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Making the most out of vegetable proteins in swine feeds

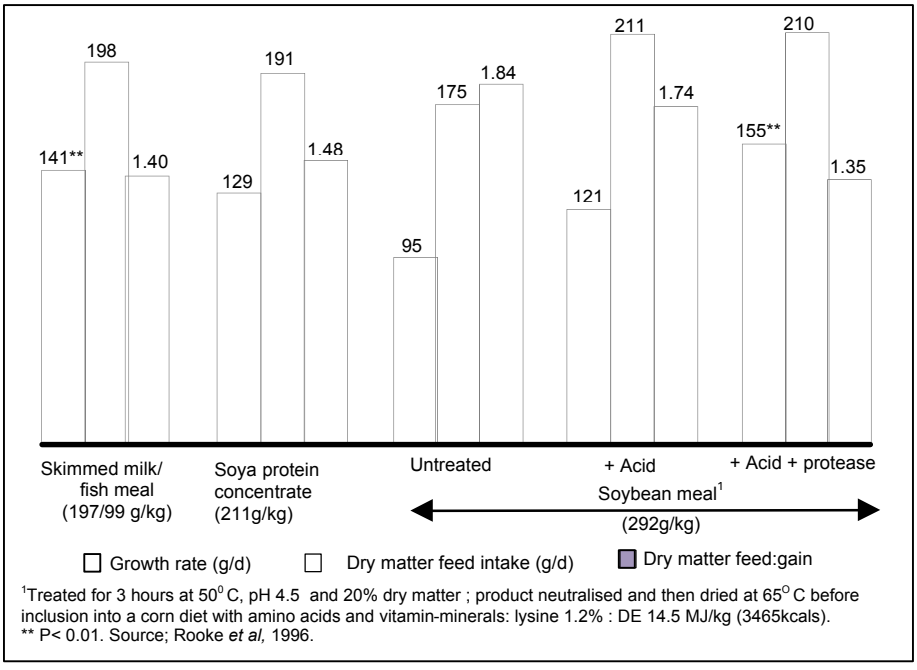
BY GARY PARTRIDGE, PHD, AND MILAN HRUBY, PHD

The European Union ban on 'processed animal proteins' in feeds increasingly leads compounders to prefer vegetable ingredients for both protein and energy in diets. But vegetable feedstuffs are prone to higher fibre content, complex protein structure and anti-nutritional factors - significant challenges, especially in diets for young animals.

The European Union Council decision at the end of 2000 to prohibit the use of certain 'processed animal proteins' in animal feeds? at first until the end of June 2001, but at the time of writing, indefinitely? presents considerable technical and economic challenges to commercial nutritionists formulating poultry and swine diets. Certain countries in Europe have also voluntarily decided to include fish meal in this prohibition, or move away from its use in mixed-species mills due to concerns about storage logistics when adjacent to the production of ruminant feeds. Simultaneously, many feed compounders also have tended to move away from the use of animal fats towards vegetable blends in an attempt to bolster confidence in an industry finding itself under increasing scrutiny.

The net result of these measures is an increased reliance on a variety of vegetable proteins in rations, with the choice of materials dependent upon relative costs and availabilities. These raw materials can present some challenges, particularly for younger animals, in terms of their potential digestibility as a result of their higher fibre content, complex protein structure and in some cases residual 'anti-nutrients' or anti-nutritional factors, such as trypsin inhibitors and lectins in soybean meal.

In both broiler chicken and swine rations, the use of appropriate feed enzymes offers an opportunity to overcome some of these potential limitations imposed by exclusively vegetable protein-based diets.



[1]Treated for 3 hours at 50[0] C, pH 4.5 and 20% dry matter ; product neutralised and then dried at 65[O] C before inclusion into a corn diet with amino acids and vitamin-minerals: lysine 1.2% : DE 14.5 MJ/kg (3465kcals).
** P< 0.01. Source; Rooke *et al,* 1996.

Figure 1. The effect of pre-treatment of soybean meal with acid? without and with protease? on piglet performance in the first 7 days after weaning.

Challenge of vegetable protein digestibility

Carbohydrase enzymes (such as xylanase, beta-glucanase and amylase), targeted primarily against the grain or grain by-product components of the diet, will have both indirect and direct benefits on the digestibility of vegetable proteins in the ration.

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Table 1.
Xylanase effect on the faecal digestibility of isocaloric, isolysinic diets based on corn and wheat middlings (250g/kg) in grower pigs (40-45 kg) in the USA.

Faecal digestibility (%)	Corn-soya-4% fat control diet	Corn-soya-wheat middlings-6.6% fat diet	Corn-soya-wheat middlings-6.6% fat diet plus xylanase[1]
Protein	82.6[a]	71.1[b]	79.2[a]
Energy	86.9[a]	73.3[c]	80.2[b]
DE(kcal/kg), measured	3465	3060	3345
DE (kcal/kg), calculated	3585	3585	3585

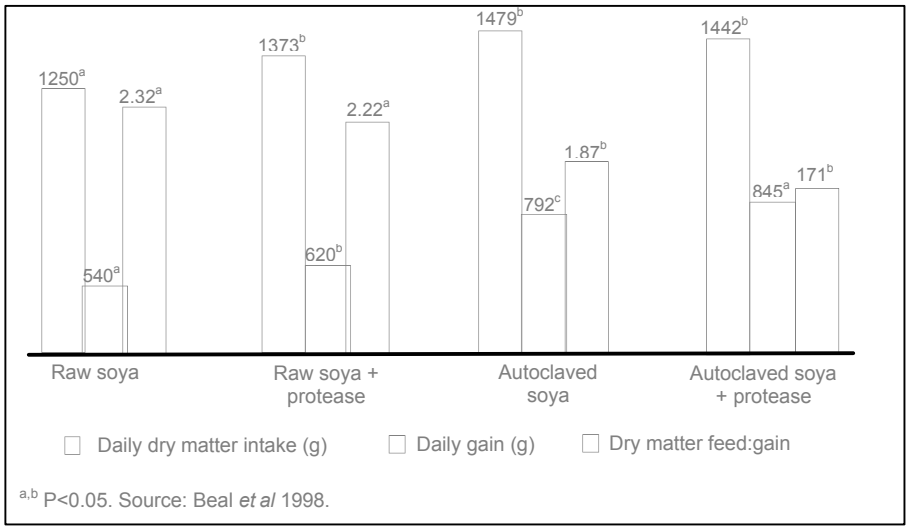
[a-c] Means not sharing a superscript differ significantly (P<0.05).
[1] Porzyme 9300 (1kg/mt) from Finnfeeds International.

Indirect benefits can arise from the enzymes dealing with fibrous anti-nutrients such as soluble arabinoxylans in wheat and beta-glucans in barley, which are present in physiologically significant quantities. These fibre fractions create a viscous environment in the water-soluble phase of the gut contents of broilers, and to a lesser extent in swine and turkeys. Such gut conditions can reduce the efficient digestion and absorption of other dietary components such as vegetable proteins.

The water-holding capacity (WHC) of soluble and insoluble fibre fractions in grain, grain by-products and vegetable proteins also can result in water soluble nutrients being trapped in the fibre matrix in the small intestine. The net result is a reduction in the apparent digestibility of other components in the ration, and significant interactions between components, such that the formulator cannot assume linear additivity in feed formulation. Enzymes, by disrupting the fibre matrix and reducing WHC, can alleviate many of these effects, as demonstrated in corn-soya (yellow maize-soybean meal) diets for growing-finishing swine containing wheat middlings at 250g/kg (Table 1). Adding an effective xylanase substantially improves digestibility in this more fibrous vegetable-based ration, allowing greater flexibility in feed formulation and improving the economic value of such diets.

Direct effects of such enzymes on vegetable proteins can also be expected because starch and a number of the fibre components - such as arabinoxylans - are common to both grains and vegetable protein meals (Table 2).

Protease addition to vegetable protein-based diets has also proved to be of particular value in studies in swine. Some of the benefits of protease addition can be attributed to its effects on the storage proteins of the grain component itself? for example, zein in corn and kaffirin in sorghum. These storage proteins are closely associated with the starch component and can effectively encapsulate some starch, limiting the action of the animal's own digestive enzymes. Some of the relatively poor ileal digestibility of starch seen in some corn samples could be attributed to such 'encapsulation'. However, this lower digestibility also may be due to starch structure - particularly amylose content - or due to physical inaccessibility of the starch resulting from 'fibre packaging' inside undisrupted cell walls.



[a,b] P<0.05. Source: Beal *et al* 1998.

Figure 2. The effect of protease pre-treatment of raw or autoclaved full fat soybeans on grower pig performance (32 kg start weight).

Improving corn and soybeans

In corn these cell walls are rich in insoluble arabinoxylans (Table 2). So clearly, in the case of poor digestibility due to fibre packaging, xylanase addition can bring potential benefits by breaking down this material and releasing the trapped nutrients. In swine, enzyme effects are often accompanied by a rise in voluntary food intake (Table 3), illustrating that fibre in the diet has many physiological effects in the animal which enzymes can help alleviate.

The specific benefits of protease addition are best illustrated by studies involving some degree of pre-processing of soy protein outside the animal. Only by doing studies in this way is it easier to dissociate the effects of the enzyme on the vegetable protein fraction of the diet from its potential effects on the grain component.

Recent studies *in vitro* and *in vivo* in swine have shown the benefits of pre-treatment of soybean with protease. The young pig is a good test model in this instance as it has been found to be particularly susceptible to soy protein in the post-weaning phase. A number of studies have shown poor digestibility due to excessive endogenous protein losses, which is linked to damaging hyper-sensitivity reactions to soy storage proteins, such as glycinin and beta-conglycinin. For this reason, nutritionists are usually cautious about high soybean meal inclusions in specialist rations designed for the newly weaned pig.

Proteases that can target both residual proteinaceous anti-nutrients? such as trypsin inhibitors and lectins? as well as soy storage proteins, have shown benefits when enzyme pre-treated products have been incorporated in diets for young pigs (Figure 1). Similar studies involving protease pre-treatment of raw or cooked soybeans have also shown benefits when these products are fed to more mature animals (Figure 2).

Although it has proved impossible so far in these trials to upgrade a raw soybean sample to that of a well-cooked or 'heat-denatured' sample, clear benefits were still seen following protease addition to both types of soy. Adding protease to autoclaved material - containing undetectable levels of

Table 2.
Starch and fibre components of some major grains and vegetable protein meals (%, as fed)

	Grains			Vegetable proteins (% crude protein)			
	Corn	Wheat	Barley	Soybean meal (48)	Rapeseed meal (36)	Pea meal (23)	Sunflower meal (32)
Starch	62	58	50	5.5	3	41	2
Crude fibre	2.2	2.5	4.5	4.5	11	5	22
Total fibre[1]	9	10	13.7	17	20	16	26
Beta-glucans	-	0.7	4	-	-	-	-
Arabino-xylans	3.7	5.8	6.0	3.7	6.5	4.5	8.7
Cellulose	2.0	2.5	5.5	4	6.6	5.6	11.4
Lignin	0.4	0.8	2.0	2.3	8	0.8	9

[1]Cell wall non-starch polysaccharides.
Sources: Various with reference to Finnfeeds International, 2002.

trypsin inhibitors and lectins - fractionated the soy storage proteins into simpler di-peptide and tri-peptide units plus free amino acids, which would have aided digestibility. However, autoclaving of soy, as in this experiment, would have produced a cooked material of greater consistency than many commercial soy samples.

Globally, soybeans have been shown to vary greatly in their composition and level of residual anti-nutrients. A protease-carbohydrase additive could reduce this variability, which would offer greater consistency in performance of animals fed vegetable protein-based diets. Recent studies have suggested that one of the major benefits of the use of an enzyme complex in corn-soya diets for broilers is to reduce variability in the final bodyweight of birds in commercial production systems (FEED INTERNATIONAL, April 2001). This has the potential to bring 'added value' beyond the recognised benefits in feed conversion.

Other vegetable protein sources

In the EU currently there is a continued focus on looking for alternatives to soy proteins in animal feeds, both for economic reasons and in the wake of the 'GM debate ' relating to genetically modified crops as food sources. Enzyme use in diets containing, for example, peas, beans, rapeseed and sunflower as the principal vegetable protein sources, may be just as attractive in such diets as in those based on soybeans. The protease effects described above are equally relevant to the storage proteins in these raw materials and to some of their anti-nutrients. To date, however, these other vegetable proteins have been studied to a lesser extent.

Protein sources such as sunflower meal are particularly challenging, as they are rich in fibre (Table 2) and, as a consequence, have the potential to respond well to specific carbohydrase additions. However, it is clear that other enzyme activities - as yet not used routinely - are needed to maximise nutritional value from this raw material and others, such as rapeseed meal (Table 2).

Increasingly complex rations ahead

The movement to higher levels of vegetable protein in diets for poultry and swine in the wake of the ban on meat-and-bone meal-with or without fish meal-will focus attention on maintaining ration digestibility in order to avoid potential reductions in performance, particularly in young animals. Formulating to digestible amino acids in poultry and swine diets will become increasingly important in this scenario.

Despite this precaution, increased vegetable protein levels bring with them an increase in dietary fibre, phytate, complex storage proteins and proteinaceous anti-nutrients. All of these factors are amenable to specific enzymes - carbohydrases, phytases and proteases, respectively. These feed enzymes can increase nutrient digestibility and maintain production economics, despite these enforced changes.

Table 3.
Effect of a multi-enzyme complex on performance of grower-finisher pigs fed corn-soybean meal diets.

	Control diet	Control plus enzyme complex [1]
Start weight (kg)	28.5	28.5
Final weight (kg)	84.1	88.2
Daily gain (g)	792	853[2]
Daily feed intake (g)	2240	2412[2]
Feed:gain	2.83	2.82

[1]Xylanase; amylase; beta-glucanase (Porzyme TP 100 from Finnfeeds International).
[2]*P<0.05
Source: University of Ceara, Fortaleza, Brazil, referenced by Finnfeeds International, 2002.

Formulating to digestible amino acids in poultry and swine diets may help to avoid loss of animal performance during the shift to all-vegetable diets, along with the use of a range of enzymes? carbohydrases, phytases and proteases.

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