GETTING MAXIMUM QUALITY from full fat soya

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Soya beans prior to oil extraction are referred to as full fat soya beans. Properly processed full fat soya beans are a valuable feed ingredient because of their energy, protein, linoleic acid, vitamin E and lecithin contents.

There are a number of different products on the international market being sold as full fat soya bean meal. These products are produced by a variety of processes, all of which have a different impact on the nutritive value of the product and its quality in terms of anti-nutritional factor levels. The focus of this paper is using extrusion technology to process quality full fat soya beans for animal feeding.

Soya beans are the most important crops in the world and are grown for a variety of agricultural and industrial uses. There are eight major oilseed meals in the world. Soya bean meal represents more than 50% of the total oilseed meal production.

Raw soya beans cannot be used as such for animal feed or human food, because they contain several different anti-nutritional factors such as:

- Trypsin and chymotrypsin inhibitors.
- Phytohaemagglutinins (lectins).
- Urease.
- Allergenic factors.
- Lipases and lipoxygenases.

These factors affect the digestion of soya beans in the stomach. All can be deactivated, modified or reduced through proper heat treatment to minimise or eliminate their adverse effect. Since all these inhibitors are proteins, caution should be taken to assure that no destruction of the oilseed protein occurs. This can be accomplished only through optimum processing and good quality control measures.

Extrusion cooking

Extrusion cooking has some additional advantages, which other methods do not offer, for example a high temperature and shorter time cooking process will minimise degradation of food nutrients while improving the digestibility of protein by denaturation. In addition, during extrusion cooking most of the cells are ruptured making oil available for the animal.

The critical factor during extrusion cooking is the prevention of over- or under-processing, since either will reduce the nutritional value. A "dry" extrusion process is one in which mechanical energy from the extruder's main drive motor is the only energy used to process the soya beans.

There are objectives that have to be reached for optimally processed extruded full fat soya beans.

Full fat soya beans are thermally processed to destroy anti-nutritional factors and to increase oil availability while preserving the nutritional quality of the protein. The major anti-nutritional factor of concern in raw soya beans is a trypsin inhibitor.

Trypsin inhibitor is a protease that is harmful to most animals and humans, and nutritionists have documented this effect conclusively. This protease enzyme can be inactivated by heat treatment. A reduction of at least 85% of the trypsin inhibitor units is considered necessary by feed technologists to avoid nutritional problems.

Moisture content

Both moist and dry extrusion are effective in the reduction of the trypsin inhibitor and urease activities. Full fat soya beans can be moist or dry extruded to destroy over 90% of the trypsin inhibitor without damaging lysine. The degree of destruction of trypsin inhibitors is influenced by the moisture content

as well as the processing time and temperature. With dry extruders the highest reduction in trypsin inhibitor activity (TIA) seems to occur at the temperature range of 150 to 160°C and a process moisture content of 9 to 11%.

Better digestion and stability

Release of intra-cellular oil and natural tocopherols (vitamin E) for better digestion and stability and to facilitate the physical extraction of the oil. The cooked full fat soya bean can then immediately enter a mechanical press where the majority of the oil is removed.

This oil can be used for other processing including bio-diesel and the production of oils that are "natural", since they have not been through a traditional hexane extraction process. The cake can be used as a protein source for animal feeds.

This process must be conducted in a low moisture environment as added water will affect expulsion efficiency and oil stability. It is usually done with a dry extrusion system.

Increase by-pass protein

Heat treatment through extrusion increases the by-pass protein for ruminants. In dry extrusion utilising the inherited moisture in the soya beans (9 to 11%) is sufficient enough to denature the protein without affecting the primary structure or changing the optimum extrusion temperature of 150 to 160°C.

However, some processors may choose to exceed those parameters by increasing the temperature even more to assure a higher by-pass protein. This will, however, be accompanied by minor discoloration or browning of the full fat soya bean meal. The amount of denatured or by-pass protein produced during extrusion may be quantified by determining the Nitrogen Solubility Index (% NSI) of the final product.

Extrusion is a continuous process and has obvious advantages over simple batch cooking processes such as boiling or autoclaving. It is also quicker than boiling, since the beans have to be kept at boiling point for about 30 minutes to achieve reasonable levels of inhibitor destruction. The main variables associated with product quality and process efficiency as far as soya bean processing is concerned are time, temperature, moisture content and the degree of physical damage needed to render the oil content more digestible.

> THERE ARE EIGHT MAJOR OILSEED MEALS IN THE WORLD. SOYA BEAN MEAL REPRESENTS MORE THAN 50% OF THE TOTAL OILSEED MEAL PRODUCTION.

Extrusion is a readily controllable process where temperature, time (to some extent), moisture content and the degree of physical damage can all be manipulated. The net result of this is that a very high quality product can be produced when the extrusion process is properly handled.

Dry extruders generate heat and pressure mechanically as a result of the frictional and shear forces produced within the extruder barrel. Provided that adequate operating temperatures are reached (150 to 160°C), this combination of heat and pressure is sufficient to substantially denature the important anti-nutritive factors in soya beans and render the material usable in feeds.

Dry extruders

Dry extruders are single screw extruders with a segmented screw put together around the shaft. In between the screw a restriction (steam lock, choke plate) of different diameters can be placed to increase the cook and shear. When material moves in the barrel, and comes across these restrictions, it is unable to pass through, and consequently, pressure builds up and a back flow is created.

Usually these restrictions are arranged in such a way that they increase in diameter toward the die end of the screw creating more pressure and shear as they reach the die. This build up of pressure and temperature, together with shear stresses developed, tends to plasticise (gelatinise) the raw materials into viscous paste or puffed shape, depending upon the raw material. In dry extrusion, pressure and temperature should be at a maximum just before leaving the die.

The die design and opening also plays a very important role in pressure build up. Different dies are used for different material and shapes. The cooking range in a dry extruder can be 90 to 160°C with very high pressure. As soon as the material leaves the extruder dies, pressure is instantaneously released from the products, which cause internal moisture to vaporise into steam, making the product expand.

Internal friction

In dry extrusion, whole oilseeds can be used and this type of extruder has the ability to grind the oilseeds during extrusion processing. Dry extruders capitalise their source of heat through internal friction for cooking. Therefore no external steam or heat is injected into an extruder barrel during cooking. The dry extruder can process the soya beans which have a wide range of moisture contents, from 9 to 13%.

Usually, in dry extrusion, we lose moisture in the form of steam at the exit and this moisture loss depends upon the initial start up moisture in the soya bean. The heat and pressure

generated in the extruder barrel typically raises the temperature to 150 to 160°C. This temperature and pressure is sufficient to denature the anti-nutritional factors in the soya beans and rupture the oil cells.

This can be accomplished only through optimum processing and good quality control measures. If too much heat and pressure is applied, significant damage may be done to the protein component of the soya beans, thereby reducing digestibility and availability in non-ruminants. Thus, the process must be carefully controlled to ensure sufficient heat is applied to denature anti-nutritive factors without excessive cooking, which would damage the protein component.

Method varies oil content

Since nothing is added or taken away in the full fat soya process, the gross composition of full fat soya will depend on a constant moisture basis. The most serious variation is with the level of moisture of the beans and the percentage of impurities such as dust, straw or weed seed among others. Full fat will obviously contain the same level of oil as found in whole soya beans with a similar moisture basis.

> IF TOO MUCH HEAT AND PRESSURE IS APPLIED, SIGNIFICANT DAMAGE MAY BE DONE TO THE PROTEIN COMPONENT OF THE SOYA BEANS THEREBY REDUCING DIGESTIBILITY.

The average oil content of full fat soya will be 17 to 18% if determined by the Soxhlet method using petroleum ether. This figure will be higher if oil is determined by the acid hydrolysis method. The oil in full fat soya which is properly processed by extrusion is very stable and provides a remarkable long shelf life for such a high fat product.

The long shelf life can be explained by the fact that full fat soya contains a high level of tocopherol and lecithin (4%) that inhibits oxidation of the full fat product. At the same time during extrusion, heat will destroy the enzymes lipase and lipoxigenase which cause rancidity. If full fat soya is not processed at the proper temperature, it will show the signs of rancidity, i.e., increased peroxide value and free fatty acid level.

This is no doubt due to the incomplete destruction of lipoxidases. A moisture level above 12% will favour hydrolytic rancidity, which triggers the oxidative rancidity and mould growth.