Effect of Manothermosonication (MTS) on Quality of Orange Juice

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Abstract

The objectives of this work were to evaluate the effect of manothermosonication (MTS) (400 kPa and 70°C for 30 sec) on the quality of orange juice during storage at 4°C and to compare the quality of MTS treated juice with that of a thermal pasteurized counterpart. Ascorbic acid, cloud stability (%T), and residual pectinmethylesterase (PME) activity were evaluated during storage. The MTS treated juice showed no pulp separation during storage. The MTS treated samples exhibited a slower ascorbic acid (AA) degradation compared to the thermal pasteurized one. At day 49, MTS treated juice had an AA concentration of 35.8 mg/100 ml, which was above 25 mg/100 ml, a number calculated from the 60 mg per 8 fluid oz (236 ml) serving to provide 100% of the daily allowance recommended by the USDA for vitamin C intake. The results of this study indicate that MTS treatment may be a promising alternative to traditional thermal juice processing methods.

Introduction

Pectinmethylesterase (PME) in orange juice leads to loss of cloud stability, phase separation and gelation of concentrate by prompting de-esterification of pectin substance. The inactivation of PME is, therefore, a key processing step in the production of orange juice. Commercial thermal treatment at 90°C for 1 min can effectively inactivate PME but has a negative impact on juice quality. Alternative juice processing technologies working under mild treatment conditions, which are often called nonthermal technologies, have hence gained interest. PME in orange products is relatively resistant to a non-thermal treatment and reversible inactivation may occur if treatment conditions are not carefully selected.

The application of power ultrasound as an alternative to inactivate pectic enzymes has been studied in recent years. It is found that a combination of ultrasound treatment with heat and low pressure (2 to 5 atmospheric pressure) can effectively deactivate PME and polygalacturonase (PG) in tomato products. In a manothermosonication (MTS) test, Lopez et al. (1998) reported a 52.9- and 26.3-fold increase in the inactivation of extracted PME and PG in a buffer compared to that treated with a thermal method. MTS treated tomato juice exhibited an improved viscosity (Vercet et al., 2002). It is postulated that a MTS treatment would provide effective inactivation of PME in orange juice with an improved juice quality compared to a thermal treated counterpart.

Objectives

The objectives of this work were to evaluate the effect of manothermosonication (MTS) (400 kPa and 70°C for 30 sec) on the quality of orange juice during storage at 4°C and to compare the quality of MTS treated juice with that of a thermal pasteurized counterpart.

Materials & Methods

Orange Juice Preparation

Raw and pasteurized orange juice (80% Hamlin, 19% Pineapple, and 1% Others) was obtained from Coca-Cola. The pasteurized orange juice was heated at 91.7^{o}C for 12 sec. Juice was stored in a freezer at -14^{o}C and thawed at 3^{o}C for 2 days before use.

MTS treatment

The MTS system was composed of a stainless steel jacketed reactor (35 ml), a temperature control sub-system, a pressurization sub-system, and a fluid handling sub-system to transfer juice in and out of the reactor. A Sonics ultrasound generator with a probe (20 kHz, amplitude 117 μm) was used to provide acoustic energy for juice treatment. The optimal treatment conditions (400 kPa and 70^{o}C for 30 sec) obtained in a preliminary test were used for the storage test. The MTS treatment was performed in duplicate.

Quality analysis

The concentration of ascorbic acid in juice samples was measured in duplicate by a high-performance liquid chromatography (Hitachi Liquid Chromatography, Naperville, IL) at 254 nm (Shimadzu UV-VIS detector SPD-10AVP) (Yeom, 2000). A reverse-phase C-18 column (Hewlett-Packard) along with a Hewlett-Packard C-18 guard column was used to analyze the ascorbic acid. Residual PME activity was measured using the method of Kimball (1991) with modifications. Cloud stability was determined by measuring % transmittance (%T) at 650 nm after centrifugation at 360 × g. In browning index, juice samples (20 ml) were centrifuged at 10240 × g for 10 min to remove pulp and coarse cloud particles. The supernatant is collected and clarified using 0.45 mm filter. The browning of the clarified juice is measured absorbance at 420 nm using a spectrophotometer at room temperature (Hewlett-Packard). The pH of the mixture containing sample (10 g) and 20 mL distilled water was measured using a pH meter (Fisher Scientific) at 20^{o}C. After measuring pH, the solution is titrated with 0.1 M NaOH to pH 8.1. Results are expressed as grams of citric acid per kilogram fresh weight for total acidity. Quality analyses were conducted immediately after a MTS treatment. For the storage test, the ascorbic acid concentration, cloud stability (%T), and residual PME activity of the orange juice stored at 4^{o}C were periodically evaluated for 49 days.

Statistical Analysis

Statistical analyses were performed using a SAS software. The general linear models (GLM) procedure was utilized for analysis of variance (ANOVA). The Fisher LSD (Least Significant Difference) procedure was used to determine any significant difference between specific means (α = 0.05).

Results

Initial quality factors

After the MTS treatment at 70^{o}C, 400 kPa for 30 sec, no significant changes in pH, total acidity, pulp content and soluble solids were observed in comparison with the control (raw juice) (Table 1). At day 0, both commercial pasteurized and MTS treated juice showed lower transmittance compared to the control. The browning index of MTS juice, however, was significantly higher than the raw juice, although it was much lower compared to the pasteurized samples. MTS reduced PME activity by 94.6% after a 30-sec treatment, which corresponds to a D value of 31.7 sec.

Table 1. Selected quality attributes of orange juice treated with MTS and commercial thermal method in comparison with raw orange juice (control) at 0 day

Treatment	Cloud Stability (%T)	Browning Index (Abs)	pH	Total Acidity (%)
Raw OJ[2]	1.79[a1]	0.49[c]	4.1[a]	0.70[a]
Pasteurized OJ	0.06[c]	2.06[a]	4.3[a]	0.71[a]
MTS- treated OJ	0.74[b]	0.88[b]	4.3[a]	0.69[a]

Treatment	Pulp Content (%)	Soluble Solids (^{o}Brix)	Residual PME activity (PEU)	Residual PME activity (%)
Raw OJ	11.1[a]	11.4[a]	5.59E-03[a]	100[a]
Pasteurized OJ	11.1[a]	11.8[a]	6.60E-05[c]	1.2[c]
MTS- treated OJ	11.3[a]	11.0[a]	8.03E-04[b]	15.4[b]

[1] Quality data in the same column that are followed by the same letter are not significantly different ($\alpha = 0.05$).
[2] Orange juice.

Quality changes during storage

At day 0, the ascorbic acid (AA) concentration in MTS treated samples was 57.8 mg/100 ml that was slightly lower than that in the raw juice (Table 2). Statistically, however, there was a significant difference between the two treatments in AA content. During storage at 4^{o}C, all juice samples experienced a decrease in AA concentration as shown in Figure 1. Since pulp separation in raw juice became evident at day 9, no further AA analysis was reported after 9 days. There was no significant difference in AA content between MTS and thermal treatment at day 13. At day 17, a more pronounced AA degradation in pasteurized juice can be observed. This trend was well maintained thereafter. After 35 days, pasteurized juice had an AA loss of over 50%. At day 49, MTS treated juice had a AA concentration of 35.8 mg/100 ml, which was still above 25 mg/100 ml, a number calculated from the 60 mg per 8 fluid oz (236 ml) serving to provide 100% daily allowance recommended by the USDA for vitamin C intake.

Table 2. Ascorbic acid concentration (mg/100 ml orange juice) in orange juice for three treatments during storage at 4^{o}C

	0 day	6 days	9 days	13 days	17days	24 days	35 days	49 days
Raw[1]	59.7[a4]	55.3[b]	52.7[a]					
P[2]	59.4[a]	58.4[a]	51.5[b]	48.5[a]	45.7[b]	36.9[b]	29.9[b]	22.1[b]
MTS[3]	57.8[b]	55.7[b]	51.0[c]	48.4[a]	47.3[a]	47.2[a]	45.0[a]	35.8[a]

[1] Raw (unpasteurized) orange juice.
[2] Commercial pasteurized orange juice.
[3] MTS treated orange juice.
[4] Quality data in the same column that are followed by the same letter are not significantly different ($\alpha = 0.05$).

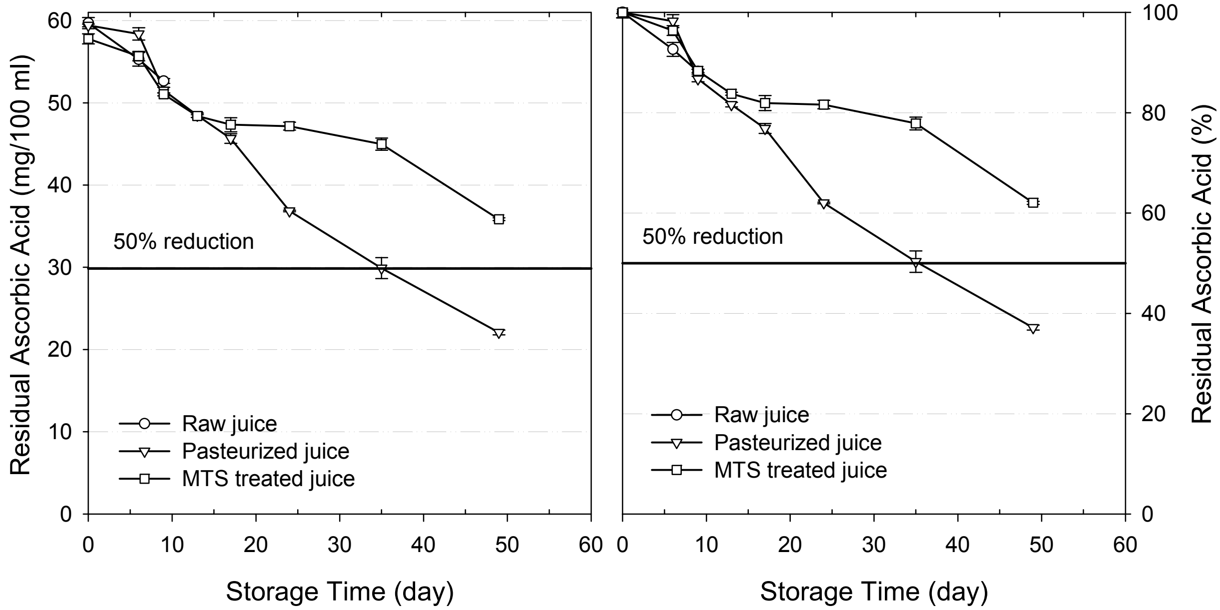

Figure 1. Changes in ascorbic acid concentration in orange juice for samples treated with different methods during storage at 4^{o}C.

The residual PME in raw juice kept at a high level during storage compared to the pasteurized and MTS treated (Figure 2). As pulp separation increased, a fast decrease in the residual PME in raw juice can be observed. After the transmittance had reached 36% (above which the juice is considered not acceptable), the PME activity remained at a relatively stable level (Figure 3). The PME activity in MTS treated samples experienced a small decrease between day 3 and day 6. It remained fairly stable afterwards. Samples treated with thermal and MTS methods maintained a good cloudiness during the 49-day storage at 4^{o}C as can be seen from Figure 3.

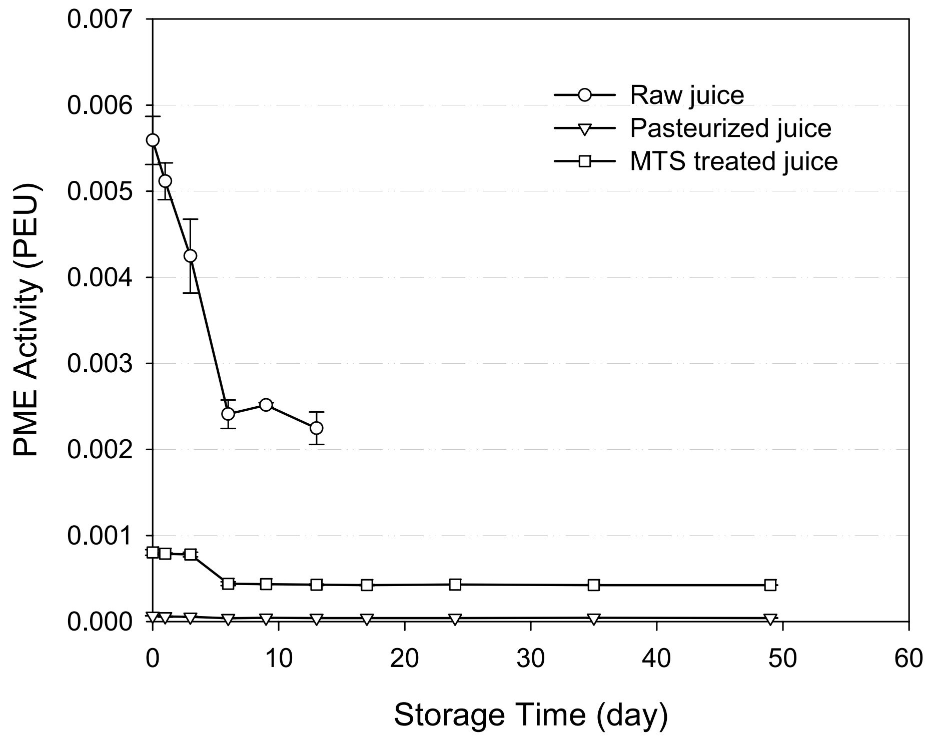

Figure 2. Changes in PME in orange juice for samples treated with different methods during storage at 4°C.

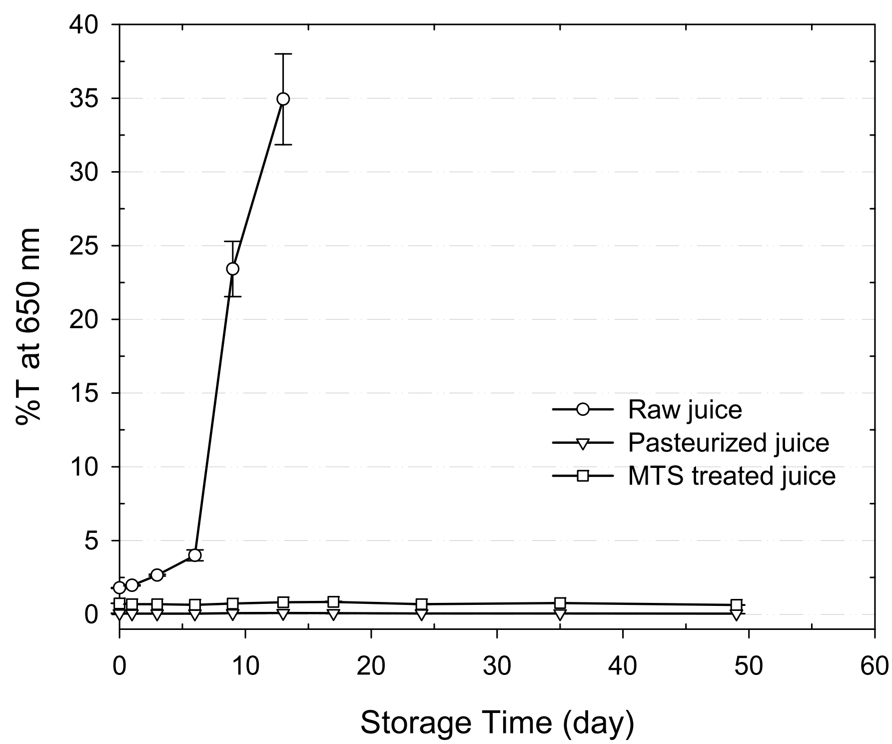

Figure 3. Changes in cloud stability (%T) in orange juice for samples treated with different methods during storage at 4°C.

Conclusion

Results from this study demonstrated that MTS treatment may be a promising alternative to traditional thermal juice processing methods. It can effective inactivate PME in orange juice while maintaining juice quality. Studies into the flavor and sensory aspects of MTS treated juice samples will further prove the technical feasibility of this technology for potential industrial applications.

References

1. Kimball, D.A. Juice cloud. *In Citrus Processing-Quality Control and Technology*; Van Nostrand Reinhold: New York, 1991; pp 117-125.
2. Lopez, P., Vercet, A., Sanchez, A.C., and Burgos, J. 1998. Inactivation of tomato pectic enzymes by manothermosonication. *Z Lebensm Unters Forsch.*, 207: 249-252.
3. Vercet, A., Sanchez, C., Burgos, J., Montanes, L., and Lopez-Buesa, P. 2002. The effects of manothermosonication on tomato pectic enzymes and tomato paste rheological properties. *J. Food Eng.*, 53: 273-278.
4. Yeom, H.W., Streaker, C.B., Zhang, Q.H,, and Min, D.B. 2000. Effects of pulsed electric fields on the quality of orange juice and comparison with heat pasteurization. *J Agric. Food Chem.*, 48: 4597-4605.