Soy Processing: From Beans to Ingredients[1]

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ABSTRACT

Soybean processing does not end with the products oil and meal. To the food ingredient business, this is only the beginning. This presentation is a simplified general scheme to show the processing of soybeans from the whole bean to each of its end protein ingredients and to show where they might fit into the food business. It portrays bean preparation and oil extraction, meal handling, and conversion of the meal into' food ingredients. Soy flour, soy concentrates, soy isolates, and modified protein products, such as spun fibers and textured vegetable protein products, are covered. Some values and applications of the ingredients also are discussed.

INTRODUCTION

Soy food ingredient processors are both enthusiastic and confident about their products for three primary reasons. The ingredients have a unique combination of nutritive, functional, and economic value. First, to use a food additive or ingredient in a food product, especially at high levels or to replace another nutritious ingredient, it must have some level of nutritive or food value. Otherwise, its use as a major ingredient is of questionable value to the consumer. Soy protein ingredients do have substantial food value, since they contain from 50-95% of well balanced protein. Also, with little cost or effort, the protein quality can be raised above that of meat or milk protein if desired. However, if the soy ingredient is to be used for functional use, i.e. to replace the function of starch, fiber, or sugar, its protein content is of unquestionable value.

The second important value of soy is that, for the food processor to benefit from an ingredient, it must have a measure of functionality. The product types shown in Figure 1 offer the food processor a full range of functionality. This refers to such functions as absorbing fat and water; thickening and thickening while cooking; gelling; whipping; retaining moisture; repelling fat; browning; foaming; emulsifying; adding crunchiness or chewiness; increasing or decreasing bulk; improving external appearance; boosting nutritional value; using as a base material to formulate new foods; using as a spray drying carrier; as pH buffer, or in film forming; and many more. Therefore, they can replace other ingredients of less or greater nutritive value with equal or greater functional value.

The third value is economics. Before an ingredient can serve the interests of both the food processor and the consumer, the ingredient must have some economical advantage. With lower priced ingredients, processing costs can be controlled to allow the processor to maintain the product price or pass cost savings on to the consumer. Again, the soy ingredients have tremendous advantage over

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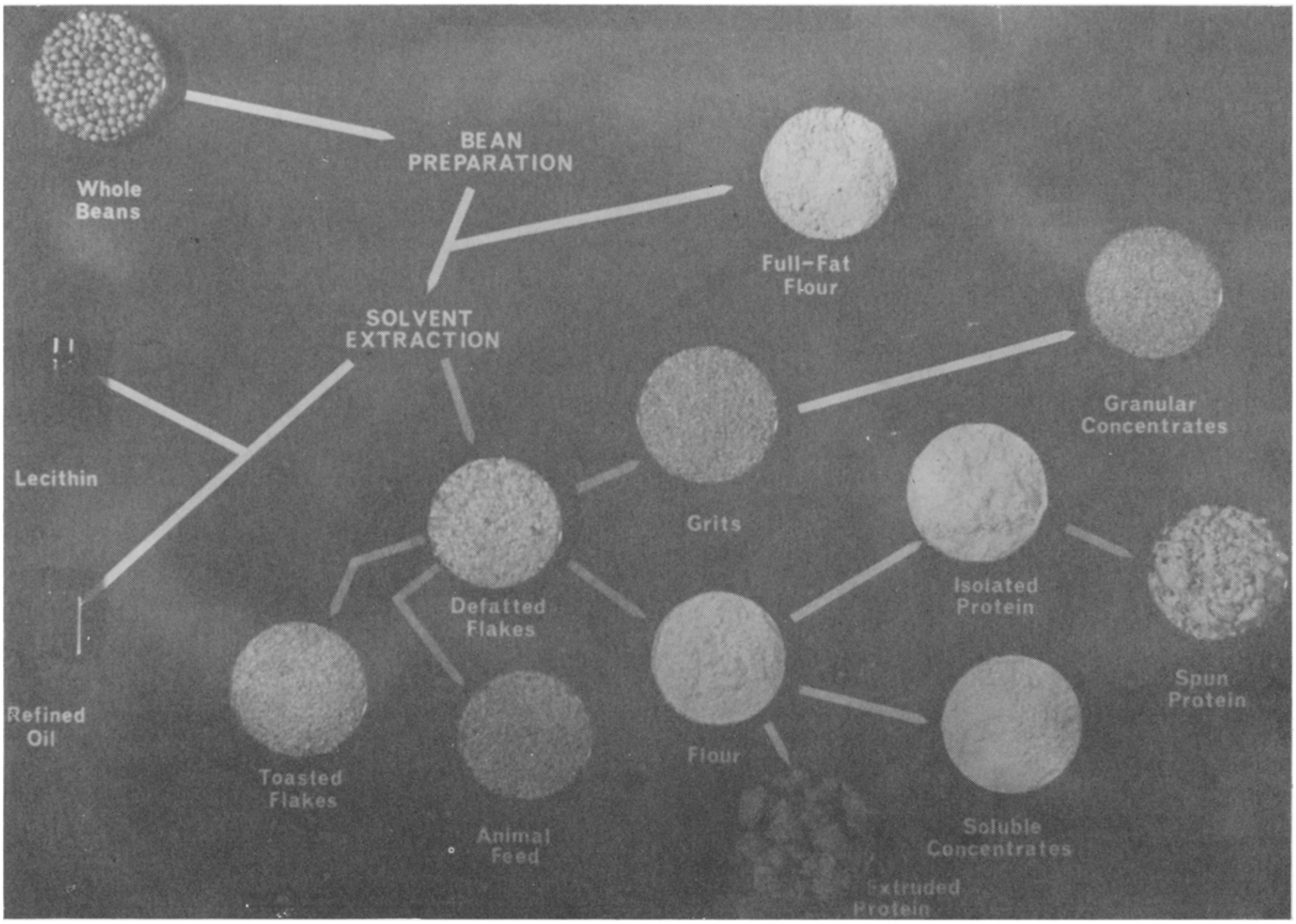

FIG. 1. Beans to ingredients.

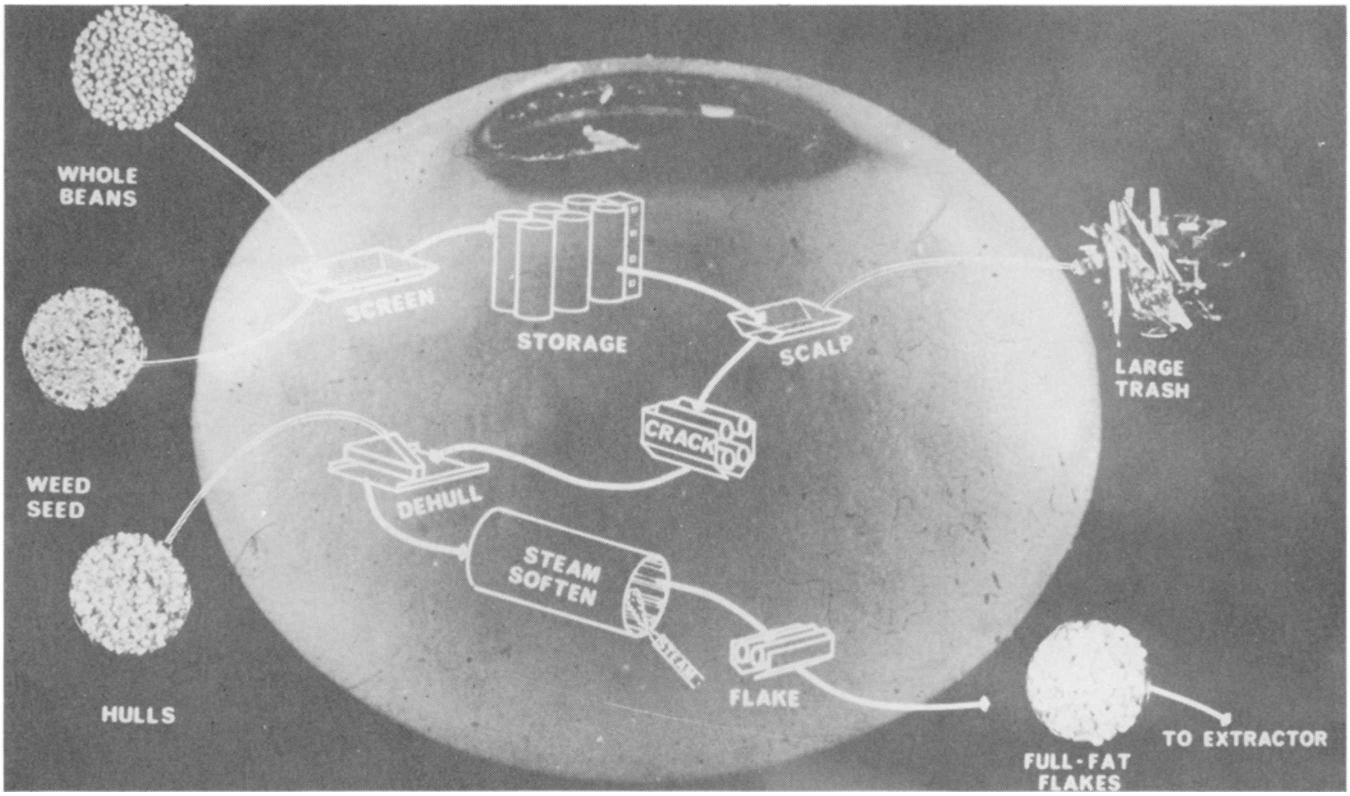

FIG. 2. Bean preparation.

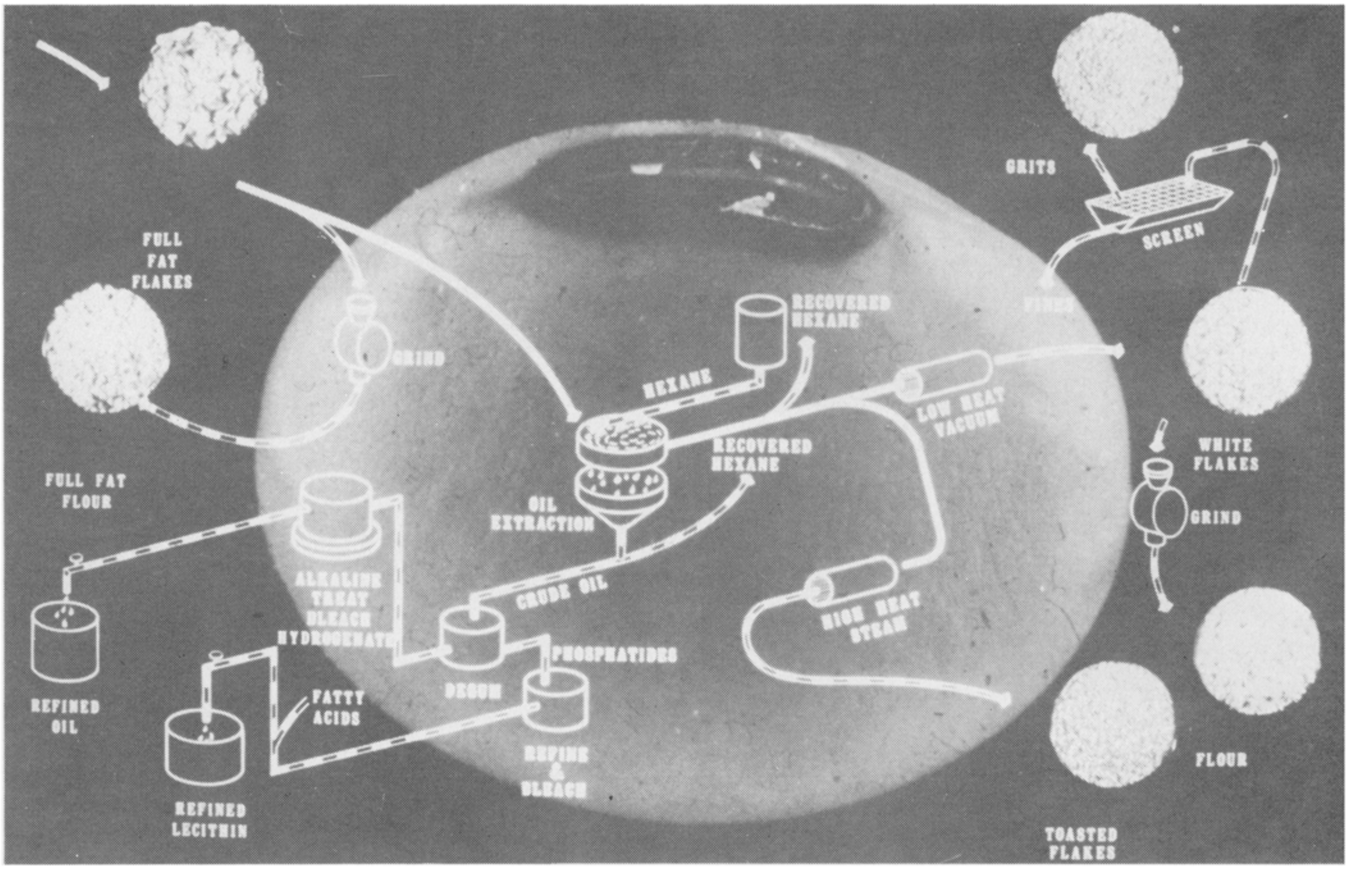

FIG. 3. Oil extraction.

their nutritional counterparts.

OIL AND MEAL FROM SOYBEANS

The two major products from the soybean are oil and meal. They are separated by extracting the fat with an organic solvent, usually hexane. Before that happens, a major processing effort is spent in preparing the bean for the extraction, as can be seen in Figure 2.

Even the best grade of beans received at elevators

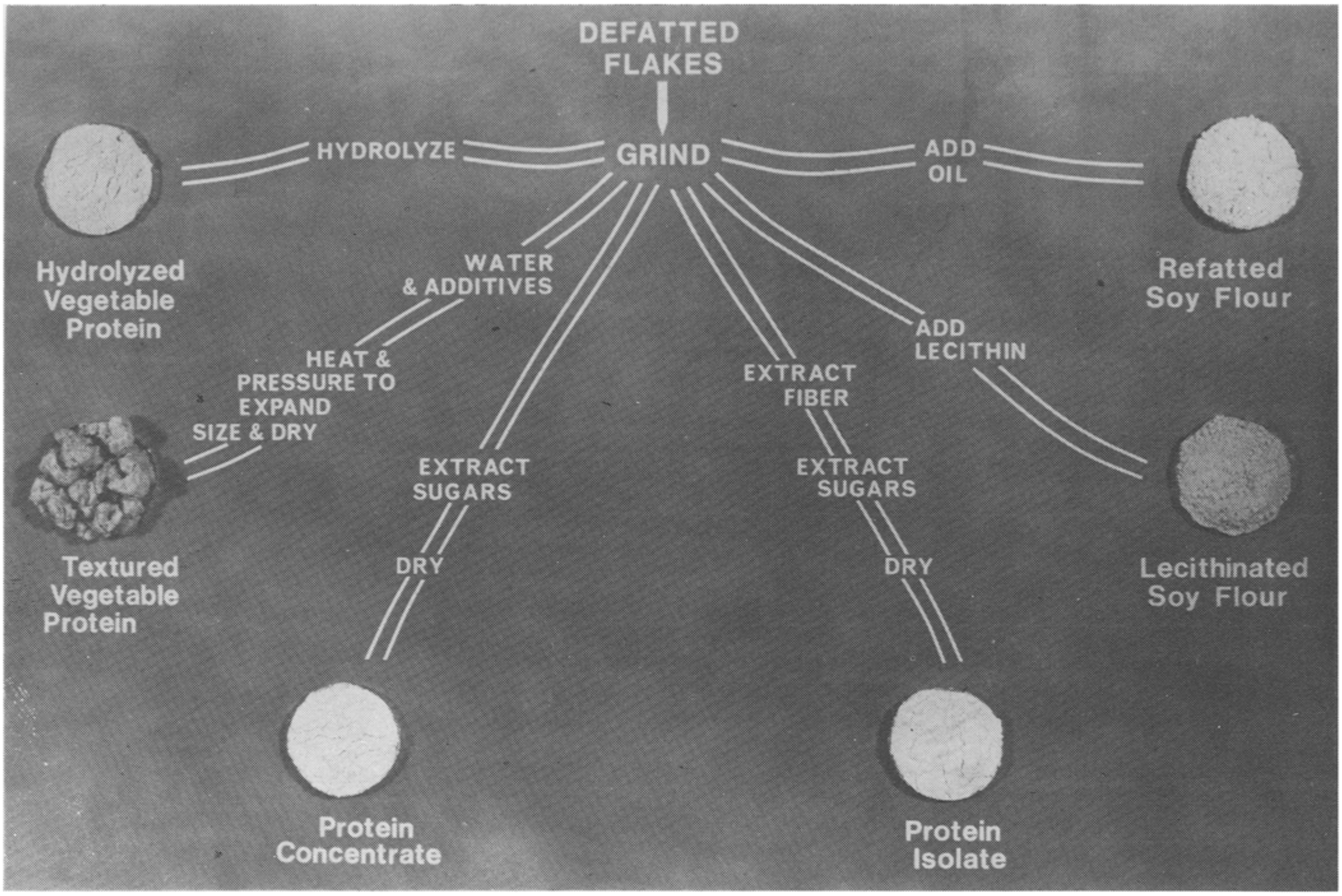

FIG. 4. Soy flour.

contain small weed seed, stems, and large trash from the field. First, the weed seed, which can be added to the mill stream at a later time for animal feed, is screened out. The beans then can be dried to 10% moisture if they are slightly too moist and then stored until needed. After storage, the beans are screened again to scalp off the large stem material, cockle burrs, etc. The sound whole beans then are cracked into 4-6 pieces between pairs of sequential rollers, each reducing the bean to smaller pieces. Since the hulls (outer skin) are lighter wt, they can be air separated from the cracks as depicted in Figure 2. The cleaned cracks are steam heated or tempered to soften the structure and then are pressed into flakes through a pair of rollers. These now are called full-fat flakes and are ready for oil extraction, as shown in Figure 3.

A product called full-fat flour can be made at this point, usually by heat treating the flakes to destroy enzymes and antinutritional factors, then grinding to a flour. The full-fat flour generally is used in bakery applications and calf milk replacers.

The full-fat flakes are loaded into an extraction unit, which is essentially a container with a screened bottom. The hexane is poured on top and percolates through the flakes carrying out the crude oil. The flakes are washed countercurrently with fresh hexane to remove the last traces of oil. The oil and hexane mixture, called miscella, is heated to evaporate the hexane which is condensed and reused. If lecithin is to be separated before refining, water is added which hydrates and precipitates the phosphatides (lecithins). The lecithin is dried, refined (oil removed), bleached to lighten the color, and may be refluidized by the addition of a small amount of fatty acids. The crude or degummed oil is alkali refined to remove free fatty acids (and lecithin if present), then bleached to lighten the color. The oil is deodorized and hydrogenated to harden if desired.

The flakes come from the extractor saturated with hexane which is removed by evaporation or steam distillation. High heat with steam sparging traditionally has been used to produce a toasted flake with the enzymes and antinutritional factors destroyed for animal feed use. This material is called soybean meal.

The percentage of the protein in soy products which is water soluble is used as an indicator of the functionality of the product. The higher the protein solubility, the more versatile the product can be. It also indicates the extent of heat treatment the product has received. The most accurate method used to determine this solubility is the standard AOCS method for nitrogen solubility index (NSI) (1). The product called soybean meal has medium to low protein solubility. Meal is used primarily for animal and poultry feed or, if screened to a uniform particle size, may be used as a food ingredient called "grits." However, if direct steam and heat are not used and low pressures (vacuum) and low temperatures are used, the natural protein solubility is preserved or controlled, producing a product which is commonly called, white flakes or defatted flakes. These highly soluble defatted white flakes are the starting raw materials for most of the other high protein ingredients. Meal is composed of ca. .5% residual fat, 50-53% protein, 2-3% fiber, 28-33% carbohydrates, and 5-6% minerals, plus a variety of vitamins.

These flakes can be ground to various particle sizes which, if larger than ca. 100 mesh, commonly are called white flakes or grits. Grits are used as a functional ingredient in a variety of food items, such as ground meats, baby foods, and cereal products. When white flakes are ground to a fine powder of various protein solubilities, the resulting products are called soy flours.

SOY FLOUR

Soy flours can be used without further treatment as an

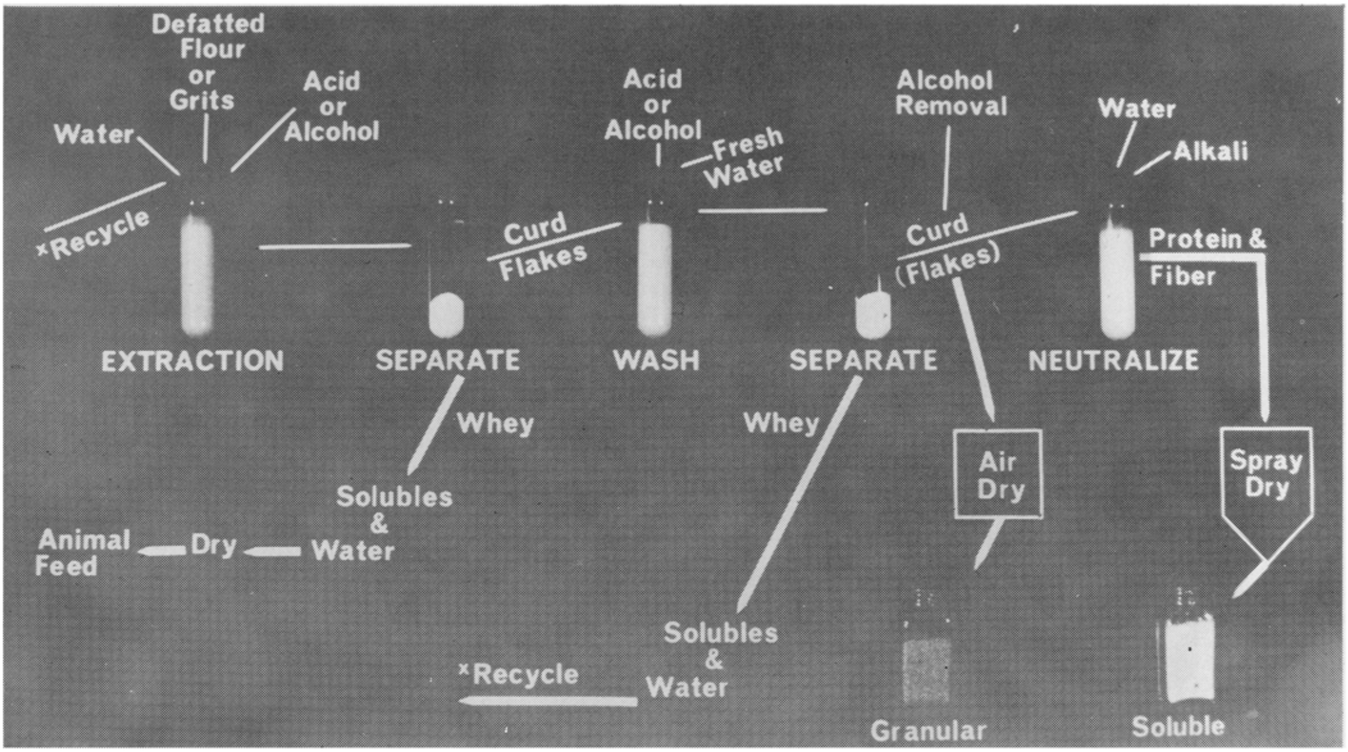

FIG. 5. Concentrate processing.

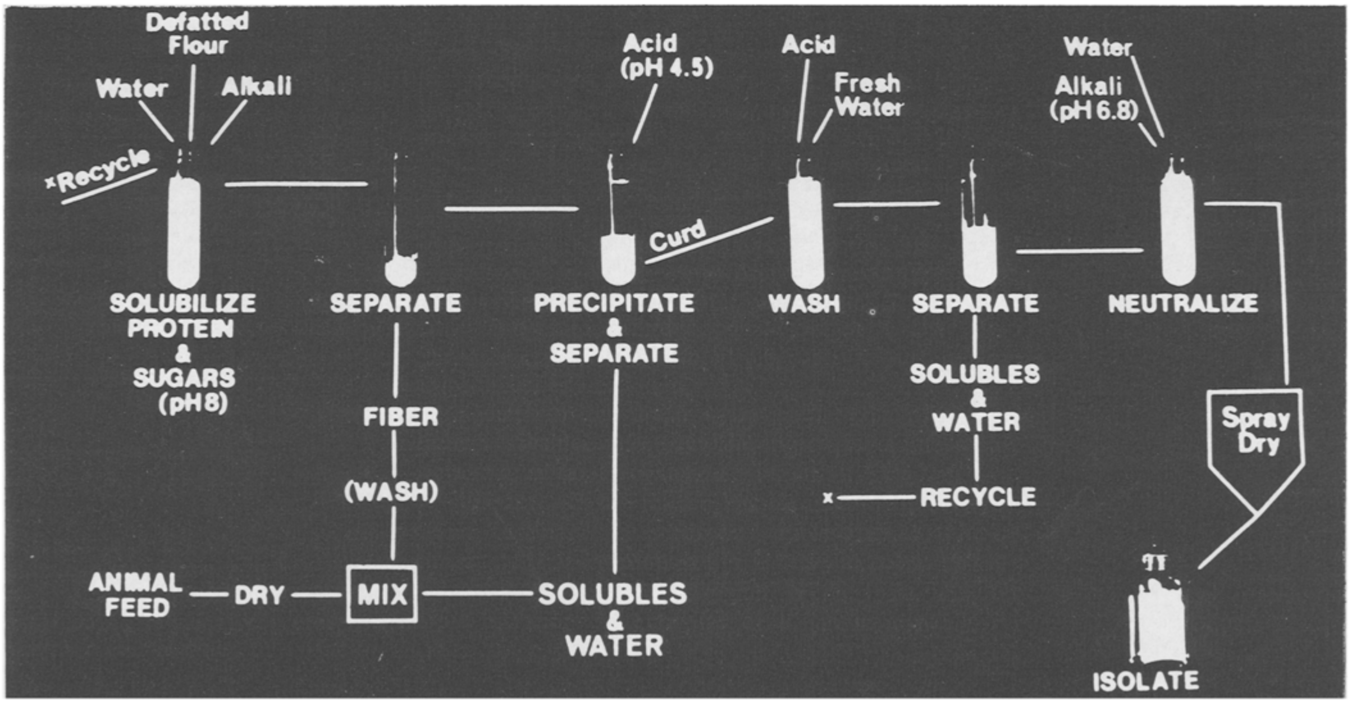

FIG. 6. Isolate processing.

ingredient in a wide variety of food items too numerous to mention here. Also, as seen in Figure 4, the flours serve as a raw material for several further refined or specially treated food ingredients. If the flour is slurried with water and enzyme or acid treated, the resulting product is a beefy tasting flavor ingredient called "hydrolyzed vegetable protein." By blending with oil or lecithin, two more functional bakery and confection ingredients can be made called refatted flour and lecithinated soy flour which are used to control fat absorption and emulsification properties.

Textured protein products are made, as we will see later, by subjecting soy flour, concentrates, or isolates to heat and pressure or by treating isolated protein with chemicals while spinning.

The protein can be concentrated or isolated from soy flour to form the ingredients shown in Figures 5 and 6.

Defatted flakes or flours contain three major components which can be separated from each other: protein, fiber, and carbohydrate. To concentrate the protein to 70%, only the soluble carbohydrates are removed; an isolate is made by removing both the carbohydrates and fiber.

Figure 5 shows the classic separation process of extracting, separating, and washing the soluble carbohydrates from the protein and fiber fractions of soy flour or grits.

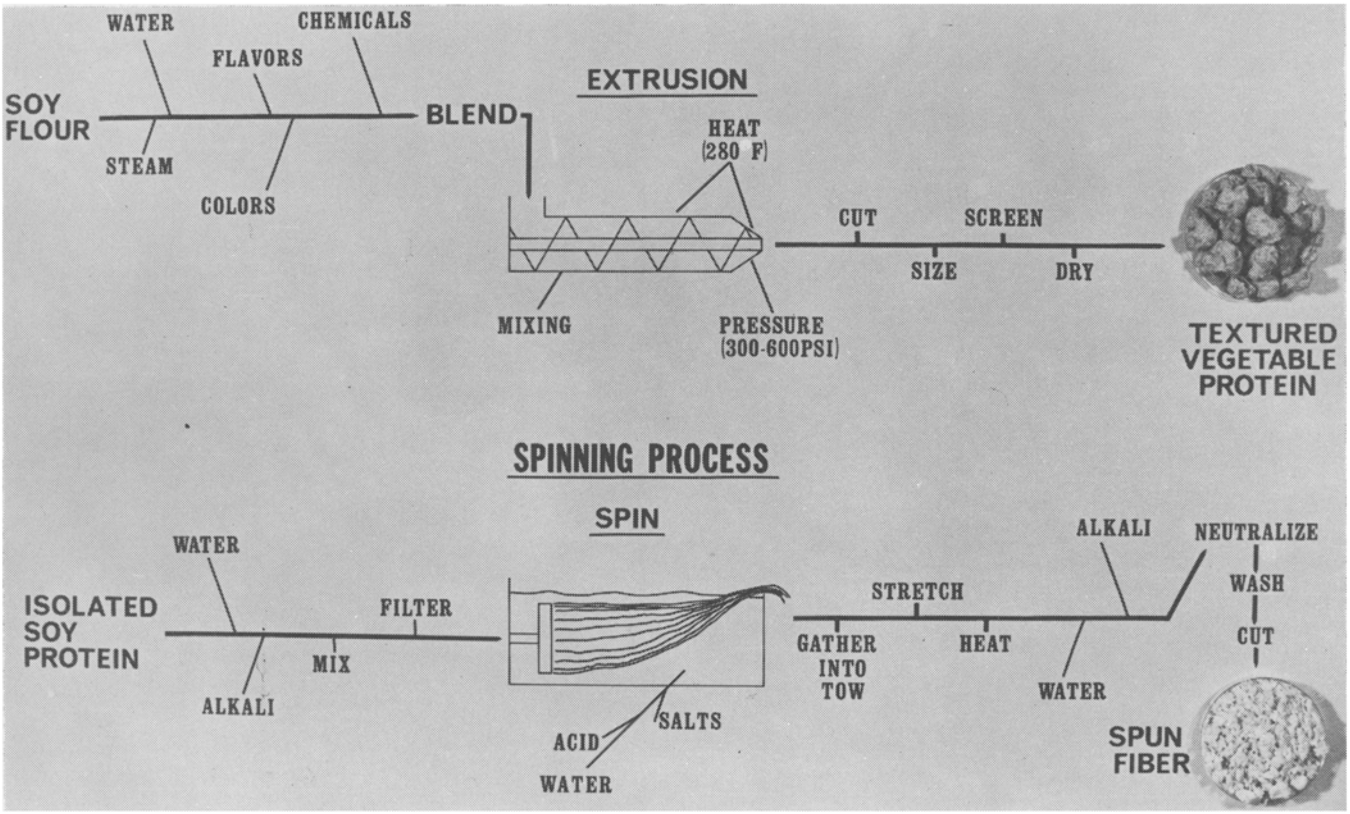

FIG. 7. Texturing processes.

Generally, acid, heat, or alcohol is used to keep the protein from being dissolved and removed. The acid is neutralized, or the alcohol is removed before drying the product. The waste effluent contains mostly soluble carbohydrates; some soluble protein; nonprotein nitrogen; the antinutritional factors, such as antitrypsin and urease; the undesirable flavors; and some minerals and vitamins. The solution can be heated to inactivate the antinutritional factors and dried to a powder which is useful as animal feed. If flour is used as starting material or defatted flakes are ground in the process, the final product is spray dried and is called a soluble concentrate. Soluble concentrates are being used more and more as a replacement for nonfat dry milk and in meat emulsions. If, however, the flake shape is retained and the product is air dried, the product is called a granular concentrate. The granular concentrates are used as conditioners or nutritional ingredients in ground meat items or in some bakery or cereal fortified products.

The isolate process in Figure 6 differs from the concentrate process principally in the initial stage where both the protein and carbohydrates are solubilized and the insoluble fiber is removed by screening or gravity separation, such as centrifuging. Then, the protein is precipitated with acid which causes it to curd and separate from the solubles. After the curd is washed it may be neutralized (resolubilized) and spray dried to form a powder of not less than 90% protein. Isolates are used as functional or nutritional ingredients in meat emulsions, confections, and bakery items or as starting materials for the spun textured vegetable products.

The final ingredients to be discussed are the textured protein products. Although the granular concentrates can be legally labeled as textured vegetable protein, the two innovative processes which are used to impart the meat-like texture to soy are extrusion and spinning, as seen in Figure 7. Soy flour is blended with steam and water, flavors, colors, or chemical additives to control density or structure. While mixing, mechanical heat is developed, and steam heat is applied which causes a high (300-600 lb) pressure near the outlet. Then, as this mixture is extruded rapidly into atmospheric pressure, the moisture expands to form tiny air pockets uniformly throughout the mass. It is the thin wall structure between these air pockets which creates the texture of the product. The mass then is cut off, chopped up, screened to various sizes, and dried, not necessarily in this order. The primary use area for these textured products are as conditioners and nutritional ingredients in ground meat products.

Spinning the isolated protein is a much more complicated and technical process, as also seen in Figure 7. The following indicates only the key steps in the process which are as follows. An isolate is made or purchased and slurried with alkali to raise the pH up to ca. 10 to prepare chemically a protein "dope." After mixing and filtering out any particles, the protein dope is forced through spinnerettes, much like the spinning mechanism used in the nylon process. The fibers then are set-up by the low pH and salt in the bath. They then are gathered into a bundle called a "tow" or rope. The fibers are stretched and heated, then neutralized, washed, cut, and frozen for shipping. The spun fibers are best used as a meat ingredient or as a flavorless, textured foundation for the fabrication of artificial meats and foods.

REFERENCE

1. AOCS, "Official and Tentative Methods of the American Oil Chemists' Society, Third Edition, AOCS, Champaign, Ill., 1964, Method no. Ba 11-65.

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