

## Effect of calcium addition and acidification on the quality characteristics of canned okra (*Hibiscus esculentus* L.)

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**SUMMARY:** A study was conducted on calcium chloride treatments of canned okra acidified by adding either acetic, citric, lactic, malic or tartaric acids or by lactic fermentation. The quality of the processed okra was determined by physical, chemical, microbiological and sensory analyses after a two month storage period at room temperature. The results indicated the possibility of processing high quality canned okra by small canneries, with low cost equipment and low energy requirements. The acidification procedures ensure minimal risk of botulism.

**RESUMEN:** Efecto de la adición de calcio y acidificación sobre la calidad de la oca o quimbombó (*Hibiscus esculentus* L.) procesados por calor. Fue conducido un estudio con la adición de cloruro de calcio a ocras acidificados con uno de los cinco ácidos orgánicos siguientes: acético, cítrico, láctico, málico tartárico o por fermentación láctica. La calidad de los productos procesados fue determinada por análisis físicos, químicos, microbiológicos y sensoriales, después de transcurrido dos meses de almacenamiento a temperatura ambiente. Los resultados indicaron la posibilidad de procesar ocras de mejor calidad en pequeñas industrias con reducción de costos en equipo y energía. Los procedimientos de acidificación aseguran un riesgo mínimo de ocasionar botulismo.

### INTRODUCTION

Most of vegetables are considered as low acid food (1) and should therefore be processed at high temperatures to avoid development of *Clostridium botulinum* (2, 3). In the United States the occurrence of botulism is frequently associated with the ingestion of home made preserves having a pH value above 4.6 (4, 5). In Brazil, Graner (6) called attention to the risk represented by the canning of home preserves using recipes that do not take into consideration the final pH of such products.

Vegetables have been generally processed by high energy using methods of freezing or conventional canning. Considering the expensive cost of energy and equipment, alternative methods must be sought to reduce cost and to maintain high safety standards from the microbiological point of view, significant nutritional quality and good texture, flavor and palatability (7).

The use of direct acidification or lactic fermentation to lower the pH value of vegetables below 4.6 seems to be an alternative technique to economize energy during processing and to furnish a product of adequate quality (8, 9).

Many vegetables cannot be canned because of their poor

texture after heat sterilization. Calcium has long been considered as an important agent to maintain the texture of fruits and vegetables, apparently though its interaction with cell wall pectic materials (10). For this reason, calcium has been used by several researchers on a variety of commodities to achieve firming or maintain firmness (9, 11, 12).

The purpose of this work was to evaluate the effect of calcium, direct acidification and fermentation and provide information, currently required, on the quality of canned okra processed in this ways at atmospheric pressure.

### MATERIAL AND METHODS

**Raw material.** Samples of okra (*Hibiscus esculentus* L., cultivar Santa Cruz) used in this study were commercially grown in Piracicaba county, State of S. Paulo, Brazil.

**Analyses of raw and/ or processed material.** a) Titrable acidity, drained weight and PH were performed by standard methods (13).

b) Total soluble solids were determined by direct reading with a hand refractometer,

c) Texture. Objective measurements were obtained on 100

TABLE 1  
Effect of acidification and calcium addition on the sensory characteristics of canned okra

Treatments	Average of evaluations (16 replications)				
	Color	Texture	Flavor	Overall Quality	
Control	8.00a	3.25d	3.31d	4.85e	
Citric acid	I	6.56abcd	5.68bc	6.62abc	6.20abcd
	II	6.50abcde	6.56abc	7.37ab	6.81abc
Tartaric acid	I	5.93cde	5.12c	5.06de	5.37de
	II	6.93abcd	5.25c	5.68bc	5.95bcde
Lactic acid	I	7.31abc	6.12abc	7.06ab	6.83abc
	II	6.12bcde	6.12abc	6.68abc	6.18abcd
Acetic acid	I	5.68de	7.50a	8.00a	7.06ab
	II	6.43abcde	7.25ab	8.12a	7.27a
Malic acid	I	4.93e	5.37c	6.43abc	5.58cde
	II	5.43de	5.87abc	6.62abc	5.97bcde
Fermentation	I	6.18bcde	6.75abc	5.68bc	6.20abcd
	II	7.56ab	6.81abc	5.81bc	6.72abc

I=Without calcium; II=With calcium. Number followed by the same letters are not significantly different at the 5% level.

grams of drained processed okra using a Food Technology Corporation shearpress model TP-2, with register TR-1 fitted with a TG-1A-3000 electronic texture gauge and a CS standard cell. Ram descending rate was 20 cm/min. The same procedure was used for the unprocessed okra.

d) Sensory evaluations. Color, texture, and flavor were evaluated by eight trained panelists on a 1 to 9 points hedonic scale, according to Larmond (14). The panels were conducted in a room equipped with individual booths, water and indoor red and fluorescent lighting. The red lighting was utilized for evaluation of texture and flavor. Each panelist was presented with an individual sample (50 g) portioned into white cups coded with random numbers. Objective texture and sensory attributes were evaluated in comparison with a no acidified control with no calcium added prepared at the same time as the samples were evaluated, following the procedures

described before for processing the acidified products. The overall quality attribute was obtained by taking the average of the sum of color, texture and flavor given to each sample.

e) Microbiological analyses were performed using two cans of each treatment and tested for commercial sterility according to Corlett and Denny (15). Results were reported in terms of presence (+) or absence (-) of biological activity.

f) Vacuum was determined, as inches Hg, by piercing the cans with a Marshalltown vacuum gauge.

g) Statistical analyses. The experiment was designed as a factorial with six treatments (five organic acids and fermentation), two levels of firmness (with and without calcium) and two replications. All analyses were conducted in duplicate and data analyzed by the analysis of variance using a randomized complete block design (16).

**Processing.** The okra was washed, the ends trimmed, sliced in two parts and blanched in boiling water (97°C) for 5 minutes and immediately cooled in tap water. After cooling the material was divided in two lots.

The first lot was acidified by adding the correct amount of either acetic, citric, lactic, malic or tartaric acid to the canning brine to reach a 4.3 equilibrium pH in the final products, as determined by acidification curves (17), previously obtained for each acid. Before filling, half of this lot was treated by immersing into a 0.5% calcium chloride solution at 50°C for ten minutes.

Okra was filled to a weight of 200 g of pieces into 74.6 x 95.2 mm epoxy lacquered cans and 156 ml of 1.5% NaCl solution were added.

The other lot was fermented at 35°C by adding 1g of a commercial starter (*Lactobacillus delbrueckii subsp. bulgaricus* and *Lactococcus lactis*, 1:1) to 10 L of a 1.5% NaCl solution, until a 4.3 pH was reached. The vegetable was filled into cans as described before, using the fermented brine solution. Half of this lot was also treated with calcium by adding 0.2% (w/v) of calcium chloride to the fermented canning solution.

All the filled cans were exhausted at 85°C (can center temperature), sealed and processed for 30 minutes in boiling water and cooled in cold water bath.

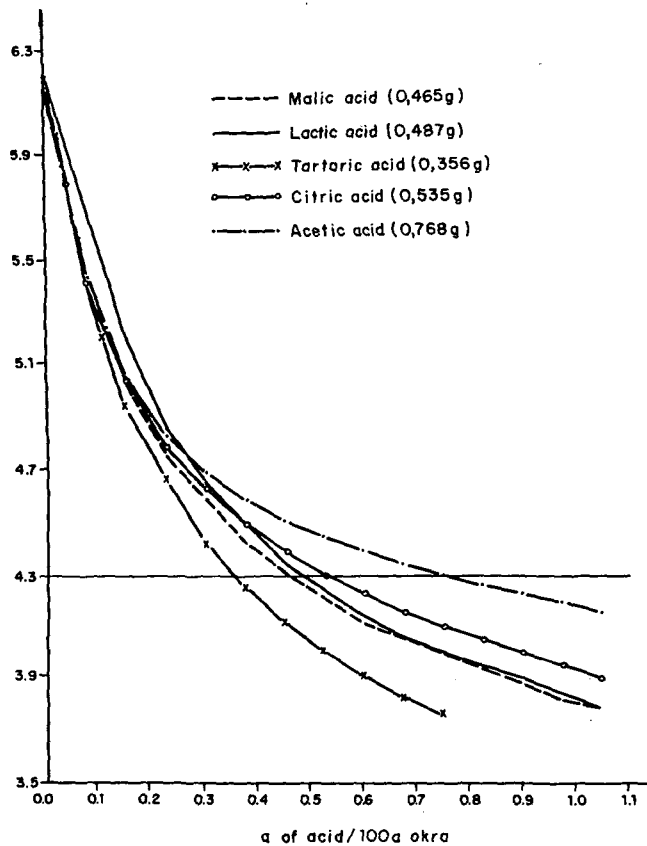
TABLE 2  
Chemical and physical analyses of canned okra

Analyses	Treatments												
	Control	Citric		Tartaric		Lactic		Acetic		Malic		Fermentation	
		I	II	I	II	I	II	I	II	I	II	I	II
Drained weight(g)	220,0	239,8	236,7	227,8	237,7	223,8	233,0	227,3	214,6	227,8	239,7	220,0	231,6
Vacuum (in.Hg)	16,5	16,0	14,0	15,5	16,0	16,0	15,0	12,0	14,5	15,0	14,0	18,5	20,0
Soluble solids (% w/w)	3,8	4,0	4,0	3,7	4,0	4,2	4,3	4,1	4,0	3,7	3,8	3,2	3,0
Equilibrium pH	5,8	4,0	4,1	4,0	4,2	4,0	4,1	4,3	4,2	4,0	4,1	4,1	4,3
Total acidity (% w/w)	0,05	0,4	0,4	0,3	0,3	0,4	0,4	0,5	0,5	0,3	0,3	0,3	0,2

I=Without calcium; II=With calcium. All values not exceeding a  $\pm 5\%$  deviation according to the technique used.

FIGURE 1

Acidification curves of okra with five organic acids to pH 4.3



After a two month storage at room temperature of 25 to 31° C, the final products were completely evaluated.

## RESULTS AND DISCUSSION

Chemical and physical characterization of the unprocessed okra presented the following data: Total soluble solids  $8.6 \pm 0.2\%$  pH  $6.2 \pm 0.2$  and texture  $11.6 \pm 0.3$  Lbf/g, as a average of six samples.

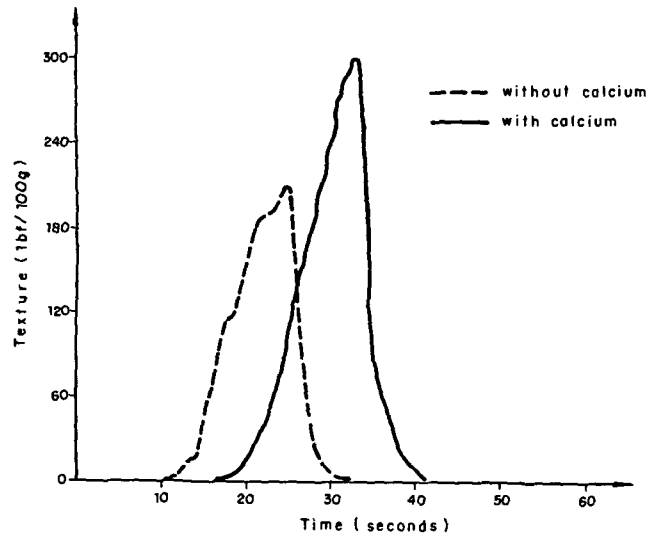
The acidification curves used to determine the amounts of acid needed to acidify okra, from a pH of 6.2 to pH 4.3 indicated that this varied according to the acid used, following the decreasing order: acetic, citric, lactic, malic and tartaric acid (Figura. 1). Such variation was probably due to the buffering capacity of okra and the acid dissociation constant (18).

In general, the acidification procedures impaired color of processed okra. The best treatments for said sensory attribute were lactic fermentation with calcium added and direct lactic acidification with no calcium added (Table 1). This fact suggests that the lactate ion could attenuate the overall negative effect of acidification. The better color acceptability presented by the fermented product is in accordance with the findings of Kotzekidou and Roukas (8).

Texture was greatly improved either by direct acidification or by fermentation, specially for okra treated with acetic acid.

FIGURE 2

Typical shearpress curves of acidified (acetic acid) canned okra



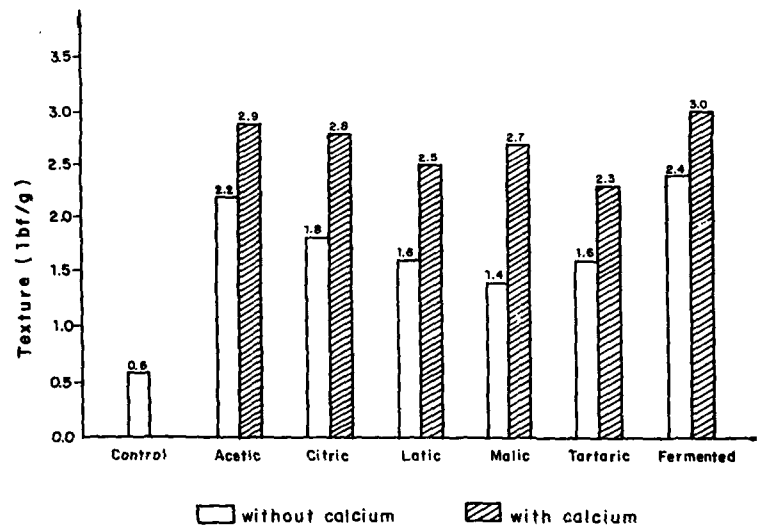
There were no great differences between okra treated with or without calcium (Table 1). However, according to shear force values (Figura 2) okra treated with calcium presented firmer texture. The most efficient acid-calcium interaction was found to be that with malic acid, presenting a 92.8% increase of shear force value, as previously reported for acidified canned carrots (19).

It was also noted a change in the shape of shearpress curves of acetic acid treated products when the compression force was reduced by calcium addition (Figura 3), resulting into a possible increase of firmness sensation in the mouth of the panelists.

Flavor was significantly enhanced by all of the acidification treatments (Table 1). The sensory analyses indicated that

FIGURE 3

Effect of acidification and addition of calcium on texture of canned okra ( Shearress values)



panelists preferred acetic acid, followed by lactic, citric, malic, fermentation, tartaric and control. Calcium seemed not to effect this sensory attribute at all. However, since it was beneficial to color and texture, such addition is recommended, specially, in association with acetic acid.

The sensory panel found acetic acid treated okra the most acceptable in terms of overall quality (Table 1). This fact could be better understood if the wide spread brazilian habit of seasoning with vinegar many foods (salads, sauces, barbecues, etc.) is to be taken into consideration.

In general, the chemical and physical analyses revealed some minor influences of the treatments (Table 2). Drained weight presented an average increase of 15%. This fact is probably accounted to less leaching of solids during the thermal treatment which permitted okra to absorb more water. Soluble solids decreased in the processed okra, possibly due to the higher absorption of water by relative increasing of okra solids, as pointed before.

Total acidity was higher for okra treated with acetic acid, followed by lactic, citric, malic, tartaric and fermentation. This increasing is in opposition to the findings of Kotsekidou and Roukas (8) that reported a decreasing as a result of slight detinning of cans originating free ions and production of salts. Detinning of cans was not detected in the present work.

The equilibrium pH slightly decreased in the final products. This fact could have resulted from a variation of okra buffering capacity caused by heating and storage. Vacuum values were considered as adequate and no paneling of cans was observed.

Microbial analyses showed no biological activities in any of final products after a two month storage.

In conclusion, acidification yielded desirable organoleptic qualities besides requiring less energy input and lower cost compared with conventional retorting procedure for low-acid foods. The procedures resulted in a non-favorable environment for the occurrence of botulism.

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