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WHOLE SOYBEANS AS A MEANS OF INCREASING PROTEIN AND CALORIES IN MAIZE-BASED DIETS

INTRODUCTION

RESULTS OF recent studies carried out in 4-month-old dogs fed maize-bean diets, as consumed by small children in many rural areas of Latin America, showed that protein and calories (as oil) added individually or together, improved the utilization of the protein of the maize-bean diet (Murillo and Bressani, 1972). These findings confirmed the fact that diets of this type are deficient in both calories and good-quality protein. Used by themselves, they cannot provide the necessary calories because of their low calorie density and their great bulk, and also because for economic reasons consumers of these diets are unable to purchase greater amounts of such foods.

Previous studies carried out by Elías and Bressani (1972) have concentrated on providing more and better-quality protein. The present article deals with the results obtained by using a single food to provide more protein of better quality and more calories. Soybean was the food chosen for this purpose after subjecting it to the cooking treatment maize receives before consumption in the area.

MATERIALS & METHODS

THE MAIZE selected for these studies was the common variety grown at the INCAP experimental farm located at an altitude of 5,350 feet above sea level. The soybean Pelican variety used was also grown on the same farm. This material contained 14.0% fat and 30.3% protein.

Processing of both maize and soybeans was carried out by the lime-cooking process commonly used to prepare tortillas (flat-cooked pancakes) as previously described (Bressani et al., 1958). After cooking and washing, the grains were ground wet in a rotary mill. The resulting dough was spread on a tray and dried using warm air at 65°C. Once dried, the material was then ground to 40 mesh.

Some of the dough was made into tortillas and then dried and ground. All samples were analyzed for their proximate chemical composition according to AOAC standard methods of analysis (AOAC, 1960).

The process was applied to prepare two types of foods, wherein both maize and soybeans were cooked together. The proportions of the two materials differed according to the type of food preparation desired. These are described under Results. Water retention capacity of the supplemented and unsupplemented tortillas was determined by continuous weigh-

ing of both types of preparations over a period of 3 days. Tortillas were then left on a laboratory bench, in a room at a temperature of 22°C.

The final dried flour form preparations were then submitted to biological assays for protein quality, using the PER method. In these assays, both protein level of the diet and fat content were adjusted so as to make valid comparisons. The different preparations were added to a basal diet containing 5% oil, 4% mineral mixture (Hegsted et al., 1941), 1% cod liver oil and 5 ml of a complete vitamin-B solution (Manna and Hauge, 1953). When necessary, diets were adjusted to 100% with maize starch. Each experimental group was made up of 10 weanling rats, placed in individual all-wire cages, with raised screen bottoms. Food and water were provided ad libitum and weight changes were measured four times every 7 days.

RESULTS

Preparation of soybean-enriched tortillas

Previous studies had indicated that the addition of 8% soybean flour, containing 50% protein, gave optimum protein quality when added to maize (Bressani and Marengo, 1963). Since 8% soybean flour provided 4g of protein, quantities supplying this additional amount were used in our studies with whole soybeans. The level chosen was rounded to 15% and added to 85% of raw, yellow or white maize, following the procedure described in Figure 1. To each batch of maize and whole soybeans were added 1.6 times water, by weight, and 1.7% calcium

Table 1—Balance of materials for tortilla preparation

Mixtures used		Amt cooked (kg)	Amt of dough recovered (%)	Amt of tortilla re-covered (%)
Maize	Soybean (%)			
100	0	8.0	87.5	—
85	15	8.0	89.3	—
100	0	2.0	—	79.6
85	15	2.0	—	84.5

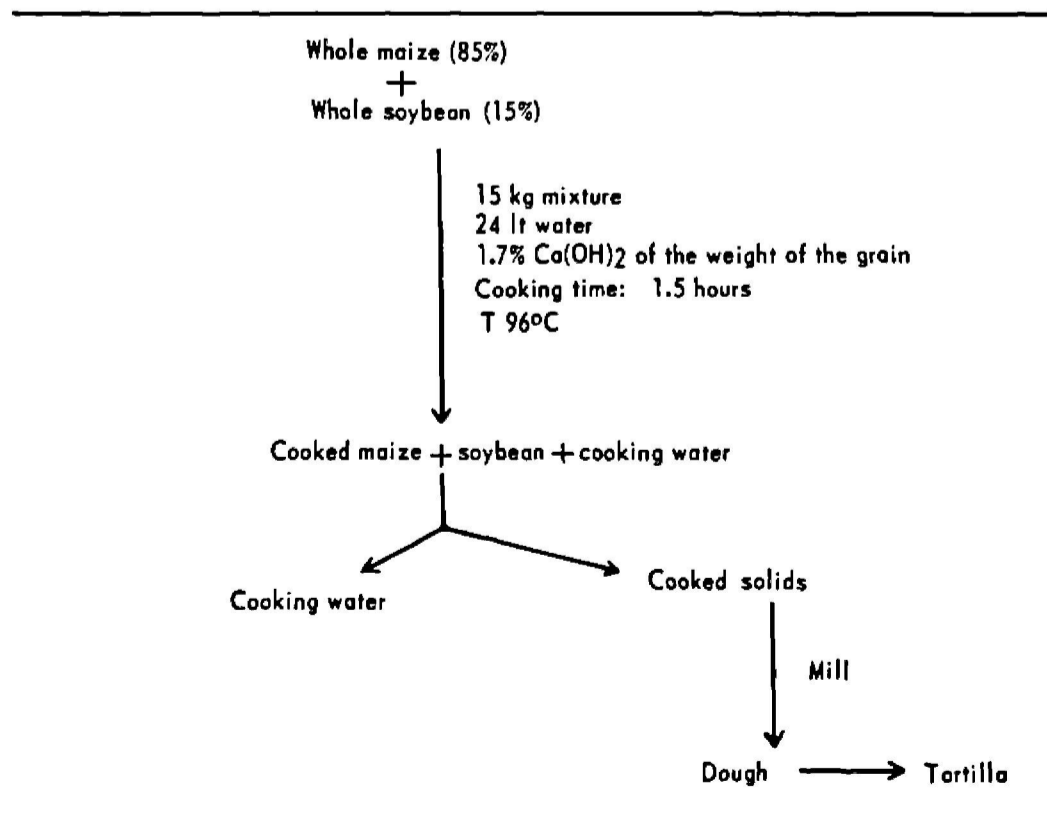


Fig. 1—Tortilla preparation from maize and whole soybeans.

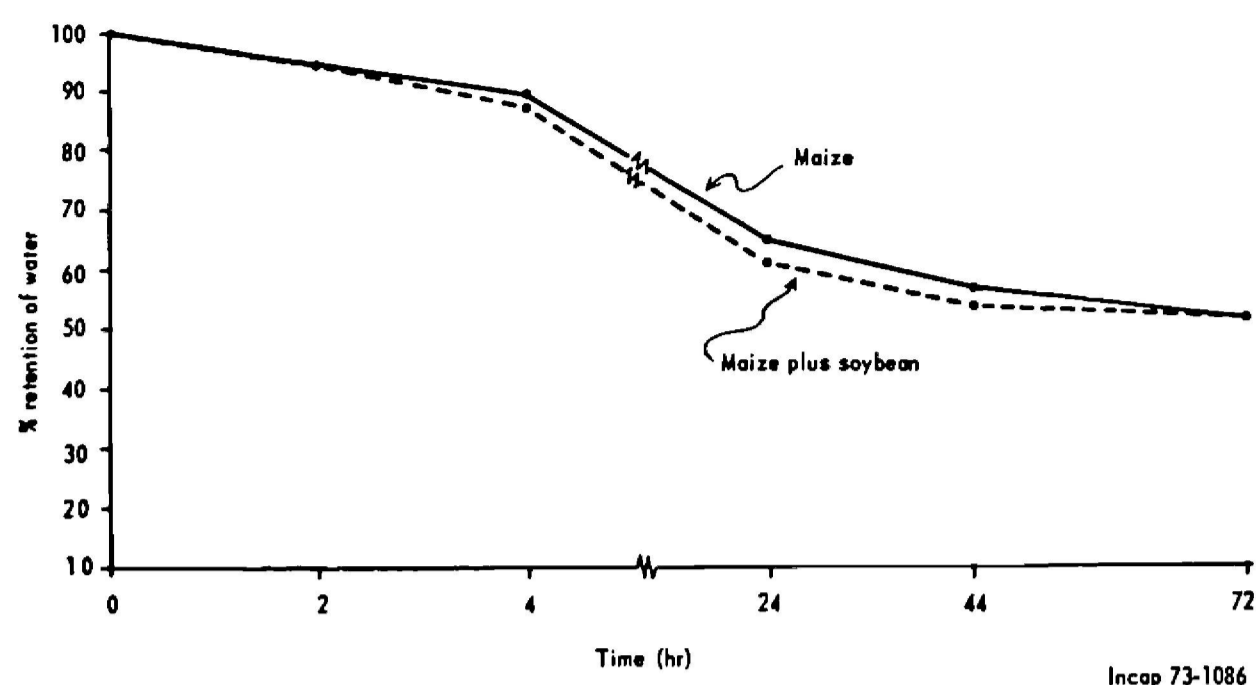


Fig. 2—Water-holding capacity of tortillas made from maize, and from maize plus soybeans (22°C).

hydroxide. Grains were cooked for 1.5 hr, the time needed to reach boiling temperature. They were then cooled to room temperature, the cooking liquor discarded, and the grains washed three times with water. Immediately afterwards the cooked material was ground and weighed, and prepared into tortillas in order to measure their yields. These results are shown in Table 1. Slightly higher yields of both dough and tortillas were obtained when maize was processed with 15% whole soybeans. The loss in yield occurs because small amounts of dough remain attached to the mill and part is also lost during actual preparation of tortillas. Table 2 shows the chemical com-

position of these preparations. Data reveal that when they contained 15% soybeans, their protein content increased from 10 to around 14%. Likewise, crude fiber, ash and fat contents increased with the presence of soybeans. Water retention of common tortillas and of those made from maize plus soybeans was essentially the same over a 12-hr period at room temperature (Fig. 2).

Data concerning protein quality of these preparations are presented in Table 3. Results show that protein quality was higher for preparations containing soybeans as whole beans or as flour, tested at 9 or 12.5% protein in the diet, and that oil in the soybean-corn preparation also

contributed to its nutritive value.

Preparation of a high-protein food from corn and whole soybeans

Mixtures of corn and soybean flour of maximum protein quality (Bressani and Elías, 1966) served as the basis for the studies reported herein. Those mixtures where each component supplied 50% of the total protein, gave maximum protein efficiency ratios and were used for the formulation of INCAP Vegetable Mixture 14 (Bressani and Elías, 1966). In the present studies, whole maize and soybeans alone and in various combinations were processed by the lime-cooking treatment described in Figure 3. The resulting dough was dried, weighed, analyzed and used for biological tests.

Table 4 summarizes the yields obtained, and results demonstrate that as the amount of soybeans increased in the preparation to be cooked, yield of these materials decreased significantly. The protein and fat content of the various preparations, as well as the weight gain of the rats consuming them, together with their protein efficiency ratio, are summarized in Table 5. As expected, protein and fat content increased as the amount of soybeans increased. Weight gain also improved, but the increments obtained when the amount of soybeans in the mixture was augmented, decreased after the mixture exceeded 28% soybeans and 72% corn, respectively. This preparation gave the highest protein efficiency ratio.

DISCUSSION

RESULTS OF the present study indicate that it is possible to prepare tortillas

Table 2—Chemical composition of dough and tortillas made from maize-soybean mixture (expressed in percentage)

	Moisture	Fat	Crude fiber	Protein	Ash	Moisture (fresh)
Dough, white maize (dehydrated)	6.5	3.0	1.6	10.0	1.8	—
Dough, white maize + soybean (dehydrated)	5.5	5.5	2.7	13.9	3.2	—
Tortilla from white maize	1.4	2.2	2.0	10.4	1.6	53.0
Tortilla from white maize + soybean	1.4	4.1	2.8	14.4	2.3	53.8

Table 3—Protein quality of maize dough prepared with or without soybeans

	Protein (%)	Avg wt gain (g)	PER	Relative nutritive value	Utilizable protein (%)
White maize dough ^a	9.0	18	0.95	23.7	2.14
85% white maize dough + 15% soybeans ^a	9.0	40	1.72	43.0	3.87
92% white maize dough + 8% soybean flour supplement ^a	9.0	40	1.70	42.5	3.82
Casein ^a	9.0	112	3.00	75.0	6.75
85% white maize dough + 15% soybeans ^a	12.5	84	1.98	57.1	7.14
92% white maize dough + 8% soybean flour supplement ^a	12.0	68	1.98	57.1	6.58
Casein ^a	12.5	124	2.60	75.0	9.38
85% white maize dough + 15% soybeans without 5% added oil in diet	12.5	78	1.98	57.1	7.14

^a All diets were supplemented with 5% soybean oil.

based on mixtures of 85% maize and 15% whole soybeans with a protein quality and nutritive value superior to that of the tortilla made from maize alone. Obviously, this increase is due to the contribution of the limiting amino acids in the maize protein—lysine and tryptophan (Bressani et al., 1968)—by the addition of whole soybeans, as well as to the higher levels of fat attained also through these means. The tortillas had similar physical characteristics, and water retention for both types of preparations was essentially the same. Furthermore, acceptability was very good among testers. These findings were to be expected, since previous research using soybean flour had shown an increase in protein quality (Elías and Bressani, 1973) and good acceptability of the product (Elías and Bressani, 1971). The difference, however, lies in the fact that when tortillas are made with whole soybeans, they contain a relatively higher level of calories, nutrient that is also deficient in the habitual diet of children and adults of poor economic resources in the Central American countries (INCAP, 1969). The biological tests conducted, proved that the addition of calories is an important factor in improving the nutritive quality of the tortilla prepared with soybeans, a finding that corroborates results of previous studies (Murillo and Bressani, 1972). In terms of total intake of protein and calories, consumption of tortillas with whole soybeans would be preferable to an increased intake of simple tortillas, since with the latter it would be difficult to obtain the calorie intake and protein quality actually needed to improve the nutritive quality of the diet.

According to results presented in this study, products with higher protein content and energy value can also be obtained. A mixture of 72% maize and 28% whole soybeans, with 18% protein and 10% fat would be a good-quality food preparation for small children. Protein-rich foods with the same protein levels are now being distributed in developing countries (Bressani and Elías, 1973) to

help alleviate protein-calorie malnutrition. Further studies with the mixture of 72:28 maize:soybeans, named "Maisoy," are now under way.

An interesting finding is that as the amount of soybeans increased, yields of cooked solids decreased. This was attributed to the solubility of the soybean protein in alkaline solutions. The fact that rats grew relatively well, therefore suggesting that the lime-cooking process inactivated the antiphenological factors present in soybeans, is another important finding (Liener et al., 1958). Nevertheless, both aspects deserve further study.

Besides, it will be necessary to test the stability of the 72:28 food preparation because of the relatively large amount of fat present in it, and considering the possible effects of the alkaline conditions used. High lipid acid values of lime-cooked maize can be detected after 3 to 4 months of storage (Bressani et al., 1962); therefore, it is possible that this may also

occur with the 72:28 maize:soybean mixture in the dehydrated form and under certain storage conditions.

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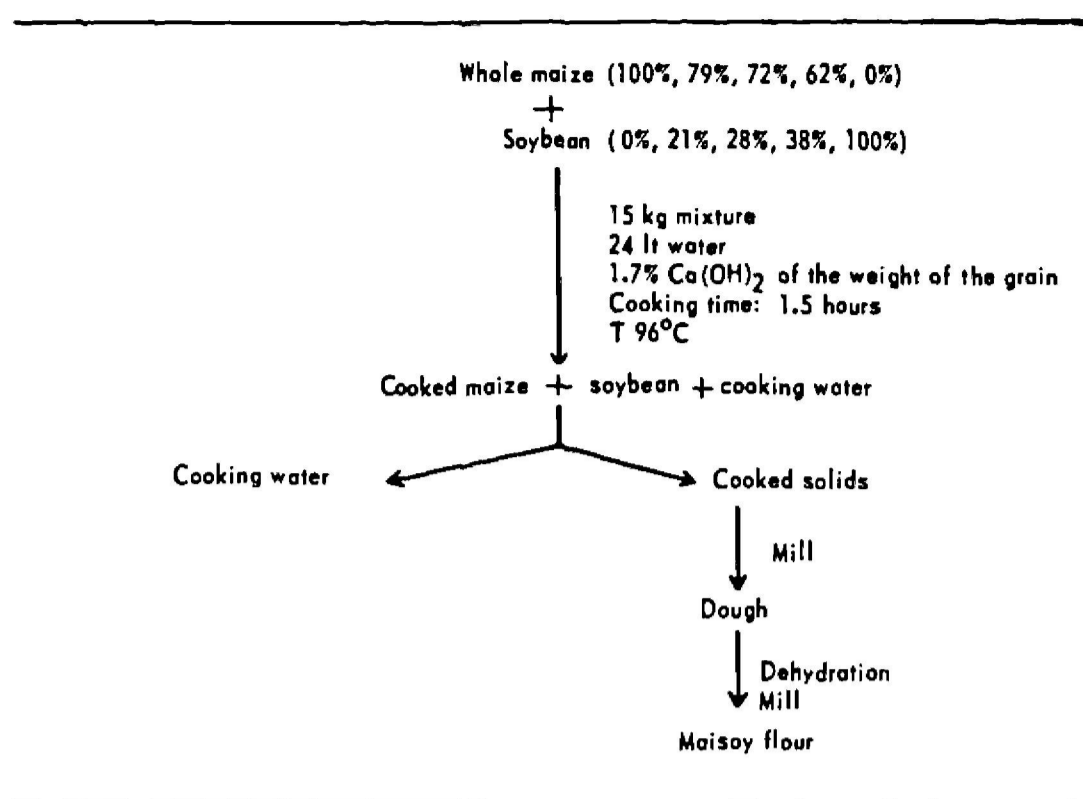


Fig. 3—Processing of mixtures of maize and soybeans.

Table 4—Balance of material of various maize-soybean mixtures

Mixture		Amt processed (kg)	Amt recovered (kg)	Yield (%)
Maize (%)	Soybean (%)			
100	0	15.0	12.0	80.0
79	21	15.0	12.2	81.1
72	28	15.0	12.0	80.0
62	38	15.0	10.8	72.0
0	100	15.0	9.4	62.7

Table 5—Protein and fat content and protein value of the different preparations^a

Mixture		Content of		Avg wt gain (g) ^b	PER
Maize (%)	Soybean (%)	Protein (%)	Fat (%)		
100	0	9.9	4.5	12	0.69
79	21	16.9	8.9	81	2.08
72	28	17.6	10.3	91	2.54
62	38	18.1	11.3	99	2.37
0	100	40.0	25.6	101	2.03
Casein		—	—	120	2.87

^a All diets were calculated to contain 9% protein.

^b Average initial weight: 47g.

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