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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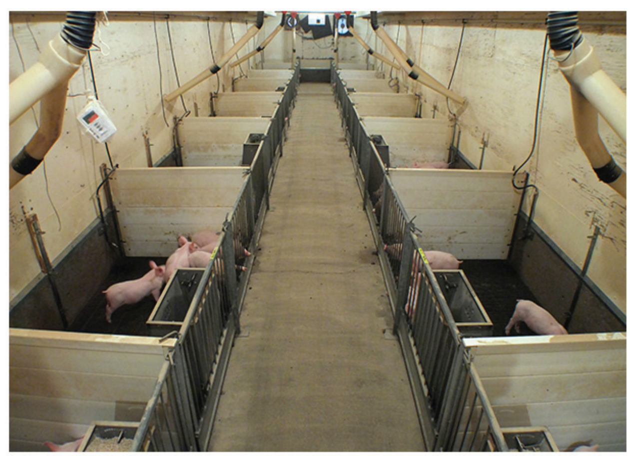
Throughout the years there have been many nutritional strategies implemented with the aim of alleviating the stress response of piglets during this time period. Omega-3 FA's are anti-inflammatory, and are pre-cursors for eicosanoid synthesis, and can also alter the production of pro-inflammatory cytokines (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.

ACKNOWLEDGEMENTS

Strategic program funding was provided by Saskatchewan Pork Development Board, Alberta Pork, Manitoba Pork Council, Ontario Pork and Saskatchewan Agriculture and Food Development Fund. Specific funding for this project was provided by Alberta Livestock and Meat Agency (ALMA) and Vandeputte s.a. (Mouscron, Belgium).

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