Endotoxins and the rule of bentonite in animal nutrition

What is Endotoxicin?

Endotoxin, also referred to as lipopolysaccharide (LPS), can stimulate localized or systemic inflammation via the activation of pattern recognition receptors. Lipopolysaccharide is a glycolipid present in the outer membrane of gram-negative bacterial cell wall. The gastrointestinal tract is a large reservoir of both gram-positive and gram-negative bacteria, of which the gram-negative bacteria serve as a source of endotoxin. Luminal endotoxin can enter circulation via two routes: 1) nonspecific paracellular transport through epithelial cell tight junctions, and 2) transcellular transport through lipid raft membrane domains involving receptor-mediated endocytosis. Paracellular transport of endotoxin occurs through dissociation of tight junction protein complexes resulting in reduced intestinal barrier integrity, which can be a result of enteric disease, inflammation, or environmental and metabolic stress. Transcellular transport, via specialized membrane regions rich in glycolipids, sphingolipids, cholesterol, and saturated fatty acids, is a result of raft recruitment of endotoxin-related signalling proteins leading to endotoxin signalling and endocytosis.

Endotoxin is released during bacterial death and during growth and division, making it an ubiquitous contaminant. Endotoxin can enter systemic circulation from live bacteria, leading to septicemia, or as cell wall components of dead bacteria. Either way, if the amounts are too great, they can ultimately antagonize anabolic growth, lead to septic shock and death. The biological activity of the endotoxin is measured in endotoxin units (EU). For example, 100 pg of endotoxin is considered to have 1 EU.

Effects of Endotoxin on Animal

A leaky intestinal epithelial barrier allows luminal commensal organism components to enter the submucosa and stimulate the immune system. The dendritic cells, through their pattern recognition receptor, recognize these commensal constituents as pathogen components and initiate the differentiation of T cells and natural killer cells. The immune cells can also be activated by their own pattern recognition receptors. This leads to the secretion of regulatory cytokines by T cells, which in turn stimulate the secretion of TNF-α, IL-1, and IL-6 by macrophages. Natural killer cells also play an active role by secreting cytokines as well as causing tissue damage.

The interplay of all these immune cells, endotoxin, and cytokines secretion can augment the inflammatory state of the intestine. During an inflammatory response, the nutrient partitioning is redirected toward meeting the metabolic requirements of the immune system. Inflammation is associated with increase in body temperature; an increase of 1°C equates to a 13% increase in the basal metabolism. The increase in the concentrations of proinflammatory cytokines such as TNF-α and IL-1β have been shown to decrease feed
consumption, rates of BW gain, and efficiency of feed utilization. Thus, endotoxin-associated inflammation results in an estimated 30% increase in energetic costs and leads to a significant negative nitrogen balance because of protein breakdown and decreased BW gain. Further, multiple immune challenges occurring simultaneously lead to a cumulative reduction in performance.

In the gastrointestinal tract, endotoxins are potent immune stimulators, which in healthy animals are removed from the gut via the reticuloendothelial system. If there is a failure in endotoxin deactivation, e.g. in cases of stress in animals, circulating endotoxin can lead to systemic inflammation, endotoxemia, shock and even death.

**Bentonite as Endotoxin adsorbent**

Smectites, in particular montmorillonites, can absorb large organic molecules, polymers and large complex ions that allow them to bind mycotoxins, heavy metals, bacteria, and viruses. Montmorillonite is the major constituent of bentonites which are found in nature and used as a feed supplement for animals. Both sodium and calcium bentonite were used for the production of animal feed pellets for many years. Bentonite is not only an effective binding agent but also an adsorbent of pathogenic microorganisms, enzymes and toxins and thus improves the growth and health of the animals. The total ration is usually supplemented with 2 to 3% of bentonite. Furthermore, the effectiveness of adsorption depends on the structure of the adsorbed molecules and their ability to penetrate into the interlayer space of smectites. Clay minerals of other structural groups (kaolinite, palygorskite, etc.) are unlikely to be effective adsorbents of aflatoxin because they lack exchangeable cations, high specific surface area and show no (palygorskite) or only reduced intercalation ability (kaolinite) compared with smectites.

Increasing attention has been given to detoxication of various toxins by smectites. Inactivation of viruses and bacteria by adsorption has also been attempted, suggesting unlimited potential of clay minerals in prevention of virus infection as well as bacterial contamination.

High adsorbent capability of smectite minerals have found wide-range applications not only in industry, but also as excellent adsorptive materials of heavy metals, toxic and antinutritive agents.

There are several products containing clay mineral(s) available in the market, targeting mainly mycotoxins. Products containing bentonite (smectites, montmorillonites) also have proven capability to bind with luminal endotoxins. All the products containing clay minerals are not similar in composition or function. Users need to select the right product carefully according to their requirements.
References:


