Sanitation and decay control: preharvest and postharvest procedures

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Definitions

- Sanitation = prevent/reduce contamination on fruit
- Contamination = undesirable/hazardous residues on fruit
- Residues = microorganisms, chemicals, inanimate particulates (dust, soil, dried spray deposits)
- Undesirable = all inclusive term meaning a threat to a product’s postharvest life, appearance or wholesomeness
- Hazardous = that portion of undesirable that affects postharvest life (decay) or its wholesomeness (food-borne infections, pesticide residues)
- Microorganisms of concern for peaches = fungal decay pathogens, bacterial human pathogens, viral human pathogens
Sanitation versus sterilization

Many forms of contamination cannot be eliminated
- Latent infections by decay pathogens
- Insoluble/systemic chemical residues
- Food-borne agents that have internalized

With effective sanitation, hazard threats are minimized

Sterilization?
- Doesn’t eliminate chemical residues
- Consumers don’t want “cooked” or “nuked” peaches
Decay control

- Postharvest diseases of stone fruit
  - Brown rot (*Monilinia fructicola*)
  - Rhizopus rot (*Rhizopus stolonifer*)
  - Gray mold (*Botrytis cinerea*)
  - Gilbertella rot (*Gilbertella persicaria*)
  - Sour rot (*Geotrichum candidum*)

- Control means to take steps to prevent loss of profits or even loss of investment

- Control steps may be considered “multiple hurdle” as each step results in a benefit and together the benefits add up.
Postharvest decays and their control

- Brown rot
  - May start as a blossom blight
  - Cankers may form on twigs
  - Blossom blight and twig cankers are important source of inoculum for fruit infection
  - Fruit can be infected with green but disease may not appear until fruit ripen
  - Probably the most important postharvest disease of stone fruit but Florida said not to have much problem, likely do to dry conditions at the time of blossoming and later at ripening.
  - However, inoculum will increase if orchard sanitation not practiced
Photos of brown rot

http://ipmguidelines.org/TreeFruits/content/CH05/default-2.asp --Clemson University
Conditions that favor brown rot

- Warm, rainy periods at blossoming or ripening to harvest (70-77°F)
- Blossom blight
- Wounds
  - Insects
  - Weather events
  - Harvest
  - Handling
Controlling postharvest brown rot

- Eliminate sources of initial inoculum—includes removal of mummies, aborted fruit, pruned fruit (those removed after pit hardening), unharvested fruit, avoiding wild prunus species, cull fruit
- Control disease in the field
- Schedule harvests according to recommendations for fruit quality
- Harvest gently into clean, smooth containers
- Clean and sanitize containers between harvests
- Handle gently during packing process—if water is used for handling, washing or cooling—maintain sanitizers
- Cool promptly (according to recommendations for fruit quality)
- Postharvest fungicide treatments are available and can be used on small batches of fruit (dip treatments)
- Your market determines your need for control practices
Three different fungi, but similar diseases with minor but sometimes important differences

Each is a good saprophyte, living on decaying plant material—all that is required is moisture

Can survive long periods of time in dried plant residues on equipment, picking containers, cull fruit piles, etc.

Each is primarily a disease of ripe fruit, starting at wounds but moving fruit to fruit in packages.

Minor difference is that Mucor progresses in cold storage (below 40°F), whereas Rhizopus does not.

As with brown rot, warm moist weather favors these decays

Ripe fruit rots--Rhizopus rot/Gilbertaria rot/Mucor rot
Ripe fruit rots

Rhizopus nest—Syngenta

Gilbertaria—Clemson U.
Controlling ripe fruit rots

- Eliminate initial inoculum (sanitation)
  - Clean plant residues off of equipment, picking containers
  - Keep water used for handling, washing, or cooling sanitized
  - Keep area around fruit handling, storage or production free of cull fruit piles
- Avoid wounds during harvest and handling
- Cool fruit promptly (as dictated by proper fruit handling)
- Avoid accumulating ripe to over-ripe fruit in storage areas
- Practice appropriate inventory control—"first-in/first-out"
- Fungicides are available for controlling these pathogens—applications maybe made pre or postharvest
- Market determines the need for and complexity of treatments
Sour rot

Pathogen infects wounds but not a major postharvest disease—lesions have a sour odor
Gray mold

- Caused by *Botrytis cinerea*, which has a wide host range
- Favored by moist cool weather.
- Coastal areas of California, Oregon, Washington where fogs are common, have more problems with this disease than elsewhere (cool, wet springs).
- Can grow at temperatures below freezing (but not in frozen tissue), however cool storage temperatures are a major control measure.
- More likely to occur during longer storage periods.
- Fungicides for preharvest or postharvest applications are available
- As with the other diseases, the need for control measures depends on market.
Any commodity that is consumed raw, has a potential of being unwholesome.

As a tree fruit, peaches have a much lower potential of being contaminated with potential human pathogens than are crops grown near the soil—fewer “critters” and little or no rain-splash.

Worker and equipment sanitation is the only major issue here and these are not subject to weather events.
Water and equipment sanitation

- The most important consideration is that any water used to sanitize equipment or peaches during handling must be potable prior to adding a sanitizing agent—pond or ditch water can harbor parasites that are not readily killed by sanitizers.
- Water sanitizers (these should be present in water used to wash equipment and containers).
- With equipment sanitation, sanitizers will not readily penetrate deposits of debris—surfaces must be clean before they are sanitized.
Sanitizers

Three types of chemistry are readily available for use by packingsheds and growers:

- Chlorine
- Chlorine dioxide
- Peroxyacetic acid

There are others that are in various stages of development but are not widely used:

- Electrolyzed salt water
- Cupric ions
- Ozone
- Combinations of specific surfactants and an organic acid
When added to water, free-chlorine producers dissociate into $\text{Cl}_2$, $\text{HOCl}$, and $\text{OCl}^-$ and are called free-available chlorine (FAC). The ratio is determined mostly by the solution pH.

- At pH 7.5, HOCl and OCl$^-$ are equal in concentration.
- At pH 6.0, ca. 97% is HOCl.
- Least corrosion is with pH around 7.0
- HOCl is between 20 and 300 times more active against microbes than OCl$^-$.
- There’s very little Cl$_2$ in the water unless the pH drops well below 5.0—500 ppm FAC has 0.26 ppm Cl$_2$ at pH 4 and < 0.000 ppm at pH 7.0
- Microbes do not become “resistant” to free chlorine and HOCl does not penetrate to and react with the cells' DNA!
Sources of free available chlorine

- Hypochlorite salts (OCl-) are manufactured by bubbling chlorine gas through a strong base such as NaOH, or CaO and are sold as liquids (5.5 to 15% NaOCl) or a solid [(Ca(OCl))₂].
- The stability of liquid chlorine products decreases as the OCl- concentration and storage temperature increases (half-life of 10% solution at 140°F is 3.5 days!). Drums of product should not be exposed to direct sunlight!!!!!!
- Strong solutions (> 500 ppm) are a good cleaner for protein and fatty materials on metal or plastic surfaces — and with ample product and contact interval those surfaces will be sanitized!
- Accumulation of Na can become a problem during treatment of peaches
Solid hypochlorite products

- Usually = Ca(OCl)₂
- Free chlorine in flakes or pellets is released as the solid dissolves.
- Since these products can ignite paper or other combustibles, the storage must be well ventilated and relatively cool.
- Add fewer salts to the water than liquid bleach but in certain types of water, the Ca cation can cause precipitates.
- pH is less affected by the solid products as compared with the liquid products.
- Particles from undissolved solids can burn spots on fruit surfaces and are a particular problem in hydrocoolers.
Liquid chlorine

- Elemental chlorine ($\text{Cl}_2$) under pressure
- Least expensive form but due to handling and safety concerns usually used only by large users (municipal water plants) who can handle railcar loads.
Free chlorine (dissociated molecules of chlorine in water) is dynamic, constantly reacting with particulate matter, chemicals and fruit surfaces entering a water system. The results of these reactions are chloride ion and various chlorinated compounds. Some of these products are considered hazardous to the environment such that there are restrictions on disposing spent handling water.

On the positive side, there is no residual on treated fruits or vegetables. The chlorinated organics, which are considered hazardous, are volatile.

Chlorine molecules that have not reacted are called free available chlorine. A free available chlorine concentration of about 100 ppm is usually recommended for hydrocoolers.
Maintaining a chlorine sanitizer

- Chlorine gas acidifies water when it dissociates, substantial bicarbonate buffering needs to be present where the gas is introduced, a Clemson bulletin indicated a bed of oyster shells was frequently used.
- Hypochlorite solutions are at a high pH (makes them more stable). Acidifiers (food grade muriatic or citric acids) can be slowly added down stream of the hypochlorite input but everything should be well-mixed and before fruit enter the water.
- Product additions can be manual or automatic and based on continuous or manual measurement.
- ORP (oxidation reduction potential) offers a continuous read/continuous product addition system, but sensors can become fouled so periodic hand measurements are recommended. ORP is most sensitive at low concentrations but at high Cl₂ concentrations some fluctuation is not as important as maintaining the set point.
Alternative sanitizers

Peroxyacetic acid (peracetic acid)
- Mixture of hydrogen peroxide and acetic acid – requires good venting due to strong vinegar odor
- Concentrated solutions must have special vented container to prevent gas build up
- Effective against bacteria over a fairly wide range of pH levels – up to about 7.5
- Efficacy against decay fungi is unknown – peroctanoic acid is better for controlling fungi
- Good for control of biofilms
- More expensive than water chlorination
More alternatives

- **Ozone**: considered GRAS by FDA—a process not a chemical—but FDA does not have jurisdiction over fresh product packinghouses
- Stronger oxidizer than chlorine
- Doesn’t produce chlorinated chemicals
- Much less stable than chlorine
- Not very water soluble, does dissociate, off-gassing a problem
- Effect on nickel in stainless steel dump tanks unknown
- Requires special ventilation over tank
- Can be applied through a spray bar
- Does it provide protection against cross contamination at fruit entry—can one keep a sufficient residual at that point in system and will that residual kill fungal contamination?
- Is it labeled for use by the EPA?
Accumulation of molds on heat exchangers, walls, etc. can affect efficiency. Solutions include:

- Ozone generator
- Chlorine dioxide generator
- Chlorine dioxide packets

  - All three are available for odor control
  - Ozone has a label for sanitizing surfaces in the room
  - Odor control likely includes reducing fungi, etc. on heat exchangers
  - Ozone reacts with ethylene
  - Ozone (and likely chlorine dioxide) reduces aerial development of fungi which includes sporulation