Feed for optimum performance – enzymes and other technologies

Feed technology has moved on a great deal in the last 30 years. Feed enzymes were first developed for poultry diets in the late 1980s and have been undergoing refinement and further development ever since. These formed the first main commercial platform of products for improving digestibility of feeds for poultry producers and are now used in virtually all professional feeds worldwide.

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Although feed enzymes started off being relatively simple and focused on reducing non-starch polysaccharides (NSP) such as beta-glucanase and xylanase in feed, the technology has moved on considerably since, with the latest enzymes being produced on target substrates to give ideal digestive profiles that match the main ingredients being used in diets via solid state fermentation (SSF) technology. This works by seeding specific fungal species with good enzyme productive capacity onto the main feed ingredient, for example maize, wheat or barley. The fungal strain then selectively produces the most appropriate enzyme mixture in response to the anti-nutritional factors present.

SSF provides a variety of enzyme activities, which are not produced by cultures in liquid fermentation. This more closely mimics the digestion encountered in the gut, as feed is not digested by only single enzymes, but rather a plethora of them, which work synergistically and are hence more effective.

Table. 1. NSP content of cereal grains (Adapted from Geraert, 2005).

Cereal type	NSP (% DM)
Barley	15.9-24.8
Wheat	10.0-13.8
Oat	19.8-38.7
Sorghum	3.4-7.3
Rye	13.2
Triticale	16.3
Corn	8.1
Rice (pearled)	0.8
Rice bran (de-fatted)	21.8
Wheat pollard	35.3

Protein seed meal	Crude protein (%)	Protein digestibility (%)	Available protein (g/kg)	Arabinoxylan (rel. SBM %)	Noted ANF
Soyabean	48	85	41	0	Lectins
Sunflower	35	78	27	+17	Tannins
Rapeseed	37	72	27	+30	Pectins
Peas	20	77	15	+37	Cell wall
Lupins	40	71	28	-43	Tannins

Table. 2. Variation in protein meals commonly used in poultry diet formulations.

Releasing important minerals

The vast majority of poultry diets around the world now contain phytase enzymes that are necessary to liberate important minerals entrapped in feed material such as phosphorus (P) from phytic acid and to reduce mineral losses from manure. However, phytases can only release P from these complexes when the phytate molecule becomes exposed in the cell matrix.

Phytate is located in the cell wall of plants and is typically surrounded by indigestible cell wall fibres and can be chemically bonded to starch and protein. When a phytase enzyme is supplied singly, it may not be able to fully free the P held under these conditions.

However, the combined activities generated in the multi-feed enzymes produced from SSF (for example Allzyme SSF*, Alltech) can degrade fibre (via the activity of xylanase, cellulase and glucanase), crude protein (protease), starch complexes (amylase) and pectic polysaccharide structures (pectinase) during digestion in the gut. This allows complete breakdown of the entrapped P, reducing the amounts of inorganic P needed in the feed and the amounts lost in manure. In addition, the other enzymes within the SSF final product increase energy and other nutrient digestion.

This is clearly illustrated in a typical trial run in Australia (QPRDC) where energy was reduced by 150kcal/kg in broiler diets formulated with wheat and soyabean meal, which were then compared against the same down-specification diet plus Allzyme SSF.

The broilers fed the control diet (full nutritional specification) had an average liveweight of 2.73kg at day 42, whereas the birds fed down-specification diet plus Allzyme SSF had a body weight of 2.74kg at the same age.

Trial results

The feed conversion ratio (FCR) data from this trial showed a similar trend, with the control-fed group having an average FCR of 1.72, whereas the birds fed the down-specification diet plus Allzyme SSF had a lower FCR of 1.70. When this trial was extended to include a reduction in available P as well as lower energy in feed, weight gain at 42 days of age in the birds fed the unmodified control diet was 2.35kg.

The broilers fed the down-specification diet in energy and P had a reduced weight gain of 2.15 at the same age, but this was increased back to the same level as the control when birds were supplemented with Allzyme SSF on top of the down-specification diet. FCR once again followed a similar pattern, with averages of 1.76, 1.78 and 1.73 for the control, down-specification and down-specification plus enzyme dietary groups respectively.

Improved understanding

There is now much better understanding of the importance of the mix and dose levels of various enzymes required for different cereals used as major components of poultry diets. For example, published studies have detailed the average levels and ranges of NSP contained within common cereals (see Table 1). This database has identified what types of anti-nutritional factor (ANF) a formulator can expect to encounter within feed materials, and how best to maintain the required levels of digestibility to attain productive performance goals.

Although early work focused on broiler chickens, laying hens and turkeys now have a substantial dataset on the benefits of using the latest feed enzymes. In addition, information on various undesirable or poorly digested compounds in feed materials is now available, with focus on various problems, especially from the use of by-products or vegetable protein sources in monogastric feeds.

The removal of meat and bone meal from poultry diets in certain regions of the world has led to the inclusion of various alternative vegetable meals high in protein. This is

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due to the relative high global cost of soyabean meal – typically the 'gold standard' for vegetable protein in diets, due to its good amino acid profile.

Some of these are highlighted in Table 2, showing the relative levels of antinutritive arabinoxylans relative to soyabean meal as well as other problematic factors that should be considered, as they are known to hinder digestion and performance.

This kind of information is very useful in allowing feed manufacturers to add the correct type and dose level of enzymes to the feed to ensure performance goals are met.

Use of by-products

Choices for selecting feed materials, including by-products, in poultry diets have changed a great deal in the last couple of decades.

As a result, an increased reliance on by-product use in poultry diets has arisen due to their availability (for example distiller's dried grain solubles (DDGS) from biofuel production) and price competition between animal feed and the human food markets.

However, such materials can be variable in their nutritional content due to differences in source material and processing methods, and so the correct application of enzymes is important to maintain desired uniform performance at poultry farms.

Issues with feed enzymes, that negatively affected their usefulness previously, have been greatly resolved with the production of more thermostable enzymes that are effective over a wide range of pH and temperatures, and are hence able to survive heat processing and passage through the acidic stomach environment.

Xylanase based products such as the fungally derived Allzyme PT* retain activity throughout the pelleting process of poultry diets at a temperature of 80°C, which is twice the survival rate of other xylanase products. In addition, feeds that are formulated with organic forms of minerals (Bioplex, Alltech Inc) have shown that these do not interfere with enzyme activity in feed.

Inorganic minerals were studied in vitro and was found to inhibit the activity of phytase enzymes and other important nutrients, in particular inorganic iron.

This is due to the dissociation of the inorganic mineral in the aqueous solution seen in the gut, releasing oxidising materials that interfere with certain nutrient availability and activities.

When this was compared with premixes containing organic chelated minerals, inhibition was significantly less. Hence, when diets are formulated using premixes containing organic forms of iron, phytase activity is maintained to a much higher degree.

As phytase enzymes are typically included at higher levels to overcome inhibition by minerals, changing the form in premix allows lower inclusions to be used with confidence, which reduces the cost of supplementation.

The same is seen for vitamins, with inorganic iron again reducing availability. In vitro trials with the antioxidants butylated hydroxytoluene BHT and vitamin E, inorganic iron sulphate and chloride reduced the availability of BHT.

Premixes made with inorganic minerals reduced availability of vitamin E in feeds, whereas the organic minerals had no discernible impact. Both of these antioxidants are expensive to add in feed, so maintaining their availability by changing the form of minerals used in the premix has an important economic payback.

Dose response trials have been used to develop effective enzymes that can be incorporated into feed at lower rates than previously, whilst still allowing full down-specification levels, such as 6% or more energy from feed materials (Allzyme range).

Trials in laying hens have shown that applying such down-specification in energy levels plus an SSF derived enzyme can maintain or even improve digestibility.

In the trial, energy and nutrients were reduced in the down-specification diet and then further supplemented with Allzyme enzyme. Faecal digestibility was measured for energy, protein, and the major minerals Ca and P. Unsurprisingly, the down-specification diet had lower levels of faecal digestibility, which was significant for protein and Ca.

However, when the same diet was supplemented with Allzyme, energy levels rose to levels 5% higher than the down-specification diet and 3% higher than the control.

Protein digestion was significantly higher than either the down-specification diet or the control.

Ca digestibility was increased to the same level as the control and P digestion was significantly higher than both other diets.

Faecal digestibility (%)	Control	Down-spec. diet	Down spec. diet + Allzyme SSF
Energy	87	85	90
Protein	67.6^{b}	61.6^{a}	75.9^{c}
Phosphorus	35.3^{a}	34.3^{a}	52.4^{b}
Calcium	56.8^{b}	46.3^{a}	58.5^{b}

Table. 4. Influence of down-specification layer diets in energy with the addition of Allzyme SSF enzymes.

Removal of AGPs

The removal of antibiotic growth promoters (AGP) has been a major change that poultry producers have had to deal with since the mid 1990s. Europe has banned use of such prophylactics since the end of the 1990s and other countries, including the USA, are now following suit. AGP were important in controlling levels of pathogens in the gut that competed with the bird for nutrients and could interfere with digestion by causing damage to the gut lining. Enzymes played an important role in preventing bacterial overgrowth in avian intestines by ensuring correct digestion in the upper ileum, preventing intact nutrients passing into the lower gut and encouraging proliferation of pathogenic bacteria.

A large amount of research has been conducted since the late 1990s proving such effects. As part of ensuring nutrient digestion and uptake in animals fed diets without AGP, trials to examine combined benefits of various feed ingredients have been conducted, resulting in the development of prebiotics such as Actigen from yeast cell wall.

Such mannan-oligosaccharide (MOS) based products are well known to improve gut conditions, with stronger and more villi lining the gut to increase digested nutrient uptake.

Increased AME

When Allzyme and MOS were added together and fed to broiler chickens in a trial run by Owens et al. (2007), there were significant increases in apparent metabolisable energy (AME) and a reduction in the amount of energy required per unit of weight gain (ME:kg).

Compared to the control diet, AME was increased from 14.01MJ/kg to 14.38MJ/kg when Allzyme was added and significantly up to 14.62MJ/kg when MOS was added on top of the enzyme.

The ME:gain levels corresponded with 19.23MJ/kg gain for the control; 18.31MJ/kg gain with enzyme supplementation and 18.56MJ/kg gain for the enzyme plus MOS diet.

This demonstrated that less energy was needed for growth due to improved uptake of energy-rich fractions from the diet.

Histological data showed that this corresponded to the increase in villus height (0.7mm control versus 0.74 for enzyme plus MOS), which is important regarding the absorptive surface area.

By using specifically produced feed enzymes in synergy with other gut active ingredients, such as MOS, the problems associated with poor digestibility in poultry due to by-product inclusion, variability in nutrient quality and restrictions on prophylactic AGP use, can be resolved to give the same or better productive performance.

These interventions should be implemented as the norm for any poultry producer to ensure uniformity of growth and to meet production goals. ■

Table. 3. Variability in different USA sourced DDGS types (Shurson, 2007).

Parameter	DDGS classification					
(DM basis) %	Golden corn	High fat	Partial de-germed	Whiskey	Pelleted	Not named
Crude protein	31.8	31.6	30.1	29.9	27.0	29.3
Crude fat	11.3	15.3	8.9	8.8	9.0	3.5
Crude fibre	6.3	-	7.8	10.6	15.1	7.9
Ash	6.9	4.6	7.3	3.7	4.3	5.3
Phosphorus	0.77	0.89	0.68	0.57	0.62	0.78

References are available from the author on request

*Not available for sale within the EU