By Dr Erhard Briedenhann

Recent developments in soya protein products and soya bean meal quality

Soya beans are the miracle bean that has transformed global agriculture and become the main source of protein for animal feeds. The current soya bean meal (SBM) production of 220 million tons in 2015 makes up over 70% of oilseed meals used in the current annual world production of 980 million tons of animal feed in 2015.

As great a success as the soya bean has been, it has a number of anti-nutritive characteristics that still present challenges and opportunities to improve the value of SBM. It has to be considered that with the huge volume of SBM consumed globally, that a small improvement in quality will have a considerable impact on global nutrient availability.

Soya beans have developed different shapes, colours and sizes over many years. The specific ideal type of soya bean can be linked to the purposes for which it is required, some of which are high-protein and oil to crush for oil and animal feed, low phytate, high-oleic, large seeds for tofu and soya milk and small soya beans for natto production.

Oligosaccharides

Non-starch polysaccharides make up 20% of soya beans, and conventional soya beans contain approximately 4% oligosaccharides. Raffinose and stachyose are undesirable components and cause digestive disturbances in the intestine. Galacto-oligosaccharides (GOS) are indigestible but fermentable by microflora and reduce digestibility and performance in chicks and pigs. Low oligosaccharide soya beans can improve metabolisable energy by up to 9%.

SBM produced with high protein and low oligosaccharide soya beans, are required at lower inclusion levels to deliver the same broiler performance due to higher nutrient content. TME values are significantly higher for low oligosaccharide SBM in poultry. Feed efficiency can be improved and amino acid (AA) digestibility is similar. It was found by the interdisciplinary plant group of the University of Missouri that it is possible to disrupt the activity of raffinose synthase to reduce the levels of raffinose and stachyose.

Sugars

Sugar concentration is influenced by processing. There is significant association between sugar-positive and oil content. Oil and sugar are negatively correlated to protein. It is possible to develop soya beans with low raffinose and stachyose and a higher sugar content.

Between 65 to 85% of raw soya bean protein is made up of beta-conglycinin and glycinin, which are the main storage proteins of soya bean.

A subunit of beta-conglycicin causes allergic response in the gut epithelia. Glycinin causes antibody formation. Antigens cause an allergic response in the gut and decrease digestive capacity of protein.

Phytic acid is a phosphorus containing acid which chelates with minerals. Its breakdown increases protein digestibility. The degradation of phytate by the phytase enzyme increases phosphorus availability. Phytase producers are increasing the dosage advice to reduce the anti-nutritional factors (ANFs) of phytic acid with encouraging cost-effective responses.

Lectins

Lectins are glycoproteins that are resistant to proteolysis. They bind to the small intestine epithelium and cause disruption of the brush border and villi ulceration.

Increased endogeic nitrogen losses using lectin-free soya beans improved true metabolisable energy, as well as protein digestibility and feed conversion by 10%. Fortunately, heat treatment is effective and necessary in the inactivation of lectins.

There is a negative correlation between ADF and AA digestibility. If ADF rises from 4,8 to 11%, it can result in as much as a 6% decrease in AA digestibility.

Anti-nutritional factors

The various processes that can be used to reduce ANFs are heat treatment, solvent extraction, enzymatic degradation or fermentation.

It needs to be considered that heat treatment only affects heat-sensitive molecules such as trypsin inhibitors, but not heat stable ANFs such as oligosaccharides.

Table 1: Analytical characteristics of common types of soya products (as feed basis).

Product type	Unit	Soya bean seeds, raw	SBM	Enzyme-treated SPC	Alcohol-extracted SPC	SPI
Humidity	%	10–12	10–12	6–7	6–7	6–7
Crude protein	%	33–37	42–50	55–60	63–67	<85
Fat	%	17–20	0,9–3,5	2,5	0,5–3,0	0,1–1,5
Ash	%	4,5–5,5	4,5–6,5	6,2–6,8	4,8–6,0	2,0–3,5
Oligosaccharides	%	14	15	<1,0	<3,5	<0,4
Stachyose	%	4–4,5	4,5–5	<0,3	1–3	<0,2
Raffinose	%	0,8–1	1–1,5	<0,2	<0,2	<0,1
Verbascose	%	–	0,3–0,4	–	–	–
Trypsin inhibitors	mg/g	25–50	1,6–5,0	1–2	2–3	<1
Glycinin	mg/g	150–200	20–70	<0,01	<0,1	<0,01
B-conglycinin	mg/g	50–100	3–40	<0,01	<0,01	<0,005
Lectins	ppm	2 100–3 500	20–600	<1,0	<1,0	<1,0
Saponins	%	0,5	0,6	0	0	0
Phytic acid bound	%	0,38	0,42–0,49	0,6	0,6	–

Source: Van Eys, 2015

United Soya Bean Board

Soya bean products' quality can be improved through processing, but the quality of the soya bean itself plays an important role.

The United Soya Bean Board (USB) has embarked on a quality improvement programme. Their objectives are to accelerate the availability of advanced compositional traits and focus on the needs of meal and oil users. They aim to enhance demand for quality soya beans, increasing levels of selected essential AAs, improving balance and AA digestibility and reducing selected carbohydrates as well as improving phosphorus availability.

Aquaculture

Fishmeal is becoming an increasingly expensive variable supply due to a long-term decline in fishery resources. It contains the lowest fibre and highest protein levels.

Cellulose in soya bean hulls is not digestible to fish and will degrade pellet quality and water stability of finished feed. Removal of 5% indigestible fibre and ash from non-dehulled SBM increases digestible energy by more than 150kcal/kg.

Due to its processing method, SBM has lost significant oligosaccharides and antigens. It can successfully replace fishmeal and animal protein in pig weaner diets. (Zoot and Stein, 2013).

Enzymes

Protease can improve the nutritive value of commercial solvent-extracted SBM. Protease isolated from different species determines the improved performance of the SBM (Ghazi, 2002 and 2003). A combination of protease and phytase additively improves the performance of maize soya diets (Aureli et al., 2015). Mono component protease has been shown to improve ileal digestibility of SBM in commercial laying hens (Angel et al., 2015).

It has been demonstrated that proteases can degrade Kunitz and Bowman-Birk inhibitors as well as lectin. Protease can degrade protein in SBMs with various levels of anti-nutritional factors. Improvement is greater for less digestible sources (Nasser-Odetallah, 2015).

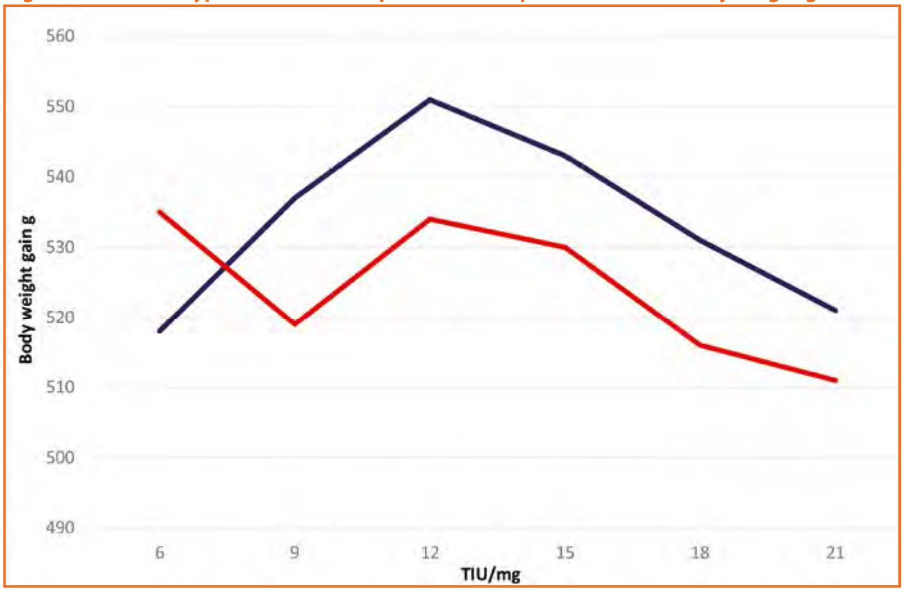
Potential effects are reduced challenge to the pancreas, better access to sulphur AAs, less stress on intestinal epithelial tissue and improved feed conversion.

Including by-products

Hulls, gums and soapstock reduce the nutritive value and consequent animal performance when using resultant meal (Bruce et al., 2006). Previous studies have indicated that particle size can influence gizzard development and retention time of feed (Ferket, 2000) and digestion could be improved (Bjerrum, 2005).

Recent research conducted with expeller soya bean found significant effects of particle size on broiler performance. Particle size had a similar magnitude of response in body weight gain (BWG) as a significant change in trypsin inhibitor activity (*Figure 1*).

Figure 1: Effect of trypsin inhibitor and particle size expeller of SBM on body weight gain.



Source: Pacheco, et al. (2014)

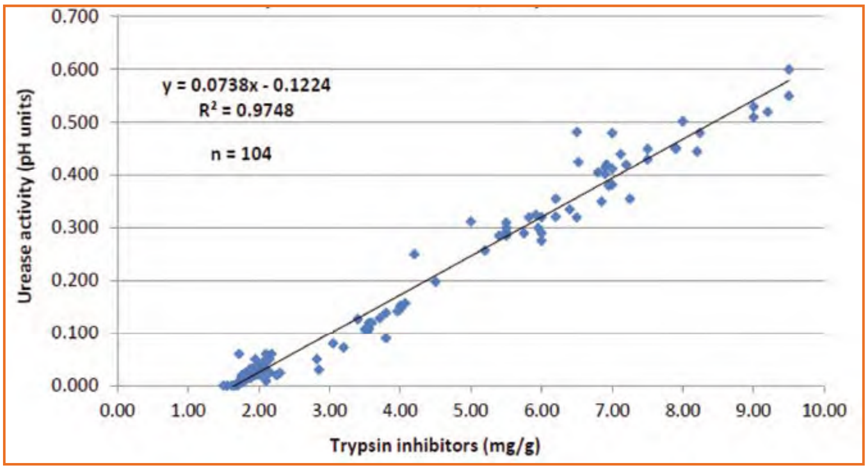
Trypsin inhibitor activity

Trypsin inhibitors block endogenous proteases trypsin and chymotrypsin, and reduce protein digestion and increase endogenous losses. The effects of trypsin inhibitor activity (TIA) are more pronounced in young animals. Older animals are capable of compensation for the loss of trypsin activity by enlarging the pancreas.

Although TIA is extremely important, it should be considered that, according to Kakade et al. (1974), 60% of growth inhibition of raw soya beans can be ascribed to anti-nutritive factors other than trypsin inhibitors. Among them are lipase inhibitors, goitrogens and haemagglutinins.

Ruiz and Belalcázar (2002) and Ruiz (2012) concluded from poultry performance in various South American countries that to avoid rapid food passage, TIA should be lower than 3,5mg/g. However, lower TIA levels improved bird performance, and optimal levels would be below a level of 2,5mg/g TIA. This should correspond to a urease index below a maximum of 0,05 (*Figure 2*).

Figure 2: Trypsin inhibitors vs urease activity.



Source: Belalcázar and Otálora, 2012

When interpreting trial results and data on TIA responses, the two main different testing methodologies and units of expression should be considered, as currently there is no statistical conversion factor between these methodologies. They are the American Oil Chemists' Society (AOCS) method 2011b with the trypsin inhibitor units (TIU/g), mainly used in the United States (US), versus ISO 2001, mainly used in the countries other than the US, expressed in mg/g trypsin inhibitor. The AOCS method delivers results with higher readings than the ISO 2001 method.

Ileal amino acid digestibility

Ileal digestibility of AAs was found to be lower for deliveries into Europe of Argentine versus US and Brazilian meal, despite no significant difference in TIA content of the meals.

Data suggested that the tested Argentine meals were processed under more severe conditions than the US or Brazilian ones, resulting in lower TIA content, but also a higher incidence of the Maillard reaction. This was consistent with lower potassium hydroxide (KOH) solubility values observed for Argentine meals.

KOH solubility was the best predictor of ileal digestibility of crude protein and lysine (Lys). The study emphasised the differences in nutritive value among commercial sources of SBM. A higher crude protein content has a positive effect on AA digestibility (Frikha et al., 2012).

There is a fine line between under- and over-processing. Care must be taken to sufficiently heat the SBM, but heat damage affects AA digestibility. NIR methodology could be used to detect over-processing effect on AA digestibility (HI). Supplementation of AAs can restore performance of over-processed SBM (Wiltafsky, 2013).

Protein dispensability index

Protein dispensability index (PDI) has been widely used in the food industry for over 30 years. This test will further distinguish the quality of SBM that is considered of high quality, based on already acceptable urease KOH and TIA.

> **Heat treatment only affects heat-sensitive molecules such as trypsin inhibitors.**

Globally there are crushing plants that market 'high-performance' SBMs with PDI values of 30 to 50%, low urease values, pH below 0,05 and KOH above 90%.

Geographic location of soya bean production has the most significant effect on soya bean nutrient content, followed by soya bean variety. Management and analysis of soya beans at intake, as well as processing conditions, are critical to deal with soya bean variation, particularly in South Africa where soya beans are sourced from varying climatic regions.

Broiler growth studies conducted at the University of Pietermaritzburg to 21 days of age indicate that, although not at a statistically significant level, there is a numerically large difference in growth of SBM from various processing origins. The growth difference between local SBM s was 70g at 21 days.

Trypsin inhibitor levels (TIU/g) were five times higher in some domestic meals versus the lowest, which had comparable TIA to imported Argentine SBM. Trial data also suggests that if the best quality South African SBM replaces its Argentine counterpart used in this trial which is of a typical imported consignment, bird performance is equal or superior.