By Brett Roosendaal, Rainbow Farms Pty Ltd

The use of SOYA BEAN MEAL in the South African poultry industry

Formulation and quality considerations

Soya bean meal is the main source of dietary protein for poultry in South Africa and many parts of the world. The increased use of vegetable protein meals in animal feed has been brought about through consumer pressure for more sustainable and welfare-oriented animal protein production. The increased use of vegetable protein sources has highlighted the importance of protein quality, and the methods used to control quality have increased proportionately.

This is particularly evident in the case of chicks, where protein quality is a major factor in early growth and performance, but is equally important in the feeding of older birds, where feed cost and conversion are the determining economic parameters. Feed manufacturers use the quality criteria and its consistency as the primary reason for selected soya bean meal from a specific supplier.

Heat treatment

Soya bean is an excellent source of protein as alluded to above. However, its potential can only be achieved after heat treatment. Heat labile anti-nutritional factors present in soya beans, including protease inhibitors, lectins, goitrogens and anti-vitamins, can cause growth inhibition, decreased feed efficiency, goitrogenic responses, pancreatic hypertrophy, hypoglycaemia and liver damage in poultry, depending on age, sex, health status and plane of nutrition.

Raw soya beans are known to contain two separate protease inhibitors:

- Proteins with a molecular weight of about 20 000Da and a specificity directed primarily against trypsin, known as the Kunitz trypsin inhibitor.
- Those that have a molecular weight of between 6 000 to 12 000Da and are capable of inhibiting chymotrypsin as well as trypsin at independent sites, referred to as the Bowman-Birk trypsin inhibitor.

The second of the major anti-nutritional factors are lectins. Lectins are glycoproteins with the ability to bind carbohydrate-containing molecules on the epithelial cells of the intestinal mucosa, with toxicity determined by the extent of binding.

Differentiation

Different sources of soya bean meal products are marketed to and used in the animal feed industry. The chemical composition of soya bean meals of different origins are given in *Table 1* (Mateos *et al*., 2011, 2012).

Table 1: Chemical composition of soya bean meal from different origins.

	n	DM	CP	CF	NDF	EE	SUC	STA	RAF
Argentina	136	88,5	45,4^{c}	4,8^{b}	9,2^{b}	1,7^{ab}	6,7^{b}	4,9^{b}	1,1^{b}
Brazil	131	88,6	46,6^{b}	5,5^{a}	10,6^{a}	1,8^{a}	5,7^{c}	4,6^{c}	1,4^{a}
USA	164	88,6	47,3^{a}	3,8^{c}	7,8^{c}	1,6^{b}	7,2^{a}	5,7^{a}	1,0^{c}
SEM		0,08	0,12	0,08	0,13	0,04	0,08	0,04	0,03
P		NS	***	***	***	**	***	***	***

n – no. of samples; DM – dry matter; CP – crude protein; CF – crude fibre; NDF – neutral detergent fibre; EE – ether extract; SUC – sucrose; STA – stachyose; RAF – raffinose.

Specifications such as these may vary among organisations and regions, and although they provide a solid basis for commercial transactions they are inadequate and of limited value when formulating diets.

Nutritional aspects

Soya bean meal inclusion in poultry diets is determined largely by the nutrient specification of the diet to be formulated, as well as the price. Other considerations that impact the inclusion of soya bean meal are the use of alternative proteinacious ingredients, sought animal performance levels and level of technological treatment (processing).

Soya bean meal is used as a protein source, and therefore the most important criteria for its use is the level of digestible amino acids. *Table 3* gives an indication of nutritional composition of soya bean meals for poultry (Mateos *et al*, 2011). They are often completed with additional quality recommendations as indicated in *Table 2*.

Table 2: Recommended quality measurements for soya bean meal.

Ash	Less than 7,5%
Acid insoluble ash (silica)	Less than 1%
Protein solubility index (0,2% KOH)	75 – 85%
Protein dispersibility index	15 – 40%
Urease activity	0,00 – 0,05 pH unit rise
Trypsin inhibitor activity of meal.	Less than 3mg/g
Bulk density	57 – 64 g/100ml
Screen analysis	95% through a #10 mesh 40 – 50% through a #20 mesh 6% maximum through a #80 mesh
Colour	Uniform particle colours of light tan to light brown
Taste	Bland
Contaminants	Free from urea Free from melamine Free of ammonia Free from heavy metals Free from Salmonella Free from mycotoxins and mould

Table 3: Amino acid composition (% of protein) of soya bean meals per origin.

	ARG	BRA	USA	SEM	P
n	112	119	161		
Lysine	6,09^{b}	6,06^{c}	6,16^{a}	0,005	***
Methionine	1,36^{a}	1,33^{b}	1,36^{a}	0,002	***
Cysteine	1,51^{a}	1,48^{b}	1,50^{a}	0,004	***
Threonine	3,93^{a}	3,88^{b}	3,91^{a}	0,003	***
Tryptophan	1,37^{a}	1,34^{c}	1,36^{b}	0,001	***

The variation in amino acids, as shown in *Table 3*, is closely related to fibre levels and to a number of anti-nutritional components. While fibre may account for the dilution effect between the two meals, differences in heat treatment still present one of the major sources of variation within types of soya bean meals.

Quality variation and control methods

Variation in protein quality among samples of soya bean meal can occur due to either insufficient heating (under-processing) or excessive heating (over-processing). The following test methodologies are used to assess the quality of soya bean meal:

Urease: The presence of active trypsin can be indirectly determined by measuring the activity of urease enzyme present in soya. Both trypsin inhibitor and urease proteins are denatured and deactivated during heating. Urease, unlike trypsin inhibitors, is easy to measure, and because of it, it is used as a marker of trypsin inhibitor activity. Although the urease test is routinely done and often used in contract specifications, the results do not correlate well with animal performance.

KOH protein solubility: Protein solubility in a 0,2% KOH has been shown to be a good indicator of in vivo protein quality for over-processed soya bean meal (Araba and Dale, 1990a; Parsons *et al*, 1991). The KOH solubility assay was also reported to be useful for detecting under-processing of soya bean meal (Araba and Dale, 1990b). However, Anderson-Hafermann *et al* (1992) later concluded that this assay was not very accurate for assessing under-processing of soya bean meal. KOH results indicate that samples with high values are most digestible as long as urease activity is below the upper recommended limit.

Protein dispersibility index: The PDI assay has been used for at least 25 years in the food industry. Recent investigators have examined the value of the PDI to predict growth of chicks fed various samples of soya bean meal. Results suggest that the PDI is useful to further distinguish the quality of soya bean meal that is otherwise considered to be of good quality based on the urease and KOH measurements. Soya bean meal with a PDI between 45 and 50% and urease of 0,3 pH unit change or below indicate extremely high quality, adequately heat processed but not over-toasted meal (Batal *et al*, 2000).

The measurement of the trypsin inhibitor activity (TIA) appears not be that common. However, data from the literature indicates that activity levels of between 30 and 40mg/g of soya bean meal indicates raw meal and levels lower than 5mg/g as being acceptable for young animals (Clarke and Wiseman, 2001). The use of this quality control method for soya bean meal routinely is probably related to the complexity of the analysis as well as the time required.

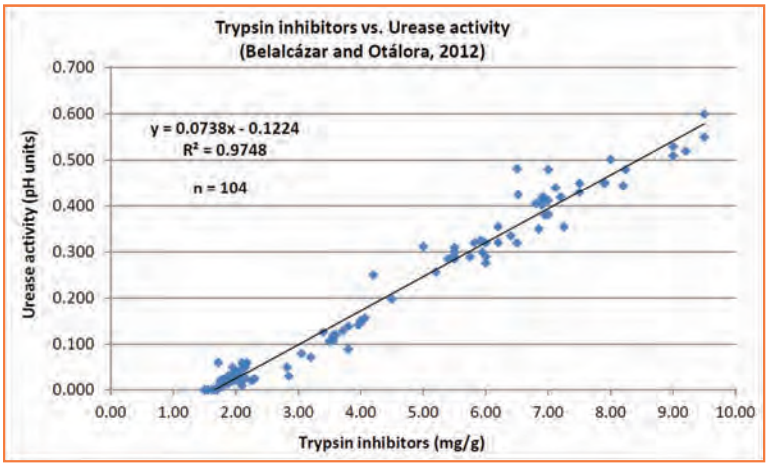
More recent data from 2005 (Ruiz and Belalcazar, 2005; Ruiz et al, 2008; Ruiz, 2012) indicated that excess intake of trypsin inhibitors in feed fed to broilers led to rapid feed passage. The authors further developed a regression equation, which can assist with interpretation and is indicated in *Figure 1*.

Table 4: Protein quality of soya bean meals according to origin.

	n	Urease	TIA	KOH	PDI
ARG	118	0,02^{b}	2,5^{b}	82,2^{c}	16,7^{b}
BRA	125	0,03^{a}	2,6^{b}	82,9^{b}	15,4^{a}
USA	164	0,02^{ab}	3,1^{a}	86,8^{a}	19,7^{a}
P		**	***	***	***

Urease activity is very low for all samples, independent of country of origin. Using the most recent data available and extrapolating the results from these trials, it appears appropriate to re-access the ranges for the quality criteria. A summary of quality control tests with limits is provided in *Table 5*.

Figure 1: Trypsin inhibitors versus urease activity.



Serrano et al (2012) and Serrano *et al* (2013) found no differences in broiler growth performance on four different soya bean meals tested. However, the TIA levels were below 2,7mg/g. Mateos et al (2013) and Frikha *et al* (2012) compared soya bean meals from three different origins (see *Table 4*).

Conclusion

Commercial specifications of soya bean products provide limited information on soya bean meal for diet formulation, detailed nutritional specifications are required. Table values are inadequate since bioavailability will vary with origin, variety and production conditions. Within a specific soya bean meal product, major variation in digestibility can and will occur with degree and quality of processing.

Current methods used by the industry to evaluate soya bean quality are not capable of detecting differences between sources. Using a combination of quality criteria and not a single parameter appears the most appropriate when interpreting data.

For more information, contact Brett Roosendaal at Brett.Roosendaal@rcf.co.za.

Table 5: Summary of quality control tests for heat-treated soya bean meal.

Test	Principal	Duration	Skill level	Accuracy	Measurement	Recommended values
Urease Index	Heat denatures urease and thus anti-nutritional components, mainly an indicator of under-heating.	20 min	Low	Average	pH increase due to ammonia release	0,00 – 0,05
0,2% KOH solubility	Over-heating reduces N solubility in 0,2% KOH quantification of over-heating.	20 min	Low/Ave	Average	Protein solubilised	75 – 85%
PDI	Heating reduces N solubilisation in water, quantification of under-heating.	10 min	Low/Ave	Good	Protein solubilised	15 – 45%
TIA (Trypsin Inhibitor Activity)	Direct measurement of trypsin inhibitor, also indicator of all anti-nutritional components.	>24 hours	High	Good	Presence of trypsin inhibitors	< 3mg/g
Dye-binding (cresol red – soy-check)	Measures lysine (free epsilon amino group), reduced by overheating.	<10 min	Low	Low	Dye binding related to protein solubility	5 – 6,5mg/g