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Intestinal environment: Impact on health and performance

Jason Frank, Ph.D.
Director, Nonruminant Research and Technical Support
Diamond V

The intestinal environment is a vital component of overall health in pigs and other animals. A growing field of research explores how management and nutrition dramatically influence this environment and affect intestinal health, which in turn impacts overall pig health and performance.

While intestinal health can be easy to recognize in terms of overall health and performance, it can be very difficult to define. A useful working definition is: An intestinal tract that efficiently digests and absorbs nutrients from the feed and water while excluding pathogenic organisms from infecting the animal. A pig that that achieves and sustains intestinal health is more likely to reach its genetic potential for growth and efficiency.

The intestinal environment consists of three major areas, including the structure and function of enterocytes (gut epithelial cells), the intestinal immune system, and the microbiota. Research shows that these components interact to affect health and performance.

Enterocytes – gut epithelial cells

Enterocyte structure and function includes villus length, crypth depth, secretions of the digestion process, tight junction complexes, and the mucous layer. The various folds and loops of the intestinal tract not only serve to increase the overall surface area for nutrient digestion and absorption, but also create areas for bacteria colonization. In addition, bacteria can interact with enterocytes and immune cells in the mucous layer. The mucous layer serves as a filter, creating a matrix that helps control pathogen interaction with the host animal. The mucous layer aids in controlling colonization and even translocation of bacteria

through the tight junctions between enteroctyes that form the epithelial layer (Maynard et al., 2012; Pelasyed et al., 2014).

Interestingly, the mucous layer can also serve as a nutrient source for some bacteria species. The tight junctions that form between enterocytes maintain the integrity of the epithelial layer and prevent bacteria and other antigens from freely crossing the epithelium and stimulating an immune response (Coskun, 2014).

Intestinal immune system

An estimated 70% of an animal's immune cells are located in the intestinal tract (Brandtzaeg et al., 1989). These cells and tissues include dendritic cells, T- and B-lymphocytes, Paneth cells, macrophages, neutrophils, Peyer's patches, and lymph nodes. Some of these cells can actually migrate throughout the body and return to the local mucosa thereby providing systemic immunity. This concept is known as a common mucosal immune system (Wilson and Obradovic, 2015).

Dentritic cells and Peyer's patches have mechanisms to sample commensal and pathogenic bacteria and present these bacteria to other immune cells in the lamina propria or mucous membranes and lymph nodes. Recognition of these bacteria by special receptors encoded in the animal's DNA, known as pattern recognition receptors, helps the immune system develop specific responses that range from helping maintain intestinal integrity to causing inflammation and permeability.

Neutrophils are a type of white blood cell common in the intestinal tract and essential to the innate immune system. When they encounter bacteria, they can respond by producing enzymes and reactive oxygen intermediates to kill pathogens. Under more severe challenges, these enzymes and reactive oxygen intermediates can be secreted from neutrophils causing collateral damage to host cells, which results in inflammation. Intestinal inflammation is associated with damage to the intestinal villi and a subsequent reduction in nutrient absorption. If the inflammation process extends systemically, animals have reduced feed intake and a significant repartitioning of nutrients away from growth toward the immune response.

The production and secretion of antimicrobial peptides and secretory immunoglobulin A – secretory IgA, a mucosal immunity antibody – are two other responses used by the mucosal immune system to help maintain intestinal integrity. Antimicrobial peptides function to kill bacteria that come into close contact with epithelial cells while secretory IgA can bind to bacteria, inactivating them and preventing their attachment to epithelial cells. These responses reduce colonization of pathogenic bacteria and therefore limit or even prevent intestinal damage and infection.

Intestinal microbiota

The intestinal microbiota has been estimated to consist of more than 10 times as many bacteria cells as host animal cells. Human clinical research and basic research in rodents have demonstrated the power these bacteria have in affecting health, metabolism, and even behavior (Hsiao et al., 2013; Ridaura et al., 2013).

The number of bacteria greatly increases from the oral cavity and stomach to the cecum and colon, while also changing as the animal develops from a neonate to an adult (Zhao et al., 2015). Most of these bacteria are commensal, or non-pathogenic. Commensal bacteria play an important role in the development of the intestinal immune system and limit the ability of pathogenic bacteria to colonize the intestinal tract. These mechanisms include the stimulation of epithelial and immune cells to produce mucous, secretory IgA, antimicrobial peptides, and enzymes.

Also, commensal bacteria in the intestinal tract produce short chain fatty acids (also known as volatile fatty acids) that contribute to the dietary energy available to the animal. Butyrate in particular has a positive impact on intestinal health. This short chain fatty acid can be used by enterocytes as an energy source. Butyrate also reduces inflammation by stimulating interleukin-10 production and reduces the virulence of pathogenic bacteria such as *Salmonella* (Gantois et al., 2006).

There is still much to discover about the intestinal microbiota. Many beneficial bacteria are known, but the dynamics of the entire bacterial community's interactions with host cells need further exploration.

Toward optimal intestinal health

The intestinal environment is a very complex system and includes the structure and function of enterocytes, the intestinal immune system, and the microbiota. These components all interact to affect intestinal health. Although some of these interactions are defined, there remains much to discover.

The goal is understanding how to help the animal achieve and sustain an intestinal environment that efficiently digests and absorbs nutrients while excluding pathogenic organisms from colonizing and causing illness. There is little doubt that reaching this goal is going to improve health and performance in pigs and other animals.

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