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Extruding full fat soy for maximum quality (Technical Paper)

Soybeans prior to oil extraction are referred to as full fat soybeans. Properly processed full fat soybeans 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 soybean 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 antinutritional factor levels. The focus of this paper is using extrusion technology to process quality full fat soybeans for animal feeding.

Soybeans 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. Soybean meal represents more than 50% of the total oilseed meal production. Raw soybeans cannot be used as such for animal feed or human food, because they contain several different anti nutritional factors.
These factors are
a) Trypsin and chymotrypsin inhibitors;
b) Phytohaemagglutinins (Lectins);
c) Urease;
d) Allergenic factors; and
e) Lipases and Lipoxygenases.

These factors affect the digestion of soybeans in the stomach. All can be deactivated, modified or reduced through proper heat treatment to minimize 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.

Methods of producing full fat soybean meal
There are a number of different products on the international market being sold as full fat soybean 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 following processes can be applied to the production of full fat soybean meal: boiling/autoclaving, roasting/toasting, micronizing, jet-sploding and extruding (wet or dry). All these methods have their advantages and disadvantages. Extrusion cooking has some additional advantages, which other methods do not offer, for example a high temperature and shorter time (HTST) cooking process will minimize 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.

It is worthy to mention that wet extrusion cannot lend itself to mechanical extraction of the oil. Moisture does interfere with oil expelling. 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 soybeans. A "wet" extrusion process not only uses mechanical energy, but also uses steam that is injected into either a pre conditioner or the extruder barrel.

Optimally processed extruded full fat soybeans result in the following objectives:
1. Minimize trypsin inhibitors
Full fat soybeans 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 soybeans 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.

Both moist and dry extrusion are effective in the reduction of the trypsin inhibitor and urease activities. Full fat soybeans 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 150-160°C and a process moisture content of 9-11%.

2. Release of intra-cellular oil and natural tocopherols
(Vitamin E) for a better digestion and stability and to facilitate the physical extraction of the oil The cooked full fat soybean 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 done in a low moisture environment as added water will affect the expelling efficiency and the oil stability. It is usually done with a dry extrusion system.

3. Increase by-pass protein level
Heat treatment through extrusion increases the by-pass protein for ruminants. In dry extrusion utilizing the inherited moisture in the soybeans (9-11%) is sufficient enough to denature the protein without affecting the primary structure or changing the optimum extrusion temperature of 150-160 ºC. 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 soybean 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.

Benefits of extrusion

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

The term ‘dry extrusion’, as opposed to ‘wet extrusion’, refers to the fact that this type of extruder does not require an external source of heat or steam. 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°C-160°C), this combination of heat and pressure is sufficient to substantially denature the important anti nutritive factors in soybeans and render the material usable in feeds.

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 90-160°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 vaporize into steam, making the product expand.

Higher shaft speed

Most standard dry extruders are manufactured in such a way that the speed of rotation of the main shaft is around 550 revolutions per minute (rpm). This shaft speed is ideal for general purpose use where everything from cereal starch to full fat soybeans needs to be processed in the same machine. However, if the machine is to be used exclusively for full fat soybean meal production, a slightly higher shaft speed (around 620 rpm) is necessary in combination with an extended three chamber barrel, since this will give a higher throughput per hour without compromising product quality.

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 capitalize their source of heat through internal friction for cooking, and therefore no external steam or heat is injected into an extruder barrel during cooking. The dry extruder can process the soybeans which have a wide range of moisture contents, i.e., 9-13%. 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 soybean. The heat and pressure generated in the extruder barrel typically raises the temperature to 150-160°C. This temperature and pressure is sufficient to denature the anti nutritional factors in the soybeans 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, then significant damage may be done to the protein component of the soybeans, 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 soy process, the gross composition of full fat soy 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 soybeans with a similar moisture basis.

The average oil content of full fat soy will be 17-18% 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 soy 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 soy 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 soy 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.

ABOUT MALIK’S FULL FAT SOY EXTRUDERS:

MALIK’S recommend and produce HTST or High shear Extruders with high installed power for efficient cooking and processing of full fat soy at high temperature and pressure- both these requirements are met solely by mechanical or motor power alone. Thus no external heat is supplied and the friction is sufficient to raise the temperature of materials as well as high pressure required for proper denaturing of soy proteins and

increase the protein content by Extrusion processing. Further, due very low moisture content in the raw materials during extrusion, sufficient friction and heat is produced to evaporate the excess moisture in form of steam when product emerges from round die opening. Usually, the raw materials are held no more than 30-35 secs inside the Extruder and are discharged after treatment through at high temperature above100 degree Celsius and the product requires immediate cooling after Extrusion, to room temperature.

HIGH SHEAR FULL FAT SOY BEAN EXTRUDER MEFFHS-200/500 (200/500 KGP.HOUR CAP)

APPLICATION

The high shear or HTST extruder is designed for production of:

- mixed feed for poultry, livestock and domestic animals such as cattle, swine etc.
- full fat extruded meal from soybeans, sunflower and rapeseed with increased digestibility and harmful bacteria purifying.

ADVANTAGES

- provides animal feed of a high quality;
- saves over 40 % of grain for animal feeding;
- saves over 30 % of electricity while processing the feedstock prior to mechanical oil extraction;
- reduces inhibitor trypsin level in the extruded full fat soy

RAW MATERIAL

soybeans, rapeseed, beans, sunflower, lupine and other grain crops.

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Pub no: MEFFS/2005/100721.

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