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Institute of Food and Agricultural Sciences

PACKINGHOUSE NEWSLETTER

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Electronic Availability of the Packinghouse Newsletter

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All previous and present Packinghouse Newsletters (PHNL) are now available on the Internet at the University of Florida's postharvest web site (http://postharvest.ifas.ufl.edu) and can also be accessed through our citrus resources web site (www.fcprac.ifas.ufl.edu). Those of you who signed up to receive the PHNL via e-mail should have already received a copy electronically. Please contact me if you wish to sign up for electronic delivery or if you signed up but did not receive your electronic copy. Printed copies will continue to be mailed out to all recipients while we complete the transition.

Quaternary Ammonia Injury on Grapefruit Peel

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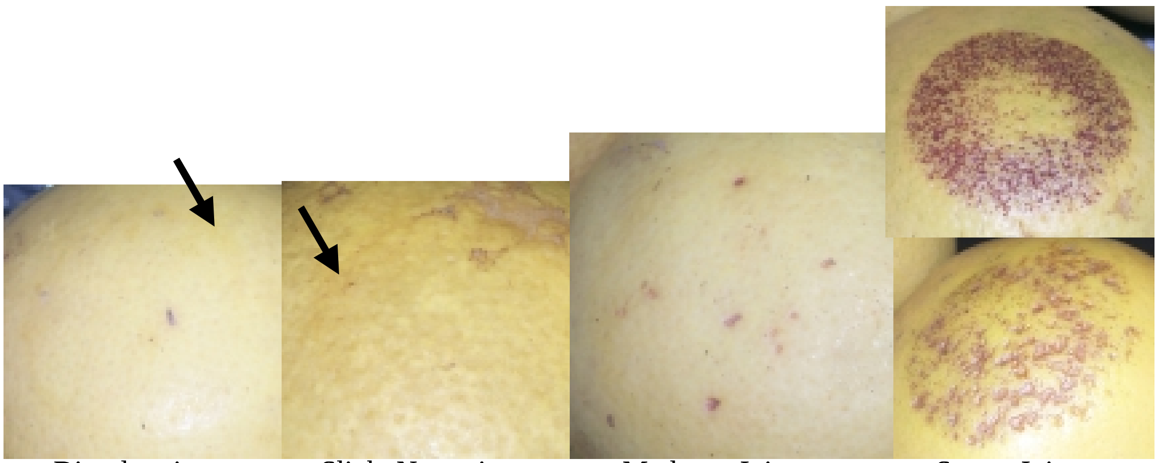
This season, there have been occasional reports of quaternary ammonia injury on citrus peel. Though apparently not a widespread problem, with increased use of quaternary ammonia to sanitize equipment and bins for canker control, the potential for injury to citrus fruit has also increased. Previous experiments provide the following conclusions:

1) Direct contact with 100 to 2000 parts per million (ppm) quaternary ammonia solutions will injure citrus peel if allowed to remain on fruit surfaces.
2) Residues of 2000 ppm quaternary ammonia solution on plastic surfaces touching fruit can injure citrus peel if re-dissolved by water on wet fruit or from condensation.

3) Quaternary ammonia injury can develop within 24 to 36 hours with symptoms ranging from very slight discoloration to severe, dark brown to black peel (Fig. 1).
4) Similar results were obtained when using any of three different quaternary ammonia products at 2000 ppm.



Discoloration (2) | Slight Necrosis (3) | Moderate Injury (4) | Severe Injury (5)

Figure 1. Quaternary ammonia injury on 'Marsh' grapefruit. Numbers in parentheses indicates relation to the injury rating scale used (1 = no injury; 5 = severe injury).

Quaternary ammonia is not approved for direct fruit contact. The top manifolds of grove canker spray stations should be turned off when trucks exit groves so that only the truck undercarriage, and not the fruit, receives the sanitizing treatment. In the packinghouse, the Florida Department of Agriculture and Consumer Services permits bins to be rinsed with fresh water shortly after quaternary ammonia applications to reduce the potential for this injury. Some packinghouses are now sanitizing bins with 200 ppm chlorine instead of quaternary ammonia to reduce quaternary ammonia residues on bins.

Because rinse stations may not remove all the quaternary ammonia residue (residues of 200 to 400 ppm have been measured after the rinse), an experiment was conducted to assess fruit injury from quaternary ammonia residues on bins and fruit expected under commercial conditions.

Experimental Design

Quaternary ammonia solutions of 0 (water alone), 100, 300, 500, 1000, and 2000 ppm were prepared from a commercial quaternary ammonia product (21.7 % quaternary ammonia + surfactant). Either 'Marsh' white grapefruit or plastic petri plates were dipped in one of the above quaternary ammonia solutions and the solutions were allowed to drip from both for 5 seconds. The dipped fruit were then placed on clean, dry petri plates or untreated, dry fruit were placed on the wet residue remaining on the dipped petri plates. An additional treatment used a dipped petri plate where the remaining 2000 ppm quaternary ammonia solution was dried with a forced-air dryer before placing the dry, untreated fruit on the plate. Peel injury was evaluated on a scale of 1 (no injury) to 5 (severe injury; Fig. 1) after five days of storage at 85°F (29.5°C) with 95% RH (to simulate degreening conditions). Experiments were conducted using a completely random design with 10 replicates (fruit) per treatment.

Results

When either petri plates or fruit were dipped in quaternary ammonia solutions, no significant injury was detected until quaternary ammonia concentration rose above 300 ppm (Fig. 2). On plates dipped in concentrations between 500 and 2000 ppm, each successive increase in quaternary ammonia concentration resulted in significantly more peel injury. Fruit dipped in quaternary ammonia solutions of 500 or 1000 ppm developed slight necrotic lesions while fruit dipped in 2000 ppm solutions developed significantly more injury. Fruit did not develop injury if placed in petri plates that were dried after dipping in the 2000 ppm quaternary ammonia solution.

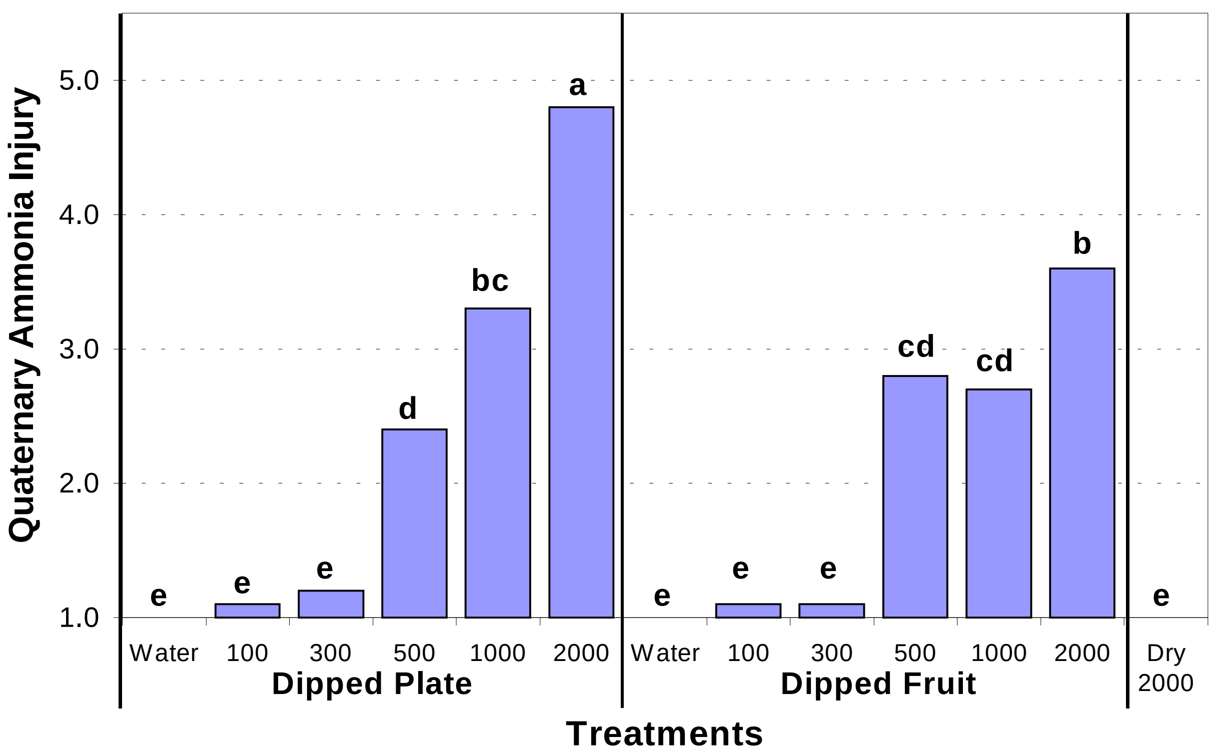


Figure 2. Peel injury on 'Marsh' white grapefruit that were dipped in quaternary ammonia solutions or placed on plastic petri plates dipped in quaternary ammonia solutions. Quaternary ammonia concentrations are indicated as 100, 300, 500, 1000, and 2000 ppm. For the "dry" treatment, remaining quaternary ammonia solution on dipped petri plates was dried before fruit were placed on the plate. Bars associated with different letters are significantly different by Duncan's multiple range test at $p<0.05$.

Conclusions

- Quaternary ammonia injury to citrus has occasionally been observed this season but currently does not appear to be a widespread problem.
- To reduce potential injury from quaternary ammonia residues, rinse bins with fresh water after quaternary ammonia treatments in the packinghouse. Alternatively, sanitize bins with 200 ppm chlorine (pH between 6 and 7.5) instead of using quaternary ammonia.
- Contact with quaternary ammonia solutions of 500 ppm or greater or their re-dissolved residue can result in blemishes on grapefruit peel. Most bin rinse operations reduce residual quaternary ammonia concentrations to below this level.
- Assure that the top manifolds of grove canker spray stations are turned off when trucks hauling fruit exit groves so that only the truck undercarriage, and not the fruit, receives the sanitizing treatment. Application directly to the fruit can result in severe damage.
- Contact of dry fruit with dry quaternary ammonia residue does not normally result in peel injury.

Chlorine Use In Citrus Packinghouses

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Introduction

Many postharvest decay problems result from the ineffective sanitizing of packinghouse dump tanks and flumes. Even healthy looking products from the field can harbor large populations of pathogens, particularly during warm, rainy weather. Pathogens present on freshly harvested citrus accumulate in recirculated water handling systems. When citrus comes in contact with water containing pathogens, fruit often become infected and subsequently decay during shipping and handling.

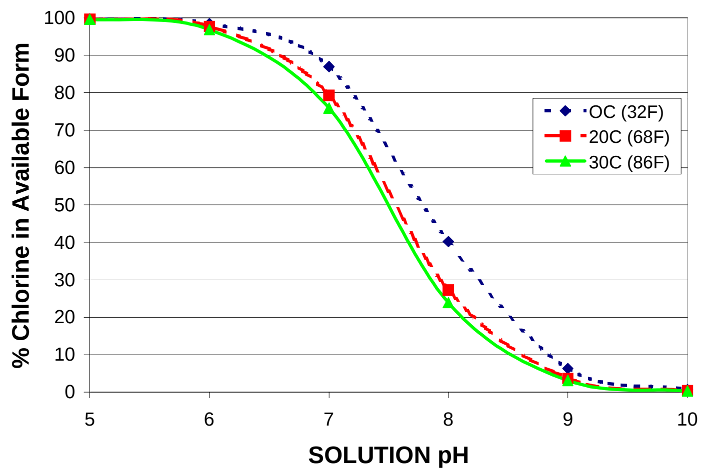
Although many packers routinely add chlorine to their water handling systems, failure to follow the IFAS guidelines for packinghouse water sanitation may greatly reduce the effectiveness of this treatment in reducing postharvest decay. **For citrus, IFAS recommends maintaining a minimum concentration of 75 parts per million (ppm) of free chlorine and pH between 6.5 and 7.5.** Recent studies suggest that greater than 100 ppm chlorine is needed to effectively kill some pathogens in dump tanks. There is a good possibility that decay problems will arise during handling and shipping whenever product contacts recirculated water that is not maintained under these conditions. In this article, we outline principles for effectively using chlorine for water sanitation.

Forms Of Chlorine

The main forms of chlorine used in packinghouses are sodium hypochlorite (NaOCl), calcium hypochlorite ($Ca(OCl)_2$) and chlorine gas (Cl_2). Sodium hypochlorite is typically sold as 12 to 15 % solutions. Calcium hypochlorite usually is sold as a powder or tablets in formulations of 65%. However, it does not dissolve readily (especially in cold water) and undissolved particles can injure fruits and vegetables. To prevent this, dissolve the powder or granules in a small amount of warm water before adding it to the tank. If using tablets for continuous, slow release of chlorine, ensure that the tablets are placed where water circulates well around them. Chlorine gas comes in pressurized gas cylinders and should be handled with caution according to label instructions.

Factors Influencing Chlorine Activity

Water pH: When sodium hypochlorite is added to water, it forms sodium hydroxide (NaOH) and hypochlorous acid (HOCl). All three forms of chlorine produce hypochlorous acid (also called available chlorine or active chlorine). **Hypochlorous acid is what kills pathogens**. In high pH solutions, most of the hypochlorous acid disassociates to form hypochlorite ion (OCl-) which is not an effective sanitizer. Testing kits for free chlorine measure both hypochlorous acid and hypochlorite ion and alone do not indicate the quantity of available chlorine that kills pathogens. Chlorine solutions with pH above 8 are relatively ineffective against pathogens. Below pH 6, chlorine is more corrosive to equipment and activity is rapidly lost. **A pH of around 7 will maintain about 80% of the chlorine in the available (hypochlorous acid) form with very little gas formed (see insert)**. Thus, in order to know the sanitizing strength of one's chlorine solution, **both pH and free chlorine must be measured**.



Both water source and form of chlorine used will affect pH management. Fresh water in Florida may have a pH above 8.0 due to dissolved calcium carbonate. Adding either sodium hypochlorite or calcium hypochlorite will increase pH, while adding chlorine gas will decrease pH. After adding commercial chlorine, adjust the pH of the water to 7 by adding either acid or base. Muriatic (HCl) or citric acid are commonly used to lower pH while sodium hydroxide (lye) will raise pH. The pH of water can be determined by using an electronic pH meter or color-changing paper indicator.

Chlorine concentration: Although low concentrations of hypochlorous acid (< 40 ppm) have been reported to kill most pathogens within 1 minute, higher concentrations (75-150 ppm) are commonly used to compensate for various losses of available chlorine in the tank.

Exposure time: High available chlorine concentrations kill pathogens after short exposure times (< 1 min.). At lower concentrations, more contact time is required to kill the pathogens.

Amount of organic matter in the water (e.g. fruit, leaves and soil): Organic matter in the water will inactivate hypochlorous acid and can quickly reduce the amount of available chlorine. Chlorine which combines with organic matter is no longer active against pathogens but may still be measured by total chlorine testing kits.

Water temperature: At higher temperatures, hypochlorous acid kills pathogens more quickly but is also lost more rapidly due to reactions with organic matter.

Type and growth stage of the pathogens: Although germinating spores and mycelium are relatively easy to kill, spores are much more resistant to chlorine, and pathogens growing inside citrus tissue (inside wounds or as quiescent infections) are shielded from the chlorine and not killed.

Maintaining Adequate Chlorine Concentrations

Chlorine must be continuously added to the water to replace chlorine lost to reactions with organic matter, chemicals, microorganisms, and the surfaces of citrus fruits. There are several ways to maintain adequate chlorine concentrations. Equipment is available to automatically measure free chlorine concentrations and to add chlorine to the water when needed. Moreover, certain types of systems also automatically maintain the proper pH range. Automated dispensing of chlorine products requires frequent measurement of the chlorine concentration to verify proper operation. Managers must be vigilant with systems designed to dispense chlorine at a uniform rate because the chlorine demand can change abruptly due to factors such as the amount of sooty mold present. Manual addition of chlorine products can be used if the manager is diligent in measuring and adjusting chlorine concentrations and pH. Samples should be taken on an hourly basis.

Chlorine Test Kits

Make certain the test kit measures free chlorine (not total) and be familiar with the concentration limits of the kit. Swimming pool-type kits usually measure in the range of 1 to 5 ppm free chlorine. These kits can provide accurate measurements if water samples are diluted to the range of the kit before testing. Distilled water should be used to dilute the sample for accurate determination of free chlorine. Diluting the sample with sulfur water or water containing organic matter or other chemicals will interfere with accurate measurement of free chlorine.

Recommendations

1. Maintain a **minimum** concentration of 75 parts per million (ppm) of free chlorine.
2. Maintain pH between 6.5 and 7.5.
3. Check free chlorine and pH levels frequently. Automated systems to monitor and adjust free chlorine and pH levels may be effective, but require regular calibration and maintenance.
4. Drain the tank at the end of each day and refill with clean water.
5. Use all chemicals according to their label instructions (e.g. chlorine, muriatic acid, lye, etc.).
6. Use self-cleaning screens in dump tanks to remove large debris.
7. Consult local regulations for disposal of chlorinated water.

MIXING CHLORINE SOLUTIONS

Desired ppm of Free Chlorine	Pints of 5.25% NaOCl solution per 100 gal. of water	Pints of 12.75% NaOCl solution per 100 gal. of water	Ounces of 65% $Ca(OCl)_2$ per 100 gal. of water
25	0.4	0.2	0.5
50	0.8	0.3	1.0
75	1.1	0.5	1.5
100	1.5	0.6	2.1
125	1.9	0.8	2.6
150	2.3	0.9	3.1
175	2.7	1.1	3.6
200	3.0	1.3	4.1

To prepare a specific **free** chlorine solution (ppm) using sodium hypochlorite (NaOCl), use the following formula.

1) Determine amount of sodium hypochlorite (NaOCl) concentrate to be added to the total volume of water (units for NaOCl concentrate to add and total volume must be the same)**:**

$$\text{Volume of NaOCl to add} = \frac{\text{Desired ppm of free chlorine} \times \text{total volume in tank}}{(\text{\% NaOCl in concentrate}) \times 10{,}000}$$

2) Add calculated amount of NaOCl concentrate to tank and bring up to final volume with water.

Example

To achieve a 150 ppm free chlorine concentration in a 1,000 gallon dump tank using a 12.75% sodium hypochlorite solution.

1) NaOCl concentrate to add (gallons) $= \frac{150 \text{ ppm} \times 1{,}000 \text{ gallons}}{(12.75 \times 10{,}000) \text{ ppm}} =$ **1.18 gallons**.

2) Add 1.18 gallons of 12.75% sodium hypochlorite to 998.82 gallons of water. Adjust pH to between 6.5 & 7.5.