Water Sanitation using Chlorine

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Common Sanitizers

- Chlorine is the most widely used in fresh fruit & vegetable operations
- Chlorine dioxide ('Sanova', 'Oxine', etc.)
- Peroxyacetic acid ('Tsunami') - less affected by organic load & pH
- Ozone and UV are used to some extent in fresh-cut operations
  - More effective treating clear water

Benefits of Chlorination

- Relatively inexpensive (Cl_2 least expensive)
- Can effectively reduce pathogen populations
- Reduces the transfer of decay organisms to healthy fruit

Sources of Chlorine

- Sodium hypochlorite (NaOCl)
  - Liquid (5.25, 12.75, or 15%)
- Calcium hypochlorite [$Ca(OCl)_2$]
  - Solid (65 or 68%)
- Chlorine gas (Cl_2)
  - Gas cylinders

Factors Affecting Chlorine's Effectiveness

- Water pH
- Chlorine concentration
- Contact time
- Organic matter
- Water temperature
- Type & growth stage of pathogen

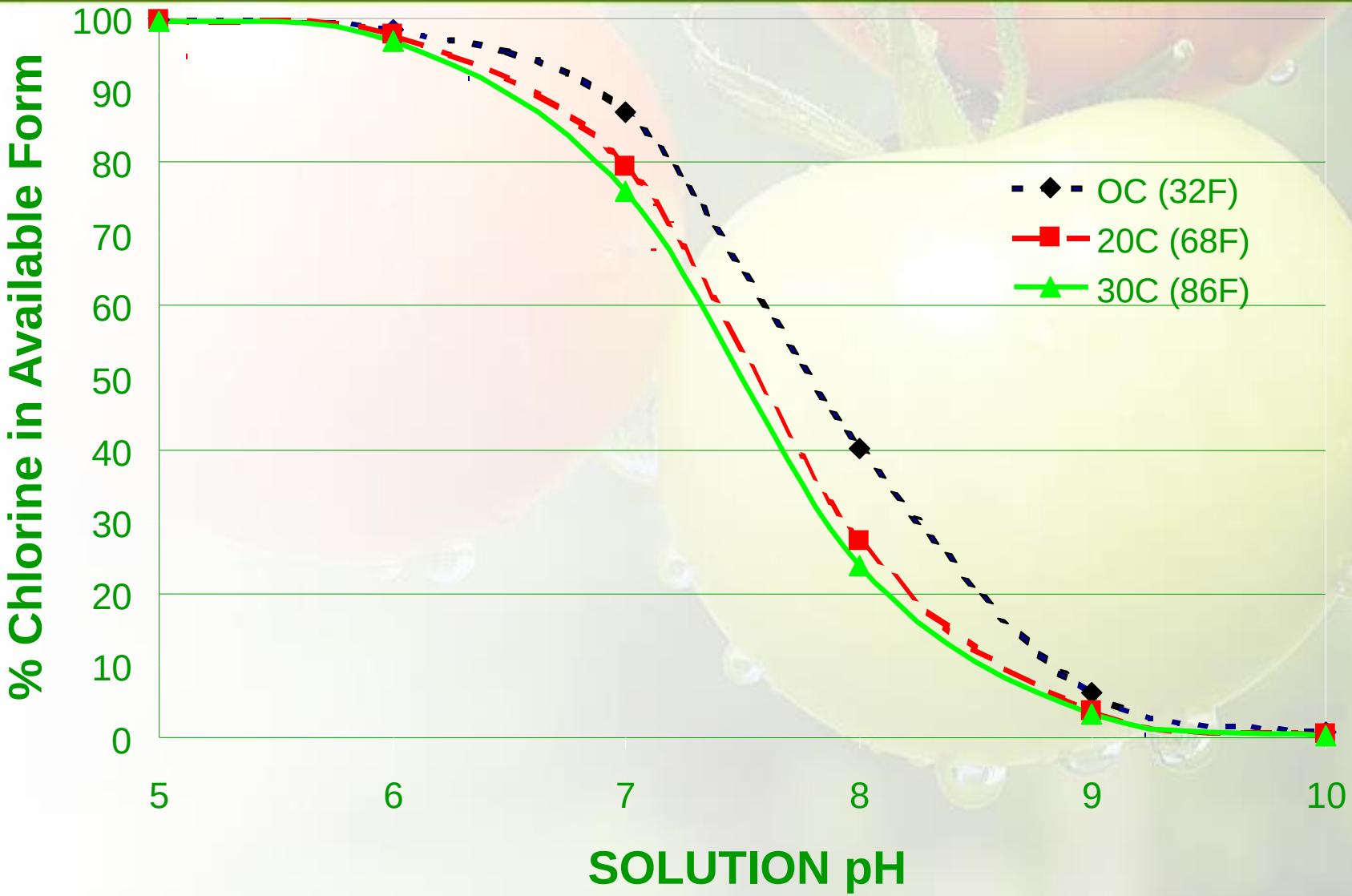
Water pH

- Hypochlorite and Cl_2 form hypochlorous acid (HOCl).
  - Hypochlorous acid is what kills pathogens

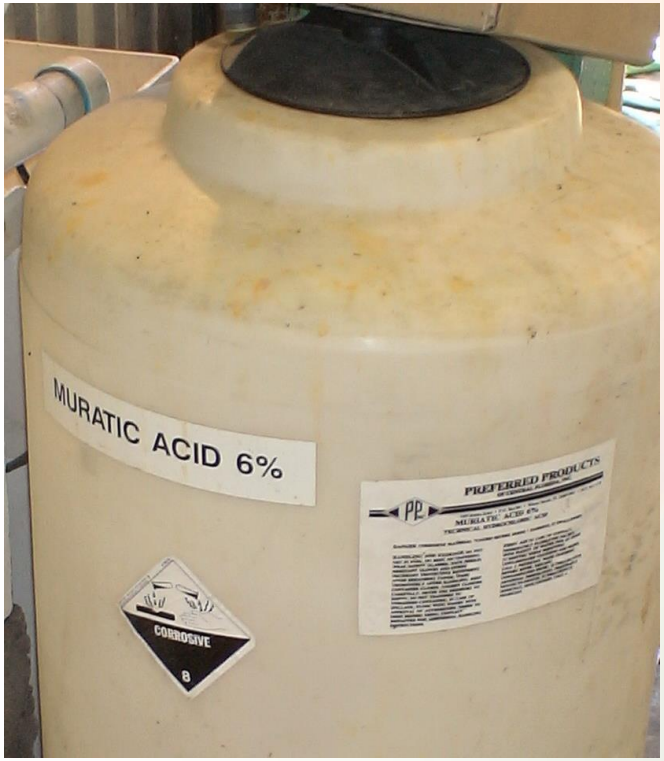
$NaOCl$
$Ca(OCl)_2$ =>
Cl_2

High pH

- At high pH, hypochlorous acid converts to hypochlorite ion (OCl^-)
  - Hypochlorite ion is relatively ineffective against pathogens


% Chlorine in Available Form
100
90
80
70
60
50
40
30
20
10
0
5
6
7
8
9
10
SOLUTION pH
OC (32F)
20C (68F)
30C (86F)

Adjusting pH



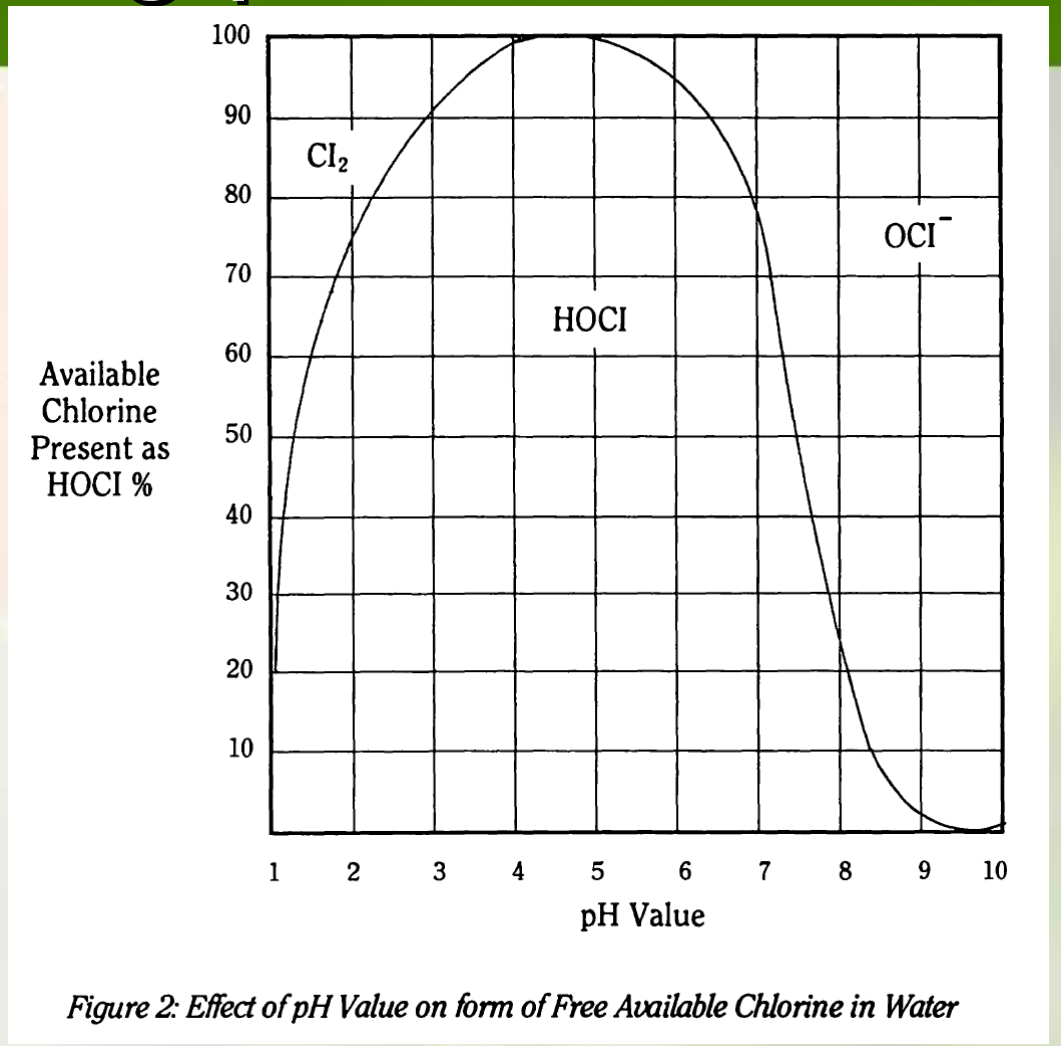


Figure 2: Effect of pH Value on form of Free Available Chlorine in Water

- Recommended pH is between 6.5 & 7.5

1983 Chemistry & Control of Modern Chlorination - Palin

Chlorine Concentration

- Relatively low chlorine concentrations (< 40 ppm) can kill pathogens
- Higher concentrations are commonly used to compensate for various losses
- Recommendation: 100 to 150 ppm free chlorine

Contact Time

- Higher chlorine concentrations kill microbes faster (e.g. < 1 min)
- Lower chlorine concentrations require longer exposure time
- More resistant microbes or stages of growth may require longer exposure times to kill

Organic Matter

- Organic matter reacts with chlorine and quickly reduces the amount of chlorine available to kill microbes
- However, this chlorine may still be measured by total chlorine testing kits

Biofilms

- Biofilms are sticky to slimy accumulations of fungi and bacteria that accumulate and grow on damp or wet surfaces
- Regular cleaning and sanitizing will prevent their formation, but cannot penetrate and remove existing biofilms
- Existing biofilms can only be removed by scrubbing

Temperature

- At higher temperatures
  - kills microbes faster
  - more rapid loss of chlorine activity
- Temperature differences between product and water can lead to internalization

Type and Growth Stage

- Bacteria, and germinating fungal spores and mycelia are relatively easy to kill with chlorine
- Quiescent spores are much more resistant to chlorine
- Microbes inside fruits and vegetables are protected and will not be killed

Chlorine Recommendations

- Maintain free chlorine levels between 100 to 150 parts per million
- Maintain pH between 6.5 and 7.5
- Drain tanks often (e.g., daily) and refill with clean water
- Use self-cleaning screens in dump tanks to remove large debris and organic matter

Maintaining Adequate Chlorination

- Manual monitoring and addition of chlorine
  - Requires frequent monitoring of chlorine concentrations and pH
- Automated chlorine dispensing
  - Timed release or based on measured chlorine concentrations or ORP
  - With or without automatic pH adjustments

Chlorine Test Kits

- Use kits that measure **free** chlorine levels
  - Total chlorine kits can measure both free and bound chlorine
  - If sample dilution is required, dilute with distilled water

Chlorine Recommendations

- Check free chlorine levels often or use automated systems
- Use all chemicals according to their labels
- Consult local regulations for disposal of chlorinated water

Demonstration

- Calculate volume of chlorine (sodium hypochlorite) needed to give a desired ppm
- Observes effects of pH and organic matter on the free chlorine levels in solution

How much NaOCl to add?

Volume of NaOCl to add

=

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

Example

- Using 5.25 % NaOCl
- Desire 100 ppm Cl solution
- Total solution volume 500 gallons

Example

Volume of NaOCl to add

=

$$\frac{\text{100 ppm of free chlorine X 500 gallons}}{\text{5.25\% NaOCl X 10,000}}$$

= 0.95 gallons

How much NaOCl to add?

- Add 0.95 gallons of 5.25% NaOCl solution to 499 gallons of water

Effects of pH and Organic Matter on Free Chlorine Levels

- De-ionized water only

Effects of pH and Organic Matter on Free Chlorine Levels

- De-ionized water with 0.95 ml of 5.25% NaOCl solution
- What form is the NaOCl in?

Effects of pH and Organic Matter on Free Chlorine Levels

- De-ionized water with 0.95 ml of 5.25% NaOCl solution
- pH adjusted to 7.5
- What form is the chlorine in now?

Effects of pH and Organic Matter on Free Chlorine Levels

- De-ionized water with 0.95 ml of 5.25% NaOCl solution
- pH adjusted to 7.5
- Then tomato juice added

Thank You!

- For more information,
  visit the UF Postharvest Website

  http://irrec.ifas.ufl.edu/postharvest/