Soy Grits, Flour, Concentrates, and Isolates in Meat Products

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ABSTRACT

Because of changing attitudes of consumers, processors, and regulatory agencies, soy protein products are being used at an increasing rate in various processed meat systems. The use of basic soy protein products in several meat systems is examined and guidelines are presented to optimize their use. Soy products as a supplemental ingredient in various meat systems can contribute nutrition, flavor, and valuable functional properties. As the price of meats continues to rise, and consumer interest in nutrition continues to increase, their demands will prompt governmental agencies to reconsider present meat regulations.

INTRODUCTION

Soy protein products have a long history of usage by the meat industry. Unfortunately, upon the first introduction of soy flours into processed meats many years ago, abuse by many processors caused undue customer reaction to their use. In many cases this led to the enactment of meat regulations that either restricted or prohibited the use of soy proteins in processed meats. Despite these restrictions soy protein products enjoyed increasing use in comminuted meat products. This growth in utilization can be attributed to a number of factors. (A) The protein products have been improving in taste and functionality. (B) The processor learned the proper use of soy protein products. He discovered that if little was good, more was not necessarily better unless major adjustments were made. (C) Economic benefits were realized without a loss in quality. (D) Consumer interest in nutrition helped focus attention on the soy protein products as excellent supplemental ingredients.

The recent rapid rise in meat prices and consumer demands are now prompting many governmental agencies to reevaluate their meat regulations. Thus, we will see an even greater use of soy protein products in various meat applications.

Although there are many new developments in the soybean industry in the area of new products, this paper will be restricted to the use of basic protein products in meat systems. These basic protein products will include soy flour, soy grits, soy protein concentrates, and isolated soy protein.

BASIC SOY PROTEIN PRODUCTS

Preparation

Basic soy protein preparations are obtained from hexane-extracted flakes that have ca. 50% protein.

Depending upon the method used to remove the solvent and upon the amount of subsequent moist heat applied, defatted flakes that have varying protein dispersibilities in water are obtained. Such flakes are placed in three broad categories: white, cooked, and toasted (1).

The white defatted flakes exhibit lipoxidase, urease, and antitrypsin activities. From the standpoint of flavor, the white flake has a bitter, beany taste. The toasted product is darker in color and the enzyme and antitrypsin activities are greatly reduced or destroyed (2). Its flavor also is improved to the point where it becomes sweet and nut-like (3). The cooked product has properties intermediate to the white and the toasted products. These characteristics are shown in Table I.

Soy Flour and Soy Grits

Since soy flour and soy grit products are obtained by grinding defatted flakes, the protein content and other characteristics of these flakes are the same in the ground products. Soy grits are obtained by grinding flakes to particle sizes larger than 100 mesh. Soy flours are 100 mesh or finer products.

Soy Protein Concentrates

Currently there are three methods by which soy protein

TABLE I

Characteristics of Soybean Defatted Flakes

Characteristic	White	Cooked	Toasted
Moist heat treatment	Minimal	Mild	Heavy
Water-dispersible protein	50-80%	25-50%	<25%
Enzyme activity	High	Moderate	Nil
Trypsin inhibitor activity	High	Moderate	Nil
Taste	Bitter, beany	Intermediate	Sweet, nutty

TABLE II

Comparative Characteristics of Various Soy Protein Concentrate Products

Characteristic	Ethanol extracted	Isoelectric wash	Heat denatured and water extracted
Moisture-free protein	70% min	70% min	70% min
Water-soluble protein	5-10%	25-35%	<5%
Sodium content	Low	Moderate	Low
Flatus factor	Low	Low	Low
Color	Light tan	Tan	Dark tan
Flavor	Very bland	Bland	Nutty

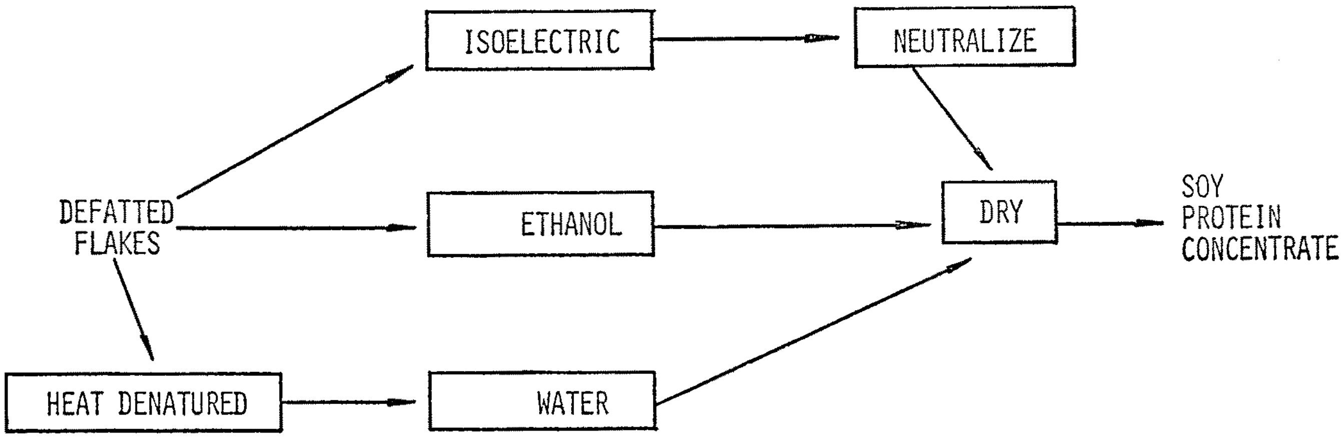

FIG. 1. The preparation of soy protein concentrate by three commercial methods.

concentrates are made (Fig. 1). These methods differ as to the means used to immobilize the protein: heat, isoelectric, and alcohol washed. All three methods are used commercially.

The comparative characteristics of the three types of soy protein concentrate products are listed in Table II.

Isolated Soy Protein

Edible isolated soy protein (ISP) is produced by extracting a white flake with water or mild alkali (4). The protein-containing liquor is separated from the flake residue and the protein in the liquor is precipitated with food-grade acid. The resulting curd is washed and spray dried in the isoelectric form, or the curd is neutralized before spray drying to produce a water-dispersible sodium proteinate. In both cases the protein content is greater than 90% on a dry basis. The sodium proteinate is the form used most widely by the meat industry.

MEAT APPLICATIONS

Fat is an important constituent in meat. Its purpose is to improve texture and to add flavor. Without fat, meat tends to be tough and lacks the richness of flavor expected in meats.

The meat processor attempts to duplicate nature in this respect when he combines lean meat with fat. This is accomplished more efficiently if the meat ingredients are comminuted, which is usually achieved by chopping, flaking, grinding, or similar processes. To achieve variety in comminuted meat products, the processor uses the following variables: meat selection, both cut and species; degree of comminution; amount and types of additives and seasonings; size and shape of the finished item; and processing conditions.

The most popular comminuted meat products throughout the world are sausage-type products. Next in popularity are the loaf-type products, many of which are the canned type. In the U.S., the coarse-ground meat products such as hamburgers, patties, and chili-type products are more popular than the loaf products.

In the U.S. and in most of the developed countries, meat is the chief item of almost every meal, but especially in the main meal of the day. Since meat is such an important part of our diet, meat processing is competitive.

Although the processor is in the business of selling a protein, he must include fat in his product for both economic and organoleptic reasons. With a relative protein shortage and a fat surplus in today's market, it is necessary to use protein to carry the fat. The U.S. population, as well as many other countries, is particularly conscious of saturated fats. This makes it especially difficult for the processor to supply tasty products on a competitive basis.

Soy proteins are considered a natural addition to processed meats for several reasons. (A.) Soy proteins are functional; many have emulsification and binding properties. Soy proteins have an affinity for the meat juices. This not only helps reduce cooking losses, but the resulting product is more juicy and flavorful. (B.) Soy protein properties are economical. On the basis of protein they are among the lowest cost products available. (C.) Soy protein products are high in nutritious protein that will complement the meat protein.

Soy flour, the finely ground soy protein product, has been used in cooked sausage and nonspecific loaves for several years. Its primary purpose has been to extend meat, and it was used because it was an inexpensive product high in nutritious protein. It was recognized early that soy flour has the advantage of holding both the meat juices and the fat. Its main disadvantage has been its taste and feel in the mouth. These factors tended to limit its use.

Of the various types of soy flours available, the toasted products are preferred in meat applications. White soy flours have high lipoxidase, urease, and trypsin inhibitor activities that can cause problems in emulsion systems. This is especially so in sausages cooked in smokehouses where temperatures are insufficient to destroy these activities.

As far as I am aware, lecithinated or fatted soy flours have never been shown to offer any advantage in meat systems.

In the U.S. soy flours currently are permitted alone or in combination with other permitted additives not to exceed 3 1/2% total. In chili the upper limit for additives is 8%. In meatballs and salisbury steaks it is 12%.

Soy grits are identical in composition to soy flours. The only difference is particle size. Soy grits also are available in various degrees of cook. Like soy flour the toasted product is preferred in meat applications.

Soy grits also are used in sausage products but to a lesser degree than soy flour. Soy grits have greater utility in coarse ground meat products such as hamburger-type products. In the U.S. additives such as soy grits are not permitted in hamburgers. Hamburger by definition is only meat; it may or may not contain seasoning.

At present the only name permitted for an extended ground meat hamburger-like product is "pattie." Thus far, patties are considered nonspecific. However, our regulations are in a state of flux and this may change in the near future.

Present usage of soy grit products in coarse ground meat products is ca. 6%. When hydrated with twice its weight in water, an 18% extension of the meat may be realized. In federally inspected plants soy grits are restricted alone or in combination to 3 1/2% in sausage, 8% in chili, and to 12% in meatballs and salisbury steak.

It is interesting to note that the disadvantage of mouth feel in products containing soy flour is not noticed in similar products containing soy grits. This may be due to expectancy on the part of the taster, i.e. if it can be seen it

TABLE III

Basic Soy Protein Products Used in Various Meat Systems[a]

Meat system	50% Protein		70% Protein dry basis — Soy protein concentrate		90% Protein dry basis
	Soy flour	Soy grits	Coarse	Fine	Isolated soy protein
Ground (coarse)					
Patties	B	A	A	B	B
Meat balls	B	A	A	B	B
Meat loaves	B	A	A	B	B
Chili	A	A	A	B	B
Sloppy joe	B	A	A	B	B
Tacos	A	A	A	B	B
Salisbury steak	A	A	A	B	B
Sausage	AB	A	A	A	A
Emulsion					
Sausage	A			A	A
Bologna	A			A	A
Loaves	A			A	A
Canned	A			A	A
Other					
Baby foods	A	A	A	A	A
Soups					
Canned	A	A	A	A	A
Dry					A
Sauces and gravies	A	A	A	A	A
Pet foods	A	A	A	A	A
Poultry rolls	B			B	B

[a]A = major additive, B = minor additive.

is expected.

Soy protein concentrate which has a protein content on a moisture free basis of 70% is used to an even greater extent in coarse ground meat products. Its advantages over soy grits are that it is blander and has a higher protein content. Because of this the product can be hydrated to a greater degree and used at higher levels. If too little water is used to hydrate the product, the supplemented meat product will tend to be dry. Usual hydration levels are ca. 2.5:1. A good guide in hydrating soy products is to achieve a protein level in the hydrated product of ca. 18%.

In supplementing ground meat in a pattie-type product, extensions can be made to ca. 20% without flavor adjustment. Above this level it will be necessary to use additional seasoning to offset the dilution effect the bland product has on the taste of the meat being reduced. Obviously in applications of this type, the coarse ground soy protein concentrate product usually is used rather than the flour-like product. For classification purposes this type of product is referred to as granular soy protein concentrate (GSPC).

The advantage in using GSPC in patties is that shrink is reduced 10%, i.e. if 25% shrink is noted in the all-meat product, the additive type will shrink 22.5%. Good dimensional stability, as well as a better tasting, juicier product, is an added benefit.

For optimum results from the use of GSPC, it is recommended that the product be presoaked with water for a short time before it is added to the meat. After mixing, the combination should be reground through a 3/16-in. plate.

The flour-like soy protein concentrate is used primarily in emulsion systems in the same manner as soy flour. Because of its higher protein content and blander flavor, it is preferred over soy flour in sausage-type products.

In federal plants soy protein concentrate is permitted alone or in combination to 3 1/2% in sausage, 8% in chili, and 12% in meatballs and salisbury steak.

Isolated soy protein (ISP) is available in either the isoelectric form or as a proteinate. Although it can be made as the salt of various cations, its usual form is the sodium proteinate.

ISP is a globulin-like fraction selectively extracted from defatted flakes. It is both an emulsifier and a binder.

One available type possesses the property of gelation. This can be seen if 12-17% dispersions are made in water and the material is heated. The gel will form at elevated temperatures. As might be expected, there is a concentration-time-temperature relationship.

ISP also is used advantageously in canned meat items because it is not affected adversely by the high processing temperatures. In this application, there appears to be a protective action for the meat protein against the effects of heat. Because of this property, it should play an important part in items to be processed at higher temperatures and shorter processing times. It is entirely possible to make a dispersion of ISP in water in which an emulsion of fat will be locked in upon heating.

This is similar to the way the lean meat proteins of sausage or loaf items lock in the fat when the emulsion is cooked. If one wishes to demonstrate this, an emulsion can be made of 15% ISP, 50% water, and 35% lard (5). It will be found that the emulsion is extremely stable. After heating, it will withstand boiling, frying, or commercial canning temperatures without breakdown. This cannot be done with any other known binder with the possible exception of high viscosity caseinate.

Although this binding property is readily demonstrated, the author does not wish to imply that even the best binder in a comminuted meat item (sausage or nonspecific loaf) will replace the myosin found in lean skeletal muscle in every respect. On a unit protein basis, myosin exhibits a somewhat higher overall functional performance; it possesses a meat flavor, and from the nutritional standpoint, closely approaches the amino acid balance of the protein needed by man. Present U.S. regulations restricting fat to 30% and water addition to 10% have changed the picture somewhat in the utilization of soy proteins. This is especially so since only 2% ISP is permitted in frankfurters, bologna, and similar products.

In a No. 1 type frank where the red meat portion is good red meat, there is little need for a myosin extender. Therefore, in this type of frankfurter the limited use of ISP at 2% offers little more than an insurance ingredient. In this case, soy protein concentrate at 3 1/2% offers more of an economic advantage to the processor. In a formulation

TABLE IV

Nutritional Value of Soy Protein Products
Rat Feeding Studies: 10% Protein Diet - 28 Days

Product	Protein efficiency ratio (range)
Soy flour (defatted)	2.16-2.48[b]
+1.0% DL-methionine[a]	2.97[c]
Soy protein concentrate	2.02-2.48[d]
+1.5% DL-methionine[a]	3.09-3.24
Isolated soy protein	1.08-2.11[d]
+1.5% DL-methionine[a]	2.11-2.45

[a]Based on protein content.
[b]See ref. 7.
[c]See ref. 8 and 9.
[d]See ref. 4.

where the animal protein additions have little binding index, where there is greater stress, ISP has more utility. By using 2% ISP in a formulation, it has the functional effect of adding an extra 10% of meat to the formulation. Lean meat is ca. 20% protein.

ISP has greatest utility in those systems, such as a nonspecific loaf, where there is no restriction on the amount of water used. To be most effective, ISP must have additional water apart from the system in which it is functioning. Depending on what is used in the meat system, ISP will need ca. 3-4 times its weight in water.

ISP also functions to an advantage in stress situations where too great a quantity of poor binding meats are used.

Firmness in a sausage product is dependent on the amount of lean meat in the formulation, while fat tends to soften the product and make it more tender. This tendering effect also is noted if excessive amounts of ISP are used. Hence, this limiting factor can be used as an advantage in the production of a high protein-low fat sausage product. In this case the combination of ISP and water (1:3 by wt) can be used in place of fat.

The Central Soya Research Laboratory (6) was able to formulate an acceptable fish frankfurter that consisted of 19% protein and 3% fat. Meat items were also produced that had fat contents ranging from 6-15%. In a commercial demonstration a frankfurter was produced that analyzed as follows: moisture, 69.4%; fat, 6.6%; protein, 17.8%; ash, 3.0%.

When compared with a frankfurter with a fat content of 30%, not only is the amount of saturated fat greatly reduced but also the caloric content is significantly lower.

A summary of basic soy protein products used in various meat systems and a reflection of actual usage by various processors are shown in Table III. Soy protein inclusion in the meat system has been classified into major (A.) and minor (B.) categories. The major category means that the product is used at relatively high levels; the minor category indicates the product is used at low levels.

Additional Consideration

At this time it would be useful to bring up various points one may need to consider in using soy protein in meat systems.

Nonfat dried milk (NFDM) has a long history of usage in sausage systems and its use is well accepted. With the pressures of increased costs many processors have attempted to replace NFDM in their formula with a soy protein product. At the usual low level replacement, little if any problem is encountered, but higher level replacements necessitate recognizing the sweetening contribution NFDM makes through its lactose content. Although lactose is not a very sweet sugar, its presence in NFDM is significant (50%). Thus, when NFDM is replaced in a sausage product with soy protein, it is often necessary to add a small amount of sugar or corn syrup solids to give the finished product a sweet taste similar to the original product.

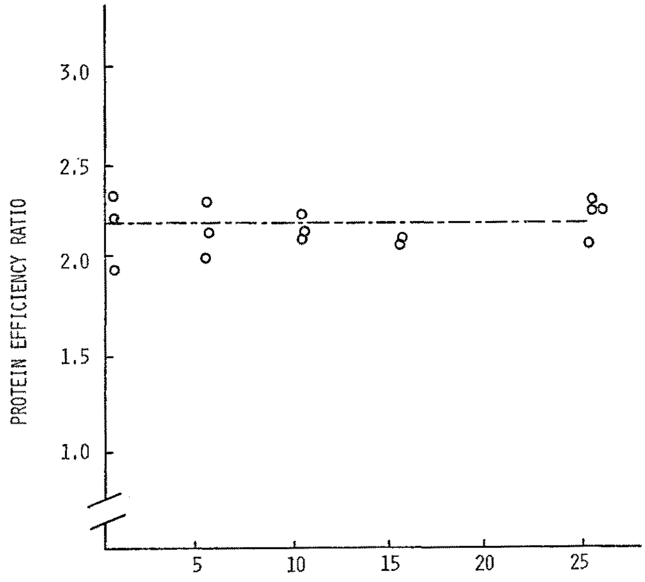

FIG. 2. Nutritional value of meat protein-soy protein mixtures (4). 28-day feeding studies in rats (10% total protein in diet).

Taste, too, may become a problem with some soy products. There have been many things done to nullify the soybean flavor that some people can detect, particularly by the sausage processor. It has been recognized that NFDM has a nullifying effect on soy. This is one reason why we often recommend keeping a major portion of NFDM present in nonspecific loaves, especially when additives are used at high levels. Rather than replacing all of the 8% NFDM in a nonspecific loaf product, we recommend replacing about half with a soy protein such as ISP.

Salt, too, has a masking effect on soy as does lemon oil. In the latter case, lemon oil can be used at a level of ca. 0.004%.

In some cases the flatus factor found in soy flour and grits can cause problems to those individuals who have sensitive intestinal tracts—particularly infants and elderly people—if the soy products are used at high levels. In these cases both soy protein concentrates and ISP are recommended since the sugars causing these problems (stachyose and raffinose) are absent.

Soy protein product analysis for regulatory agencies has been a problem for some time, depending upon the goal of the agency in question. If the goal is to prohibit a product, then a qualitative method is sufficient. However, if the goal is to regulate, then a quantitative method is necessary.

The hour-glass cell technique has been used to detect soy products in sausage. This method depends upon finding the palisade cells in the soybean hull. In processing soybeans it is next to impossible (from the practical standpoint) to remove all of the hull material, but by using special methods the presence of minimal amounts of hull material is readily detected. The disadvantage of the hour-glass cell determination is that the cells also are found in other bean-type products. However, this does not appear to be much of a disadvantage because it is highly unlikely that such products would be used in sausage products.

There is a great need for a reliable qualitative method. In the case of soy flour, soy grits, and soy protein concentrates, the official U.S. Department of Agriculture's (USDA) method is the quantitative analysis for hemicellulose. Special conversion factors are used for soy flour or grits and soy protein concentrate. The method is not without its problems.

Other methods being examined are immunological, electrophoretic, chemical, and combinations of these methods. Thus far an acceptable procedure is still lacking.

One approach to the problem is tagging. This, too, poses problems because some countries will not accept tagging. It is felt, in this case, that the product is adulterated.

Presently ISP destined for inspected meat plants in the U.S. is tagged with 0.1% titanium in the form of TiO_2. This practice is well accepted by USDA laboratories because it is accurate and reproducible.

Nutritional Considerations

Of concern to some processors in using soy protein products as additives in meat items is whether they detract from the nutrition of the meat. Table IV shows the range of protein efficiency ratio (PER) reported for the three basic soy protein products.

PER is the relationship of the weight gain of a growing rat per unit of protein intake. A PER of 2 means that the average weight gain was 2 g for every g of protein consumed. Thus PER may be used to compare the nutritional value of various proteins on growing rats. The standard is casein which has a PER of 2.5.

All vegetable proteins, when compared with animal proteins, are lacking or limiting in one or more essential amino acids. Lysine is the limiting amino acid for wheat and corn. For soy proteins, methionine is the limiting amino acid.

Soy flours and soy protein concentrate are good nutritional sources of protein (Table IV). When supplemented with methionine, they are considerably improved. Although ISP has a relatively low PER, when supplemented with methionine it, too, elicits an improved response in the rat.

Figure 2 shows the PER's observed in feeding studies in which rats are fed mixtures of meat protein and ISP. The meat protein was replaced from 0-25%. This figure shows that there is little if any change in observed PER's in the replacement up to 25%.

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