Key drivers of soya bean product quality for feed use in South Africa

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The Oilseeds Advisory Committee funded a study undertaken by the Bureau for Food and Agricultural Policy (BFAP) to investigate the drivers of soya bean product quality for feed use in South Africa.

The livestock industry in South Africa consumes an estimated 1,2 million tons of soya bean meal per annum. The soya bean meal is either procured locally or imported. Over the past few years, there has been a slow but steady trend within the local feed industry from using imported to domestically produced soya bean meal, as the domestic soya bean crushing industry matured.

To include locally produced soya bean meal in their formulations/rations, the feed industry requires a reliable and consistent supply of soya bean meal that has been properly processed to eliminate anti-nutritional factors, and which furthermore meets quality standards for oil and protein content. In addition, the locally produced soya bean meal should be competitively priced, especially for feed mills in coastal areas where deep-sea imports may be cheaper.

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Soya bean composition limits

The feed industry requires a minimum of 46% protein in soya bean meal (with 12% moisture content). Furthermore, feed must conform to the *Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act, 1947 (Act 36 of 1947*). Soya bean composition establishes the limits for soya bean meal composition – i.e. protein and oil content of the soya bean itself are the starting point for protein content bounds of the finished soya bean meal.

Thus, shifting the focus from increasing yield per hectare to increasing the oil and protein content, as well as preserving quality during processing, could benefit everyone in the soya bean supply chain, from the farmer, silo owner and crusher to the feed/food manufacturer.

Product quality at farm level

At farm level, it is known that several factors influence yield, protein and oil content of soya bean seed. Since factors such as longitude, altitude, environmental temperature (heat units) and rainfall play major roles in determining the quality of seeds produced, it is apparent that soya bean producers have only a limited capacity to influence the oil and protein contents of seeds.

Nevertheless, seed inoculation before planting, the judicious application of nitrogen and micro-elements, and the choice of variety and planting time can be managed by the farmer to contribute to the quality and yield of soya beans.

Although the national cultivar trials measure the oil and protein content of seed, most of the emphasis is on yield parameters. Furthermore, unlike some cultivars advertised in Brazil, soya bean seed cultivars advertised in South Africa are not accompanied by any information on oil or protein content parameters.

Breeding for soya bean seed composition traits is a complicated process and, to underline this, the major function of protein meal in nutrition is to supply sufficient amounts of essential amino acids – therefore, merely taking soya bean protein content into account is likely not sufficient. However, a combination of conventional breeding strategies and genomic approaches can aid breeding for improvement of seed composition traits.

Product quality at silo level

South Africa has only two grades for soya bean seed which are based on a few physical aspects. At silo level some silo owners have invested in NIR equipment that could potentially inform on quality aspects, such as oil and protein content of delivered seed.

However, based on the current grading regulations there is no requirement for these measurements. Furthermore, no reference to a quality-based incentive system (e.g. price premiums for higher oil and/or protein content) has been found in reference to the soya bean industry, locally or internationally.

Due to logistical challenges at silos, the different soya bean seed qualities cannot be kept separate in the downstream value chain. Thus, there is no sufficient quality-based (oil and protein content)

grading system in place to take these aspects that are important to the feed industry further in the value chain.

Product quality at crushing level

In an ideal world, a sourcing strategy at crushing level would aspire to quality-based sourcing to increase efficiencies and profitability of crushing operations. However, South Africa's soya bean industry is not fully mature yet and occasionally experiences shortages. This renders a quality-driven sourcing strategy from a crushing perspective impractical in the current market environment.

> Full-fat soya, solvent extracted and extruded soya bean meal are three completely different products that are not interchangeable.

Some crushers have explored the methodology of buying soya beans directly from farms or regions known to have good quality soya beans. This way, they can implement quality control, and pay a premium for higher and more consistent oil and protein levels (e.g. irrigation soya beans). However, this can only be done during the harvest season, as any surplus soya beans are then stored in silos (where they lose their identity) until they are crushed.

Table 2: Solvent meal vs extruded meal vs full-fat soya. (Source: BFAP industry interviews)

	Protein content	Oil content	Fibre
Solvent soya bean meal	46,5%	2%	Max 4%
Extruded soya bean meal	42,5 to 43,5%	5 to 7%	Max 6%
Full-fat soya bean meal	36 to 37,5%	15 to 18%	Max 6,5%

Outside of the soya bean harvesting season, crushers' sourcing options are significantly constrained and 'crushing something' – even if the best-priced available soya bean is of suboptimal quality – is preferrable to 'not crushing'. *Table 1* provides a high-level summary of local and imported soya bean characteristics and pricing.

Soya bean seed destined for processing is inevitably of variable quality. Therefore, processors test for this variability, most using NIR technology, and they adjust their processing practices accordingly. Mostly the soya bean seed is tested for moisture, crude fibre, crude protein and oil content.

Processing of soya beans

Full-fat soya, as well as solvent extracted and extruded soya bean meal are three completely different products that are not interchangeable. Full-fat soya is an energy and protein source (containing all the oil originally in the bean), while solvent extracted soya bean meal is mainly a protein source (most of the oil has been extracted). Extruded soya bean meal is a midway where some of the oil has been extruded, but the result is less energy-dense than full-fat soya and lower in protein than solvent meal (*Table 2*).

In South Africa, the majority of soya bean seed is crushed and processed by solvent extraction to remove around 99% of the oil content. The majority of soya bean meal produced is consumed by poultry, followed by the swine, beef, dairy, pet-food and aquaculture industries.

Soya beans must be thermally processed to destroy anti-nutritional factors and increase oil availability while preserving the nutritional quality of the protein. The crusher greatly contributes to the nutritional value of the soya bean meal by reducing the bioactivity of anti-nutritional soya bean proteins through the proper use of heat during processing.

Processing challenges

The challenge with processing is that sufficient heat must be applied during processing to denature the anti-nutritional proteins thereby rendering them biologically inactive, but not to the extent that the soya beans are overheated, resulting in lower digestibility of the protein.

Table 1: Comparing local to imported soya beans. (Source: BFAP industry interviews)

	Local soya beans*	Imported soya beans
Protein content	34 to 38%	39 to 40%
Oil content	14 to 19%	>18% (usually >20%)
Other considerations	Consensus that yield and protein content have improved, but that there's space for improvement on consistency in protein content. Local seed has a high-quality variation regarding: ● Growing regions. ● Between seasons (e.g. drought vs normal climate). ● Within seasons (increasing quality towards end of the season).	Some reports of lower protein and oil content levels and high free fatty acids in imported seed. Reports of soya beans that were dried resulting in a darker colour and negatively affected oil content.
Pricing (average 2019/20)	R 7 173,06/ton	R 7 828,51/ton

**Local processors report that beans are bought at a discount of R200 to R450 to import parity due to supply and demand dynamics.*

Table 3: Potential mitigations for soya meal. (Source: BFAP industry interviews)

Parameter	Crusher mitigation	Feed mill mitigation
Protein	• Dehull beans. • Blend meal. • Manipulated with the oil, fibre and moisture content of the beans. • Sometimes sell for discount.	• Adjust formulation. • Add other protein source. • Add amino acids. • Apply for discount.
Over-processed	• Decrease cooking time. • Dehull (limited for cold dehulling). • Blend (only small volumes). • Sometimes sell for discount.	• Downgrade digestibility, and apply for discount and add probiotics. • Only see effect later, calculate effect and talk to supplier.
Under-processed	• Increase cooking time. • Dehull (limited for cold dehulling). • Blend (only small volumes). • Re-process bit by bit.	• Downgrade digestibility, and apply for discount and add probiotics.
Meal size		• Mill again.

Several factors must be continuously managed to consistently achieve proper processing, including the combination of heating time and temperature. Therefore, feed manufacturers require reliable methods to differentiate between under- or overprocessed soya bean meal.

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In South Africa, most feed manufacturers make use of in vitro analysis to assess soya bean meal quality before formulating. Some believe that the combination of the KOH and PDI test gives the best representation of soya bean processing quality. Stakeholders in the industry disagree on which test is the best indicator, but agree that a single test is not indicative by itself, and most prefer to conduct a combination of tests to achieve reliable results. However, this has cost and time implications.

Many feed mills have a system where some of the basic tests are conducted on all soya bean meal loads delivered before off-loading, e.g. urease, KOH and PDI. More complex tests, such as TIA or reactive lysine, are determined as required for a broader continuous improvement process in collaboration with the suppliers who also test deliveries before selling.

Product quality at feed mill level

At feed mill level processing consistency is the most important factor. It is even more important than protein content as there is no proper mitigation for incorrectly processed meal at feed mill level. Most South African feed mills prefer solvent soya bean meal and add oil (i.e. sunflower or soya bean oil), which is a major energy source, separately because this enables them to better control energy and protein levels and the associated costs when formulating feed.

> Soya beans must be thermally processed to destroy anti-nutritional factors and increase oil availability, while preserving the nutritional quality of the protein.

However, some feed mills cannot add oil separately during their milling process because they do not have a liquidating system. These feed mills often use full-fat soya bean meal. In general, the use of full-fat soya bean meal in feed formulations has not been as popular because feed mills had difficulties procuring sufficient, reliable, good quality sources at competitive rates. This can in part be ascribed to full-fat crushing plants being operated at smaller scales, namely 5 000 to 50 000 tons per annum in contrast to solvent plants with levels of 50 000 to 600 000 tons per annum.

Nevertheless, in recent years some feed mills have overcome these supply-chain challenges and include full-fat soya and extruded meal in their feed formulation. In addition, they have come to prefer it to regular soya bean meal due to its higher energy contribution.

Soya bean meal comparisons

International soya bean meal quality comparisons found that soya bean seed and soya bean meal composition varied depending on the country of origin and where they were processed. Most of the soya bean meal that has been imported to South Africa for the last 20 years, has been produced by Molinos in Argentina.

Table 4: Proposed quality measurements and minimum standard for soya bean meal. (Source: AFMA personal communication)

Quality parameter	Minimum standards
Minimum protein	46%
Maximum moisture content	12%
Maximum ash content	6,5%
Acid insoluble	1,5%
Maximum fibre content	5%
Fat basis content	2% (maximum 2,5%)
Particle size	10mm maximum with no lumps
Maximum urease activity	0,15%

Several trials evaluating and comparing imported soya bean meal to locally produced meal in recent years, have indicated that locally produced soya bean meal is not inferior to imported meal.

The soya bean meal is regarded as very high quality, delivering excellent animal performance and as such has been historically regarded to be the 'gold standard' in South Africa. Consequently, some stakeholders maintain that the imported meal from Argentina has better consistency, with set specifications, including processing quality indicators.

On the other hand, each South African crusher has different processing equipment and methodologies. This results in a wider product range. Furthermore, the products of newer plants are reportedly more consistent over product batches and are thus conceived to deliver better-quality products.

Quality of local soya bean meal

Several trials evaluating and comparing imported soya bean meal to locally produced meal in recent years, have indicated that locally produced soya bean meal is not inferior to imported meal, based on proximate analysis, quality tests and broiler performance. Some South African stakeholders even state that they believe that South African soya bean meal is even better than the Argentinean imports in terms of quality.

If the produced soya bean meal's protein content is below the specification, crushers can blend the meal with higher protein meal. However, this can only be done up to a point if the protein content is not too low. Often this blending process leads to inconsistent feed as the amalgamation process is never perfect. The protein content should rather be manipulated with the beans' oil, fibre and moisture content. For example, by removing more moisture and fibre in the beans, the protein level is increased.

From a feed formulation perspective, shortcomings in raw materials used in feed formulation such as soya bean meal can be corrected to some extent using additives. The most common is the addition of synthetic amino acids, enzymes, pro- and prebiotics. However, the cost of additives is high, and they cannot mitigate all the negative effects of poorly processed soya bean meal. *Table 3* presents potential mitigations for soya bean meal.

Quality standards for soya beans

Over the past few years, significant work has been done through close collaboration between crushers and feed manufacturers to improve the crushing process and its delivered product, especially to lower the trypsin inhibitors and deliver a 46,5% protein meal.

Soya bean meal has become the choice ingredient as protein source in poultry diets. Within the regulatory framework to date (February 2021), no official reference is made towards a required minimum protein and/or oil content of soya beans. Thus, the industry is, along with developing a soya bean meal futures contract to be listed on SAFEX, in the process of developing quality standards for soya bean meal.

Table 4 presents preliminary minimum quality standards for soya bean meal as proposed by the Animal Feed Manufacturers' Association (AFMA). To measure the standards, approved analytical methods must be used, i.e. AOCS, ISO or AOAC. Currently, there are no regulatory mechanisms that police these minimum standards. However, a recent study undertaken by BFAP has found multiple reports of self-regulation regarding soya bean product quality specifications, as well as close collaboration between large off-takers and suppliers towards improving the quality and consistency of soya bean products.

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