USE OF POSTHARVEST TREATMENTS FOR REDUCING SHIPPING DECAY IN KUMQUATS

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Abstract. Mature kumquats are subject to some of the same postharvest diseases as citrus. Since the kumquat is a near relative (genus Fortunella) of the citrus (genus Citrus) the similarities in the fruit suggest that it would react to postharvest treatments in a similar manner. Treatments tested were chlorine, sodium o-phenylphenate (SOPP), thiabendazole (TBZ), 2,4-dichlorophenoxyacetic acid (2,4-D), and waxes. All treatments except 2,4-D alone improved resistance to decay, while a combination of SOPP and TBZ with a wax gave the best results. At the level tested 2,4-D had little apparent effect.

The kumquat (genus Fortunella) is subject to losses from postharvest decay during shipment. Due to its popularity with some ethnic groups it commands a high price on the market and is usually shipped in small packages. Kumquat production in Florida is a small volume operation, amounting to only about 10,000 bushels before the 1984 & 1985 freezes greatly reduced the amount of fruit available (F. Gude, Kumquat Growers, Inc., personal communication). The large population of orientals in these cities probably accounts for this market. The kumquat probably originated in China and is still popular in most of the orient as a fresh fruit (8,25,26,27).

Eaten fresh, the kumquat has a peculiar sweetness not like that of other citrus. The peel has been found to contain dihydrochalcone flavonoids (10,13,14) similar to those recently developed as artificial sweetening agents (11,12,15). Differences in the oil of Fortunella (kumquat) as compared to Citrus have also been noted (17). Another notable difference between the kumquat and other members of the citrus family is its resistance to sour orange scab (20).

Before restrictions were placed upon fruit handling due to the outbreak of citrus canker in Florida (16), the fruit was clipped from the tree and packed loose into cartons or berry baskets for shipment to out of state markets. In addition, a considerable amount of fruit was harvested before canker quarantine restrictions were put into effect, whole fruit were clipped from the tree and packed into shipping containers with a minimum of handling. The restrictions require a chemical treatment (either chlorine or sodium o-phenylphenate (SOPP)) be given the fruit before packing (16). One Florida packer noted that since they began using a chlorine treatment in order to meet the quarantine requirements they have experienced increased decay in shipments (F. Gude, personal communication).

Their method of treatment was to dump the harvested fruit into a large wire basket (approximately 3 bushel capacity) which was lowered into a chlorine solution for 2 minutes. This basket of fruit was then transferred to another tank containing fresh water to rinse, then the fruit was dumped upon a perforated metal table to drain before packing. This extra handling apparently was causing injury to the fruit making it susceptible to decay (2). Also contributing to injury was the requirement that all leaves and excess stem be removed. Picking thus, pickers tended to include more pulled or plugged fruit.
The choices of postharvest treatments for kumquats are the same as those for citrus (5,18) as far as US Government regulations are concerned (1). In spite of this, since the kumquat has many differences in composition and reaction to disease as noted above, confirmation of the efficacy of any particular treatment would be in order. Because of the relatively small quantity of fruit involved and the short season, methods of treatment were sought that would be compatible with the equipment available and current regulations. All tests were conducted at the packinghouse and used the equipment available or scaled down versions of this equipment. In place of the wire baskets, plastic baskets were used.

Materials and Methods

Except as noted, all materials used in these trials were commercially available products. The test materials and treatments used were:

**Chlorine.** Commercial sodium hypochlorite supplied at 10% strength as used by the packinghouse. Product diluted to produce a dipping solution with 200-250 ppm chlorine at a pH of 6.0 to 7.5. Exposure time 2 min followed by fresh water rinse. Treatment indicated by the abbreviation Cl₂ in the tables. Currently used at packinghouse to meet quarantine requirements (16).

**SOPP.** Traditional “Dow-Hex” solution (9,18) containing 2% sodium o-phenylphenate tetrahydrate and 1% hexamethylenetetramine at pH 11.6 to 12.0. Prepared from concentrate (Fresh Flood DX). Exposure time 2 minutes followed by fresh water rinse. As normally used, it would meet the requirements of citrus canker quarantine (16).

**TBZ.** Thiabendazole. Prepared from concentrate (Fresh Ban Z). Used at 1000 ppm active ingredient (a.i.) in water or 1000 or 2000 ppm a.i. in dilute wax. Dip for 30 seconds, no rinse. Does not meet quarantine requirements by itself, but is compatible with other possible treatments. Concentration indicated by TBZ(I) for 1000 ppm and TBZ(II) for 2000 ppm. Benomyl was discarded as a possible treatment as packinghouse conditions would not have resulted in prompt use of prepared fungicide. Such conditions would have resulted in breakdown of the fungicide (6).

**Wax P.** Emulsion type wax (7) containing high percentage of oxidized polyethylene solids (Fresh Wax 625). Used at 5, 2, and 1% calculated solids content. Fruit dipped for 30 seconds then drained, no rinse, both with and without fungicides. 5% solids wax indicated in tables by Wax P5.

**Wax D.** Developmental storage wax provided by Fresh Mark. Emulsion type wax containing high percentage of true waxes, similar to storage waxes used for lemons in California (7). Used at 2% and 1% calculated solids content. Applied in the same way as Wax P and solids concentration indicated in the same way.

**2,4-D.** 2,4-dichlorophenoxyacetic acid, triethanolamine salt (Fresh Shield D). Used at 250 ppm acid basis. Chosen for simplicity of application and its usefulness against stem-end rot (2). Applied in combination with wax or fungicide.

**Biph.** Biphenyl (diphenyl) impregnated kraft paper. Chosen for inclusion in these trials because of the simplicity of application (2,18) and low toxicity (24). Standard dosage is one or two sheets of biphényl paper per 40 pound carton of fruit (18). One standard package used for kumquats contains 10 pounds of fruit. This size carton was used, with 1/4 of a standard sheet of biphényl paper, for the biphényl treated treatment in these trials. In order to get a more thorough distribution of this vapor phase fungitstat throughout the carton each quarter sheet was further quartered for packing among the fruit. Its use in a treatment is indicated in the tables by Biph.

In each trial fruit was taken as it arrived at the packinghouse in Dade City, Florida. Each sample of the incoming fruit was divided into lots of about 3 quarts each (4 to 5 lbs.) (except as noted for biphényl treatments) then given the treatments or combinations of treatments as indicated in Table 1. In the table the abbreviations above are used with “Check” indicating no treatment. Where treatments are separated by a slash (e.g., SOPP/TBZ(I)) one treatment followed another (fruit first treated with Dow-Hex for 2 minutes, rinsed, then treated with 1000 ppm TBZ). Treatments separated by “+” are combined (wax P2+TBZ(II) indicates 2% solids Wax P applied with 2000 ppm TBZ incorporated in the wax). Biphenyl was always incorporated in with the packed fruit.

**Trial #1 (10 treatments)**

Initiated 11 Nov. 1985. Check indicates that only fresh water was used as a dip for 2 minutes. Fruit were then packed in 1/5 bushel boxes and stored for 7 days at 58°F and 85% relative humidity. The fruit was then transferred to ambient temperature for 17 days and examined for end rot (2). Applied in combination with wax or fungicide.

A table showing the treatments used in the kumquat trials is provided below:

Table 1. Treatments used in kumquat trials.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Check</td>
<td>Cl₂—Only*</td>
<td>Cl₂—Only*</td>
</tr>
<tr>
<td>2.</td>
<td>Cl₂—Only</td>
<td>SOPP</td>
<td>SOPP/Wax P₁</td>
</tr>
<tr>
<td>3.</td>
<td>TBZ(I)</td>
<td>SOPP/Wax D₁</td>
<td>TBZ(I) + 2,4-D</td>
</tr>
<tr>
<td>4.</td>
<td>SOPP</td>
<td>SOPP/TBZ(I)</td>
<td>TBZ(I) + Wax D₁</td>
</tr>
<tr>
<td>5.</td>
<td>Cl₂/SOPP/TBZ(I)</td>
<td>SOPP/TBZ(II) + Wax P₁</td>
<td>TBZ(I) + Wax D₁ + 2,4-D</td>
</tr>
<tr>
<td>6.</td>
<td>Cl₂/SOPP/TBZ(II)</td>
<td>SOPP/TBZ(II) + Wax D₁</td>
<td>TBZ(I) + Wax D₁ + 2,4-D &amp; Biph.</td>
</tr>
<tr>
<td>7.</td>
<td>SOPP/TBZ(I)</td>
<td>TBZ(II) + Wax P₁</td>
<td>TBZ(II) + Wax D₁ + 2,4-D &amp; Biph.</td>
</tr>
<tr>
<td>8.</td>
<td>SOOP/TBZ(I) + Wax P₅</td>
<td>TBZ(II) + Wax D₁</td>
<td>TBZ(II) + 2,4-D &amp; Biph.</td>
</tr>
<tr>
<td>9.</td>
<td>Cl₂/TBZ(I) + Wax P₅</td>
<td>TBZ(II) + Wax D₁</td>
<td>TBZ(II) + 2,4-D &amp; Biph.</td>
</tr>
<tr>
<td>10.</td>
<td>Cl₂/SOPP/Wax P₅</td>
<td>TB(II) + Wax D₁</td>
<td>TBZ(II) + 2,4-D &amp; Biph.</td>
</tr>
</tbody>
</table>

*All treatments in these trials were treated first with chlorine. See text.

decay, soilage and marketable fruit (Table 2). The SOPP treatment was chosen because it also meets the requirements of quarantine (16) and could replace the chlorine if desired. The TBZ(I) treatment would be simple to implement; while not meeting requirements of quarantine it is approved for use on kumquats and is similar to processes already used (1,7). With the exception of treatments 1 and 3, all treatments in this trial would meet the requirements of the canker quarantine (16).

**Trial #2 (13 treatments)**

Initiated 4 Dec. 1985. Fruit were treated as indicated in Table 1, packed in 1/5 bushel boxes and stored for 12 days at ambient temperature, then examined for decay, soilage and marketable fruit. When applied in wax it has been recommended that the concentration of most fungicides be doubled when compared with a water based application (3,7). In trial TBZ was used at 2000 ppm when used applied in a wax and at 1000 ppm when applied in a water carrier. Treatments using biphenyl as described above, were included in this trial. The results are reported in Table 3.

**Trial #3 (10 treatments)**

Initiated 19 Jan. 1986. Fruit were treated as indicated in Table 1, then packed in 1/5 bushel boxes and stored for 25 days at ambient temperature, then examined for decay, soilage and marketable fruit. This trial included 2,4-D in several treatments because of its reported ability to reduce mold in products packed with stems and leaves (21) in addition to its usefulness against stem-end rot (2). (Table 4). The longer storage time was due to lower ambient temperatures during Jan-Feb 1986.

**Results and Discussion**

In Trial #1 (Table 2), early season fruit, chlorine was found to have a definite effect on reducing the amount of decay. This probably was due to simply reducing the inoculum present on the fruit. Upon the conclusion of this trial, the fruit was examined for decay and soilage and the clean, sound fruit were counted as marketable. On this test all treatments markedly reduced decay, the best control being those treatments involving TBZ. In the check lot green mold (*Penicillium digitatum* Sacc.), was a major cause for fruit loss due to decay and soiled fruit. Besides green mold, sour rot (*Geotrichum candidum* Lk. ex pers.) and stem end rot (*Diplodia natalensis* Pole Evans) were identified (4). The stem end rot did not follow the normal course of development for diplodia (decay from both end) but presented itself as a clearing of the fruit from the stem end. The typical darkening of tissues as usually noted in *Citrus* was absent.

### Table 2. Results of Trial 1.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Total fruit</th>
<th>Decay</th>
<th>Marketability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Green mold</td>
<td>Other*</td>
</tr>
<tr>
<td>1. Check</td>
<td>190</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>2. Cl₂—Only</td>
<td>142</td>
<td>0</td>
<td>22</td>
</tr>
<tr>
<td>3. TBZ(I)</td>
<td>132</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>4. SOPP</td>
<td>141</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>5. Cl₂/SOPP</td>
<td>126</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>6. Cl₂/SOPP/TBZ(I)</td>
<td>146</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>7. SOPP/TBZ(I)</td>
<td>162</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>8. SOPP/TBZ(I) + Wax P₅</td>
<td>145</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>9. Cl₂/TBZ(I) + Wax P₅</td>
<td>170</td>
<td>0</td>
<td>32</td>
</tr>
<tr>
<td>10. Cl₂/SOPP/Wax P₅</td>
<td>158</td>
<td>9</td>
<td>19</td>
</tr>
</tbody>
</table>

*Stem end, sour and other rots.

Values not followed by the same letter differ significantly at the 5% level of confidence.

### Table 3. Results of Trial 2.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Total fruit</th>
<th>Decay</th>
<th>Marketability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Green mold</td>
<td>Other*</td>
</tr>
<tr>
<td>1. Cl₂</td>
<td>166</td>
<td>15</td>
<td>28</td>
</tr>
<tr>
<td>2. SOPP</td>
<td>183</td>
<td>6</td>
<td>34</td>
</tr>
<tr>
<td>3. SOPP/Wax P₁</td>
<td>190</td>
<td>12</td>
<td>71</td>
</tr>
<tr>
<td>4. SOPP/Wax D₁</td>
<td>178</td>
<td>9</td>
<td>44</td>
</tr>
<tr>
<td>5. SOPP/TBZ(I)</td>
<td>177</td>
<td>1</td>
<td>21</td>
</tr>
<tr>
<td>6. SOPP/TBZ(I) + Wax P₁</td>
<td>171</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>7. SOPP/TBZ(II) + Wax D₁</td>
<td>173</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>8. TBZ(I)</td>
<td>202</td>
<td>0</td>
<td>47</td>
</tr>
<tr>
<td>9. TBZ(II) + Wax P₁</td>
<td>201</td>
<td>1</td>
<td>33</td>
</tr>
<tr>
<td>10. TBZ(II) + Wax D₁</td>
<td>233</td>
<td>0</td>
<td>44</td>
</tr>
<tr>
<td>11. Biph.</td>
<td>393</td>
<td>27</td>
<td>51</td>
</tr>
<tr>
<td>12. TBZ(II) + Wax P₁ &amp; Biph.</td>
<td>371</td>
<td>0</td>
<td>55</td>
</tr>
<tr>
<td>13. TBZ(II) + Wax D₁ &amp; Biph.</td>
<td>374</td>
<td>1</td>
<td>42</td>
</tr>
</tbody>
</table>

*Stem end, sour and other rots.

Values not followed by the same letter differ significantly at the 5% level of confidence.
Not included in the rating for marketability were two factors that could affect the acceptability of the fruit to consumers. In this trial, the waxed fruit all had a very pleasing shine but were all objectionably sticky to the touch which would detract from their acceptability. All treatments involving chlorine also were noted to have a much brighter appearance, probably due to the bleaching effect of the treatment.

Trial #2 was examined and rated in the same manner as Trial #1. Since all treatments started with a chlorine treatment no difference in brightness of the fruit was noted. Again, all treatments using TBZ gave good control. When biphenyl was added a very slight improvement was noted. Waxing seemed to reduce the effectiveness of an SOPP treatment but not a TBZ treatment. Wax P and Wax D were both used at the 1% level and did not give any objectional feel to the fruit. Wax P gave a slightly improved appearance as compared to the other treatments including Wax D.

Trial #3 involved fruit from late in the season, as a consequence a large number of fruit past the peak of maturity were included. This fruit was also more susceptible to plugging at the time of picking. Plugging and other injuries are apparently the cause of the high amount of green mold found in the chlorine only treatment. The waxes used were applied at 2% solids and Wax P gave a very pleasing appearance without being sticky. Wax P seemed to interfere with the action of TBZ to a slightly greater extent than Wax D, but Wax D did not improve the appearance of the fruit. 2,4-D was included in several of the treatments but had only minor effect on decay control, as did biphenyl. A slight effect on reducing the amount of soft fruit was noted but not enough trials were run to reach any definite conclusion.

Included in the evaluation of this trial was a notation of a large number of soft fruit. These fruit had no visible external signs of decay but were too soft to be acceptable to a consumer expecting a normally firm, slightly crisp fruit. A few of these soft fruit were found to be decayed inside. It is interesting to note that in every treatment using biphenyl the proportion of soft fruit was less (approximately half) than in the other treatments. The quantity involved was not enough to draw any conclusions. Biphenyl has a distinct odor and there was concern that this could affect the flavor of the fruit. Informal trials by packinghouse personnel that had acquired a taste for kumquats did not indicate that any objectional flavor had developed (F. Gude, personal communication).

These trials indicate that the fungicides SOPP and TBZ are both of value in controlling postharvest decay in kumquats. Chlorine followed by TBZ, with or without wax, is a simple procedure readily adaptable to the needs of a limited production situation. Superior appearance and decay control in plugged fruit would make this the process of choice.

**Literature Cited**

OBSERVATIONS OF EARLY SEASON GRAPEFRUIT IMPORTED INTO ROTTERDAM

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Additional index words. Citrus paradisi, acids, fruit size, juice volume, soluble solids.

Abstract. Fruit size, rind thickness, fruit weight, juice volume, total soluble solids and total acids of newly arrived grapefruit (Citrus paradisi Macf.) imported into Rotterdam from Florida, Mexico, Cuba, and Honduras during the period of Oct. through mid Nov. 1984 and 1985 were measured and compared at weekly intervals. Florida fruit had the highest solids/acid ratio during these sampling periods. The juice content (volume/weight) ratio was higher for Florida fruit than for fruit from Cuba. The mean juice volume per size 56 fruit was the highest for fruit from Mexico and Honduras, however, within a specific diameter range, juice volume per fruit for Florida fruit was comparable with that for Mexican fruit. Fruit from Cuba and Florida of selected size categories was smaller in diameter than fruit from Mexico and Honduras. Grapefruit from Florida and Mexico had the thinnest rinds.

Palatability of grapefruit depends on the sweetness and a high ratio of total soluble solids to total acids (4). Solids and acid homographs are used to determine palatability (1,2). Other research showed that the solids/acid ratio was a good standard for grapefruit, although it was noted that the relationship of palatability to solids/acid ratio was not as close as it should be (5). Besides the solids/acid ratio, the volume of juice is used as a basis for determining maturity and palatability (1,2).

A survey on the variation of three physical and three chemical characteristics of the quality of fresh grapefruit originating from 13 countries, and imported into Western Europe, indicated that 'Marsh' seedless grapefruit (C. paradisi) from Florida had a higher juice/fruit weight ratio, and a higher solids/acid ratio than fruit from most other countries (3). However, these findings were based on year-round averages.

Seasonal changes of the internal quality of grapefruit have been reported (6). Early season grapefruit is known to have a low juice content (2,5). Also, the solids/acid ratio increases as the season advances (2,4).

Due to reduced supplies of U.S. grapefruit entering Western Europe over the last few years, other grapefruit exporting countries, such as Cuba, Honduras and Mexico, have increased their volume to the European market. Therefore, because of the rapidly changing quality parameters on early grapefruit, this study was undertaken to investigate the extent of the variation of some physical and chemical characteristics of early season grapefruit from Florida compared to simultaneously marketed fruit originating from competing production areas.

Materials and Methods

From 8 Oct. through 12 Nov. 1984, and 22 Oct. through 12 Nov. 1985, grapefruit samples were collected weekly from the lots displayed at the Rotterdam Citrus Auction. Each lot was sampled only once, when placed on the auction. Each standard sample (7) contained five fruit out of one box, with fruit never larger than size 48. Samples were collected from four points of origin: Florida, Mexico, Cuba and Honduras.

To determine the solids/acid ratio and the juice/fruit weight ratio (ml/100 g) for each fruit sample the following characteristics were measured:
- Total soluble solids. Total soluble solids were determined with an Atago refractometer, model ATC-1, with a range of 0 to 32%.
- Total acid. Total acid was measured by titrating a 25-ml juice sample with a sodium hydroxide solution (0.4063 N) to the phenolphthalein end point. The concentration was expressed as percent of anhydrous citric acid.
- Juice volume. The five-fruit samples were juiced with a type 7 Sunkist juice extractor. The juice was strained.

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