Exposing the anti-nutritional properties of phytate

Previously viewed primarily as a source of dietary phosphorus, plant phytates (or phytin) should instead be seen as a significant anti-nutritional factor capable of disrupting protein, energy and mineral digestibility.

That was the message taken home by delegates at the 1st International Phytase Symposium (IPS) held in Washington DC, with a number of the presentations highlighting not only evidence for the anti-nutritional properties of phytate, but also possible mechanisms by which it might act.

Massive success story

"The phytase enzyme market is one of the massive success stories in the animal feed industry of the last two decades – it is a $350m market generating a benefit to the animal feed industry worth $2bn globally," stated Richard Cooper, managing director of AB Vista, which jointly hosted the IPS with Massey University, the University of Maryland and the University of Sydney.

"But I believe we are now at a point of change," he continued, "and the destruction of phytate in monogastric diets could be worth another $2bn to the industry."

Amongst the speakers at the IPS was Professor Peter Selle, University of Sydney, who explained that although the significance of phytate-protein complexes was recognised as far back as the early 1950s, there had been little improvement in understanding until now.

"As far as I am concerned, phytate does have an impact on protein digestion," he explained. "I think phytate results in delays to – and a distal shift in – amino acid absorption. It appears that the addition of phytase brings that forward, which is important not just to digestibility, but also to the synchronicity of protein and starch digestion."

Professor Selle presented a range of data demonstrating the impact of phytate destruction using phytase enzymes. Fig. 1 shows the results from a trial using weaner pigs, for example, where addition of phytase increased daily gain by 18.7% and improved feed conversion efficiency by 11.0%, irrespective of dietary phosphorus supply.

Further evidence came from a study looking at the effect of phytase addition on the ileal digestibility of linola meal amino acids in grower pigs.

On average, amino acid digestibility was increased by 14.5%, with improvements ranging from 5.6% for methionine to 24.4% for threonine (Fig. 2).

The unique nature of these phytate-protein interactions was addressed by Dr Nathan Cowieson, Australian Synchrontron, who challenged current dogma that suggested the formation of simple phytate-protein complexes in the stomach that could naturally dissociate in the duodenum.

His studies had shown that phytate did not bind directly with proteins, but appeared instead to affect the hydrogen bonding between the protein and water molecules that kept the former in solution.

Most interestingly, the effect varied with phytate concentration – phytate strengthened the hydrogen bonds at low concentrations, but acted to weaken them at high concentrations. This weakening of the hydrogen bonds would result in the proteins dropping out of solution, leading to reduced digestibility in the gut.

Anti-nutritional properties

The lack of recognition of these anti-nutritional properties was reiterated by Professor Ed Moran of Auburn University, who stated: "Up until recently, we have not really fully appreciated phytin's adverse effects."

He went on to explain additional mechanisms by which plant phytates (or phytin) could impact on digestive efficiency due to adhesion of cations, particularly calcium.

Free calcium ions are important in improving the stability of certain gut enzymes, extending their half-life and so improving

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Fig. 1. Indexed responses to 500 FTU/kg A. niger phytase in 640 weaner pigs (19-40 days post-weaning) offered 3.5 and 4.5g/kg available P diets (Campbell et al, 1995).

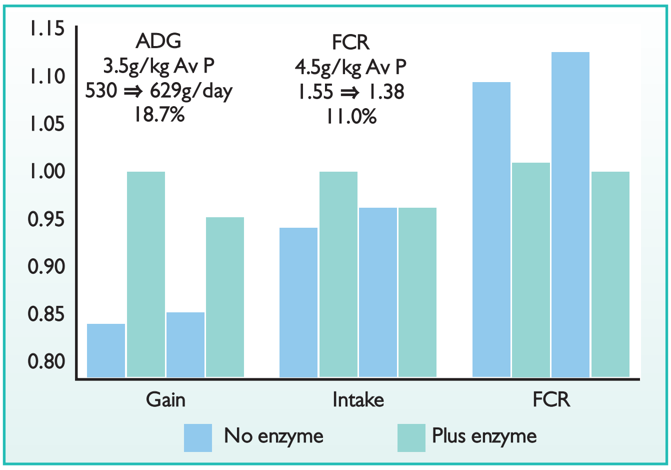
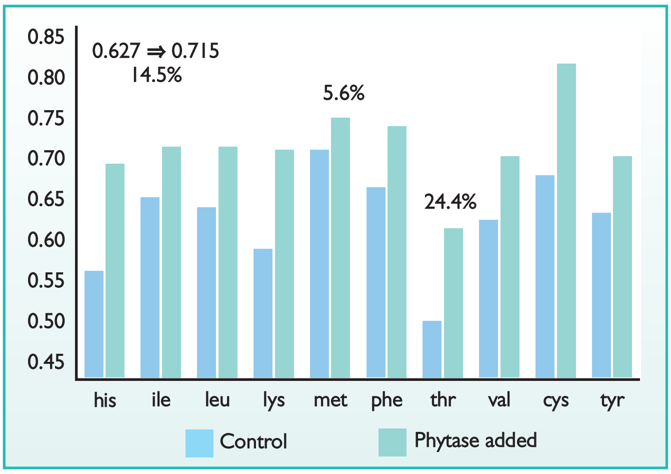


Fig. 2. Impact of phytase on AID of 10 amino acids ex Linola meal in grower pigs (Officer and Batterham, 1992).



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both starch and protein digestibility. Professor Moran also outlined the important role calcium ions play in creating optimum conditions for final breakdown and absorption of nutrients, helping maintain the structure of the mucin 'mat' that regulates a very precisely controlled pH 6.2-6.5 'unstirred water layer' at the surface of the small intestine epithelium (Fig. 3).

Additional cation effects were mentioned by Professor Selle, who discussed the impact of phytate-protein complexes in 'dragging' sodium ions into the small intestine lumen, potentially compromising sodium dependent transport systems.

Impact on digestibility

In summing up the impact of phytate on nutrient digestibility, Associate Professor Aaron Cowieson, University of Sydney, stated: "Phytate causes very significant changes to the characteristics of proteins and their solubility profile, although if the digestibility co-efficient in the diet is high, the response to phytate is reduced."

He went on to discuss the potential to move towards 'phytate-free' nutrition, utilising higher than currently recommended doses of phytase to achieve 95-100% phytate degradation within the proximal gastric gut. Known as 'superdosing', the effect is achieved by supplying phytase in excess of 1500 FTU/kg (as measured at pH 3.0).

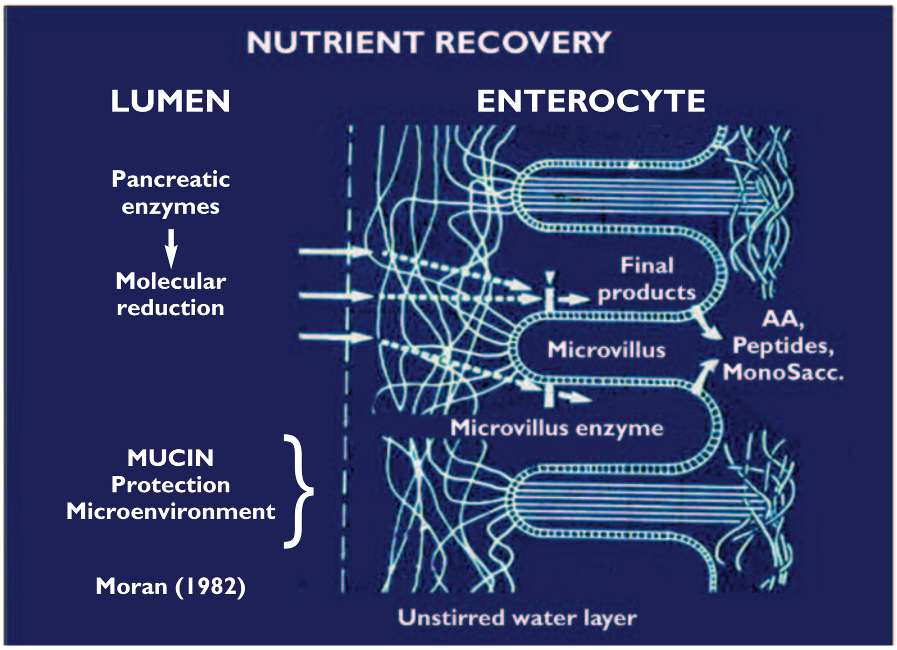

Fig. 3. The 'unstirred water layer' at the surface of the small intestine epithelium.

Initial investigations suggest that the feed cost savings from superdosing can be substantial. One example discussed at the IPS was the potential to replace expensive animal proteins in young pig diets with cheaper plant proteins, without affecting growth or performance. "The absence of phytate has an effect, a general relaxing of nutrient requirements," continued Associate Professor Cowieson.

"In the future, the release of phosphorus from phytate could be of secondary importance compared to the removal of 'reactive' phytate from the diet." ■