TABLE VIII

PER and NPU Values of the Green Pods at Different Periods of Maturity

Genotype	Days	PER ± S.D.	%	NPU ± S.D.	%
G_1	65	1.82 ± 0.25	72.8	50.0 ± 7.98	80.6
	75	2.00 ± 0.27	80.0	59.0 ± 8.40	95.1
	85	2.35 ± 0.45	94.0	59.3 ± 4.88	95.6
G_2	65	1.78 ± 0.19	71.2	59.2 ± 5.75	95.4
	75	1.73 ± 0.11	69.2	56.7 ± 5.66	91.4
	85	2.01 ± 0.17	80.4	61.3 ± 6.87	98.9
G_3	65	1.73 ± 0.20	69.2	58.8 ± 6.15	94.8
	75	1.73 ± 0.11	69.2	59.3 ± 6.82	95.6
	85	2.44 ± 0.31	97.6	58.9 ± 7.98	95.1
Casein		2.5 ± 0.43	100	62.0 ± 8.93	100

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Soybean Products for Feeding Infants, Children and Adults under Nutritional Stress

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ABSTRACT

This review points out the good quality of well-processed soya products. Normal infants, children and adults are able to utilize the protein and other nutrients present in the soya, when fed these products in amounts that will cover their needs. Under nutritional stress, such as in infant malnutrition, soya products such as soya-milk have been shown to help in the children's recovery. Clinical and biochemical data show that their recovery is similar to that obtained with cow's milk. Milk- or lactose-intolerant children and adults, who present a public health problem in some developing countries, could benefit from the high nutritive value and low cost of soy milk. Soya products have been shown to decrease cholesterol and other levels of blood lipids. Considering the availability of the several soya products in the market, this possibility has to be further explored. The utilization of soya products in preparing liquid formulas for oral or tube-feeding opens new fields for the treatment of several diseases, insuring at the same time adequate nutrition for the patients. From a practical point of view, in spite of all that is known about soybeans and soybean products, its use as human food, even in countries where it is produced in large quantities, is very low. It seems that local governments are not aware of the importance of soya for the solution to their serious food and nutrition problems. What is known on the subject has to leave the laboratories, research centers and universities and be transferred as food for the mouths of the needy populations. This has to be understood as an urgent duty of national governments. There is no doubt that soya is the cheapest and one of the best-quality foods available to help solve the present hunger problem of the world today.

Soybeans have only recently, in the past 10-20 years, received serious attention as food for humans in western countries. They have been widely used as food by many Oriental groups. Western civilization started to use soya mainly as edible cooking oil and has since increased its consumption. The cake left from the oil extraction has been used as animal feed.

One of the first uses of soya products in the western world was as a substitute for cow's milk for intolerant infants. In the U.S., it was estimated in 1975 that approximately 10% of formula-fed infants were being fed formulas containing protein from soya (1).

The adequacy of the soya protein as a well-balanced source of amino acids able to maintain nitrogen balance in infants and children has been tested by different authors. Fomon (2) has shown that infants 113-154 days of age fed a formula with 6.8% energy from a soya protein isolate supplemented with methionine had similar growth and nitrogen retention as another group receiving cow's milk formulas. Similar results were obtained in Peru by Graham et al. in 1970 (3), who studied malnourished infants and children fed soya formulas with added methionine.

The need of methionine supplementation of soya protein formulas when fed to infants and children has been questioned. There is no doubt about the improved nutritive value of the methionine-supplemented soy protein when tested in rats. The question relates to the fact that methionine requirements of the rats are different from those for infants and young children. It also seems that the methionine requirements of young children (2-4 years old) are definitely lower than those currently accepted (4). Recent studies by Fomon et al. (1) showed very little difference among infants fed soya formulas with or without methionine. Because of differences in serum concentrations of urea nitrogen, improvement of the soya protein quality through methionine supplementation was accepted. The supplementation did not influence nitrogen retention.

In preschool children, the nutritional protein qualities of two soybean protein isolates were shown to be similar to that of cow's milk, as tested by balance studies at INCAP (4).

The nutritive value of soya products in adult humans has been studied by several groups of researchers. Nitrogen balances studies (5) have shown that methionine-supplemented soya protein products have a nutritive value similar to that of well-known sources of protein, such as beef. This, of course, will depend on the composition of the product and the level of intake. Scrimshaw and Young (6) demonstrated that well-processed soya protein isolate products fully replace beef at intakes that approximate current dietary allowances for good-quality protein. They also conclude that under normal conditions, methionine-supplementation of these soya products is unnecessary and probably undesirable.

RIBEIRÃO PRETO STUDIES

The majority of the available studies were carried out on normal infants, children and adults fed soya products produced in the U.S. for human consumption. In Ribeirão Preto, we have studied the nutritive value of Brazilian-produced soya products and tested them in malnourished and normal children.

Our first studies on the utilization of a soya product, soya milk, for the treatment of malnourished children with kwashiorkor and marasmus were reported at the Meeting on Protein Needs of Infants and Preschool Children, held in Washington in 1960 (7). One group of four malnourished children was fed with a local soya milk formula; results from this group were compared to those of a similar group of children receiving a cow's milk formula. Through clinical studies, weight changes, biochemical data and nitrogen balance studies, it was shown that the soya milk used had a nutritive value similar to that of cow's milk.

Further studies on malnourished children 1-3 yr of age, fed soya milk or cow's milk with similar protein content, showed again that the nutritive values of the protein for both milks was similar (8,9). It was also found that the response to treatment depended largely on the presence or absence of clinical edema in the malnourished children. Children with clinical edema who were fed the soya milk formulas retained more nitrogen than those without clinical edema. The opposite was found to be true with the group of malnourished children who received the cow's milk formula. Of this group, those with clinical edema retained less nitrogen than those without clinical edema (Table I). Because infant malnutrition is a multiple deficiency disease, it is expected that factors other than protein could be important in responses to treatment of the disease. The protein in the soya milk and cow's milk formulas is one of the differences in the responses: the content of other nutrients such as minerals or vitamins could also be important to the interpretation of these results. Sodium content, for example, is lower in soya and this could influence the disappearance of the edema.

Other studies from our group have shown that when the soya product is not soya milk, but a vegetable mixture including defatted soya flour, the nitrogen absorption and retention of malnourished children is slightly below that of a similar group of children fed similar amounts of cow's milk (Table II). When normal children of the same age group were fed a basic local diet, and part of it was replaced by the soya vegetable mixture or cow's milk, the nitrogen balance improved; therefore, it could be said that the nutritive value of the local diet is better supplemented with the vegetable mixture than with cow's milk (Table III). These results show that foods commonly eaten by low socioeconomic groups in our countries could be improved in their nutritive protein value through the supplementation with well-balanced mixtures, including soya (10).

TABLE I

Nitrogen Balance in Malnourished Children with and without Clinical Edema Fed Soya Milk or Cow's Milk

Patients with edema			Patients without edema		
Average nitrogen intake (mg/kg/day)	Absorption (% of intake)	Retention (% of intake)	Average nitrogen intake (mg/kg/day)	Absorption (% of intake)	Retention (% of intake)
Group fed soya milk 565	85.1	37.1	705	82.0	19.8
Group fed cows' milk	80.8	23.8	622	78.8	34.4

TABLE II

Nitrogen Balances in Malnourished Children Fed Corn-Soya Mixture or Cow's Milk

	Soya mixture	Cow's milk
Nitrogen intake (g/day)	2.3	2.5
Absorption (%)	70.1	79.7
Retention (%)	21.3	34.2

More recent, unpublished results of our laboratory are concerned with the nutritive value of soya milk and soya isolate, produced and available in Brazil for human consumption. These products were tested in malnourished children at lower levels of protein intake than in our previous studies (1.5 g%, rather than 3.0-3.5 g% previously). We also tested the influence of methionine supplementation on the nitrogen retention of the children fed both soya products. Compared to a control group that received a cow's milk formula with the same protein content, it was found that the soya formulas did not have the same protein nutritive value as the cow's milk. However, the nutritional quality of the soya milk was improved by methionine supplementation, whereas the nutritive value of the soya isolate was not affected by the addition of the same amino acid (Table IV).

The overall analysis of our results obtained with soya milk and soya products in malnourished children is of great importance and calls our attention to the quality of products and the quantity or concentrations in which they are fed. The quality of the product has a lot to do with its processing. Testing the protein value of the same soya product produced by different companies has given different results, in spite of their similar protein content. We have had this experience with Brazilian soya flour, and our last study with the soya protein isolate showed that it had a much lower nutritive value than similar products tested in the U.S. The concentration of the soya protein in the formulas is also of great importance. The soya milk we used previously with a protein content similar to that of cow's milk (3.0-3.5 g%) showed no different results when tested in the malnourished children. At a low protein concentration (1.5 g%), cow's milk was better and the soya milk improved with methionine supplementation. We do not think that means that there is a need for methionine supplementation in all soya products for human consumption. It seems that well-processed soya products, fed at levels that will cover the protein needs of an individual, will not need further methionine supplementation. We think our results stress the need for the most adequate technology and local testing of soya products for human consumption, in spite of good results obtained elsewhere with similar products.

BRASÍLIA STUDIES

Studies carried out by the Nutrition Group at the University of Brasília have also shown the good-quality protein of soya products for feeding infants and small children. Their studies were made with 240 children, from birth to 18 months of age. The results showed, through growth and biochemical data, that there is no difference among the children fed whole cow's milk formula and those fed a soya milk formula produced and processed in Brasil.

Interestingly, some of these studies were made with lactose intolerant-children. In these patients the effectiveness of soya milk was clearly shown in their recovery (Fig. 1). As lactose intolerance has been shown to be a public health problem in several developing countries, the use of these soya products in these areas is of great medical, social and economic interest (11).

SOYBEAN PRODUCTS IN CLINICAL NUTRITION

Clinical nutrition is an important branch of medicine dealing with the physiopathology, diagnosis and treatment of nutritional diseases and related medical problems (12). A recent development in clinical nutrition is the study of the effect of different diets on the treatment of some diseases such as atherosclerosis, and the formulation of nutritionally complete liquid diets that could be useful for patients with problems related to the intake of solid foods.

In both cases the use of soya products is important. Since the beginning of the 20th century, a protective effect of vegetable proteins in atherosclerosis has been reported

TABLE III

Nitrogen Balances in Normal Children Fed Local Diets with Soya or Cow's Milk

	Average nitrogen intake (g/day)	Absorption (%)	Retention (%)
Basic local diet	4.1	56.4	13.9
Basic diet plus soya protein mixture	4.5	69.4	25.5
Basic diet plus cow's milk	4.5	71.1	19.7

TABLE IV

Nitrogen Balance Studies in Malnourished Children Fed Brazilian Soya Products with and without Methionine

Formula	Mean nitrogen intake (g/day)	Absorption (%)	Retention (%)
Cow's milk	2.49	80.3	34.7
Soya milk	2.55	71.8	15.3
Soya milk + methionine	2.45	69.0	24.8
Soya isolate	2.63	76.3	14.7
Soya isolate + methionine	2.58	68.3	9.7

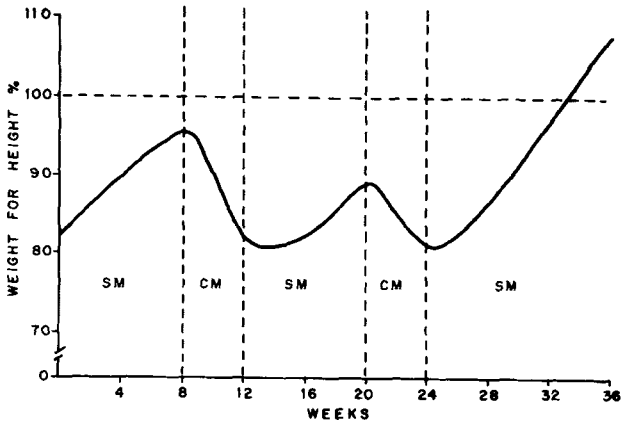

FIG. 1. Changes in weight for height in a malnourished child, intolerant of cow's milk, fed soya milk (SM) or cow's milk (CM).

and clinical and experimental work have supported this. Among vegetable proteins, one of the most effective has proven to be soybean protein.

A soybean-textured protein diet was fed to patients in Italy (13). All of them had blood lipid problems; they were followed both in the hospital and home. Cholesterol and triglyceride analyses were made at frequent intervals. The hypocholesterolemic effect of the soybean protein diet occurred in almost all the patients and appeared to be independent of the lipoprotein phenotype (Table V).

Although the study does not indicate the mechanism through which the soybean diet acts, it supports the idea that it should be through its protein component. Of course, the subject should be better explored. The availability today of different soya products for human consumption could facilitate the studies on this subject.

The development of liquid diets for oral and tube-feeding is another area in which soya products will be important. Most of the present hospital tube-feeding formulas are based on milk, and a large portion of the adult population will not digest or are intolerant to large amounts of milk. This is also true for children, especially in some developing countries.

Several formulas are already on the market, including soya products, mainly soya flour and soya protein isolates. Others include a mixture of milk and soya proteins. Reports in the literature of the successful treatment of cachectic patients with these formulas, including soya protein isolates, make us realize the importance of this treatment for our countries. One of the main advantages of feeding with these formulas is that it is safer and cheaper than parenteral nutrition. It was calculated that it costs $135.00 (U.S. dollars) to deliver 3,000 kcal intravenously; the same amount of calories consumed through a commercial product based on soya and milk protein costs only $5.00 (U.S. dollars) (14).

TABLE V

Overall Results of Blood Cholesterol of 42 Patients Receiving Soybean Protein Diet

Patients	Total cholesterol		LDL cholesterol	
	Initial	Final	Initial	Final
IIa (22)	346.0	288.8	277.8	224.3
IIb (16)	325.6	261.9	245.8	220.9
IIb-III (4)	336.7	247.5	190.0	135.2

PRACTICAL ASPECTS

There is no doubt that soybean products should be and will be used as food for infants, children and adults. They are already used in several countries and their nutritive values compare well with those of conventional foods.

Flours and vegetable milks from soya can be easily formulated to supply the needs of infants and children. Soya products in this situation should be considered to be not only good sources of protein, but also of energy and of a few vitamins and minerals. It has been shown that iron absorption from soy protein approaches that of animal proteins. Among the essential trace elements important to human nutrition, only zinc has a low bio-availability in the presence of soy protein, but this can be improved by lowering the phytate content of the soya protein through processing (15).

Mixtures of soya flour with cereals such as wheat, corn and rice have been extensively tested in various products in several countries. They can be used to make bread, cookies and macaroni-type products. As source of protein, these mixtures are better than the original products because cereal and leguminous protein complement each other. Of course, as complete, well-balanced supplements, these products should have vitamins and minerals added to fulfill the needs of different age groups. Soya can be used as food by children and adults alike because of the large spectrum of products that can be obtained from it. Some of these products, such as vegetable meat, could be important as daily foods for poorer populations if their prices offer advantages when compared to those of animal meats.

As a rule, human use of soya products is practically nil (except for cooking oil) in our developing coutries, and even in countries like Brazil, Argentina and Paraguay, which are large producers of soya. The message that soybeans are good has circulated only among scientists—it has not reached the politicians and the people. In Brazil, where we have been working on the subject for the past 20 years, it is only in the last few years and especially now in 1980 that the Brazilian government has discovered that soya can be used as human food. A campaign to use soya bean cooked as our common beans is underway, and has had some success. New brown and black varieties similar to our common beans have a great possibility of being consumed directly. Mixed flours that include soya to make cookies have been used for a long time in Brazil and there has been no problem with them. What is basic to us in relation to the practical use of soybean and soybean products is the knowledge and support of local governments.

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