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 parameters such as solvent treatment, desolventizing, enzyme treatment, heat, or pH adjustment of the soy flakes during processing must be stringently controlled to prevent variation in finished product characteristics and functionality.

This paper is primarily concerned with the processing and product characteristics of soya protein concentrates and isolates. The basic technology on processing concentrates and isolates has been published (1-3). However, the specific process details relative to the individual products available in the marketplace are kept confidential by manufacturers.

In order to improve our basic understanding of the subject, the terms "soy protein concentrate" and "soy protein isolate" should be defined. In the commercial trade, it is accepted that soy protein concentrates contain no less than 70% protein (N × 6.25) and isolates contain no less than 90% protein (N × 6.25) on a dry or moisture-free basis (4).

Defatted soybean flakes usually are used in the U.S. as raw material for concentrate and isolate manufacture. Although there is no varietal selection of soybeans to manufacture the flakes, there is some regional selection of flake sources because of variation in extractable protein (1).

A critical factor which must be considered in the production of soya flakes is that as little heat as possible must be used to desolventize the spent flakes (1,5). This operation has a direct influence on the solubility and extractability of the protein. Extractability of soya proteins is also influenced by several other factors, including method of oil extraction, particle size, meal age, temperature, solvent-to-meal ratio, pH and salt concentration.

The equipment design and operating conditions directly influence the microbial population and extraneous material in the soya flakes. This affects acceptability of the finished concentrates and isolates in food product applications.

Three basic processes (Fig. 1) are presently used to produce commercially available soya protein concentrates. The first process uses a 60-80% aqueous alcohol extraction. The second process involves extraction of the solubles with water acidified to pH 4.5 with food-grade acid. The third basic process also involves water extraction, but the flakes are heated or toasted to denature the protein before extraction of the solubles.

The primary objectives in each of these processes is immobilizing the major protein fraction while extracting the soluble carbohydrates, nitrogenous material and other soluble minor constituents. The method of extraction can also influence the color of the finished product. The water extraction process usually has a darker colored end-product resulting from the toasting process.

Following removal of the soluble materials, the residue can be dried using any one of several types of conventional driers commercially available. In addition, the wet product from the acidified extraction can be dried at the isoelectric point or it can be further modified by neutralization and/or additional heat treatment before drying.

Although other processes have been reported for the production of soya protein concentrate, these three basic processes have been proven commercially successful. Soya concentrates can also be made from full-fat dehulled beans, but this has not been commercially available (1,5-7).

The basic elements of the commercial process for the production of soya protein isolates (Fig. 2) include aqueous extraction of protein from defatted flakes at neutral or elevated pH, separation of the protein-containing extract from the insoluble residue, acidification of the protein extract to precipitate the protein, separation and washing of the curd, and either drying at the isoelectric point or neutralizing with food-grade alkali before drying (1,8,9). Soya isolates reportedly can be manufactured by using reverse osmosis, but this method has not been commercialized (10).

The isolated protein can be subjected to various chemical, thermal, or enzymatic treatments before drying. These various treatments can be utilized to modify the isolate to have specific functional characteristics, including improved whipping ability, gelation, protein binding, solubility, fat and oil emulsification, and water absorption. Thermal treatment can also be used to control microbial populations. It should be understood that information on the various processes to produce specific products generally is unavailable. The commercial companies producing soya protein isolates do not publish information on how they manufacture specific products.

Stringent process control must be maintained during the production of both concentrates and isolates in order to produce consistent products from lot to lot. These process controls include not only soy flake selection, but also types of solvents, temperature, types of enzymes, pH and microbial monitoring.

A point should be made about the by-products derived from both the concentrate and isolate processes and their disposal. The insoluble residue derived from the isolate process is normally dried and sold for animal feed. However, the stream containing the soluble carbohydrates, nitrogenous material and other soluble, minor constituents presents the biggest disposal problem. The solids in this stream are usually to low to concentrate economically for recovery, but are of sufficient concentration to create a very heavy BOD load on a sewage disposal facility (1,2,11).

Because it is nearly impossible to relate the product characteristics to a particular process, the remainder of this report will discuss how various process treatments can

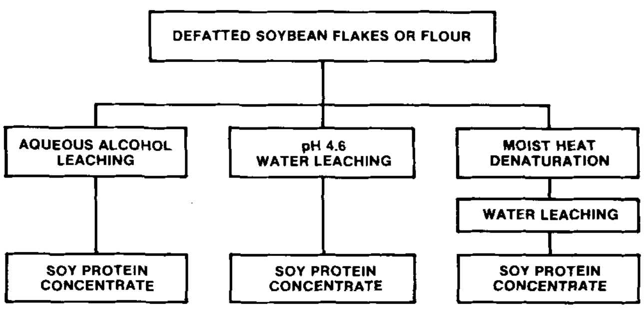

FIG. 1. Soy protein concentrate processing (1).

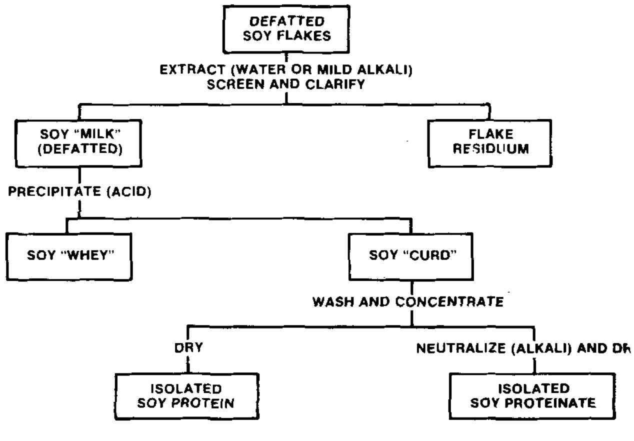

FIG. 2. Soy protein isolate processing (1).

change the functional characteristics of soya protein concentrates and isolates (1,11).

Whipping Ability

The soya isolates can be hydrolyzed with various food-grade acids and/or proteolytic enzymes including pepsin, papain, and bromolein to reduce the molecular weight and improve the whipping properties. These partially hydrolyzed proteins are called "soy albumins." However, these products do not have the traditional physical and chemical characteristics of the normal albumens and more nearly resemble the low molecular weight products called "peptones."

These hydrolyzed proteins do show solubility at both low and high pH. They can also be used alone as aerating agents or in combination with gums, egg albumen and/or whole eggs. However, these hydrolyzed proteins have the disadvantage that they will not heat-coagulate like egg whites. They have generally been used as aerating agents in confections such as nougats, creams, or icings (1).

Solubility and Dispersibility

The solubility or dispersibility of concentrates and isolates can be varied using different process techniques. The solubility can be influenced by changing pH, heat, ionic strength, multivalent ions, interacting food ingredients, and solvents, among others.

Protein solubility can be characterized by several arbitrary methods, including nitrogen solubility index (NSI), water soluble protein (WSP), water dispersible protein (WDP), protein dispersibility index (PDI) and others. However, the values derived from these tests can be varied by changes in pH, ionic strength, temperature and other ingredients such as salts, starches, gums, fats and oils.

To illustrate the effect of processing on solubility, soya concentrates made by methods using alcohol extraction or water extraction at high temperatures have relatively low solubility as measured by the methods just mentioned, whereas the concentrate made with the acid extraction would have relatively high solubility after neutralization.

In the case of isolates, the solubility of the isolate can be influenced by the pH of the finished product. The isolates can also be made insoluble by neutralizing with multivalent ions, including calcium and magnesium ions (1).

Viscosity and Gelation

Viscosity and gelation of dispersions of soy concentrates and isolates can be varied by processing changes. Similar conditions that affect solubility also affect viscosity and gelation, including pH, ion strength, salts, divalent ions, temperature, concentration, and the particular process used to manufacture the concentrate or isolate.

Many of the gels formed by some dispersed protein isolates are heat-induced and are irreversible. However, it is very difficult to describe the types of gels formed with different products. These gels can vary from very fragile gels to hard, rubbery gels, depending on concentration and functionality of the specific proteins. The types of gels are influenced by various conditions such as pH, temperature, salt concentration, and basic conditions used in manufacturing the particular concentrate and isolate (1, and unpublished data from Grain Processing Corp.).

Water Absorption

Soya concentrates and isolates have the water absorption property common to most proteins. This is primarily due to many exposed polar side-chains on the protein which tend to retain or bind the water. In reference to soya concentrates, they contain polysaccharides which also absorb a significant amount of water.

It should be understood that processing conditions can vary the amount of water that can be absorbed. In fact, these conditions can be varied to influence how tightly the water is bound by the protein in the finished food product. Water absorption is influenced by the same conditions as previously mentioned for solubility, viscosity and gelation (1, and unpublished data from Grain Processing Corp.).

Emulsification and Emulsion Stabilization

Soya concentrates and isolates can be used to emulsify fats or stabilize fat emulsions in food systems. They have several functions in forming fat emulsions in food systems such as fat-micelle stabilization, water absorption, fat absorption, viscosity control, and textural control. Many of these are interrelated in developing a stable food system.

Their ability to stabilize fat systems can be influenced by the process used to manufacture the concentrate or isolate as well as pH, ions present, and interaction with other ingredients in the finished food system. It is very difficult to predict how the concentrate or isolate will function in the finished food product based simply on chemical analysis or model systems (1, and unpublished data from Grain Processing Corp.).

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