Use of Spun Soy Protein in Meat Systems

W. QUASS, Dawson, MN USA

ABSTRACT

Fabricated products made with spun protein analogues, even at 50% levels, are very similar to their all meat counterparts and have high acceptability. The flavor and texture problems associated with many other meat extenders which restrict their use to 10-30% can be overcome by use of spun protein analogues. These spun protein analogues are very adaptable to applications with sectioned and formed products and in some cases actually improve product quality.

INTRODUCTION

Throughout the world, the main dish for the main meal is usually a meat dish. For the more affluent, it is more often whole muscle products, such as steak, roasts; ham, fish fillets, or shellfish. In more modest homes, comminuted meat products are the usual fare. Relative to the total grocery basket, meat is the most expensive category. The consumption of meat per capita often differentiates between the developed and underdeveloped countries.

Side dishes, such as bread, pasta, rice, potatoes, and vegetables are eaten along with and as an integral part of the meat entree. In most cases, these less expensive foods are served to satisfy the appetite rather than merely to provide variety. For centuries, these products have been used to *extend* the enjoyment of the meal and particularly of the meat dish.

In modern times, highly technical engineered protein products (1) have been developed to *replace* meat altogether. To be accepted, these "imitations" have generally needed a motivating factor stronger than their own appeal, such as strict diet control or religious restrictions.

The protein portion of some of the side dishes competes for the role of meat extender or even meat replacer. Thus, caseinates, glutens, albumins and various protein isolates all vie as ingredients in a variety of meat products and analogues.

The economics of harvesting and processing legume crops, especially soybeans, plus the functional properties of processed soy proteins result in their frequent and economic use as a substitute for meat protein. Attempts to simulate the texture and fibrous nature of muscle bundles have resulted in the laminated structure (2) of extruded soy flour, which is clearly the most successful meat extender ever developed.

When the hulls are removed from the beans by aspiration and the lipids are removed from the meats by solvent extraction, what remains is called defatted soy flour. Defatted soy flour (with more than 50% protein) has been described (3) as containing roughly equal amounts of solubles, insolubles, and protein.

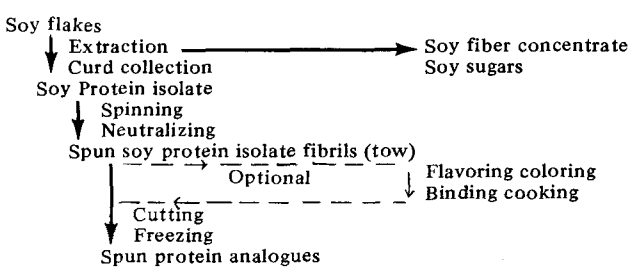

FIG. 1. Schematic flow diagram for the production of spun protein analogues.

The solubles' fraction contains simple carbohydrates and other soluble organic components which contribute much of the undesirable soy flour. These materials are soluble in water or polar solvents and are generally discarded as a "whey."

The insoluble complex carbohydrate fraction is low in protein and low in caloric content (4). The insolubles' fraction makes up about half of the material in commercial soy protein concentrates.

The purified protein fraction (with more than 90% protein, dry basis) is commercially available as soy protein isolate with a variety of functional properties. (5) These functional properties include gelling, emulsifying, and whipping.

SPUN PROTEIN ANALOGUE PROCESS

One of the more interesting functional properties of soy protein isolates is their ability to form threads or fibrils after emerging from a spinnerette into an acid bath. Other proteins have also been shown (6,7) to possess this functional property; however, only soy has been reduced to commercial practice.

A preferred first step (Fig. 1) preparation of spun protein analogues is to solubilize the protein in a high solubility soy flake-flour and then separate the solubles from the insolubles. A common method of commercial separation is centrifugation.

The desired soy protein is separated from the "whey" by collecting the precipitated protein curd which forms when the pH of the clarified liquor is adjusted to the isoelectric point (pH 4.5) of the protein (8). The resulting white curd is a bland soy protein isolate.

The creamy, refined curd is redissolved in alkali to a honey-like viscosity and pumped through a spinnerette, which is immersed in an acid bath. (9) The spinnerette is a platinum plate containing several thousand laser-etched holes. The protein streams coagulate immediately to form somewhat fragile threads which can be drawn out of the acid bath in the form of a continuous ribbon or tow.

These spun soy protein isolate fibrils, as a tow, have strength in numbers and can be stretched and/or heated to adjust their texture or chewability. The acid in the tow is neutralized and washed out to leave a continuous white bundle of chewy protein which is very bland and resistant to softening by further thermal processing, such as canning.

The white chewy bundles readily absorb flavors and/or colors and thus serve as an excellent base material for making muscle bundle analogues. Vegetable oil, colors, flavors, and the bundles are all bound together with a binding system containing heat coagulable protein such as egg albumin when the mixture is formed and cooked in a continuous cooker.

The emerging colored and/or flavored continuous slab is the conventional spun protein meat analogue. It should

TABLE I

Proximate Analysis of Fibrils

% Protein (as is)	28.5
(dry basis)	95.0
% H_2O	70.0
% Ash	1.2
% Fat	<0.1
% Sodium	0.4
% Calcium	0.1
pH	4.9
Acid content (ml 0.1N NaOH/g)	0.02

TABLE II

Formulations: Examples of Formulation Need to Evaluate Fibril Extension of Turkey Rolls, Beef Rolls and Deviled Crab

Turkey rolls;	
Fibrils	0 - 50%
White turkey meat	76.7-26.7%
Emulsion[a]	23.3%
Beef rolls;	
Fibrils	0-50%
Beef round	64.5-14.5%
Emulsion[b]	32%
Water (with caramel)	3.5%
Deviled crab;	
Fibrils	0-30%
Crab meat	30-0%
Precooked fish	14%
Broth from fish	15%
Rehydrated vegetables[c]	24%
Seasonings, etc.[d]	17%

[a]Turkey emulsion contains 7% turkey meat, 12% turkey skins, 3% broth, 1% salt, 0.3% phosphate blend.

[b]Beef emulsion contains 15% lean beef, 15% beef trim, 1.2% salt, 0.5% HPP, 0.32% phosphate.

[c]Rehydrated vegetables are 12% onion, 8% celery and 4% bell pepper.

[d]Seasonings include 8.1% bread crumbs, 4.5% mayonnaise, 2% margarine, 1.2% seasoning, 0.5% salt, 0.5% Worchestershire sauce and 0.2% alginate.

be emphasized that this coloring-flavoring, binding-cooking step is optional, since the white, chewy spun soy protein isolate fibrils can be used in many applications directly as a spun protein analogue.

The continuous white, unflavored tow or the continuous colored and/or flavored slab can be prepared for packaging in much the same manner. Either of them can be cut into pieces or dices and individually quick frozen prior to packing, storing, and shipping.

Specialized applications can be satisfied with specialized cutting techniques, such as a longitudinal cut of the segmented tow to resemble the muscle bundles of roast beef, or the tow can be shredded to resemble the shredded appearance of fish or shellfish meat.

FIBRILS AS AN INGREDIENT-EXTENDER

Table I lists the proximate analysis of the spun soy protein analogue. Since the analysis of the colored and/or flavored analogue can vary somewhat, depending on the nature of the analogue, the analysis of the spun soy protein isolate fibrils will be reviewed.

The fibrils are generally distributed in a frozen state since they contain 70% moisture and are subject to bacteriological spoilage. The fibrils are a thread-like soy protein isolate with a dry basis protein content of about 95%. The fat content of the fibrils is less than 0.1% and the ash content is 1.2%. Sodium and calcium account for almost half of the ash content.

The pH of the tow is 4.9, and the acid content is only 0.02ml of 0.1N NaOH/g. An orange has an acid content of 1ml/g. The low acid content partly expalins the low flavor contribution when spun fibrils are used as an ingredient in mild flavored food systems.

The color of the fibrils resembles the natural white color of crab meat. Because they are 70% moisture, water soluble food colors can easily be used to modify their color.

The manufacturing process for these fibrils includes more than one washing step which essentially removes all of the flavor components. The resulting product is a very bland ingredient which is readily adaptable to even the subtle flavors of fish products.

The most important functional property of this ingredient is its chewy texture. Overall, the texture of meat products is more difficult to imitate and maintain at high levels of extension (10) than are their color or flavor. Lyon et al. (11) suggest that in products with a reasonable flavor, texture (chewiness and elasticity) is more important to overall reaction than moistness (mouthfeel).

The water absorption of the fibrils, after cooking them in boiling water for 10 min or in a retorted can at 230 F for 30 min, was 35% and 10%, respectively. The texture of the cooked product was still chewy. In contrast to muscle bundles, the low water absorption properties of the fibrils aid their resistance to destruction, softening or toughening when exposed to further thermal processing.

Processed meat emulsion products are cooked so that they will be bound together by the heat coagulation of muscle proteins, and it is useful to take advantage of this gelling phenomenon for other nonemulsion products. A significant and growing proportion of meat is consumed as sectioned and formed products, which are made by mixing large pieces of meat (such as beef or ham) together with a compatible meat emulsion. The pieces are bound together when the mixture is compressed into a form and cooked.

The form can be a casing or an enclosed metal container. The cooking method can be in water, a retort, or a standard smoke house.

The resulting products can be sliced and sold as sandwich meat or sold as a unit for home or institutional preparation. They can also be cut into cubes for stews, ala kings or stroganoffs. They can be sold fresh or frozen, packaged in oven-wrap or canned.

The most welcome characteristic of these sectioned products is their textural resemblance to whole muscle products. The use of spun soy protein isolate fibrils reinforces and maintains (rather than dilutes) the desired chewy characteristics of these products.

The fibrous nature of the fibrils permits them to blend in very well with fibrous muscle bundles. When frozen blocks of fibrils are thawed and run quickly through a bowl chopper, they resemble chopped meat.

The nature of the process for preparing mechanically deboned meats virtually destroys their textural properties. However, when used with fibrils, the fibrils can provide the missing fibrous character.

Perhaps the earliest entries in the category of sectioned and formed meats were the wide variety of luncheon meats which are often sold presliced for sandwiches. These products can be roast beef, corned beef, ham, chicken or turkey. Any of these products can be extended with the fibrils.

The white color of the fibrils makes them particularly suitable for applications with turkey breast meat or with fish and shellfish products. However, when properly prepared and mixed, it is difficult to tell by appearance alone that even the roast beef has been extended with fibrils.

In the United States, the fish sandwich competes with the hamburger in most fast food chains and its very presence there and in the frozen foods section of the supermarket indicates its popularity. Formed fish sticks and fish scallops or fillets along with formed shrimp pieces are excellent demonstrations of the use of fibrils as meat extenders. In addition, in nonformed applications such as salads and sandwich spreads, the stringy character of shellfish muscle bundles is very compatible to extension with fibrils. The high cost of these products makes extension, even at low levels, quite attractive.

Specific examples of some formulations will serve to illustrate the simplicity of using the fibrils as meat extenders.

Turkey Rolls (Table II)

Turkey breast meat was blended with shredded, uncolored, unflavored fibrils. The formed and cooked roll was bound together with an emulsion of turkey meat and skins. The fibrils were incorporated at levels of 0, 12, 20, 30, and 45%. The corresponding levels of white turkey meat were

TABLE III

Economics Example of the Savings in Ingredient Costs When Fibrils are used to Extend Turkey Roll and Beef Loaf at 10 and 50% Levels and Deviled Crab at 10 and 30%

	$ Savings in 3 lb. roll	Savings $/lb.	% of cost
Turkey roll:			
@ 10%	0.24	0.08	5
@ 50%	1.20	0.40	26
	$ Savings in 5 lb. loaf	Savings $/lb.	% of cost
Beef loaf:			
@ 10%	0.10	0.02	2
@ 50%	0.52	0.10	10
	$ Savings in 4 oz. serving	Savings $/lb.	% of cost
Deviled crab-			
@ 10%	0.07	0.30	21
@ 30%	0.17	0.69	49

76.7, 64.7, 56.7, 46.7 and 31.7%, respectively.

Varying levels of seasoning were used, depending on the degree of meat extension. In this experiment, the seasoning level was kept constant in order to evaluate the potential flavor introduced by the fibrils.

These products were all quite acceptable in terms of appearance, flavor, and texture. Although a flavor change was noted at the 30 and 45% levels, it was not objectionable. The satisfying mouthfeel was very promising even at high levels of extension.

Beef Loaf

The fibrils blended with a small amount of water containing powdered caramel coloring were used to substitute directly for beef round at 0, 10, 25, and 50% levels. The corresponding levels of beef round were 64.5, 54.5, 39.5, and 14.5%, respectively. The emulsion made from lean beef (5% fat) and beef trim (55% fat) contained 30% fat. The coagulation of the emulsion satisfactorily bound the pieces of beef and fibrils together. A proper level of caramel coloring provided a good agreement between the appearance of the all meat control and the extended products.

Deviled Crab

A deviled crab was prepared using the uncolored, unflavored fibrils as the meat extender by substituting 10% of the crab meat with fibrils. The shredded crab meat was thawed and mixed with the shredded fibrils before adding the other ingredients. These included three rehydrated vegetables (onion, celery, and bell pepper) plus bread crumbs, mayonnaise, margarine and seasoning.

The mixture was stuffed into plastic crab shells and frozen. Prior to serving the product, it was thawed and cooked in a microwave oven and then browned in a deep fat fryer. This product was highly acceptable.

Economics (Table III)

In addition to acceptability, a critical question for food product manufacturers is the economics of the concept. This is an individual and somewhat complex question, but will be treated in a straightforward manner.

At 10% levels. At low levels the economics of the concept is best appreciated with high volume items. Furthermore, the simplicity of this application, the absence of waste, the decreased preparation time, and the high acceptability of the products is certainly worth remembering.

With turkey breast meat at $1.85 per pound, the savings in a three pound roll is about $.24, or an additional margin of $.08 per pound which represents 5% of the ingredient costs. With beef loaf at $1.35 per pound, the savings in a five pound loaf is $.10 or an additional margin of $.02 per pound which represents 2% of the ingredient costs. With crab meat at $3.00 per pound, the savings in a four ounce serving is a little over $.07, or an additional margin of $.30 per pound, which represents 21% of the ingredient costs.

At high levels. For turkey roll extended with 50% fibrils, the savings in a three pound roll is $1.20, or $.40 per pound which represents 26% of the ingredient costs. Beef loaf extended with 50% fibrils yields savings in a five pound loaf of $.52 or $.10 per pound which represents 10% of the ingredient costs. The deviled crab with all of the crab meat replaced with fibrils has a savings of over $.17 in a four ounce serving, or $1.69 per pound which represents 49% of the ingredient costs.

These calculations of added margins do not take into account the expenses for marketing of these extended products. The percent of the ingredient cost which could be available for these marketing expenses ranges from 2 to 49% depending upon the application and the levels of extention. These expenses would be greater for penetrating consumer product areas than for food service areas.

REFERENCES

1. Thulin, W.W., and S. Kuramoto, Food Tech. 21:64 (1967).
2. Atkinson, W.T., U.S. Patent, No. 3,488,770, Jan. 6, 1970.
3. Circle, S.J., and A.K. Smith, in "Soybeans: Chemistry and Technology," Edited by A.K. Smith and S.J. Circle, AVI Publishing Company, Westport, CT, 1978, pp. 294-338.
4. Mullen, J.D., H.E. Miller, J.D. Concoran, and B.R. Dunshee, "Fiber Constituents of Soybeans," 61st National Meeting of American Association of Cereal Chemists, New Orleans, October, 1976.
5. Pour-El, A. "Measurement of Functional Properties of Soy Products," Proceedings of World Soy Protein Conference in Urbana, IL, August, 1975.
6. Fletcher, D.L., and E. Ahmed, Peanut Sci. Vol. IV, 17 (1977).
7. Young, R.H., and R.A. Lawrie, Food Tech. Vol. IX: 171 (1974).
8. Circle, S.J., in "Soybeans and Soybean Products," Vol. 1, Edited by K.S. Markely, Interscience, New York, 1951, p. 336.
9. Boyer, R.A., U.S. Patent No. 2,682,446, 1954.
10. Cole, M.S., Cereal Foods World 23:535 (1978).
11. Lyon C.E., B.G. Lyon, W.E. Townsend and R.L. Wilson J. Food Sci. 43:1524 (1978).