

Immune System Stimulation Increases Nursery Pig Maintenance Energy Requirements

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Summary and Implications

The objective of this experiment was to determine how immune stimulation and β -mannanase supplementation affect nursery pig maintenance energy requirements through changes in serum immune parameters, nutrient digestibility, growth performance, nitrogen and energy balance. While it's well-known that disease negatively impacts pig performance, the specifics of how immune stimulation affects metabolism and causes these negative effects are not clearly understood. This experiment demonstrated that an immune response to *E. coli* LPS did not impact nitrogen balance or nutrient digestibility, but increased total heat production (19%) and maintenance energy requirements (23%), resulting in decreased lipid deposition (-27%) and ADG (-26%). This is the first experiment in pigs to show a direct relationship between immune stimulation, increased energy use for maintenance purposes, and decreased energy partitioned toward growth. Understanding how immune challenges change energy metabolism in the pig may inform more effective feeding strategies to mitigate negative impacts of disease.

Introduction

Disease challenges and immune activation drastically diminish pork production productivity and efficiency by partitioning energy and nutrients away from productive growth. Immune activation occurs when pathogen-associated molecular patterns are detected, such as lipopolysaccharide (LPS) from gram-negative bacteria. However, certain dietary components, such as β -mannan in soybean, copra, and palm kernel meals, mimic carbohydrate structures on pathogen surfaces and can activate the innate immune system, termed a feed-induced immune response (FIR). Few studies have addressed comprehensive changes in energy partitioning during an immune response and clear relationships between measured immune responses and the direction and magnitude of changes in energy partitioning have yet to be elucidated.

Therefore, the objective of this experiment was to determine how immune stimulation and β -mannanase supplementation affect maintenance energy requirements

through changes in serum immune parameters, digestibility, growth performance, nitrogen and energy balance. We hypothesized that LPS immune stimulation would increase maintenance energy requirements by initiating a cytokine-driven febrile response and inflammatory state, and that β -mannanase supplementation would decrease maintenance energy requirements through an energy sparing effect of FIR prevention.

Materials and Methods

In a randomized complete block design, 30 pigs (10.27 \pm 0.15 kg) were assigned to either the control treatment (CON; basal corn, soybean meal and soybean hulls diet), the enzyme treatment (ENZ; basal diet + 0.056% β -mannanase), or the immune system stimulation treatment (ISS; basal diet + 0.056% β -mannanase, challenged with repeated increasing doses of *Escherichia coli* LPS). The experiment consisted of a 10-d adaptation, 5-d digestibility and nitrogen balance measurement, 22 h of heat production (HP) measurements following the final injection, and 12 h of fasting HP measurements in indirect calorimetry chambers. The immune challenge consisted of either LPS (ISS) or sterile saline (CON and ENZ) injections every 48 h, for a total of 4 injections on d 10, 12, 14, and 16. Blood was collected pre- and post-injection for complete blood counts with differential analysis, haptoglobin and mannan-binding lectin, 12 cytokines, and glucose and insulin concentrations. Data were analyzed using the MIXED procedure of SAS (9.4) with blood immune parameters and rectal temperature data analyzed as repeated measures.

Results and Discussion

The ENZ treatment did not differ from CON in growth performance, digestibility, immune parameters, or HP variables ($P \geq 0.10$); thus, results did not support the hypothesis that β -mannanase supplementation resulted in an energy sparing effect by inhibiting a FIR. The ISS treatment induced fever, elevated proinflammatory cytokines (TNF α , IL-6, IL-1 β), and decreased leukocyte concentrations ($P < 0.05$). The ISS treatment did not impact nitrogen balance or nutrient digestibility ($P > 0.10$), but increased total HP (CON = 278.8 vs. ISS = 333.0 kcal·kg BW^{-0.60}·kg DMI⁻¹·d⁻¹; $P = 0.04$) and estimated ME_m by 23.6% ($P = 0.045$). This resulted in decreased lipid deposition (CON = 76.2 vs. ISS = 55.5 g/d; $P = 0.047$) and ADG (CON = 447.1 vs. ISS = 330.7 g/d; $P = 0.01$). Immune stimulation increased energy partitioning to the immune system which limited energy available for lipid deposition and weight gain.

During an immune challenge, pro-inflammatory cytokines initiate a shift in nutrient and energy partitioning

away from tissue growth to support activation and maintenance of an immune response. This experiment clearly demonstrated that a systemic inflammatory response to LPS was induced by pro-inflammatory cytokines and elevated body temperature, increased ME_m , and decreased LD consequently leading to decreased growth in young pigs. Decreased ADG was attributed primarily toward increased ME_m in ISS pigs as opposed to decreased feed intake or effects on nutrient digestibility.

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