

Training bacteria to degrade fiber: New nutritional strategy

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FIBER has become a renewed topic of interest with respect to gut health and animal performance as the U.S. moves toward antibiotic-free production. Fiber, however, is a broad term and encompasses many components, as recently discussed in the article “Demystifying Fiber: Understand Role in Monogastric Nutrition” (Van Wyhe and Santos, 2019).

Although the composition of cell wall fiber fractions differ, some are more digestible than others. The indigestible fiber fractions are often referred to as non-starch polysaccharides (NSPs), and a wealth of data exists demonstrating their anti-nutritive properties in poultry diets (Bedford et al., 1991; Bedford and Classen, 1992; Choct and Annison, 1992).

However, the literature also contains numerous published articles demonstrating the improvements in animal performance observed since the introduction of NSP enzymes. These enzymes breakdown arabinoxylan into xylo-oligosaccharides (XOS), smaller carbohydrate fragments that are fermented by bacteria. The fermentation of XOS is believed to prompt changes within the microbiome of the gastrointestinal tract, leading to improved animal performance through the produc-

tion of short-chain fatty acids (SCFAs).

Past research has suggested that bird performance may be correlated with microflora and the metabolites they produce (Rinttila and Apajalahti, 2013), but as our knowledge of fiber and NSP enzymes has evolved, it seems like we may finally be able to utilize fiber to the benefit of the animal by training the microbiome and igniting its fermentation capabilities.

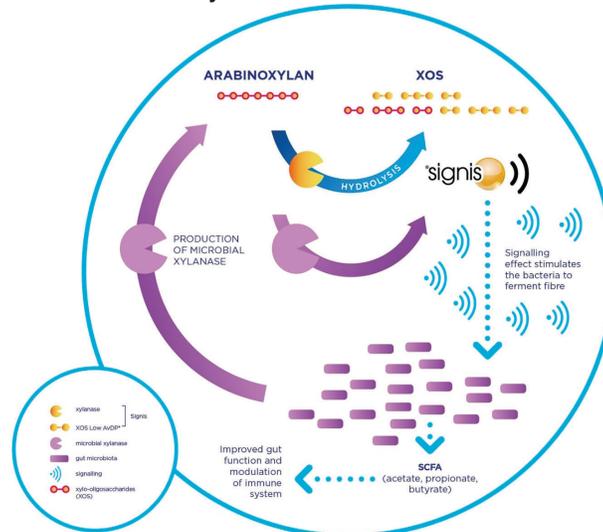
diets for almost 40 years to improve nutrient absorption, with the primary focus on fat, allowing for reduced dietary costs. During this time, our understanding of how they work has evolved.

A recent paper by Bedford (2018) discussed the three principal modes of action suggested for NSP enzymes: viscosity reduction, cell wall destruction and generation of prebiotics. Within this review, he proposed an adaptation to the prebiotic hypothesis such that NSP enzymes are not producing prebiotics *per se* but sending signals to the microbiome to develop its fiber-

Fiber benefits

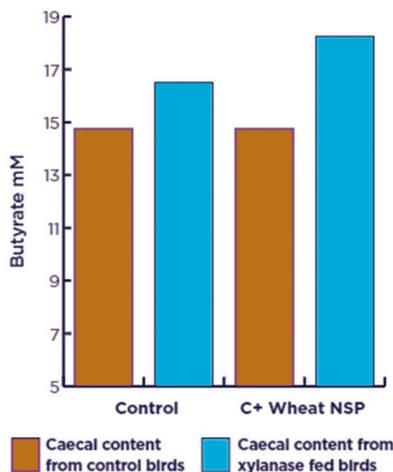
NSP enzymes have been used in poultry

2. Dual-action effect of combination product containing XOS and xylanase on fiber fermentation



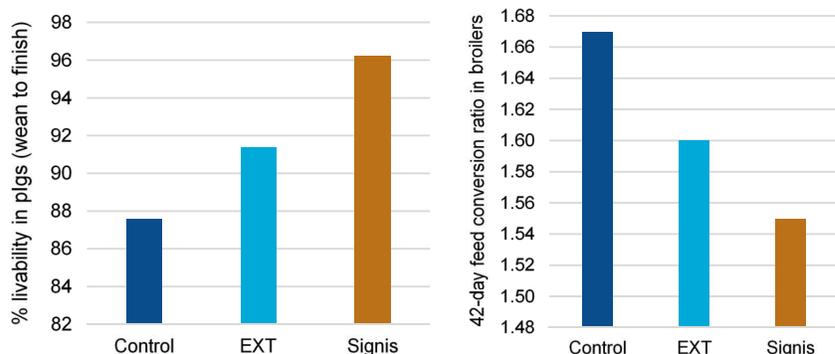
Source: AB Vista.

1. Cecal contents from birds fed diets with xylanase and used as inoculum resulted in increase in butyrate production versus control



Source: Bedford and Apajalahti, 2018.

3. Improvements in pig livability and 42-day poultry feed conversion when fed dual-action enzyme product (Signis) containing XOS and xylanase (EXT)



Source: AB Vista, internal data.

degrading ability. As the NSP substrate is broken down into smaller xylo-oligosaccharide fragments, the bacteria can utilize the substrate more effectively, leading to increased cecal fermentation (Masey O'Neil et al., 2014).

Bedford proposed that it may be the fermentation of dietary fiber rather than the oligosaccharides generated by the enzyme that provides the additional energy to the bird and feedback to the gizzard that allows the gizzard to grind more efficiently, resulting in improved nutrient digestion. It is believed that the generation of XOS leads to a shift in the microbiome toward butyrate-producing bacteria.

Although most microbes in the gut of chickens are unknown, approximately 75% come from the species belonging to the phyla *Firmicutes*. The major species within this phylum belong to the families *Ruminococcaceae* and *Lachnospiraceae*, also known as the Clostridium Cluster IV and XIVa, both of which are known to produce butyrate as a fermentation end product (De Maesschalck et al., 2015).

These same researchers recently demonstrated that when 26-day-old chickens were fed diets with or without XOS supplementation, an increase in Clostridium Cluster XIVa, along with other bacteria, was found in the ceca, which corresponded with an increase in butyrate production.

Signaling the microbiome

Although it has been previously suggested that the bird and its microflora are fundamentally linked, our new understanding of fiber breakdown into XOS and the benefits XOS plays in inducing changes within the microbiome of the

gastrointestinal tract only supports the significance of this link. The benefits of XOS reported in the literature on animal performance, however, have been shown when feeding XOS directly as a feed additive and at much higher levels than would be produced by the addition of an NSP enzyme alone (De Maesschalck et al., 2015; Liu et al., 2018).

In the study by De Maesschalck et al., the improvements observed on bird performance when feeding XOS were suggested as a result of stimulating butyrate-producing bacteria through cross-feeding lactate and the beneficial effects of butyrate on gastrointestinal function. Microbial populations within the gastrointestinal tract of the animal change over time, with a more specialized fiber-fermenting population evolving as the animal ages.

Although the levels of SCFAs are quite low in the intestine and ceca of younger birds (van der Wielen, 2000; Lee et al., 2017), the ability to possibly signal or train the microbiome to become more efficient at degrading fiber and producing SCFAs earlier may provide even greater benefits.

A recent study (Bedford and Apajalahti, 2018) suggested that the bacteria can be trained to begin fermentation earlier (Figure 1). Researchers in this study asked whether an animal was pre-exposed to an NSP enzyme and if that changes the ability of the cecal microbiome to digest fiber later. Chickens were fed a control diet with no enzyme or a diet containing a xylanase enzyme for 35 days. On day 35, birds were sacrificed, and their ceca and microbiome contents were collected. The microbes were then exposed to a variety of inoculants.

What they found was that the mi-

crobiome from birds pre-exposed to a xylanase enzyme showed not only an improvement in gas production but an increase in the production of butyrate compared to the non-exposed control treatment (Figure 1). These data suggest that the microbiome was trained and ready to ferment xylan more effectively due to prior exposure.

Complementary dual action

Over the last several years, AB Vista has been conducting research studies to determine what drives the microbiome's ability to degrade fiber and whether that knowledge can be optimized to make it even more efficient.

This research has led to the development of a novel dual-action product. Research conducted with this new product suggests that the butyrate-producing bacteria are able to be signaled to up-regulate their ability to degrade fiber and begin producing their own enzymes for enhanced fiber degradation as well as SCFA production.

The dual action of improving fiber solubility and nutrient absorption occurs through a series of events, as shown in Figure 2. Additional benefits gained with the production of SCFAs, such as butyrate and its reported benefits on gastrointestinal health (Brons et al., 2002) and the impact of slowing gastric emptying, have led to improvements in animal livability and performance in pigs and poultry (Figure 3).

References

The complete list of references can be obtained from nam@abvista.com. ■