IV. PROGRESS REPORT- Processing

4.1 USE OF SALT SOLUTIONS TO DECREASE COOKING TIME OF THE HARD-TO-COOK BEANS.

L.G. ELIAS, L.F.LEON AND R. BRESSANI

DIVISION OF AGRICULTURAL AND FOOD SCIENCE
INSTITUTE OF NUTRITION OF CENTRAL AMERICA AND PANAMA (INCAP)
P.O. BOX 1188, GUATEMALA, GUATEMALA, C.A.

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Main findings related to this subject and previously reported are as following:- a) different ratios of mono (Na, K) to divalent (Ca, Mg) ions (0.30, 2.30, 6.30, 8.30, 8.38 and 9.80) used as soaking solution has shown to influence cooking time and protein quality; b) as far as cooking time is concerned the most significant reduction is obtained after soaking with 6.30 ratio; c) pH of the salt solutions are related to the ions content, but pH values decreases after soaking; pH of the cooking broth and the cooked beans are lower when the grain is soaked with salt solution and cooked with water; d) Protein Efficiency Ratio (PER) values indicated that lower (0.30) and higher (0.90) ratios of mono to divalent ions reduced drastically protein quality; intermediate ratios gave normal PER values; e) beans soaked with salt solutions and cooked with water gave higher PER values as compared with beans soaked and cooked with salt solutions. The soaking process used in the laboratory studies is shown in Figure 1. A summary of results obtained with hardened beans treated with selected conditions are snown in Table 1; f) 4 hours soaking time gave similar cooking time values as compared with 16 hours soaking with the salt solutions; in all cases protein quality was similar or improved by reducing soaking time.

- Because the final objective of this approach was to transfer the technology to the industry additional studies were carried out to improve and adapt the use of the salt solution process.

Technology Transfer

A local Guatemalan food industry was selected for the study, which was undertaken in three phases. The first one consisted in studying at laboratory level additional variables in the soaking process, such as, the effect of different soaking times with the salt solution on the cooking time and the ions content in the cooked beans. Furthermore, the effect of the repeated use of the salt solutions in the cooking time was also assessed (Table 2). In this phase cooking time was determined by using the Mattson cooker. In the second phase which was carried out at a pilot plant level, the repeated use of the salt solution and its effect on the cooking time was evaluated by using an autoclave (16 lbs pressure and 250°F temperature). In the third phase fried beans were processed according to the best conditions found in the previous phases, and using the same process used by the industry. The final product was stored for 15 days at 37°C and 70% relative humidity to observe the effect of salt addition during storage. Sensorial analysis, protein content, trypsin inhibitors activity and Na and K content was carried out in the samples. A preliminary cost analysis was also determined.

RESULTS. Phase 1

Table 3 shows the effect of different soaking times with a salt solution with 8:30 ratio of mono to divalent ions, on the cooking time of hardened beans used by the industry. As it can be observed, no significant

differences in cooking time were found at different soaking times, indicating that one hour could be selected. This Table also indicates that the second use of the same salt solution gave acceptable values of cooking time as compared with the first use. No explanation can be offered for the higher cooking time value obtained with beans soaked for 2 hours, since a repeated experiment (Table 4) for the same soaking time indicated that cooking time was 30 minutes less as compared with one hour soaking. Even when the concentration of salts for the soaking solution is increased (0.15% $NaHCO_3$ + 3.0% of K_2CO_3) the best cooking time again is obtained after 2 hours soaking (Table 5). Therefore, from the previous results, 2 hours soaking was selected as the most appropiate to be used at industrial level without altering the unit operations used in the preparation of fried beans.

Table 6 shows the selected mineral content (Na and K) of the raw, soaked and cooked beans, indicating that the proposed salt treatment did not increased potassium content; in the case of the sodium ions the increment was not significative as will be further discussed, when the final product will be analyzed. Using twice the same soaking salt solution decrease even more the ions content in the cooked beans.

As far as the repeated use of the soaking salt solution is concerned, the data obtained (Table 7) indicated that beyond the second use, cooking time is not significantly reduced.

Phase II

An additional attempt to use more than twice the same salt soaking solution is shown in Table 8. Cooking time was carried out in the autoclaves (15 lb pressure and 250°F).

In this case for the third use 50% of the original amount of the salts was added to the soaking solution. The data obtained indicated that reconstitution of salt solution resulted in cooking time reduction at industrial level, similar to those obtained in the first and the second use. This option now is available and should be analyzed by the industry from the economic and practical point of view for their future application.

Phase III

According to the best conditions found in the laboratory and in the pilot plant (soaking time: 2 hours; cooking time: 15 minutes in the autoclave) hardened beans from the industry was processed according to the method used by the industry (see Figure 2). Sensory analysis of the final products, which include beans soaked and cooked with water as well as beans processed with salt solutions before and after storage are shown in Table 9. As it can be seen there is no significant difference between treatments except in the case of flavor where the panelists showed a higher preference for the fried beans processed with the salt solution either before and after storage. Therefore soaking beans with the proposed salt solution before cooking, did not affect the organoleptic characteristics during processing or storage. Finally, Table 10 shows the nutritional evaluation of the fried beans prepared by the industry according to the developed and

proposed salt solution process. Sodium and potassium content was similar for all products including the commercial sample. Protein content and protein quality (Net Protein Ratio) determination gave similar or higher values as compared with the commercial sample, and trypsin inhibitors content reported smaller values for the salt treated samples. In conclusion the proposed process using salt solutions to decrease the cooking time of the hard-to-cook beans, resulted in an acceptable product from the organoleptic and nutritional point of view.

Cost Analysis

Based on the actual prices in Guatemala for the beans, salts used and energy cost, the following calculations were made for each batch of beans (2,200 lbs) processed.

Normal Process		Salt Solution Process	
Cost of fresh beans=	Q.1,540 00	Cost of hard beans=	Q. 770.00
Cost of salts=	Q. 0.00	Cost of salts=	Q. 25.47
Energy cost=	Q. 15.30	Energy cost=	Q. 5.10

Based on this calculation, saving costs by the use of the salt solution process is about Q.754.73 per each batch of 2,200 lbs, demostrating the economic feasibility of implementation this process at the industrial level utilizing the hard-to-cook beans.

TABLE 1

RESULTS OBTAINED WITH THE HARDENED BEAN TREATED WITH THE THE SALT SOLUTION WITH 8.30 RATIO OF MONO TO DIVALENT IONS AS COMPARED TO THE UNTREATED BEAN SAMPLE

Parameters	Hard-to-Cook Beans (4:60 ratio)	Hard-to-Cook Beans treated with salt solution (8:30 ratio)
Cooking time (min.)	> 360	105
pH of cooked and dried bean flour	6.0	7.0
Protein efficiency ratio (PER)	1.0	0.86
True digestibility	76.1	74.1
Cost to cook 1 kg/bean (US. $Dollar)	0.29	0.10

TABLE 2

ADDITIONAL VARIABLES STUDIED IN THE SOAKING PROCESS IN ORDER TO TRANSFER LABORATORY DATA TO INDUSTRIAL LEVEL

- Temperature, pH and soaking time
- Use of the same salt solution in various soaking processes.

TABLE 3

COOKING TIME OF HARD-TO-COOK BEANS SOAKED WITH SALT SOLUTION
(8:30 ratio) AT DIFFERENT SOAKING TIME

SOURCE OF ENERGY
(750 watts)

Soaking time (hrs.)	COOKING TIME (Min.)		
	Without salt solution	With Salt Solution	
		First Use	Second Use
1	---	159 ± 1.0	172.5 ± 2.5
2	343	178.5 ± 1.5	198.5 ± 1.5
3	---	142 ± 2.0	166 ± 1.0
4	---	160.5 ± 1.5	199 ± 6.0

TABLE 4

COOKING TIME OF HARD-TO-COOK BEANS SOAKED WITH SALT SOLUTION (8:30 ratio) AT DIFFERENT SOAKING TIME (Energy source 1100 watts)

Soaking time (hrs.)	COOKING TIME (min.)		
	Without salt solution	With salt solution	
		First use	Second use
0	270	---	---
1	300	136 ± 6.0	163 ± 4.0
2	224 ± 9.0	106 ±10.0	156 ± 7.0
3	---	---	---
4	---	---	---

TABLE 5

COOKING TIME OF HARD-TO-COOK BEANS SOAKED WITH A SALT SOLUTION WITH AN INCREASED AMOUNT OF SALTS (0.15% $NaHCO_3$ AND 3.0% K_2CO_3)

Soaking time (hrs.)	Cooking Time (min.)	
	First use	Second use
1	109 ± 2	119 ± 5
2	80.5 ± 6.5	103 ± 4

TABLE 6

MINERAL CONTENT (mg) IN RAW, SOAKED AND COOKED BEAN, BASED ON 100 g OF BEAN DURING COOKING AND EXPRESSED IN DRY MATTER

Bean Treatment	TOTAL MINERAL CONTENT (mg)	
	K	Na
Raw	1546.75 ± 21.00	12.86 ± 00.00
Soaked with salt solution and cooked salt water*	1529.44 ± 54.44	17.22 ± 0.22
Soaked with salt solution and cooked salt water**	1379.18 ± 84.10	14.81 ± 0.75

* Salt solution made of 0.05% $NaHCO_3$ and 1.0% of K_2CO_3 (first use).

** Same salt solution (second use).

TABLE 7

THE EFFECT OF REPEATED USE OF SALT SOLUTION* ON THE COOKING TIME OF HARDENED BEAN

Soaking Time (hrs.)	COOKING TIME (Min.) USE OF SALT SOLUTION			
	First	Second	Third	Fourth
2	82	93	141	160
2	81	88	150	164
$\bar{x}$	81.5 ± 0.5	90.5 ± 2.5	145.5 ± 4.5	162 ± 2.0
Control**	165			

* 0.05% $NaHCO_3$ and 1.0% of K_2CO_3.

** Control: Soaked in water for 2 hours.

TABLE 8

THE EFFECT OF REPEATED USE OF SALT SOLUTION (0.05% $NaHCO_3$ and 1.0 K_2CO_3) ON THE COOKING TIME OF COMMERCIAL BEANS*

Soaking Time (hrs.)	COOKING TIME			
	USE OF SALT SOLUTION			
	First	Second	Third	Fourth
2	15	20	15	20
Control**	45 min.			

* Cooked in the autoclave at 15 lbs. and 250°F.

** 50% of the original amount of salts was added.

*** Control: bean cooked without soaking.

TABLE 9

SENSORY ANALYSIS-(flavor,-color and texture) OF FRIED BEANS MADE OF HARD-TO-COOK BEANS, SOAKED WITH SALT SOLUTION (8:30 ratio of mono to divalent ions) AND COOKED WITH WATER

Bean Treatment	SENSORY ANALYSIS		
	Flavor 1/	Color 2/	Texture 3/
Bean cooked and soaked with water	7.0 ± 1.5 [a]	1.9 ± 0.6 [c]	2.0 ± 0.6 [d]
Bean soaked and cooked with salt solution	5.6 ± 1.8 [b]	2.3 ± 0.8 [c]	2.2 ± 0.6 [d]
Bean soaked with salt solution and cooked with water	7.6 ± 0.8 [a]	1.9 ± 0.5 [c]	2.2 ± 0.7 [d]

* Average of 30 "in house" panelists.

1/ According to a hedonic scale: 1= dislike extremely; 9= like extremely.

2/ Color: 1= Pale; 2= Black; 3= Deep black.

3/ Texture: 3= pasty; 2= normal; 1= granular.

TABLE 10

MINERAL CONTENT (Na and K) PROTEIN AND TRYPSIN INHIBITORS (UTI/ml) IN FRIED BEANS

Bean Sample	Minerals (mg/100 g moisture sample		Protein (g/100 g moisture sample)	Trypsing inhibitors UTI/g moisture sample	Net Protein ratio
	Na**	K***			
Commercial sample	323.2 ± 12.1	398,2 ± 3.4	5.1 ± 0.07	0.62	1.39 ± 0.5
With salt solution (first use)	312.1 ± 68.6	405.1 ±12.1	5.4 ± 0.03	0.48	1.42 ± 0.6
With salt solution* (second use)	296.9 ±55.6	392.5 ±11.7	5.0 ± 0.05	0.48	1.86 ± 0.7
Casein					4.30 ± 0.5

* Bean soaked with salt solution and cooked with water.

** Recommended intake: Na, 1,100 to 3,300 mg/day. FDA Consumer 18(4). 1936.

*** Recommended intake: 3,700 to 7,400 mg/day. Present Knowledge in Nutrition. 1971

FIGURE 1

SOAKING PROCESS USING SALT SOLUTIONS

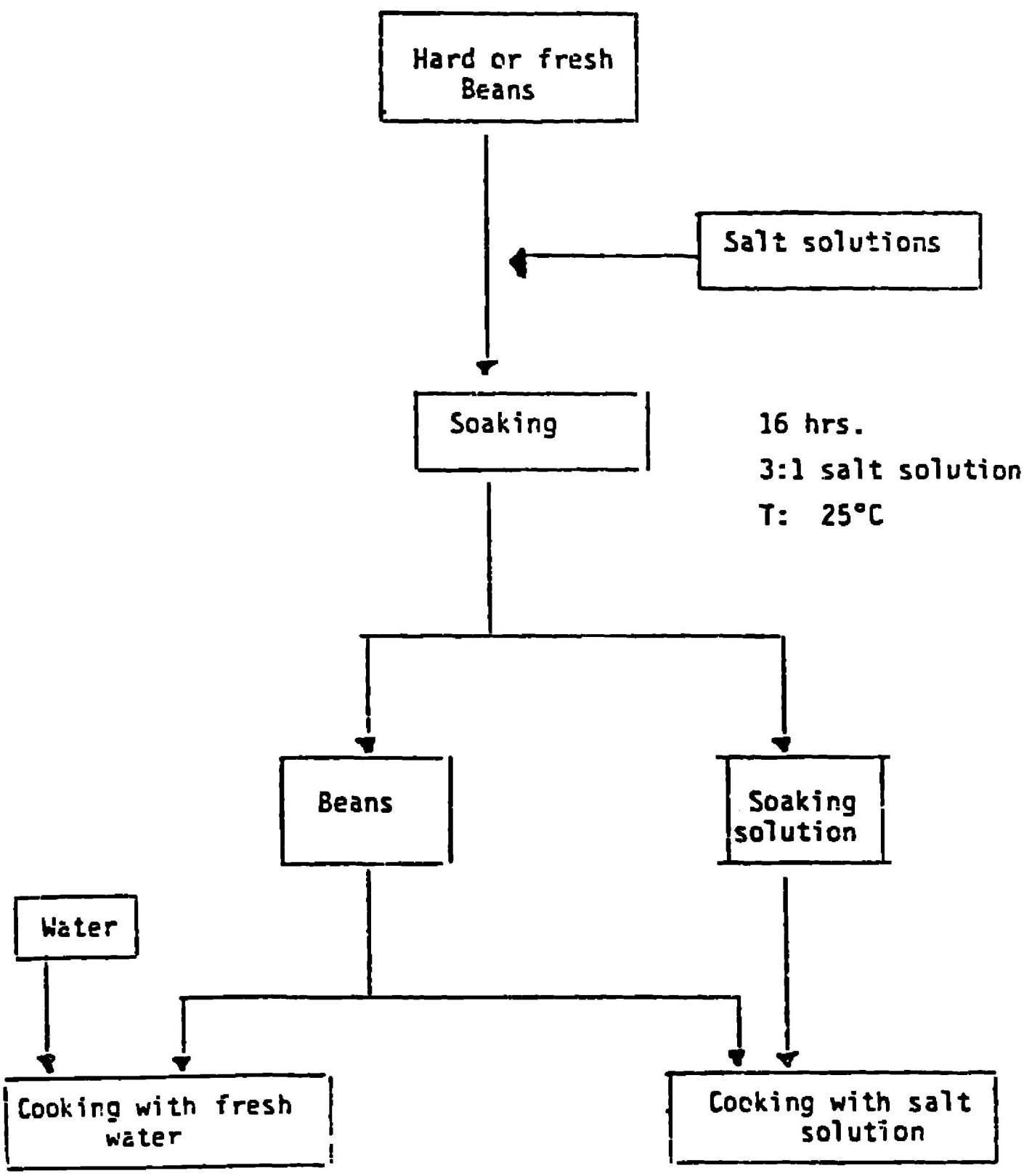

FIGURE 2

INDUSTRIAL PROCESS FOR THE PREPARATION OF FRIED BEANS