Firmness and Cell Wall Characteristics of Pasteurized Jalapeño Pepper Rings as Affected by Calcium Chloride and Rotary Processing

Y.S. Gu, L. R. Howard, and A. B. Wagner

ABSTRACT

Rotary processing resulted in more uniform heat penetration and texture retention throughout the container than after nonagitated processing. Localized softening in nonagitated peppers was due to prolonged heating at the top of the container, which hydrolyzed large molecular weight pectic substances (chelator and nonextractable) to more soluble forms. Calcium improved the texture by maintaining greater levels of insoluble pectic substances (chelator, dilute alkali and nonextractable) and reducing pectin solubilization. The combination of rotary processing and calcium chloride treatment resulted in a product with fresh-like, uniform texture throughout the container.

Key Words: Jalapeño pepper, firmness, calcium chloride, rotary processing, pectic substances

INTRODUCTION

LOW ACID VEGETABLES PROCESSED IN STILL RETORTS ARE TYPICALLY overheated due to slow heat transfer throughout the product. This excessive heating results in loss of color, texture and nutrient content (Abou-Fadel and Miller, 1983; Rao et al., 1985; Anantheswaran et al., 1986). Softening during processing is largely due to turgor loss and solubilization of pectic substances in the cell wall middle lamella (Van Buren, 1979). Such changes ultimately result in cell separation and collapse of cell structure.

Rotary processing, which entails end-over-end agitation, improves heat penetration and shortens processing time of canned food. Several studies have investigated effects of rotary processing on quality retention of low acid foods. Rotary processing prevented carotene isomerization in sweet potatoes (Lee and Ammerman, 1974) and improved color retention in green beans (Steele, 1987). Texture of potatoes, carrots and green beans was improved by rotary processing, but color was unaffected relative to nonagitated processing (Abbatemarco and Ramaswamy, 1994). Improved texture was attributed to faster heat penetration and reduced processing time. Rotary processing has not been reported to pasteurize acidified foods.

Jalapeño pepper rings processed in high acid, salt brines soften during pasteurization and storage, due to acid hydrolysis of pectic substances (Howard et al., 1994). Softening occurs at the top of the container, while firmness retention is best at the bottom. This texture gradient may be due to convection heating, whereby heat rises to the top of the container. Rotary processing, with end-over-end agitation may improve uniformity of heat penetration and prevent excessive softening at the top.

Our objective was to determine if rotary processing and CaCl₂ could prevent localized softening of jalapeño pepper rings. Heat penetration, firmness and cell wall characteristics were measured in peppers processed using both static and rotary methods.

MATERIALS & METHODS

Processing and storage

Fresh jalapeño peppers (cv Mitla) were obtained from a local supermarket. Diseased and decayed fruit were removed, and peppers were washed thoroughly with chlorinated water (100 ppm). Pepper rings (10 mm thickness) were packed in #303 cans in three positions, top, middle and bottom (63-67g in each position). Rings were separated in the cans using wire mesh screens. The pack out ratio was 40% pepper rings and 60% brine. Brine treatments provided 3.2% NaCl, 0.8% acetic acid and 0 and 0.08% CaCl₂ in the final product. Cans were processed in water at 75°C for 5 min in static or agitated (19 rpm) modes in a Stock Rotomat Model PR-900-G retort (Stock America, Milwaukee, WI). Sampling was conducted 0 (fresh pepper) and 1 wk after processing.

Heat penetration

Heat penetration in the top, middle and bottom of each can was recorded every 30 sec. using Ecklund-Harrison screw-type thermocouples (3.81 cm long), CALPlex data logger and CALSoft thermal processing software (TechniCAL, Inc., New Orleans, LA). Three thermocouples were attached to each container in each position (top, middle and bottom). Processing time commenced when the slowest heating thermocouple at the bottom of the container reached 75.0°C. Peppers were held at processing temperature (75°C) for 5 min, and then cooled to room temperature.

Firmness

Firmness of samples was determined using a Model TP-6 texture press and Model TR-5 texture recorder (Food Technology Corp., Rockville, MD). The instrument was operated with a full scale deflection force of 453.6 kg. Pepper rings (75g) were placed in a Model CS-1 standard shear compression cell, and peak height of the force required to shear the sample was recorded. Firmness was expressed as newtons (N) of force required to shear the sample.

Cell wall extraction

Mesocarp tissue (50g) was dissected from pepper rings, blended with 5 volumes of 95% ethanol (v/v) by a tissuemizer (Tekmar Co., Cincinnati, OH) and filtered through Miracloth (CalBiochem, La Jolla, CA). The residue was twice resuspended in 95% ethanol, blended and filtered. The final alcohol insoluble solids (AIS) were dried under vacuum at 50°C, and ground to a fine powder using a commercial coffee grinder.

Pectic substances

Pectic substances were fractionated by sequentially extracting AIS (50 mg) three times with deionized water (WSP), followed by extraction three times with 0.5% disodium ethylenediamine-tetraacetate (CSP), and finally three times with 0.05N NaOH (OHSP). Each extraction
was conducted with 25mL solvent while mixing in stoppered funnels for 30 min at 22±2°C. After each extraction sequence, the solution was drained through Whatman 541 ashless filter paper, and the residue was resuspended in the next solvent. The WSP and CSP fractions were adjusted to contain 0.05N NaOH to allow uniform saponification. Aliquots of each fraction (1 mL) were assayed for uronic acid content by the m-hydroxydiphenol method of Kinter and Van Buren (1982).

Total pectins were extracted by the method of Ahmed and Lahavitch (1977). Aliquots from each sample (1 mL) were assayed for uronic acids by the m-hydroxydiphenol method of Kinter and Van Buren (1982). The difference between the total pectins and sum of WSP, CSP and OHSP was used to determine the amount of nonextractable pectins (NXP).

Statistical analysis
All assays/measurements except texture were analyzed with 3 replications per treatment using analysis of variance (P<0.05). Five replications were used for texture measurements. Means were compared using Duncan’s multiple range test (SAS Institute, Inc., 1985).

RESULTS & DISCUSSION

HEAT PENETRATION PROFILES FOR JALAPEÑO PEPPER RINGS processed in static and agitated modes were compared (Fig 1). Pepper rings processed in a static mode exhibited different heat profiles throughout the container. The top of the container came up to pasteurization temperature much faster, and cooled much slower than the middle and bottom. These profiles were consistent with convection heating. The cold spot for cans, which heat primarily by convection, was 4.5 cm above the bottom on the longitudinal axis of the can. These differences in heat penetration were consistent with pepper rings at the top of the container having the softest texture and rings at the bottom having the most firm texture (Fig. 2). Abbatemarco and Ramaswamy (1994) reported that softening occurred in canned vegetables when they were processed in a static mode.

In contrast, pepper rings processed in an agitated mode (19 rpm) exhibited uniform heat penetration throughout the container (Fig. 1). After 2.5 min, there were no differences in heat penetration between the three locations, they heated and cooled uniformly. Rings processed in an agitated mode also came up to pasteurization temperature (76.7°C) much faster (6 min) than rings processed in a static mode (10 min). This difference could result in substantial energy savings for commercial processors. Uniform heat penetration resulted in uniform texture throughout the container (Fig. 2), indicating that convection heating was responsible for localized softening in nonagitated processed rings. End-over-end rotation induces product agitation due to rapid migration of the headspace bubble through the container. Clifcorn et al. (1950) reported that end-over-end rotation increased heat transfer in canned foods. Price and Bhowmik (1994) found that high rotational speed and horizontally positioned cans during agitation yielded higher heat transfer coefficients.

Firmness of pepper rings was affected by calcium and location in the can (Table 1). Firmness of pepper rings increased from the top to the bottom of the container in both calcium and noncalcium treated samples without agitation (Fig. 2). However, calcium treated rings had firmer texture than noncalcium treated rings at all three locations. Calcium treatment has been used to firm many acidified foods including cucumber pickles (Tang and McFeeters, 1983; Hudson and Buescher, 1985), and jalapeño peppers (Saldana and Meyer, 1981; Fleming et al., 1993; Howard et al., 1994), due to its ability to bind with demethylated polyuronides (Grant et al., 1973). Agitation without calcium treatment did not result in firmer texture of pepper rings, but resulted in uniform texture throughout the container (Fig. 2). Extensive softening occurred in peppers located at the top of the container.

![Fig. 1—Heat penetration profiles of pasteurized jalapeño pepper rings as affected by static (A) and rotary (B) processing.](image1)

![Fig. 2—Firmness of jalapeno pepper rings after one week storage, as affected by calcium chloride (CaCl₂) without agitation (A) and rotary processing without CaCl₂ (B).](image2)
Characteristics of Pasteurized Jalapeño Pepper Rings

Table 1—Analysis of variance for effects of calcium chloride, agitation and location on firmness and solubility characteristics of pectic substances in pasteurized jalapeño pepper rings

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Calcium</th>
<th>Agitation</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firmness</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>WSP</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>CSP</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>OHSP</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>NXP</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

When processed in a static mode. More uniform texture in the agitated process was the result of more uniform heat penetration throughout the product (Fig. 1). Rotary processing improved the texture of canned potatoes, carrots and beans due to more rapid, uniform heat penetration (Abbatemarco and Ramaswamy, 1994), and canned Romano beans had more uniform texture when they were processed in an agitated mode (Taherian and Ramaswamy, 1996).

Levels of WSP were affected by calcium treatment, but not by agitation or location (Table 1). WSP are highly methylated, low molecular weight pectic substances. Calcium treated rings had much lower levels of WSP, and higher levels of OHSP and NXP (Fig. 3) than non-calcium treated rings, indicating that calcium treatment prevented pectin depolymerization and solubilization. These findings confirmed other results in which we observed that a 4% acetic acid brine treatment in combination with pasteurization resulted in degradation of large molecular weight CDTA and Na₂CO₃ fractions, and increased solubilization of polyuronide in the PAW fraction (<10 kD, unpublished data). Treatment with CaCl₂ resulted in greater maintenance of large molecular weight polymers in CDTA and Na₂CO₃ fractions, which prevented polyuronide solubilization. Increased levels of WSP were associated with acid/heat catalyzed softening of pasteurized jalapeño pepper rings (Howard et al., 1994). Elevated levels of WSP were also associated with softening of fermented cucumber pickles (Hudson and Buescher, 1985). Calcium treatment reduced levels of WSP in fresh pack cucumber pickles and jalapeño peppers compared with non-calcium treated samples (Howard and Buescher, 1990; Howard et al., 1994).

Levels of CSP were affected by calcium, agitation, location, calcium * location and agitation * location (Table 1, Fig. 4, 5). CSP are pectic substances linked together by ionic bonds. Calcium treatment resulted in greater amounts of CSP, which was consistent with calcium crosslinking demethylated polyuronides in the cell wall (Grant et al., 1973). Formation of calcium pectates retarded softening of pasteurized jalapeño pepper rings (Howard et al., 1994), fresh pack cucumber pickles (Howard and Buescher, 1990) and frozen cherries (Alonso et al., 1995). In rings processed in a static mode, an increasing gradient of CSP was observed from the bottom to the top of the container (Fig. 4). Rings from the bottom had the highest texture values and highest CSP, and those from the top had the softest texture and lowest CSP. Prolonged heating at the top may have disrupted ionic linkages between pectic substances, resulting in pectin solubilization and softening. In CaCl₂ treated samples, CSP levels were also affected by location. Rings from the bottom and top of the container had the highest CSP, and rings from the middle had the lowest levels.

Pepper rings processed in an agitated mode had higher levels of CSP than those processed in a static mode (Fig. 5). Greater levels of CSP in agitated rings may be due to more uniform heat penetration and shorter processing time, or greater incorporation of Ca⁺⁺ ions into the cell wall-middle lamella complex. Maintenance of CSP by the calcium treatment and/or agitated process protected against softening.

Calcium affected levels of OHSP (Table 1, Fig. 3). OHSP are highly methylated, large molecular weight pectic substances. Calcium treated rings had higher levels of OHSP than non-calcium treated rings, and may have contributed to greater firmness retention in calcium treated rings. Greater maintenance of OHSP protected against softening of fermented cucumber pickles (Hudson and Buescher, 1985). Acetic acid brine concentrations >1.5% resulted in erosion of OHSP and CSP to WSP in pasteurized jalapeño pepper rings, resulting in softening (Howard et al., 1994).

Nonextractable pectic substances (NXP) are those that resist extraction with water (WSP), EDTA (CSP), and dilute alkali (OHSP). They were determined by the difference between total pectins (determined using acid digestion) and the sum of WSP, CSP and OHSP. NXP are large molecular weight, demethylated pectic substances that may only be solubilized using strong acids or polygalacturonase (Howard and Buescher, 1990). NXP levels were affected by calcium and agitation (Table 1, Fig. 3 and 6). Pepper rings treated with calcium had higher levels of NXP than non-calcium treated rings (Fig. 3). Greater maintenance of NXP in fermented cucumber pickles was important to prevent softening (Hudson and Buescher, 1985).

![Fig. 3—Levels of water soluble (WSP), alkali soluble (OHSP) and non-extractable pectic substances (NXP) in jalapeño pepper rings after one week storage, as affected by calcium chloride.](image)

![Fig. 4—Levels of chelator soluble (CSP) pectic substances in jalapeño pepper rings after 1 wk storage, as affected by calcium chloride and location in the can.](image)
Fig. 5—Levels of chelator soluble and non-extractable pectic substances in jalapeño pepper rings after 1 wk storage, as affected by rotary processing.

CONCLUSIONS

ROTARY PROCESSING RESULTED IN MORE UNIFORM HEAT PENETRATION and better texture retention throughout the container. Localized softening in nonagitated peppers was due to prolonged heating at the top of the container, which caused hydrolysis of large molecular weight pectic substances (CSP and NXP) to more soluble forms. Calcium improved texture by maintaining greater levels of insoluble pectic substances (CSP, OHSP and NXP) and reducing pectin solubilization. The combination of agitated processing and CaCl₂ treatment resulted in a product with fresh-like, uniform texture throughout the container.

REFERENCES

Steele, R.J. 1987. Effect of can rotation during retorting on retention of color in canned green beans. CSIRO Food Res. Quart. 47: 25-29.

Ms received 8/26/98; revised 12/14/98; accepted 1/14/99.