions:** Young porcine jejunal IAP displayed the lower kinetic affinity for the digestive dephosphorylating *p*NPP, and the pro-inflammatory molecules of LPS and ATP relative to that of Caco-2 cell IAP.

**Industry Implications:** This study connects the low kinetic affinity of young porcine jejunal IAP with the vulnerability of young pigs to intestinal inflammation and infection. This understanding will justify the need to develop novel feed enzymes for improving pig gut digestion and fermentation, thus pork production efficiency.

**Acknowledgments:** Funding provided by the NSERC Discovery Program; the Food for Thought Research program at the University of Guelph with funding from the Canada First Research Excellence Fund.; and the AAFC Swine Innovation Porc (SIP) Swine Cluster Program.

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## Investigating of single-nucleotide variants related to *Streptococcus suis* resistance using a genome-wide association study approach

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**Introduction:** *Streptococcus suis* is commonly found in the upper respiratory tract of pigs and it can cause disease under certain conditions related to the environment, host, and bacteria itself. Currently, *S. suis* is the most common cause of meningitis in weaning pigs. This aim of this is to identify single-nucleotide polymorphisms (SNPs) in pigs associated with *S. suis* infection using a genome-wide association study (GWAS) approach.

**Methods:** Whole blood from weaned pigs were collected as part of a larger *S. suis* project in southern Ontario and categorized into two phenotypes: healthy (controls) and clinically sick pigs infected with *S. suis* (cases). DNA was extracted from the whole blood and genotyped using a custom-designed 54K single-nucleotide polymorphism (SNP) chip and the Genome-wide Efficient Mixed Model Association (GEMMA) program was used for GWAS analysis.

**Results:** There were three variants within introns that had a suggestive association with *S. suis* resistance. The first variant was in the PLEKHM1 gene ( $p = 1.74 \times 10^{-6}$ ), the second variants was in the LRRC37A gene ( $p = 1.74 \times 10^{-6}$ ), and the third variant was in the WNT3 gene ( $p = 5.83 \times 10^{-6}$ ).

**Conclusions:** These findings may contribute to our understanding of which genes underly resistance to disease or susceptibility to *S. suis* in pigs.

**Industry Implications:** A better understanding of host genetic resistance and/or susceptibility, and identification of variants in these genes could be applied in selective breeding programs to reduce the risk of disease in pigs and the spread of disease to humans.

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## Determination of true digestibility and the endogenous outputs of magnesium in corn for growing pigs by using the regression analysis technique

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**Introduction:** Dietary magnesium (Mg) is essential to bone mineralization. Supplemental Mg is typically not considered in commercial swine diets by assuming high bioavailability of Mg from bulky feed ingredients such as corn grain. The objectives of this study were to determine true ileal and fecal digestibility and the endogenous losses of Mg associated with corn in growing pigs by the regression analysis technique (1).

**Methods:** A total of 48 (Duroc × Yorkshire × Landrace) barrows, with an average initial body weight (BW) 32 kg, were randomly assigned to 6 grower pig diets and were fed close to ad libitum for 10 d, with 8-d adaptation and 2-d collection fecal and the terminal ileal digesta samples, according to a randomized complete block design. Six cornstarch-based diets, containing 6 levels of Mg at 0.22, 0.32, 0.38, 0.51, 0.71 and 0.79 g/kg dry matter intake (DMI) of diets, were formulated from corn.

**Results:** There were linear relationships ( $P < 0.05$ ), expressed as g/kg DMI, between the ileal and fecal outputs of Mg and the total intake of dietary Mg, suggesting that true ileal and fecal Mg indigestibility values ( $94.8 \pm 12.5$  vs.  $89.2 \pm 17.7\%$ ); and the ileal and fecal endogenous Mg outputs ( $0.16 \pm 0.02$  vs.  $0.21 \pm 0.11$ , g/kg DMI of diets) associated with corn could be estimated by the regression analysis.

**Conclusions:** Our results have shown that Mg associated with conventional corn grain was very poorly digested and the gastrointestinal endogenous fecal loss of Mg was significant in the grower pig.

**Industry Implications:** Mg bioavailability in feeds for pigs should be assessed and supplemental of Mg may be warranted in swine diet formulation.

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## **The small intestinal responses in the determination of true digestibility and the endogenous outputs of phosphorus in corn for growing pig using the regression analysis technique**

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**Introduction:** It is of important methodological considerations to understand how the small intestine would respond to feeding of a series of assay diets deficient in gradient levels of multiple assay nutrients supplied from one single feed ingredient for an experimental period of time for the determination of feed ingredient-specific true digestibility and the endogenous outputs of assay nutrients in pigs by the regression analysis technique (1,2). The objectives of this study were to investigate intestinal responses in the determination of true ileal and fecal digestibility and the endogenous losses of phosphorus (P) associated with corn in growing pigs by the regression analysis techniques.

**Methods:** A total of 48 (Duroc × Yorkshire × Landrace) barrows, with an average initial body weight (BW) 32 kg, were randomly assigned to 6 grower pig diets and were fed close to ad libitum for 10 d, with 8-d adaptation and 2-d collection fecal and the terminal ileal digesta samples, according to a randomized complete block design. Six cornstarch-based diets, containing 6 levels of P at 1.3, 1.9, 2.0, 3.6, 3.4 and 4.0 g/kg dry matter intake (DMI), were formulated from corn. The gut permeability marker of D-mannitol was fed 0.30 g/kg BW at 4 h, prior to be sacrificed for terminal blood, digesta and jejunal sampling.

**Results:** Average daily gain and the apparent ileal DM digestibility were linearly affected ( $P < 0.05$ ); however, the average daily feed intake, feed conversion ratio, the apparent fecal DM digestibility, transcellular gut permeability and the jejunal alkaline phosphatase kinetics were not affected ( $P > 0.05$ ) by the increasing dietary levels of corn inclusion. There were linear relationships ( $P < 0.05$ ), expressed as g/kg DMI, between the apparent ileal and fecal digestible P and the total intake of dietary P, suggesting that true ileal and fecal P digestibility ( $33.3 \pm 4.7$  vs.  $52.7 \pm 3.8\%$ ); and the endogenous P outputs ( $0.37 \pm 0.12$  vs.  $0.60 \pm 0.09$ , g/kg DMI) associated with corn could be estimated by the regression analysis technique.

**Conclusions:** Our results have shown that the small intestinal normal physiology and functions were not affected in the grower pigs fed on a series of test diets that were deficient in gradient levels of multiple assay nutrients, including macro-minerals, crude protein and amino acids supplied from the testing corn, for a period of 10 d, in the determination of corn-specific true digestibility and the endogenous outputs of Pi by the regression analysis technique.

**Industry Implications:** True rather than apparent P digestibility values should be determined and used in diet formulation for growing pigs.

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## Intestinal responses and the determination of true total tract trace mineral digestibility and the endogenous losses in weanling pigs by the regression analysis technique

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**Introduction:** The apparent trace mineral digestibility and trace mineral availability, as measured by the slope-ratio technique, have been reported in the literature (1). There is limited knowledge regarding true trace mineral digestibility and bioavailability in trace mineral supplements and common feed ingredients and the trace mineral endogenous losses in pigs. The objectives of this study were to investigate intestinal responses and to determine true total tract trace mineral digestibility and the endogenous losses of trace minerals associated with corn and SBM based diets in weanling pigs by the regression analysis.

**Methods:** Twenty-four crossbred barrows, with an average initial BW of 14 kg, were randomly assigned to 4 weanling pig diets with inclusion of titanium dioxide (0.30%) and a commercial trace mineral-vitamin premix at 0.125, 0.250, 0.375 and 0.500%, respectively, to result in 4 graded dietary levels of Cu, Zn, Fe, Mn and Se. The pigs were fed close to *ad libitum* for 11 d according to a randomized complete block design. Nutritional chemical analyses and the calculations of true trace mineral digestibility and their endogenous output values were carried out according to our previous work (2).

**Results:** The dietary inclusion did not affect ( $P>0.05$ ) growth performances, ileal and fecal DM digestibility, D-mannitol gut permeability and jejunal alkaline phosphatase kinetics. With the regression analysis, true total tract Cu, Zn, Fe, Mn and Se digestibility values ( $\pm$ SE;  $n=23$  or  $24$ ;  $P<0.05$ ) in the trace mineral-vitamin premix were determined to be  $137.3\pm 27.9$ ,  $40.5\pm 15.4$ ,  $66.2\pm 24.6$ ,  $94.3\pm 21.6$  and  $96.6\pm 2.8\%$  vs. the corresponding values measured in the four weanling pig compound diets for Cu at  $137.4\pm 3.2$ , Zn at  $40.4\pm 3.1$ , Fe at  $66.2\pm 3.0$ , Mn at  $94.2\pm 3.8$  and Se at  $96.2\pm 0.8\%$ , respectively. The total tract endogenous Cu, Zn, Fe, Mn and Se outputs ( $\pm$ SE) associated with the weanling pig diets were also determined ( $23.4\pm 0.6$ ,  $9.2\pm 2.7$ ,  $37.2\pm 3.5$ ,  $19.4\pm 1.0$  and  $0.07\pm 0.003$  mg/kg DMI diets;  $n=23$  or  $24$ ;  $P<0.05$ ).

**Conclusions:** Our results have shown that the intestinal physiological functions and performances were not significantly affected in the weanling pigs fed on the diets with reduced gradient levels of a trace mineral-vitamin premix for the determination of true total tract trace mineral digestibility and the endogenous losses of trace minerals associated with corn and SBM based diets in weanling pigs by the regression analysis technique.

**Industry Implications:** Swine diets should be formulated on the basis of true total tract digestible trace mineral supply to reduce feeding cost and detrimental impacts of excessive manure heavy trace minerals on the environment.

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