Dietary ω-6 to ω-3 Ratio Impacts Nursery Pigs More than ω-3 Intake Alone

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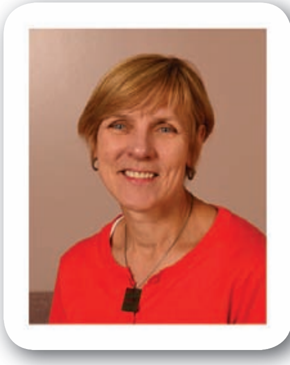

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SUMMARY

Results from these experiments indicate that altering the omega(ω)-6 to ω-3 fatty acid (FA) ratio can improve nursery pig performance, and protein deposition, potentially by diverting nutrients away from an unnecessary inflammatory response. Additionally, we found no effects on piglet performance or health by altering the amount without changing the FA ratio. Results from this project indicate that in order to observe benefits of feeding ω-3 FA's to nursery pigs, it is more important to ensure the ratio of ω-3's relative to ω-6's are altered as opposed to simply increasing the amount without changing the ratio.

INTRODUCTION

Weaning is a stressful time in a piglet's life. They undergo social, environmental and nutritional stressors at a time when their immune system is not fully developed. This can precipitate the 'post-weaning growth lag', which is characterized by animals going off feed, reduced or negative growth rates and increased susceptibility to pathogens. These stresses can trigger an inflammatory reaction in some piglets. Although a certain degree of an inflammatory response is beneficial, an over-production of inflammatory cells may become detrimental to the animals, leading to reduced muscle synthesis or even muscle degradation, characteristic of the post-weaning growth lag.

Over the years, there has been a high degree of interest in nutritional modulation aimed at helping piglets cope during this time period. Omega 3 fatty acids have many potential health benefits, including anti-inflammatory properties. Previous research however, has shown conflicting data in terms of inflammatory responses and animal performance when ω-3's are fed. We hypothesize that different concentrations of ω-6 fatty acids in the diet among the different studies may explain some of these contradictions. In fact, it has been suggested that it may be more beneficial to reduce the dietary ω-6 to ω-3 FA ratio when feeding pigs than to simply increase the ω-3 amount, in order to see benefits.

This project was designed to determine if whether altering the dietary ω-3 to ω-6 ratio or changing the absolute intake amount of ω-3 FA's was more important for impacting nursery pig health and performance. To achieve this, we conducted 2 experiments. First, our aim was to characterize how the FA ratio and intake would affect the growth and performance of nursery pigs, including whole body FA and protein deposition. Secondly, we wanted to look specifically at how the ω-3 ratio and intake amounts affect the piglets' ability to mount an acute inflammatory response post-weaning.

"Altering the ω-6 to ω-3 ratio, not the absolute intake amount, improves nursery pig performance and protein deposition."

EXPERIMENTAL PROCEDURE

A total of 5 dietary treatments were used for each trial. Diets consisted of a control (Con; 10:1 ω-6:ω-3 , 3.5% total fat, tallow based), 3 diets with 3.5% fat (plant based) and ω-6:ω-3 ratios of 10:1, 5:1 or 1:1 (3.5/10, 3.5/5 and 3.5/1 respectively), and a 10:1 ratio diet with 5% total fat (5/10). This design allowed the comparison of increasing ω-3 intake at a constant ratio (10:1 ratio, 3.5% vs 5% fat) and decreasing ratio at a constant ω-3 intake (3.5% fat, 10:1, 5:1 and 1:1 ratios).

Experiment 1: Nursery Pig Performance

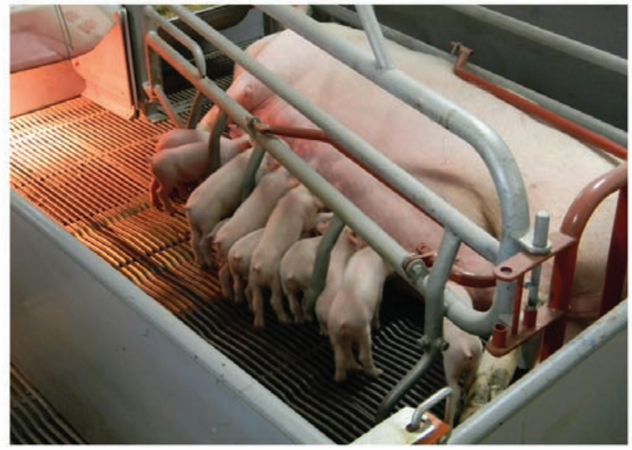
Newly weaned pigs (n = 300; 26 ± 2 days of age) were housed in groups of 5/pen. Pens were assigned to one of the 5 diets described above. Pigs and feeders were weighed weekly for 4 weeks. Additionally, 6 pigs were slaughtered on d 0 (initial slaughter group, ISG) and 6 pigs/diet were slaughtered on d 28, allowing the calculation of whole body protein, fat and water deposition rates throughout the course of the 4 week trial.

Experiment 2: Inflammatory Challenge

Individually housed, newly weaned pigs (26 ± 2 days of age; n = 100) were assigned to one of the five diets and one of two inflammatory challenge groups arranged as a 5 x 2 factorial with repeated measures. Challenge groups consisted of a saline or LPS (15 µg/kg BW E. Coli lipopolysaccharide) injection. Pigs were fed their assigned diets for 22 d prior to the 24 h inflammatory challenge on d 23. Rectal temperatures were measured hourly for the first 6 h, then at 12 and 24 h post-injection. Blood samples were collected at 0, 2, 6 and 12 h post-injection for analysis of certain inflammatory proteins (interleukin (IL)-1β, IL-6, IL-8 and tumor necrosis factor (TNF)-α) as well as blood urea nitrogen (BUN) as an indicator of muscle catabolism.

RESULTS AND DISCUSSION

During the nursery performance study (Table 1), increasing ω-3 amount (constant 10:1 ratio), did not affect average daily feed intake (ADFI) or average daily gain (ADG); but when the ω-6:ω-3 ratio decreased (constant total fat) from 10:1 to 1:1, ADFI improved (0.93 vs 1.13 g/d, $P = 0.02$) during d 21 to 28 post-weaning. Pigs consuming the 3.5/5 diet tended to have increased protein (82.5 vs 71.1 vs 74.2 g/d, $P = 0.07$) and water (342.1 vs 301.0 vs 313.0 g/d, $P = 0.06$) deposition rates relative to those consuming the 3.5/10 or 3.5/1 diets. Lipid deposition was unaffected by treatment ($P > 0.10$). These results indicate that altering the ω-6:ω-3 ratio is more beneficial than altering the intake amount of ω-3's in terms of eliciting positive responses such as increased feed intake and protein deposition in nursery pigs when using plant based ω-3 FA's.



In the inflammatory challenge experiment, ADG and ADFI from d 0 to 22 or just during the challenge period were unaffected by diet ($P > 0.05$). During the challenge, LPS pigs had lower ($P < 0.01$) ADFI (0.93 vs 0.40 kg, saline vs LPS) and ADG (+0.44 kg vs -0.52 kg, saline vs LPS). Rectal temp, BUN, IL-1β, IL-6 and TNFα were unaffected by diet ($P > 0.05$), but were increased by LPS ($P < 0.01$). Serum IL-8 concentration was reduced with decreasing ω-6:ω-3 ratio (16.79 vs 11.14 pg/ml; 10:1 vs 1:1; $P = 0.03$) but was unaffected by dietary ω-3 amount at a constant ratio ($P > 0.05$). Pigs consuming the 3.5/1 diet had lower IL-8 responses relative to those consuming the 3.5/10 and 3.5/5 diets (diet × challenge $P = 0.03$). Additionally, the IL-8 response of pigs fed the 1:1 diet and challenged with LPS was similar to the saline injected pigs fed the 10:1, 5:1 or 1:1 diets ($P = 0.09$, Figure 1), indicating that reducing the dietary ω-6:ω-3 ratio impacts a piglets inflammatory response post-weaning.

CONCLUSION

During the inflammatory challenge, we observed a significant reduction in interleukin (IL)-8 (an inflammatory cytokine) as the dietary ω-6:ω-3 ratio decreased, but there was no effect on IL-8 when just the ω-3 amount was altered. In addition to this, during the challenge, pigs consuming the 1:1 diet had an IL-8 response level similar to the non-challenged pigs on any diet. During the performance study, increasing the amount of dietary ω-3 fatty acids while keeping the ω-6:ω-3 ratio constant did not affect piglet growth, feed intake or carcass composition; however, when total fat was held constant, a 5:1 ratio led to improved feed intake in older nursery pigs, as well as increased protein deposition without altering lipid deposition. It is possible that this reduction in inflammatory response at weaning may help explain why pigs consuming the lower ratio diets had increased feed intakes and improved protein deposition rates, as they did not require as much protein to mount an inflammatory response.

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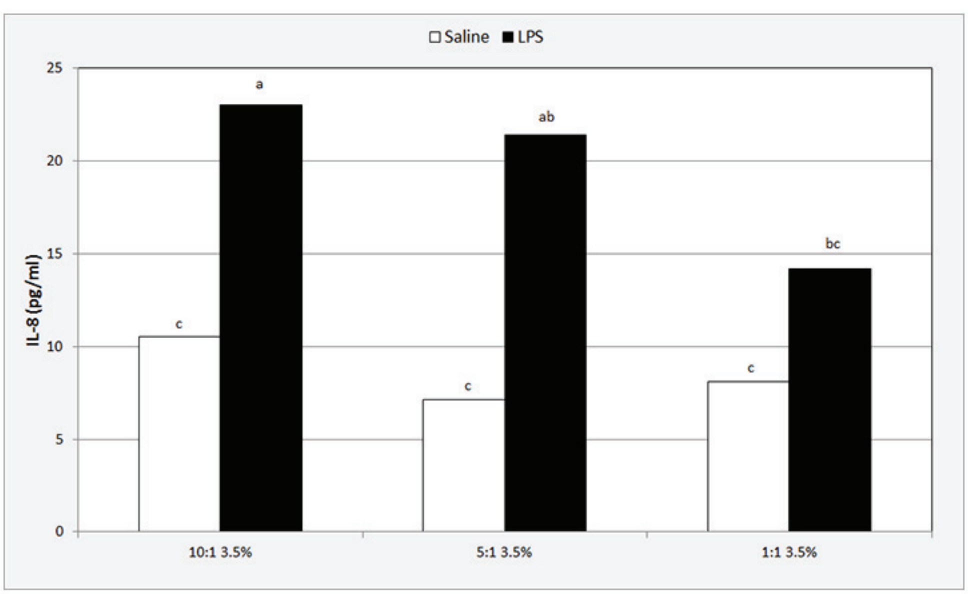

Figure 1. Diet by challenge interaction for pigs fed decreasing ω-6 to ω-3 fatty acid ratios during an inflammatory challenge (SEM = 2.02, P = 0.09)

Table 1. Effects of altering the dietary omega-3 fatty acid amount or ratio on nursery pig performance and carcass composition

	Dietary Treatment[1]					Effect of Ratio[2] (Diet B vs. D vs. E)	
	A	B	C	D	E		
n6:n3 Ratio	10:1s	10:1	10:1	5:1	1:1		
% Fat	3.5%	3.5%	5%	3.5%	3.5%	SEM	P Value
ADFI (kg/d)							
d 21-28	0.97[a]	0.95[a]	0.93[a]	0.97[a]	1.13[b]	0.042	0.02
d 7- 28	0.68	0.67	0.66	0.69	0.78	0.031	0.08
d 0-28	0.56	0.55	0.54	0.56	0.63	0.025	0.11
ADG (kg/d)							
d 21-28	0.97	0.97	0.95	0.94	1.01	0.031	0.59
d 7- 28	0.48	0.49	0.48	0.49	0.51	0.016	0.65
d 0-28	0.39	0.40	0.39	0.40	0.42	0.015	0.58
G:F							
d 21-28	1.00	1.02	1.03	0.98	0.92	0.032	0.18
d 7- 28	0.71	0.73	0.75	0.72	0.68	0.023	0.38
d 0-28	0.70	0.73	0.74	0.71	0.69	0.024	0.64
Deposition Rate (g/d)							
Protein	78.45[ab]	71.07[bc]	69.27c	82.45[a]	74.24[abc]	3.241	0.07
Lipid	35.62	31.88	34.03	31.37	30.29	2.800	0.92
Water	328.72[ab]	300.95[bc]	298.61c	342.05[a]	313.01[bc]	11.520	0.06

[1] 10:1s diet contains a saturated fat source whereas all other diets contain unsaturated fat sources

[2] Effect of altering the ω-3 amount (diet B vs. C) was non-significant for all parameters