Can functional amino acids help low birth weight pigs in a Salmonella challenge?

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SUMMARY

It is not known if supplementation with functional amino acids (FAA) may mitigate the negative effects of intrauterine growth retardation seen in low birth weight (LBW) pigs. The objective was to determine the effects of birth weight category (BWC) and FAA supplementation during the postweaning period in Salmonella-challenged pigs. Thirty-two LBW (1.08 – 0.11 kg) and normal birth weight (NBW; 1.58 – 0.11 kg) pigs were assigned to a nursery feeding program at weaning (25 d) for 31 days in a 2 x 2 factorial arrangement. Factors were BWC (LBW vs. NBW) and basal (FAA–) or supplemented FAA profile (FAA+; Thr, Met, and Trp at 120% of requirements). At d 31, pigs were placed onto a common grower diet and, after a 7-d adaptation period, were inoculated with Salmonella Typhimurium (ST) and monitored for 7-d post inoculation.

Post-inoculation ADG was increased in NBW fed FAA+ compared to the other groups. There was no effect of FAA supplementation on rectal temperature or fecal shedding ($P > 0.10$). Salmonella shedding and translocation to spleen were lower in NBW-FAA+ compared to NBW-FAA- pigs ($P < 0.05$). Inoculation haptoglobin, superoxide dismutase, and colonic myeloperoxidase were increased in LBW-FAA- pigs ($P < 0.05$). Ileal alkaline phosphatase was decreased in LBW compared to NBW ($P < 0.05$).

Overall, the beneficial effects of FAA were dependent on birth weight category, with NBW pigs benefiting more from supplementation compared to LBW pigs. Therefore, functional amino acid supplementation represents a potential strategy to mitigate the effect of enteric disease challenges in normal birth weight, but not low birth weight pigs.

INTRODUCTION

The constant genetic selection for increased litter size in pigs has resulted in a higher proportion of piglets born with low birth weights (LBW). Alterations to intestinal functioning and the microbiome may impair the response to nutrient intake in LBW compared to normal birth weight pigs.

The positive effects of dietary amino acids (AA) on overall health, recently regarded as ‘functional’ roles, are mainly associated with improvements in intestinal mucosal barrier, antioxidant defense, and immune molecule synthesis. Previous work has shown that dietary supplementation with key functional amino acids (FAA) improves growth performance and immune status of disease-challenged normal birth weight (NBW) pigs. It is not known if supplementation with FAA may mitigate the negative effects of intrauterine growth retardation seen in LBW pigs.

The objective of the present study was to determine the effects of birth weight category (LBW vs. NBW) on the susceptibility of pigs to an enteric challenge during the grower phase and how this is influenced by the supplementation with FAA during the nursery phase. The hypothesis of this study was that supplementation with FAA would support a robust immune system, improve growth performance, and decrease disease susceptibility of LBW piglets.

EXPERIMENTAL PROCEDURES

After weaning, 32 mixed-sex piglets (LBW=16; NBW=16) were randomly assigned to 1 of 2 treatments in a randomized complete block design and individually housed for 45 days, including a 38-day adaptation period (no inoculation) and a 7-day post-inoculation period. Pigs were fed the experimental dietary treatments from d 0 to 31 post-weaning. Experimental diets were corn- wheat- barley-soybean meal-based with a basal (FAA-) or functional (FAA+) AA profile. The FAA- profile met the standardized ileal digestible (SID) AA requirements according to NRC (2012) and the FAA+ profile contained Thr, Met, and Trp at 120% of requirements for growth. At d 31, pigs were placed onto a common grower diet and, after a 7-d adaptation period, were inoculated with Salmonella Typhimurium (ST; 2.2 x 109 colony-forming units/mL) and monitored for 7-d post inoculation.

Growth performance, rectal temperature, fecal score, indicators of gut health, ST shedding score in feces, intestinal ST colonization and translocation, and blood parameters of acute-phase response and antioxidant balance were measured pre- and post inoculation.

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RESULTS AND DISCUSSION

Low BW pigs had lower BW than NBW pigs throughout the trial, and tended to have a lower ADG during the pre-inoculation period (Table 1). Pigs fed FAA+ tended to have a higher final BW than pigs fed FAA- regardless of BWC. Post-inoculation ADG was increased in NBW fed FAA+ compared to the other groups. There was no effect of FAA supplementation, BWC, or their interactions on post inoculation average daily feed intake and feed efficiency ($P > 0.10$).

Inoculation with ST increased temperature and fecal score, and the overall rectal temperature was higher in LBW compared to NBW pigs ($P < 0.05$). There was no effect of FAA supplementation on rectal temperature ($P > 0.10$). There was no effect of BWC or FAA supplementation on fecal score ($P > 0.10$).

Salmonella shedding score in feces and translocation to spleen were lower in NBW-FAA+ compared to NBW-FAA- pigs ($P < 0.05$). Post inoculation (d 7), reduced:oxidized glutathione was increased in NBW compared to LBW pigs ($P < 0.05$; Table 2). Post inoculation (d 4), serum haptoglobin and superoxide dismutase (Table 2), as well as colonic myeloperoxidase were increased in LBW-FAA- pigs ($P < 0.05$). Ileal alkaline phosphatase was decreased in LBW compared to NBW ($P < 0.05$).

Collectively, the results show that supplementation of nursery diets with FAA, specifically with Thr, Met, and Trp, above estimated requirements for growth improved growth performance, reduced pathogen shedding and suppressed bacterial translocation to lymphoid tissues when pigs were subsequently challenged with Salmonella. However, the beneficial effects of FAA were dependent on birth weight category, with normal-birth-weight pigs benefiting more from supplementation compared to low-birth-weight pigs, which were more susceptible to the gastrointestinal disturbance, oxidative stress, and systemic commitment of the immune system.

IMPLICATIONS

This study is the first to determine the effects of functional amino acid supplementation in the nursery on performance during a subsequent disease challenge in both low and normal birth weight pigs. Overall, the development of feeding strategies, such as altering dietary amino acid content, to support pig robustness will reduce reliance on antibiotics while maintaining animal performance. This study showed that functional amino acid supplementation represents a potential strategy to mitigate the effect of enteric disease challenges in normal birth weight, but not low birth weight pigs.

ACKNOWLEDGEMENTS

Funding for this project has been provided by Swine Innovation Porc, Evonik Nutrition & Care GmbH, and Mitacs. The authors would also like to acknowledge the strategic program funding provided by Sask Pork, Alberta Pork, Ontario Pork, the Manitoba Pork Council, and the Saskatchewan Agriculture Development Fund. In addition, we wish to acknowledge the support of the production and research technicians at Prairie Swine Centre and the Animal Care Unit at the Western College of Veterinary Medicine that make it possible to conduct this research.

Table 1. Pre- and post-inoculation growth performance of low and normal birth weight pigs inoculated with Salmonella[1]

Item	Low birth weight		Normal birth weight		SEM	P-value		
	FAA-	FAA+	FAA-	FAA+		BWC	FAA	BWC×FAA
Phase I (day 0 to 10)								
Initial body weight, kg	6.79	6.98	8.24	8.72	0.347	<0.01	0.64	0.27
Average daily gain, kg	0.246	0.249	0.287	0.313	0.044	0.45	0.22	0.16
Average daily feed intake, kg	0.386ab	0.405ab	0.361b	0.446a	0.025	0.73	0.21	0.05
Gain:Feed, kg/kg	0.64	0.62	0.79	0.70	0.093	0.28	0.86	0.89
Phase II (day 10 to 31)								
Initial body weight, kg	9.25	9.47	11.11	11.85	0.605	<0.01	0.44	0.68
Average daily gain, kg	0.382	0.400	0.360	0.403	0.036	0.80	0.41	0.72
Average daily feed intake, kg	0.699	0.721	0.780	0.773	0.050	0.20	0.88	0.79
Gain:Feed, kg/kg	0.55	0.55	0.46	0.52	0.043	0.17	0.36	0.63
Pre-inoculation (day 31 to 38)								
Initial body weight, kg	17.27	17.87	18.67	20.31	0.460	0.05	0.70	0.15
Average daily gain, kg	0.416	0.529	0.718	0.784	0.157	0.07	0.56	0.88
Average daily feed intake, kg	0.854	0.914	0.926	1.099	0.106	0.21	0.26	0.58
Gain:Feed, kg/kg	0.49	0.58	0.78	0.71	0.153	0.55	0.71	0.35
Post-inoculation (day 38 to 45)								
Initial body weight, kg	20.18	21.57	23.70	25.80	0.967	0.01	0.63	0.16
Average daily gain, kg	0.436b	0.446b	0.477b	0.565a	0.034	0.33	0.08	0.03
Average daily feed intake, kg	0.831	0.913	0.938	1.065	0.146	0.55	0.31	0.34
Gain:Feed, kg/kg	0.52	0.49	0.51	0.53	0.038	0.43	0.76	0.82
Final body weight, kg	23.23	24.69	27.04	29.76	0.841	0.03	0.07	0.48

FAA-, Basal amino acid profile; FAA+, Functional amino acid profile (Thr, Met, and Trp at 120% of requirements for growth). SEM, standard error of the mean. BWC, birth weight category. [1] Values are least squares means; n=8 pigs/treatment.
[a–b] Means within a row with different superscripts differ ($P \leq 0.05$).

Table 2a. Pre- and post-inoculation blood parameters of Salmonella-inoculated low and normal birth weight pigs[1]

Item	Low birth weight		Normal birth weight		SEM
	FAA-	FAA+	FAA-	FAA+	
Serum albumin, g/L					
Pre-inoculation (d 0)	33.75	32.75	33.37	38.29	4.064
Post-inoculation (d 4)	29.38	27.13	29.75	33.43	
Post-inoculation (d 7)	28.63	26.75	27.25	27.29	
Serum haptoglobin, g/L					
Pre-inoculation (d 0)	0.48	0.36	0.33	0.49	0.121
Post-inoculation (d 4)	1.01a	0.65b	0.73b	0.68b	
Post-inoculation (d 7)	0.54	0.54	0.53	0.55	
Serum antioxidant capacity, mM					
Pre-inoculation (d 0)	0.33	0.36	0.36	0.43	0.099
Post-inoculation (d 4)	0.19	0.31	0.23	0.34	
Post-inoculation (d 7)	0.18	0.21	0.20	0.21	
Plasma superoxide dismutase, mU/mL					
Pre-inoculation (d 0)	49.53	41.79	39.38	44.31	7.654
Post-inoculation (d 4)	93.32a	53.09b	76.58ab	67.81b	
Post-inoculation (d 7)	65.17	77.37	55.92	66.54	
Reduced glutathione (GSH), µM					
Pre-inoculation (d 0)	3.65	4.19	3.14	3.77	0.489
Post-inoculation (d 4)	2.05	1.41	1.98	1.69	
Post-inoculation (d 7)	0.89	1.04	1.62	1.21	
Oxidized glutathione (GSSG), µM					
Pre-inoculation (d 0)	0.67	0.70	0.58	0.68	0.234
Post-inoculation (d 4)	1.57	1.17	1.21	1.36	
Post-inoculation (d 7)	0.61	0.56	0.61	0.52	
GSH:GSSG					
Pre-inoculation (d 0)	5.45	5.98	5.41	5.54	0.289
Post-inoculation (d 4)	1.31	1.21	1.64	1.24	
Post-inoculation (d 7)	1.46	1.86	2.66	2.33	

FAA-, Basal amino acid profile; FAA+, Functional amino acid profile (Thr, Met, and Trp at 120% of requirements for growth). SEM, standard error of the mean. BWC, birth weight category.
[1] Values are least squares means; n=8 pigs/treatment.
[a,b] Means with a row with different superscripts differ ($P \leq 0.05$).

Table 2b. Significance of main and interactive effects of birth weight category (BWC), functional amino acid (FAA) profile, and day for pre- and post-inoculation blood parameters[1]

Item	FAA	Day	BWC × Day	FAA × Day	BWC × FAA × Day
Serum albumin	NS	0.05	NS	NS	NS
Serum haptoglobin	NS	0.02	NS	NS	0.03
Serum antioxidant capacity	0.05	0.04	NS	NS	NS
Plasma superoxide dismutase	NS	<0.01	NS	0.03	0.04
Reduced glutathione (GSH)	NS	<0.01	NS	NS	NS
Oxidized glutathione (GSSG)	NS	<0.01	NS	NS	NS
GSH:GSSG	NS	0.02	0.04	NS	NS

[1] Interactive effects not presented were not statistically significant (NS) for any of the parameters measured.