

Impact of indigestible protein on nursery pig performance and intestinal health

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INSIGHT FOR PRODUCERS

Indigestible crude protein is available for microbial fermentation, which may lead to intestinal upset. Understanding how dietary protein content influences gut health, development, and microbial community will help to optimize diet formulation.

SUMMARY

While much work has been done on the concept of dietary protein content impact on performance and health of nursery pigs, it is unclear what factors are primarily responsible for the negative response to high protein diets. While there is a trend for reduced incidence of diarrhea with decreasing protein content, this is not consistent across studies when examining the same protein content. This suggests factors other than total dietary protein content are involved. While the presence of fermentation metabolites have been suggested as a potential mechanism for the negative effects, their actual contribution to intestinal health remains unclear. The concept of indigestible protein content is relatively new and, therefore, has not been specifically examined in past studies. Currently, diet formulations are based on meeting nutrient requirements and, in the case of nursery pig diets, to limit crude protein content. This project will be the first to characterize and validate the effect of indigestible protein on measures of animal health and performance and to examine the interaction between dietary indigestible protein, fibre content, and pathogen type. The overall goal is to provide insight into strategies to mitigate negative effects of indigestible protein and enhance the ability to utilize feedstuffs common Saskatchewan while improving sustainability of pork production.

INTRODUCTION

Stress experienced in the post-weaning period contributes to increased susceptibility of the newly weaned pig to several enteric pathogens, including enterotoxigenic *Escherichia coli* (ETEC) and *Salmonella* spp.. ETEC is the cause of approximately 25% of post-weaning diarrhea in pigs and a major contributor to post-weaning growth lag. Common *Salmonella* spp. serotypes produce less severe infection in the pig but induce an inflammatory response and limit pig performance, are a major cause of foodborne illness in Canada, and can be a barrier to international trade.

Dietary indigestible protein content (i.e., protein not absorbed in the small intestine) is available for microbial fermentation and may have detrimental effects on gut health. Metabolites of protein fermentation have been associated with toxic and pro-inflammatory effects on the gut epithelium. It has been suggested that high protein diets increase susceptibility to enteric pathogens and are a predisposing factor in the development of post-weaning diarrhea, with the assumption that high dietary protein equals high indigestible protein. Further, it has been suggested that feeding a low protein diet reduces the amount of substrate available for the proliferation of pathogenic bacteria, improving gut health and function in piglets.

Unlike with protein, fermentation of fibre is generally considered to produce beneficial metabolites that promote gut health and limit pathogen growth. As with protein, the impact of fibre on nursery pig performance and intestinal health has been inconsistent, likely due to differences in the physicochemical properties and fermentability of fibre sources. Inclusion of a non-structural/soluble fibre source may provide intestinal bacteria an alternative substrate for fermentation whereas inclusion of structural/insoluble source of dietary fibre may reduce the impact of indigestible protein through increased digesta flow through the gut and reduced adhesion of pathogens.

While reducing dietary crude protein has generally been shown to reduce the incidence of diarrhea, this comes at added cost through addition of supplemental crystalline amino acids and/or through reduced growth performance. The costs associated with enteric disease in the post-weaning period can be substantial. Understanding key risk factors related to dietary protein and diarrhea will support the development of mitigation strategies, helping farmers participate in raised without antibiotics programs while maintaining animal health and performance.

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EXPERIMENTAL PROCEDURES

1. Impact of indigestible protein on nursery pig performance and intestinal health

A total of 80 nursery pigs were randomly assigned to 1 of 2 dietary treatments over 2 blocks (n = 8 pens/treatment) for 28 days. Dietary treatments contained similar dietary crude protein (DCP) content (21 %), but different levels of IDP [low IDP, 2.74% (LIDP) or high IDP, 4.20% (HIDP)]. The IDP levels were based on the difference between DCP and SID CP and were achieved using protein sources that were digestible (soy protein concentrate) and less digestible (canola meal and corn distiller dried grain with soluble). Diets were corn-soybean-based and formulated to meet or exceed nutrient requirements according to NRC (2012) and AMINODat 6.0 requirements. Feed and water were available ad libitum. On d 0, 1, 2, 3, 4, 5, 6, 7, 14, 21, and 28, fecal samples were collected and visually scored for fecal consistency (FCS). One average weight pig per pen was humanely euthanized on d 9 for collection of blood, distal GIT content, and fecal matter.

2. Determination of effect of enteric pathogen and indigestible protein content on performance, immune status, gut health, and gut microbiome in nursery pigs

At 3 days old, tail samples were collected for the determination of ETEC F4 receptor gene following a DNA marker-based test. The collected tissues contained either resistant alleles (R) or susceptible alleles (S); pigs with allele S were selected for the ETEC F4 challenge study.

Animals, housing, diets, and experimental design

Thirty-two newly weaned pigs were randomly assigned to 1 of 2 dietary treatments in a completely randomized design (n = 8 pigs/treatment) for 14 d, comprised of 7 day adaptation and post-inoculation periods. Dietary treatments were corn-soybean-based and contained similar dietary crude protein (DCP) content (21 %), but different levels of IDP [low IDP, 2.74% (LIDP) or high IDP, 4.20% (HIDP)]. The IDP levels were based on the difference between DCP and SID CP and were achieved using protein sources that were digestible (soy protein concentrate) and less digestible (canola meal and corn distiller dried grain with soluble). Feed and water were available ad libitum. Pigs and their feed intake were individually weighed at the beginning of the experiment and on weekly basis. Fecal matter was scored daily.

Pathogenic inoculation

Enterotoxigenic E. coli K88+ F4

The ETEC F4 was obtained and selected for antibiotic resistance to chloramphenicol. The ETEC F4 culture was prepared following procedure adapted from Jayaraman et al. (2017). On d 7 pre-inoculation, pigs were orally inoculated with 5 mL of 1.36×10^6 CFU/mL ETEC F4.

Salmonella Typhimurium var. Copenhagen

Salmonella Typhimurium var. Copenhagen (ST) was selected for antibiotic resistance to Nalidixic acid (Nal+) and Novobiocin (Nov+). On d 7 pre-inoculation, the pigs were orally inoculated twice within 4 h with 1 mL of 1.14×10^{10} CFU/mL ST at 0900 h in accordance with the same procedure described for ETEC F4.

RESULTS AND DISCUSSION

Results on the impact of indigestible protein on performance, intestinal health, and response to disease challenge are pending further analysis.

In previous experiments from the same study, it was found that supplementing high IDP diets with dietary fibre fractions (DFF) improved fecal consistency scores, reduced the incidence of diarrhea, and improved select aspects of gut health, though growth performance was not impacted. These results suggest that the addition of fibre in nursery diets has a beneficial impact on piglet gut health. For more information on a previous trial related to this report, please see our 2024 Annual Research Report – Impact of fibre on performance and intestinal health of pigs fed a high indigestible protein level (Erinle et al., page 15).

IMPLICATIONS

Results of a previous literature review indicate that the IDP index is a more sensitive variable compared to DP, because small changes in IDP have a greater impact on simulated weanling pig performance responses, although further validation of the model is necessary. Results show that protein source, rather than DP, is a major contributor to the negative effects of DP on simulated performance.

Furthering our understanding of how protein digestibility influences gut health in nursery pigs is paramount to ensuring good health and optimal growth throughout the production flow.

ACKNOWLEDGEMENTS

This study was completed with support from the Saskatchewan Agriculture Development Fund. The authors would also like to acknowledge the participation of the cooperating farm in this research project, as well as the strategic program funding provided to Prairie Swine Centre by Sask Pork, Alberta Pork, Ontario Pork, the Manitoba Pork Council and the Saskatchewan Agriculture Development Fund.