Opening up the potential of pig feed with the use of enzymes

by Arne Korsbak, Market Development Manager, Feed Enzymes and Rene Bonekamp, Swine Specialist EMEA, DSM.

Many feed ingredients contain indigestible or poorly digestible components. These can be surrounded by a layer, or layers, that block access to important nutrients and are therefore known as Anti-Nutritional Factors (ANFs). Examples of such ANFs in swine feed are arabinoxylan, trypsin, lectin, Bowman-Birk inhibitors, mannans, and phytate. One way to combat their negative effects is to include feed enzymes in the pig's diet.

Improved feed efficiency

In general, the limiting factor for pigs is their ability to utilise the nutrients from the ingredients incorporated in the feed. Any inefficient digestion by the animal directly translates into increased costs for the farmer and food companies, greater impact on the environment, and ultimately, a higher price for the consumer to pay. Among all the biotechnological additives available to improve feed utilisation, feed enzymes have had the most impact on monogastric feeding in recent years.

The use of feed enzymes appears to be one of the most promising answers to the economic and environmental challenges faced by the feed industry. Many different animal feeds can be utilised more efficiently with the supplementation of enzymes, leading to improved animal health and production and a better financial result for the farmer.

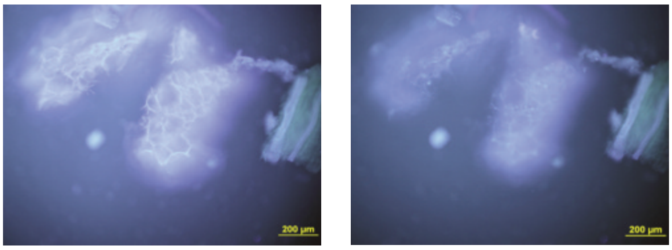

Fig. 1. The degradation of cell walls in corn by Ronozyme WX after 0 minutes and 120 minutes.

Enzymes are biological substances that accelerate (catalyse) the rates of chemical reactions by a factor of a million or more, without being changed themselves. They act on specific substrates for example beta-glucanase, which acts on the beta-glucans found in barley, rye, oats and many other raw materials.

When feed enzymes are added to the diet, they are able to break down problematic components. Consequently, more nutrients become available for use by the animal. As a result, some feed ingredients that have previously been used less frequently or at low inclusion levels acquire more nutritional value and can be used at much higher inclusion rates. As a consequence, other expensive feedstuffs such as high quality protein sources, fat and inorganic phosphates are needed in lower quantities or are indeed entirely superfluous.

Table 1. Analysis of cereal NSP content (K. E. B. Knudsen, 2009).

Results in % of dry matter						
Test		**Ara**	**Xyl**	**Man**	**Glu**	**NSP**
Barley	Soluble NSPs	0.43	0.6	0.17	5.6	7.05
	Insoluble NSPs	1.96	5.39	0.34	2.05	16.31
	Total NSPs	2.39	5.99	0.51	7.65	23.37
Wheat	Soluble NSPs	0.42	0.76	0.07	0.16	1.69
	Insoluble NSPs	1.71	3.56	0.18	1.4	9.52
	Total NSPs	2.13	4.32	0.25	1.56	11.21
Maize	Soluble NSPs	0.09	0.06	0.09	0.04	0.51
	Insoluble NSPs	1.23	1.93	0.11	0.62	6.83
	Total NSPs	1.32	1.99	0.19	0.66	7.34
Rye	Soluble NSPs	0.98	1.8	0.2	0.77	3.98
	Insoluble NSPs	1.85	3.54	0.34	3.69	11.67
	Total NSPs	2.83	5.34	0.54	4.46	15.65

Maximising feed value

Feed enzyme supplementation in pig diets has quickly followed the evolution of enzyme usage in poultry diets. Today, more than 35% of all feed enzymes are used for pig feed production. The main objective in using exogenous feed enzymes in swine diets is to improve the nutritional value of the feed.

Generally, feed costs make up the largest cost element of pig production (between 60-75% of total costs), and hence profitability can actually depend on the costs and nutritional value of the available feed ingredients. With feed enzymes, pigs will be able to utilise more nutrients from their feed, thus reducing the cost of the feed.

The availability and pricing of feed ingredients are currently crucial factors for the pig industry, and there have been long periods of relatively stable price levels. However, more recently there has been turbulence in the markets with the price of most raw materials. It is paramount not only to utilise the most cost effective ingredients but also to achieve the absolute maximum nutrient utilisation from each feed raw material in the formulation.

Typical feed ingredients used in pig diets are maize and soybean meal. Further feed ingredients used in Europe are wheat, barley, sorghum and oats. However, more and more feed companies are looking for other protein sources, such as peas, field beans, sunflowers, lupines and canola meal, all of which are used worldwide. Other special protein sources such as milk proteins and fishmeal are only used for piglet diets.

The supplementation of monogastric diets with exogenous feed enzymes is now a common practice aimed at improving the nutritional value of feed for piglets and pigs.

Two types of enzyme play a major role in feed enzyme supplementation today: phytases and non-starch polysaccharides (NSP) degrading enzymes.

In Table 1, the analysis of the NSP content of various cereals is shown. For example, there is a clear difference in β-glucan content (Glu) between wheat (1.56) and barley (7.65). By contrast, the difference in arabinoxylan (Ara) is relatively small between the two ingredients. Today it is possible to visualise microscopically just how quickly and efficiently feed enzymes break down cell walls in cereals and vegetable proteins.

The power of enzymes

Fig. 1 shows the degradation of the cell walls by Ronozyme WX. The decrease in fluorescence results from the breakdown of the xylan-rich cell walls into soluble oligomer NSP enzymes.

The breakdown of the xylans in the cell wall occurs rapidly. Caged nutrients such as starch and proteins are then set free, and are available for digestion by the animal. These studies, together with in-vivo studies, have determined the effects of enzymes on the structure of common cereals and proteins.

In a meta-analysis performed on a number of trials with 10 different wheat qualities from five different countries, we found that the mean apparent metabolisable energy

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(AME) was 13.4 MJ/kg DM (with phytase) and the release of additional energy by adding Ronozyme WX was 0.43 MJ/kg DM(P<0.001), with an increased starch digestibility of 3.7%.

In addition, the data showed that the highest efficacy with the Ronozyme WX occurred in lower-quality wheat.

In a French trial of growing pigs from 69-165 days of age, Ronozyme WX was tested. The diets were based on wheat, barley and soybean meal. The negative control (NC) diet was reduced in energy by 0.4 MJ/kg and in protein by 1% compared with the positive control (PC). The animals supplemented with 200ppm Ronozyme WX showed similar performances to those in the positive control but with 3.2% lower production cost per kg meat, which gave a Return on Investment (ROI) of 1:2.5.

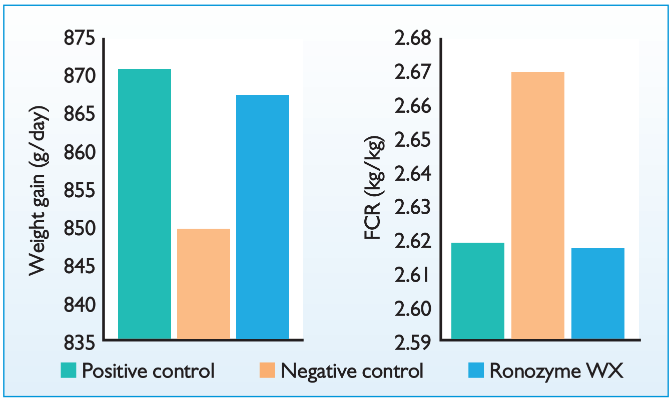

Fig. 2. Experimental farm (France, 2006).

Why phytase in pig diets?

Phytases are phosphatases with a high specificity towards phytate, the primary storage form of phosphorous in plants. Exogenous phytases have been used commercially since the early 1990s to reduce the detrimental environmental impact of intensive animal agriculture and to improve the profitability of the production of poultry and swine.

Phytate is generally not bioavailable for monogastric animals. They lack the digestive enzyme phytase, which is required to remove phosphate from the inositol in the phytate molecule.

In typical plant-based feed ingredients, the phytate-bound phosphorous often exceeds two thirds of the total phosphorous (P) content available. However, due to the lack of endogenous phytase, pigs cannot utilise the phytate-bound phosphorous successfully, and this valuable source of phosphorous is simply excreted into the environment, where it poses a huge pollution problem, especially in areas with intensive agriculture.

In addition to the hydrolysis of phytate in the feed, phytase also indirectly releases other nutrients such as macro-minerals (calcium), trace minerals (copper and zinc), and amino acids, which are also bound to the phytate molecule.

Phytases make the phosphorus present in animal feed more available to the animal, reducing the need for inorganic phosphate supplementation (monocalcium phosphate), and ultimately reducing the phosphorus content in manure. As well as the benefits to the animal, phytase also has a positive impact on the environment, reducing pollution.

The impact on the planet

In order to meet the daily phosphorous requirements for swine, the addition of inorganic phosphorous sources such as mono- or dicalcium phosphates or P-rich feedstuffs such as meat and bone meal is needed (the latter is now prohibited in many countries).

This brings another problem into the equation – namely, the fact that the global reserves of rock phosphate are not renewable, and that they are rapidly disappearing.

This may lead to a crisis in phosphate supply in the future, with prices potentially increasing even more than we have seen so far. Improved utilisation of phytate-P is therefore necessary, as it would both alleviate P pollution and preserve rock phosphate deposits at one and the same time.

Potential of myo-inositol

Historically, phytase has been used to reduce dietary costs by the displacement of inorganic phosphate sources and occasionally energy sources such as animal or vegetable fat. There has also been a reduction in limestone, synthetic amino acids and salts. These displacement effects are linked to a nutrient release matrix for a particular feed ingredient at a defined inclusion concentration. The matrix value will depend on the shadow prices of the various displaced nutrients, which can be readily calculated.

However, attention has more recently shifted from P release and the reduced anti-nutritive effect of phytate to the role of myo-inositol (MYO) in the phytase response – the so-called Extra Phosphoric Effect (EPE). Myo-inositol is a cyclical sugar alcohol with a formula similar to glucose and is the nucleus of phytic acid (known as inositol hexakisphosphate [IP6]).

The role of MYO in nutrition is not clear and is being actively studied, particularly in human dietetics. However, MYO has been found to be an insulin mimetic and so may regulate glucose transport, gluconeogenesis and protein deposition.

As the involvement of MYO in phytase response is not well understood, two studies were recently undertaken to examine the effect of Ronozyme HiPhos GT (DSM) on plasma MYO concentrations in pigs.

Extra phosphoric effects

Pig and piglet trials have successfully shown the Extra Phosphoric Effect (EPE) in a growing pig trial (Figs. 3 and 4) with two-phase feeding from 35-80kg of weight involving a diet containing wheat, barley and soybean meal. The negative control had a reduction of 0.12% in calcium and 0.08% in digestible P.

Moreover, energy was reduced by 0.14 MJ/kg (which corresponds to the value that 250FYT/kg Ronozyme HiPhos contributes).

Results showed that 250 FYT/kg dose of Ronozyme HiPhos improved the performance to the level of the positive control.

The additional dosing of up to 2000 FYT/kg significantly increased the total weight gain by more than 5kg, and numerically decreased the feed cost ratio (FCR) from 2.37 to 2.31. Return on Investment was calculated to be 1:12.

Conclusion

Used in the right combination and quantities, feed enzymes can reduce and control the anti-nutritional effects of various raw materials in the feed.

This allows the feed producer to use higher amounts of fibrous and phytate-rich ingredients and at the same time maintain and increase animal performance while reducing the overall feeding costs for the farmer.

Further research promises to bring an even better understanding of the combination of enzymes and other relevant factors. ■

References are available from the authors on request

Fig. 3. The EPE on daily gain and FCR (University of Leeds 2012).

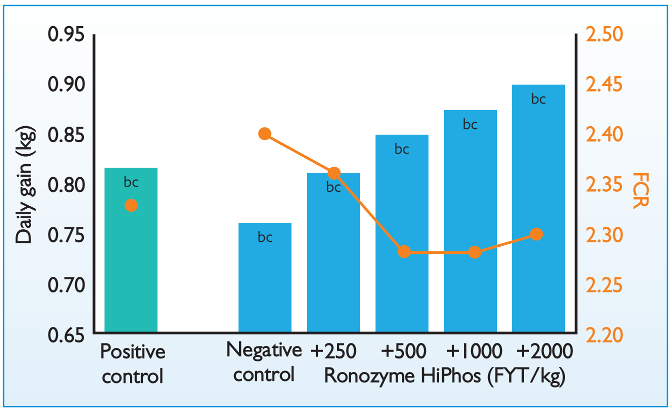

Fig. 4. The EPE on slaughter weight (University of Leeds 2012).