

## The Role of Feed Enzymes in Swine Feeding Programs

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There has been a tremendous increase in interest and use of various types of dietary enzymes in swine diets to improve nutrient digestibility in recent years. Enzymes are biologically active proteins that break specific chemical bonds to release nutrients for further digestion and absorption. Enzymes that breakdown proteins are called proteases, lipases breakdown fats, and there are several carbohydrases that breakdown carbohydrates to allow them to be better digested and absorbed as energy sources. The most widely used enzyme in the U.S. has been phytase, an enzyme which improves phosphorus digestibility in a wide variety of plant-based feed ingredients such as corn and soybean meal. The chemical characteristics of plant-based feed ingredients are very diverse (Table 1), and the effectiveness of commercial enzymes and enzyme mixtures depends partly on how well they are matched to the specific chemical characteristics of the ingredients used in swine diets. For example, the amount of non-starch polysaccharides (complex carbohydrates that make up fiber and are relatively undigestible in pigs) can range from 10 to 37%

**Table 1. Concentrations of starch (and sugars), non-starch polysaccharides, protein, and fat in selected feed ingredients (as-is basis).**

<b>Ingredient</b>	<b>Starch, %</b>	<b>Non-starch polysaccharides, %</b>	<b>Protein, %</b>	<b>Fat, %</b>
Wheat middlings	25	37	16	4
Oats	39	31	11	5
Barley	54	18	11	2
Soybean meal	14	17	47	2
Field peas	47	14	23	1
Wheat	61	10	12	2
Corn	63	10	9	4

Adapted from Zijlstra (2004), Proceedings from the Carolina Nutrition Conference.

Fiber can be defined as a nutritional fraction that is resistant to digestion by the pig's digestive enzymes. By this definition, cellulose, hemicellulose, lignin, pectins, and  $\beta$ -glucans are the major components of fiber. Cellulose is a complex carbohydrate made up of glucose linked by  $\beta$ -1,4 glycosidic bonds which cannot be broken by the digestive enzymes in the small intestine of the pig. Hemicellulose is found in high concentrations in the cell walls of plants, is associated with cellulose and pectin, and consists of several

non-starch, non-cellulosic polysaccharides including arabinoxylans, glucomannans and galactans. Fiber has been considered to be an anti-nutritional factor for young pigs because it can decrease nutrient digestion, especially protein, amino acids, and minerals. It can also increase the rate of stomach emptying and withhold nutrients from absorption. The increased use of corn for fuel ethanol production, and the increased use of fats and oils for biodiesel production of biodiesel is contributing to increased amounts of low energy and high fiber by-products for animal feeds. Pigs can only moderately utilize fiber for energy, unlike cattle which can utilize fiber extremely well to meet their energy needs. Therefore, in order to improve the energy value of fiber in swine diets, effective commercial enzyme products need to be added to match the carbohydrate composition of corn, soybean meal, and dried distiller's grains with solubles as shown in Table 2. Compared to corn and soybean meal, DDGS contains a significant amount of fiber which may play a significant role in decreasing dry matter (DM) digestibility of the diet. The main components of fiber in the DDGS are cellulose and insoluble arabinoxylans, similar to fiber in corn. Substituting 25% DDGS for corn and soybean meal in a young pig diet will increase the dietary fiber from 14% to 19%.

The addition of dietary enzymes to swine diets in efforts to improve nutrient digestibility has been researched for decades. However, the majority of commercial enzyme products have been targeted toward poultry diets and have typically been added to diets containing barley, oats, peas, rye, or wheat, although some studies have evaluated their use in corn-soybean meal diets. The most common fiber-degrading enzymes that have been supplemented in pig and poultry diets are  $\beta$ -glucanase, xylanase, and cellulases. In general, fiber-degrading enzymes may have several modes of action: (1) partial hydrolysis of soluble and insoluble fiber, (2) decrease in digesta viscosity to improve lower gut microbial fermentation and energy value, (3) rupturing of fiber-containing cell walls, thereby making the contents available for digestion, and (4) cause shifts in the population and activities of intestinal microflora.

Several studies have shown that when wheat and hull-less barley-based diets are fed to young pigs (< 55 lbs in body weight), responses to non-starch polysaccharide degrading enzymes are positive and consistent, where digestibility of protein and energy and pig performance are improved. For growing-finishing pigs (> 55 lbs in body weight), research results have shown a declining response to enzyme supplementation in wheat or barley-based diets as the pig gets older. Data from several studies range from no response from dietary enzyme supplementation to studies where there is a clear, significant improvement in nutrient digestibility and/or growth performance. However, a significant and positive effect on protein digestibility and numerical improvements in energy has been observed after dietary enzyme addition in some trials even when there was no growth performance response.

For corn-based diets, relatively few studies have been conducted to determine the effects of adding dietary enzymes on nutrient digestibility. Results from one study showed no

significant effect on protein and energy digestibility when adding  $\beta$ -glucanase to simple corn-soybean meal diets for weaned pigs. Similar results were obtained in another study where adding multiple enzymes (cellulase, hemicellulase, xylanase, amylase,  $\alpha$ -galactosidase) to diets for growing pigs (> 95 lbs in body weight). However, when corn-soybean meal-based diets contained 20% wheat or wheat middlings/bran, significant benefits to xylanase supplementation on growth rate and/or feed conversion in growing/finishing pigs have been observed. More recently, researchers at JBS United in Sheridan, IN reported that adding an enzyme preparation to diets containing 30% DDGS increased growth performance in nursery pigs. Whether dietary enzyme additions will enhance growth performance in growing-finishing pig diets containing increased levels of corn fiber is unknown. Research is underway to evaluate the effectiveness of various commercial enzyme products on improving the energy value of high fiber corn-based by-products for swine.

In general, the use of exogenous enzymes to degrade indigestible dietary fiber has yielded inconsistent results. Possible reasons for these inconsistent responses are:

- (1) Different grains and grain by-products have different dietary fiber (substrate of enzyme) composition and content. For instance, wheat and rye, are rich in arabinoxyloses, whereas barley is rich in  $\beta$ -glucan. Corn has a much lower fiber content than barley and wheat. As a result, the response to supplemental enzymes is small in simple corn-soybean meal diets. However, if corn-soybean meal diets are supplemented with high fiber by-products, which contain significant quantities of insoluble cell wall material, the potential for a response to an effective enzyme source (particularly xylanase) is increased considerably.
- (2) Potential responses to enzymes will be greater in the younger pigs because daily energy and amino acid intake, often limits the ability of the pig to achieve its lean gain potential, and poor nutrient utilization has been partially attributed to the immaturity of the digestive system including the breakdown of fiber.

Overall, the response to enzyme supplementation is greatest when feeding poor quality (high fiber) ingredients to young pigs.

**Table 2. Carbohydrate composition of fiber in corn, soybean meal, and corn dried distiller's grains with solubles (dry matter basis, g/kg).**

	<b>Lignin</b>	<b>Uronic acid</b>	<b>Rhamnose</b>	<b>Frurose</b>	<b>Arabinose</b>	<b>Xylan</b>	<b>Mannose</b>	<b>Galactose</b>	<b>Cellulose</b>	<b>Dietary fiber</b>
Corn	23	10	0	0	15	24	4	6	38	120
Soybean meal	39	34	3	4	19	14	11	48	40	212
DDGS	32	16	1	0	50	76	19	48	85	327

Source: Dr. Hans Jung, University of Minnesota.