Effects of Vegetable Oils, CO₂, and Film Wrapping on Chilling Injury and Decay of Lemons

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Abstract. Film wrapping or holding for 3 days at 21°C reduced chilling injury (CI) and decay of ‘Bearss’ lemons (Citrus limon Burm. f.) stored at 1°C for 21 days plus 14 days at 21°C. Prestorage treatments of 40% CO₂ for 3 days at 21°C or dips in 2%, 10%, or 20% vegetable oils were not effective in reducing CI or decay during a similar storage and holding period. The use of 10 μl·liter⁻¹ ethylene to degreen lemons significantly increased CI and decay compared to degreening without ethylene, especially when lemons were stored at 1°C.

Ethylene dibromide (EDB) currently is used as a postharvest fumigant for Florida citrus fruits exported to Japan to protect against the spread of Caribbean fruit fly, Anastrepha suspensa (Loew). Withdrawal of registration for the use of EDB for fumigation of domestically consumed fruits in 1984 (14) and its possible elimination for treating exported fruits, has led to the search for alternatives, such as low-temperature storage. The USDA has authorized the use of low storage temperatures as a quarantine treatment against certain fruit fly pests (13). However, citrus fruits, particularly grapefruit and lemon, are susceptible to CI when exposed to temperatures below 10°C for more than 14 to 21 days (4, 8).

Recently, several treatments that reduce the susceptibility of citrus fruits to CI during storage have been reported. These include prestorage treatment of 40% CO₂ (5), film wrapping (9, 15), coating fruit surfaces with vegetable oils (1), use of the fungicide thiabendazole (TBZ) (10, 15), and conditioning at high temperatures prior to low-temperature storage (3, 6, 7).

Although conditioning at high temperatures has been effective in reducing CI with other types of citrus, holding lemons at 15.5°C prior to low-temperature storage did not reduce CI (6). However, since treatments other than conditioning at high temperatures have been effective in reducing CI, it may be possible that their use as adjuncts to conditioning would mitigate the effects of subsequent low-temperature storage on the development of CI.

The purpose of this study was to evaluate various treatments in combination with the normal degreening process (0 μl·liter⁻¹ ethylene) and also with ethylene degreening (10 μl·liter⁻¹) at 15.5°C, followed by a low-temperature storage period necessary to qualify as a quarantine treatment against the Caribbean fruit fly.

‘Bearss’ lemons were obtained from a commercial packinghouse from different groves 3 times between 9 Aug. and 20 Sept. 1984. On each occasion, fruit were harvested commercially the previous day into bulk field bins, transported to the packinghouse, and left overnight. Fruit, free of blemishes and green in color, were hand-sized into a count range of 140–200 and conditioned according to the types of storage and holding period. The percentages of CI and decay increased with 0.2% Tween 80 surfactant added to the water; 4) CO₂ plus wax, 3 days in 40% CO₂ at 21°C; 5) a CO₂ control, waxed, 3 days in normal atmosphere at 21°C; 6) film wrap, sealed in Cryovac D955 film (W.R. Grace, Duncan, S.C.) with a Weldomatic sealer and Weldomatic heat tunnel (Weldotron, Piscataway, N.J.); and 7) film control, waxed only. CO₂ treated, CO₂ control, and film control fruit were waxed with Fresh Wax 3202 (Fresh Mark Chemical, Orlando, Fla.), a water-type wax, before the respective treatments.

In each of 3 different tests (harvests), 4 replications of 25 fruit per treatment were held in separate storage containers. The fruit then were stored for 21 days at either 1°C or 10°C under a RH of 80% to 92%.

Table 1. F value significance for effects of storage temperature, method of degreening, and prestorage treatments on chilling injury and decay development in lemons.

<table>
<thead>
<tr>
<th>Effect</th>
<th>Chilling injury</th>
<th>Decay</th>
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<tbody>
<tr>
<td></td>
<td>After 21 days of storage</td>
<td>After holding at 21°C</td>
</tr>
<tr>
<td></td>
<td>7 days</td>
<td>14 days</td>
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<tr>
<td>Temperature (TE)</td>
<td>***</td>
<td>***</td>
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<tr>
<td>Ethylene (C₃H₄)</td>
<td>***</td>
<td>***</td>
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<tr>
<td>Treatments (TR)</td>
<td>NS</td>
<td>NS</td>
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<tr>
<td>TE × CH₄</td>
<td>***</td>
<td>***</td>
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<tr>
<td>TE × TR</td>
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<td>**</td>
</tr>
<tr>
<td>C₃H₄ × TR</td>
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<td>*</td>
</tr>
<tr>
<td>TE × C₃H₄ × TR</td>
<td>*</td>
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</table>

**NSSignificant at 5%, 1%, and 0.1%, and not significant, respectively.

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developed.

CI was most prevalent on lemons treated with 10% vegetable oil and those treated with 40% CO₂ after holding for 14 days at 21°C (Table 3). Coating grapefruit with vegetable oil has been reported to reduce CI when the fruit is held for protracted periods at low temperatures (1). Hatton and Cubbedge (7) found that a prestorage treatment of 40% CO₂ for 3 days significantly reduced CI development in grapefruit, but this was not true for lemons. Lemons, like limes, may be injured by CO₂ levels >10% (12).

The lowest incidences of CI were found on film-wrapped fruit and the CO₂ control fruit after holding for 14 days at 21°C. Polyethylene film wraps have been reported to reduce the development of CI (9, 15). Carbon dioxide control lemons were degreened fruit that were merely waxed and held at 21°C for 3 days prior to storage. It may be that a temperature of 21°C is required to condition lemons against CI during low-temperature storage, although a temperature of 15.5°C is optimum for conditioning grapefruit against CI during certain times of the year (7).

There was negligible decay in lemons after 21 days of storage in all treatments (Table 3). Decay increased during the high-temperature holding periods. If one assumes an upper limit of 3% decay for fruit to be still marketable, only the film-wrapped and CO₂ control fruit had acceptable decay levels after 14 days of holding at 21°C. The treatments that showed the lowest incidence of CI also showed the lowest amount of decay. Decay was predominantly green mold, caused by *Penicillium digitatum* Sacc., that enters the fruit through injured tissue (11).

The results of this study indicate film wrapping or holding fruit for 3 days at 21°C after degreening and waxing (CO₂ control) would ameliorate the effects of chilling at 1°C. Also, excessively large amounts of CI and decay would be expected when lemons are degreened with 10 μl-l⁻¹ ethylene and stored at 1°C for 21 days followed by 14 days of holding at 21°C.

**Literature Cited**