bottle.

Presently the company is trying to introduce a soya milk beverage in powder form by using soya protein isolate and selling it to school lunch programs. In the 1970 decade, other soya milks were developed and marketed in Latin America. The first was Provesol, which was developed in IIT, Colombia, by Dr. Diaz Delgado. This milk was produced in a powder form by modern techniques and the process was later sold to a Brazilian company, Olvebra, which started producing soya milk in 1975 with the Coca-Cola pilot plant. Presently, they are using a mixed process which combines Coca-Cola and Provesol techniques. The product is sold canned in powder form, under two brand names: Novo Milk and Nova Vida. Novo Milk is sweetened and flavored orange, chocolate, banana and strawberry. Nova Vida has the same Provesol composition of 50% protein, 25% fat, 19% carbohydrates, and 19% fibers.

The main use of Nova Vida is in the school lunch program in Brazil. It is well accepted by school children.

In 1975-76, two new projects were started, again in Brazil. ITAL, the Institute of Food Technology, developed a soya milk with brand name Vital which was first processed by dehulling soybeans, and later, by hot grinding and extraction. The centrifuged and formulated soya milk was sterilized by UHT and asceptically packed in Tetrapak. Several flavors were developed and tested by school children and industry workers. It is well accepted, but is limited by the high cost. Later, in 1977, Vital was also packed in polyethylene bags, but at that time, only in pasteurized form. Vital can be kept refrigerated for 2-3 days. The same soya milk was also developed in powder form.

In 1976, a new concept of soya milk processing was developed in Brazil. This technique consists of producing on a small scale, the soya milk at the market spot. The project was called "mechanical cow" and produces 200 ℓ/hr of sterilized soya milk, with 3.0% protein, 1.9% fat, 1.2% carbohydrates, 0.5% ash, 8.0% added sugar and at pH 7.0.

This project was introduced in 1977 and, presently, there are 80-90 "mechanical cows" in Brazil. The idea already is being exported to Paraguay, the Seychelles Islands and Ecuador.

The process uses the most modern techniques of soya milk processing. Soybeans are soaked for 6 hr in running tap water or 3 hr in 60 C water. Soaked soybeans are ground with 98 C water to render a finely divided suspension of 1 part dry soybeans to 10 parts water, and a final grinding temperature of 80-85 C is reached. Insoluble residue is separated with a basket centrifuge and soya milk is pumped to a sterilizer-cooler after formulation with sugar, flavor and optional vitamin and mineral pre-mix. Sterilization is done at 135 C for 2 min, and the mixture is immediately cooled to room temperature. The cooling water, which is heated by the soya milk, is used for grinding the soaked soybeans, thus saving heat energy.

The main advantages of this project are: (a) small and simple equipment can operate in small towns, giving employment to workers; (b) water is not transported, as it is used at the moment of usage or sale of final milk; (c) only soybeans are transported, facilitating storage and reducing working capital to a minimum; (d) by being very cheap, the equipment can be bought by very small entrepreneurs, or by the government to implement school lunch programs or health programs; (e) the equipment uses only water and electricity and does not need a steam generator.

Presently, the Brazilian federal government gives tax exemptions for this equipment when it is bought in a full package: Mechanical Cow, polyethylene bag filler and residue dryer, which shows Brazil's interest in the project and also the success of the product all over the country.

With one kilo of soybeans, 8 ℓ of 3% soya protein milk is produced which has the antitrypsin factor correctly inactivated. Packed soya milk can stand for two days at room temperature and 10 days under refrigeration (5 C). The production cost of 1 ℓ of this formulated soya milk is US $1.10.

Soybeans As an Extender of Common Beans

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ABSTRACT

Soybeans were used as extenders of common beans in the form of whole beans and precooked, powdered form. Mixtures containing 20, 25, 30, 35, 40, 45 and 50% soybeans were studied. Sensory evaluations (preference tests) showed no preference for mixtures containing up to 50% soybeans over 100% common beans. On the other hand, nutritional differences were detected between common beans and mixtures with more than 20% soybean. The mixture with 50% common beans and 50% soybeans contained 27.9% crude protein, 13.2% lipids and 47.2% carbohydrate. The amino acid composition was improved particularly by increasing cystine from 0.6 to 1.2% of the protein and methionine from 0.7 to 1.2%. The protein efficiency ration (PER) values fo the 50:50 mixture for rats was 1.6 compared to 1.0 for the common bean. Acceptability of the 50:50 mixture in different institutional trials did not differ in consumption from that of common beans and no sign of physiological disturbance was observed. When the mixture was precooked, dried and ground to a powder, it served as an excellent base for an instant soup. The formulation containing 80% of the 50:50 mixture, 10% corn starch and seasonings had (%) 21.3 protein, 10.8 lipid, 5.3 crude fiber and 51.9 carbohydrate with total metabolizable energy of 390 Kcal/100 g and an NDP Cal% = 12. The hydration capacity of the 50:50 mixture was 162 g water/100 g mixture whereas that of the soup with all ingredients added was 205 g water/100 g soup. The acceptability as well as the storage stability of the soup was good.

INTRODUCTION

Legume seeds constitute a very important source of protein and energy for human populations of many countries (1). The common bean is the main legume consumed directly in human diets. Although it contains a good source of protein (20–25%) in most cultivars, its protein quality is low, primarily because of a limiting concentration of sulfur-containing amino acids (methionine plus cystine), in addition to the low biological availability of these amino acids from bean proteins (2, 3).

The strategy to improve bean protein quality is (a) genetic

manipulation and selection to obtain strains and varieties capable of producing higher quality protein (4), (b) combination in the diet of bean with foods which have complementary protein quality (5–7), and (c) infusion of the beans with the limiting amino acids, particularly methionine, prior to cooking and consumption (8).

In this paper, the results of nutritional evaluation with rats and acceptability by humans of mixtures of common beans and soybeans are described.

EXPERIMENTAL PROCEDURES

Materials

Soybean varieties Santa Rosa, Viçoja, UFV and Davis produced in 1975 were obtained at the Agronomic Institute of Campinas, S.P., Brazil. The varieties IAS-1, IAS-5 and Hardee, were supplied by a cooperative from southern Brazil (Ijuí, Rio Grande do Sul). The common bean used in the mixtures was of only one variety (Rosinha G2).

Rats used in the biological assays were all weanling Wistars. The ingredients used for the preparation of diets, besides common beans and soybeans, were food or chemical grades.

Analytical Methods

Determination of a standard proportion of soybean to common bean in the mixture. For establishment of a standard proportion of soybeans in the mixture, a series of sensorial experiments were performed, arbitrarily using 15% soybeans and applying the psychophysic method of Constant Stimulus developed by Galanter (9) for determination of the "jnd" value (just noticeable difference). This difference, added to the 15% arbitrary value, gave an estimated standard of 25% soybeans for the mixture. The standard mixture containing 25% soybeans was then compared with mixtures containing up to 80% soybeans.

The proportion of soybeans in the mixture, which still maintained the characteristic flavor of common beans, was determined by the method of Directional Paired Comparison (bicaudal test) in which the panel members were asked to indicate, in a series of paired samples, which ones had the best flavor. In these tests, mixtures containing 20–45% soybeans were compared among themselves and with 100% common beans.

Determination of soybean proportion by preference tests. Preference tests were performed on mixtures containing 20, 25, 30, 35, 40, 45 and 50% soybeans. The method used was the 0–9 points Hedonic Scale of Peryan and Pilgrim (10) with a statistical design of completely randomized blocks and 6 repetitions.

The samples were soaked in water for 8 hr and cooked in an autoclave for 15 min with proper addition of condiments prior to tasting.

Cooking properties and sensory evaluation of mixtures of common bean with different soybean varieties. For this study, soybeans and common beans were soaked in distilled water (1:3 w/v) for 8 hr. Cooking time was determined for pressure cooker and also for open kettle using the proportions of soaked seeds to water (w/v) of 1:9 and 1:30, respectively.

Sensory evaluations were conducted for flavor, texture and general appearance of the cooked mixture, and for preference, using the unstructured Hedonic Scale (10).

Composition and nutritive value of the mixtures. Proximate compositions of common beans, soybeans and mixtures were determined by AOAC procedures (11).

Amino acid determinations were made on a Beckman 120 C Amino Acid Analyzer by the Spackmann et al. method (12).

Protein efficiency ratios (PER) were determined on groups of 6 weanling rats using essentially the method of Osborne and Mendel (13). The animals, weighing an average of 45 g, were caged individually. The diet contained ca. 10% protein. Food and water were fed ad libitum. For all biological assays, a control group of 6 rats was maintained on a 10% casein diet.

Consumer acceptability of the 1:1 (w/w) common bean soybean mixture. The acceptability of the 1:1 mixture was studied on institutional mass feeding of people of different ages and socioeconomic levels, as well as at different residential sectors of Campinas, S.P., Brazil.

The institutional acceptability tests were done: (a) at the University of Campinas Cafeteria with ca. 1,000 persons, including students, professors and employees of the University, in a total of 13 tests on different days of the week, and (b) at a preschool children's nursery with ca. 100 children given 2 servings/week for ca. 5 months. The acceptability in these groups was estimated by the total consumption on a weight basis.

The domestic acceptability of the uncooked mixture was studied in 2 sectors of the population of Campinas of ca. 200 families taken at random. One sector was an upper-middle-class residential area and the other a low-income group on the outskirts of town. In both groups, the housewife was informed about the proper way to prepare the mixture and the purpose of the study, and was asked to fill out a questionnaire expressing the general feeling of the family about the product. The questionnaires were collected one week after each trial and used for computation of acceptability.

Production of 1:1 precooked mixture for use in instant soup. A 1:1 (w/w) mixture of common beans and soybeans was precooked, dried and ground into powder for use as ingredients of formulated instant soups. The process involved soaking the seeds in water for 6 hr, autoclaving, drying to 7% moisture (5 hr at 65 C) in a conventional tunnel dryer, milling in a hammer mill to pass a 70-mesh screen, and then 1 kg was packed in 0.10-mm-thick polyethylene bags.

RESULTS AND DISCUSSION

Results of the sensory evaluation using the Directional Paired Test are shown in Table I, and clearly indicate that a mixture with 20% soybeans could not be distinguished from the common beans. On the other hand, when the difference in soybean concentration was greater than 20%, the panelists were able to find significant differences among samples.

When preference tests (Hedonic Scale, 0–9 points) were performed, the results showed no significant differences among mixtures with 20, 30, 40 and 50% soybeans (Table II). On the basis of these results, it became apparent that the addition of 20% soybeans to common beans resulted in a mixture which was not significantly different from 100% common beans. On the other hand, the mixture with 20% soybeans was not preferred to the mixtures with 30, 40 and 50% soybeans by the panelists.

For nutritional and economical reasons, the mixture with 50% soybeans was considered of practical value in human nutrition as an extender of common beans.

There was no significant difference among mixtures containing different soybean varieties of the same harvest. However, when the fresh-harvested (1976) soybeans were compared with the same varieties stored one year, a significant increase in the cooking time was observed. The average pressure cooking times increased from 42 min for the 1976

TABLE I

Difference in Flavor and Preference for Mixtures of Soybeans and Common Beans (Directional Paired Test)[a]

Comparison of mixtures	Difference		Preference[b]					
	TJ	CJ	1	2	3	4	5	Total
1 x 2	26	16 (ns)	11 (ns)	5				16
1 x 2	25	22[d]	17[d]		4			21
1 x 4	24	23[e]	17[c]			6		23
1 x 5	16	16[e]	13[c]				3	16
2 x 3	15	11 (ns)		6 (ns)	5			11
2 x 4	15	13[d]		9 (ns)		4		13
2 x 5	15	15[e]		10 (ns)			5	15
3 x 4	15	11 (ns)			7 (ns)	4		11
3 x 5	16	15[e]			13[d]		2	15
4 x 5	16	13[c]				9	4	13
Total	157	137[e]	58	30	29	23	14	136
(%)			76.3	54.5	50.0	38.3	24.7	

[a] TJ = total judgements; CJ = correct judgements; ns = not significant.

[b] Soybeans (%): 1 = 0; 2 = 20; 3 = 40; 4 = 60; 5 = 80.

[c] $p = 0.05$.

[d] $p = 0.01$.

[e] $p = 0.001$.

harvest to 105 min for the 1975 harvest. In open kettles, the cooking time was 4 hr and 30 min and 6 hr and 35 min, respectively, for beans from the two harvests.

The composition and nutritive value of the mixture with 50% soybean was significantly superior to 100% common bean. Table III shows the proximate compositions. As a whole, the composition of the 50:50 mixture is more balanced for human consumption than either common beans or soybeans alone.

Amino acid compositions of soybeans, common beans and mixtures of soybeans and common beans, as well as mixtures of soybeans, common beans and rice, and soybeans and rice, are shown in Table IV. As the proportion of soybeans increased, a significant increase in sulfur-amino acids was observed. These changes in the contents of sulfur-amino acids are probably responsible for the improvement of the biological value. It may also be that the biological availability of the amino acids increases in the mixtures with increasing proportions of soybean.

Table V and Figure 1 show the improvement in nutritive value of common beans extended by increasing proportion of soybeans or by the combination of common beans and rice. The mixture with 50% soybean is 60% more nutritive for the rat than common beans alone, as judged by PER values and growth curves.

The precooked, dehydrated and powdered (1:1 w/w) mixture of common beans and soybeans was used as the base for an instant soup. The composition of the formulated soup is shown in Table VI.

The proximate nutrient composition of the dehydrated instant soup shown in Table VII supplies (per 100 g dried soup) 390 kcal of total metabolizable energy, 85 kcal of which is from protein. About 25% of the total energy comes from the lipid material.

The hydration capacity of precooked and powdered common beans, soybeans and the 1:1 mixture was 175, 150 and 160 g water/100 g material, respectively (Fig. 2A). The hydration capacity of the mixture (160 g H_2O/100 g) increased to 105 g H_2O/100 g mix due to addition of corn starch in the formulation (Fig. 2B).

The acceptability of the cooked, 1:1 mixture of beans in institutional feeding was better than 95%, based on the consumption of groups of all ages (children and adults).

The consumer acceptance at a domestic level (based on the questionnaires returned by the families) was ca. 70% for the uncooked mixture of seeds, as well as for the precooked instant soup.

TABLE II

Analysis of Variance for Preference and Mean Values of Mixtures of Soybeans and Common Beans (Hedonic Scale)[a]

SV	DF	SS	MS	f
Total	23	3.36986		
Mixtures	3	0.10341	0.03447	0.22337 (ns)
Blocks	5	0.95166	0.19033	1.23337 (ns)
Error	15	2.31479	0.15432	

Soybeans (%)	Mean values[b]
20	7.22
30	7.32
40	7.14
50	7.22

[a] ns = not significant.

[b] Mean of 6 replicates.

TABLE III

Proximate Composition of Soybeans, Common Beans and Their Mixture (50/50)

Components	Products		
	Soybeans	Common beans	Mixture
Crude protein	36.6	19.4	27.9
Total lipid	22.7	3.5	13.2
Water	7.5	4.9	7.3
Ash	5.3	3.4	4.5
Crude fiber	5.2	4.6	5.1
Carbohydrate	27.9	68.8	47.2

TABLE IV

Amino Acid Compositions (g/16 g N)

Amino acid	Protein sources: Beans (A); Soybeans (B); Rice (C)						
	100A + 0B	65A + 35B	50A + 50B	20A + 80B	0A + 100B	20A + 10B + 70C	0A + 0B + 100C
Lys	7.9	8.9	8.5	8.4	8.4	5.6	3.1
His	2.2	2.5	2.8	2.8	2.4	2.1	1.7
NH_3	2.2	2.4	2.7	3.1	2.4	2.4	2.8
Arg	5.6	6.3	6.4	6.6	6.5	5.8	6.0
Asp	16.2	16.1	16.9	15.6	16.3	13.3	10.9
Thr	4.8	4.5	5.0	4.6	4.4	3.8	3.3
Ser	6.8	6.2	6.6	6.4	6.4	5.8	5.5
Glu	23.3	26.0	27.8	25.3	32.5	23.1	27.9
Pro	3.8	4.5	5.3	5.3	5.5	4.4	4.5
Gly	4.3	4.6	5.2	5.2	5.0	4.5	4.6
Ala	4.3	4.6	5.3	5.2	4.9	5.2	5.9
1/2 Cys	0.6	0.9	1.2	1.3	1.5	1.3	1.4
Val	5.0	5.3	5.6	5.5	5.1	5.4	5.5
Met	0.7	0.9	1.2	1.3	1.3	1.4	1.9
Ile	4.5	4.8	5.4	5.3	5.1	4.1	3.8
Leu	9.3	9.3	9.3	10.0	9.6	9.2	9.8
Tyr	2.8	3.0	3.3	3.4	3.5	2.7	3.4
Phe	5.5	5.3	5.7	4.9	5.0	5.1	4.9

TABLE V

Biological Values (PER)

Protein sources					PER corrected (casein = 2.5)
Beans (%)	+	Soybeans (%)	+	Rice (%)	
100	+	0			1.0
65	+	35			1.3
50	+	50			1.6
20	+	80			2.0
0	+	100			2.0
20	+	10	+	70	2.1

TABLE VI

Composition of the Dehydrated Soup Base

Ingredients	g/100 g
Common bean/soybean mixture (1:1 w/w)	80.00
Corn starch	12.00
Table salt	3.60
Monosodium glutamate	0.30
Dehydrated onion	1.20
White pepper	0.60
Dehydrated garlic	0.30
Cumin	0.30
Dehydrated parsley	0.08

TABLE VII

Proximate Nutrient Composition of the Dehydrated Instant Soup of Table VI

Components	g/100 g
Crude protein	21.34
Total lipid	10.84
Water	6.00
Ash	8.40
Crude fiber	5.30
Carbohydrate (difference)	51.88

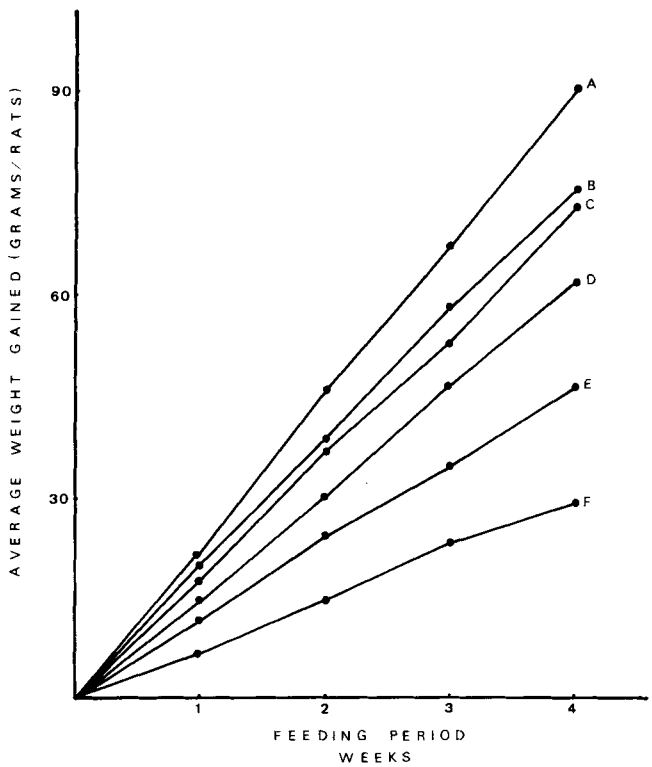

FIG. 1. Growth rate curves for rats (6/group) on diets containing the following ingredients (%) as source of protein: A, casein; B, common beans 20, soybeans 10 and rice 70; C, soybeans 10; D, common beans 50 and soybeans 50; E, common beans 65 and soybeans 35; and F, common beans 100.

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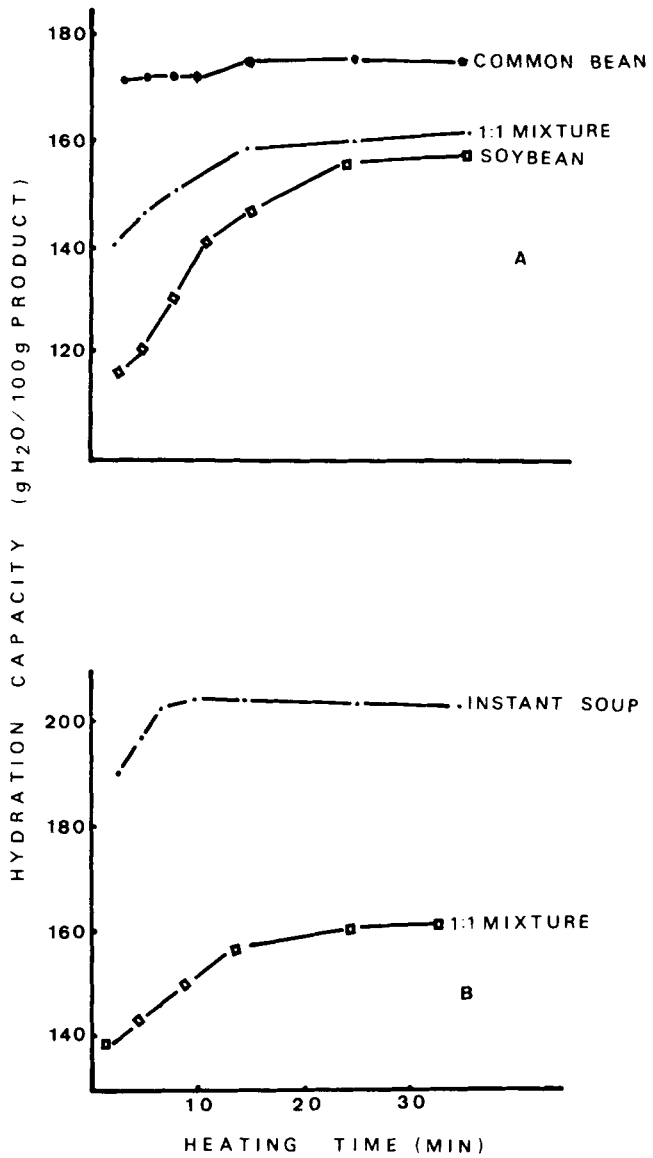

FIG. 2. Hydration capacity of common beans, soybeans, 1:1 mixture of common beans and soybeans and dehydrated instant soup. A: common beans, soybeans and 1:1 mixture; B: instant soup, 1:1 mixture.

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