Dietary ω-6 to ω-3 Fatty Acid Ratios Affect Protein Deposition in Nursery Pigs

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SUMMARY

An experiment was conducted to determine if decreasing the dietary omega-6 (ω-6) to omega-3 (ω-3) fatty acid (FA) ratio would affect protein deposition in nursery pigs during a prolonged E. coli lipopolysaccharide (LPS) inflammatory challenge. Following a one week long challenge, six week old piglets fed a lower ω-6: ω-3 ratio had increased protein deposition rates, increased liver protein synthesis rates and increased average daily weight gains relative to those pigs consuming a diet with a higher ω-6: ω-3 FA ratio when feed intakes were similar. Protein synthesis was unaffected by the presence of an LPS induced inflammatory challenge. Overall, reducing the ω-6:ω-3 FA ratio improves the efficiency by which piglets can utilize nutrients for growth, regardless of the presence of an inflammatory challenge.

INTRODUCTION

In the swine industry, weaning is a critical time in a pig's life. They are exposed to a series of stressors (social, environmental, nutritional), which can impact animal health and performance. These stressors can lead to the 'post-weaning growth lag' characterized by decreased growth performance, reduced feed intakes, and an inflammatory response. Although a certain degree of inflammatory response is beneficial during this time, an over-production of immune cells can be detrimental, leading to increased muscle degradation and reduced protein synthesis.

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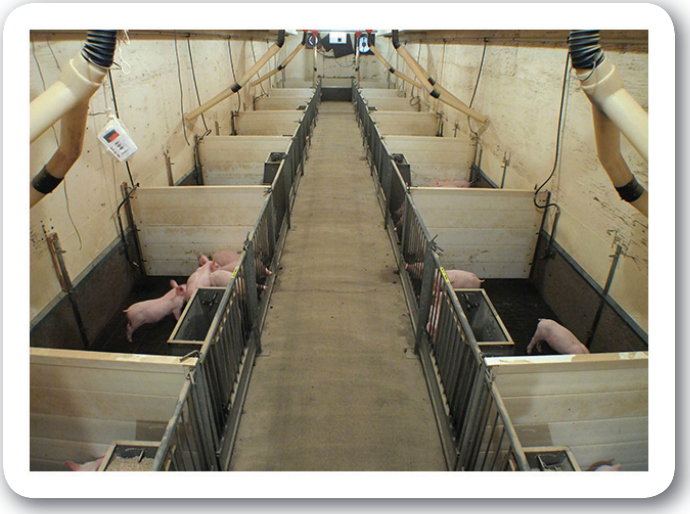
Throughout the years there have been many nutritional strategies implemented with the aim of alleviating the stress response of piglets during this time period. Omega-3 FA's are anti-inflammatory, and are pre-cursors for eicosanoid synthesis, and can also alter the production of pro-inflammatory cytokines (proteins secreted by immune cells in response to stimuli) which assist in regulating the inflammatory response. Omega-6 FA's are pro-inflammatory, and thus the ratio between the ω-6 and ω-3 FA's may be important to establish a well-balanced immune system in these animals.

The objective of this experiment was to determine if decreasing the dietary ω-6:ω-3 FA ratio would affect protein deposition in nursery pigs during a prolonged E. coli lipopolysaccharide inflammatory challenge, used to model a stress response.

EXPERIMENTAL PROCEDURE

Twenty-four individually housed barrows (21 days of age) were acclimated to one of 2 dietary treatments for a period of 14 days. Diets were wheat and barley based, and formulated to meet nutritional requirements according to NRC 2012. Total fat was constant across diets; however, the specific FA profile of the diets changed (10:1 ω-6:ω-3 vs. 5:1 ω-6:ω-3). These changes were accomplished by adjusting the amount of corn oil (high in ω-6) and flax oil (high in ω-3).

On d 15, within diet, pigs were randomized to an LPS (challenge) or saline (control) injection group. Pigs received either 15 µg/kg BW LPS or saline. Repeat injections were given on d 18 and 21. Throughout the challenge period, saline injected pigs were pair fed to the consumption level of LPS injected pigs.



On d 21, pigs were given a flooding dose of deuterium (^2H_2O; 4 ml/kg body water using an estimate of 72% body water) 1.5 h post-feeding in order to determine the fractional rate of protein synthesis (FSR). The LPS or saline injections were then given 2.5 h post feeding, followed by euthanasia and sample collection (liver, semi-tendinosus muscle and blood) at 5.5 h post-feeding. Carcasses were then ground and protein and water deposition were determined for the 21 day period relative to an initial slaughter group (ISG) of 6 pigs. Liver, muscle and blood samples were used to determine the FSR.

RESULTS AND DISCUSSION

During the acclimation phase (d 0-15), dietary treatment had no effect on feed intake (P > 0.10); however, piglet ADG tended to be impacted by dietary treatment, with pigs fed the 10:1 diet gaining 25.0 g/d and those consuming the 5:1 diet gaining 28.8 g/d (SEM = 1.4 g/d, P = 0.06).

Throughout the challenge phase (d 15-18), pigs were pair fed (saline injected pigs were restricted fed to the level of LPS injected pig intakes), and thus ADG and ADFI were similar for all pigs (P > 0.10) regardless of diet or challenge group.

Table 1 shows the effects of diet and inflammatory challenge on carcass composition, carcass protein deposition rates and specific protein synthesis rates in pigs with similar feed intakes. For the whole 3 week period (d 0-21), pigs consuming the 5:1 diet, regardless of challenge group, had higher whole body protein deposition rates relative to pigs consuming the 10:1 diet (87.8 g/d vs. 61.3 g/d; P = 0.04). Similarly, 5:1 fed pigs tended to have increased FSR in the liver on the final day of the challenge relative to those consuming the 10:1 diet (8.55 % synthesized/h vs 6.16 %/h; P = 0.08). There was no effect of LPS challenge on carcass composition, protein deposition rate or on liver or muscle FSR measured using ^2H_2O enrichment (P > 0.05). Protein deposition measured over time and on the final challenge day (FSR) was also unaffected by LPS challenge (P > 0.10).

CONCLUSION

This experiment shows that reducing the n-6:n-3 FA ratio in nursery pig diets improves the efficiency by which the animal utilizes nutrients for growth, as evidenced by similar feed intakes but improved ADG and protein deposition rates.

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Table 1. Effects of diet and inflammatory challenge on the carcass composition, carcass protein deposition rates and specific protein synthesis rates in pigs with similar feed intake levels

Diet *(ω3-ω6)*		**10:1**	**10:1**	**5:1**	**5:1**			**P Values**	
Challenge	**ISG[1]**	**LPS**	**Saline**	**LPS**	**Saline**	**SEM**	**Diet**	**Challenge**	**D x C[7]**
n	6	6	6	6	6				
Slaughter BW, kg	9.72	12.45	12.03	12.24	12.17				
Carcass Composition, g/kg[2]									
Protein	157.42	164.19	168.13	169.31	168.21	2.215	0.25	0.53	0.27
Water	741.69	739.49	730.86	727.17	724.59	3.685	0.02	0.14	0.42
Deposition Rate, g/d[2]									
Protein	-	67.20	55.46	97.45	78.08	12.193	0.04[4]	0.22	0.76
Water	-	260.58	168.65	338.54	256.04	47.306	0.10	0.08	0.92
Deposition Rate, g/kg BW gain[2]									
Protein	-	137.91	173.93	199.10	245.44	27.720	0.03[5]	0.15	0.85
Water	-	536.27	536.03	678.57	802.69	103.620	0.06	0.56	0.56
Nutrition Deposition Ratio[2]									
WDR:PDR	-	5.26	3.05	3.31	3.25	0.836	0.31	0.19	0.21
Protein Synthesis Rate, % newly made/hr[3]									
Semitendinosus	-	3.83	3.26	3.19	3.13	0.272	0.17	0.27	0.36
Liver	-	5.45	6.87	9.70	7.39	1.306	0.08[6]	0.73	0.17

[1] ISG's are not included in statistical analysis; values are presented for information only

[2] Carcass composition, deposition rates and deposition ratios were determined for d 0-21 relative to ISG pigs

[3] Protein synthesis rates determined using $^2H_20$ enrichment of the carcass on experimental d 21

[4] 10:1 diet PDR (g/d) = 61.33, 5:1 diet PDR (g/d) = 87.76

[5] 10:1 diet PDR (g/kg BW gain) = 155.92, 5:1 diet PDR (g/kg BW gain) = 222.27

[6] 10:1 diet liver synthesis = 6.16 %/hr, 5:1 diet liver synthesis = 8.55 %/hr

[7] No diet x challenge interactions were present