E N Z Y M E R E S E A R C H
p u t t o g o o d u s e i n S w e d e n

Heavier obligations to produce cleaner food and the increasing ability to withstand commercial manufacturing processes is making enzyme supplementation a popular choice amongst both pig producers and the feed industry, says Dr Johan Inborr, who is currently the Director of Feeds Division in Svenska Foder, one of the leading feed manufacturers in Sweden. In the wake of some Scandinavian countries' ban on growth promoters and antibiotic use other than for therapeutic purposes, producers are turning increasingly to enzyme supplementation as a natural aid to maintain feed efficiency, growth rates and minimise the health risks from nutritional disorders.

In a series of trials conducted at various establishments throughout Europe, Dr Inborr's results establish that adding supplementary enzymes to pig feeds improves the rate and efficiency of digestion, especially in young pigs and indicate that the incidence of digestive disorders can be reduced.

Also, as they can remain stable during steam pelleting, enzymes can be added beforehand in the compound mill without any loss to their digestibility-enhancing benefits.

These findings form the basis of his recent thesis which was completed at the University of Helsinki with support from Finnfeeds International and Cultor Animal Nutrition Division. Drawing on the experiences from the commercial use of enzymes in broiler feeds, Dr Inborr set out to establish whether similar benefits were possible in pigs as well as helping to explain and to explore some of the mechanisms behind the enzyme-induced performance responses.

Initially, Finnish Sugar looked at the use of enzymes in pig diets some ten years ago. However, some trials tended to give inconclusive results often because of the instability of the enzymes used at that time, believes Dr Inborr.

'Being proteins, any subsequent heat treatment involved in further processing, and the use of enzymes with inappropriate pH and temperature spectra, may have contributed to the failure of some experiments in the past,' he says. 'Now, we know that enzymes with the right characteristics and proven stability need to be identified before initiating elaborate experiments.'

Enzyme success hinges on the ability to disrupt dietary fibre and render nutrients found in barley and wheat more digestible to monogastric animals such as pigs. The animals' own digestive enzymes are incapable of coping with dietary fibre which can be as high as 25 per cent of the diet. Consequently, most pig diets based on cereals and cereal by-products are not optimally utilised.

'One of the main reasons is that dietary fibre can influence many processes and reactions in the digestive system of the pig thus depressing overall digestibility of the diet,' says Dr Inborr. 'High levels impair nutrient absorption in the small intestine and seriously affect energy digestibility.'

One theory is that most dietary fibre sources have a common feature in their abilities to hold water which is particularly true for the soluble fibres such as beta-glucans and xylans. This increases gut viscosity which can impact on the efficiency of the natural digestive processes. Adding fibre-degrading enzymes to diets with high amounts of dietary fibre can help alleviate some of these anti-nutritive effects.

The first experiments looked at the effects of steam-pelleting on the response to animal performance from enzyme supplementation. With increasing commercial use of high temperature processing, there is some concern that the various feed manufacturing processes such as double pelleting, expansion and extrusion could impair stability. Also, differing pH levels found in the gastro-intestinal tract could inactivate these supplementary enzymes. For instance, pH levels can be as low as 1-2 in the empty stomach and increase rapidly once ingested food arrives.

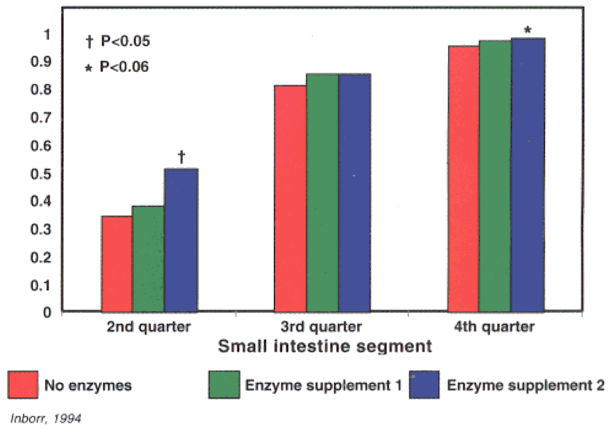
Using Avizyme - a commercial poultry feed enzyme from Finnfeeds International - the results of the pelleting stability experiment showed that the product maintained its effectiveness in conditioning temperatures up to 85ºC. Furthermore, Dr Inborr found in-vivo tests (using actual digesta to measure enzyme recovery in pelleted feeds) provided more accurate assessments on specific enzyme stability than the traditional laboratory procedure.

Another trial looked at the effects of adding fibre-and starch-degrading enzymes to a barley/wheat diet for early-weaned pigs. A total of 96 early-weaned pigs were divided into three treatment groups and housed in flat-deck pens for 21 days.

The base diet consisted of 35 per cent barley, 35 per cent wheat and 22 per cent soyabean meal and was used as the control. The two treatment groups had enzyme supplements containing xylanase, alpha-amylase and beta-glucanase, the latter from one of two different sources. Diets were fed ad-lib during the three week period with pigs weighed weekly.

Beta-glucan, starch and dry matter digestibilities significantly improved in the last quarter of the small intestine of enzyme supplemented pigs. Although in this trial this did not statistically improve growth or feed utilisation, the results showed enzyme supplementation increased the rate of digestion with more nutrients absorbed higher up in the small intestine (See Figure 1.)

Figure 1: Effect of enzyme addition to a pig starter feed on starch digestibility in the small intestine



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Having established this, Dr Inborr looked at the effects of enzyme supplementation on barley-based diets (75 per cent). Using high and low betaglucan varieties, he recorded higher live weight gains and feed utilisation amongst pigs fed the enzyme-treated barley diets. Generally, he puts this down to the role of supplementary enzymes creating more efficient conditions for digestion.

'There are significant changes in gut structure and associated enzyme development after weaning which means cells have limited ability to produce sufficient or appropriate

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enzymes to break down some of the nutrients found in the new foodstuffs provided in post-weaning rations,' explains Dr Inborr. 'Also, the pancreas - important for producing enzymes as well - is undergoing change. All this leaves the animal short of enzymes and particularly vulnerable to digestive disorders.'

As the sow's milk is withdrawn and dry feed introduced, the digestive system of the pig is challenged by a completely new set of raw materials such as vegetable protein, starch and fibre. The reduced secretion of digestive enzymes at this stage can lead to growth depression - the classic growth check at weaning - and digestive upsets due to malabsorption.

Enzyme supplementation of pig starter diets can serve two purposes. Firstly, to complement the production of the pig's own digestive enzymes and, secondly, to reduce the effect of fibre on the digestibility of the nutrients in the diet. In poultry, the fibre fractions of barley (mixed-linked ß-glucans) and wheat (xylans) are responsible for reduced nutrient digestibility in the small intestine. Many experiments have highlighted how this can be overcome with enzyme supplementation. Now, several recent trials with pigs have shown how supplementation of barley-based pig feeds with ß-glucanase results in better performance and reduces incidences of diarrhoea in early-weaned pigs.

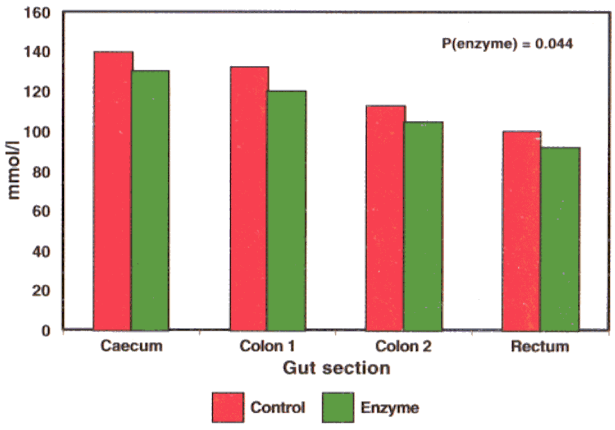
The research shows the extent to which gut viscosity plays a significant role as well. Previous experience with broiler nutrition confirms that the lower the digesta viscosity, the better the digestive process. While broilers fed enzyme-treated diets showed extremely large reductions in digesta viscosity, the level of decrease found in pig trials proved relatively small although possibly no less significant towards the efficiency of the digestive process.

'We know that in broilers it is the relative reduction in gut viscosity that matters, not the actual amount,' adds Dr Inborr. 'Consequently, we believe the same relationship is valid for the pig. There is a positive relationship between improved weight gain, better nutrient absorption and feed utilisation with reductions in gut viscosity as a result of enzyme supplementation.

'It appears the conditions for better digestion are partly determined by reductions in digesta viscosity. This means lower nutrient losses from the animal, improving the utilisation of dietary energy for growth.'

Further analysis of the digesta samples showed a significant reduction in the concentration of volatile fatty acids

Figure 2: VFA concentration in the hindgut of pigs fed barley-based feeds with and without enzymes



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(VFA) in the distal small intestine and hind gut of the pigs fed the enzyme-supplemented diets (See Figure 2.)

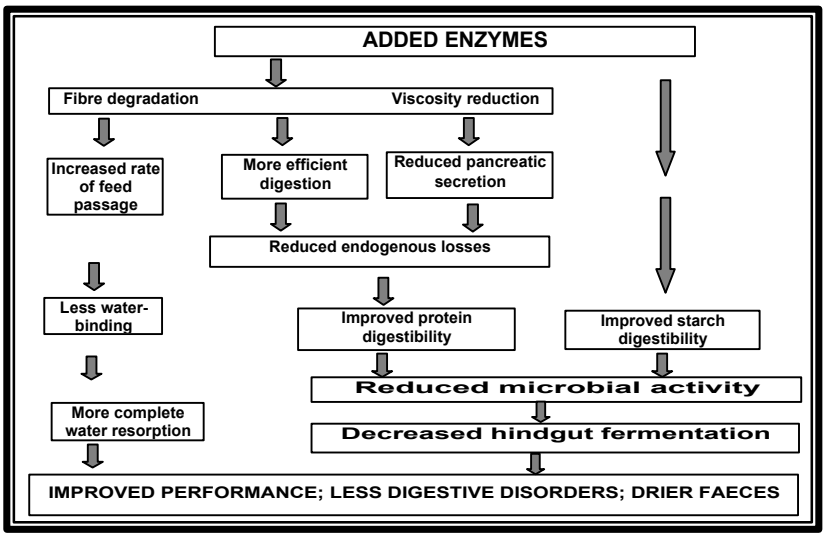
'This provides further evidence that enzyme supplementation leads to fewer nutrients escaping digestion and absorption in the small intestine - reducing the amount of readily fermentable material available for microbial growth. These results are supported by the reduced incidence of diarrhoea often observed in commercial conditions when pigs are fed enzyme-supplemented feeds,' says Dr Inborr.

From the results of these pig experiments, nutritionists now have firm evidence about how feed enzymes work (See Figure 3.) For instance, appropriate enzymes, when added to cereal-based pig starter diets, exert their activity along the digestive tract of the pigs, partly by reducing digesta viscosity, helping to increase the efficiency and rate of digestion.

As a result, less digestive enzymes produced by the animal are needed and a greater portion of the nutrients is absorbed in the upper part of the small intestine. This leads to reduced microbial activity in the distal parts of the digestive tract, resulting in lower fermentation losses and fewer digestive upsets. *'All these effects contribute to the overall improved performance and health status of the pigs,'* adds Dr Inborr.

* Copies of Dr Inborr's thesis, which includes details of all trial results, are available from Finnfeeds International Ltd, PO Box 777, Marlborough, Wiltshire, UK, SN8 IXN.

Figure 3: Mode of action of fibre- and starch-degrading enzymes in pig starter feeds based on barley and wheat



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