

# Effect of Processing Parameters on Trypsin Inhibitor and Lectin Contents of Tortillas from Whole Raw Corn-Soybean Mixtures

F. R. DEL VALLE, M. L. PICO, J. L. CAMACHO, and H. BOURGES

## ABSTRACT

Trypsin inhibitor and lectins in raw corn-soybean blends (92/8 and 84/16 w/w, dry basis) cooked in limewater decreased with cooking time and increasing lime concentration, with total inactivation occurring, in all cases, after 30 min. These factors, determined in raw corn-soybean (92/8 and 84/16 w/w, dry basis) tortillas decreased with increasing hot plate contact time; total inactivation of both occurred only with 92/8 tortillas after 60 sec. Antinutritional factor inactivation rates were considerably higher for hot plate cooking than for limewater boiling. Soaking cooked blends in liquor after turning off the heat and allowing to cool, followed by grinding into a dough had little effect on antinutritional factors, while washing cooked blends with water resulted in some reduction of both factors. Corn-soybean tortillas prepared with normal heat treatment had no residual factors, while those prepared with minimum heat treatment had insignificantly low residual trypsin inhibitor and no lectins.

## INTRODUCTION

IN PREVIOUS WORK Del Valle and Perez-Villaseñor (1974) found that it was possible to enrich tortillas with soy proteins by applying the traditional tortilla-making process, normally utilized with whole raw corn, to mixtures of whole raw corn and soybeans. Del Valle et al. (1976) further found that the same procedure of cooking whole raw corn-soybean mixtures in place of whole raw corn alone, could also be used for enrichment of industrially produced tortilla flour. In both cases, it was found that this procedure appreciably increased protein quantity and quality of tortillas and tortilla flour, with degree of enrichment dependent upon soy level in the mixture. Subsequent work by other investigators (Bressani et al., 1974; Franz, 1975; Green et al., 1976 and 1977; Bressani et al., 1979) has verified these results.

Since soybeans are known to contain antinutritional factors, most important of which are trypsin inhibitor and lectins (hemagglutinins), it was thought that it would be desirable to determine effect of different processing parameters on inactivation of these factors when preparing tortillas by the method described. Previous related work by Bressani et al. (1979) showed that trypsin inhibitor content of 85/15 corn-soybean blends decreased with cooking time in limewater, with total inactivation occurring after 30 min. It was also found that trypsin inhibitor inactivation was apparently unaffected by lime concentration. These authors, however, did not investigate all processing parameters involved in tortilla preparation, and particularly did not consider lectins which, like trypsin inhibitor, are known to be antinutritional factors. Moreover, some tortilla making processes are known to involve a low degree of heat treatment, and such aspects were also not considered.

*Author Del Valle is President, Fundacion de Estudios Alimentarios y Nutricionales, A.C., Apartado Postal 1545, Sucursal C, Chihuahua, Chih, Mexico and also Professor of Food Science at Facultad de Ciencias Quimicas, Universidad Autonoma de Chihuahua, Chihuahua, Mexico. Author Pico is with Sistema Alimentario Mexicano, Chihuahua, Mexico. Authors Camacho and Bourges are with Instituto Nacional de la Nutricion, Mexico City, Mexico.*

Del Valle and Perez-Villaseñor (1974) gave a complete description of the traditional process used for making tortillas. Briefly, the process involved cooking corn in limewater, turning off the heat after cooking and letting the cooked corn steep in the cooking liquor, decanting the liquor, washing the corn several times with fresh water and grinding the corn, usually in a stone mill into a dough or "masa." Thin pancakes prepared from the dough, either by hand or pressing in a tortilla-making machine, were then cooked on a hot plate. Normally, one side of the pancake was cooked for a short time, then turned over and the other side cooked for approximately the same time. The pancake was finally turned over again and the first side cooked once more, for the same length of time.

Wide variations in processing parameters were found when this process is applied in practice. Thus, limewater concentration, cooking time in boiling water, soaking time after cooking, number of washings of cooked corn with fresh water and hot plate cooking time can all vary within fairly wide limits. In corn-soybean tortillas, all of these factors, obviously, could have an effect on antinutritional factor content of the final product.

In this work, a thorough study of the effect of principal tortilla-making parameters and variations of tortilla-making processes on trypsin inhibitor and lectin contents of corn-soybean blends and tortillas was carried out.

## MATERIALS & METHODS

THE EXPERIMENTAL WORK was divided into three parts. In the first part, effect of limewater cooking parameters was investigated; in the second part, effect of hot plate cooking per se was studied; finally, in the third part, effect of two tortilla-making processes on trypsin inhibitor and lectin content was investigated: one with normal and one with minimum degree of heat treatment. It might be noted that most tortilla-making processes encountered in practice fall within the two procedures of the third part. This part of the study was also used to determine effects of soaking after cooking, and washing and grinding after soaking, on trypsin inhibitor and lectin contents of cooked corn-soybean blends.

### Effect of limewater cooking

In the limewater cooking study, whole raw corn-soybean mixtures with 8% and 16% soya (w/w, dry basis) were cooked in boiling limewater containing 0%, 2% and 4% calcium hydroxide in the manner described by Del Valle and Perez-Villaseñor (1974). Samples were withdrawn after cooking for 0, 15, 30, 45, and 60 min, thoroughly washed with tap water and immediately ground in a laboratory mill. Trypsin inhibitor and lectin contents of the ground samples were determined utilizing the methods of Kakade et al. (1974) and Jaffé et al. (1974). In the case of the 8% soybean blends, pH of samples cooked for 30 and 60 min was also measured after washing and grinding: the cooked samples were mashed into a dough with a pestle inside a mortar, and pH meter electrodes inserted into the dough for pH measurement.

### Effects of hot plate cooking

In the hot plate cooking study, the effect of hot plate treatment per se was determined. Raw tortilla pancakes were prepared by mixing raw soybean flour, made by grinding whole raw soybeans in a laboratory mill, with commercial tortilla flour at 8% and 16% levels (w/w, dry basis); adding water to form a dough (120 ml of water per 100g mixed flour); weighing 30-g portions of dough, and

pressing these to a standard size (15 cm diameter) in a hand tortilla-making machine. The pancakes were then cooked on a hot plate, alternating sides, allowing each side to contact the hot plate for 15 seconds. Trypsin inhibitor and lectin contents were determined in tortillas, by the methods previously described, after total contact times of 0, 15, 30, 45, and 60 sec, and reported on a moisture-free basis. Hot plate temperature was controlled at 200°C.

#### Effect of tortilla-making processes

In the third part of the study, the process with normal heat treatment was investigated as follows. Whole, raw corn-soybean mixtures, with 8% and 16% soybeans (w/w, dry basis), were cooked in limewater containing 2% and 4% calcium hydroxide, as previously described, for 30 min. After cooking, the heat was turned off and the mixtures were allowed to soak in the cooking liquor for 10 hr. The liquor was decanted, the cooked mixtures were washed three times with fresh tap water and ground into a dough using a stone mill. Thirty-gram dough balls were weighed, pressed into standard size (15 cm diameter) tortillas using a hand tortilla machine and cooked on a hot plate, controlled at 200°C, allowing a 15-sec contact time for each side. Samples for trypsin inhibitor and lectin determinations were withdrawn after cooking and soaking, after washing and grinding, and after cooking on the hot plate for total contact times of 0, 15, 30, 45 and 60 sec. The process with minimum heat treatment was similar to that for normal heat treatment, except that the corn-soybean mixtures were not cooked in limewater; instead, the limewater was heated to boiling, the heat was turned off and the mixtures were immediately added and allowed to soak in the limewater for 10 hr. As in the former case, mixtures with 8% and 16% soybeans (w/w, dry basis), treated in limewater containing 2% and 4% calcium hydroxide, were studied. Samples for trypsin inhibitor and lectin content were withdrawn at the same points as before, i.e., after soaking in limewater, after washing and grinding, and after total hot plate contact times of 0, 15, 30, 45 and 60 sec. Trypsin

inhibitor and lectins were determined by methods previously described, and reported on a moisture-free basis.

Soybeans utilized were of the *Tropicana* variety. Proximate analysis (AOAC, 1970) and trypsin inhibitor content (Kakade et al., 1975) of both raw materials, corn and soybeans, were determined and are reported on a moisture-free basis.

## RESULTS & DISCUSSION

TABLE 1 REPORTS data on proximate analyses and trypsin inhibitor contents of raw corn and soybeans. *Tropicana* variety soybeans were found to have relatively low protein and fat contents when compared with other varieties, whose corresponding values may be as high as 46% and 26%, respectively, with average values of approximately 40% and 20% (Smith and Circle, 1978). Trypsin inhibitor content of these soybeans, on the other hand, was considered normal (Rackis, 1974). It is interesting to note that raw corn was found to possess some trypsin inhibitor activity, although this was, of course, very low.

#### Limewater cooking study

Table 2 contains data on the limewater cooking study. Trypsin inhibitor content of uncooked corn-soybean mixtures was directly proportional to soy content, and closely paralleled values calculated considering inhibitor content of raw materials and mixture soybean level. Both trypsin inhibitor and lectin contents decreased with increasing cooking time, verifying Bressani et al.'s (1979) results as far as trypsin inhibitor is concerned. Also, in all cases, trypsin inhibitor and lectin levels were reduced to zero after cooking for 30 min, irrespective of mixture soy level or lime concentration, again verifying Bressani et al.'s (1979) results in the case of trypsin inhibitor. Since processes utilized for manufacture of tortillas or tortilla flour, both domestic and industrial, normally employ limewater cooking times of the order of 30 min, these results indicate that tortillas utilizing these processes would probably be free from both trypsin inhibitor and lectins.

An important finding was that increasing lime concentration accelerated trypsin inhibitor inactivation; this was consistently observed in mixtures containing both levels of soybeans and for the three lime concentrations studied. These results are in disagreement with those of Bressani et al. (1979), who found that lime dose had no effect on heat inactivation of trypsin inhibitor when cooking corn-soybean mixtures in limewater. One possible explanation for this discrepancy might be that in this study, fairly high lime concentrations were utilized (up to 4%), while Bressani et al. (1979) employed a maximum concentration of only 2%. It is interesting to note, however, that in this study a definite effect of lime concentration was observed even at the 2% level. Another, although less plausible, explanation could lie in the different procedures employed for determining effect of lime dose on trypsin inhibitor. Bressani et al. (1979) measured inhibitor in soybeans manually separated from corn in limewater cooked mixtures, while in the present study inhibitor content was measured in the total mixtures themselves. Presence or absence of corn when determining inhibitor content could have affected results, although this possibility was not checked in the present work. If this were the case, however, no explanation for the phenomenon is apparent at this time.

A possible explanation for the effect of lime concentration on heat inactivation of antinutritional factors observed in this work could be the known fact that proteins are denatured by pH extremes as much as by heat. Both trypsin inhibitor and lectins are proteins, and an increased lime concentration led to increased blend pH (Table 3), with a consequent increase in denaturation or inactivation of these factors.

—Continued on next page

Table 1—Results of proximate analyses and trypsin inhibitor determinations in whole raw corn and soybeans

COMPONENT	CORN	SOYBEANS
Protein	8.5%	35.5%
Moisture	11.5	7.1
Ash	1.7	5.1
Lipids	5.2	15.6
Crude fiber	2.2	7.5
Carbohydrates	71.0	29.2
Trypsin inhibitor (TIU/MG <sup>a</sup> )	1.9	46.3

<sup>a</sup> TIU/MG = Trypsin inhibitor units per milligram sample, dry basis

Table 2—Effect of limewater cooking parameters on trypsin inhibitor and lectin contents of corn-soybean blends

Percent soya in blend	Percent lime in limewater	Cooking time, minutes	Trypsin inhibitor, TIU/MG <sup>a</sup>	Lectins <sup>b</sup> Type of Blood	
8	0	0	4.6 <sup>c</sup>	4	1
		15	0.8	2	1
		30	0	0	0
	2	15	0.6	1	0
		30	0	0	0
		30	0	0	0
16	0	0	7.2 <sup>d</sup>	6	2
		15	2.5	2	0
		30	0	0	0
	2	15	1.9	2	0
		30	0	0	0
		30	0	0	0

<sup>a</sup> TIU/MG = Trypsin inhibitor per milligram sample, dry basis  
<sup>b</sup> Maximum dilution of 1:10 corn-soybean blend dispersion (dry basis) in 1% NaCl solution which still agglutinates red blood cells  
<sup>c</sup> Calculated value from raw material trypsin inhibitor contents = 5.4 TIU/MG  
<sup>d</sup> Calculated value from raw material trypsin inhibitor contents = 9.0 TIU/MG

# TORTILLAS FROM CORN-SOYBEAN MIXTURES...

The experimental data (Table 2) suggest that increasing lime concentration also accelerated heat inactivation of lectins, although the results are not so clear as those obtained with trypsin inhibitor. An interesting observation is that lectin agglutinating activity to human blood was much lower, and more rapidly destroyed, than to rabbit blood.

## Hot plate cooking study

Data obtained in the hot plate cooking study are reported in Table 4. Again, both trypsin inhibitor and lectin contents decreased with increasing cooking time. In this study, however, trypsin inhibitor was reduced to zero only in the case of the 8% soybean blend, and after cooking for 60 sec. Lectin agglutinating activity to human blood was reduced to zero only after heating for 30 sec in both cases (8% and 16% soybeans), but agglutinating activity to rabbit blood was never totally destroyed.

These results are interesting for a number of reasons. It is apparent that hot plate heat treatment was much more effective in destroying antinutritional factors than boiling in limewater. Comparing data in Tables 2 and 4, it may be seen that for both the 8% and 16% soybean blends, boiling in limewater for 15 min was approximately equivalent to heating in the hot plate for 45 sec, since trypsin inhibitor and lectins were reduced to roughly the same levels. This is probably because: (1) heat treatment in the hot plate occurred at a much higher temperature than in boiling limewater (200°C vs 100°C), and it is known that heat inactivation of antinutritional factors increases strongly with temperature (Del Valle, 1981); and (2) raw tortillas cooked on the hot plate had a much higher initial moisture content than raw whole corn-soybean blends boiled in limewater; it is also known that antinutritional factor heat inactivation rate increases with moisture content (Del Valle, 1981).

The data in Table 4 indicate that hot plate cooking alone would be insufficient to totally inactivate antinutritional factors contained in corn-soybean tortillas, since most tortilla-making processes employ hot plate contact times of the order of 45 sec. This situation, however, would not normally be encountered in practice since, due to previous heat treatment in boiling limewater, in no case would antinutritional factor inactivation depend solely upon hot plate heat treatment. Actually, hot plate heat treatment should be viewed as a safety factor since, as Table 4 shows, a total hot plate contact time of 45 sec would further lower residual trypsin inhibitor and lectins, remaining after cooking in limewater, by at least 75% and 50%, respectively.

Tortillas containing high proportions of soybeans obviously possessed higher levels of antinutritional factors (Table 4); as a result, total inactivation times for these factors would necessarily be higher than those required for tortillas containing lower soybean proportions. Also, as in the case of limewater cooking study (Table 2), human blood agglutinating activity of the lectins was lower, and was destroyed more rapidly, than that of rabbit blood.

## Two tortilla-making processes

Data obtained in the tortilla-making processes applying normal and minimum heat treatment are reported in Tables 5 and 6, respectively. As might have been expected, tortillas prepared with normal heat treatment were totally free from trypsin inhibitor and lectins. In the case of blends containing 8% soybeans, boiling in limewater was sufficient to destroy all trypsin inhibitor, all hemagglutinating activity to human blood, and most activity to rabbit blood. With 16% soybean blends, some trypsin inhibitor remained after cooking in limewater which was, however, removed by washing. Table 5 also shows that rabbit blood lectins remaining after cooking were similarly eliminated by washing. These observations are interesting because they show that some trypsin

Table 3—pH of washed and ground 92.8 corn-soybean blends after cooking in limewater for different times

Lime conc in limewater	pH of blend after cooking in limewater for	
	30 Min	60 Min
0%	6.5	6.5
2%	9.6	9.7
4%	10.0	10.1

Table 4—Effect of hot plate cooking on trypsin inhibitor and lectin contents of corn-soybean tortillas

Percent soya in blend	Cooking time sec. <sup>a</sup>	Trypsin inhibitor, TIU/MG <sup>b</sup>	Lectins <sup>c</sup> Type of Blood	
			Rabbit	Human
8	0	4.6	4	1
	15	2.7	3	0
	30	1.6	2	0
	45	0.9	2	0
	60	0	2	0
16	0	7.2	6	2
	15	5.2	4	1
	30	2.9	3	0
	45	2.0	3	0
	60	1.0	3	0

<sup>a</sup> Total cooking time, alternating sides, 15 seconds each side

<sup>b</sup> TIU/MG = Trypsin inhibitor units per milligram sample, dry basis

<sup>c</sup> Maximum dilution of 1:10 corn-soybean blend dispersion (dry basis) in 1% NaCl solution which still agglutinates red blood cells

inhibitor and lectins (although not in very large amounts) are probably leached out into the liquor during cooking, and are subsequently removed by washing. It might be noted that reductions in trypsin inhibitor and lectins after washing and grinding, as reported in Tables 5 and 6, have been attributed wholly to washing because it was found that dough temperature after grinding was too low (35°C) to assign any significant antinutritional factor reduction to grinding.

The process with minimum heat treatment (Table 6) showed totally different results. The procedure of heating limewater to boiling, turning off the heat, adding whole raw corn-soybean mixtures and letting them soak for 10 hr produced relatively little reduction of both antinutritional factors. This treatment — i.e., soaking for different periods of time in limewater initially at boiling temperature — is similar to that which would be encountered in processes with preliminary limewater cooking. It may be concluded that soaking in cooking liquor, per se, would probably be of limited effectiveness in reducing antinutritional factor activity in normal tortilla-making processes due, most probably, to the low heat applied, since liquor temperature begins to drop after the heat is turned off. It is conceivable that in some processes liquor temperature could drop at a slower rate than in normal ones, so that an important future experiment would be to measure rate of temperature drop of soaking liquor and correlate it with effectiveness in inactivation of antinutritional factors.

As in the process with normal heat treatment, washing and grinding produced a small reduction of both trypsin inhibitor and lectins remaining after soaking. With the exception of tortillas containing 8% soybeans, however, trypsin inhibitor remaining after washing and grinding could not be totally eliminated by hot plate cooking. Fortunately, the residual activity of this factor in fully cooked tortillas was too low to be of any significance (Liener, 1979).

Table 6 clearly shows that, for equal soybean levels, blends cooked in higher limewater concentration exhibited faster hot plate inactivation rates for trypsin inhibitor than

Table 5—  
inhibitor

Percent  
soya in  
blend

8

16

<sup>a</sup> Bler  
off.  
<sup>b</sup> TIU  
<sup>c</sup> Max  
basi  
<sup>d</sup> Tot

thos  
sam  
whi  
prot  
in v  
cou  
coo  
plat  
tort  
soy

EF  
anc  
lim  
sur

pla



Table 5—Effect of process with normal heat treatment on trypsin inhibitor and lectin contents of corn-soybean tortillas

Percent soya in blend	Percent lime in limewater <sup>a</sup>		Trypsin inhibitor, TIU/MG <sup>b</sup>	Lectins <sup>c</sup>	
				Type of Blood	
				Rabbit	Human
8	2	Raw blend	4.6	4	1
		After cooking and soaking <sup>a</sup>	0	1	0
		After washing and grinding	0	0	0
		After cooking on hot plate <sup>d</sup>			
		15 Sec	0	0	0
		30 Sec	0	0	0
		45 Sec	0	0	0
		60 Sec	0	0	0
	4	Raw blend	4.6	4	1
		After cooking and soaking <sup>a</sup>	0	0	0
		After washing and grinding	0	0	0
		After cooking on hot plate <sup>d</sup>			
		15 Sec	0	0	0
		30 Sec	0	0	0
		45 Sec	0	0	0
		60 Sec	0	0	0
16	2	Raw blend	7.2	6	2
		After cooking and soaking <sup>a</sup>	0.9	1	0
		After washing and grinding	0	1	0
		After cooking on hot plate <sup>d</sup>			
		15 Sec	0	0	0
		30 Sec	0	0	0
		45 Sec	0	0	0
		60 Sec	0	0	0
	4	Raw blend	7.2	6	2
		After cooking and soaking <sup>a</sup>	0.8	1	0
		After washing and grinding	0	0	0
		After cooking on hot plate <sup>d</sup>			
		15 Sec	0	0	0
		30 Sec	0	0	0
		45 Sec	0	0	0
		60 Sec	0	0	0

- <sup>a</sup> Blend was cooked for 30 min in boiling limewater, heat was turned off and blend was soaked in liquor for 10 hr  
<sup>b</sup> TIU/MG = Trypsin inhibitor units per milligram sample, dry basis  
<sup>c</sup> Maximum dilution of 1:10 corn-soybean blend dispersion (dry basis) in 1% NaCl solution which still agglutinates red blood cells  
<sup>d</sup> Total cooking time, alternating sides, 15 sec each side

those cooked in lower concentrations. This effect is the same as that observed in the limewater cooking experiments, which was previously explained as being due to additional protein denaturation by higher pH's. This was the only case in which effect of lime dose on hot plate heat treatment could be studied, since tortillas prepared directly from cooked corn-soybean mixtures were employed; in the hot plate cooking experiments previously discussed (Table 4), tortillas were prepared from industrial tortilla and raw soybean flours.

### SUMMARY & CONCLUSIONS

EFFECTS of processing parameters on trypsin inhibitor and lectin contents of corn-soybean tortillas prepared by lime cooking of whole raw corn-soybean mixtures may be summarized as follows.

- (1) Cooking time in boiling limewater and on the hot plate produces the largest reduction of both trypsin inhib-

Table 6—Effect of process with minimum heat treatment on trypsin inhibitor and lectin contents of corn-soybean tortillas

Percent soya in blend	Percent lime in limewater <sup>a</sup>		Trypsin inhibitor, TIU/MG <sup>b</sup>	Lectins <sup>c</sup>	
				Type of Blood	
				Rabbit	Human
8	2	Raw blend	4.6	4	1
		After soaking <sup>a</sup>	3.1	3	1
		After washing and grinding	2.4	2	0
		After cooking on hot plate <sup>d</sup>			
		15 Sec	2.1	1	0
		30 Sec	1.9	0	0
		45 Sec	1.2	0	0
		60 Sec	0.8	0	0
	4	Raw blend	4.6	4	1
		After soaking <sup>a</sup>	3.0	3	1
		After washing and grinding	2.5	2	0
		After cooking on hot plate <sup>d</sup>			
		15 Sec	1.4	1	0
		30 Sec	0.9	0	0
		45 Sec	0	0	0
		60 Sec	0	0	0
16	2	Raw blend	7.2	6	2
		After soaking <sup>a</sup>	6.4	4	2
		After washing and grinding	6.1	2	1
		After cooking on hot plate <sup>d</sup>			
		15 Sec	4.6	1	0
		30 Sec	3.1	0	0
		45 Sec	2.7	0	0
		60 Sec	2.2	0	0
	4	Raw blend	7.2	6	2
		After soaking <sup>a</sup>	6.9	2	0
		After washing and grinding	6.7	1	0
		After cooking on hot plate <sup>d</sup>			
		15 Sec	4.4	0	0
		30 Sec	2.6	0	0
		45 Sec	1.9	0	0
		60 Sec	1.3	0	0

- <sup>a</sup> Limewater was heated to boiling, heat was turned off, blend was added and soaked for 10 hr  
<sup>b</sup> TIU/MG = Trypsin inhibitor units per milligram sample, dry basis  
<sup>c</sup> Maximum dilution of 1:10 corn-soybean blend dispersion (dry basis) in 1% NaCl solution which still agglutinates red blood cells  
<sup>d</sup> Total cooking time, alternating sides, 15 sec each side

itor and lectins. Due to higher temperature and higher initial blend moisture content involved, hot plate cooking exhibits higher inactivation rate than limewater boiling. Total reduction of antinutritional factors is higher when boiling in limewater, however, due to considerably longer processing time employed as compared with hot plate cooking.

- (2) Trypsin inhibitor and lectin inactivation rates on boiling in limewater appear to increase with increasing lime concentration due, probably, to additional protein denaturation by higher pH's.

- (3) Soaking in cooking liquor after boiling in limewater and turning off the heat results in relatively little reduction of trypsin inhibitor and lectins, because temperature begins to drop after the heat has been turned off.

- (4) Some trypsin inhibitor and lectins appear to be leached out into the liquor during cooking and removed by subsequent washing. This effect, however, produces relatively little reduction of both antinutritional factors.

- (5) Grinding of cooked corn-soybean mixtures into a dough involves relatively low temperatures and produces very low temperature rise; consequently, this process prob-

—Continued on page 252

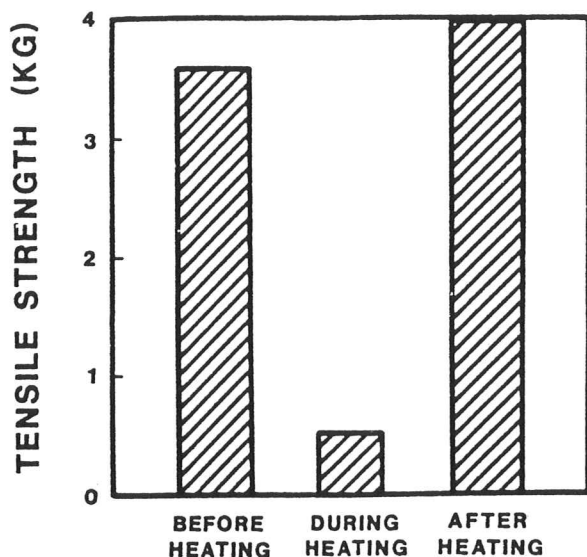


Fig. 3—Comparison of retort pouch seal strip tensile strength with respect to heat exposure.

### CONCLUSIONS

THE SEAL STRENGTH of retort pouches containing water was not affected by agitation and processing in 100% steam. Failures during testing were due to the material strength being lower than the seal strength. This indicated

that seals were sufficiently strong to withstand extreme stress situations. Further research is suggested using actual food products.

Thermal processing increased the tensile strength yet decreased the compression strength. This conflict of data demonstrates the necessity of using several tests when drawing conclusions on seal strength or pouch integrity.

### REFERENCES

- Beverly, R. 1979. Sterilization methodology applied to pouches and trays. Presentation for the symposium: "Using The Retort Pouch Worldwide: Focus On The Present With A Look To The Future." March 14-15, 1979. Purdue University Food Sciences Institute, p. 102.
- Corning, A.O. 1979. Sterilization methodology applied to pouches and trays. Presentation for the symposium: "Using The Retort Pouch Worldwide: Focus On The Present With A Look To The Future." March 14-15, 1979. Purdue University Food Sciences Institute, p. 92.
- Davis, E.G., Karel, M., and Proctor, B.E. 1960. The pressure-volume relation in film packages during heat processing. *Food Technol.* 14(1): 165.
- Lampi, R.A. 1977. Flexible packaging for thermoprocessed foods. *Adv. Food Res.* 23: 306.
- Pflug, I.J., Bock, J.H., and Long, F.E. 1963. Sterilization of food in flexible packages. *Food Technol.* 17(9): 87.
- Pflug, I.J. 1964. Evaluation of heating media for producing shelf stable food in flexible packages. Phase 1. Final Rep., contract DA19-AMC-145(N) U.S. Army Natick Laboratories, Natick, MA.
- Pflug, I.J. and Long, F.E. 1966. Static load tests evaluate flexible packaging materials at elevated temperatures. *Package Engineering* 11(5): 91.
- Roop, R.A. and Nelson, P.E. 1982. Processing retort pouches in conventional sterilizers. *J. Food Sci.* 47(1): 303.
- Rubinate, F.J. 1964. Army's obstacle course yields a new look in food packaging. *Food Technol.* 18(11): 71.
- Whitaker, W.C. 1971. Processing flexible pouches. *Modern Pkg.* 44(2): 83.
- Ms received 4/16/82; revised 10/12/82; accepted 10/15/82.

### TORTILLAS FROM CORN-SOYBEAN MIXTURES... From page 249

ably results in negligible change in trypsin inhibitor and lectins.

(6) In all experiments performed, lectin agglutinating activity to human blood was appreciably lower and more easily destroyed by heat treatment or increasing lime concentration, than to rabbit blood.

(7) Tortillas prepared by limewater cooking of whole raw corn-soybean mixtures by the traditional method would probably be free from trypsin inhibitor and lectins if normal heat treatment, resulting from employment of usual processing conditions (i.e., boiling in limewater for 30 min and cooking 45 sec on a hot plate, alternating sides, 15 sec each side) were applied. In this case most antinutritional factor activity would be destroyed by limewater cooking, with additional heat treatment applied on the hot plate serving as a safety factor. If, on the other hand, a heat treatment lower than normal were applied, tortillas with residual trypsin inhibitor, but no lectins, could result. Trypsin inhibitor level, however, would probably be too low to be of any significance.

It can be concluded that, because of the reduction of the concentration of trypsin inhibitor and lectins, corn-soybean tortillas prepared by the method described in this paper would probably be suitable for human consumption.

### REFERENCES

- AOAC. 1970. "Official Methods of Analysis," 11th ed. Association of Official Analytical Chemists, Washington, DC.

- Bressani, R., Murillo, B., and Elias, L.G. 1974. Whole soybeans as a means of increasing protein and calories in maize-based diets. *J. Food Sci.* 39: 577.
- Bressani, R., Braham, J.E., Elias, L.G., and Rubio, M. 1979. Further studies on the enrichment of lime-treated corn with whole soybeans. *J. Food Sci.* 44: 1707.
- Del Valle, F.R. and Perez-Villaseñor, J. 1974. Enrichment of tortillas with soy proteins by lime cooking of whole raw corn-soybean mixtures. *J. Food Sci.* 39: 244.
- Del Valle, F.R., Montemayor, E., and Bourges, H. 1976. Industrial Production of soy-enriched tortilla flour by lime cooking of whole raw corn-soybean mixtures. *J. Food Sci.* 41: 349.
- Del Valle, F.R. 1981. Nutritional quality of soya protein as affected by processing. *J. Am. Oil Chem. Soc.* 58(3): 419.
- Franz, K. 1975. Tortillas fortified with whole soybeans prepared by different methods. *J. Food Sci.* 40: 1275.
- Green, J.R., Lawhon, J.T., Cater, C.M., and Mattill, K.F. 1976. Protein fortification of tortillas with oilseed flour. *J. Food Sci.* 41: 656.
- Green, J.R., Lawhon, J.T., Cater, C.M., and Mattill, K.F. 1977. Utilization of undefatted glandless cottonseed kernels and soybeans to protein-fortify corn tortillas. *J. Food Sci.* 42: 790.
- Jaffé, G., Levy, A., and Gonzalez, D.I. 1974. Isolation and partial characterization of bean phytohemagglutinins. *Phytochemistry* 13: 2685.
- Kakade, M.L., Rackis, J.J., McGhee, J.L., and Poski, G. 1974. Determination of trypsin inhibitor activity of soy products: A collaborative analysis of an improved procedure. *Cereal Chem.* 51: 376.
- Liener, I. 1979. Significance for humans of biologically active factors in soybeans and other food legumes. *J. Am. Oil Chem. Soc.* 56(3): 121.
- Rackis, J.J. 1974. Biological and physiological factors in soybeans. *J. Am. Oil Chem. Soc.* 51(1): 161A.
- Smith, A.K. and Circle, S.J. 1978. "Soybeans: Chemistry and Technology, Vol. I, Proteins," Avi Publ. Co., Westport, CT.
- Ms received 3/3/82; revised 9/24/82; accepted 10/1/82.

The seeds contain 4% This oil gives propenoic fatty acid (GLC). The stearic (3) heat on C 180°C. Ma doration genation o results in C

BAOBAI the Mala are proce baobab t family) Bâthie an A. suare used for previous these see.

Cyclo (8,9-met methyle higher p and Bor and Fra ence of Thomas and Mor gation ( positive tic of t (1981). S logical d have so 1968; L oils. Pro from oi and Berr CPEFA, not give Hydrog ing both hydroge acids (C and brai

Authors Chimie d Centre d 4, France with the Etablisse ques, B.P