production for more affluent populations. The increased demand already indicated for animal protein will put continuing pressure on soy production capabilities. However, there is every reason to believe that soy protein processed in forms that make it a functionally acceptable replacement or extender of animal products will play an increasing role in the diets of the more affluent, and will help to compensate to some degree for the high prices and limited supplies of products of animal origin.

In Asia, soy products eaten with rice have been a major factor in sustaining the population of this region that has nearly 60% of the world's population. Most of this soy has been consumed directly by humans, in contrast to its current use for feedings animals in much of the rest of the world. In these Asian countries, soy products play a role traditional for animal products elsewhere. Each sector of China's large cities has its own soy product factory that uses soybean curd as a base for turning out some 30-40 consumer products. These are rationed, since demand far exceeds supply. In Indonesia, a soy-fungal product, "Tempeh," is sold in a number of different processed forms in every market. Soybean curd "Tofu" plays a significant dietary role in Japan and is even beginning to be found in stores in the U.S. In addition, various forms of textured soy protein, marketed in the U.S. and Europe as meat extenders, are beginning to find their way into Third World markets. For example, they are now popular for rice dishes and soups with plantation workers on the Pacific Coast of Guatemala, who can seldom afford meat.

Soy products for direct human consumption could thus play a comparable role for wheat- and corn-based diets if soy were grown in the right regions, and if the people of these areas become accustomed to processing and eating it. In the humid tropics, to which the soy plant is not currently satisfactorily adapted, other legumes are likely to remain more important. In the more temperate parts of Africa and Latin America, however, introduction of locally processed soy protein products directly into human diets can make a major contribution to meeting protein needs.

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The Role of Soybeans in Food Systems

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ABSTRACT

Technological advances have made it possible to have soybean protein available in various forms: as whole seeds and flours, protein concentrates and protein isolates. These products differ in functional properties as well as in fat and protein content; however, amino acid patterns on a protein basis are essentially the same. Nutritionally, these products have in common a highly digestible protein with ample amounts of lysine and a relatively good essential amino acid pattern. Soybeans have contributed to food systems as sources of calories, as supplementary protein, and as complementary protein because of their good essential amino acid pattern. Furthermore, soybean protein products have made significant contributions to food systems because of their functional properties, which are essential to derive benefit from the nutritional or economic enhancement they impart to other foods. Many examples of this are found in the literature and in practice. Whole soybeans have been used to extend common beans, providing higher energy concentration and higher protein content and quality. Full-fat flour or protein concentrates added in variable amounts to cereal grain flours have introduced higher energy and higher protein content and quality into foods based on maize, rice or wheat. Finally, the amino acid pattern of soybean protein products has allowed them to be used as extenders for cow's milk and meat products, without altering the protein quality or acceptability of the food product.

INTRODUCTION

Soybeans have a long history as a foodstuff in the Orient. From there, their cultivation and use have expanded to other regions of the world, in particular to the American continent. During the past 25 to 30 years, mankind has seen significant advances in the use of the soybean as a food. This paper will attempt to summarize the role soybean plays in various food systems, with emphasis on the Latin American diet. For a time, particularly in the developed countries, soybean products were used primarily for their functional effects; however, recently the developing countries have begun to take advantage of their nutritional properties as well. Actually, these two main properties, functionality and nutritive value, are not mutually exclusive; both can and must play a significant role in meeting all desirable characteristics in processed foods required by the human population.

SOYBEAN PRODUCTS

The numbers and types of soya products have increased appreciably in the past several years. However, basic product grouping may be classified for the purpose of this paper as shown in Table I. From these main products, using particular technologies, other soybean foods have been prepared, including: textured vegetable proteins, expanded or compacted with 50-53% protein; spun-fiber textured products, and other soy food products such as milk and cheese, Oriental foods, and hydrolyzed products.

TABLE I

Typical Chemical Composition of Soy Protein Products (g/100 g)

Product	Protein	Fat	Fiber	Ash	CHO
Whole soybean	41.0	20.0	2.3	5.4	31.3
Soy flours	50.0	1.0	3.5	6.0	39.5
Concentrates	70.0	1.0	4.5	5.0	19.5
Isolates	96.0	0.1	0.1	3.5	0.3

FUNCTIONAL PROPERTIES

With increasing world population and increasing demand for food, especially animal foods, more use will be made of plant proteins. These proteins must retain esthetic, organoleptic and other functional properties to be useful. Many efforts have been made to introduce soybean products; however, commercial success has been limited. This may be attributable to the conservative tastes of consumers, which may be stronger for populations that have low economic resources and use staple foods such as cereal grains and legumes. Therefore, when soybean or other plant protein products are used in food systems, it is important to retain or improve as much as possible the characteristics that make foods attractive to the consumer.

One of the significant attributes of soybean protein is that, by controlling processing conditions, soybean products can be made with different functional properties that are useful in a variety of food systems and applications. These functional properties have been well described (1,2), and are shown in Table II. They include emulsification, fat and water absorption, texture, dough and film formation, adhesion, cohesion and elasticity, foaming, color and flavor control. These properties are generally attributed to the protein; however, other chemical components in some products may also participate in imparting functional characteristics. For example, polysaccharides in soybean flour and grits will absorb more water than an equivalent amount of protein. These functional properties have been studied in soybeans as they apply to food systems that prevail in developed societies, such as those including meat products and wheat-derived foods, but little has been done for food systems of underdeveloped populations. It would be appropriate, therefore, to do the same for other food systems if it seems that soya will enter and be accepted in such systems.

An example of the amount of water retention induced by the addition of 8% soybean flour to tortillas is shown in

TABLE II

Functional Properties of Soy Protein Preparations in Food Systems (2)

Functional properties	Mode of action	Food system	Preparation used[a]
Solubility	Protein solvation, pH dependent	Beverages	F,C,I,H
Water absorption and binding	Hydrogen-bonding of HOH, entrapment of HOH, no drip	Meats, sausages, breads, cakes	F,C
Viscosity	Thickening, HOH, binding	Soups, gravies	F,C,I
Gelation	Protein matrix formation and setting	Meats, curds, cheese	C,I
Cohesion-adhesion	Protein acts as adhesive material	Meats, sausages, baked goods, pasta products	F,C,I
Elasticity	Disulfide links in gels deformable	Meats, baked goods	I
Emulsification	Formation and stabilization of fat emulsions	Sausages, bologna, soup, cakes	F,C,I
Fat adsorption	Binding of free fat	Meats, sausages, donuts	F,C,I
Flavor binding	Adsorption, entrapment	Simulated meats, bakery goods	C,I,H
Foaming	Forms stable films to entrap gas	Whipped toppings, chiffon desserts, angel cakes	I,W,H
Color control	Bleaching of lipoxygenase	Breads	F

[a]F,C,I,H, and W denote soy: flour, concentrate, isolate, hydrolyzate and whey, respectively.

Figure 1 (3). In this study soybean flours derived from diverse technologies were used. Two findings were interesting: all the soybean products increased water retention, and the soybean products differed in this particular capacity. Higher water retention is beneficial because desirable organoleptic properties are retained longer. On the other hand, the addition of a supplement such as soya may have undesirable effects if it is not accompanied by other measures, particularly if such activities are done under field conditions. This is apparent from the data in Table III. These data refer to the pH changes and bacterial count of a tortilla supplemented with 8% soybean flour in comparison with an unsupplemented sample (4). The results clearly demonstrate that the supplemented tortilla rapidly developed a higher acidity than the unsupplemented sample and had a higher bacterial count, which was obviously responsible for the lower pH values. Therefore, the capacity for higher water retention, induced by the addition of soya flour, was negated by the off-flavor indirectly induced by the higher bacterial count.

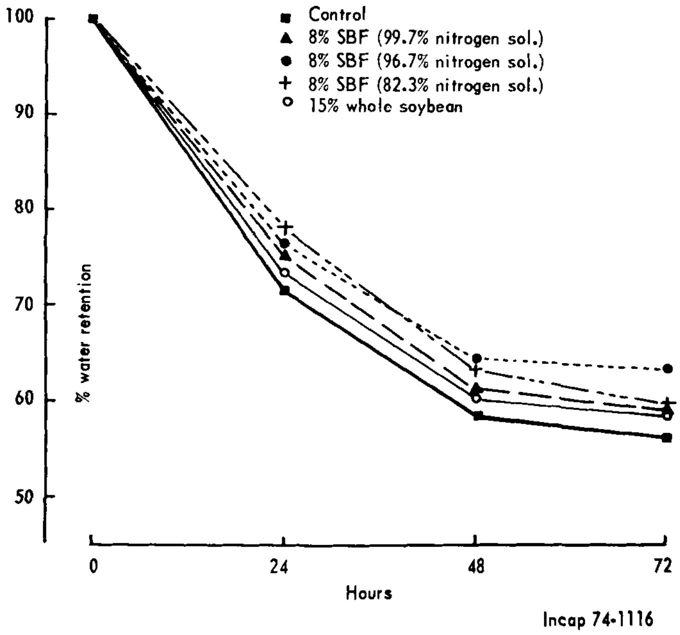


FIG. 1. Water-holding capacity of tortillas made from corn and corn supplemented with various types of soybean protein.

Thus it is important to introduce functional properties into food systems, but generally, more attention must be given to the food systems of populations in developing countries.

NUTRITIONAL PROPERTIES

Although soybeans and some soybean products contain a variety of nutrients, the particular attraction of the soybean is its protein. As shown in Table IV, soybean proteins are made of an essential amino acid pattern, probably one of the best among vegetable protein sources. This pattern resembles, with the exception of the sulfur amino acids, the amino acid patterns of high-quality animal protein sources. The relatively high lysine content of soybean protein also makes it an effective supplement to cereal grains, which are low in lysine.

Results from many assays with experimental animals indicate that raw soybeans decrease weight gain due to inhibiting factors such as trypsin inhibitors, urease and hemagglutinin compounds, which do not permit the demonstration of the quality of the essential amino acid pattern. However, the destruction of these inhibiting factors by moist heat treatment shows that the protein quality is relatively high.

Studies with experimental animals have also demonstrated that protein quality improves when supplemented with methionine, which is the limiting amino acid in soybean protein. Nutritional information on soybean protein from human studies has become available recently.

The digestibility of soybean protein in humans is lower than digestibility of animal protein, depending on the type of soybean product tested (Table V). Thus protein isolates and concentrates have a higher digestibility than soybean flour. This suggests that in flours, the processing conditions or other compounds, which are not present in concentrates or isolates, may be the responsible factors (5).

Studies of children and adults have shown that at low levels of protein intake, methionine supplementation improves protein quality. An example is shown in Table VI from Zezulka and Calloway (6). Nitrogen balance improved as protein intake increased from 3 to 6 g N/day. Methionine supplementation improved nitrogen retention at all levels.

TABLE III

Bacterial Count and Acidity Development of Maize Dough and Tortilla with and without an 8% Soya Flour Supplement (4)

	Maize dough		Tortilla	
Storage time	Without supplement (pH)	With supplement (pH)	Without supplement (pH)	With supplement (pH)
0	4.7	5.4	4.9	5.5
12	4.4	4.0	4.7	5.1
24	–	–	4.6	4.6
36	–	–	4.5	4.3
		Gram + Bacillus		
0	8300	9500	900	8000
12	19100	33200	1200	9100
24	–	–	10700	9900
36	–	–	–	14400
		Total bacteria count/g		
0	8300	9500	7900	8200
12	19100	33200	9100	10300
24	–	–	13300	11200
36	–	–	–	11400

TABLE IV

Essential Amino Acid in Soybean Protein and Other Foods (mg/g N)

Amino acid	Soybean	Maize	Meat	Milk
Isoleucine	336	289	327	407
Leucine	482	810	512	626
Lysine	395	180	546	496
Phenylalanine	309	284	257	309
Tyrosine	199	382	212	325
Cystine	111	81	79	57
Methionine	84	116	155	156
Threonine	246	249	276	294
Tryptophan	86	38	73	90
Valine	328	319	347	438

TABLE V

Protein Digestibility of Various Foods by Adults (Range) (5)

Protein source	Digestibility (%)	
	Apparent	True
Whole egg	73-86	93-100
Milk	69-77	90- 98
Beef	73-82	91- 99
Casein	71-78	94- 97
Soy flour	70	75- 92
Soy flour, defatted, extruded	66-79	84- 90
Soy protein isolated	81-82	93- 97
Soy protein, spun	83-88	101-107

TABLE VI

Methionine Supplementation of Soybean Protein Isolate in Adults (6)

Level of protein intake (g N/day)	Methionine supplementation[a]	N Retention (g/day)
3.0	-	-1.21
3.0	+	0.08
4.5	-	-0.08
4.5	+	0.64
6.0	-	-0.26
6.0	+	0.76

[a]A - indicates no methionine supplementation; a + indicates methionine supplementation.

Other researchers have reported similar findings (7-10), and have indicated that the effect of methionine no longer exists when intake of N increases to above 0.6 protein/kg/day.

Because of their nutritional characteristics, soybeans and soybean products play important nutritional roles in food systems. These roles may be classified into three groups: as supplementary proteins; as complementary proteins; and as nitrogen sources or protein extenders.

All protein products, from the whole seed to the isolate, may serve in any of these roles since the difference between each role lies in the amount of soybean used in any particular food system. Furthermore, the net effect of any of these roles is to increase or retain protein quality and quantity, and to provide, at the same time, desirable functional properties. Levels of soya, when used as supplementary protein, may be as high as 8% protein equivalent; its application is mainly in cereal grains and their products. Typical examples are shown in Table VII. In these examples, the protein quality of the three cereal grains is increased two-fold, and not only does protein quality increase, but total protein increases also, from 4-5 g (11).

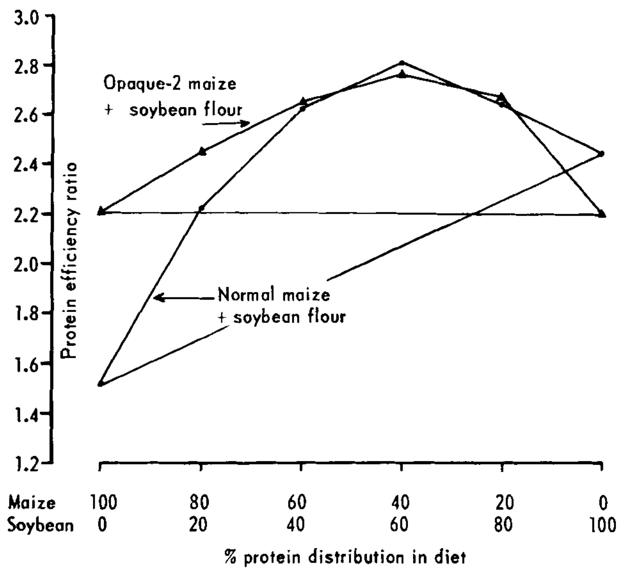
The complementary role of soybean protein is represented by that situation in which the quality of the product is higher than the quality of the individual ingredients, as shown in Figure 2 for the complementary effect between maize and soybean. In both situations, the results show a higher protein quality with a blend in which 40% of the protein is derived from maize and 60% from soybeans (11).

When soybean is used as a protein extender, no change in either protein quality or quantity is expected; however, neither should decrease. Figure 3 shows an example of this, when replacement of meat protein by an equal amount of soya protein as textured vegetable protein (TVP) did not significantly alter protein quality in human adults. This was indicated by the coefficients of regression of 0.86 for meat and 0.91 for the mixed food, and also by the amount of protein needed for nitrogen equilibrium, that is, 0.52 g/kg body wt/day for meat, and 0.57 g/kg/day for the mixture (12). This is not always the case, however, since other studies report a decrease when soya protein replaces more than 25% of the meat protein, particularly if protein intake is below minimum physiological needs (9).

TABLE VII

Effect of Soybean Flour (SBF) as Protein Supplement to Cereal Grains (11)

Cereal grain	Level of soybean (%)	Protein efficiency ratio (PER)	Additional soy protein (g)
Maize	–	1.00	4
Maize + SBF	8.0	2.25	–
Rice	–	1.87	4
Rice + SBF	8.0	2.88	–
Wheat flour	–	0.70	5
Wheat flour + SBF	10.0	2.01	–
Whole wheat	–	1.32	5
Whole wheat + SBF	8.0	1.91	–



	Lys	Try	T.S.A.A.
	mg/g N		
Normal maize	180	38	197
Opaque-2 maize	306	94	234
Soybean flour	395	86	195

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FIG. 2. Protein efficiency ratio of combination of normal or Opaque-2 maize and soybean flour.

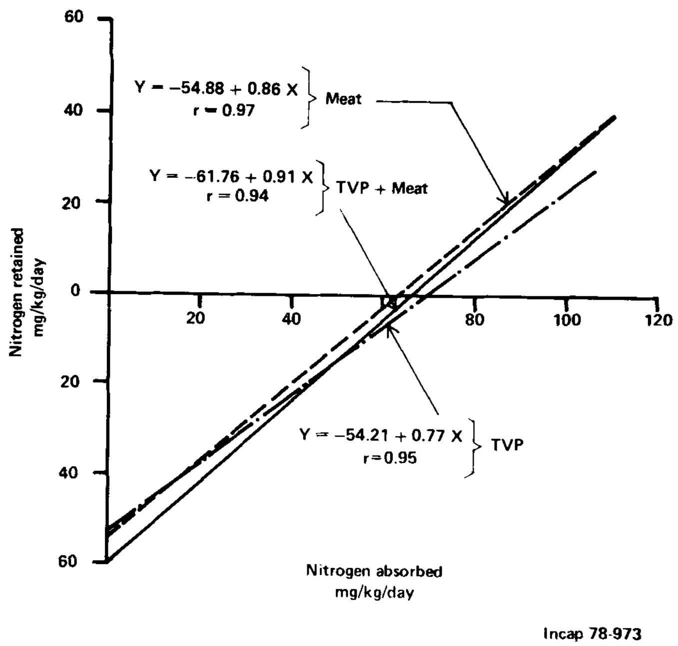

FIG. 3. Nitrogen balance index of soybean protein (TVP) and meat (12).

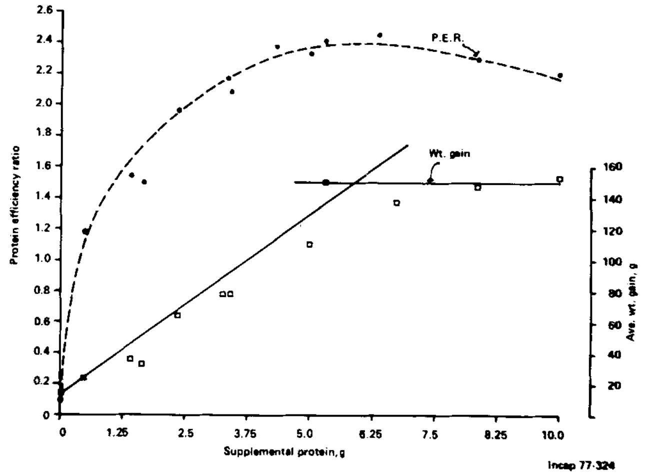

FIG. 4. Protein quality improvement of maize from soy protein supplementation (13).

SELECTED APPLICATIONS FOR LATIN AMERICA

During the past few years, much interest has developed in Latin American over the use of soybeans as a means to increase the supply of better-quality foodstuffs, in view of the nutritional problems, the low availability of foods and the high cost of animal food products in Latin America.

The applications to be presented were selected on the basis of the food consumption systems that prevail among the majority of the populations. These systems are based on cereal grains, such as maize, rice and wheat and common beans, or on starchy foods such as cassava, yams or plantains and common beans. Animal food products are also consumed, but in relatively low amounts.

Applications for Cereal Grains

The best example of using soya in an application to cereal grains is the supplementation of maize with soybeans. Maize is consumed in many forms and in variable amounts throughout Latin America by young and adult populations. Therefore its nutritional value is of great importance. Many studies have demonstrated (Fig. 4) that adding 4-6 g of soybean protein improves the protein quality of maize (13). This is due to the lysine and tryptophan contribution of soya protein to maize. Furthermore, protein content increases also. The extent of these improvements depends on the basic nutritional quality of the cereal and the quality of the soybean product used (14).

Table VIII shows the results of an example of this kind of supplementation. In this example, the maize products used were tortilla flours made from various maize types; a sample of degerminated cooked maize was also included. These products represent the main forms of maize consumption in Latin America. The soybean products used were an edible grade soybean flour, a soybean texturized product and a protein isolate. The level of supplement used was the equivalent of 5% protein. The results show the greatest improvement for the degerminated maize with all soya products and the least improvement for Opaque-2 maize. These results were to be expected since the protein quality of degerminated maize is low. On the other hand, the soybean products behaved quite differently, with soybean flour superior to the other two (14).

Other soya products can also be used, of which whole soybeans are particularly interesting. In the example shown in Table IX, tortilla flour was prepared by cooking maize with 15% whole soybeans; the quality was compared to tortilla flour supplemented with 8% soybean flour. The results show essentially the same response in terms of protein quality; however, the use of whole soybeans increased the fat content of the tortilla, making it better all-around nutritionally (15).

Applications such as these can be of great nutritional benefit and, in general, can improve functional properties. Such measures are also applicable to rice and to wheat and wheat products. Many reports have shown that functional and nutritional improvements are obtained by the use of soybean protein in food products based on wheat, products which are becoming more popular as the socioeconomic condition of the people improve. Over 41% of the foods industries in Central America produced are bakery products

TABLE VIII

Interaction in Protein Quality between Different Maize and Soybean Products (14)

Maize product	Basal (PER)	Soy product: Soybean flour (PER)	Soybean texturized food (PER)	Soybean isolate (PER)
Degerminated	0.40	1.98	1.90	1.97
Cuarenteño	1.19	2.07	1.99	1.97
Azotea	1.02	2.36	2.13	2.12
Opaque-2	2.02	2.12	1.99	2.10

TABLE IX

Protein Quality of Tortilla Flour Supplemented with Soybean Protein (15)

	PER	Relative nutritive value	Utilizable protein (%)	Fat (%)	Protein (%)
Tortilla flour	0.95	23.7	2.1	3.0	10.0
+15% whole soybean	1.98	57.1	7.1	5.5	13.9
+ 8% soy flour	1.98	57.1	6.6	2.8	13.2
Casein	2.60	75.0	9.4	–	–

(16). These products are excellent carriers of nutrition, including protein, and more efforts should be made in this area since these products are reaching those groups of people that need better quality foods. If measures such as those described increase protein quantity and quality and improve or do not alter functional properties, why are they not adopted? Whatever the answers, they must be defined to improve the nutritional status of the population.

Adaptations for Common Beans

The main protein source or at least the most common supplementary protein to the regular diets of most Latin Americans is the common bean (17). However, very little has been accomplished in increasing the availability of this bean through increased yields. Furthermore, the protein quality of the common bean is relatively low; therefore, attempts have been made to extend common beans with soybeans. From a nutritional point of view, this is an improvement, as indicated in Figure 5. Results were obtained by replacing equivalent amounts of protein by the two bean species, common beans and soybeans. The protein quality of soybeans was retained when 50% of their protein was replaced by 50% of protein from common beans. This protein distribution is equivalent to 33 g of soybeans and 67 g of common beans (11). Because of the higher level of common beans, the mixture retains the flavor of common beans, resulting in a product with higher protein and fat content. This observation was also found and applied in Brazil (18), and a food product was made available to consumers with acceptable results. Besides having an increased protein quality, the common bean/soybean mixture had other interesting attributes as well (Table X), such as high protein and fat contents, which make the mixture an excellent supplement to cereal grain diets. However, such foods require that soybeans be modified in shape and color to make them similar to common beans. Furthermore, cooking time and rate of water absorption during cooking must also be alike to insure acceptability.

Other alternatives are also available that are based on forms in which common beans are consumed, such as bean flour or paste, where either whole soybeans or other soybean products may be utilized.

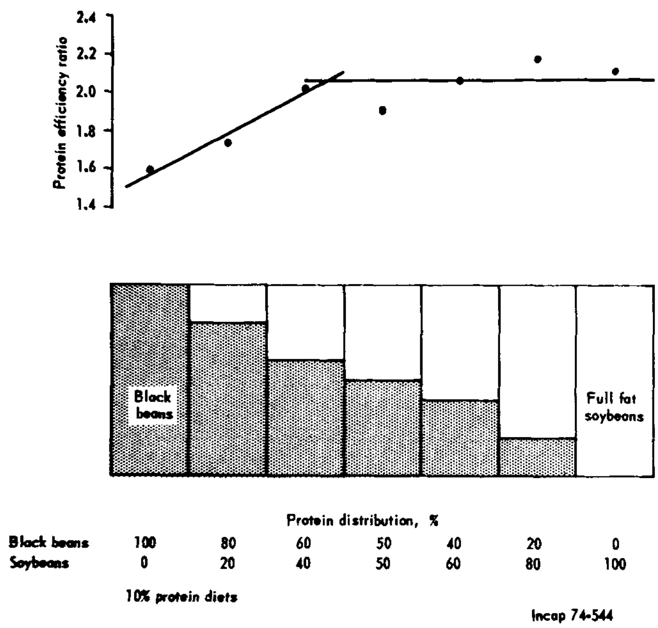

FIG. 5. Protein quality of black bean and soybean mixtures (11).

TABLE X

Proximate Composition of Soybeans, Common Beans, and a Mixture of Soybean/Common Beans (50/50 by wt) (g/100 g) (18)

Component	Product		
	Soybean	Common bean	Mixture
Crude protein	36.6	19.4	27.9
Total lipid	22.7	3.5	13.2
Water	7.5	4.9	7.3
Crude fiber	5.2	4.6	5.1
Ash	5.3	3.4	4.5
Carbohydrate	27.9	68.8	47.2

Adaptations for Starchy Foods

The most popular starchy foods consumed in Latin America are cassava and plantain; however, due to the forms in which they are consumed, the use of soybean products becomes difficult. Despite this, studies have been conducted in Brazil to prepare soybean products that simulate particular cassava products (19). Since cassava flour or grits are low in protein content, it follows that small amounts of soybean grits may result in food preparations of superior protein content and quality. Based on the needs of young adult human subjects (12) for soybean protein, and assuming no other protein is consumed, cassava flour providing about 35% of the total energy intake equivalent to 200 g of flour should be supplemented with not less than 32 g of soybean protein per day (12), which is equivalent to about 13% soy protein in a soy/cassava mixture.

In studies with experimental animals (20), plantain flour was supplemented with increasing levels of soybean flour or skim milk (Fig. 6). From the weight gains and the amounts of protein ingested, regressions were calculated. From these data, it was then estimated that plantain flour should be supplemented with no less than 8.8% protein equivalent or about 18% soy flour with 50% protein content, or with 24% skim milk with 33% protein content.

These innovations have not been readily accepted since little attention has been paid to the functional properties of the soybean grits or protein in relation to the characteristics

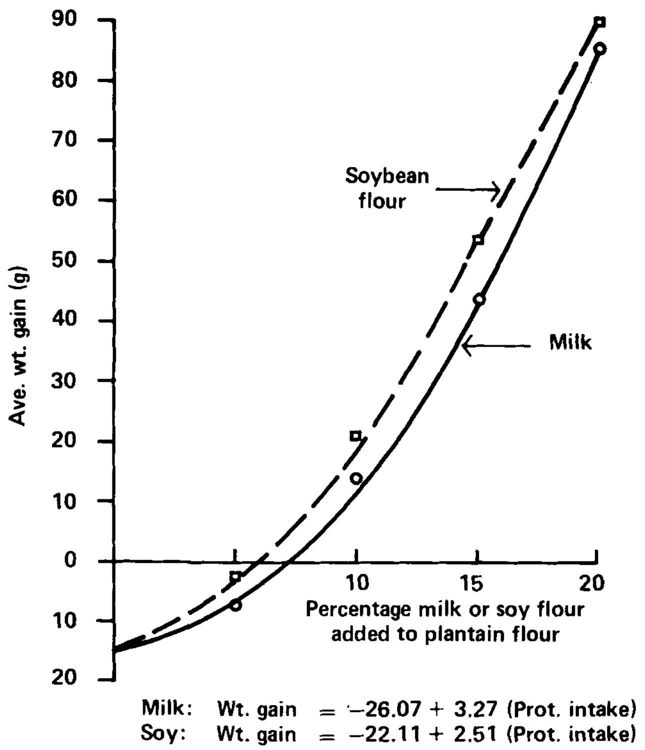

FIG. 6. Supplementary effect of skim milk and soybean flour on plantain flour (20).

of cassava or plantain flour. Many efforts have been made and are still being made to use whole soybeans in such food systems. The flavor of the soybean, however, is a significant factor in the acceptance of such approaches.

Soybean in Foods for Supplementary Feeding

Malnutrition in Latin America is very serious for the small child, particularly after weaning, because he enters the family eating pattern and gets not only small amounts of foods, but foods unsuitable for weaning purposes. Therefore, many efforts have been made to develop high-quality supplementary foods for weaning purposes. Some examples are shown in Table XI. The soybean product used in such formulations may be full-fat soybean flour or soybean flour; the amounts vary from 10 to 30%. Other ingredients include cereal grains, milk, vitamins and minerals. There is a nutritional advantage when full-fat soya flour is used because of the higher energy density in such formulations. Many such products have been developed and some are being used in supplementary feeding programs. The problems in the success of these products are related to their energy density, particularly when fed to young children, and to their acceptability. These problems are now under consideration and some advances have been made, through

TABLE XI

Protein Quality of a Cassava/Soy Mixture (19)

	Cassava/soy[a] (60/40)	Casein
% Protein	12.9	–
% Fat	6.9	–
PER	2.35	2.50

[a]Residue from soy milk production, 27.5% protein.

extrusion cooking and the use of amylolytic enzymes, to increase energy density and suspension in water. Sweetening agents and flavors and fruits have been used to increase acceptability.

Soybean Milk and Milk Products

Milk has always been associated with feeding of children, but its use is restricted by economic considerations as well as undesirable physiological effects. On the other hand, soybean milk is a product that has received much attention, from its manufacturing to its nutritive value and acceptability. Therefore it is logical to accept that one way in which the animal and vegetable milk may come together is in the preparation of blends from the two products.

The extent to which cow's milk is replaced by soybean milk is determined by nutritional aspects and acceptability factors. Figure 7 shows that the protein quality of milk decreases as the level of cow's milk is replaced by soybean milk or protein beyond 25%. Even though this may be considered a small amount, the total amount needed is high and the economic implications are significant (11). It seems advisable to develop better characteristics of acceptability in the product rather than increasing the level of soybean addition.

Soybean in Meat and Meat Products

Meat consumption in Latin America is relatively low; values ranged from 10 g to 78 g (21). Meat consumption is not only low, but the forms in which it is consumed, particularly for rural populations, do not include forms that permit a favorable way to extend it with texturized soybean protein or any other soya product. Extending meat in this way would appear to be feasible, however, for urban and semi-urban populations. In any case, extension of meat with soybean products should not decrease the nutritional

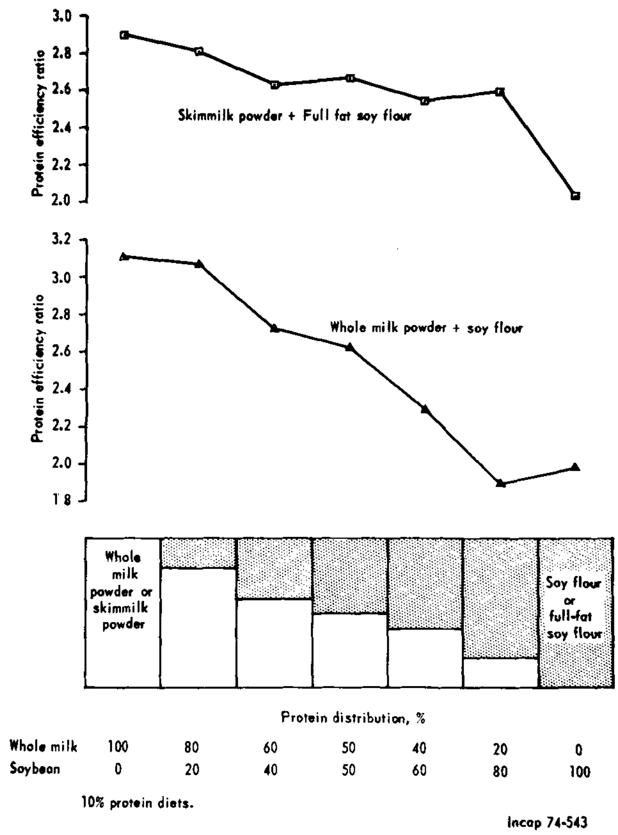

FIG. 7. Protein quality of milk and soybean protein mixtures (11).

TABLE XII

Protein Quality of Mixtures of Meat and Soybean Texturized Product (22)

Protein distribution (%)		Average wt	
Meat	TVP	gain (g)	PER
100	0	126	3.11
75	25	108	3.04
50	50	109	2.79
25	75	84	2.47
0	100	82	2.30
Casein	–	119	3.03

quality of the product.

In some of our studies (Table XII), we obtained information about the fact that quality decreases when more than 50% of the meat protein is replaced by soybean protein (22). Two points are important in this respect. One is the particular quality (which is not constant) of the product, for samples being produced and commercialized in Latin America (23). Therefore, if a low-quality TVP product is used and 50% or more is added to replace meat, the quality of the final product will be much lower. The second point is that such a decrease in quality would not be important if other foods consumed were of high nutritional value. However, this is not usually so in diets consumed by people in developing countries. It is essential, therefore, not only to limit the level of replacement but to insure that the quality of the soybean product is as high as possible.

DISCUSSION

To illustrate the nutritional significance of the information presented in this report, the results shown in Figure 8 (17) will be discussed. Although these results were obtained with experimental animals, human studies of children and adults have corroborated the nutritional value of the extreme points, and that of the point of maximum nutritional response for this food system of maize and common beans, which is very common in Latin America. Similar systems have been worked out for other cereal grains and common beans, and for starchy foods such as cassava or plantain, and common beans. The maize/bean system illustrates the protein quality values of various mixtures of maize and beans, which are low at the extremes and have a peak value when both foods supply 50% of the protein. This is equivalent to a mixture of 70 parts of maize, by weight, to 30 parts of beans. Above the response curve, a horizontal line has been drawn, representing the protein quality which is desirable, assuming other nutrients, including calories, are adequate. To reach this area of desirable protein quality, quality of the individual components of the system must be improved. This can be attained by adding soybean protein added to the components of the system, as shown in this report. The amount of soy protein that must be added at any point in the curve response line to reach the horizontal line varies. However, soybean protein can be added to maize, to beans and to any other food consumed, be it from vegetable or animal origin.

An important point to remember is that the addition of soya protein should retain the protein quality of the enriched product and should take advantage of the complementary effect, since methionine will be the amino acid limiting efficiency of utilization. Energy intake will also increase if whole soybeans or full-fat flour is added. Obviously, this perspective could be achieved only if functional properties, mainly acceptability, are improved. Economic considerations are also important, but probably the most

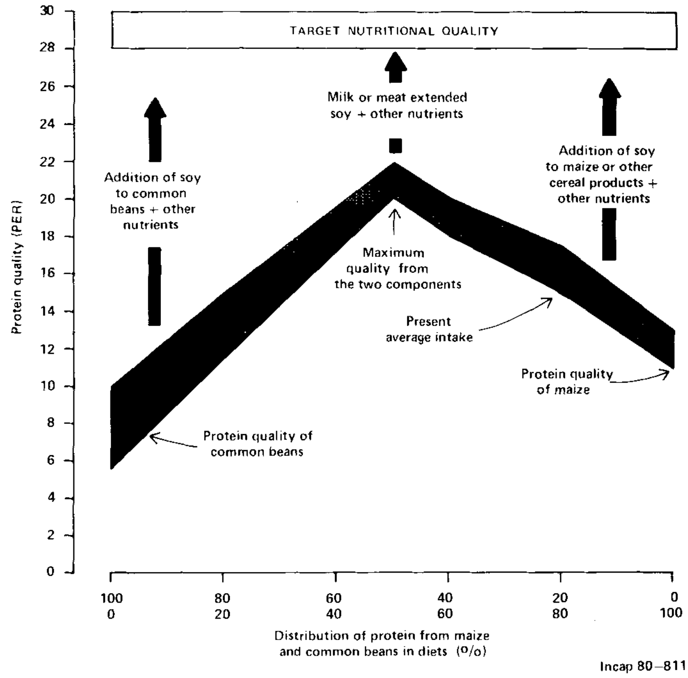

FIG. 8. Protein quality of maize/bean consumption system and improvement through soy protein supplementation.

important factor is to make these products available and to reach those population groups in need of better-quality foods.

No other agricultural crop has received as much attention in recent years in both scientific and applied aspects as the soybean. Nevertheless, in spite of its attractive functional properties and of its excellent nutritional characteristics, only a small percentage of world soybean production goes to human food. In developing countries, the answer may be found in the lack of developed food industry, marketing know-how and conservative food preferences. In the developed countries, the answer may lie in their economic affluence. Whatever the reason, efforts to further develop the functional and nutritional properties of soybeans must continue as well as efforts to learn about its food applications for mankind.

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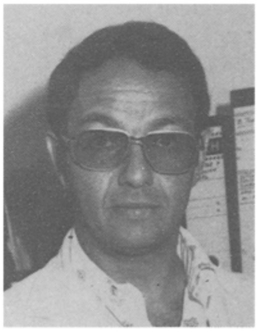

Nutritional Role of Soya Protein for Humans[1]

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ABSTRACT

This paper reviews the role played by soya protein in human nutrition on the basis of protein quality, energy and protein densities, and availability of trace minerals. The importance of supplementation with methionine was analyzed and it was concluded that there is little nutritional or public health justification for such supplementation when the intake of protein is adequate. The use of refatted soy products has good potential to increase the dietary concentrations of protein and energy, which may be particularly important for children in developing countries and for the elderly or other persons with limited dietary intakes and digestive capacity. Investigations based on chemical balance and on the use of stable isotopes indicate that the iron from soybean is well absorbed by humans, as are inorganic iron and zinc in the presence of soy protein. Soybeans and properly processed soy products have a good protein quality, and when fed in adequate amounts, they can satisfy the total nitrogen and essential amino acid needs of children and adults. Further research related to soy products should be directed mainly toward establishing their overall nutritional value as part of mixed diets or food systems, and not just assess their protein quality. Assessing the protein quality of soy products may be required when major processing modifications are made in the manufacture of soy products for human consumption.

INTRODUCTION

Soybean protein has played an increasing role in human nutrition over the last two decades in both developing and industrialized regions of the world. The production of soybeans has increased in many countries, notably the U.S., Brazil and China (1). Technological advances leading to the development of soy concentrates, isolates and textured extended-expanded products have increased soy consumption by humans. The functionality of these products and their mixtures with other foods have increased their acceptance by persons of all ages and of different cultural backgrounds. Major applications of soy protein products include infant formulas; hypoallergenic foods; vegetable protein mixtures; protein supplements; bakery products; traditional food items; snacks; food analogs, replacers and extenders, such as dairy products, processed fish and meat products; and a variety of formulated or fabricated food products (2,3).

The primary nutritional function of dietary protein is to furnish the essential amino acids and the nitrogen required for the synthesis of tissue proteins and other compounds necessary for normal function and growth of the organism. Therefore, the different food proteins and protein sources are considered in relation to their capacity to meet the amino acid and total nitrogen requirements of the host. This so-called "protein quality" of soybean products is the main issue addressed in this short review. However, a comprehensive assessment of the potential role of soy proteins in the human diet requires consideration of the impact of increased soy consumption on the overall nutritional health of individuals and population groups. The effects of soy protein or of soy-based foods on the utilization and requirements for other nutrients are addressed elsewhere in this conference. We will, however, refer briefly to some such aspects, based mainly on recent investigations carried out in our laboratories and on selected examples of the results obtained by other investigators. We intend to emphasize the complexity of the relationship between food proteins and overall nutritional health, including the utilization and requirements for other nutrients. We also intend to stress the importance of such factors in the evaluation of the nutritional role of soybean and other protein sources, which transcends merely assessing that the essential amino acid and total nitrogen requirements have been satisfied.

SOY PROTEIN QUALITY EVALUATED IN HUMANS

General Considerations

The criteria to evaluate the nutritional quality of a protein for humans have been the subject of numerous reviews and conferences (e.g., 4,5). The following considerations can be derived from them.

There are discrepancies between protein quality evaluations in animals and in humans, especially in the case of vegetable proteins, in which methionine is the limiting

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