I-456 In En: "Proceedings of International Conference on Soybean Protein Foods", held at Peoria, Illinois, October 17-19, 1966. Agricultural Research Service, United States Department of Agriculture (ARS-71-35) May 1967. p. 28-37.

SOYBEANS AS A SOURCE OF PROTEIN FOR HUMAN FEEDING IN LATIN AMERICA

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It is a well-established fact that most of the Latin American population suffers from protein deficiency, which is particularly prevalent and serious in children during the weaning and post-weaning period, that is, before 4 years of age. There are several reasons for the wide occurrence of this deficiency, one of which is the low availability and high prices of foods, which are adequate dietary sources of protein in quantity and in quality. This is particularly true for foods that can be used in the feeding of infants and small children. The remarks in this paper will be based on the experience with rural populations of Central America; however, it can safely be stated that the situation is similar for other areas or countries in Latin America.

Table 1.--Mean daily food consumption of Guatemalan Indian families in terms of edible portion (1962)[1/]

Food--grams per head	Town[2/] A	B	C
Milk and milk products[3/]	7	26	12
Eggs	7	6	5
Meat	20	24	17
Pulses	53	71	28
Fresh vegetables	84	64	130
Fruits	40	30	18
Tubers	4	5	9
Cereals[4/]	425	428	430
Sugar	48	58	52
Fat	2	4	1
Coffee	7	6	5

1/ Taken from: Flores and coworkers, Brit. J. Nut. 18: 281, 1964.

2/ Town A: Sta. Catarina Barahona; Town B: Sta. Ma. Cauqué; Town C: Sta. Cruz Balanya.

3/ Expressed as liquid milk.

4/ Dry weight basis.

Table 1 shows the average composition of rural diets of three rural towns of Guatemala (1). It can be seen that consumption of cereal grains and other carbohydrate sources is large. Although some bread and rice are also consumed, the main cereal grain is corn. Consumption of beans is below what would be needed to improve the protein quality of the cereal grains. INCAP studies (2) have indicated that the best protein balance with corn and beans is obtained when they are consumed in the ratio of 2.6 parts of corn to 1 part of beans. The ratio in Towns A, B, and C is 8, 6, and 15 parts corn to 1 part beans, respectively. Consumption of animal products is also lower than desired. Furthermore, the average figures given are the result of sporadic consumption of these products by only some of the subjects studied.

Table 2.--Mean daily intake of calories and protein by Guatemalan-Indian families (1962)[1/]

	Mean daily intake per head in: Town A	Town B	Town C
Calories, number	2054	2163	1938
Total protein, grams	59.0	62.7	53.5
Animal protein, grams	6.2	6.3	4.5
Protein score	61	56	51

[1/] Taken from: Flores and coworkers, British J. Nut. 18: 281, 1964; J. Am. Diet. Assoc. 48: 480, 1966.

Table 2 shows that total protein intake appears to satisfy the needs for protein for the adult population; however, the protein scores based on tryptophan content show that the quality of such diets is very low. Even lower quality values would be obtained if the net protein utilization of such diets is considered, that is, when the protein intake is corrected for both digestibility and biological value. Although the percent protein digestibility is not available, it can be estimated to be no greater than 75 percent. Because of the large amounts of cereals consumed, such diets are low in lysine content and usually tryptophan and methionine are also limiting amino acids, resulting therefore in diets of low biological value.

Table 3 shows the average daily food intake of preschool children in the same three villages in Guatemala (3). Again, it is striking to see the excessively large intakes of cereal grains, mainly corn, as compared to animal protein sources.

Table 3.--Foods consumed per child per day in three rural towns in Guatamala (3 to<4 years)[1/]

	Foods consumed per child per day in: Town A	Town B	Town C
Milk and milk products, grams[2/]	28	23	14
Eggs, grams	4	4	2
Beef, grams	10	11	4
Pulses, grams	24	26	15
Fresh vegetables, grams	41	30	48
Fruits, grams	68	21	31
Cereals, grams	281	295	277
Potatoes, grams	3	2	3
Sugar, grams	37	33	33
Fat, grams	1	1	--
Protein, percent (dry wt. basis)	11.9	12.3	11.5

[1/] Taken from: Flores and coworkers, J. Amer. Diet. Assoc. 48: 480, 1966.

[2/] Expressed as liquid milk.

Leguminous seeds are also consumed in very low amounts. As with the adult diets the amount of beans consumed is too low for the amounts of cereal grains ingested by the children. The crude protein concentration of these diets on a dry weight basis is only 12.0 percent, equal to or not much higher than that of corn. Diets for children of these same age groups should contain not less than 18 percent high quality protein on a dry weight basis.

Table 4 shows the mean intake of calories and protein, and the percent of the recommended allowance for both nutrients, as well as the protein score based on tryptophan values and protein efficiency ratio (PER). From these figures it can be seen that the quality of such diets is very poor and utilized very inefficiently. The total protein in these diets is deficient in lysine, methionine, and tryptophan. The problem is more complicated by insufficient intake of calories which will further interfere with protein utilization.

It is evident, therefore, that adequate dietary sources of protein are needed to correct both the concentration and the quality of this nutrient in such diets. Animal products, particularly milk, are not available and have other limitations for their wider use; the possibility of using available and less expensive sources of protein of vegetable origin is therefore of interest.

Table 4.--Mean intake per child per day of calories and protein in the three towns (3 to < 4 years)[1/]

	Town A	Town B	Town C
Calories, number	1065	978	847
Recommended allowance, percent	93	86	74
Protein total, grams	32.1	27.1	21.9
Animal, grams	7.9	3.5	1.8
Recommended allowance, percent	80	68	55
Protein score	64	58	51
Protein efficiency ratio (PER)	1.64	1.32	1.13

[1/] Taken from: Flores and coworkers, J. Amer. Diet. Assn. 48: 480, 1966.
Braham and coworkers, INCAP studies.

Cottonseed, when properly processed, has served as a good source of protein suitable for human feeding, and vegetable protein mixtures based on cottonseed protein concentrate have been developed, tested, and commercially produced in Central America and Colombia (4, 5). Although cottonseed has been and still is a source of oil and of protein for both animal and lately for human nutrition, the need for other sources is extremely high.

Soybeans can provide the need for protein for both the human and animal population as well as to supply the need for oil, which is also in demand in Latin America.

Soybean production in Latin America is limited to only a few countries as shown in Table 5. Production in Brazil reached 12.7 million bushels in 1962; 11 million bushels in 1963; and 11 million bushels in 1964. In Mexico, Colombia, and Argentina production of soybeans during the last 10 years has increased gradually; however, it is still low. Mexico's production reached 1.3 million bushels in 1963 and increased to almost 2.5 million bushels in 1964, while in Colombia production exceeded 1.4 million bushels in 1963 and increased to over 1.8 million bushels in 1964. In Argentina, production was slightly over 500 thousand bushels in 1964 (6).

Although the production figures are low, yields per acre are comparable to those obtained in the United States. The yields reported vary from 1,200 to 2,000 kg./ha. (18 to 30 bu./acre). Lately, other countries besides

Table 5.--Soybean production in Latin America
(million bushels)

Country	Soybean production 1964	1965
Brazil	11.2	16.6
Mexico	1.3	2.5
Colombia	1.4	1.8
Argentina	0.5	< 0.4

Mexico, Colombia, Brazil, and Argentina are selecting varieties adaptable to the area to replace part of cotton and to serve as an auxiliary crop. In Guatemala, for example, 22 varieties are being tested and yields as high as 2000 kg./ha. have been produced from experimental plots.

Utilization of Soybean Flour. INCAP Studies

During the last 4 or 5 years, soybean flour has been tested at INCAP as a protein supplement to lime-treated corn, which is used in the form of tortillas in several Latin American countries (7). Similarly, soybean flour has been used to enrich cereal gruels, which are very popular among the human population, both young and adult (8, 9). Results of these studies are summarized in Table 6, where it can be seen that 6 to 10 percent of soybean flour increase the protein value of lime-treated corn flour, rice flour, and both whole and white wheat flour. It is obvious that besides increasing protein quality, the quantity of protein is also increased, which is a needed factor in most diets of populations of low socio-economic condition.

Table 6.--Supplementation of cereal grains with soybean flour[1/]

Soybean flour added, percent	Protein Efficiency Ratio: Lime-treated corn	Whole wheat	Wheat flour	Rice
none	1.00	1.62	0.86	1.66
6	--	1.89	--	--
8	2.25	--	--	2.88
10	--	--	2.01	--

1/ INCAP studies.

Several tests have been carried out to determine if the amount of soybean flour added would affect the texture and flavor of the tortilla produced from enriched lime-treated corn and of whole wheat bread. The result of these studies indicated that flavor and texture did not change significantly and the foods prepared were very well accepted. Very little use has been made of these observations, first, because of the low availability of soybean flour, and second, because at least in the case of corn, this cereal is processed at home for the preparation of "tortillas." Studies have also been carried out to test the possibility of including soybeans together with corn in the home preparation of tortillas. The results were also successful but lack of soybeans, education, and possibly other factors have also prevented the utilization of this information.

Table 7.--Composition of INCAP vegetable mixtures 14 and 15

Ingredient	Mixture 14	Mixture 15
Soybean flour, percent	38	19
Cottonseed flour, percent	--	19
Corn flour, percent	58	58
Torula yeast, percent	3	3
Calcium carbonate, percent	1	1
Vitamin A, Intl. Units	4500	4500
Protein content, percent	26	26
Protein Efficiency Ratio	2.56	2.21

INCAP studies.

Better success has been achieved in the development of high protein vegetable mixtures based on soybean flour and corn and of soybean, cottonseed flour, and corn. Two such mixtures have been developed and tested in experimental animals and children, and one mixture is already in commercial production (5, 10). The composition of INCAP formulas 14 and 15 is shown in Table 7. One contains 38 percent soybean flour while the other contains 19 percent. The protein content is around 26 percent for both and their PER is 2.56 and 2.21, respectively. Table 8 shows that the protein quality of mixture 14 can be increased significantly by adding 0.2 percent methionine, while the addition of 0.1 percent lysine and 0.2 percent methionine to mixture 15 caused also a significant increase in PER approaching the value of casein. The addition of 16 and 30 percent of skim milk will result in similar PER values as those obtained by adding the respective limiting amino acids.

Table 8.--Amino acid supplementation of mixtures 14 and 15[1/]

Formula	Amino acids added	PER
Mixture 14	none	2.56
	0.2 percent DL-Methionine	2.93
	0.2 percent each of methionine, lysine, threonine	3.39
Mixture 15	none	2.22
	0.2 percent Methionine + 0.1 percent lysine	2.68
Casein		2.87

1/ INCAP studies.

As indicated before, these two mixtures have been tested in children (11). The results are summarized in Table 9. Calculations from the regression lines showed that the true protein digestibility and biological value (BV) were 91.8 and 78.6, respectively, for mixture 14 as compared to 92.0 and 80.6 for skim milk. The plot indicates that 92 mg. of N from mixture 14 are needed for nitrogen equilibrium as compared to 79 for milk.

Table 9.--Relationships between NI and NA to NR in children fed mixture 14 and mixture 15[1/]

Protein	Regression equation	Value of NI for NR=0, mg. N/kg./day
Mixture 14	NR = -53.8 + 0.586 NI	92
	NR = -37.7 + 0.621 NA	--
Mixture 15	NR = -48.0 + 0.426 NI	113
	NR = -34.4 + 0.474 NA	--
Skim milk	NR = -50.7 + 0.640 NI	79
	NR = -39.2 + 0.730 NA	--

1/ NI = Nitrogen Intake; NA = Nitrogen Absorbed; NR = Nitrogen Retention.

With respect to mixture 15, true protein digestibility and BV were 88.7 and 71.9, respectively. With this mixture, 113 mg. of N gave nitrogen equilibrium. The data indicates mixture 14 to be superior nutritionally to mixture 15. Mixture 15 is already being produced commercially in Colombia and INCAP is making arrangements for mixture 14 to be commercially produced in Brazil.

Additional studies have been carried out to develop mixtures using full-fat soybean flour. Using the values for the optimum combination between corn and soybean protein found while developing mixture 14 (10), and using the method employed for the preparation of lime-treated corn, mixtures with full-fat soybean flour have been developed. The method used consisted in cooking corn and soybeans together in lime water, followed by drying with or without toasting. Such mixtures, prepared with different proportions of corn and soybeans, have been tested in experimental animals (12). Representative results are shown in Table 10. It can be seen that they have a high nutritive value as compared to casein. The growth of the animals was normal and food intake was as high as that from casein indicating that the lime cooking process is capable, if carried out correctly, of destroying the trypsin inhibitors present in soybeans.

Table 10.--Protein quality of full-fat soybean flour-corn mixtures

Protein distribution in mixture	Average weight gain, grams 1/	PER
100 percent corn protein	12	0.69
50 percent corn protein + 50 percent soybean protein	81	2.08
40 percent corn protein + 60 percent soybean protein	91	2.54
30 percent corn protein + 70 percent soybean protein	99	2.37
100 percent soybean protein	101	2.03
INCAP mixture 14	80	2.48
Casein	120	2.87

1/ INCAP studies, basis 28 days.

The results presented in this paper indicate that the diets of rural populations in Latin America, for both the young and the adult, provide relatively low amounts of proteins and that this is usually of very poor quality. These diets can be improved only if intake of good quality proteins is increased. Animal products are still in very short supply, expensive and have other limitations in their use due to various socio-economic and cultural factors. Therefore, we cannot depend upon them to supply both the quantity and quality of protein needed; other sources must be found and utilized. Soybeans can provide such needed protein. Data was also presented in how soybean flour can improve the protein quality of cereal grains and of the work of INCAP in developing and testing vegetable protein mixtures based on soybeans. It is believed that the cultivation and interest in soybeans is to increase in the near future in all Latin America.

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