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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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.

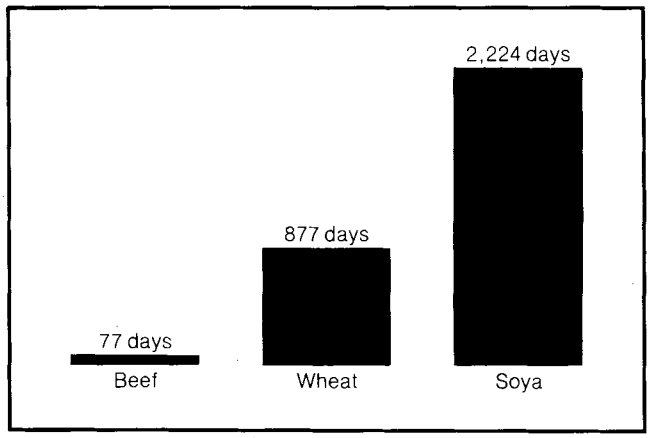

FIG. 1. Protein yields per acre for one man's need.

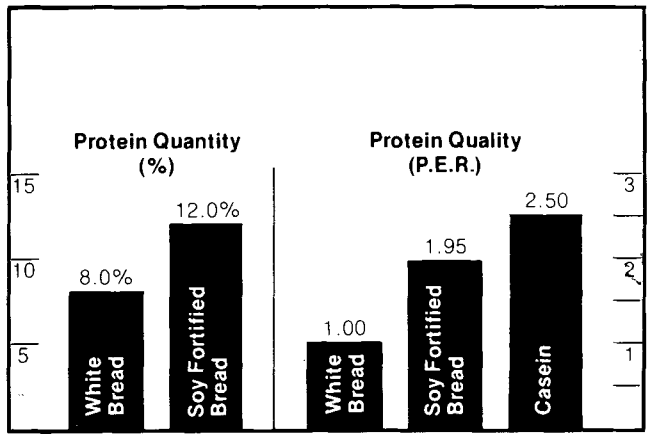

FIG. 2. Soy-fortified bread (12% soy).

In developing countries, soya fortification of bread is proving economically feasible when protein shortages, meat imports and practical delivery systems are considered (Fig. 2).

The nutritional aspects of wheat flour fortification with 12% defatted soya flour have been known for many years. Studies using soy-fortified wheat flour were made at Kansas State University many years ago. The "know how" is well understood, but too many people made only the cost comparison of soya flour to wheat flour and decided that fortification was too expensive.

In countries where protein deficiency is a problem, including most of the developing countries, fortification of wheat, corn or manioc flour is potentially tremendous, and is a rapidly growing market. The use of soya grits and textured soya bits to fortify rice has also been a nutritional booster in many countries. Because of the color difference of the particles, this has caused problems, as some people remove the soya. Nutritional education seems to be the best answer to this problem. Presently, soya fortification is the most economical method of bringing a high quality protein supplement to a rice-eating people.

"Selling" nutrition is one of the most difficult sales in the world. People usually eat what they like or what is visually attractive. Many people near starvation refuse to change or add new items to their diet; habit is difficult to overcome.

Probably the most concerted effort to improve the diet of people in developing countries has been made by U.S. A.I.D. with PL-480 blended foods, such as wheat soy blend (WSB), corn-soy milk (CSM) and the new wheat protein concentrated soy (WPC-SOY). WPC-SOY is one of the highest protein calorie density food products available for lactating mothers, weaning infants and preschool children. It addresses both the protein and caloric needs of these target groups. Compared to similar products in commercial distribution, the economy of the WPC-SOY and elimination of lactose intolerance that is found in many parts of the world truly make WPC-SOY a food of the future.

Both full-fat and defatted soya flour, soy concentrate and soya isolate have found their way into soya milks. These have been tried primarily as milk replacers, but are now being studied for milk extension, which offers a worthwhile savings in most parts of the world, particularly the developing countries where milk has become a staple in the diet.

SOY PROTEIN ECONOMICS

Wholesale price ranges of the various edible soya proteins in the U.S. at the end of October 1980 are shown in Table I.

As stated earlier, we are picking up the soy flake or meal after oil extraction and processing to the PDI or NSI needed. Table II shows the range of additional processing costs to convert these flakes into the various "further processed" soya proteins. The costs shown are practical estimates, as facts usually are confidential with each producer. Some differences can be observed between these costs and those in the Mustakas and Sohns article (1).

Additional factors, such as "shrink," must be considered, as well, as the energy cost of drying the various products. Also essential is to calculate carefully the investment in the plant to manufacture each of these items. For the most part, existing, depreciated plants are producing at calculated costs much lower than the actual cost of production when the replacement of machinery and equipment is considered. That is, soy protein products from existing plants probably are the best buy in the world.

Table III compares the prices of various protein sources in the U.S. using prices from June 1980. It is important that we consider the protein content of the product when we talk about relative costs. Soya again is the most eco-

TABLE I

Wholesale Prices of Various Soy Protein Products in the United States[a]

	Per pound F.O.B. production point
Soy flour	$0.18 - .20
Soy grits	.18 - .20
Textured soy protein (unflavored)	.32 - .36
Soy protein concentrate	.42 - .46
Soy protein isolate	.92 - 1.02

TABLE II

Approximate Guidelines on Relative Costs of Soy Protein Products (Excluding Cost of Raw Material)

Product	Production Cost (Cents/Pound)
Soy flour and grits	$0.03 - .05
Textured soy flour	.08 - .15[a]
Soy protein concentrate	.20 - .30[b]
Soy isolate	.45 - .65[b]

[a]Varies with size, shape, color, and flavors.
[b]Costs vary, depending on soluble or insoluble product.

TABLE III

Relative Costs of Protein in Selected Food Sources

Protein source	Protein (%)	Price of food[a] ($/lb retail)	Cost of protein ($/lb)
Beef (round)	20	2.48	12.40
Eggs (medium)	13	.88	6.77
Fish (pollock)	18	1.00	5.50
Chicken	18	.59	3.25
Milk (nonfat dry)	33	1.60	4.85
Dry beans	18	.49	2.72
Soy protein concentrate	64	.66	1.03
Textured vegetable protein	50	.50	1.00

[a]Prices as of June 1980.

nomical source of protein available. It also fits an amino acid profile that allows substitution without sacrificing nutrition.

Probably the easiest way to take advantage of the economics of soya protein is in various meat systems. Correctly included in a ground or minced meat, or in sausage application, these economics are easily calculated.

In 1971, the U.S. Department of Agriculture allowed the addition of textured vegetable protein into hamburger in the school lunch program. Table IV shows the savings when USDA requirements are met. Addition of soy to sausage and corned beef is being accomplished at much higher levels in some parts of the world. With the high price of meat in most parts of the world, the meat producer and processor can be certain that they can actually increase the use of meat by adding soya. The money saved using soya allows more meat to be consumed for the same cash outlay. The consumer is quick to recognize this savings; the frozen food market in the U.S., for which no restrictive labeling is required, shows the interest in correctly extended products.

The major drawback in putting economical, nutritional, extended meat products on the U.S. meat market today is the labeling restriction required on marketable products. The word "imitation," required on combination meat-soya products in the U.S., carries with it enough of a stigma that the meat processor is reluctant to invest resources heavily. These regulations must, and will, change in the U.S. Inflation has become a sales tool for us as the consumer looks for more ways to feed the family well at the least possible cost.

I urge those of you in countries that do not have these restrictions or regulations to take a stand against any regulation that takes the choice of product out of the consumers' hands. Soya products are good, nutritious products for which consumption should not be hampered by unnecessary, burdensome restrictions.

Textured soya protein finally is making its entry into the marketplace in the U.S. as a meat analog. These products are good, nutritious and economical. One product that entered the U.S. market last August retails for $1.49 for a package that serves 4 generous portions of a nutritionally balanced meal just by addition of water. With a hamburger costing 65¢ for about 2 oz of cooked meat, you can readily see that these products should have a place in the U.S. food system.

The expected growth of soy protein consumption will result from a squeeze on disposable income versus availability of "traditional foods" at affordable prices. People with higher disposable income will continue to buy their steaks or roasts, but the market today needs nutritious, low-cost soya foods to offset inflation that is emptying the pocketbooks of Americans as well as people worldwide.

I am not ignoring the further refined soy products of soy protein concentrate or soy protein isolate. I tend to think of these as functional protein products. These items have been established in the marketplace for their binding, emulsifying and other functional properties and have a function in meat extension and even as meat analogs. Certainly, the meat analog market has been supplied in the U.S. with simulated sausage and bacon products, but these items are principally purchased by people on a low-cholesterol diet or those who need to reduce or eliminate fat from their diets. These products also suffer from overpricing. They usually retail at a price equal to or higher than the meat they replace.

I really feel these soya concentrates and isolates have a future outside their functional market. We are presently blending textured soya protein, concentrate and isolates with various meat products, processing in a slightly different manner and producing a reasonably good roast meat type product at a fraction of the cost of a true roast. We have the texture, flavor, and appearance, and are finding markets in those areas of institutional feeding where trained chefs or cooks carefully watch the results of their efforts. These products presently take some special handling to prepare, but can be as attractive on the plate as an all-meat product. They are lower in cost, nutritious and good when correctly prepared. Our present work is directed at making these products as easy to prepare and serve as any traditional food.

Edible soya protein products have been available for years. The western world is presently becoming aware of these products. We have a large and growing market, but we have not begun to reach the vast majority of the world's people who need low-cost, nutritional, and above all, good tasting food served in customary manners. We must devote our efforts to produce these needed products.

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TABLE IV

Cost Savings in Ground Meat Patties Using Textured Vegetable Protein (22% Fat)

Product	Pounds per 100 lb meat block: Lean meat	Trimmings	Soy	Water	Cost/ 100 lb	Savings/ 100 lb
100% Beef	$ 70.00	$30.00	$00.00	$00.00	$110.30	
70% Beef + 30% TVP	32.50	37.50	12.00	18.00	71.08	$39.22
100% Pork	100.00	00.00	00.00	00.00	112.00	
75% Pork + 25% TVP	55.36	19.64	10.00	15.00	75.61	36.39

Meat prices (yellow sheet October 31, 1980)

90% Lean beef	$1.20/lb	78% Pork boneless butts	$1.20/lb
50% Lean beef trimmings	$0.69/lb	50% Lean pork trimmings	$0.54/lb
	TVP (dry)	$0.30/lb	