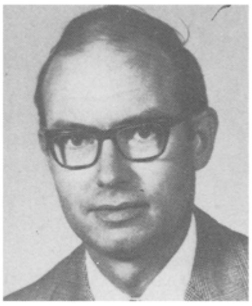

Processing and Product Characteristics for Textured Soy Flours, Concentrates and Isolates

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ABSTRACT

During the last 25 years, the development of processes to provide textural properties in soy proteins has greatly increased the market potential for soy protein products. Many different processes based on soy flour, concentrates and isolates have been developed. They have ranged from products to be used in extension of meats to meat analogs themselves. The real success of new processes is measured by their success in the commercial marketplace. The most successful products have been based on thermoplastic extrusion of soy flour. More recently, second generation products made by the thermoplastic extrusion of soy protein concentrates have been introduced. These products have less flavor, wider variety of functional characteristics and greatly reduced flatulence characteristics compared to textured soy flour products. This paper describes processes used to texturize soy proteins and characteristics of the various products. Product characteristics, functionally and economics are key factors in deciding which product to use in end-product formulations. The wide variety of textured soy proteins available provides a product for each individual need.

INTRODUCTION

In recent years, processes have been commercialized for the transformation of powdered soy protein into a form that had meat-like textures. These processes contributed significantly to the development of new markets for soy proteins. Using these processes, soy protein could be processed to simulate the eating characteristics of various meat foods.

Since the original developments, there have been many new innovations and attempts to market the new concepts. Some have been successful and others have failed for a variety of reasons. Initially, various groups were optimistic that meat analogs would replace a portion of the meat consumed. Other companies devoted significant time and money to development of the extension concept. After a decade or so, we are seeing a stabilization on the approach to the production and use of textured proteins.

The objective of this review is to update previously published reviews on textured soy products, discuss commercial successes, review processes currently used and characterize current products.

PROCESSES TO PRODUCE TEXTURED SOY PRODUCTS

Initial attempts to produce textured protein products were based on the spinning of protein fibers. In 1954, Boyer (1) was issued an early patent on spun protein fibers. This process involved solubilizing protein in alkali and forcing the solution through a spinneret similar to the type used in the production of synthetic fibers. The emerging protein streams were coagulated in an acid bath. The fibers were stretched to develop the desired size and strength. Many individual fibers were combined to form a tow. The tow was used as a matrix for the formulation of meat analogs. Various additives such as binders, fats, flavorings and colors, were mixed into the matrix. Then the binders were heat-set to form the finished meat analog.

Many variations and approaches to the development of fibers have been published. Recent reviews on this subject discuss the processes in detail (2,3).

Currently, there are very few producers of this type of fiber. Soy isolates are generally used as starting material. The cost of a highly processed starting material plus an expensive process has made this approach economically unattractive. Other early attempts to develop meat analogs from vegetable proteins are reviewed by Horan (2) and Horan and Wolff (3).

In the late 1960s and early 1970s, numerous textured protein products were commercialized by various manufacturers. Several references (1,4-6) discuss some of these processes.

Previous references (7-9) have detailed variations of the basic thermoplastic extrusion process. The first generation products utilized defatted soy flour, grits or flakes as a starting material. The soy material is preconditioned with water and steam to hydrate the protein and form a dough. The dough is fed into the extruder which combines high shear mixing, high temperatures and pressures to plasticize the protein matrix. The plastic mass exits through a die and the superheated mixture is allowed to expand and flash off. The sudden expansion leaves a porous structure which is the textured soy product.

Fundamental elements of extrusion cooking (7) are: (a) uninterrupted feeding of raw material to an extruder cooker at a controlled rate; (b) preconditioning of process feed with steam at carefully controlled temperatures (180-210 F) and at atmospheric pressures; (c) uniform application of moisture; (d) equipment to transform flour material to a dough at 180-230 F and convert the dough to a colloidal structure; (e) elevating and controlling the temperature of the dough during the last 10-30 sec in the extruder to the desired extrusion temperature; (f) forming the extrudate into the desired size and shape in a final die and cutting the extrudate into the desired size; and (g) drying and cooling the extrudate.

In recent years, many new processes have been developed to yield textured protein products. However, very few have been commercialized. Reportedly, the direct steam texturization process (10) has been used. Soy flour, the raw material, is mixed with water to form a dough which is texturized by passing it through a gaseous fluid pressurized rotary chamber. The concept is similar to the puffing of cereal grains for ready-to-eat breakfast cereals. Reportedly, the steam texturization process (10), yields a soft-textured, bland, fast-hydrating product. It is used in applications similar to those for extruded soy flour products.

In the start-up of the textured soy flour industry, several processors developed extruded-compacted products. These products were not plasticized as in thermoplastic extrusions and were closely related to soy grits in textural contribution. Except for a few specialized applications, most of these products are no longer on the market.

In the early 1970s, another process was developed to structure soy isolates (11,12). The product is produced by heating a slurry of isolate and other ingredients in a heat exchanger under high pressure. The slurry is formed into textured filaments or fibers when heated under pressure. The fibers are collected and excess water is removed by centrifuging. The final moisture content is 55-60% and the product is sold in the frozen state.

One disadvantage of this process is that a high purity protein is required. A protein purity of above 70% is necessary, but most examples in the patent (11) use soy isolate.

A variation on the thermoplastic extrusion process was patented by Sair and Quass (13). This patent describes a process for preparation of a hydratable protein food by subjecting moist protein to mechanical pressure under suitable, nonpuffing conditions. Reportedly, the protein is converted to a glassy, coherent, bonded protein product that is extremely retort stable.

Another variation of the thermoplastic extrusion process was reported in the mid-1970s (14). This process uses two extrusion cookers in series. The first extruder is a cooking extruder that heats and denatures the protein. The second extruder completes the texturization process. The dried material is dense and is rehydrated by heating in water. The hydrated product is reported to be meat-like and is used as a meat analog, rather than as an extender.

COMMERCIAL SUCCESS TO DATE

The analog or total meat replacer concept has been a failure for several reasons. The major reasons were economics, consumer acceptance and flavor. I believe that, in general, the technology of producing the products was satisfactory, but the cost of the meat analogs was as much as the meat products they were replacing. Consumer acceptance can be encouraged by economic factors, but the high cost of meat analogs slowed customer acceptance. The flavoring systems required for meat analogs were expensive and did not satisfactorily simulate the flavor of meats. In the final analysis, the consumer was not willing to pay the price of meat for a simulated meat that did not taste as good as meat.

Currently, there is a small market for meat analogs in the U.S. Persons desiring a vegetable-protein-based diet for health or religious reasons are the primary markets. In these cases, the economic factor is not as important as for the general public.

One analog-type product that is widely accepted today and, in fact, more so than the all meat products is the imitation bacon bit. The use of bacon bits for salads and garnishes is a significant segment in the textured protein business. The product originated with technology developed for meat analogs (spun fibers) and has switched to the technology used for processing of extenders (thermoplastic extruders). Introduction of textured proteins into the meat extension market has been very successful and has developed into a permanent and growing market. The primary reasons for success of the meat extension concept with textured protein products include (a) low cost extrusion processes, (b) flavoring not required, (c) trend of increased consumption of ground beef in U.S., (d) the USDA school lunch program, and (e) textural contribution to meat products.

Rapid growth in the use of ground meat in the U.S. has provided an ever increasing market for the extension concept. The popularity of fast food restaurants serving hamburgers, pizzas, tacos and similar ground meat products has shifted the consumption of ground beef to 50-60% of total beef consumed. This resulted in a larger market potential for soy protein each year.

The first generation textured soy flour products possessed adequate texture but had the disadvantages of soy flavor and soluble sugars. Recently, the development of textured soy protein concentrates made via thermoplastic extrusion has overcome these disadvantages.

Generally, textured soy flour products are used at 15-18% (rehydrated) extension of ground meats for optimal flavor performance. Textured soy concentrate products can be used at 30-50% or higher (hydrated) levels because of low flavor levels and greatly reduced level of soluble sugars.

There is no reliable source of information on production and sales of various textured soy proteins in the U.S., but, I am sure most people in the business will agree, the biggest percentage of products sold are those made by thermoplastic extrusion.

The regulatory climate, in terms of labeling and other restrictive factors, has slowed somewhat the growth of textured soy proteins. However, the great economic advantage and good quality of textured soy products has led to widespread acceptance us as extenders.

Analog products generally are used only by motivated markets that purchase the products for health or religious reasons. Cost is not a primary objective.

PROCESSES CURRENTLY USED

Processes used commercially in the U.S. include thermoplastic extrusion, steam texturization, fiber spinning, and structured protein isolates. Each process yields different characteristics in the final product and the raw material used can have a significant effect on the final product characteristics. Product characteristics resulting from the various processing techniques are summarized in the next two sections.

Thermoplastic Extrusion and Steam Texturization Processes

In these processes, (a) raw materials can be soy flour or concentrate; (b) lower capital investment is required than for fiber spinning and structured isolates; (c) final products are sold in dry form, and (d) primary applications are in ground meats, restructured meats and meat analogs.

Fiber Spinning and Structured Isolate Processes

Using these techniques, (a) generally, raw material is purified protein such as soy isolate; (b) high capital investment requirements are characteristic; (c) final products are sold in a frozen state; and (d) generally used in meat analogs, but sometimes are used in restructured meats.

CHARACTERISTICS OF CURRENT PRODUCTS

Many types of finished textured proteins are from different processes and starting protein materials. Characteristics of textured products based on three different basic proteins are summarized in Table I.

Using commercial success as a measure of meeting the goal of developing a meat-like product to provide a source for a low-cost meat alternate or extender, the less expensive processes such as the thermoplastic extrusion of soy flour have done better than the more expensive processes using

TABLE I

Characteristics of Textured Protein Products

Characteristic	Product based on		
	Soy flour	Soy concentrate	Soy isolate
Flavor	Moderate to high	Low	Low
Retort stable	Yes	Yes	Yes
Flavor development on retorting	High	Low	Low
Flatulence	Yes	No	No
Form/shape	Granules or chunks	Granules or chunks	Fibers
Cost (dry basis)	Low	Low	High
Recommended hydration level	2:1	3:1	4:1
Cost of hydrated protein	Low	Low	High
Fat retention	Moderate	High	Moderate
Optimum usage level in meat extension (% hydrated level)	15-20	30-50	35-50

isolate. Even so, the success has not been as great as predicted 10 years ago. However, with the experience gained in processing and marketing the various textured soy protein products, we have been able to better define the market needs. Based on my experience in the industry during the last 10 years, it is my judgment that textured soy protein concentrates are the best products for the next decade. The improved flavor and functionality, plus reasonable cost, allows them to be used both as meat extenders and as analogs in many applications. They can fit the needs of various people throughout the world. We have had false starts in the past, but I believe we are steadily making progress in the development of textured soy products that can be used to make delicious food products in all parts of the world. The textured soy protein concentrate products can easily be incorporated into traditional food products that are now consumed and formulated into new foods that will broaden the variety of food available as a high quality protein source.

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Economics of Soya Protein Products and Outlook

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Paper presented by R.T. Sleeter.

Economic factors involved in the commercialization of soya flours, concentrates, and isolates and textured products made from them are discussed. Some socioeconomic factors will be pointed out to emphasize likenesses and differences in marketing soya protein products in the U.S. and in other countries.

Figure 1 suggests our future dependence on soybeans for protein.

A detailed account of the processing requirements for the various soy protein products being produced today is given in a paper by Mustakas and Sohns (1).

Inflation must be factored into the cost estimates of feeding the world. In fact, I recommend a careful check of the cost figures in general given in this article (1). Some of the processes are not fully described, but it would be a good reference article for those who want to know more details on processing than I will describe here.

It must be understood that the PDI of soy flour is critical in the production and the cost of most further processed protein products.

Although soya flour and grits are definite edible soya protein ingredients and have many uses in food systems, they tend to be overlooked as we strive for more sophisticated products, such as textured soy protein, soya protein concentrate and soya protein isolate. Soya flour and soya grits have been receiving more attention from the food industry lately. The U.S. baking trade is using soy flour at levels of up to 5% to give additional shelf life to products and to replace part of the milk and eggs in their dough formulas.