Comparative Functionality of Soy Proteins Used in Commercial Meat Food Products[1]

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ABSTRACT

The use of soy isolates, concentrates, and texturized flours in meat food products is discussed. Functional characteristics of soy products in relation to their market application are reviewed. Soy isolates find more limited usage in meat food systems (2%) than the concentrates and textured soy flours (8-12%). In weak meat systems containing large amounts of fat (30-45%), the concentrate emulsifier and isolate are more important than the texturized soy flour. In chopped meat systems with 18-25% fat, the textural properties of soy flour (extruded) are more important than the use of an isolate. However, combinations of concentrate emulsifier and texturized flour are used. The method of cooking, i.e. fresh, deep fat-fried, or char-broiled, will affect the usage of soy combinations. In comminuted cooked cured meat food mixes, soy concentrates, and textured flours currently are being used. Nutritional properties are improved by inclusion of available ingredients high in lysine and methionine. Functional measurements of textural properties have been completed using the Instron with a Lee Kramer cell. Both model emulsion systems and finished product results substantiate the accuracy of textural properties in soy-meat mixes using the Instron.

INTRODUCTION

Economic necessity has been the primary stimulus for recent developments in soy protein chemistry. During 1973, the U.S. agricultural economy was faced with a strong, world-wide demand for raw material commodities. Protein based commodities were demanded strongly in both U.S. and international trade. Devaluation of the U.S. dollar further increased foreign demand for these commodities. Domestic wage and price controls forced real and imaginary retail prices for beef, pork, poultry, and fish spiraling upward, and U.S. consumers began to change eating habits to compensate within their disposable income.

In a nation that has the natural land resource base and availability of capital and technology to develop it, livestock and meat production is a most significant part of the total food economy. Historically, as the per capita income increases, there is a shift in eating habits away from a predominantly cereal based diet to a meat based diet. Advertising may influence dietary trends via certain products, but cost is the major factor. When per capita income is low, generally the disposable income spent for food is high and vice-versa. As nations become more industrially mechanized, income increases and food production increases in the direction of livestock production.

Since livestock and products derived from them are relatively expensive due to the biological inefficiency of converting plant foods into animal products, only the wealthier nations can afford a predominantly meat based diet. Therefore, the world-wide protein utilization base currently is being expanded to include oilseed crops, leafy crops, yeast, etc., as a source of protein. The primary question being asked is: Given a fixed amount of protein based material, can one more economically use it for direct human consumption or animal consumption? In economic terms, how can we best allocate the scarcity of our protein resources?

Since the quantity and availability of soy proteins are quite adequate, they have received the most attention in development of competitive meat alternates. It is in direct competition with meat that the soy proteins show the largest cost differential and, therefore, the most profit potential.

SOY-MEAT REVIEW

The use of soy isolates and concentrates in processed meat has been reviewed by Schweiger (1), Rakosky (2), and LaCourt (3). Isolates initially were used at low levels (2%) in processed meats. Their functional properties gave increased yields, moisture retention, fat binding, and cost reductions. Isolates were reported to work exceptionally well in canned meat systems. Thermoplastic extrusion brought a textural property to the soy industry. Wilding (4) has discussed the use of these texturized soy flours in meat blends for chili, pizza toppings, and loaves. The functional property of texture is imparted to the meat mix, and the losse-open structure was preferred by flavor panelists. These products are entirely different meat food systems than the comminuted canned meat products; therefore, the functional properties of the soy are altered to suit specific

[1]One of 13 papers presented in the symposium, "Soy Protein," at the AOCS Spring Meeting, Mexico City, April 1974.

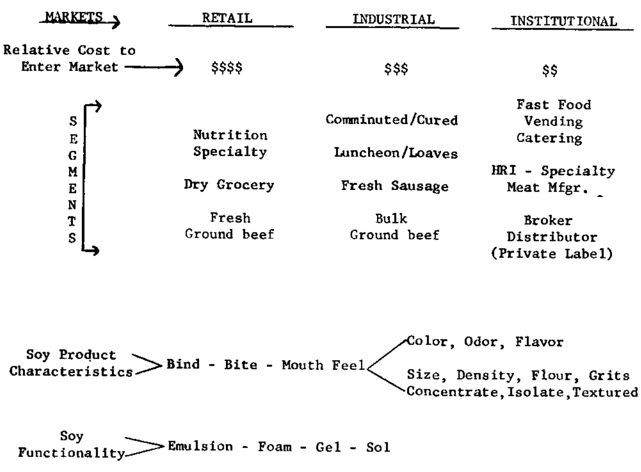

FIG. 1. U.S. meat food-soy protein economy.

TABLE I

Comparative Evaluation of Soy Proteins in Weak Meat System

Ingredients (lb)	Test 1	Test 2	Test 3
Beef navels	33.0	33.0	33.0
Defatted beef tissue	20.0	20.0	20.0
Beef cod fat	10.0	10.0	10.0
Textured Promate	6.0	5.0	4.0
Patti-Pro (SPC)[a]	1.0	1.0	1.0
GL-301 (SPC)	3.0	4.0	5.0
Salt	1.0	1.0	1.0
Mustard GM-252	1.0	1.0	1.0
Seasoning #715-9125	1.4	1.4	1.4
Water	23.0	23.0	23.0
Grill shrink (%)	22.0	20.0	18.4

[a]SPC = soy protein concentrate.

TABLE II

Commercial Formulations of U.S. Patty Products[a]

Component	Fresh frozen		Deep fat-fried			Char-broiled	
	NE	SW	SW	W	NW	NE	W
Skeletal meat	72.0	66.0	38.8	37.9	61.7	55.0	55.0
Total soy proteins (Isolate, concentrate, textured)	9.1	9.9	9.6	14.1	12.4	5.9	12.0
Residual ingredients (Starches, flours, seasonings, moisture)	18.9	24.1	35.4	48.0	25.9	39.1	33.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[a]NE = northeast, SW = southwest, W = west, and NW = northwest.

TABLE III

Instron Textural Evaluation of Commercial U.S. Patty Products[a]

Product	Fresh frozen		Deep fat-fried			Char-broiled
	Northeast	Southwest	Southwest	West	Northwest	West
GSVP	7.86 (1.23)	7.61 (1.50)	4.13 (.08)	2.87 (.04)	10.74 (2.84)	10.28 (2.45)
ULTRASOY		6.27 (1.05)	3.70 (.10)	2.68 (.08)		
ADM-240			4.64 (.33)			
BONTRAE				2.65 (.29)		
EDDI-PRO						10.02 (.45)
ADM-120	5.84 (.32)					
TEXTRASOY						7.63 (2.12)
TEXGRAN					9.55 (1.24)	
MAXTEN						12.16 (4.93)
Hypothesis that means are equal	Rejected	Rejected	Rejected	Accepted	Accepted	Rejected
Confidence level (rejection)	(.005)	(.05)	(.01)			(.01)

[a]Numbers in parentheses indicate variance estimators.

product applications. More recently, the retail acceptance of a ground beef-soy blend has been demonstrated. Heretofore, most meat-soy combinations were made for the industrial or institutional market rather than retail. Wolford (5) has discussed the consumer acceptance and manufacturing methods for retail ground beef-soy blends. Color and microbiological stability are major considerations in developing these soy product concepts for the fresh refrigerated meat display case.

Other product concepts entering the retail shelf are those in the dry grocery product category. These may consist of a pouch pack or boxed instant dinner concept, using soy proteins as a base, rather than cereal or noodles. It is too early to estimate sales success from these products; however, the cost tends to be more expensive/oz food than buying the textured soy protein already incorporated into a finished, branded meat food mix.

Complete meat analogue products, such as ham crumbles, bacon crumbles, breakfast sausage, etc., have been in the retail frozen case for several years. Initially, these products were geared to a specialized vegetarian consumer market, but, more recently, the meat analogues are being sold at the retail consumer level for home use in casserole-type dishes. Flavored soy proteins for use as salad toppings and replacements for nuts and vegetable crops (bell peppers) also are being developed for the retail and institutional markets.

The functional properties of soy proteins in relation to the segmented market in which they are sold are becoming more important. Roberts (6) has outlined tests with high levels of soy in comminuted meat systems. For canned, meatless emulsion, the Instron textural measurements tend to be a reliable tool. Rheological studies are opening up a new field in product development of meat-soy combinations. Rapid evaluations via a cold or hot water absorption test for production control are giving way to more sophisticated measures by model emulsion systems and finished product tests. The following studies will point out functional considerations for soy products in relation to market segments of the meat economy in which soy products are used.

MARKETING DECISIONS

Figure 1 presents a schematic of the U.S. meat food-soy protein economy. The major markets are defined as retail, industrial, and institutional. The first management decision by the soy protein manufacturer is: What major market should he enter? Of course, this decision is based upon internal corporate structure, availability of capital, size of market, equipment, personnel, and product mix. The next step is to consider relative cost to enter the chosen market. Generally, the lowest entry cost is in the industrial area. However, profit margins are lower, unless a product

TABLE IV

Frankfurter Formulations Using Various Nonmeat Protein Sources[a]

Ingredients	Batch no. 14 (%)	15 (%)	16 (%)	17 (%)	18 (%)	19 (%)
Pork picnics	40.6	27.4	27.4	27.4	26.6	26.6
Pork hearts	4.0	2.5	2.5	2.5	2.4	2.4
Pork stomachs	4.0	2.5	2.5	2.5	2.4	2.4
Pork jowls	25.8	17.5	17.5	17.5	16.9	16.9
	(74.4)	(49.9)	(49.9)	(49.9)	(48.3)	(48.3)
Ice water	19.1	33.9	33.9	33.9	32.9	32.9
Soy flour	---	9.9	---	---	---	---
Textured vegetable protein	---	---	9.9	7.5	7.3	7.3
Soy protein concentrate	---	---	---	2.4	2.4	2.4
Seasoning, sugar, etc.	4.5	4.6	4.6	4.6	4.5	4.5
Salt	2.0	1.7	1.7	1.7	1.7	1.7
Egg albumen	---	---	---	---	2.9	---
Devitalized wheat gluten	---	---	---	---	---	2.9
Total	100.0	100.0	100.0	100.0	100.0	100.0

[a]Numbers in parentheses indicate wt % of edible flesh.

uniqueness for a given market segment is established. The retail sector is the most costly because of advertising and promotion dollars, as well as extensive sales demonstrations. Segments within each market also are listed in Figure 1. The established systems for sales and distribution often vary within each segment, and, therefore, a direct sales force may not be successful. Further, the numerous products sold within each segment may dicate that the functional properties of the soy proteins be varied. Commodity markets must be distinguished from branded product markets where profitability is generally greater. Often, when no uniqueness or significant differences in soy properties are evident, price differentials are not justified in the customers' minds; and, therefore, the soy product becomes a commodity to be bought at the lowest price. Soy product characteristics for each market must be established and controlled uniformly throughout manufacturing. Such things as color, size, odor, flavor, density, and type of soy product should be considered. The functionality of the soy product in the type of food system used must be determined. Is the soy used as a cost reduction, a product improvement, or both? Does the food system require an inert carrier, emulsification, texturization or other functional properties?

This schematic may be used as a management guide for quick reference to marketing objectives and the product development, advertising, and sales steps essential to a profitable return on investment.

CHOPPED MEAT SYSTEMS USING CONCENTRATE, TEXTURIZED, AND ISOLATE SOY PROTEINS

The functional aspects of soy proteins in commercial patty products often are measured by "cook shrink" and bite (texture). The study summarized in Table I was presented by Terrell (7). A weak meat system having low myosin protein and large amounts of fat and collagen protein was used as the basic economy formula. To this, varying ratios of texturized soy flour, soy protein concentrate-granular, and soy protein concentrate-emulsifier were added. All tests were prepared according to standard industry manufacturing practices, and finished patties were grilled 7 min at 375 F. Test 3 had the lowest percentage of grill shrink, and subsequent triangular and preference evaluations indicated that test 3 had more bite (texture) and was a better product than test 1 or test 2. These data indicate that no one type of soy protein will do the job in this meat system, and it is essential to use a combination of textured proteins and concentrates.

The method of cooking as it relates to original formulations and the types of soy proteins is also important. Table II outlines general formulations of patty products that are fresh frozen, deep fat-fried, or char-broiled. These data were summarized by Terrell (8). Because of the importance of color, fresh frozen patties generally contain a higher percentage of red skeletal meat than the precooked products. In the fresh product, only the texturized and concentrate proteins are found, usually in smaller quantities (8-9%). However, in the deep fat-fried and char-broiled products, increasing quantities of concentrates, texturized, and isolates are used in various combinations.

A very reliable measure of texture in food products is the Instron machine, using a Lee Kramer cell. Table III presents means and variance estimators for various commer-

TABLE V

Proximate Analysis of Frankfurters Using Various Nonmeat Protein Sources

Analysis	Batch no. 14 (%)	15 (%)	16 (%)	17 (%)	18 (%)	19 (%)
Moisture	56.0	56.6	58.3	57.9	56.1	56.5
Protein	12.7	15.6	15.2	16.2	16.9	17.2
Fat	24.6	17.4	16.8	14.8	17.4	16.0
Carbohydrate	3.6	7.0	6.9	7.6	6.4	7.8
Ash	3.1	3.3	2.8	3.5	3.2	2.5
M/P ratio	4.4	3.6	3.8	3.6	3.3	3.3

[a]M/P = moisture divided by protein expressed as a ratio.

TABLE VI

Protein Efficiency Ratios of Frankfurters Using Various Nonmeat Protein Sources

Comparison	Batch no. 14	16	17	18	19	Casein
Corrected protein efficiency ratio	2.28	1.95	2.17	2.59	2.10	2.50
Percent all meat (14)	100.00%	85.50%	95.20%	113.60%	92.10%	
Percent casein	91.20%	78.00%	86.80%	103.60%	84.00%	100%

TABLE VII

Nutrition Information/serving[a]

Component	Batch no. 14	16	17	18	19
Calories	130	108	103	113	118
Protein (g)	5	7[b]	7	8	8
Carbohydrate (g)	1	3	3	3	5
Fat (g)	11	7	7	8	7

[a]Serving size = 1 link; 10 servings/container.
[b]Not a significant source of protein.

cial soy products used in patty formulations. These data were explained in detail by Terrell (8). Generally, when the amount of skeletal meat in a formulation is 55% or greater, significant textural differences are measurable and reflect the type of soy protein used. However, when the amount of skeletal meat is 55% and less, differences in textural properties due to the soy proteins are less distinguishable. Variance estimators (in parentheses) are a measure of dispersion around the mean. These figures tell management that either the consistency of the soy protein used is highly variable from lot to lot or sampling errors should be investigated and held to a minimum. Variance estimators of the soy functionality as it relates to objective measures of texture should be an important part of product development and manufacturing control by the soy protein processor.

COMMINUTED-CURED MEAT FOOD MIXES WITH TEXTURIZED SOY PROTEINS AND PLASTICIZERS

The application of soy proteins in chopped meat mixes, such as patties and fresh ground beef, is well established. These products represent one aspect of the segmented retail, institutional, and industrial markets for soy products. However, of more recent interest is the use of texturized soy in comminuted cooked or cured meat food products.

It is well established that a simple stomached animal will product more lb protein/acre than a complex stomached animal. Neither will produce the lb/acre of protein equal to a legume crop (soy). However, if we are to do "more with less" as a matter of economic necessity in the world food economy, we must look at the combination of various protein sources from edible flesh and plants. Where equal nutrition and functional properties can be built into the products, this should be done.

Table IV outlines formulated concepts relative to the use of different types of nonmeat proteins in a comminuted and cured meat food product. These data were summarized by Terrell and Staniec (9) and are subject to U.S. and foreign pending patents. This table compares an "all meat" product to products containing soy flour, texturized soy flour, soy concentrate and texturized in combination, and the inclusion of plasticizers, such as egg albumen and wheat gluten. The obvious point in Table IV is the cost reduction in the meat component of the formulation.

These products were manufactured according to standard industry practice and included 1/4 oz cure. To bring the pH of the added soy proteins closer to the pH of a refrigerated shelf stable frankfurter-type product, 7 oz sodium acid pyrophosphate (food acidulant) was used. The loss in process shrink was greatest for the product containing soy flour alone and lowest for the combination of concentrate, texturized, and gluten.

Proximate analysis of these products is presented in Table V. Generally, as protein increased, fat decreased, and moisture remained constant. However, it is interesting to note that a meat food product containing nonmeat proteins offers a source of carbohydrates above the typical "all meat" product. Products containing the plasticizers (egg albumen and gluten) were judged by the preference panel as having the best meat-like chew or bite.

The nutritional aspects of these product concepts are presented in Table VI. The product containing soy flour alone had the lowest protein efficiency ratio and could not be nutrition labeled according to the current proposal.

The product containing soy concentrate and texturized protein was 86% of the protein efficiency ratio of casein, while the addition of egg albumen raised the protein efficiency ratio to 103% of casein. This table illustrates that nutritionally sound comminuted meat food mixes using various sources of edible flesh and nonmeat proteins can be produced commercially.

A comparative format for nutrition labeling of these products is presented in Table VII. Generally, the caloric intake is lower when the fat is lower, and the protein and carbohydrate increases with increasing nonmeat proteins. Products of this nature currently are being manufactured and sold in the U.S. as a nonspecified meat-type product. Price and repeatable quality, rather than nutritional benefits, are being emphasized in the marketing approach. Both retail and institutional markets are being sold.

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