humans (24).

CONCLUSIONS

Investigations into the biological effects of specific types of dietary fiber are in their infant stages. Progress is hampered by the dramatic effects that the type of isolation technique has on physical and physiological properties of the isolated fiber. Development of uniform procedures for isolation and analysis of types of fiber must precede major progress in ascertaining physiological roles of fiber components. However, there is little argument that the components of plant fibers will be shown to have a much greater effect on animal and human nutrition than was previously realized (25).

For soya products specifically, consumption of moderate amounts of hulls has been shown to produce beneficial effects on glucose and lipid metabolism in man. Both animal and human feeding trials suggest that soya hulls in moderate levels in the diet have little effect on mineral bioavailability. Little is known about the biological effects of the fiber contained within the cotyledon.

Americans are receiving little of their total dietary fiber from soybeans. Few soybean hulls are consumed and soya isolates have had the bulk of the fiber removed during processing. Insoluble, spent soya flakes and hulls are largely used in animal rations. These soya processing by-products seem to be well utilized by animals. For man, the metabolic effects of soya fiber is a scientific curiosity, not a practical question.

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Review of Earlier Soya-Protein-Fortified Foods to Relieve Malnutrition in Less Developed Countries

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INTRODUCTION

Alleviation of malnutrition has become a national priority in many less developed countries (LDC). An adequate diet is believed to be a basic right of every human being. Governments have also come to realize that proper nutrition plays a key role in socioeconomic development, i.e., that of providing citizens with improved physical and mental capacities (1).

Nutrition intervention programs to relieve protein-calorie malnutrition (PCM) have three population targets: infants (0-6 months), preschool children (7 months-3 years) and pregnant and lactating mothers.

The Consultative Group on Maternal and Young Child Nutrition of the Advisory Group on Nutrition, United Nations, has recently recommended that, because the first 6 months in a child's life are the most critical for nutrition, breast milk should be the exclusive food source during this time. In the case of infants who cannot be breast fed, the Group recommends that milk-based mixtures be used preferentially to cereal-protein mixtures (2). Besides supplying some unique biochemical substances that protect the infant against certain infectious diseases, maternal feeding involves a natural contraceptive effect, is hygienic and economic compared to formulas, and allows a satisfying psychological interaction between mother and child (3).

According to Scrimshaw and Underwood (4) infant malnutrition in LDC occurs because of inadequate complementary feeding practices during the weaning period as breast feeding alone becomes insufficient. The introduction of complementary foods presents many problems including timing, quality and quantity, sanitation in preparation and delivery of the food to the infant, and the danger of premature adoption of commercial formulas. This last point has been highly controversial in the past decade and resulted in accusations against multinational food companies for avidly promoting formulas among the poor. The connotation of status associated with this feeding practice among marginal income groups encouraged premature weaning, forced excessive dilution of expensive formulas and resulted in unsanitary preparation due to lack of proper facilities. One multinational company executive said that, even though it is certain these companies have contributed to improvement of nutritional status and are decreasing infant mortality in LDC, the poor classes of the population have not yet benefited from their development (5).

Efforts to alleviate malnutrition in LDC have emphasized development of low-cost foods using indigenous sources of vegetable protein. The Food for Peace Program has played a fundamental role in the fight against malnutrition by providing foods to millions of hungry people, and is also responsible for introducing soybeans in many countries where local sources of vegetable protein were not readily available. Soya products have proven to be a versatile source of high quality, low-cost protein. The extent of usage of soybeans in this program is illustrated by the fact that food shipments during 1974 contained 61,000 MT of soya flour. This figure represents more than 30% of the defatted soya flour produced in the U.S. (6).

This paper reviews use of industrially processed, soya-based foods in complementary food programs in LDC. For a more extensive evaluation of the role of all vegetable food mixtures in LDC, the review by the Tropical Products Institute (TPI) in the early 1970s on behalf of the Protein Advisory Group (PAG) of the United Nations (7) should be consulted. This TPI/PAG study was updated in 1977 (8).

TYPE OF SOYA PRODUCTS

Figure 1 illustrates different types of products, raw materials and technologies used in producing low-cost nutritional foods. Products range from simple soya milk to sophisticated and expensive proprietary infant formulas. Intermediate products include beverages, cereal mixtures (which may contain other legumes also) and soya-cereal-milk mixtures.

Animal milks are listed, as they will always be alternative sources of protein. An interesting application of vegetable protein has been the use of peanut isolate to balance the protein/fat ratio in buffalo milk (8.5% fat). Production of this beverage, Miltone, in India is reported as 36,000 ℓ/day (9).

Soybean Milk

Soybean milk is an aqueous extract of ground, whole soybeans. The traditional Oriental process involves cold-water extraction and heating near the boiling point to improve its nutritional value and flavor, and to sterilize the product. Upon removing the insoluble residue, the resulting milk is a highly stable oil emulsion (10).

The rapid action of the enzyme lipoxygenase in ground, wet soybeans produces a beany or painty off-flavor and odor that is undesirable in many areas of the world. Numerous modifications of this Oriental process have been reported to reduce off-flavor and odor effects, including hot-water extraction (11), alkali soaking (12), acid grinding (13) and a blanching pretreatment (14).

Soybean milk has been an important substitute for cow's or human milk in feeding allergic infants. Soybean milk and cow's milk have similar protein contents (3.5-4.0%) and correspond fairly close in their amino acid pattern; soybean milk is deficient in S-containing amino acids. Animal experiments have shown that the nutritive value of properly processed soybean milk generally ranges from 60 to 90% of that of cow's milk, and that methionine supplementation raises it to an equivalent level (15). This deficiency appears to be of little consequence in practical infant feeding, perhaps because of a less intensive requirement for the S-containing amino acids by a growing child than by young rats (16).

Use of soybean milks as industrially processed beverages in other parts of the world has been limited. Banzon and Escueta (17) reported production of a soya milk, Philsoy, in the Philippines. Due to a retail price which was lower than that of a competing skim milk, chocolate-flavored beverage, production reached 3,500 bottles/day. Production breakdowns halted the project. In India, a small soya milk plant has been established at a University and pro-

BASIC INGREDIENTS	SOYBEANS					
			CEREALS			
				SKIM OR WHOLE MILK POWDER		
PRODUCT TYPE	Soy milks	Soy beverages	Soy-cereal mixtures	Soy-cereal-milk mixtures	Soy-based infant formulas	Milk-based foods
SOYBEAN SOURCE	Whole soybeans	Whole soybeans Full-fat flour	Whole soybeans Defatted flours	Defatted flours Concentrates	Isolates	None
TECHNOLOGY	Liquid extraction	Liquid extraction Extrusion	Extrusion	Extrusion Hydrolysis Wet processing	Proprietary	Packaging Reconstituting
EXAMPLES	Village-type soy milks	Vitasoy	Maisoy Incaparina	Superchil ProNutro	Sobee	(Miltone)

FIG. 1. Types of soybean-based foods used to relieve malnutrition in less developed countries.

duces nearly 700 ℓ/day (18).

In Mexico, soya milks have been produced experimentally, although actual consumption is minimal (19). The author has visited a college in Northwest Mexico where soyamilk was being produced in its pilot plant.

The Brazilian government has become interested in use of soya milk as a substitute for skim milk powder (NFDMS) in supplementary institutional feeding programs. This would not only solve nutritional problems but also reduce foreign exchange deficit, because Brazil imports NFDMS (20).

Soya-Based Beverages

There have been several projects to produce liquid or powdered beverages containing soya in which the soybean has been deliberately concealed. Although these beverages are not primarily intended to reduce malnutrition, they may become widely distributed and regularly consumed even by very low income groups (21).

A good example of a commercial soya beverage is Vitasoy. Originally developed in Hong Kong as a milk substitute and made by the traditional Oriental process, it was almost a complete failure. After World War II, the company sought to enter the soft drink market and the product was reformulated so that its taste was refreshing and appealing to consumers. Although it was marketed as a soft drink, its advertising emphasized that Vitasoy was also nutritious (". . . . will make you grow taller, stronger and prettier"). In 1968, Vitasoy had captured 24% of the retail soft drink market; by 1970, plant capacity had trebled and ca. 120 million bottles were being produced. Vitasoy contains 2.5-3.0% protein (from soybeans), 2.5% fat and 5.7% carbohydrates (on wet basis) (7).

Another similar effort was that initiated by Monsanto in Guyana in 1969 with "Puma." Based on soya isolate (ca. 2.5% protein), Puma had a strong banana flavor. In the early years, sales volume was around 29 million bottles/year, wholly on the retail market (7,22). By 1976, Puma was still in regular production (8).

Coca-Cola introduced a caramel-flavored protein beverage, Saci, which contained 3% soya protein, in Brazil in 1969. By 1976, the production was terminated and a new type of beverage using whey powder was being considered (8).

A spray-dried infant beverage that can be reconstituted with water was developed at the USDA Northern Regional Research Laboratory using extruded, full-fat soya flours. A low-viscosity formulation with additives such as hydrogenated soybean oil, flavorings, emulsifier, sucrose, salt, vitamins and minerals, it contained ca. 3% protein and a similar amount of oil when reconstituted (23). The product was introduced into the commercial market in Mexico and was also promoted as part of the Mexican National Food Program (24).

A whey-soya drink mix (WSDM) was developed by USDA, AID and private industry in 1973 (25) in response to the needs for a low-cost replacement for skim milk powder when its prices became so high that it could no longer be purchased for Public Law 480 (PL-480). The composition of WSDM is 41.4% sweet whey, 36.5% full-fat soya flour, 12.1% soybean oil and 9.5% corn syrup. Addition of a broad spectrum of vitamins and minerals resulted in a product that, when mixed with water at 15% solids, had a nutritional value similar to whole milk. Through September 30, 1978, over 2.7 million gal of WSDM at a cost of $7.8 million had been shipped overseas (26).

Soya-Fortified Cereals

Cereals are staple foods in most parts of the less developed world, are well accepted, and provide most of the calories and part of the protein requirement. Because cereal protein is deficient in the amino acid lysine, fortification with soybeans represents an inexpensive, short-term solution to scarcity of well-balanced foods.

The U.S., through PL-480, has supplied large volumes of protein-fortified cereals, Title I of PL-480 provides for sale of food commodities to friendly countries on concessional terms, whereas Title II authorizes donations to meet famine or other urgent relief requirements to combat malnutrition and to promote economic and community development. A major priority of Title II is to help meet the nutritional needs of groups that are vulnerable physiologically. Program emphasis is given to nutrition in maternal-child groups and substantial amounts of blended and fortified foods are used for this purpose (27).

In fiscal year 1978, 59 million people in 79 countries received a total of 1.67 million MT of food at a cost of $458 million ($328 million for commodities and $130 million in freight costs). This food is distributed through U.S. voluntary agencies (e.g., CARE, Catholic Relief Services), the World Food Program of the United Nations, and through government to other government channels. During the period 1954-73, over 41 million MT of food commodities valued at $8 billion were distributed under PL-480, Title II.

Crowley (25) reviewed the role of soya protein in Title II commodities as shown in Table I. The protein content of supplemented products is increased by 27 to 65% and the nutritional value is improved significantly through amino acid complementation.

Blended foods, e.g., corn-soya-milk (CSM), corn-soya blend (CSB) and wheat-soya blend (WSB), were specifically developed as nutritional supplements for the diets of weanling infants, preschool children, and pregnant and lactating mothers. Although guidelines have changed somewhat with time, initially, they provided 350 Cal/100 g, 18-20% protein and ca. 6% fat.

CSM has been the most widely distributed blend, accounting for one-third of all the soya flour. CSM's formula consists of 64% precooked corn meal, 24.0% defatted toasted soya flour, 5.0% skim milk powder, 5% soybean oil plus minerals and vitamins. The blend supplies a minimum of 19% protein with an adjusted protein efficiency ratio (PER) of 2.42-2.48. Extensive feeding tests conducted at the outset demonstrated that CSM maintained nitrogen balance in children 1 to 3 years old when it is fed as a primary source of protein. Its acceptability was improved with added sweeteners (28). Although originally designed to be used as a gruel after 1-5 min in boiling water, CSM can be instant by increasing the extent of cooking of the cereal component, and using a roll-cooker for gruels and a cooker-extruder for beverages (29). CSM and WSB have been used as bases for other formulations, and without further processing in some African countries (30).

Tables II-IV summarize data gathered for 10 products which have soybeans as a source of protein. The majority also contain a starch component, nonfat dried milk and a vitamin-mineral mix. Corn is the preferred cereal in the formulas. Protein contents vary from 17 to 27.5%, whereas fat ranges between 4.2 and 8.3%. The caloric contents of these blends are 345-420 Cal/100 g and the nutritional value is 85-100% that of casein. Production and marketing practices depend strongly on local economic and political circumstances. A brief summary follows on the most important features of these foods.

Superchil and Fortesan were developed in Chile in 1974-75 to respond to a massive program of complementary foods supported by the government. Both products are

TABLE I

Foods Containing Soya Distributed under PL-480, Title II (25)

	Soya flour (%)	Protein increase by fortification (%)	Amount soya flour (1,000 MT)
Corn-soya-milk (CSM)	24.2	–	20
Corn-soya blend (CSB)	22	–	12.3
Wheat-soya blend (WSB)	20	–	11.0
Soya-fortified bulgur	15	65	9.1
Soya-fortified bread flour	6/12	24/47	3.2
Soya-fortified corn meal	15	63[a]	2.3
Soya flour	100	–	1.4
Soya-fortified sorghum	15	67	0.9
Soya-fortified rolled oats	15	33	0.9
Whey-soya drink mix (WSDM)	36.5[b]	–	0.2
Total			61.3

[a]Estimated.
[b]Full-fat soya flour.

TABLE II

Ingredients of Major Soybean-Based Foods for Relieving Malnutrition

	Soya (%)	Cereal (%)	NDFM (%)	Others (%)	Mineral and vitamin	Flavors
Superchil (Chile)	Defatted flour, 14	Wheat flour, 55	20	Oil, 7.5	yes	yes
Fortesan (Chile)	As WSB, 70	–	25	Cocoa, 5	yes	no
Incaparina no. 14 (Colombia)	As flour	Corn or rice	–	–	yes	no
ProNutro (S. Africa)	Defatted flour	Corn	yes	Egg white solids	yes	yes
Maisoy (Bolivia)	Extruded soybeans, 27	Corn, 64	–	Sugar, 9	yes	–
Licha (Tanzania)	Dehulled soya, 25	Corn, 70	5	no	yes	no
Thriposha (Sri Lanka)	As CSM, 70 Extruded soya, 10	Corn, 20	–	–	yes	–
Leche Avena (Ecuador)	Defatted soya flour, 15	Oats, 70	15	–	–	–
Cerex (Guyana)	Defatted flour, 20	Cornmeal, 36 White rice, 15	10	Soya oil, 7 Sugar, 10	yes	no
CSM (Worldwide)	Defatted flour, 24	Corn meal, 64	5	Soya oil, 5	yes	no

produced by private companies. Maximum purchases for this program were 16,000 to 20,000 MT. Superchil derives its improved functional properties from enzymatic hydrolysis of the cereal fraction (31), whereas Fortesan is precooked by extrusion-cooking (32). Although both developments relied heavily on sales in the retail market, this outlet has never represented more than 10% of the sales (P. Miranda, personal communication). The products have recently been modified to comply with new purchase specifications from the government which require higher quality and acceptability.

Incaparina was developed at the Institute for Nutrition of Central America and Panama in the late 1950s, and can be considered the precursor of all mixtures which contain vegetable protein and provide nutritional value similar to milk. The first mixture recommended for commercial production in Guatemala contained 38% cottonseed flour as the protein source and corn as cereal base (33). The Incaparina formula introduced in Colombia replaced 50% of the cottonseed flour by soybeans (7). Sales of Incaparina in Colombia grew to ca. 2,000 tons in 1967. But, although Incaparina cost one-eighth the price of whole milk powder and one-third that of Guatemalan Incaparina, the Colombian company, Productos Quaker, had terminated production by 1975 (8,34,35).

ProNutro was developed by a South African private company in 1962 without governmental or international backing. The product was marketed on its taste appeal after the health image had been attractively and convincingly advertised. It was promoted to the native population as a separate dietary item, as a breakfast food, or as a soup powder in flavored form. In the original TPI/PAG study, ProNutro was the product with the largest volume after Bal-Ahar.

Bal-Ahar, a product in India, is made from raw materials that are available locally and has mainly peanut flour as the vegetable protein source. Production in 1974 was estimated at 15,000 MT and in 1976, 40,000 MT. Over the last 17 years, the sales of ProNutro have constantly increased, and present maximal production is 10,000 MT/year. Processing techniques include dry and wet processing, extrusion and drum drying. Several raw materials are included in a low-

TABLE III

Components and Nutritional Value

	Protein (%)	Fat (%)	CHO (%)	Cal/100 g	Nutritional value (PER)[a]
Superchil (Chile)	20.0	8	–	420	2.5
Fortesan (Chile)	23.0	6	–	345	2.3
Incaparina no. 14 (Colombia)	27.5	4.2	53.8	370	2.2
ProNutro (S. Africa)	22.0	6.0	59.0	413	63
Maisoy (Bolivia)	20.0	6.5	–	407	2.5
Licha (Tanzania)	18.8	8.3	65.0	411	–
Thriposha (Sri Lanka)	19.0	6.2	61.2	377	–
Leche Avena (Ecuador)	20.0	–	64.0	380	–
Cerex (Guyana)	17.0	8.0	–	387	–
CSM (Worldwide)	19.0	6.0	–	350	2.5

[a]PER = protein efficiency ratio.

TABLE IV

Production and Marketing Aspects

	Price (P) or cost (C) ($/kg)	Sales into retail market (%)	Maximum production or capacity (MT/year)	Current informed production (MT/year)	Year	References
Superchil (Chile)	1.13 P	5	6,700	2,500	1980	31, and P. Miranda, personal communication
Fortesan (Chile)	.90 P	5	8,000	5,000	1977	32
Incaparina no. 14 (Colombia)	.26 P	>0	2,000	0	1967	33
ProNutro (S. Africa)	1.86 P 1.20 C	>0	10,000	10,000	1980	7 H.J.H. DeMuelenaere, personal communication
Maisoy (Bolivia)	.35 P	>0	–	141	1979	37
Licha (Tanzania)	.64 C	0	–	600	1978	41
Thriposha (Sri Lanka)	.22 C	0	9,882	1,200	1978	CARE, personal communication
Leche Avena (Ecuador)	–	0	–	5,000	1980	CARE, personal communication
Cerex (Guyana)	.70 C	80	–	215	1979	40
CSM (Worldwide)	.39 P	10	–	120,520	1978	26,28

cost formulation, including soybeans (H.J.H. DeMuelenaere, personal communication).

Maisoy, Thriposha, Cerex and Lisha belong to a product subclass originated from well known, nutritionally sound formulations that employ low-cost extruder cookers (LEC) to inactivate antinutritional factors and gelatinize the starch. The LEC program has been conducted by Colorado State University with the support of USDA and AID (36). Low-cost extruders were originally used for cooking soybeans for feed use and are now used as simple, inexpensive, relatively low-capacity machines to make food-grade products such as full-fat soya-flour, precooked corn meal and textured vegetable proteins. Different approaches have been taken throughout the world to adapt LEC technology to local conditions; Maisoy, Thriposha, Cerex and Lisha represent some of these.

Maisoy is an extruded and micropulverized blend of 70/30 corn-soya sold by a Bolivian private entrepreneur to the government for distribution in mother's clubs (37). Thriposha, also a blend of corn/soya, is distributed throughout Sri Lanka in a CARE/Ministry of Health Feeding Program which benefits ca. 550,000 recipients. The Thriposha program was using ca. 1,270 MT of soybeans as of January 1981 (38).

Cerex, a corn-rice-soya blend, is produced and distributed by a state agency, the Guyana Pharmaceutical Corp., to reduce malnutrition which affects 60% of the children. The primary target market is the malnourished children in the 4-month to 2-year age group (39,40).

Lisha (corn-soya-milk) production in Tanzania in 1978 was 572 MT. It has been distributed through institutional channels to malnourished children in health clinics (41).

LEC technology is now being introduced in Mexico to produce full-fat soya flour which is expected to have a retail price of $0.55/kg. An infant weaning food is among the applications foreseen for this product (42).

Leche Avena is a food supplement of milk, oats and soya flour distributed to 125,000 preschool children, 87,500 children and 37,500 pregnant and lactating women. It is produced under a tripartite program which has been in operation since 1977 under the Ecuatorian Ministry of Health, CARE and the World Food Program. During FY '80, CARE is expected to import ca. 742.5 MT of defatted soya flour for this program (CARE, personal communication).

Other vegetable mixtures of importance have at times included or had plans to include soya in their formulations. Faffa, manufactured by th Ethiopian Nutrition Institute, has expanded considerably in output since being funded by various donors; in 1975, production reached 1,500 MT. Some of the formulations included 18% soya besides NFDMS, peas, chick peas, and cereals such as tef and wheat (7,43).

Superamine, developed in Algeria and Egypt in collaboration with UNICEF, was produced by governmental enterprises using chick peas and lentils as vegetable protein sources and an interesting enzymatic process to solubilize the starch fraction (44). Commercial sales of Superamine were aimed at the middle-income group, whereas the low-income group was expected to be reached through government distribution. Retail sales have not developed as planned; production has increased only to ca. 1,000 MT/year in Egypt. According to the technical consultant, use of soya flour would significantly reduce production costs (E.S. Hegazi, personal communication).

The Colombian Food and Nutrition Plan has used several products which contain soya, including Bienestarina, for which production was 5,000 tons in 1975. Currently, two companies supply vegetable mixtures containing 20-25% soya flour for this program. As of November 1979, ca. 3,500 MT/year were being distributed under a government-subsidized program using coupons which discounted 60% of the price (T.Z. deBuckle, personal communication). The Venezuelan School Lunch Program has replaced pasteurized milk with an instant formula that costs 25% less and contains rice flour, NFDMS, soya flour, flavors and a vitamin/mineral mix (W. Jaffe, personal communication).

Soya-Based Infant Formulas

Although use of proprietary infant formulas as a substitute to breast-feeding has only minor accepted applications in LDC, middle- and upper-income groups in those countries have access to these products. Milk-based formulas generally contain whole or skim milk powder, vegetable oil and sugar, and are fortified with vitamins and minerals (3).

Soya-based infant formulas have been developed as replacements for milk for infants and children which are, or are suspected to be, allergic to milk. Incidences of allergy have been estimated to be 0.3-7% in the first case and 14-30% of infants and children are suspected to be allergic (45). Under these circumstances, and because lactose intolerance is more severe in certain racial groups than others, soya-based formulas are viable alternatives in LDC.

Since the early 1970s, soya protein isolates have largely replaced soya flour in the formulas. Those products contain all nutrients known to be essential for the infant, and provide a protein quality similar to that of milk (46). In malnourished infants from an LDC, a soya isolate formula fortified with D-L methionine was shown to be equivalent to a milk-based formula (47).

CONCLUSIONS

The 1972 TPI/PAG study concluded that available capacity for producing low-cost, nutritious food mixtures based on vegetable proteins was insufficient to have any impact in relieving malnutrition.

Industrially processed, soybean-based foods seem well-adapted to combat malnutrition in the following circumstances: (a) the poorest people in low-income countries who are at the greatest risk of being malnourished and who have virtually no purchasing power. Unless governments subsidize distribution of products among these neediest segments, they will remain out of the market. These are foods which cannot compete on a price basis with normal staple foodstuffs. Such has been the case of Incaparina (35), Faffa, ProNutro and Superamine (48), and probably other products. However, a definite place for high-quality, well-marketed, soya-based foods also exists among middle-income groups in LDC. (b) The most acute nutritional problems are found in rural areas of LDC (49). Although distribution has been satisfactory for poor, urban populations, rural areas lack the institutional infrastructure necessary for proper distribution and nutrition surveillance. (c) In many countries with severe malnutrition problems, soybeans are not a major crop nor is there a taste for unrefined soybean products. Development of new varieties which can be adapted to these regions and appropriate technologies that allow for a gradual introduction of soybeans into local diets will spur their adoption. LEC may be an example of this direction. (d) Many of the products are currently used in food assistance programs. These programs, in turn, are contingent on availability of surplus commodities which are readily available at no cost or are highly subsidized. Continuation of supply is threatened by political instability and, often, long-term planning of nutrition intervention programs is difficult.

Donations of surplus milk products to LDC have reached nearly one-tenth of world dairy product exports in recent years. Availability of highly subsidized products such as skim milk powder in international trade encourage substitution of milk for soya. As an example, the price of NFDMS varied from $0.40 to $0.55/kg, FOB New Zealand during 1976 and 1979–less than one-third the support price of NFDMS in the U.S. and less than one-half the EEC in support price (50).

In general, no other protein source can substantially compete with soybeans where good quality, low-cost protein is requested. Nutrition intervention programs will continue to rely on soya as a main component in most processed foods available for distribution.

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Soya Fortification of Tortilla and Pinole in Chihuahua

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Among the states of the Mexican Republic that produce soybeans, the state of Chihuahua, with 60,000 tons/year (1), produces the best planting seed. About 27% of the inhabitants of the State of Chihuahua do not eat eggs, meat or bread, and do not drink milk. In the rural areas and the mountainous regions where the Tarahumara Indians live, there is an alarming rate of malnutrition, as well as tuberculosis caused by malnutrition, mostly among the Indians. The rural population eats "atole" (gruel made by boiling corn or maize in water) and "pinole" (ground corn), which have very low contents of protein.

Because of this and the fact that 70% of the Mexican diet is corn prepared as tortillas or atole, we decided to look for a way to increase the nutritional quality of corn. We found that, if we add 8% of full-fat soya to corn by the process of extrusion, we can produce a low-cost corn flour enriched with protein and fat. CIATECH, in its fight against malnutrition, received the approval of the President of Mexico, in March, 1979, to set up the first plant which would produce corn flour with 8% soya and make tortillas the same price as commercial corn flour made by the traditional nixtamalization.

This is how ALMESA, Alimentos Mejorados S. A., had its origin; it was the first factory to process enriched corn flour with soya in Latin America. It was decided to set up this factory in the mountainous region of the state of Chihuahua, near the inhabitants of the rural areas who are mostly Tarahumara Indians.

Adding soya to corn not only increases the quantity of proteins, but also the quality, because soya flour adds tryptophane and lysine which are deficient in corn, and corn, in turn, has methionine to supply the deficiency of soya (2). We obtain a product that is accepted by everyone and, at the same time, contains a high percentage of proteins with a low cost of production. This process saves large quantities of energy and water, and prevents the loss of nutrient in water by the traditional process of nixtamalization.

On November 28, 1979, a very important agreement (3) was signed, so that under the supervision of CIATECH, the Almesa factory would produce 300 tons of corn enriched with soya and 50 tons of pinole with soya for 5,000 children of the 76 boarding schools in the Tarahumara mountains. The factory was inaugurated on December 8, 1979 and to date, has produced 110 tons of corn and 2 tons of pinole.

The federal government has recently created 76 boarding schools where 5,000 Tarahumara children between the ages of 5 and 13 go all week. They are provided food and shelter, and they are taught to read, write and speak Spanish.