Processing for Production of Edible Soya Flour

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ABSTRACT

Conventional soybean processing plants, as normally designed and constructed for production of animal feeds, are not suitable for production of edible soya flour without some modifications being made in equipment, process design and operating procedures. All sections of the plant are involved, from receiving and bean storage to final products handling. Experiences from four edible soy plants are described: one is part of a new processing complex, the others are conversions of existing, older processing plants. All are in commercial operation. The processing requirements for production of edible soya flour are reviewed and described with special reference to their application in the plants under study. Any conventional soybean processing plant that is normally well operated can be modified to permit production of edible soya flour.

INTRODUCTION

In the past 20 years, soya flour production has increased dramatically in the U.S. and around the world. Since 1960, edible flake production has grown from 120 million lb/year to almost three billion lb/year for use in a growing array of products.

In the early days of soya flour production, the technology was unknown and untried, the processing steps required had to be developed from scratch by application of educated guesswork combined with sound process engineering principles and a substantial amount of trial and error. The first processes were cumbersome, complex and expensive. As experience was gained, however, these processes were refined, simplified and improved. This was accomplished by a unique partnership, that of the supplier and engineering consultant working closely with the producing companies, to develop jointly the engineering technology and operating procedures which have proven highly successful in producing the high quality soya flour and grits products available today. The result of over 20 years of this close cooperation between us in the engineering-supplier business, and pioneering companies in the soya flour business is the development of processing techniques and systems which have become industry standards. The application of these techniques and systems vary widely, depending on the specific conditions encountered within each company's plant, but the basic principles are universal.

In this paper are discussed these general principles and the processing steps needed for the production of edible soya flour, illustrated by four plants in which these facilities have been installed. They are Farmland Industries, St. Joseph, Missouri; Honeymead Products Co., Mankato, Minnesota; Nutricasa, Mexico, D.F.; and Los Molinos, Ciudad Obregon, Mexico.

Basic processing of whole, clean beans includes preparation, solvent extraction, desolventizing and cooking the flakes to controlled solubility levels, and grinding the cooked flakes to produce finely graded soya flour (Fig. 1).

Basic processing involves working with soybeans, but what are "soybeans?" Just soybeans? Not on your life! There are a lot of other things besides soybeans in soybeans. Extraneous materials include incidental large trash, pieces of wood, nuts and bolts, rocks, paper and miscellaneous metal; plant stems, straw, stalks; other grains, corn, wheat, sunflower seeds; cockleburs; stones, nails from grain doors; weed seeds, e.g., morning glory, tobacco seed, mustard seed and others; rodent pellets; field dirt and dust and pods, both with and without beans. In addition, the beans themselves may contain shrivels, undersized beans; burnt beans; immature, green beans; black beans; splits (1/2 beans); chips and pieces; loose hulls; and wet beans.

So, some additional steps are needed in basic processing to arrive at acceptable, cleaned soybeans.

Cleaning (Fig. 2) is a key step in processing and results in a cleaned soybean stream, which is not 100% pure, unadulterated soybeans, but is acceptable in practical terms. The degree of cleaning required varies widely, depending on the foreign material present and the source of the beans. The specific equipment and procedures indicated will vary widely from plant to plant. The local conditions must be carefully reviewed before specific recommendations can be made for cleaning methods and equipment.

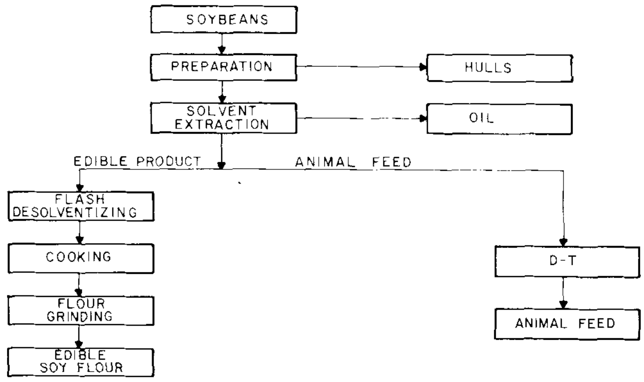

FIG. 1. Basic Processing.

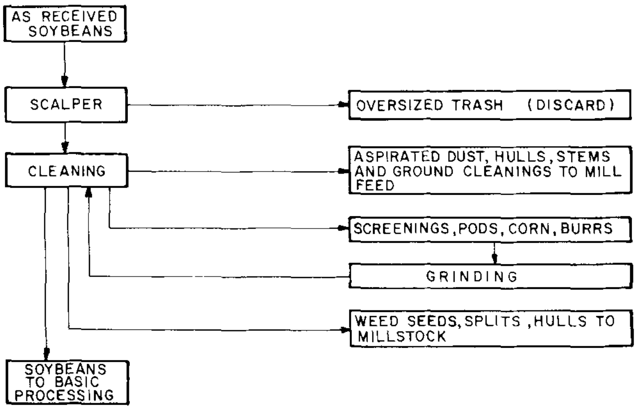

FIG. 2. Cleaning.

DRYING AND TEMPERING

Soybeans to be processed into foods for human consumption must be dehulled, and to facilitate dehulling, common practice is to dry and temper the beans. Beans usually are received at moisture contents ranging from 13 to 15%. Those with the higher moisture should be dried to 13% for storage for any extended period. Efficient dehulling for human consumption cannot be accomplished at this moisture, however, and it is necessary to dry them to between 9.5 and 10.5% moisture and temper them for 7-10 days. In this case, "tempering" means holding the beans in storage after drying to equilibrate the moisture level throughout the bean and allow the bean meat to shrink slightly away from the hull. This loosens the hull, which normally adheres to the bean, and allows it to be removed by aspiration during dehulling. In some climates with moderate humidity, the tempering bins may be equipped with aeration systems for assisting the tempering process by removing interstitial moisture.

DEHULLING

The cleaned, dried and tempered beans are then dehulled by cracking in corrugated roller mills, followed by aspiration and screening of the cracked beans. The heavily aspirated hulls contain fine and coarse meats which must be recovered and returned to the dehulled bean stream. This is accomplished by screening the fine meats and aspirating the coarse ones with the hulls being sent to toasting and grinding and, finally, to "mill feed" storage. With proper precleaning, drying and tempering, the dehulled beans will have 95% or more of the hulls removed.

Many variations in the basic flow pattern for dehulling are used, but they all make use of the same aspirators and screens in some combination.

Prior to extraction, the dehulled beans are conditioned and flaked, with the flaking mills ventilated to allow evaporation of up to 0.25% of surface moisture and promote sanitary conditions. This surface drying facilitates extraction and drainage and helps to control dusting.

EXTRACTION, DESOLVENTIZER-TOASTER

The prepared flakes are extracted in conventional solvent extraction equipment, taking care to reduce the fat content to under 1% for best performance in later protein processes. The extracted flakes, wet with solvent, are now at a most critical stage of processing, that of removing this occluded solvent and properly heat-treating the flakes. For animal feeds, the solvent-wet flakes flow to the desolventizer-toaster, or D-T, for treatment with live steam and high temperature cooking to inactivate urease activity and trypsin inhibitor and produce a nutritional meal for animals.

A discussion is important, at this point, of the effects of heat and especially, moist heat on proteins. Proteins in soybean flakes processed with a minimum of heat treatment are readily extracted with water, but if the flakes are steamed, the proteins are denatured and their solubility decreases rapidly. Protein solubility drops from an initial value of 90% to 20-25% after steaming flakes for only 10 min.

Time, temperature and moisture content are crucial factors in controlling heat denaturation of soya proteins. Because denatured proteins are insoluble, solubility measurements serve to measure the extent of heat treatment given to flakes, flours and grits.

Two procedures are commonly used to measure the degree of protein denaturation: Nitrogen Solubility Index (NSI) and Protein Dispersibility Index (PDI). In both procedures, the sample is extracted with water under specified conditions, it is centrifuged, and the supernatant is then analyzed for Kjeldahl nitrogen. The NSI value is the percentage of total nitrogen in the sample that is soluble whereas PDI is the percentage of total protein that is soluble. For a given sample, NSI and PDI will differ because of variations in extraction conditions between the two procedures.

Uncooked, desolventized flakes are required for specialty industrial products and for products for human consumption. These products require desolventizing under more gentle heat conditions with minimum retention time at low temperature and at low moisture to minimize protein denaturation and produce the lightest possible color. These flakes are then heat-treated under carefully controlled conditions to strip residual solvent and produce high, medium, or low PDI flakes as required, still with a light color.

The most widely used method for achieving this is by desolventizing the solvent-wet flakes in a super-heated vapor stream of the same solvent, using turbulent vapor heat transfer to evaporate the bulk of the solvent at its boiling point. This is commonly done in Flash Desolventizing Systems, or FDS, first reported on by the Northern Regional Research Center in 1959.

The FDS (Fig. 3) begins with a variable speed conveyor which diverts a measured portion of the solvent-wet extracted flakes flowing to the D-T and feeds it to the FDS. This system consists of a desolventizing tube, flake separator, circulating blower, and vapor heater arranged in a closed loop system in which superheated solvent vapor is circulated continuously. Solvent-wet flakes are fed into the

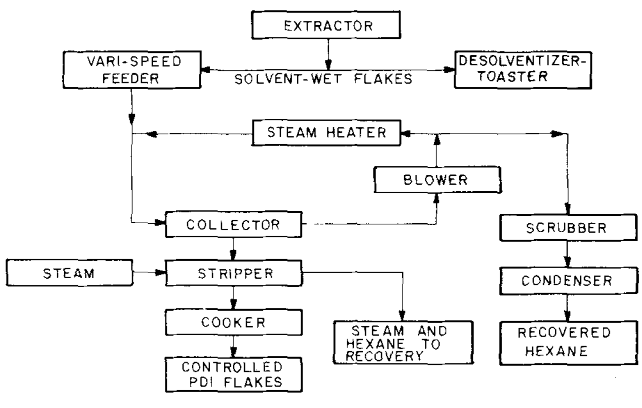

FIG. 3. Block flowsheet—FDS.

system and are entrained in and conveyed by the high velocity circulating vapor stream. Turbulent contact with superheated vapor results in the evaporation of most of the solvent from the flakes.

The FDS is capable of achieving the highest possible PDI. Protein denaturation is affected by moisture content, temperature and time. In the FDS, a dry dehydrating atmosphere prevails; the temperature of the flakes is no higher than the boiling point of the solvent for most of the period in the desolventizer, and the retention time in the system is only several seconds. These favorable conditions result in least denaturation and highest PDI: as high as 90, if the flakes fed to the unit have a PDI of 95. The Flash Desolventizing System is also capable of cooking these flakes to any desired value of PDI down to 20 (or fully cooked), by simple alterations in processing conditions of temperature, moisture and retention time. This is done by feeding the desolventized flakes into a horizontal vessel for stripping the residual solvent with superheated steam which acts as an inert carrier gas.

At this point, the flakes must be cooled prior to further processing. The controlled PDI flakes are dropped into a pneumatic cooling system which also transports them to the flour and grit grinding process, which is usually housed in a separate building. To insure sanitary conditions, the cooling air inlet may need to be filtered to control airborne bacteria. The flakes are collected in a cyclone and the air is filtered through cloth dust collectors. In some cases, the dust collected must be rejected as animal feed.

FLOUR AND GRIT GRINDING

Cooled, solvent-free flakes are delivered to a feed bin which feeds to the rotary feeder on the grinding mill. The ground product from the hammermill is conveyed by air up through a mechanical air-whizzer classifier where particles larger than the desired size are separated and returned to the hammermill for regrinding. The fine product, typically 95%–100 or 200 mesh, is collected in a cyclone and discharged through a rotary valve for conveying to storage or bagging. The air from the cyclone is removed by a fan and is vented through a cloth bag dust filter for removal of fine dust which is combined with the product. All of the air generated in the system is vented through the filter to avoid over-heating the flour.

The coarse particles discharged from the classifier just described form the feed for grits separation. They are fed at the desired rate through a variable-speed feeder to a pneumatic conveyor, to another whizzer classifier which removes dust from the grits. The dedusted grits then drop to a sifter for separation or rejection, and for medium and fine grits as desired.

REJECT HANDLING

Off-specification flakes, flour and grits must be returned to the process and blended with the animal feed stream to avoid economic losses. In the enzyme-active, or untoasted materials, they must be toasted and well blended with the regular production run to avoid off-color.

SANITATION

Bacteria exists to a great extent on the hull, on the faces of split beans and on the field dirt and filth. Therefore, a combination of thorough cleaning for removal of foreign material and dehulling for separation of the hulls makes it possible to operate the plant in a sanitary manner.

In the various plants, we found that the total plate count in the storage area is quite low and remains low until the cracking rolls stage. Care must be taken from this point further to properly ventilate equipment and periodically remove accumulations of moist dust in order to avoid creating conditions conducive to bacterial growth. In the FDS and flour grinding systems, a weekly clean-up is usually sufficient to maintain adequate sanitation.

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Process and Product Characteristics for Soya Concentrates and Isolates

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ABSTRACT

Product characteristics of soya protein concentrates and isolates can be varied by using various processing treatments. These treatments can involve the use of enzymes, solvents, heat and pH adjustment, or combinations of these treatments to produce concentrates and isolates with the desired functional properties, such as water absorption, gelation, whipping ability, fat and oil emulsification, binding and varying degrees of protein solubility. The defatted soya flakes customarily used for the manufacture of concentrates and isolates are not segregated on the basis of variety. However, regional differences exist in the extractable protein content of the defatted flakes. Processing controls are essential in producing consistent quality and functional soya protein concentrates and isolates. Production