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Trypsin inhibitor activity in soya bean meal and its effect on broiler performance

Growth depression effects on poultry due to antinutritional factors present in soya beans, have been well documented for over 50 years. Trypsin inhibitors are the primary antinutritional factor in soya bean meal (SBM), which is a globulin-type protein. Trypsin inhibitors inhibit the conversion of zymogens to active proteases of trypsin and chymotrypsin. In addition to their detrimental effects on proteolytic action, trypsin inhibitors dramatically affect the size of the pancreases and amount of trypsinogen produced.

The requirement to heat treat soya beans has been understood for nearly a century. The pH rise was adopted as the common method of determining adequate heat. A change in pH above 0,2 pH units is considered underheated. Animal feed manufacturers in Brazil use 0,3 pH units as the upper limit of SBM processing.

It has been established that a pH unit change of zero is not an adequate measure of overprocessing, but that if it is between zero and 0,05, the SBM has been adequately processed. This is a level considered ideal and should be strived toward. It must be noted that heat treatment of SBM only destroys those antinutritive factors that are heat-labile.

High correlation expected

As recently as 2001, standardised tests were established for trypsin inhibitor analyses. The correlation between trypsin inhibitors and urease activity is expected to be high. Urease activity is still the methodology of choice for measuring the acceptable estimation of the trypsin inhibitor content in SBM.

It is unclear what the optimum residual concentration of trypsin inhibitors should be. Work published as far back as 1991 shows a linear response between bird performance, body weight gain (BWG) and feed conversion, and levels of trypsin inhibitor activity (TIA) (mg/g) in soya bean in the ration. There still seems to be considerable uncertainty regarding these levels. As recently as 2014, Pacheco et al. showed optimal bird performances at TIA of 6,7mg/g rather than the lowest value of 3,6, which was also fed as a treatment.

Response of performance to TIA did not appear linear in this trial. Ruiz (2012) observed that if feed contained high levels of SBM with a TIA of more than 3,5mg/g or urease activity above 0,06 pH units, rapid feed passage outbreaks could occur (observation not a trial), detrimentally affecting bird performance.

Genetic potential

TIA tests are expensive and time-consuming, with a repeatability standard deviation of 0,27 (Sueiro, 2015). Considering the correlation found by Belalcazar and Otalora (2012) as quoted by Riaz (2012) (0,0738x – 0,1224 with an R2 = 0,9748), it has been proposed that the urease index should continue to be used in conjunction with TIA – a more rapid test for underprocessing, but a figure as low as zero is not an indication of overprocessing.

The genetic potential of the modern-day broiler has resulted in broilers being slaughtered at an earlier age each year, also resulting in a continuous improvement in gain-to-feed ratio. Diets have become more nutrient-dense, since high-density diets not only achieve maximum performance but have become synonymous with optimal performance.

Globally, soya bean processing has improved with the consequential improvement in SBM quality. The measurement of SBM quality is extremely complex and starts with proximate analysis, higher protein levels obviously still being the major economic value driver of SBM. The ratio of amino acids to protein also differs depending on the source of SBM – the main influence on this being the composition of the soya bean used in processing.

Digestibility of nutrients is critical

and affected by many criteria other than heat-sensitive antinutritive factors, such as levels of lectins, mannans, raffinose and stachyose. Lower fibre levels have therefore been required.

The nutrient profile differs among the various sources of SBM. Higher protein not only increases the quantity of essential amino acids, but there is solid evidence that amino acid digestibility improves as the protein content of the SBM increases.

Conclusion: SBM quality is determined by many other factors other than TIA level. The global industry still considers urease index as the appropriate measurement for underprocessing. Levels have been driven down to below 0,1 urease index to ensure sufficient processing. SBM with a higher TIA may have significantly higher digestible amino acid levels, irrespective of TIA value.

Testing methods

The international standard method for the determination of soya products is ISO 14902, when compared to the American Association of Cereal Chemists (AACC) standard AACC 22-40.01 as modified by Hamerstrand in 1981 and expressed as mg of inhibited trypsin per gram of sample. TIA values according to ISO 14902 result in significantly lower values than the previously mentioned method. These methods are not directly comparable (Sueiro et al. 2015). The particle size of samples during analysis was found critical.

Conclusion: The testing method needs to be clearly stated and understood when TIA levels vs performance is quoted. Particle size is of critical importance.

Overprocessing

TIA unfortunately does not measure overprocessing of SBM and is something which is of definite concern. There is compelling evidence that overprocessed SBM would lead to reduced broiler performance (Wiltafsky, 2013). The lower the TIA, the higher is the risk of overprocessing and reduced amino acid availability.

Conclusion: TIA is not a measure of overprocessing, but has become a key criterion with regard to SBM quality. Lower TIA is a higher risk of overprocessing.

Broiler performance and TIA

In studies conducted on SBM of various origins, it has been found that United States (US) SBM with a TIU/mg of 2,52 (urease 0,08) versus that of Argentina with a TIU/mg of 1,98 (urease 0,007) exhibited a better crude protein (CP) digestibility and an 88% lysine (Lys) and 88% methionine (Met) digestibility, versus Argentina at 86% digestibility.

The lower potassium hydroxide (KOH) level of 78% for Argentine SBM tended to overprocessing, which could have resulted in lower amino acid digestibility (Ravindran 2014). US SBM consistently resulted in better broiler performance due to its protein quality, despite higher TIA levels.

Gous (2016) replaced Argentine (Molinos) SBM with a TIA of 1,28, with South African SBM with a TIA of 3,04. Although not statistically significant, the South African SBM had a numerically better feed conversion of 0,05 and superior BWG of 45g at slaughter for Ross broilers.

This could be ascribed to the higher protein content and quality of our local SBM, and clearly corroborates what has been experienced commercially that high-quality South African SBM not only performs as well as Argentine-imported meal in broiler rations, but can demand a premium due to its higher digestible nutrient content.

Conclusion: There is no trial work in the literature which demonstrates that a difference of one TIA mg/g will have any significant effect on broiler performance at low levels of TIA. Such trial work still needs to be done. Contrary to this significant difference in broiler performance, it has been found between SBMs with the same TIA levels.

Particle size

In the US, Pacheco (2014) concluded that when using expeller SBM there was not a linear response in bird performance to TIA. A curvilinear response for both feed conversion and BWG was experienced. The particle size of the SBM had a greater effect on bird performance than the TIA.

Conclusion: Particle size of SBM could have as significant an effect on broiler performance as TIA. Broiler performance response to TIA is not necessarily linear.

Enzymes

There is compelling evidence that the use of various enzymes – mainly protease, pectinase and phytase – could positively influence the negative effects of antinutritive factors in SBM, further complicating the correlation between TIA and bird performance (Stefanello, 2012), (Aureli, 2013) and (Faruk, 2013).

Conclusion: Enzyme inclusion and their combinations could have a significant effect on TIA level, which will affect broiler performance.

Uniformity

Uniformity of SBM is considered globally and by the local feed industry to be an important criterion. At the beginning of soya bean volume crushing in South Africa, it presented a challenge due to the restricted continuity of processing. This aspect has been improved considerably, so much so that major end users of certain locally produced material are starting to report subtle differences between Argentine- and South African-produced SBM uniformity.

Conclusion: High-quality South African SBM, if produced in large consistent volumes, can obtain the uniformity experienced by Argentine suppliers.

TIA in full-fat and expeller SBM

It can be confirmed that laboratories testing TIA are very comfortable to analyse for TIA in soya bean, full-fat soya, expeller SBM and solvent-extracted SBM. TIA tends to be higher in full-fat and expeller SBM, but they can confirm this is not due to the TIA test but the fact that trypsin inhibitor content of these raw materials is generally higher than solvent-extracted SBM, due to the fact that they have not been heat-treated to the extent that solvent-extracted SBMs are. Despite this, they can still deliver good broiler performance to the same extent that moderately higher TIA SBMs can.

Conclusion: TIA analysis can be performed equally well on soya beans, full-fat soya, expeller oilcake and solvent-extracted meal. TIA limits are applicable to all soya bean protein sources.