RECOMMENDATIONS

Nutrition is a key aspect of health in the aging process. Most experts recommend an intake of ca. 0.8 g protein/kg/day for the elderly, or ca. 12-15% of the total calories.

Soya protein appears to be as good as animal protein in meeting essential amino acid and total protein needs of adult humans when consumed in adequate quantities. Attention must be given to appropriate heat treatment and processing of soybeans. In addition, the mineral and vitamin content of the diet should be monitored, because some of these nutrients may have been altered or removed from the raw beans in processing.

Further research is needed to identify nutritional requirements of the elderly, especially as affected by disease, trauma and drugs. In addition, nutrient interaction and bioavailability should be studied in foods which are processed by new techniques.

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Progress and Future Needs for Research in Soya Protein Utilization and Nutrition

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ABSTRACT

Although soya protein was clearly recognized as an essential part of the diet in the Orient centuries ago, its acceptance in the western world has been slow and recent. Progress in utilization has revolved around solving problems of flavor, nutrition and functionality, and has resulted in commercial development of flours and grits, concentrates, isolates, textured products, cereal-soya blends and beef-soya blends. Among the latter two developments, cereal-soya blends established the principle of using soya to increase protein content and quality of cereal diets consumed in many countries, and beef-soya blends demonstrated the usefulness of soya in extending expensive meat supplies. Governmental actions such as approval of soya in school lunches and in military diets in the U.S. have also contributed to progress in utilizing soya protein in foods. Future research needed to increase food uses of soya protein includes: further improvement in flavor, greater versatility in functional properties, development of new foods rather than simulation of traditional items, and elaboration of adequate methods for determining soya proteins in regulated products. Highlights in soya protein nutrition research include: discovery of the need for moist heat treatment to develop maximal nutritive value; establishment of methionine as the first limiting amino acid; isolation and characterization of trypsin inhibitors; determination that trypsin inhibitor retards growth and causes pancreatic hypertrophy; discovery of negative feedback control of pancreatic enzyme secretion; and demonstration of apparent adequacy of soya proteins in meeting protein requirements of young children and adults. Further nutritional research is needed in the following areas: long-term studies with humans to determine protein quality as well as possible needs for fortification with vitamins and minerals; establishment of need or lack of need for supplementation with methionine; mechanism of action trypsin inhibitors when ingested from soya and other sources; and development of rapid methods for measuring protein quality.

INTRODUCTION

Food use of soybeans has a long and somewhat paradoxical history. The plant was probably domesticated in the eastern half of North China as long ago as the 11th century B.C. (1) and the seed was used as a foodstuff for centuries before written records were kept (2). Through experience rather than scientific experiments, the Oriental people learned that soybean protein was essential and could not, with safety, be omitted from their diet. By contrast, adoption of soybeans by the western world has been very recent. Soybeans did not become established as a commercial crop in the U.S. until the 1920s, and usage was considerably different than the traditional foods in the Orient. The industry that has developed produces two basic products: oil and defatted meal. The oil is used primarily for edible purposes, and the defatted meal is largely fed to poultry and livestock. Nutritional studies in the 1930s and 1940s demonstrated that when properly processed, soya meal is an excellent protein source for animal feeding. However, early attempts to use soya proteins for human feeding met with problems of acceptability by consumers and with skepticism by many nutritionists in spite of the centuries-long experience with this protein in the Far East.

PROGRESS IN UTILIZATION

The progress made in utilization of soya proteins that I will discuss is based primarily on the experience in the U.S., which has required solving the problems of flavor, nutrition and functional properties. These problems have been resolved to varying degrees through research and development efforts by industrial, government and university workers. The net result is that, today, soya proteins are produced on a moderate scale (Table I) and are accepted ingredients in a variety of processed foods. Indeed, it has been suggested that soya proteins have reached the stage of development at which they are no longer considered new or novel (3). Some of the developments leading to the present status of soya proteins are listed chronologically in Table II.

Although a crude form of soya flour was introduced in the U.S. as early as 1926, more acceptable flour and grit products were produced only after World War II and began to be used in baked goods, confections and processed meats. Bakery products are still the major outlet for soya flours (20).

More highly refined isolates became available in commercial quantities in 1957. Isolates are free of the soluble and insoluble carbohydrates found in defatted flakes. Because of the extensive processing involved in their preparation, they are quite expensive soya proteins and often compete with sodium caseinate. Isolates are used in processed meats, meat analogs, infant formulas and dairy analogs.

Development of isolates was quickly followed by protein concentrates, which became commercially available in 1959. Made from defatted flours, they are processed to remove the soluble carbohydrates, sucrose, raffinose and stachyose. Like isolates, they find use in processed meats and are also added to diet and infant foods.

Notable in promoting use of edible soya products has been a series of international conferences devoted to summarizing progress and problems in use of soybeans as foods. One of the first of these conferences was held in Peoria in 1961 and attracted about 100 persons; several have been held since then (Table II).

Spinning of soya isolates into fibers and their conversion into meat analogs were first described (21,22) in the mid-1950s, but commercial development did not occur until the 1960s. After about eight years of research and development, General Mills, Inc. opened their commercial plant in 1970. Although General Mills withdrew from this field in 1976, introduction of meat analogs in the retail and institutional markets was an important first step in introducing consumers to the concept of these new foods. Production of spun fiber products is continuing by Dawson Mills under license. Traditional food habits do not change rapidly, but economic pressures, concerns with diet and health, and the desire for convenience have made consumers more receptive to these types of products.

Another significant development of the 1960s was textured soya flours. These products are made from defatted soya flours by thermoplastic extrusion (23), a simpler process than isolate spinning. Consequently, textured flours are less expensive and have developed a larger market than the spun fiber products. Their primary use, however, is as extenders of ground meats rather than as analogs, although some are complete replacements for meat products (e.g., fried bacon bits and pizza toppings).

Also important in the 1960s was the formulation of the

TABLE I

Production Estimates for Edible Soya Protein Products in the U.S., 1979[a]

Product	Minimum protein content (%)	Annual production (million lb)
Defatted flours and grits	50	648
Concentrates	70	60
Isolates	90	60
Textured flours	50	85

[a]Source: N.R. Lockmiller (personal communication).

TABLE II

Developments Contributing to Use of Edible Soya Proteins

Date	Development	References
1946-50	Improved soya flours	4
1957	Commercial availability of isolates	5
1959	Commercial availability of protein concentrates	5
1961	Conference, "Soybean Products for Protein in Human Foods," Peoria, IL	6
1962-70	Spun fiber meat analogs	7
1966	Conference, "Soybean Protein Foods," Peoria, IL	8
1966	Textured soya flours	9
1966	Cereal-soya food blends	10,11
1971	Approval of textured vegetable proteins for use in National School Lunch Program	12,13
1973	Retail sale of ground beef-textured soya blends	14
1973	World Soy Protein Conference, Munich, Germany	15
1975	Textured protein concentrates	16
1975	First Latin American Conference on Soya Protein, Mexico City, Mexico	17
1978	Organization of Soycrafters Association of North America	–
1978	World Conference on Vegetable Food Proteins, Amsterdam, The Netherlands	18
1980	Approval of soy extender use in ground beef by U.S. Armed Forces	19
1980	World Conference on Soya Processing and Utilization, Acapulco, Mexico	–

cereal-soya blended foods that have been distributed internationally to alleviate malnutrition. One of the best known of these is corn-soya-milk (CSM), which has gone through several modifications since introduction in 1966 (24). An estimated 250-300 million lb of CSM-type products were produced in 1979 (R.A. Anderson, personal communication). The cereal-soya blended foods have served as important models for blending soybeans with cereals in other forms, especially in countries where cereals such as corn are an important part of the traditional diet. An example of the latter is the blending of whole soybeans with corn in the preparation of tortillas, thereby providing more protein, a better balance of essential amino acids and more calories (25).

A significant breakthrough in the use of textured soya flours as meat extenders occurred in 1971, when the Food and Nutrition Service of USDA permitted addition of up to 30% hydrated, textured flour to ground beef or pork served to students in the U.S. National School Lunch Program. As a result of this action, millions of students have been introduced to extended meat products at considerable savings to the school systems and with no sacrifice in nutritional quality. School systems in other countries are now also using soya proteins as meat extenders. A notable example is the Inner London Education Authority, which began incorporating soya proteins into their school meals in January 1977 (26).

In 1973, General Mills, Inc. and the Red Owl supermarkets in Minneapolis introduced ground beef-textured soya blends into the retail market. The blends were well received by consumers because of the rapid rise in meat prices. However, when beef prices declined again, consumers switched back to ground beef and the blended products were withdrawn from the market. Subsequently, beef-soya blends have reappeared in some supermarkets. Although predictions made in 1973 about the extent of textured soya protein usage in 1980 were far too high, there is a present annual market of about 85 million lb of textured soya flours (Table I) divided between the retail and institutional markets, including the National School Lunch Program. The institutional sector consumes the largest share of textured soya flours.

Textured protein concentrates were introduced in 1975. These products are made by thermoplastic extrusion and have the advantage of being low in oligosaccharides, hence, they are less prone to cause problems with flatulence. Because of their higher price, textured concentrates are produced in smaller amounts than are textured flours.

In 1978, the Soycrafters' Association of North America was organized as a trade group to represent a growing number of small companies engaged in the production of soybean foods including tofu, miso and tempeh. As of June 1980, there were 225 companies in business employing 900 persons, producing 45 million lb of soya foods with a retail value of $45 million annually (27). The organization holds annual meetings and publishes a quarterly journal entitled *Soyfoods*. This marks a new approach to use of soya foods, because the products are marketed and consumed as foods in their own right rather than as ingredients for other products.

An important decision that will result in increased usage of soya proteins was made by the U.S. Armed Forces early in 1980. Approval was given for the permanent use of soya proteins as extenders of ground beef. The military services purchase more than half of their beef in ground form (ca. 60 million lb annually); use of soya-extended ground beef is expected to yield significant cost savings. The extender approved at present is a granulated soya protein concentrate which, in hydrated form, can be added up to a 20% level (5% on a dry basis). Studies are underway to evaluate soya flours as extenders because of their lower cost compared to protein concentrates.

RESEARCH NEEDS IN UTILIZATION

Although soya proteins are used in modest amounts in foods at present (Table I), future increases depend on solution of a number of technical problems that limit the amount than can be added to certain food items. These problems include flavor, functional properties, development of new foods rather than analogs, and analytical methods to determine the amount of soya in regulated products.

Flavor

Much progress has been made in reducing flavor, but residual flavors remain (28) which are often diluted and masked when the proteins are incorporated into foods at low levels. However, at levels at which soya ingredients would contribute significantly to the protein contents of the finished products, they may cause undesired flavors. Flavor is a particular problem in bland foods such as dairy products (29). Soya proteins also suffer from the absence of desired flavors, such as those of meats (30). When used as meat extenders, textured soya products dilute the natural flavors of meats. Flavors are frequently added, but they are often released too rapidly. Interaction of spices with soya proteins sometimes results in new off-flavors (30).

Research is needed to find practical methods to further reduce flavor levels in soya proteins and to develop desired flavors in finished food products.

Functional Properties

Soya proteins exhibit a wide range of interesting functional properties (31), but they are not suited for all food systems. Modifications such as denaturation, partial hydrolysis, and chemical reaction may be necessary to make them compatible with a wider range of applications. Information is needed about the structures of the major proteins of soybeans, i.e., the 7S and 11S globulins, and how these structures are related to their functional properties. For example, the 7S globulin fraction forms a weaker tofu gel than does the 11S globulin (32). What are the structural features responsible for these differences in gelation in the presence of calcium ions? Basic studies of soya proteins need to be continued and increased to answer such questions.

Studies on the primary structure of the 11S protein are underway (33) and, upon completion, will make it possible to compare amino acid sequence with those of the major caseins, which are also widely used for their functional properties. Rapid increases in cheese production coupled with declining milk production have provided a large potential market for soya protein isolates (34). Soya proteins, however, do not possess the stretching property characteristic of casein in mozzarella cheese. Further research may reveal the basis for this property of casein and how soya proteins may be modified or manipulated to duplicate casein.

Additional work on methods for producing meat-like textures has been suggested as a solution to the rapid release of flavors from textured soya products (30). With conventional textured soya products there is a tendency for the flavor to be released before chewing is complete, leaving one with a relatively tasteless mass before swallowing.

A better understanding of the interrelationships between soya proteins, shortening levels and emulsifying systems in baked goods, such as cakes and donuts has also been advocated (20).

New Foods versus Analogs

A general trend in the food industry has been to use soya proteins as extenders or to make a complete replacement, i.e., an analog, for a variety of foods. A natural reaction of consumers is to consider such products as imitations or substitutes and, therefore, inferior. Often, there must be a strong economic incentive for consumers to use extended products or analogs. Consequently, more effort should be made to develop new food products that are appealing in their own right and therefore less likely to be rejected because they do not compare closely with a traditional food item.

Analytical Methods

Regulations concerning use of soya proteins in various foods already exist or are under consideration in many countries (35,36). Meat is a classic example of a food for which composition is often closely regulated. Such regulations require analytical methods for their enforcement, hence, there is a need for methods that will enable one to measure how much soya protein (in its various forms) has been added. Many methods have been proposed, but each has limitations that depend on the type of soya product considered and the heat treatment it has received (37). Establishment of reliable and simple analytical methods for quantitative determination of soya proteins in meat products would likely speed up adoption of regulations to permit soya in a number of European countries (35).

PROGRESS IN NUTRITIONAL STUDIES

Nutritional investigations of soya proteins can be divided logically into two aspects: (a) animal studies and (b) human studies. Animal studies on soybean proteins go back to the late 1910s, whereas the tests with humans began primarily in the late 1960s and early 1970s. Both types of studies are now underway.

Animal Assays

Progress in nutritional studies with animals is summarized in Table III. Among the early studies with experimental animals, a key discovery was reported by Osborne and Mendel in 1917 (38). They observed that raw soybeans failed to support growth of rats, but that the rats grew well when the beans were cooked on a steam bath. This observation is still the basis for present-day processing of soybean proteins and has kept several generations of nutritionists occupied with studies to explain why moist heat is beneficial.

Following the discovery of the effect of moist heat came the realization in the 1940s that methionine is the first limiting amino acid of soybeans. This fact has been very important in formulating feed rations, particularly for poultry, and until recently was of considerable concern in the use of soya proteins for humans.

Discovery, isolation and characterization of a trypsin inhibitor from soybeans in 1944-45 began to provide an inkling of why moist heat improves the nutritive value of raw soybeans or meal. It was suggested that trypsin inhibitor merely inhibited the trypsin in the digestive tract and thereby interfered with hydrolysis of the dietary proteins and release of essential amino acids, with the result that undigested protein was subsequently lost in the feces.

Feeding studies revealed that partially purified trypsin inhibitors retarded growth of rats (44), mice (45), and chicks (42) in agreement with this theory. However, when protein hydrolyzates or free amino acids were fed with the trypsin inhibitor preparations, growth was still inhibited (53-55). Consequently, the theory that trypsin inhibitor merely prevents protein hydrolysis has not stood the test of time.

Subsequent studies revealed that raw meal causes hypertrophy in chicks (46) and that trypsin inhibitor causes hypersecretion of the pancreas (47). These findings shifted emphasis from the proteinase inhibitory properties of the inhibitor to its mode of action on the pancreas. In 1960, the hypertrophic effect of raw meal was also found to occur in rats (48). It was then postulated that hyperactivity of the pancreas was the cause of growth inhibition (47,48). Presumably, excessive secretion of pancreatic enzymes that have a high content of sulfur amino acids, such as trypsin and chymotrypsin, causes depletion of these amino acids from the body tissues. Because soybean proteins have a limited content of sulfur amino acids, a net deficiency of methionine plus cystine results in growth inhibition.

Feeding tests with crystalline trypsin then demonstrated that the inhibitor accounted for most of the pancreatic hypertrophy and 30-50% of the growth inhibition observed with raw soybean meal (49).

Elucidation in 1972 of the mechanism of negative feedback control of pancreatic secretion has provided a plausible explanation of the mode of action of dietary

TABLE III

Developments in Animal Nutritional Studies of Soya Proteins

Date	Development	References
1917	Beneficial effects of cooking of soyabeans	38
1941-46	Methionine, first limiting essential amino acid	39,40
1944-45	Discovery and isolation of trypsin inhibitors	41-43
1945-48	Trypsin inhibitor retards growth	42,44,45
1948	Raw meal causes pancreatic hypertrophy in chicks	46
1957	Trypsin inhibitor causes hypersecretion of the pancreas	47
1960	Raw meal causes pancreatic hypertrophy in rats	48
1965	Crystalline trypsin inhibitor causes pancreatic hypertrophy and inhibits growth	49
1972	Negative feedback mechanism for control of pancreatic secretion	50
1973	Contribution of trypsin inhibitors and protein digestibility to growth inhibition	51
1979	Long-term feeding studies with commercial soya protein products	52

trypsin inhibitors (50). The presence of free trypsin or chymotrypsin in the small intestine prevents secretion of these enzymes by the pancreas; but, when the level of these two proteolytic enzymes falls below a threshold concentration, the pancreas is signaled to begin secretion. The chemical signal to the pancreas is believed to be the hormone cholecystokinin-pancreozymin from the intestinal mucosa. Trypsin inhibitors are thus believed to cause hypersecretion by forming inactive complexes with trypsin and chymotrypsin in the intestine. In the absence of active trypsin or chymotrypsin, cholecystokinin-pancreozymin is released and pancreatic secretion is initiated.

Although interference of trypsin inhibitor with the negative feedback mechanism of pancreatic secretion is an attractive theory, it does not explain all of the growth-inhibition effects noted with raw soybeans. When Kakade et al. (51) selectively removed the trypsin inhibitors from water extracts of defatted meal by affinity chromatography, they found that the treated extracts still inhibited growth of rats and caused significant hypertrophy of the pancreas. The trypsin inhibitors accounted for only ca. 40% of hypertrophy and 40% of growth inhibition. In vitro studies indicated that the undenatured proteins are resistant to digestion by trypsin compared to heat-denatured proteins. Formation of complexes between trypsin and the raw proteins is suggested as another means by which the pancreatic feedback control mechanism can be influenced to cause hypersecretion of the pancreas.

Long-term studies with rats were conducted to measure the effects of residual trypsin inhibitor levels in a commercial, toasted soya flour, a protein concentrate (alcohol extraction process) and an isoelectric protein isolate (52). After feeding from weaning to adulthood (285 days), pancreas weights were normal. Residual trypsin inhibitor activities in the protein products ranged from 13 to 33% of the activities in raw soya flour.

Human Assays

Although animal assays are useful in estimating the nutritional quality of proteins intended to be used as human foods, the ultimate test subjects must be humans. Nonetheless, it wasn't until the late 1960s and 1970s that an important turning point in soybean protein nutritional studies was reached when several investigators began to report their results with humans. Results are now available on evaluations with infants, growing children and adults (Table IV).

Results with infants. Quality of soya protein for infants is very important, because many of those allergic to cow's milk are given formulas in which soya protein isolate is the sole source of protein for up to several months (64). Nitrogen-balance studies of infant formulas containing soya protein isolates enriched with DL-methionine with malnourished and normal infants indicated that nitrogen absorption and retention and growth rates equaled those obtained with cow's milk (56,57). Fomon and Ziegler (57) have conducted growth studies on infants with methionine-fortified soya protein isolate, cow's milk and human milk. There were no significant differences in growth rate between the three protein sources. More recent studies indicate that infants fed soya formulas that were unsupplemented with methionine performed slightly poorer than breastfed infants and infants fed other formulas (58). Indications are that methionine may be limiting for infant feeding.

Results with growing children. Comparison of nitrogen-balance studies with soya isolates (without added methionine) and cow's milk in children 19 to 44 months old showed no significant differences (59). These results, indicating that methionine supplementation is unnecessary for growing children, are contrary to what had been predicted from rat bioassays such as the protein efficiency ratio test, which rates soya isolates lower than casein, the major fraction of milk products.

Results with adults. Kies and Fox (60) found that adults were in negative nitrogen balance at an intake of 4 g of beef nitrogen/day and that the negative balance was greater with the same intake of nitrogen from textured soya flour. Supplementing with methionine improved nitrogen retention, indicating that methionine was limiting at the low protein intake from both sources. When the daily intake of textured soya flour was increased to 8 g of nitrogen (50 g of protein), nitrogen balance was positive and the same as with beef.

According to Zezulka and Calloway (61), 3 g of soya protein nitrogen as a protein isolate resulted in a negative nitrogen balance in adult men. When the isolate was supplemented with methionine to bring the total sulfur amino acid level to 900 mg/day, as recommended by FAO/WHO (65), the men were in nitrogen balance. The subjects were nearly in balance with a daily intake of 4.5 g of soya protein nitrogen. At intakes of 6.0 g of soya protein nitrogen/day or higher, the men were in positive nitrogen balance. It is apparent that methionine is limiting at low levels of protein intake, but consumption of 38 g or more of isolate/day meets the sulfur amino acid requirements.

Scrimshaw and Young (62) compared egg protein and

TABLE IV

Developments in Human Nutritional Studies of Soya Proteins

Subjects	Development	References
Infants	Absorption and retention of nitrogen and growth rates with protein isolates plus methionine equal to cow's milk	56,57
	Unsupplemented isolates may be limiting in methionine	58
Growing children	Nitrogen retentions of unfortified soya isolates equal to cow's milk; methionine supplementation unnecessary	59
Adults	Methionine may be limiting at low soya protein intake but adequate at 38-45 g/day	60,61
	Soya isolate equivalent to 80% of egg protein; methionine supplementation unnecessary	62
	Mineral metabolism normal with soya concentrate diet	63

soya protein isolate by the nitrogen balance method and found that soya protein was ca. 80% as effective as egg protein in maintaining nitrogen balance. They also examined the effect of supplementing isolates with methionine at low levels of isolate intake (0.51 g protein/kg/day). Supplementation with 1.1% methionine gave a positive response equal to that obtained with egg protein. However, addition of 1.6% methionine resulted in a negative nitrogen balance more pronounced than without any supplementation. When the dietary allowance for protein was met by increasing intake to 0.8 g/kg/day, the subjects were in positive nitrogen balance and supplemental methionine had no significant effect. It was concluded that, under normal usage, methionine supplementation of properly processed soya proteins is unnecessary and probably undesirable for adults.

Availability of minerals in soya protein diets has been of ongoing concern for the last two decades (66). A 4-week study with 89 adult subjects involved feeding practical diets that contained an average of 23 g of soya protein/day (63). The soya protein was primarily in the form of protein concentrates made by alcohol extraction. Detailed monitoring of mineral levels in blood serum, urine and feces revealed some statistically significant changes in mineral metabolism, but all were small and well within the normal physiological ranges.

RESEARCH NEEDS IN NUTRITION

Numerous animal studies and limited tests with humans indicate that properly processed soya proteins closely approach the nutritional properties of traditional animal proteins such as meat and milk. Additional studies are needed, however, to provide more information about: long-term effects in humans; need for fortification with vitamins and minerals; need for supplementation with methionine; mechanism of action of trypsin inhibitors from soya and other dietary sources; and development of rapid methods for measuring protein quality.

Long-Term Studies in Humans

Studies with humans have been encouraging thus far, but more long-term data are needed. As the use of soya in the diet gradually increases, a point will be reached where soya protein begins to contribute a significant portion of the dietary supply. Will this affect vitamin and mineral availability and will there be a need to fortify with vitamins and minerals? Increasing the amount of soya in the diet will likely lead to a decrease in the amount of animal proteins consumed. Are there beneficial effects from such a shift in diet? Studies comparing the effects of soya protein and casein on plasma cholesterol levels suggest that there may be advantages in consuming soya proteins (67). These and other questions can only be answered by continuing research with humans.

Need for Methionine

The recent studies with humans concerning the question of the need for supplementing soya diets with methionine indicate that supplementation is unnecessary in young children and adults. Because this conclusion is in conflict with tests in experimental animals, there is good reason for continuing studies with humans, even though they are more difficult and much more expensive. For infants, it appears prudent to continue to supplement soya proteins with methionine until further research is done. However, is it necessary to add methionine to the levels currently used (64)?

Mechanism of Trypsin Inhibitor Action

Studies with experimental animals, particularly rats, have provided a plausible mechanism for the manner in which soybean trypsin inhibitor affects the pancreas. We do not know, however, whether the human pancreas responds in the same way. Could tests be devised that could be conducted safely in humans to obtain such information? Additional animal studies may provide guidance in this area. The problem with trypsin inhibitor is not restricted to soybeans, because these inhibitors occur in other foodstuffs, such as eggs and potatoes. Clearly, additional research is necessary, and it should not be restricted to soybean trypsin inhibitors.

Tests for Protein Quality

As new soya protein ingredients become available and as new food items are formulated from them and existing soya proteins, there is a need for experimental evaluation of protein quality. The official method used for this purpose in the U.S. and Canada is the protein efficiency ratio (PER). This test, however, has been critized because it is slow and expensive and does not adequately reflect biological value of proteins with respect to human requirements (68). Better methods for assessing protein quality as they relate to humans are needed and additional research is needed to find methods that are simpler and less expensive.

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Labeling and Compliance Assurance of Soya Protein Foods

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ABSTRACT

This paper describes two main federal feeding programs: the School Lunch Program and the Military or DOD.

The National School Lunch Act of 1946 empowered the Secretary of Agriculture to set nutritional standards. Section 9 of the Act, as amended, states: "Lunches served by schools participating in the school lunch program under this Act shall meet minimum nutritional requirements prescribed by the Secretary on the basis of tested nutritional research." In the 33 years since the passage of the Act, this power has not been significantly altered.

Section 210.10(a) (1) (ii) of the regulations governing the National School Lunch Program, *issued September 4*, 1970, outlines the meat and meat alternate requirements for the Type A School Lunch as: (ii) Two ounces (edible portion as served) of lean meat, poultry or fish; or 2 ounces of cheese; or one egg; or one-half cup of cooked dry beans or peas; or 4 tablespoons of peanut butter; or an equivalent quantity of any combination of the above-listed foods.

Textured vegetable protein products, when prepared and served in combination with meat, poultry, or fish, may be used as a meat alternate to meet part of the minimum requirement of two ounces of cooked meat for the Type A school lunch. It would also meet part of the meat and meat alternate requirement for the Special Food Service Program for Children. Textured vegetable protein products are food products made from edible protein sources and are characterized by having a structural integrity and identifiable texture such that each unit will withstand hydration, cooking, and other procedures used in preparing the food for consumption.

The textured vegetable protein product shall be made from food-grade oilseed or cereal flours, protein concentrate, or isolates, edible fats or oils, carbohydrates, binders, stabilizers, natural or artificial flavors, colors, amino acids, vitamins and minerals. The proportion of hydrated vegetable protein to meat in the combination shall not exceed 30%. The hydration level of the rehydrated vegetable protein shall be 60-65%.

Compositional requirements for the textured protein expressed on a dry basis are:

	Minimum
Protein (wt %)[a]	50.0
Fat, 30% max by wt	–
Magnesium (mg/100 g)	70.0
Iron (mg/100 g)	10.0
Thiamin (mg/100 g)	0.3
Riboflavin (mg/100 g)	0.6
Niacin (mg/100 g)	16.0
Vitamin B_6 (mg/100 g)	1.4
Vitamin B_{12} (mcg/100 g)	5.7
Pantothenic acid (mg/100 g)	2.0

[a]Nitrogen times 6.25

The protein efficiency ratio (PER) of the textured vegetable protein shall be not less than 1.8 on basis of PER = 2.5 for casein. Labeling requirements are: (a) the phrase