

# Shelf Life Evaluation of Bartlett Pears in Retort Pouches

R.A. KLUTER, D.T. NATTRESS, C.P. DUNNE, and R.D. POPPER

## ABSTRACT

Retort pouch pears in syrup were developed for a military ration. Processing variables were: syrup pH (4.0 and 3.5) and processing temperature (88°C and 96°C). Periodic sensory and biochemical/instrumental analyses were conducted during storage at 4, 21 and 38°C. pH had the most effect on quality measures. Bivariate correlations from Partial Least Squares (PLS) analysis indicated high positive relationships between the first PLS factor and sensory and analytical determinations: color quality, overall quality, pear flavor intensity, Hunter L, ascorbic acid and sucrose. Pears at pH 4.0, processed at either temperature, met minimum military shelf life requirements at 21° or 38°C.

Key Words: pears, retort pouches, shelf life, sensory, instrumental analyses

## INTRODUCTION

PROTOTYPE RETORT POUCH PEARS IN SYRUP received higher acceptance ratings in a prolonged use field ration study with Army troops and had higher consumption rates than freeze-dried pears (Popper et al., 1987). The freeze-dried pears were a component of existing Meal, Ready-to-Eat ration menus; wet pack pears had been substituted in the same menus. Although prototypes performed well, further refinement of procedures for packing pears in retort pouches and storage stability evaluations were needed. There are few reports on effects of processing variables on sensory properties and consumer preferences for canned pears and none on pears in retort pouches.

Procedures for processing canned pears are well established (Woodruff and Luh, 1986). Typically, Bartlett pears are harvested at full size in hard, green condition, shipped in bins to the cannery and held under controlled temperature, ripened at elevated temperature or with ethylene gas to a penetrometer test of 0.9–1.35 kg. They are then size graded, mechanically or lye peeled, washed, halved and cored, sorted, filled into cans, syruped, steam exhausted, closed, processed at atmospheric pressure and cooled. Previous research has considered several quality factors: pre- and post-harvest maturation, pectin chemistry and calcium and magnesium content (Esau et al., 1962); instrumental texture profiling of ripening pears, relating readings of the Magnuson-Taylor pressure tester with the General Foods Texturometer and Instron (Bourne, 1968); polyphenol oxidase (Tate et al., 1964); and various methods of recovering pear aroma essence during processing for adback (Heinz et al., 1964).

To determine consumer preferences, Pangborn (1958), using pears harvested from two California growing regions, studied effects of five sucrose syrup levels, ranging from 30 to 70° Brix, and inherent total acid levels on consumer ratings of the canned products. Consumer responses were segmented according to other characteristics on questionnaires. Based upon final brix:total acid ratios, consumers found pears most acceptable at 138–171. Pears at a low acid level ( $\approx 0.135\%$ ) were liked best at cutout brix levels of 18.5 or 22.6° (heavy syrup) which represented original levels of 30 and 40° Brix, respectively. At a total acid of  $\approx 0.160\%$ , the highest found, pears were liked best at a final brix of 22.8° (40° Brix originally). No data were available on

effects of pH adjustment or processing times/temperatures on pear shelf life.

Critical parameters for processing Bartlett pears in retort pouches were identified through consultations with other researchers and fruit processors with retort pouch packing capability in California and Oregon. Recommendations were that (1) using individual quick frozen (IQF) pears as source material would be infeasible due to texture breakdown; (2) syrup acidification to  $\geq$  pH 3.5 would be potentially beneficial to color and flavor retention.

Our objectives were to: (1) investigate effects of two pH levels and two processing temperatures on quality and acceptability of Bartlett pears packed in retort pouches, and (2) determine the effects of these conditions on shelf life. Minimum military shelf life requirement was that products be acceptable after 36 mo at 21°C and 6 mo at 38°C.

## MATERIALS & METHODS

BARTLETT PEARS (1987 harvest) were processed on a retort pouch line at J.R. Wood, Inc. (Sanger, CA). Two processing temperatures and two pH levels were the main variables. To select two processing temperatures, pilot studies were conducted at various temperatures with 141.8g retort pouches. The two temperatures selected were sufficient, with a 3–4 min hold time, to inactivate enzymes. One temperature, 88°C was considered optimal for the product and the other, 96°C, excessive but typical of commercial practice. Target pH levels were: 4.0, the approximate unadjusted pH of ripened fruit; and 3.5, obtained by adding 0.5% citric acid and 0.25% sodium citrate buffer (Pfizer, 1983) to the packing medium, a 66° Brix sucrose syrup. Measured pH levels 3 mo after processing and thereafter were close to target levels: fruit/syrup homogenates of target pH 4.0 fruit averaged 4.07 ( $R=3.73-4.23$ ); target pH 3.5 fruit, 3.42 ( $R=3.15-3.67$ ). This indicates that excellent pH control was achieved, in contrast to a study of retort pouch peaches, in which a buffer was not used (Kluter et al., 1994).

### Processing procedures

Pears were conditioned in a ripening room to a penetrometer reading of 2.3 to 3.6 kg, (McCormick fruit pressure tester, Model FT011 with a 0.8 cm diameter plunger). As an additional ripeness indicator, fruit glucose was measured, using an enzymatic analysis method. The processing sequence outlined previously was followed with a modification that peeled and halved fruit was sliced into an ascorbate dip  $\approx 10\times$  the desired end residual to inhibit browning. Targeted end product ascorbate level was 200–800 ppm (Anonymous, 1992). Slices were filled to maximum volume into preformed retort pouches. Sufficient ( $\approx 30$  mL) 60° Brix (heavy) sucrose syrup was added to achieve a cutout after equilibration of 18–22° Brix. A high Brix syrup was used to minimize osmotic shock to pear cellular structures during processing. Pouches were then steam swept and sealed, processed 3–4 min at each temperature and cooled by water sprays to  $<38^\circ\text{C}$ .

Polyphenoloxidase was analyzed, in plant, before and after heat processing, as a measure of process effectiveness. A continuous kinetic spectrophotometric procedure, a modification of the method by Gorin and Heidema (1976), was used. To minimize interference with the assay, residual levels of ascorbate were removed with immobilized ascorbate oxidase (Boehringer Mannheim Catalog No. 736619 - Ascorbate oxidase spatula). Prior to biochemical and sensory analyses, pouched product aerobic plate, mold and yeast counts were done. These indicated commercial sterility at both pH and process temperature levels.

Target minimum drained weight (Anonymous, 1992) was 100g. Drained weights were determined initially and after various times during 21°C storage on pouches other than those used for analytical studies.

Authors Kluter, Nattress, and Dunne are with the U.S. Army RD & E Center, Sustainment Directorate, Natick, MA 01760-5018. Author Popper is affiliated with Ocean Spray Cranberries, Inc., Lakeville/Middleboro, MA.

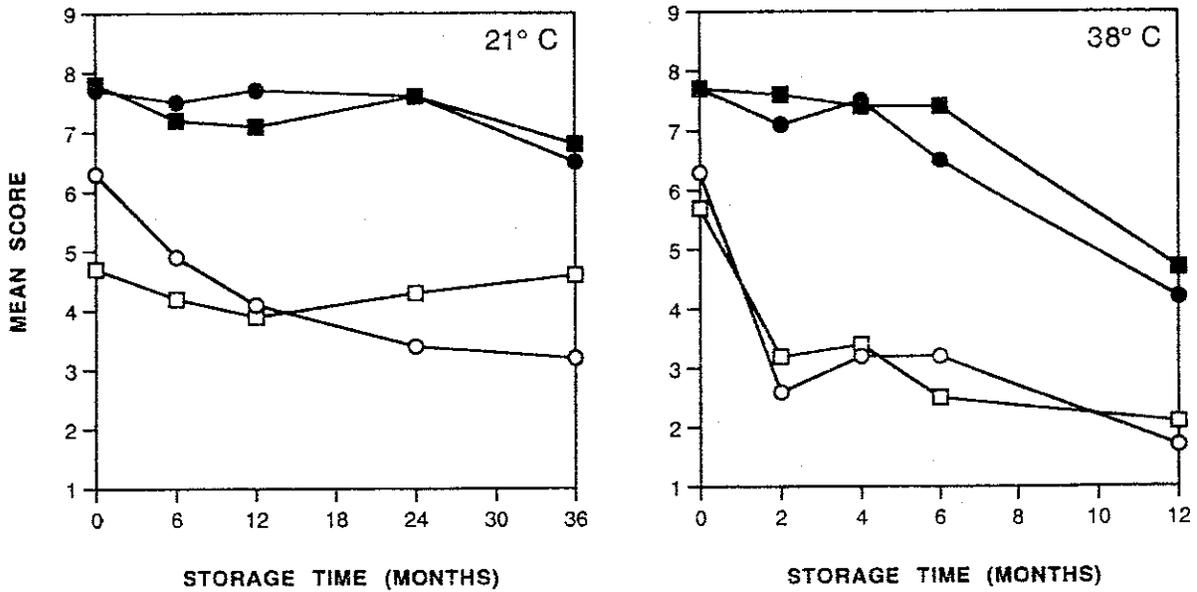


Fig. 1—Relationship of storage time and temperature to sensory color of pear slices. Optimum process: pH 4.0 ■, pH 3.5 □; Excessive process: pH 4.0 ●, pH 3.5 ○.

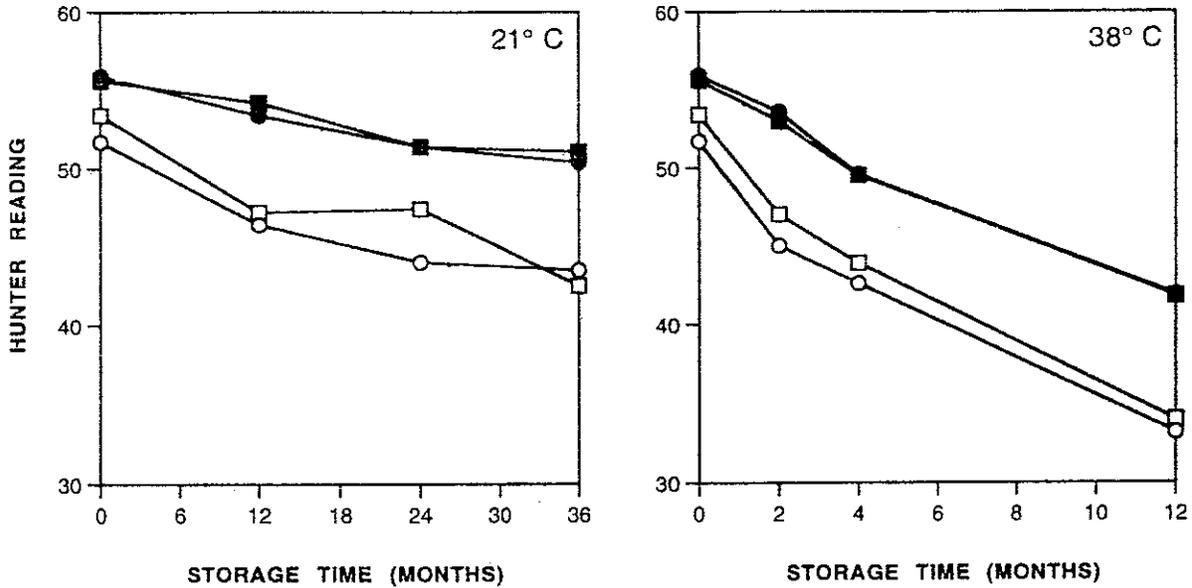


Fig. 2—Relationship of storage time and temperature to Hunter L values of fruit/syrup homogenates. Optimum process: pH 4.0 ■, pH 3.5 □; Excessive process: pH 4.0 ●, pH 3.5 ○.

Overall, drained weights were higher than target: 17 pouches from the pH 4.0/optimum process treatment averaged 102g (R=88–115g); 8 pouches from the pH 4.0/excessive process treatment averaged 102g (R=91–113); 10 pouches from the pH 3.5/optimum process averaged 102g (R=91–113g); and 8 pouches from pH 3.5 averaged 108g (R=84–124g). Variations in net weight were within limits of the check weigher in place after pouch filling and averaged 142g, slightly higher than the 128g requirement. Pouches with excess (>10 cc target) headspace were rejected before retorting using a flotation test.

Following processing, pouches were held at room temperature ( $\approx 3$  mo @  $\approx 23^\circ\text{C}$ ) until Brix and pH analyses indicated both syrup and fruit had reached equilibrium. Product was then moved into controlled temperature storage (4, 21, and  $38^\circ\text{C}$  chambers) and the prestorage (initial) sensory and biochemical analyses conducted. The  $4^\circ\text{C}$  storage temperature served as a reference condition.

#### Sensory analyses

For sensory analyses, two types of panels were used. The first panel consisted of food technologists who had demonstrated odor and taste acuity and had judged attributes of a wide variety of military rations. Purpose of this panel was to acquire sensory attribute data that might relate to biochemical/instrumental measurements. Five attributes were evaluated: color, sweetness, sourness, pear flavor and texture. Color was rated with reference to the USDA Grade A description for canned pears (The Almanac, 1987). A scale of quality (extremely poor = 1 to fair = 5 to excellent = 9) was used. Grade A color was assigned the "excellent" rating. Sweetness, sourness and pear flavor were rated using 9-category intensity scales, extremely low = 1 to extremely high = 9. Texture was rated using a firmness scale, extremely soft = 1 to extremely firm = 9. A sixth scale, "overall quality," using the same anchors as the color scale, was included due to its standard use in eval-

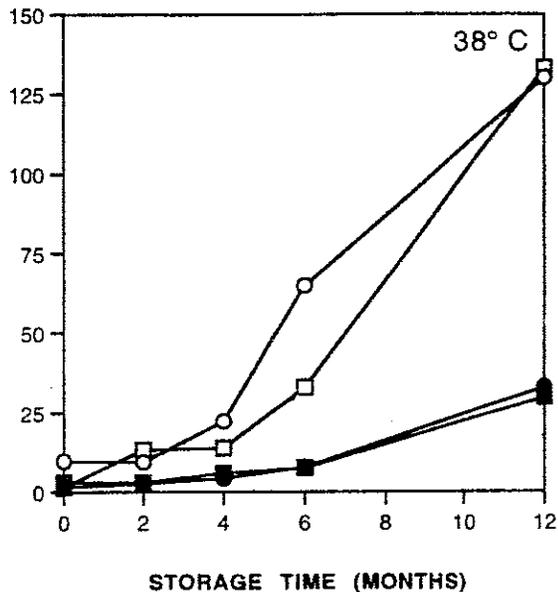
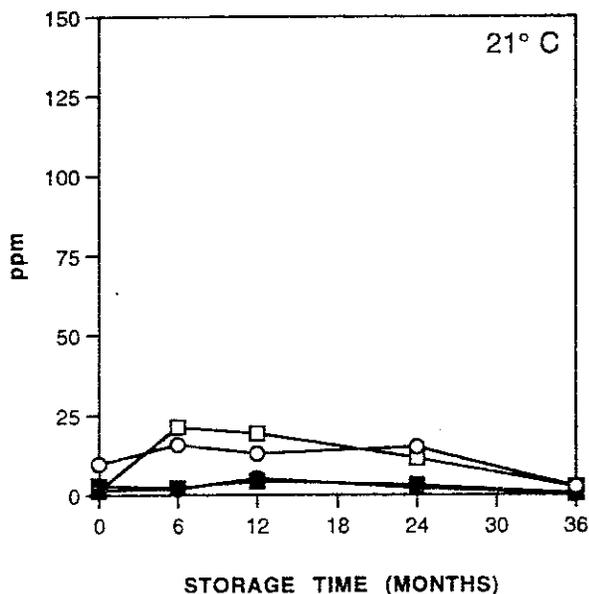


Fig. 3—Relationship of storage time and temperature to hydroxymethylfurfural levels in fruit/syrup homogenates. Optimum process: pH 4.0 ■, pH 3.5 □; Excessive process: pH 4.0 ●, pH 3.5 ○.

uating military rations. For these panels, the same group of 15–20 food technologists rated each sample set. Samples were presented simultaneously but evaluated one at a time in counterbalanced order.

Acceptability panels consisted of randomly selected untrained judges from a roster of U.S. Army RD&E Center employee volunteers. Acceptability was rated using the 9-point hedonic scale. Different groups of 36–38 individuals were selected for each set of samples, which were presented monadically in counterbalanced order.

After the initial (zero time) sensory analyses, planned samplings from storage were: 38°C samples at 2, 4, 6, and 12 mo; 21°C samples at 6, 12, 24 and 36 mo; and 4°C samples at 12, 24 and 36 mo. Due to dissimilar withdrawal intervals, each temperature series was run as a separate experiment. Samples for both panel types were served at room temperature ( $\approx 23^\circ\text{C}$ ).

#### Biochemical/Instrumental analyses

Analyses were run at each sampling on whole pouch homogenates which were further extracted/diluted as required. Separate homogenates were prepared from two pouches. For most analyses, three aliquots were taken from each of the duplicate homogenates. The following analyses were run: (1) brix and pH: brix was determined with an Atago Model PR-1 digital refractometer and pH using a Corning Model 150 digital pH meter with a glass electrode standardized with pH 4.0 and 7.0 buffers; (2) reflectance color measurements (L,a,b) determined with a Hunter Labs Model D25-9 colorimeter; (3) sugar profiles (sucrose, glucose and fructose) determined by the high pressure liquid chromatographic method of Hurst et al. (1979), using the Waters, Inc. aminopropyl carbohydrate analysis column ( $3.9 \times 300$  mm); eluent was 80/20 acetonitrile/water at 2 mL/min. External sucrose, glucose and fructose standards were used to set response factors for the R.I. detector and Spectra Physics Model 4270 integrator; (4) sugar degradation products, furfural and hydroxymethyl furfural (HMF), using a rapid HPLC procedure modified from the method of Kim and Richardson (1992). An ion retardation ( $30 \times 4.6$  mm, Biorad, Inc., catalog No. 125-0114 or 125-0129) was used with 0.001N  $\text{H}_2\text{SO}_4$  as the eluent in a Varian Model 8500 Chromatograph at a 0.5 mL/min flow rate with the UV detector set at 283 nm. External standards were used to set individual response factors for furfural and HMF on the Spectra Physics Model 4270 integrator; and (5) ascorbic acid, estimated for guidance of in-plant quality control testing by EM Quant test strips from EM Science which read colorimetrically in the 50–2000 ppm range. Ascorbic acid was quantified during storage by a photometric method (Association of Vitamin Chemists 1966).

#### Statistical analyses

At the conclusion of the study, descriptive attributes and consumer acceptability ratings were analyzed by unreplicated three-way analyses

of variance (ANOVA) to determine significance of pH, process and storage time.  $P \leq 0.05$  was the criterion for significance. When a significant main effect of storage time occurred, a posthoc Neumann-Keuls statistic was computed to determine significance of differences between means. In addition, an analysis using the method of least squares (Martens and Martens, 1986) was computed to relate sensory and biochemical/instrumental data. The first factor (PCA 1) was correlated with each individual dependent sensory attribute and sensory overall quality. In addition, it was correlated with the following instrumental analyses: the 3 Hunter color values, HPLC sugar analyses, hydroxymethylfurfural (HMF) and vitamin C.

## RESULTS & DISCUSSION

### Color

Initially (Zero time, Fig. 1), the technologist panel rated color quality of pH 3.5 pears processed at  $88^\circ\text{C}$  and  $96^\circ\text{C}$  lower than pH 4.0 pears. The color change, described as darkening and loss of translucency compared to the original translucent greenish white color of the samples, probably occurred during the pre-storage equilibration period since the same color change was also noted in samples designated for  $4^\circ\text{C}$  storage (plot not shown). Kluter et al. (1994) reported a similar observation in retort pouch peaches. At  $38^\circ\text{C}$  storage, pH 3.5 samples deteriorated rapidly by 2 mo, while ratings for pH 4.0 samples indicated good color quality retention through 6 mo. The ANOVA indicated significant effects of pH, process and time. Process-pH, process-time and pH-time interactions were also significant (Fig. 1).

Instrumental/analytical measurements showed trends over time similar to sensory ratings. Hunter L (100 = white, 0 = black) measurements were grouped similarly (Fig. 2) and were comparable to sensory color ratings. Initially and thereafter, pH 3.5 fruit was consistently darker than pH 4.0 fruit, with no evident effect of process temperature. Analyses of furfural (Fig. 3) and HMF (Fig. 4) indicated considerably greater rates of increase in  $38^\circ\text{C}$  than in  $21^\circ\text{C}$  stored fruit and higher levels at all times in pH 3.5 than in 4.0 fruit. Very low levels of both compounds were also noted in  $4^\circ\text{C}$  fruit with no changes over time (data not shown). At  $21^\circ\text{C}$ , furfural content reached a maximum by 24 mo but decreased by 36 mo to near 0 ppm. A probable explanation is that the long storage time allowed secondary reactions of these carbonyl compounds with amino acids (Ledl et al., 1986).

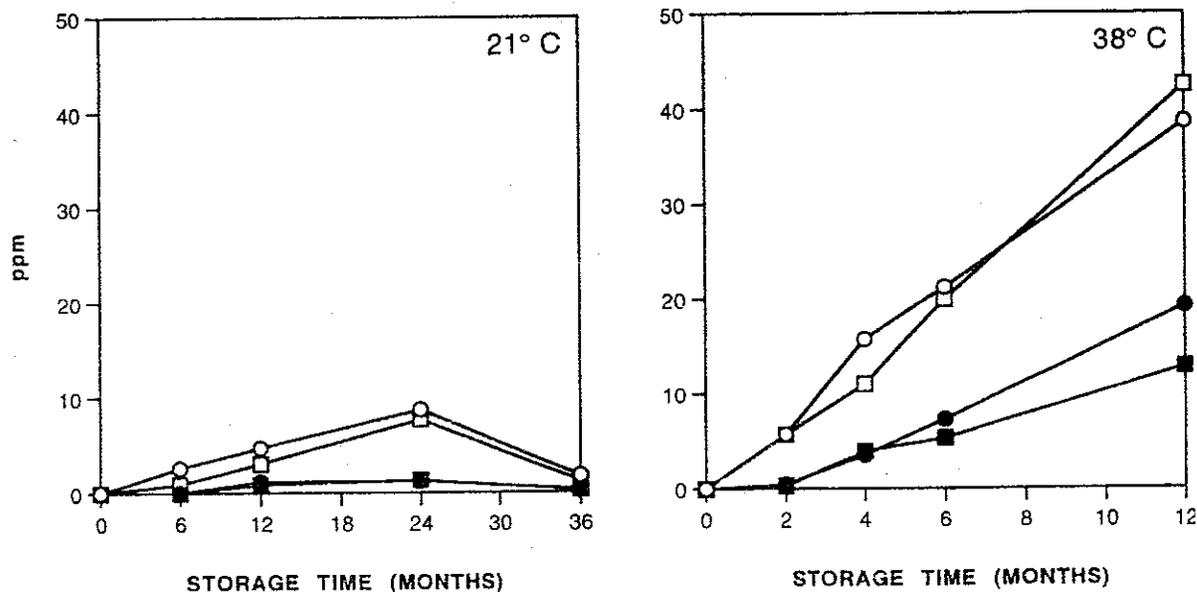


Fig. 4—Relationship of storage time and temperature to furfural levels in fruit/syrup homogenates. Optimum process: pH 4.0 ■, pH 3.5 □; Excessive process: pH 4.0 ●, pH 3.5 ◻.

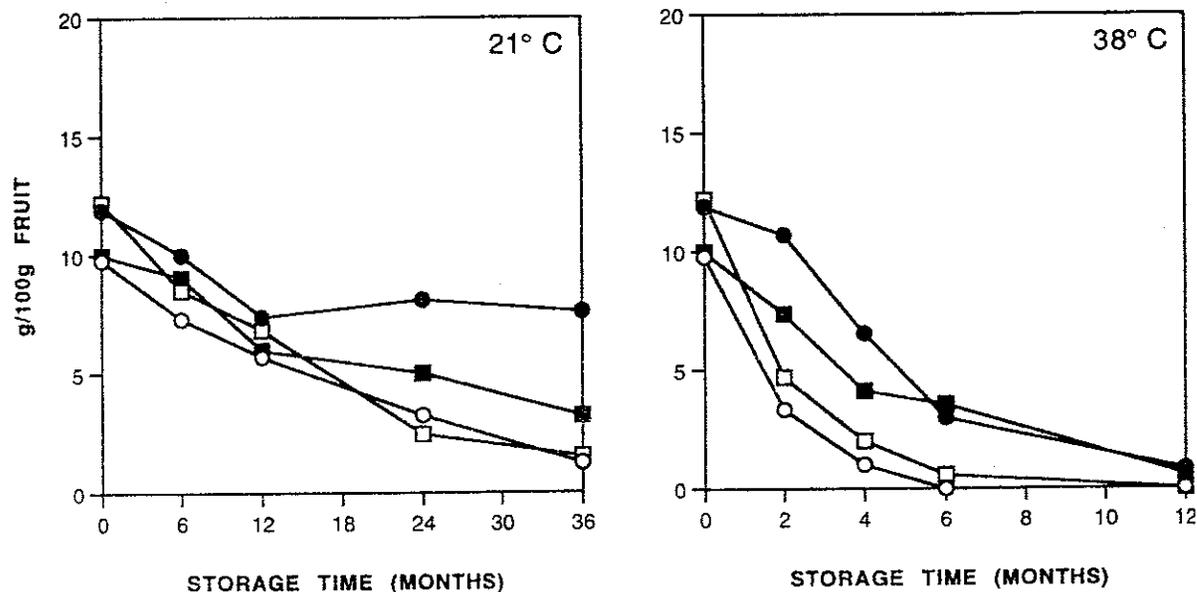


Fig. 5—Relationship of storage time and temperature to sucrose levels in whole fruit homogenates. Optimum process: pH 4.0 ■, pH 3.5 □; Excessive process: pH 4.0 ●, pH 3.5 ◻.

**Sweetness and sourness**

Sensory sweetness of pH 4.0 fruit was higher than for pH 3.5 fruit. The difference was significant only for 21°C stored fruit. No decrease in sweetness was noted in 4°C stored samples (data not shown), and decreases were noted over 36 mo at 21°C and but not in the 12 mo/ 38°C samples. Rate of sweetness decrease was generally greater in pH 3.5 than in pH 4.0 fruit.

HPLC data (Fig. 5) indicated that most of the sucrose in 38°C stored pH 3.5 and 4.0 pears disappeared by 6 mo, indicating it had hydrolyzed. Rate of disappearance was slower in 21°C stored fruit and, by 36 mo, was nearly zero in pH 3.5 fruit. Corresponding increases in glucose and fructose analyses were noted at these temperatures (data not shown). At 4°C, sucrose levels were stable at both pH levels.

Differences in sourness ratings over time were more clearly delineated than sweetness: the two pH levels differed, with a significant pH-time interaction at 38°C. Mean sourness intensity

ratings of pH 3.5 pears ranged from 4.0 to 5.0 (4.0 = intermediate) on the intensity scale, increasing slightly over time at all temperatures; pH 4.0 pears ranged between about 3.0 and 3.6 (3.0 = slight).

**Pear flavor intensity**

At all three storage temperatures, statistical analyses indicated that pH 3.5 pears were lower in characteristic pear flavor intensity than pH 4.0 pears (data not shown). The effect of storage time was also significant. At 38°C, ratings of pH 4.0 samples indicated little flavor loss up to 6 mo; a sharp decrease occurred by 12 mo. The pH 3.5 fruit stored at 38°C lost flavor intensity incrementally between initial and 12 mo evaluations. In pears as in peaches, changes in pear flavor intensity ratings over time corresponded to changes in sweetness (Kader et al., 1982; Kluter et al., 1994).

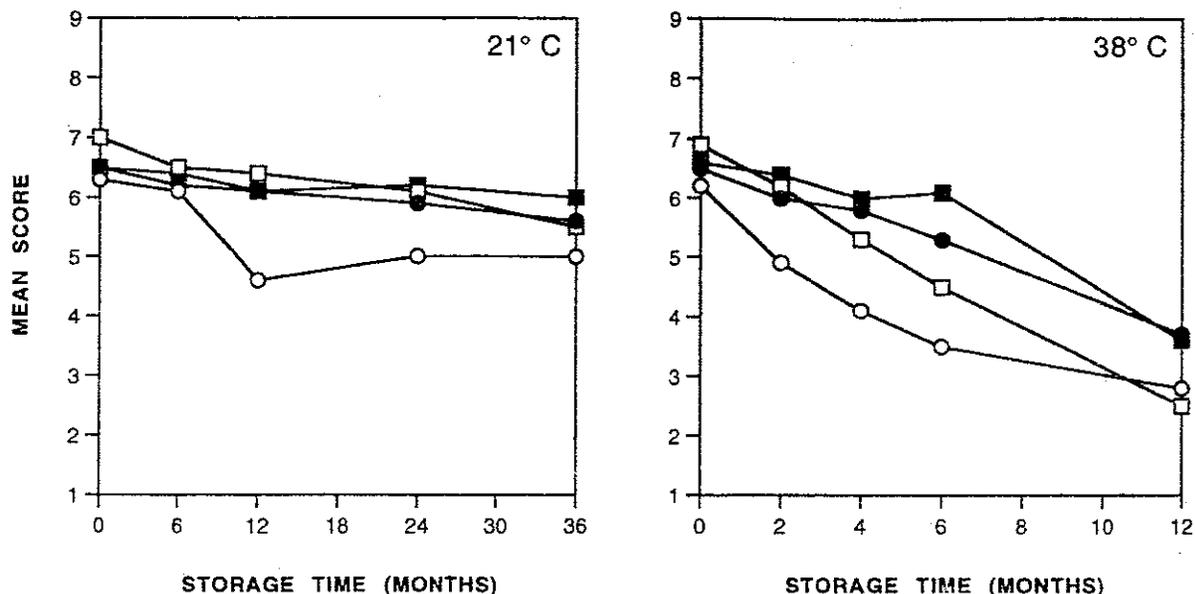


Fig. 6—Relationship of storage time and temperature to sensory firmness of pear slices. Optimum process: pH 4.0 ■, pH 3.5 □; Excessive process: pH 4.0 ●, pH 3.5 ○.

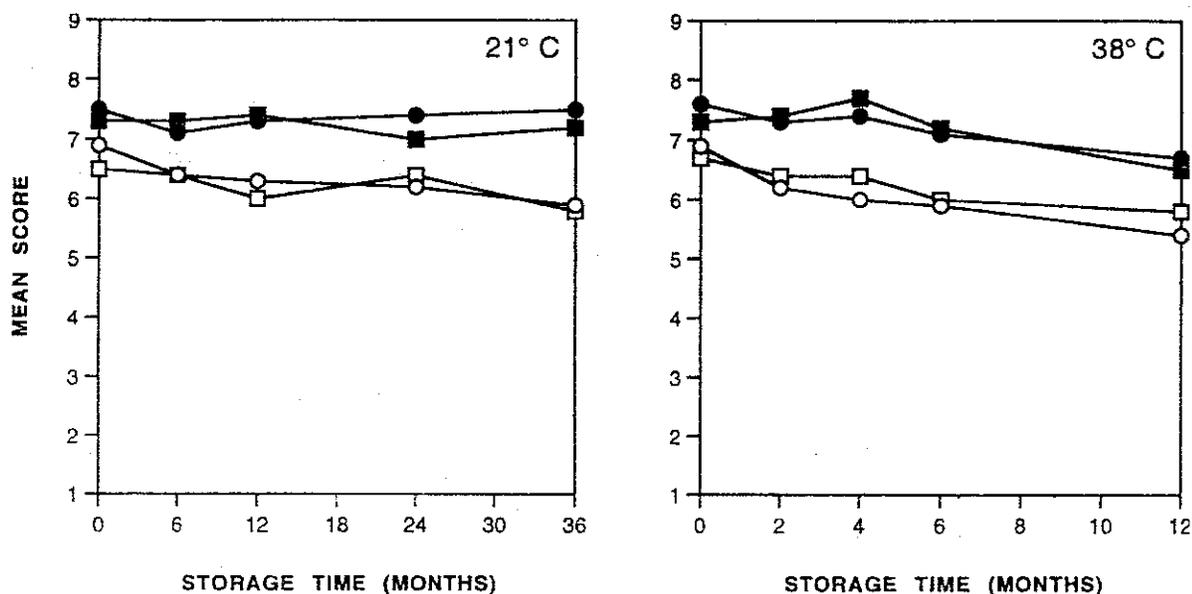


Fig. 7—Relationship of storage time and temperature to acceptability of pear slices. Optimum process: pH 4.0 ■, pH 3.5 □; Excessive process: pH 4.0 ●, pH 3.5 ○.

### Texture

Processing temperature had a significant effect on sensory firmness over time at all storage temperatures. Pears processed at 88°C were firmer than those processed at 96°C. Minimal loss of firmness occurred during 4°C storage (plots not shown). After 12 mo storage at 21°C (Fig. 6), the 96°C processed samples at pH 3.5 became less firm than 88°C processed samples at the same pH. In the 38°C plots, the pH 3.5 samples became substantially less firm by 4 mo, and the higher process temperature, in combination with the low pH, clearly had an adverse effect on firmness. In addition to statistical significance of the main effects of pH, process temperature and storage time in samples stored at 21°C and 38°C, all 2- and 3-way interactions were also significant, as suggested by crossovers in the plots.

### Acceptability

Consumer panelists consistently rated acceptability (Fig. 7) of pH 4.0 pears significantly higher than pH 3.5 fruit after all with-

drawals. Mean ratings for 4°C (plots not shown) and 21°C stored fruit were stable over the 36 mo of the study, the 4°C sample ratings remaining in the same ranges as the 21°C samples. Over 12 mo, 38°C sample ratings decreased in small increments; after 12 mo, pH 3.5 fruit was considered marginally acceptable. Consumer acceptability ratings generally corresponded with overall quality ratings of the technologist panel.

### Partial least squares (PLS) analysis

A single factor, PLS1, (Table 1) accounted for 68% of the variance in the sensory data and 62% of the variance in the instrumental data. A second factor (not shown) accounted for an additional 5 and 15%, respectively. Additional factors only marginally increased the percent variance explained. Color quality, overall quality and pear flavor intensity, Hunter L, ascorbic acid and sucrose were highly correlated positively with PLS 1, while fructose, glucose and Hunter a values were highly correlated negatively.

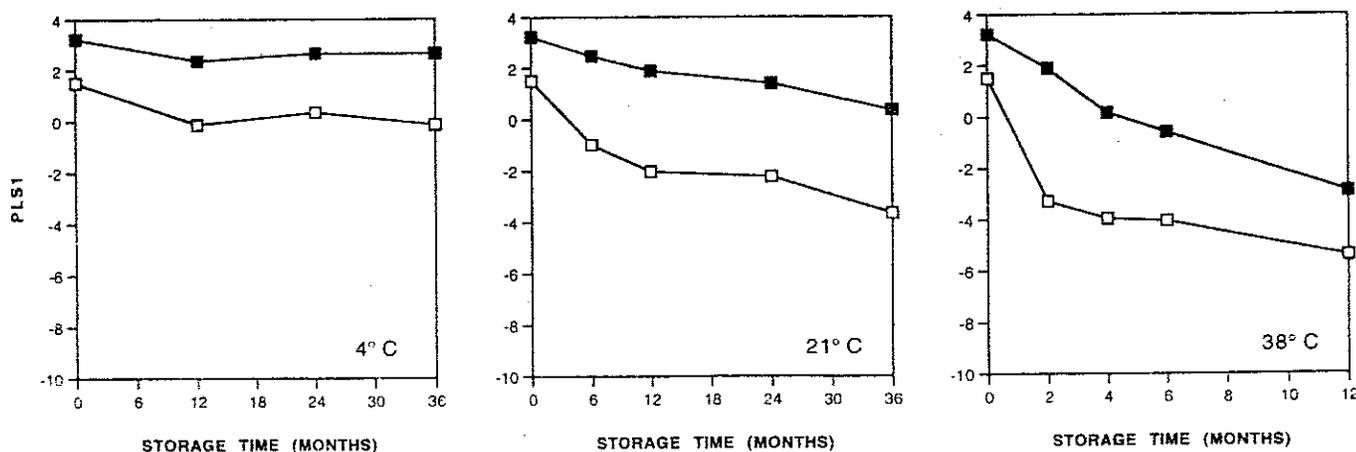


Fig. 8—Relationship of pH to PLS 1 values across two processing temperatures on pears stored at 21° and 38°C. pH 4.0 ■, pH 3.5 □.

Table 1—Bivariate correlations (N=55) with PLS Factor 1

Variables	Correlation
<b>Sensory (Dependent)</b>	
Color quality	+0.91
Overall quality	+0.90
Flavor intensity	+0.89
Texture	+0.79
Sweetness	+0.77
Sourness	-0.68
<b>Instrumental/Analytical (Independent)</b>	
Hunter L	+0.95
Vitamin C	+0.84
Sucrose	+0.84
Brix	-0.52
Hunter b	-0.57
Total sugars	-0.64
Ln HMF	-0.71
Fructose	-0.95
Glucose	-0.97
Hunter a	-0.97

The PLS1 factor over time showed clearly the interactive effects (Fig. 8) of storage temperature, pH and processing temperature on sensory and instrumental measurements. As indicated elsewhere, better quality retention was noted over time in pH 4.0 than in pH 3.5 pears.

### CONCLUSIONS

ACIDIFICATION OF SYRUP to pH 3.5 had an adverse effect on retention of quality attributes, particularly color and texture, initially and during storage of retort pouch pears. Syrup pH 4.0 resulted in better quality retention at 21°C and 38°C storage temperatures than syrup pH 3.5. Minimum military shelf life requirements were met when pH 4.0 syrup was used at either processing temperature. The 88°C processing temperature, in combination with pH 4.0 syrup, was advantageous in retention of sensory texture and syrup sucrose level over time, as well as in sensory color, Hunter color, and inhibition of HMF and furfural production and acceptability.

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