Can Omega-3 Fatty Acids Modulate the Immune Response of Pigs?


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Introduction:

In the hog industry, weaning is the most stressful time in a piglet's life. The piglets are removed from the sow, mixed with unfamiliar pen mates and begin consuming an unfamiliar diet of solid food. These social, environmental and nutritional stressors contribute to the post-weaning growth lag. This growth lag is characterized by anorexia (for 24-48 hours in some cases), reduced or negative growth rates and increased susceptibility to pathogens. Some piglets undergo an immune reaction triggered by these stresses. Although a certain degree of immune response is beneficial, an over-production of immune cells may become detrimental to the animals, leading to reduced muscle synthesis or even muscle degradation, characteristic of the post-weaning growth lag.

There have been many nutritional strategies implemented with the goal of improving piglet performance at the time of weaning. These strategies may include the use of creep feed, inclusion of highly palatable protein sources, or even the use of novel ingredients, flavours and aromas to stimulate feed intake. The use of omega-3 (n3) fatty acids is becoming a growing area of interest for hog producers due to their known health benefits. Recently, the nutrition group at the Prairie Swine Centre has conducted a set of experiments to determine how nutritional modulation using n3 fatty acids can improve piglet health and performance at weaning.

The n3 and omega-6 (n6) fatty acids are long chain, essential, polyunsaturated fatty acids. Depending on the source (plant or fish), the n3 or n6 fatty acids differ slightly in structure and function. The metabolites of these fatty acids are highly active in the body, and are involved in many processes, including inflammation and immunity. In general, the n6 fatty acid products are considered to be pro-inflammatory (cause inflammation) and the n3 products are anti-inflammatory (prevent inflammation). Typical western hog diets have an n6 to n3 fatty acid ratio of 10:1 or greater. Because of competition between the enzymes required in the conversion of n6 and n3 to these metabolites, the amount of n3 provided in the diet relative to n6 may be important to obtain optimal benefits. In other words, the n3 fatty acids may assist in regulating the body's immune response, and thus may help alleviate the stress-induced immune response generated at weaning, but optimal benefits probably require a specific n6 to n3 ratio.

The objectives of our experiments were to determine the effect of feeding different dietary n6:n3 ratios to (1) sows or (2) piglets post weaning, on the immune responses of piglets when challenged with a bacterial component.

Materials and Methods:

Two experiments, using similar designs, were conducted. In the first trial, experimental diets were fed to sows throughout lactation, and piglets were weaned onto a common commercial starter diet. In the second trial, piglets were weaned from sows fed a common commercial lactation diet, and fed the experimental starter diets post weaning for one week. For both trials, piglets were acclimated in the nursery for 6 days, followed by an immunologic challenge to determine the effects of feeding n3 fatty acids on acute immune responses.

Experiment 1:

Sows consumed 1 of 5 diets with varied n6:n3 fatty acid ratios. The diets consisted of a control (tallow based), plant based ratios of 10:1, 5:1, 1:1, and a fish based 5:1 ratio. Sows remained on these diets for 2 reproductive cycles and piglets weaned from the 2nd cycle (day 26 ± 2 of lactation) were used in the immune challenge study. The fatty acid ratios were 7.5:1, 4.5:1, 1.5:1 and 3:1 in the milk of sows fed the 10:1, 5:1, 1:1 and 5:1 fish diets respectively.

Weanling pigs (n=100), 20 from each diet group, were randomized to a challenge control group (saline injected) or to an E. Coli lipopolysaccharide (LPS) injected group (n=10/challenge/diet). Piglets were given 6 days to acclimate to their new environment prior to the immune challenge. Rectal temperatures were recorded at 0, 1, 2, 3, 4, 5, 6, 12 and 24 hrs post injection and blood samples were collected at 0, 2, 6 and 12 hrs post injection for cytokine analysis (IL-1β, IL-6, Il-8, TNFα). Cytokines are molecules involved in inflammatory and immune reactions, and can be measured to monitor the immune responses of animals.

Experiment 2:

Pigs (n = 120) were weaned on day 26 (± 2) of lactation from sows consuming a common commercial lactation diet and were randomly assigned to 1 of 5 test starter diets. The test diets consisted of a control (tallow based), plant based ratios of 10:1, 5:1, 1:1, and a fish based 1:1 ratio.

Individually housed pigs were acclimated to their new surroundings and diets for 6 days and then randomized to a challenge control group (saline injected) or to an E. Coli lipopolysaccharide (LPS) injected group (n=12/challenge/diet). Rectal temperatures were recorded at 0, 1, 2, 3, 4, 5, 6,

12 and 24 hrs post injection and blood samples were collected at 0, 2, 6 and 12 hrs for cytokine analysis (IL-1β, IL-6, Il-8, TNFα).

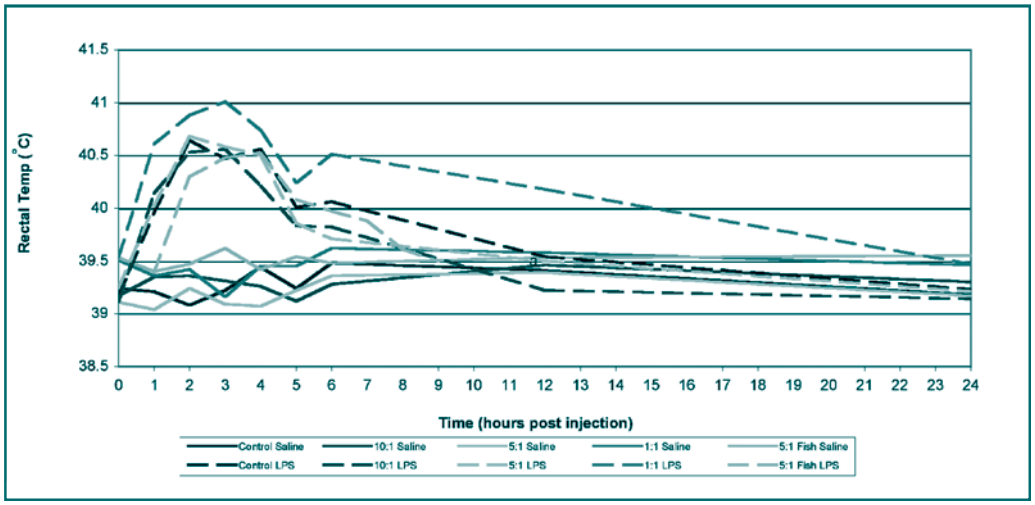

Figure 1: Rectal temperatures of challenged and unchallenged piglets on each dietary treatment group during experiment 1

Results and Discussion:

For both experiments, baseline rectal temperatures and cytokines were similar between treatments ($P > 0.05$). Challenged pigs had decreased ADG and ADFI, increased rectal temperature and increased plasma cytokine concentrations ($P < 0.05$), indicating that LPS elicited an immune response, and our challenge model worked.

In experiment 1, sow diet affected piglet body temperature, where the 1:1 treatment group had the highest maximum temperature ($P = 0.10$) regardless of challenge. Piglets from the 1:1 fed sows had a greater febrile response to the challenge when compared to the other groups ($P=0.01$). Piglets from sows consuming the 1:1 diet had an increase in nearly 1°C when challenged, whereas body temperature increased between 0.5 to 0.7°C for the other treatment groups. Effect of challenge and diet on body temperatures are shown in Fig. 1. Maximal IL-8 production was highest for piglets raised by sows consuming the 1:1 diet group ($P = 0.09$), indicating that the piglets from this diet group had a greater cytokine response to the immune challenge.

In experiment 2, rectal temperature and IL-1β were unaffected by dietary treatment ($P > 0.05$) as shown in Fig. 2. Pigs consuming the 5:1 ratio diet had an increased IL-6 response ($P < 0.01$) and tended to have increased responses for IL-1β ($P < 0.1$) and TNFα($P = 0.1$). Indicating that piglets consuming an n6:n3 ratio of 5:1 had increased immune responses when challenged.

Summary:

Our experiments demonstrated that feeding n3 fatty acids to sows can affect piglet responses to immune challenges at weaning. We also showed that feeding piglets' starter diets with n3's in the nursery can also modulate their inflammatory reactions. Altering the n6:n3 fatty acid ratio in either sow or piglet diets can affect febrile and inflammatory cell responses of piglets when challenged with E. Coli LPS post-weaning.

When sows consumed an n6:n3 ratio of 1:1, their piglets had elevated body temperatures and a greater response to the immune challenge compared to piglets from sows consuming the other diets. When fed to piglets, a ratio of 5:1 n6:n3 tended to increase production of some inflammatory cells, but did not affect body temperature.

The Bottom Line:

Based on these results we hypothesize that either the n6 fatty acids are not as inflammatory as we originally thought; or alternatively, that there is an 'optimal' n6:n3 ratio in the diet. Going below this 'optimal' ratio, the energy required to generate the immune response takes nutrients away from growth and can actually be a hindrance to piglet productivity and health.

Based on our preliminary results, we can recommend that pork producers include plant based n3 fatty acids such as those found in flaxseed, into the diets of lactating sows or newly weaned piglets, but to ensure that the ratio does not go below 5:1 n6:n3. Further experiments are being conducted to determine the consequences of generating immune responses, and the implications on animal health and performance.

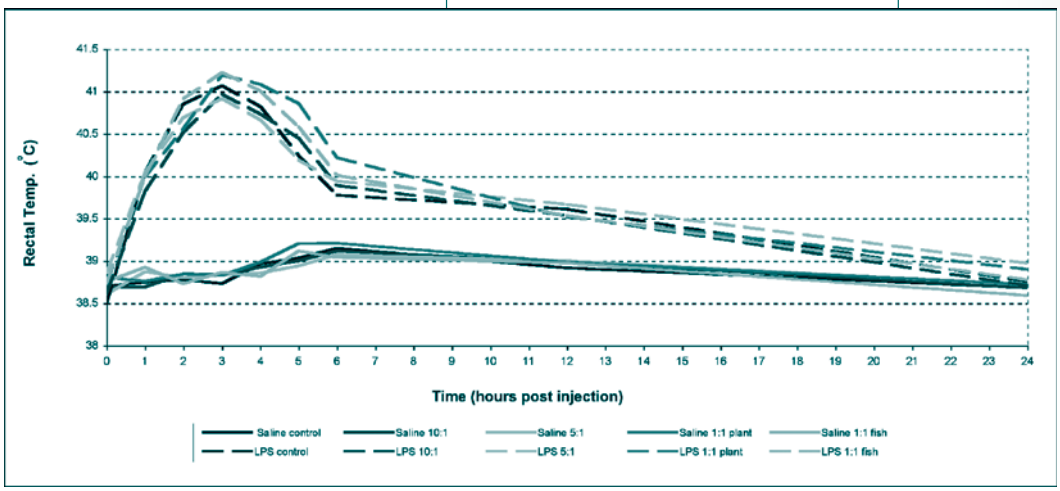

Figure 2: Rectal temperatures of challenged and unchallenged piglets on each dietary treatment group during experiment 2

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