Introduction to Postharvest Water Disinfection Management

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Postharvest Water Applications

Postharvest Water Applications

- Pre-Cooling Operations:
  - HydroVac™
  - Ice Injection
  - Hydro-Cooling
- Wash and Dip Tanks
- Flume Wash Systems
- Spray Wash Systems
- Ice-making
- Cooling Canals

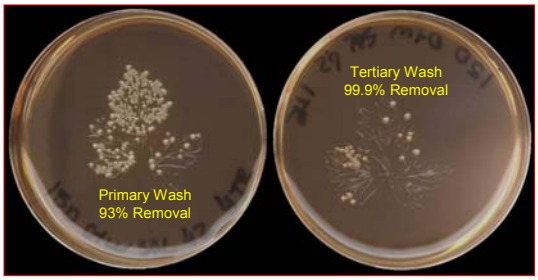
In Many Cases of Produce Related Food-borne Illness, Postharvest Water Quality at Centralized Packing Has Likely Played a Role in the Extent of the Outbreak

What is the Goal of Water Treatment?

The Predominant role of Disinfection is to prevent introduction and to minimize re-distribution of plant and human microbial pathogens in water

Reduction of surface microbial load is secondary

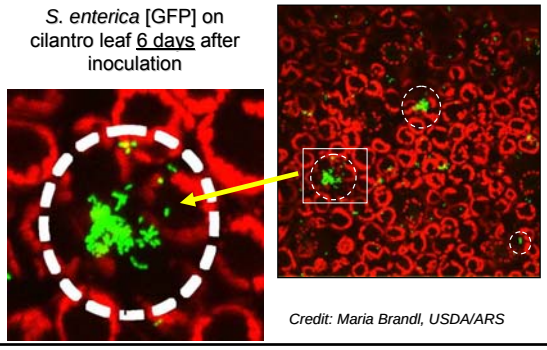
Washing Will Not Remove 100% of Firmly Attached Pathogens



Triple washed cilantro leaves

Presence of aggregates remaining attached to the plant surface after vigorous washing

S. enterica [GFP] on cilantro leaf 6 days after inoculation



Credit: Maria Brandl, USDA/ARS

Appropriate Mechanical Action Contributes to Removal of Microbes from Surfaces to Allow Disinfectants to Do Their Work

Examples

- Brush bed
- "Jacuzzi" bath
- Ultrasonic bath
- CO_2 cavitation

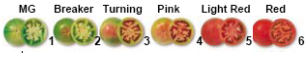
Water Infiltration to Produce May Be Significant During Postharvest Handling

Fruit pulp should be 10ºF (6ºC) cooler than water temperature to prevent infiltration.

Apples
Melons
Peppers
Spinach
Mango
Citrus

Temp
Pressure
Time
Depth
Water deficit
Vacuum

Factors in Tomato Fruit Infiltration



- More than 2 min immersion
- More than one layer of fruit submerged
- Typical weight gain < 0.2%
- Stage 1 and 2 fruit more prone than 5 and 6
- Stem scar drying promotes air barrier formation
- Fruit with stem/calyx attached behave as fresh
- Surfactants in water may increase infiltration > 1%
- Waxed fruit may absorb more water in re-pack

Proper Packing and Processing Water Sanitation is no Mystery

Proper Packinghouse Water Sanitation is no Mystery

- **Maintain consistent sanitizer levels in dump tanks and spray washers**
- **Regularly check automated sanitizer equipment during daily packing**
- **Double check automated equipment with manual methods**

Types of Water Disinfection Methods

- Non Chemical
  - Ultra Violet
  - Ultra-Filtration
- Chemical
  - Oxidizer
  - Oxidizer and Acid
  - Non-Oxidizer

Highly Purified Facility Water Reverse Osmosis and UV-C

UV and Ozone are Especially Good for Disinfection in Ice Production

The Problem
What is the right treatment level?

- Multiple chemical choices
- Multiple product types
- Diverse microbe types
- Different load throughput
- Varying wash/cooling conditions
- Different equipment designs
- Different retention times

Examples of Chemical Disinfection Options

- Chlorination
  - Hypochlorous Acid (HOCl) + ROS
  - Chlorine Gas
  - Sodium Hypochlorite
  - Calcium Hypochlorite
- Chlorine Dioxide
- Chlorobromination
- Peroxyacetic Acid
- Peroxide
- Ozone
- Copper ions + low HOCl (+ Silver ions)

Measuring Chlorination Dose

OCl- has about 1/80th the killing potential of HOCl

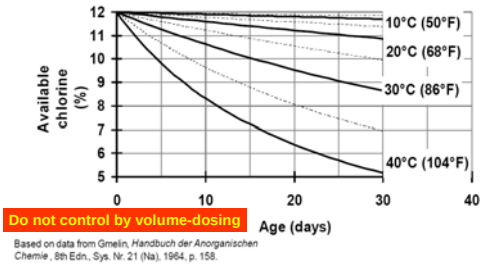
Free Cl is a mix of forms

Chlorine is Strongly Impacted by pH

Total Chlorine → Combined Chlorine
Total Chlorine → Free Chlorine → HOCl + $^{-}$OCl

pH	HOCl	$^{-}$OCl
6.5	95%	5%
7.0	80%	20%
7.5	50%	50%
8.0	20%	80%

Sodium Hypochlorite Stability Is Reduced with Heat and Light

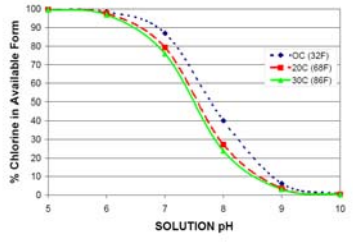


Do not control by volume-dosing

Based on data from Gmelin, *Handbuch der Anorganischen Chemie*, 8th Edn., Sys. Nr. 21 (Na), 1964, p. 158.

pH Impact is Much Greater Than Temperature

Figure 1: AVAILABLE CHLORINE (%) AT DIFFERENT pHs AND WATER TEMPERATURES



From Ritenour et al. IRREC Report - 1999-9

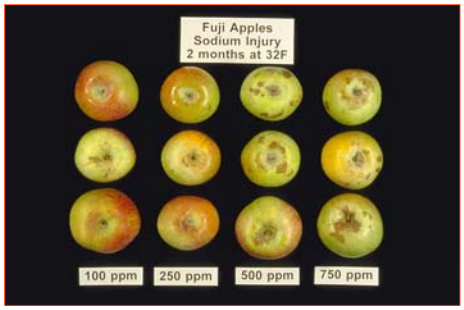
Chlorination Advantages

- Sodium Hypochlorite (liquid)
- Most widely used method
- Relatively inexpensive
- Readily available and flexible
- Easy to adopt for small-scale
- Broad spectrum of activity (yeasts, molds, bacteria, most viruses, algae)

NaOCl Disadvantages

- Potential for toxic chlorine gas formation
- Poor penetration
- Corrosive
- Irritation
- Unstable (out of pH range <6.0, high temp), short half-life
- Formation of potentially toxic by-products (THM's, chloramines)
- Potential for sodium injury

Sodium Injury from Liquid Chlorine



Calcium hypochlorite

- Controlled erosion delivery
- No sodium build-up

Hyperchlorination of Surface Water May Increase Formation of Undesirable Disinfection By-Products

Trihalomethanes

chloroform, bromodichloromethane

Known or suspected cancer inducers

Ozone < Chlorine Dioxide < Chlorine

S. Richardson, EPA

Chlorine Dioxide ClO_2

- Oxidizer 2.5x “more effective” than chlorine
- Low Sodium, Low Chlorite
- Does not form by-products THMs /DBP’s
- Does not form chloramines
- Effective at wide pH ranges

Chlorine Dioxide Generators

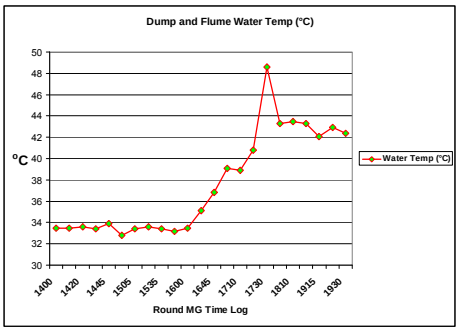
Preliminary Assessment on Efficacy of Chlorine Dioxide in Dump and Flume Water Quality Management

Michelle Danyluk, UF
Karan Khurana, Pulse Instruments, Inc.
Cooperating Tomato Packers
Trevor Suslow, UCD

POTENTIAL MICRO-LOAD FROM INCOMING TOMATO FRUIT

Fruit – average log CFU/fruit (25 fruit/sample)

Sample Location Code	PCA	ECC-TC	ECC-E. coli (presumptive)
Roma-type incoming	6.25	5.11	< 1.0
Mature Green Incoming	7.16	6.16	4.15



Dump and Flume Water – average log CFU/100 ml

Sample Location Code	PCA	ECC-TC	ECC-E. coli
Dump Tank Roma-line	< 1.0	< 1.0	< 1.0
Return Flume Roma Line	2.1	< 1.0	< 1.0
Brush spray nozzle – Roma (source water)	< 1.0	< 1.0	< 1.0
MG Round Dump Tank	2.18	< 1.0	< 1.0
MG Round Return Flume	2.58	< 1.0	< 1.0
MG Round 2nd Flume Tank	1.63	< 1.0	< 1.0

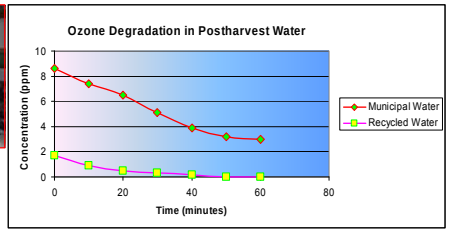
ClO_2 – 1.8 to 3.3 ppm over 5h period
pH 7.8-7.9

Ozone (O_3)

- Highly effective oxidizer
- No residual concerns
- Minimal DBP's
- Kills pathogens Cl doesn't

Ozone (O_3) Disadvantages

- Unstable (short half life)



Ozone (O_3) Disadvantages

- Unstable (short half life)
- Difficult to monitor concentrations
- Difficult to adjust needs based on demand
- May require use of secondary disinfectant
- Must be generated on site
- Worker Safety Issues, Toxicity
- Corrosive

Peroxyacetic Compounds

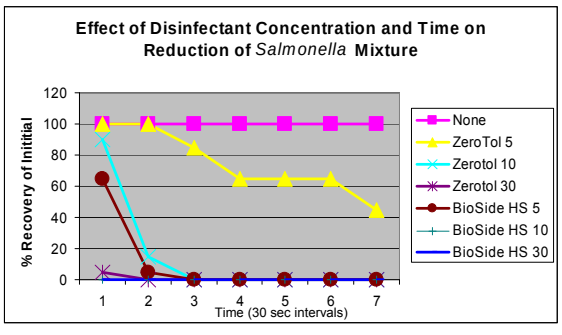
H_2O_2	+	CH_2COOH		H_3COOH
Hydrogen Peroxide		Acetic Acid	⇌	Peroxyacetic Acid

Peroxyacetic Acid (POAA) Advantages

- Less impacted by organic matter and soil
- Low foaming

Peroxyacetic Acid (POAA) Advantages

- Less impacted by organic matter and soil
- Low foaming
- Oxidizer and Metabolic Poison
- Broad spectrum of antimicrobial activity (particularly good on yeast and mold spores)
- No residue & breaks down to water,oxygen and acetic acid)
- Generally non-corrosive



Peroxyacetic Acid Disadvantages

- Corrosive to soft metals and skin
- Strong, pungent odor of concentrate and dilution (worker discomfort & safety)
- Varied activity against fungi
- Build up of acetic acid in water
- Need to monitor water turn-over closely
- Prolonged exposure to product may cause tissue damage

Copper Ionization Treatment

- **Low voltage electrodes release ions in water stream**
- **Cu ~ 300 ppb ; sometimes Ag ~ 40 ppb**
- **Research supports efficacy**
  - **Cooling towers**
  - **Ponds and pools**
  - **Well water holding tanks**
- **Very stable in 'clean' water systems**
- **Very slow acting**
- **Performance requires low (0.4-0.8 ppm) chlorination**
- **Uses in postharvest wash and cooling operations ???**

Measurement

- Spot Checking
  - Chemical Test Kit
  - Chemical Test Strips
  - Colorimeter
  - Direct Measurement Meter
- Portable ORP and pH Meter
- Fixed Continuous Meter
  - ORP and pH Meter
  - Direct Ion Sensor

Test Strips

- Fast Spot Checking
- Simple “Dip & Read” 1 Step
- Colorimetric Analysis
- Visual Reading
- Low Cost

Analysis Methods - Colorimeter

Portable Hand Meters

- Spot Checking
- Simple “Dip & Read” 1 Step
- Relatively Fast
- Higher Accuracy
- Calibrated Measurements
- Digital Reading
- Relatively Low Cost

Chlorine Sensors

Sensor flow cell

Readout

Measurement Range

0-2.00 ppm
0-20.00 ppm standard,
0-200.0 ppm optional

Monitor, Control, Document *Demand-based Disinfection*

- **Oxidation Reduction Potential (mV)**
- **Predicts Disinfection Potential**
- **Measures Disinfection Potential *NOT* ppm**
- **Single Value Assessment of Disinfection**

PUBLICATION 8149

Oxidation-Reduction Potential (ORP) for Water Disinfection Monitoring, Control, and Documentation

TREVOR V. SUSLOW, Extension Research Specialist, Department of Vegetable Crops, University of California, Davis

Large volumes of water are commonly used during the postharvest handling and processing of minimally processed fruits and vegetables. Economic considerations and wastewater discharge regulations make water recirculation a common practice in the industry. Few practices have the capacity of water recirculation to increase the potential risk of foodborne illness by readily distributing a point source contaminant (one lot, one bin, or even one plant) to noncontaminated produce.

Disinfection of water is a critical step in minimizing the potential transmis-

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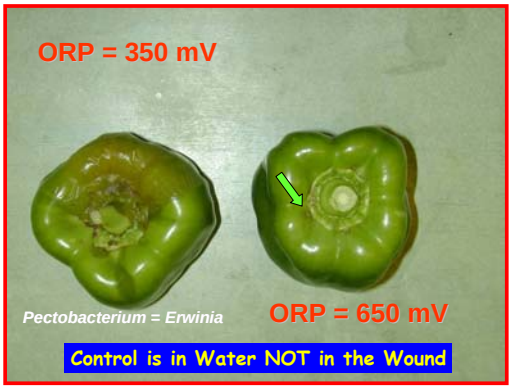
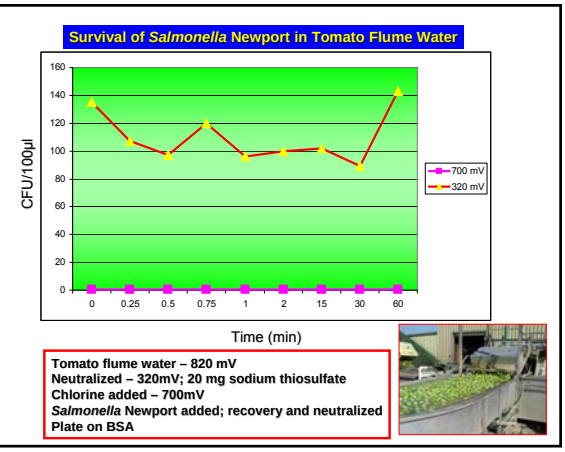
Division of Agriculture and Natural Resources
http://anrcatalog.ucdavis.edu

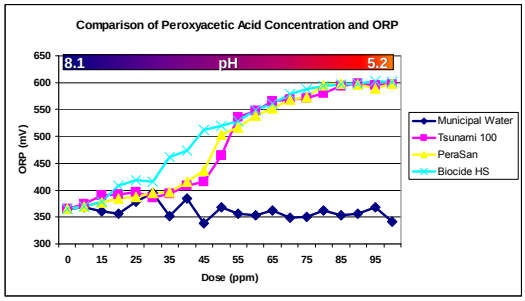
http://ucgaps.ucdavis.edu or http://ucfoodsafety.ucdavis.edu





Comparative Oxidative Disinfection Potential: *Penicillium expansum*

Treatment	pH	Free Cl	ORP (mV)	% Spore Kill 15 secs	% Spore Kill 5 min
100 ppm Cl	8.2	100	698	0.9	55
100 ppm Cl	7.1	100	900	90	99.9
200 ppm Cl	9.8	201	742	20	99.9
200 ppm Cl	6.9	200	919	99	99.99
MWS	7.5	2.2	372	0.1	0.1



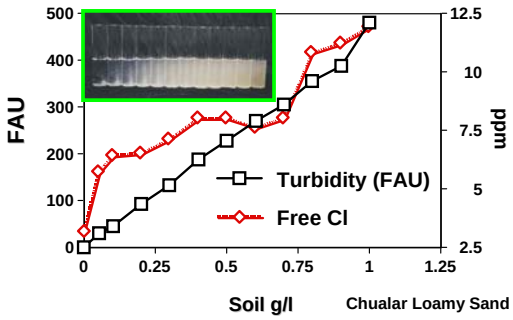
pH 5.2-8.1
Temp = 2.5C

T. Suslow UCD; unpublished data

Soil may carry pathogens and Interferes with Disinfection

Tomato Flume Water Clarity (FAU = NTU)

HOCL Needed to Maintain ORP 750 mV

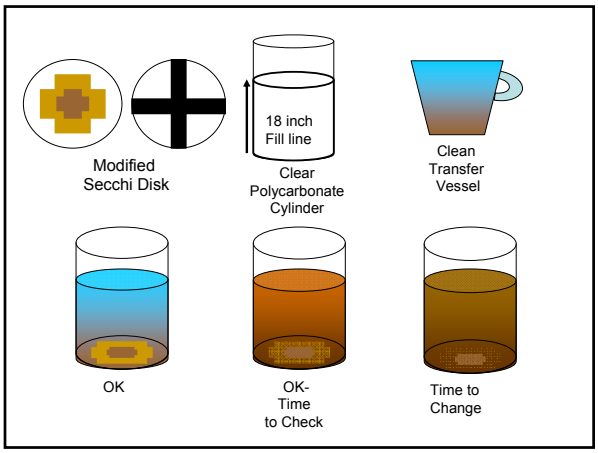


	Flume Line Shed A	Flume Line Shed B
Quality Turbidity (FAU)	3060	333
Conductivity	1558 mS	721 mS
pH	7.2	6.4
Free Cl	55	12
ORP	420	825
Total fecal coliform	log 5.4 CFU/100ml	< 0.9 log CFU/100ml

Investment in Filtration and Sedimentation Makes All Recirculating Systems Perform Better

Self-purging filtration

Flume Flocculant



Take Home Messages

- ❖ **The potential risks of waterborne contamination demand special attention for Quality and Safety**
- ❖ **Select disinfectant on microbial reduction objectives**
- ✓ **Weigh the pros and cons of each sanitizer to find the one that's right for your operation**