Examining the effectiveness of providing functional amino acids to enhance pig robustness

L. Rodrigues and D. Columbus

Dan Columbus

SUMMARY

Pigs are continuously exposed to microbial pathogens and immune-stimulatory antigens that have a negative impact on productivity. Pigs exposed to immune challenge, without exhibiting any clinical signs of disease, show reduced appetite and growth and less efficient use of nutrients compared to healthy pigs. While current dietary strategies include use of in-feed antibiotics, increasing consumer pressure and regulatory restrictions have led to the complete elimination of antibiotic use for growth promotion and pressure to reduce overall antibiotic usage in animal agriculture. Therefore, novel nutritional strategies designed to minimize costs must maintain or promote animal health and resistance to infectious challenge. Results from this project show diet supplemented with key functional amino acids (FAA), specifically threonine (Thr), methionine (Met), and tryptophan (Trp), above estimated requirements for growth improves growth performance and immune status of pigs, regardless of dietary protein content.

INTRODUCTION

Stress experienced in the post-weaning period contributes to increased susceptibility of newly weaned pigs to a number of enteric pathogens, including enterotoxigenic E. coli (ETEC) and Salmonella. ETEC is the cause of approximately 25% of post-weaning diarrhea in pigs and a major contributor to the post-weaning growth lag through further damage to the intestinal epithelium and activation of inflammatory responses.

Stimulation of the immune system alters protein and amino acid (AA) metabolism and utilization, with AA redirected from growth towards supporting the immune response. The increase in AA requirement to support the immune response is met through a reduction in protein synthesis and increase in protein catabolism in the muscle, which represents the largest pool of AA.

However, the AA profile of muscle protein differs significantly from that of protein involved in the immune response, resulting in an AA imbalance and a disproportionate use of some AA during immune challenges leading to an obligatory increase in whole-body AA catabolism and reduction in body protein growth.

Alterations to the gut epithelium induced by dietary protein and/or fibre content may lead to increased susceptibility to pathogens and immune stimulation. In the post weaning pig, feeding diets high in crude protein content has been associated with increased incidence of diarrhea following ETEC challenge; however, the performance responses of piglets fed such diets have been variable.

An increased understanding of the interaction of nutrition and the pig's immune response will be a key component in efforts to reduce feed costs and antibiotic use while improving animal robustness and profitability of the swine industry.

EXPERIMENTAL PROCEDURES

Effect of functional amino acids and dietary protein content on performance and health of Salmonella-challenged weaned pigs

A total of 64 mixed-sex weanling pigs 13.9 ± 0.82 kg initial body weight (BW) were randomly assigned to one of eight treatments in a 2 × 2 × 2 factorial arrangement in a randomized complete block design (n=8 pigs/treatment) for 14 d, including a 7 d adaptation period (no inoculation) and 7 d post-inoculation period. Dietary treatments consisted of a low [LP; 16% crude protein (CP)] or high (HP; 20% CP) protein diet with either a basal (AA-) or functional (AA+) AA profile. Diets were corn- wheat- barley- soybean meal-based and were formulated using the reported nutrient content and analyzed AA content of ingredients to meet or exceed nutrient requirements based on NRC (2012) and AMINODat 5.0 (Evonik, 2016).

High protein (HP) diets were formulated by partly replacing corn in the low protein (LP) diet with soybean meal. The AA- profile met the standardized ileal digestible (SID) AA requirements according to NRC (2012) and the AA+ profile contained Thr, Met, and Trp at 120% of requirements. Pigs were fed ad libitum and had unrestricted access to water. Individual pig BW and feed intake was obtained on d -7, 0, and 7 of the study for calculation of pre- and post-inoculation average daily gain (ADG), average daily feed intake (ADFI), and gain:feed (G:F).

Effect of functional amino acids adaptation time on performance of Salmonella-challenged weaned pigs

A total of 32 mixed-sex weanling pigs 11.6 +/- 0.34 kg initial BW were randomly assigned to one of four treatments in a randomized complete block design (n=8 pigs/treatment) for 21 d, which consisted of a 14-d adaptation period (no inoculation) and 7 d post-inoculation period.

Dietary treatments consisted of a basal (AA-) AA profile fed throughout the experimental period, or a functional (AA+) AA profile fed either post-inoculation (AA+0), for 1 wk pre-inoculation and post-inoculation (AA+1), or throughout the experimental period (AA+2). AA+0 and AA+1 pigs were fed AA- diets for 2 and 1 wk pre-inoculation, respectively. Diets were corn- wheat- barley-soybean meal-based and were formulated using the reported nutrient content and analyzed AA content of ingredients to meet or exceed nutrient requirements according to NRC (2012).

The AA- profile met the standardized ileal digestible (SID) AA requirements according to NRC (2012) and the AA+ profile contained Thr, Met, and Trp at 120% of requirements. Pigs were fed ad libitum and had unrestricted access to water.

RESULTS AND DISCUSSION

Effect of functional amino acids and dietary protein content on performance and health of Salmonella-challenged weaned pigs. Growth performance data for pre- and post-inoculation (Table 1) indicates there was no effect of dietary treatment (P> 0.10). There was no effect of FAA supplementation or CP content on post-inoculation performance of CT pigs (P > 0.10). Both ADG and ADFI were reduced post- inoculation in ST compared to CT pigs (P < 0.05). Salmonella-inoculated pigs fed AA+ diets had greater ADG (P < 0.05) and tended to have increased G:F compared to ST pigs fed AA- diets (P < 0.10). There was no effect of CP content and no significant interactive effect among dietary treatments on post-inoculation growth performance of ST pigs (P > 0.10).

IMPLICATIONS

Results clearly show that diet supplementation with key FAA, specifically Thr, Met, and Trp, above estimated requirements for growth improves growth performance and immune status of pigs, regardless of dietary protein content. Data further suggests the positive effects of these FAA are due to beneficial effects on intestinal health and antioxidant defense systems. Further to this an increased adaptation period will further enhance the effectiveness of functional amino acid supplementation to improve growth performance and attenuate the immune response in Salmonella-challenged weaned pigs. It may, therefore, be beneficial for producers to adjust diets in advance of known times of stress of disease challenge to get the maximum benefit from these amino acids, however, provision of supplemental amino acids at the time of disease challenge is still beneficial.

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Table 1. Pre- and post-inoculation growth performance of control (CT) and Salmonella-inoculated (ST) pigs fed diets differing in functional amino acid and protein content[1]

	CT				ST				
	Low protein		High protein		Low protein		High protein		
	AA-	AA+	AA-	AA+	AA-	AA+	AA-	AA+	SEM
Initial BW (d -7), kg	13.96	13.93	13.93	13.94	13.98	13.96	13.95	13.90	0.31
Inoculation BW (d 0), kg	16.92	17.33	17.08	17.18	17.14	17.15	17.18	17.22	0.97
Final BW (d 7), kg	20.92av	21.36ax	21.18av	21.24ax	19.22bv	20.36bx	19.27bv	20.40bx	1.31
Pre-inoculation period (day -7-0)									
Average daily gain, kg	0.423	0.486	0.450	0.463	0.451	0.456	0.461	0.474	0.05
Average daily feed intake, kg	0.580	0.602	0.563	0.636	0.614	0.646	0.632	0.648	0.05
Gain:Feed, kg/kg	0.72	0.80	0.79	0.72	0.73	0.70	0.73	0.73	0.10
Post-inoculation period (day 0-7)									
Average daily gain, kg	0.571a	0.576a	0.586a	0.580a	0.297bv	0.459bx	0.300bv	0.456bx	0.06
Average daily feed intake, kg	0.880a	0.906a	0.916a	0.936a	0.738b	0.673b	0.744b	0.686b	0.08
Gain:Feed, kg/kg	0.64	0.63	0.63	0.62	0.40y	0.68z	0.40y	0.66z	0.13

AA-, Basal amino acid profile; AA+, Functional amino acid profile (Thr, Met, and Trp at 120% of requirements for growth); BW, body weight; SEM, Standard error of the mean.
1 Values are least squares means; n=8 pigs/treatment. Main or interactive effects not presented were not statistically significant for any of the parameters measured.
a,b Means within a row with different superscripts differ (CT vs ST) (P < 0.05).
v,x Means within a row with different superscripts differ (AA- vs AA+) (P < 0.05).
y,z Means within a row with different superscripts tend to differ (AA- vs AA+) (P < 0.10).

Table 2. Pre- and post-inoculation growth performance of Salmonella-inoculated pigs fed diets with a basal amino acid profile (AA-) fed throughout the experimental period or a supplemented amino acid profile for 0 (AA+0), 1 (AA+1) or 2 (AA+2) weeks pre -inoculation, and post-inoculation1

Item	AA-	AA+0	AA+1	AA+2	SEM	P-value
Pre-inoculation wk 1 BW (d -14), kg	11.74	11.63	11.63	11.73	0.346	0.98
Pre-inoculation wk 2 BW (d -7), kg	13.77	13.37	13.65	13.70	0.465	0.87
Inoculation BW (d 0), kg	16.85	16.34	16.74	17.40	0.701	0.71
Final BW (d 7), kg	18.33	18.62	19.55	20.59	1.093	0.26
Pre-inoculation wk 1 period (day -14 to -7)						
Average daily gain, kg	0.290	0.248	0.289	0.281	0.032	0.79
Average daily feed intake, kg	0.446	0.381	0.405	0.407	0.049	0.75
Gain:Feed, kg/kg	0.65	0.65	0.71	0.69	0.089	0.73
Pre-inoculation wk 2 period (day -7 to 0)						
Average daily gain, kg	0.440	0.424	0.441	0.529	0.061	0.59
Average daily feed intake, kg	0.778	0.750	0.740	0.801	0.042	0.92
Gain:Feed, kg/kg	0.57	0.57	0.60	0.66	0.088	0.49
Post-inoculation period (day 0 to 7)						
Average daily gain, kg	0.211b	0.326ab	0.401ab	0.456a	0.059	0.01
Average daily feed intake, kg	0.720	0.705	0.763	0.727	0.052	0.87
Gain:Feed, kg/kg	0.29b	0.46ab	0.53ab	0.63a	0.099	0.02

AA-, Basal AA profile fed throughout the experimental period. AA+0, Basal AA profile fed pre-inoculation and supplemented AA profile (Thr, Met, and Trp at 20% above basal) fed post-inoculation. AA+1, Basal AA profile fed for 1 wk pre-inoculation and supplemented AA profile fed post-inoculation. AA+2, Supplemented AA profile fed throughout the experimental period. SEM, Standard error of the mean. 1Values are least squares means; n=8 pigs/treatment