Interaction of Dietary Fibre and Immune Challenge on Threonine Requirements and Pig Robustness

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Summary

Sub-clinical disease results in reduced growth and less efficient use of nutrients. With the elimination of in-feed antibiotics for growth promotion it is increasingly important to understand the interaction between nutrition and health and nutrient requirements during disease challenge events. This project set out to more fully understand the interaction between dietary feedstuffs and immune status on nutrient requirements and utilization for body protein deposition, aiding in the development of effective techniques and protocols to reduce the negative effects of disease/stress on pig performance, as well as nutrition alternatives to antibiotics. Results suggest that supplemental threonine was able to mitigate the effects of Salmonella challenge and dietary fibre alone, but was only partially able to improve growth performance when both are present. Additional threonine is required in pigs fed high fibre diets and subjected to an enteric pathogen challenge.

Introduction

Feeding high-fibre feedstuffs reduces the efficiency of utilization of dietary threonine for growth in pigs due to an increase in endogenous threonine loss as a result of increased mucin production. The mucus layer serves to protect the intestinal mucosal surface against threats, such as enteric pathogens, with mucin production shown to also increase with immune challenge. In addition to mucin production, threonine is an important precursor for the synthesis of many acute phase proteins involved in the immune response. While an increased threonine requirement has been shown with increased fibre (i.e, mucin production) and with immune challenge (e.g., immunoglobulin production), the interaction of these factors on threonine requirements is unknown. Greater dietary threonine may therefore be required to improve pig robustness and ability to resist immune challenge. With the increased use of high-fibre co-products, such as DDGS, and other feedstuffs resulting in an increase in total dietary fibre content in swine rations, studies into the interaction between high-fibre diets and immune challenge are warranted.

Experimental Procedures

Phase 1 – Nitrogen-balance study

A total of 90 growing barrows were used in a nitrogen (N) balance study. Dietary treatments represented two main factors 1) threonine level (0.49,0.57,0.65,0.73 and 0.81% SID) and 2) fibre level (high fibre or low fibre). A basal diet was formulated, based on wheat and barley, to be first limiting in threonine but to meet or exceed nutrient requirements and all other amino acids according to NRC (2012). Whole body N-balance was measured during a pre-ISS (immune system stimulation) and ISS period of 4-days each. At the start of the ISS period, pigs were injected intramuscularly (I.M) Escherichia coli lipopolysaccharide (LPS) to stimulate the immune system.

Phase 2a - Dietary Fibre Study

A total of 160 growing pigs were randomly assigned to wheat and barley-based diets formulated to contain 10% sugar beet pulp and 5% wheat bran as sources of soluble and insoluble fibre respectively, and one of five levels of SID Thr (0.66, 0.71, 0.76, 0.81 and 0.86%). All other AA were balanced at 110% of NRC (2012) requirement, diets were fed ad-libitum.

Phase 2b – Enteric Pathogen Challenge Study

A total of 128 growing pigs were randomly assigned one of four dietary treatments based on wheat-barley-soybean diets containing high or low dietary fibre and a standard (STD; 0.68% SID based on NRC(2012)) or supplemented (SUP; 0.78% SID based on Phase 1 and 2a results) level of dietary threonine. At day 0 of the challenge period, all pigs were orally inoculated with a culture containing Salmonella typhimurium. Growth performance was monitored for 21-days post challenge during which body weight gain and feed intake were measured.

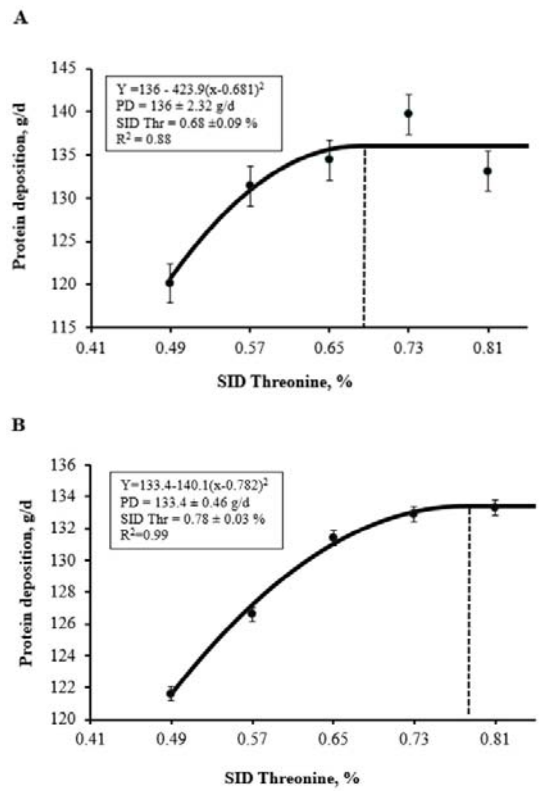

Figure 1. *The quadratic break-point model analysis estimate during the pre-immune system stimulation period for low fiber (A) and high fiber (B). Low fiber diets show a breakpoint at 0.68 % SID Thr for maximum protein deposition (PD) at 136g/d. High fiber diets show a breakpoint at 0.78% SID Thr for maximum PD at 133 g/d.*

Results and Discussion

Phase 1 – Nitrogen-balance study

During the pre-ISS period, protein deposition (N-balance) increased linearly ($P < 0.01$) as threonine concentration in the diet increased, with a significant interaction between fibre and threonine ($P < 0.05$). During ISS, protein deposition increased linearly ($P < 0.05$) as threonine concentration in the diet increased. Quadratic break-point model estimated SID threonine required to maximize protein deposition of pigs fed low and high fiber diets without ISS at 0.68% and 0.78%, respectively (Figure 1). During ISS, the SID threonine requirement was estimated at 0.76% and 0.72% for low and high fibre diets, respectively (Figure 2). Overall, both dietary fibre and ISS increased the estimated threonine requirement, although these effects were not additive.

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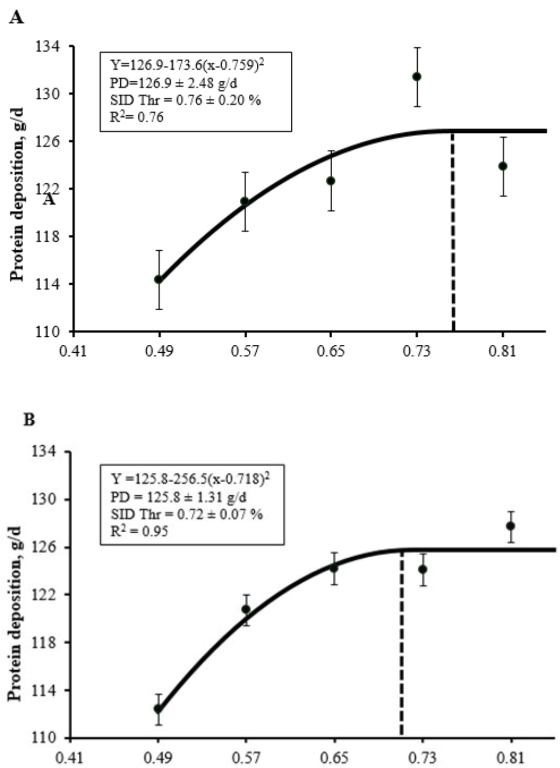

Figure 2. *Quadratic break-point analysis estimates during the immune system stimulation period for low fiber (A) and high fiber (B). Low fiber diets show a breakpoint at 0.76 % SID Thr for maximum protein deposition (PD) at 127g/d. High fiber diets show a breakpoint at 0.72% SID Thr for maximum PD at 126g/d.*

Phase 2a - Dietary Fibre Study
Increasing the dietary SID threonine concentration did not affect the overall ADFI however, between d21-28 there was a linear increase in ADFI. The overall ADG reported in this study showed both linear and quadratic responses as dietary Thr level increased. There were no significant differences in the initial BW among dietary treatments, however, as dietary SID threonine concentration increased, the final BW increased. Increasing dietary SID threonine increased the overall G:F. Dietary SID threonine required to maximize ADG was estimated at 0.76% and 0.80% based on linear and quadratic break-point models, respectively, confirming results from Phase 1.

Phase 2b – Enteric Pathogen Challenge Study
The initial BW was not different between treatments ($P > 0.05$), however final BW was higher in low fiber treatment group compared to the high fiber group ($P < 0.0001$). The effect of threonine on final BW was significant ($P < 0.01$), with greater final BW with high dietary threonine (Table 1). Regardless of dietary fibre content, average daily gain was improved with threonine supplementation compared to unsupplemented ($P < 0.05$), although this increase was less in pigs fed high fibre diets.

Implications

This series of studies indicate an increased threonine requirement may be necessary when pigs face immune disease challenge and/or fed high dietary fibre diets.

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Table 1. *Growth performance of pigs after Salmonella thyphimurium challenge*

	Low Fiber		High Fiber			P value		
Parameters	Low STD Thr	High SUP Thr	Low STD Thr	High SUP Thr	SEM	Fib	Thr	Fib × Thr
Initial BW, kg	22.76	22.32	22.69	22.45	0.167	0.8646	0.0521	0.564
Final BW, kg	49.51	51.45	46.34	48.57	1.055	0.0001	0.0041	0.832
Post Challenge (d0-7)								
ADG, kg	0.965	1.082	0.843	0.911	0.025	<.0001	0.0011	0.3397
ADFI, kg	1.788	1.635	1.653	1.551	0.047	0.0081	0.0025	0.5200
GF, kg/kg	0.543	0.665	0.511	0.588	0.022	0.0164	<.0001	0.2915
Post Challenge (d8-21)								
ADG, kg	0.940	1.093	0.783	0.938	0.031	<.0001	<.0001	0.9840
ADFI, kg	1.983	1.944	1.934	1.831	0.075	0.2922	0.3566	0.6758
GF, kg/kg	0.483	0.566	0.409	0.514	0.022	0.0072	0.0002	0.6291
Overall (d0-d21)								
ADG, kg	0.953	1.088	0.813	0.9243	0.020	<.0001	<.0001	0.5356
ADFI, kg	1.885	1.789	1.793	1.691	0.042	0.0299	0.0243	0.9382
GF, kg/kg	0.514	0.615	0.459	0.553	0.017	0.0016	<.0001	0.8255