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Technical Forum

The Effects of Xylanase on Poultry Gut Health

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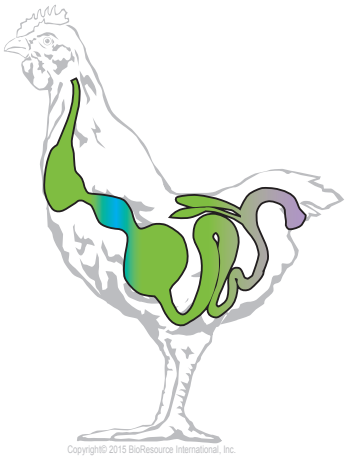
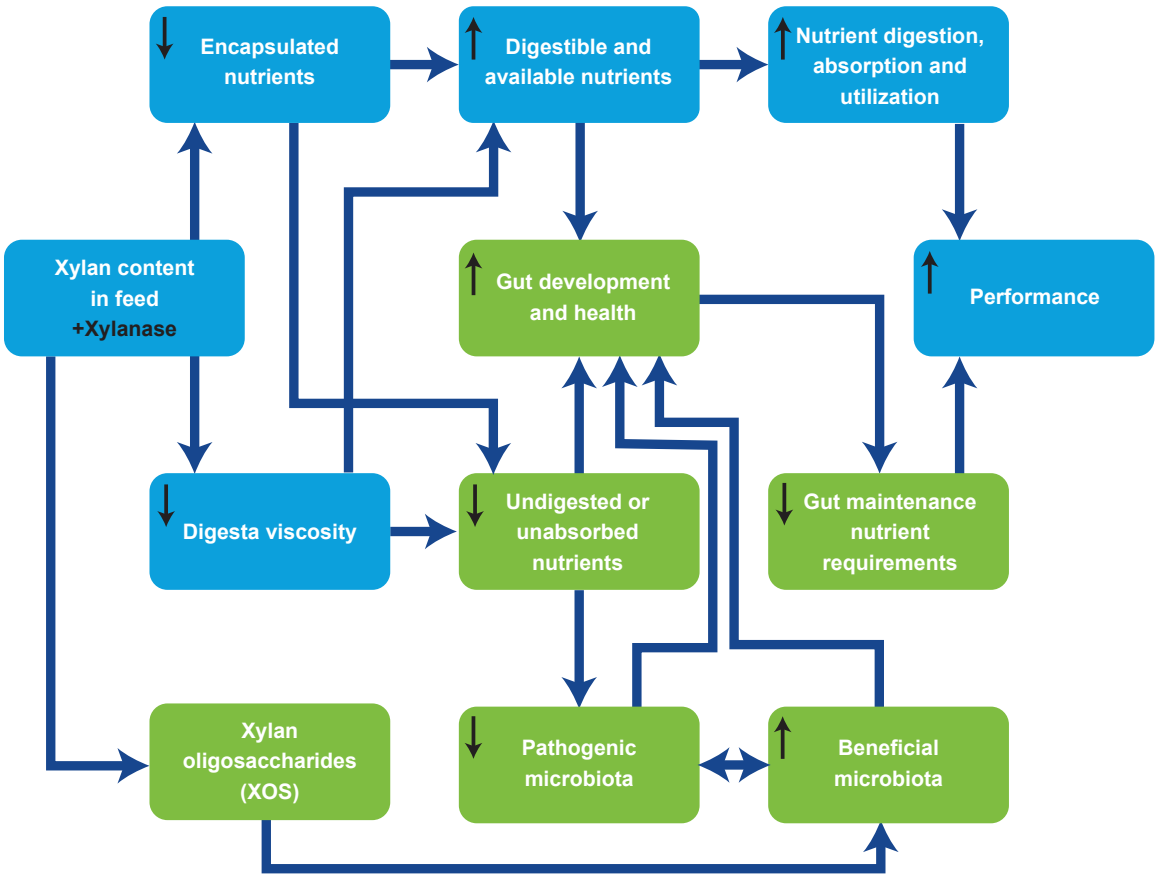
Given the increasing pressure to limit the use of antibiotic growth promoters in animal production, the availability of alternative approaches to maintaining animal health and productivity becomes imperative for the poultry industry. Essential in evaluating such an alternative is its ability to promote and maintain gut health, which can be measured by 1) gut integrity and morphology, 2) intestinal microbiota, and 3) impact on immune responses, such as inflammation and oxidative stress. An unhealthy gut is often associated with reduced villus height, elevated levels of pathogenic bacteria in the intestine, excessive mucin secretion, and persistent inflammation, which lead to reduced feed intake, poor feed conversion, and mortality.



Introduction

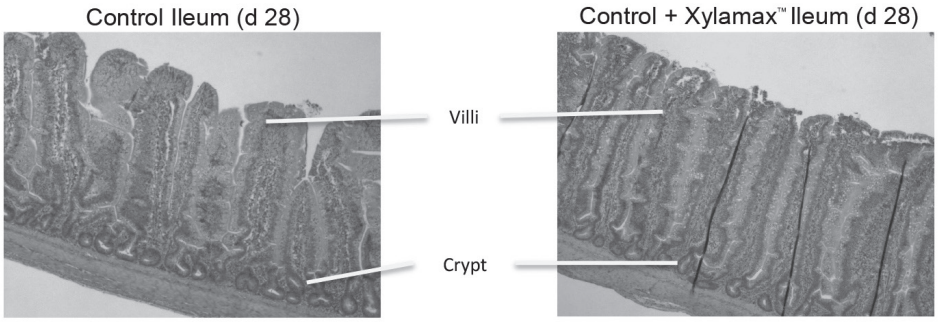
Recent development and applications of feed enzymes, such as phytase, protease, and xylanase, as well as advancements in immunology and biotechnology, have enabled scientists to better understand the impact of enzymes on gut health, nutrient digestibility and animal performance. While xylanases' ability to improve digestibility of plant-based feed ingredients and to reduce digesta viscosity is well-accepted, their impact on gut health and the intestinal environment is still an active area of scientific research. In this article, we discuss some of the benefits of using feed enzymes, xylanase specifically, to promote gut health in poultry production.

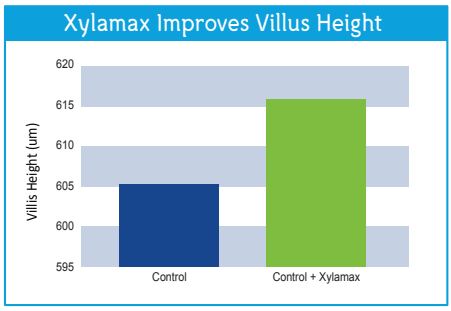


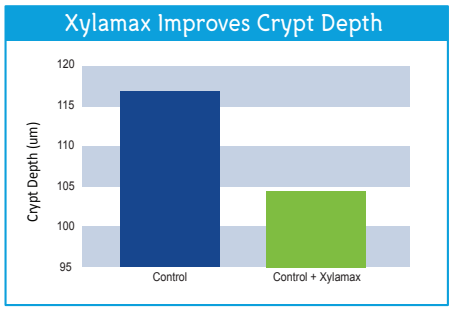
Xylanase impact on gut mucosal morphology

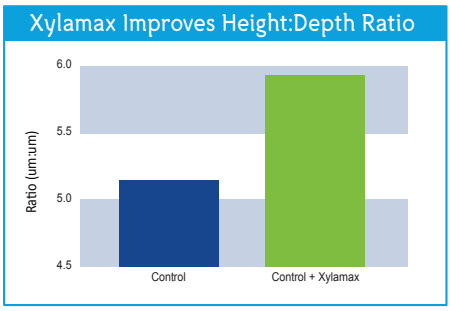
Intestinal mucosa is comprised of a layer of connective tissue (lamina propria) and epithelial cells originating from stem cells that differentiate into either absorptive enterocytes or one of a number of secretory cells, including goblets. Villi, the tiny protrusions lining the surface of the mucosa, are covered by these epithelial cells. In the unhealthy gut, villus height may be shortened, reducing the overall surface area and leading to reduced absorptive capacity of the animal. Muscularity of the small intestine may also be compromised, which can lead to reduced gut motility and accumulation of toxins in the lumen. Other indicators of poor gut health can include excessive fluid in intestinal contents and discoloration (darkening) of the tissues as a sign of inflammation.

The growth-promoting effects of xylanases appear to be partially related to their indirect impact on mucosal morphology of the small intestine of birds. In the intestine, undigested NSPs, including arabinoxylans, stimulate the proliferation of pathogenic bacteria and serve as substrate for their fermentation processes. The associated pathogen-induced inflammatory response can hinder morphological development in the intestine and lead to high turn-over of gut epithelial cells (partially due to sloughing and replenishing of cells at the villus tips). This leads to reduced absorption of nutrients and a diversion of energy away from productive growth towards maintenance of the gut itself. The net effect on the animal is reduced growth performance and feed efficiency. Xylanases reduce nutrient availability for pathogens, thereby indirectly helping to protect mucosal morphology and absorptive capacity of the intestine.



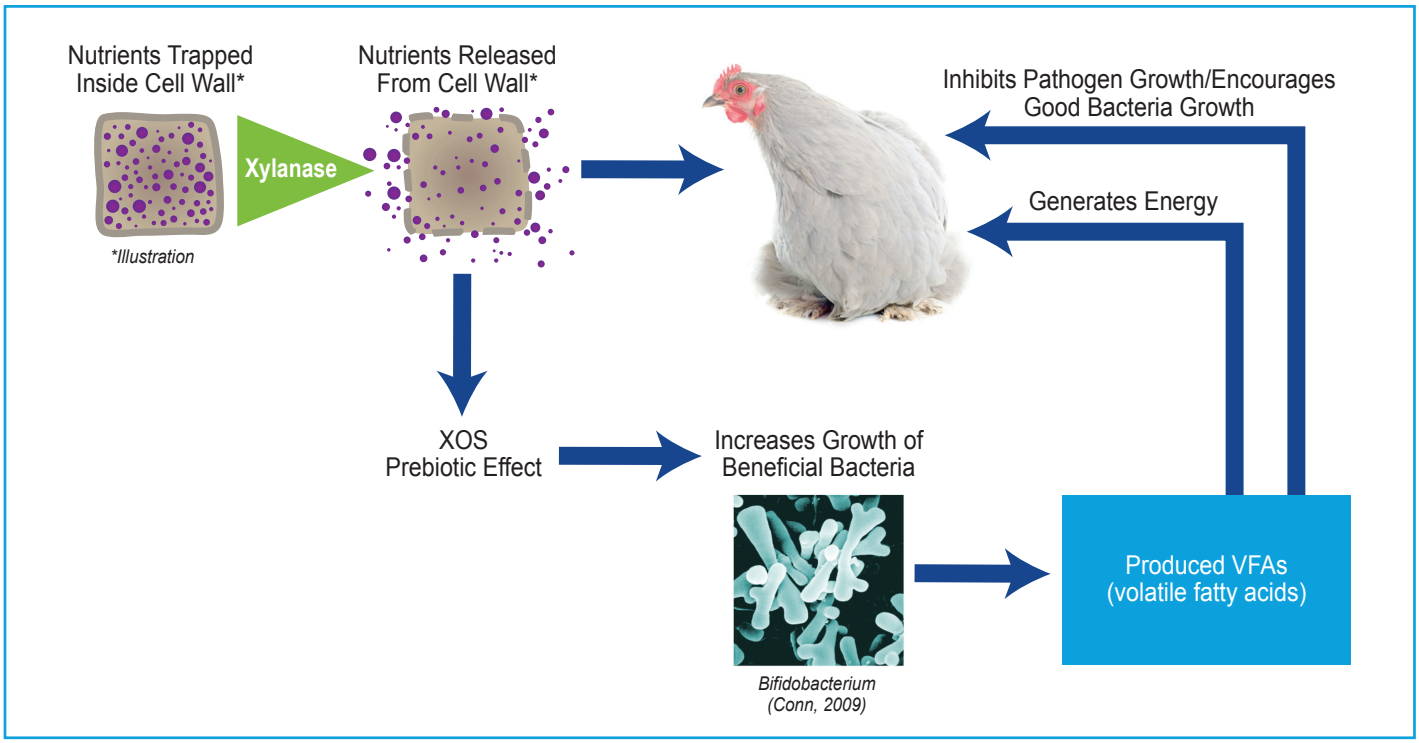






Xylanase reduces nutrient availability for cecal pathogens

Aside from being the major organ for nutrient digestion and absorption, the gut is the largest immune organ of the body. It protects the body against pathogens which try to colonize host cells and tissues. Anything that affects the gut health will consequently affect nutrient digestion and absorption. Pathogens that colonize the ceca could spread out of the ceca into the intestine when they have the suitable conditions and nutrients. Nutrients entrapped within plant cell wall structures are not efficiently digested and absorbed in the foregut of monogastrics and often pass to the hindgut where they promote proliferation of harmful bacteria. Xylanases have been shown to reduce the nutrient encapsulating effect of cell walls which makes cell components more accessible to endogenous and exogenous enzymes and acids, which in turn could result in an increase in starch, protein and other nutrients utilization. This more complete digestion in the small intestine, also reduces the amount of nutrients available for pathogenic bacteria present in the hindgut. Stated slightly differently, xylanases improve energy utilization in the foregut, and increase feed passage rate, reducing nutrient availability for pathogenic bacteria in the hindgut, thereby limiting the risk of proliferation of potentially pathogenic bacteria.

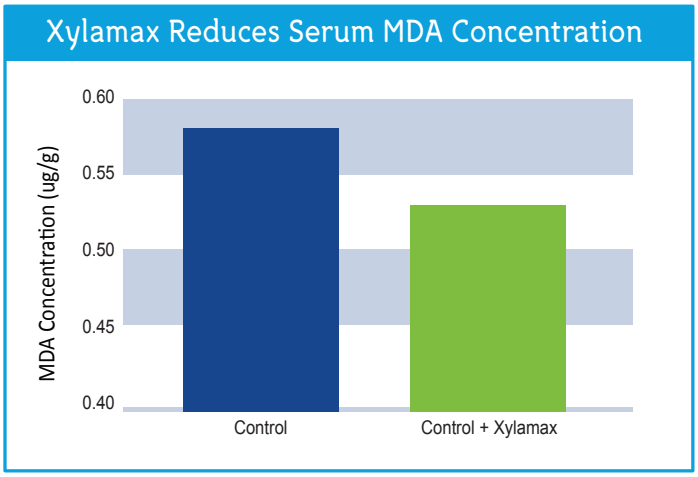


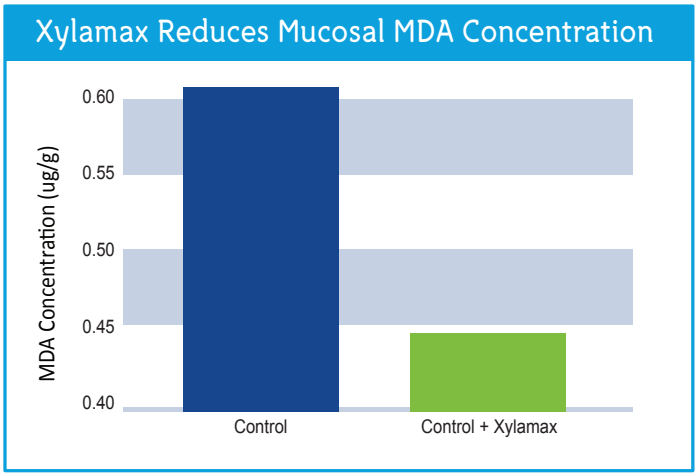
Xylanase creates a prebotic effect

It is generally accepted that a proper bacterial balance between the number of beneficial bacteria and pathogenic bacteria in the intestine is vital for the host. Thus, the negative impact on gut health often comes from a microbial imbalance in the gut of the chicken. Xylanase not only reduces digesta viscosity through the hydrolysis of soluble arabinoxylans in the small intestine; but, this process can also improve gut health by generating xylo-oligosaccharides (XOS), which are fermented, particularly in the foregut. These have a prebiotic effect that selectively stimulates the growth of beneficial gram-positive bacteria in the foregut such as Bifidobacterium and Lactobacillus, improving gut health. The gut health-related effects of XOS's in poultry are well documented in chickens and XOS's have been shown to reduce Salmonella in the bird's caeca, cloaca and spleen. Additionally, through fermentation, these beneficial microflora also produce volatile fatty acids, which have a beneficial impact by decreasing populations of Salmonella, and possibly Campylobacter. These VFAs can also be utilized as an energy source by the bird, thus further enhancing the benefits of xylanase supplementation.

Xylanase reduces oxidative stress in the gut

Oxidative stress, defined as an imbalance between the production of free radicals and their neutralization by antioxidants, can have many deleterious effects in the intestine, including tissue damage and necrosis. Recent animal studies have demonstrated that measuring biomarkers for oxidative stress can be an effective tool for assessing the health of the gut. For example, in instances of inflammation-associated lipid peroxidation in cellular membranes, malondialdehyde (MDA) is produced and is measurable by immunosorbent assays. Similarly, carbonylation of proteins due to oxidative stress can be measured by the presence of protein carbonyl groups. Increases in these biomarkers has been correlated with suppressed gut morphology development, reduced growth performance and poorer feed efficiency in broilers. Recently, xylanase supplementation has been shown to reduce MDA and protein carbonyl in the ileal mucosa of broilers, possibly by minimizing the proliferation of pathogens and thereby reducing pathogen-induced inflammation in those birds.





Xylanase reduces mucin secretion

Mucin is an excellent nutrient source for some pathogenic bacteria such as E. coli and Clostridium perfringens. Mucin is also rich in the amino acids threonine, proline and serine, therefore, the increased secretion of mucin adds to endogenous nitrogen losses.
Excessive NSPs, especially soluble fractions, may lead to the proliferation of undesirable bacteria in the hindgut, causing inflammation of the intestinal mucosa. This enteric inflammation activates the innate immune system, leading to stimulation of intestinal mucous secretion by the goblet cells, which costs the bird energy.

Conclusion

In summary, gut health involves complex interactions among nutrients, the host immune system, and gut microbiota. Research has shown that xylanases can reduce the adverse effects of anti-nutritional factors in feeds, facilitate the development of healthy gut microbiota, and maintain optimal gut function and integrity. With continued research and development, we expect to see more feed enzymes, such as xylanases, to be integrated in animal production not only to improve nutrient and energy digestibility but also as a cost-effective tool to manage gut health.

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