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A new approach to handling anti-nutritional factors:

Soya bean meal as principal source of protein

The principal source of protein used in monogastric feed in South Africa and many other parts of the world is soya bean meal (SBM). In recent years, the source of SBM used in the South African feed industry has shifted from the imported product to locally grown beans and processed SBM.

The majority of nutritionists make regular changes to the crude protein levels of SBM, with digestible amino acid values being derived from these levels. Very few, however, make any adjustments to the digestibility values of crude protein and individual amino acids. This is mainly due to the fact that there is no quick way of determining the digestibility of raw materials.

To assume, however, that the digestibility values do not change over time or with sources, is probably incorrect. The nutrient values and quality of the protein fraction of SBM depend on numerous factors, including processing conditions, soil characteristics and growing methods, as well as the origin of the beans.

In a 2011 swine study, Gonzalez-Vega and his group proved that the type and time of heat application will affect the apparent and standard ileal digestibility of amino acids in SBM. The concentrations of dry matter, ash and crude protein were found to be similar in all four samples of SBM, regardless of the heat treatment applied.

Impact of processing conditions

However, with increasing harshness of heat treatment, lysine, cysteine and arginine values were reduced. The concentrations of other amino acids were, however, not influenced by heat treatment. These reductions may be due to advanced Maillard reactions. During these reactions, some cross-linkages are established between lysine (Lys) and other amino acids and polypeptide chains within the protein, which may reduce the efficiency of proteolytic enzymes, thus reducing amino acid digestibility.

On the other end of the scale, if the heat treatment of SBM is insufficient, the trypsin inhibitors commonly present in raw soya beans are not deactivated and the performance of animals will be compromised. Numerous research papers have been published on the optimal processing time and temperature to optimise the nutrient availability of SBM.

In 2013, Serrano and his group evaluated SBM samples from Brazil, the United States (US) and Argentina. As a first step, they determined the apparent as well as standard ileal digestibility of the amino acids in the samples. Results indicated that the apparent and standard ileal digestibility of most limiting amino acids were insignificantly lower for the Brazilian samples than in the US (US-2) meal, with US values (US-1) and Argentinian samples being intermediate. Whereas the differences in Lys content were statistically significant.

The inclusion of these SBM samples from the different sources in diets were also studied to determine the effect on growth performance, apparent retention of nutrients along the total gastro-intestinal tract and digestive organ size in broilers reared in cages from one to 25 days of age.

Table 1: An evaluation of SBM samples for ileal digestibility.

	Apparent ileal digestibility				Standard ileal digestibility			
	US-1	US-2	Brazil	Argentina	US-1	US-2	Brazil	Argentina
Arg	90,1	91,7	89,3	90,9	93,4	94,8	92,5	94,2
Ile	85,5	87,5	85,2	86,4	92,6	94,2	91,1	93,1
Leu	85,5	87,5	85,5	86,3	90,2	92,0	89,8	90,7
Lys	87,7^{ab}	89,0^{a}	85,0^{ab}	88,0^{ab}	91,8^{ab}	92,9a	89,3^{b}	92,0^{ab}
Met	87,8	88,7	87	88	96,0	96,8	95,6	96,3
Thr	79,4	81,3	79,5	80,1	91,5	93,1	91,3	92,0
Val	83,9	85,9	83,6	84,5	92,2	93,3	91,4	92,4

Serrano et al., 2012.

Anti-nutritional factors in SBM

Several anti-nutritional factors – including trypsin inhibitors, β-conglycinin and glycinins – are present in raw soya beans. As some of these anti-nutritional factors are heat-sensitive, the purpose of the drying and toasting phase during soya bean processing is not only to reclaim the solvent used, but also to destroy the anti-nutritional factors.

The nutritional quality of the meal is thus improved by heating, and insufficient heating may result in lower quality meal for animals, as significant amounts of the anti-nutritional factors remain active.

The hydrolysing capability of keratinase on casein, collagen, elastin, keratin and other proteins of animal or plant source is well documented.

Although the desolventisation-toasting treatment degrades anti-nutritional factors in SBM to low levels, the residual anti-nutritional factors still affect the digestion, absorption and utilisation of nutrients from the diet.

In 2012, a group of European researchers published a comprehensive study on linking the nutrient and quality analyses results of soya bean meal to the ileal digestibility of amino acids and protein in broilers. The group collected 22 soya bean meal (SBM) samples from three countries – USA (8), Brazil (7) and Argentina (7).

Nutrient and quality analyses were performed on the SBM loads, and the coefficient of standardised ideal digestibility was determined using 21-day-old Ross 308 broilers. The research group established that the commercial SBMs tested in this study differed extensively in nutrient content, crude protein quality and ideal digestibility of the majority of the amino acids.

Table 2: Effect of SBM inclusion in diets.

	Average daily gain	Average daily feed intake	Feed conversion ratio	Mortality
US-1	36,5	57,7	1,59	1,29
US-2	35,0	57,2	1,64	3,22
Brazil	35,9	57,7	1,62	1,93
Argentina	35,2	57,8	1,65	3,86

They also found that the coefficients of standard ileal digestibility of crude protein and lysine of the SBM were positively correlated with crude protein content, KOH solubility, trypsin inhibitor activity and reactive lysine, with no correlation to non-detergent fibre and the oligosaccharide content.

The coefficient of standard ileal digestibility for lysine and most other amino acids in the US and Brazilian SBMs, was higher than that of the Argentine meals. They also found KOH solubility to be the best predictor of the digestibility of both crude protein and lysine.

Protein concentrations

In recent years, plant breeding research has focussed on further increasing the protein concentration of soya beans. However, high protein levels were correlated with an increase in the accumulation of β-conglycinin and glycinin. β-conglycinin and glycinin, the two major antigenic proteins in SBM, could impair the capacity to digest and absorb nutrients. Several studies have shown that young animals which are sensitised to soya bean protein at a very young age and then later fed diets including SBM, exhibit a temporary hypersensitivity.

While most of the proteins present in soya bean meal are digested without difficulty, some are more difficult to digest, especially for young animals. Challenging proteins include glycinin (approximately 40% of the total globulin proteins found in soya bean), β-conglycinin (approximately 30%) and other minor proteins.

Research has shown that these proteins can damage intestinal morphology and impair the immune function of young animals. The cysteine disulfide bonds in glycinin and β-conglycinin reduce digestion of these proteins. β-conglycinin and glycinin are not routinely commercially analysed. Therefore they are an unknown risk that may affect animal performance.

Keratinase as solution

One possible solution for the anti-nutritional factors present in SBM is the use of a keratinase enzyme. The hydrolysing capability of keratinase on casein, collagen, elastin, keratin and other proteins of animal or plant source is well documented.

Keratinase is composed of protein-disulfide reductase and peptidohydrolase, which allow keratinase to perform this function. Protein-disulfide reductase breaks down the cysteine disulfide bonds present in some indigestible proteins, and then peptidohydrolase hydrolyses the denatured protein into peptides and amino acids.

As a result of the large number of disulfide bonds in the chemical structure of glycinin and β-conglycinin, keratinase can hydrolyse glycinin and β-conglycinin. It can also act to decrease the negative effect of trypsin inhibitors present in SBM, which would enhance the ability of the gut enzymes to hydrolyse dietary proteins. This would result in a more consistent animal performance by limiting the variation in quality between batches or sources of soya bean meal.

References are available from the author. Contact Natasha Snyman on 012 665 5377 or email Natasha.Snyman@novusint.com for more information.