

PACKING FLORIDA'S FRESH CITRUS FRUIT ORGANICALLY

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Abstract. Florida packers of organic fresh citrus fruit face some obstacles unique to this growing area. Practical methods of dealing with these are discussed. Some promising new methods are being developed. Some of these are highlighted along with their possible future application.

With a growth rate of approximately 20% a year, organic food is the fastest growing sector of the food market (OTA, 2005). Of that sector, fresh produce accounts for approximately 50% of the total. Acceptance and demand has grown to the extent that most large chain retailers have an organic section in their produce department. Europe is experiencing similar increases (Sansavini, 2004).

Interest in organically grown produce has a long history. Pesticides applied before and after harvest have caused some to be concerned about their possible health effects. Many give this as the main reason that they are willing to pay higher prices for organically produced foods. In a related case many foreign produce buyers are requesting "Chem-Free" citrus from Florida packers. There is no universal standard for Chem-Free, but this is usually defined as citrus packed without the use of artificial pesticides. In this way the packer of Chem-Free fruit will need to take the same precautions as the packer of organic fruit.

In 2002 the National Organic Program (NOP) became law in the United States. Before this, the definition as to what constituted organic was left up to the producer with little or no oversight. Some organizations set standards but many of these were influenced by local opinions with little consistency. Membership in these groups was purely voluntary. This law established standards for organic production and provided penalties for those not adhering to these (Anonymous, 2005).

The reliance on conventional pesticides in growing and packing Florida's fresh citrus has resulted in handling practices that can promote postharvest decay to the extent that the packer deprived of these could face disastrous losses. However by applying the lessons learned early in the 20th century, packers might well avoid the worst of these (Hall 2003).

Florida's growing conditions are unique when compared with those of the other major citrus producing areas of the United States. The hot wet summers, and warm dry winters of Florida result in a different set postharvest pathogens causing the main losses. For example, Florida's main postharvest disease is Stem-end Rot caused by either *Diplodia natalensis* or *Phomopsis citri*, where as in California the majority of losses are caused by either *Penicillium digitatum* (Green Mold) or *Penicillium italicum* (Blue Mold). While Green Mold is encountered in Florida,

Blue Mold is a rarity and by the same token the 'stem-end rots' are seldom, if ever a concern in California.

While the options available to the packer are limited, applying some general principles will greatly improve packout and survival during the market period. The causes of loss to decay can be broken down into three main factors; the presence of the pathogen, the condition of the host (the citrus fruit) and the environment. The three are sometimes referred to as a loss triangle. Break one leg, the triangle collapses, and loss does not occur. Since it is impossible to perfectly control any of these factors, one must develop an approach that will minimize their impact.

Pathogen. In addition to 'stem-end rots' and 'green mold', other important postharvest pathogens of citrus are 'sour rot' (*Geotrichum candidum*) and 'anthracnose' (*Colletotrichum gleosporioides*). These fall into two main categories, quiescent infections and wound pathogens. Controlling decay caused by these calls for two different approaches. With quiescent infections, spores of the pathogen are already present on the fruit in a dormant state. They are awaiting some trigger to stimulate growth and infection. Wound pathogens encountered in handling the fruit require a wound in order to enter the fruit. Once established, these will produce toxins further wounding the fruit and promoting infection. By controlling the presence of the pathogen, the environment the fruit is held in, and the condition of the fruit (host), postharvest decay can be controlled at an acceptable level with the use of synthetic pesticides.

Penicillium. 'Green mold' is a wound pathogen that usually propagates by means of airborne mold spores. The other major wound pathogen is 'sour rot' which propagates through water borne spores. Decay from these organisms can be kept down by handling practices, packinghouse sanitation and acceptable postharvest treatments.

The 'stem-end rots' and *Alternaria* infections occur while the fruit is on the tree. Acceptable control of these decays is dependent upon cultural, harvesting and environmental conditions. At present there are no proven and acceptable post-harvest treatments for these decays.

Control. If the packer is also the grower and harvester, there is much that can be done to reduce the risk of loss to decay. Both the 'stem end rots' and *Alternaria* depend upon dead wood in the tree as a base for producing the spores that infect the fruit (Fawcett, 1936; Timmer et al., 1998). Removing dead wood from the trees has been demonstrated to reduce decay (Ismail and Zhang, 2004). If the fruit can be harvested without its button a large percentage of the 'stem-end rot' spores will be left behind. It is also during picking and hauling that a great number of injuries occur, providing access for the wound pathogens. Gentle handling at this point can pay off handsomely for the packer (MacRill, 1971).

Once the fruit reaches the packinghouse the packer should make every effort to control the environment to which the fruit is exposed. Fruit should be promptly brought out of direct exposure to the sun and processed as soon as possible.

When degreening is required, very careful control of the degreening environment is important. By maintaining the optimum conditions for Florida fruit of 85°F and 95+% rela-

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tive humidity (Wardowski and McCornack, 1978) the growth of Green Mold is inhibited and wounds that have occurred in harvesting and hauling are healed (Brown et al., 1978).

The level of ethylene used should be carefully controlled. Ethylene will stimulate the 'stem-end rots' and anthracnose. Since ethylene begins to effect degreening at levels as low as 0.1 ppm (Reid, 2002) the packer should be careful to keep the ethylene level below 1.0 ppm at all times. It has been demonstrated that using excessive ethylene will greatly stimulate 'stem-end rot' (Brown, 1986). As to anthracnose, the peel of a mature citrus has natural defenses against invasion by this organism. However, degreening fruit before this natural defense has developed can result in significant losses, as much as 100% of a crop has been observed (Grierson, 1994). In some cases it appears that the peel of the fruit lags behind the pulp in reaching maturity. The best indicator for the packer is to delay harvest until the fruit displays a strong color break.

Once the fruit has reached the packline, the key word is gentle. All fruit contact surfaces should be smooth. Drops should be minimized and shears should be avoided whenever possible (Miller et al., 2001). Packinghouse personnel should be alert to small twigs or other debris hanging up at places along the packline where passing fruit could become injured. 'Green mold' and 'sour rot' spores can infect injuries too small to be easily seen by the naked eye. Deliveries, brushes and water eliminators are common places for debris to collect.

Special attention needs to be given to the water eliminator section of the packline. Foam donut eliminators often serve as reservoirs of 'sour rot' spores. There are several alternatives to these donuts (Hall and Sorenson, 2006; Miller et al., 2001). The user of foam donuts also needs to be cautious with his source of supply. Some manufacturers are incorporating antifungal compounds in their formulation, these compounds could be incompatible with the NOP.

Once the fruit reaches the packers there remain some procedures that can help to reduce loss. First do not over fill the cartons. While the bulge pack is attractive to buyers, they seem to think there are getting extra fruit, it can be damaging to the fruit. Without synthetic fungicides to cover up the damage, decay can result.

Before synthetic fungicides were introduced, tissue wrapping was used to isolate a decaying fruit in the carton and prevent it from soiling or infecting other fruit (Hall, 2003). While this was labor intensive it added a measure of protection unobtainable any other way. An additional advantage to tissue wrapping was that the tissues could serve as proof of purchase for promotional programs or as a form of advertising. Some even printed recipes on the wrappers. An added feature is that tissue wrapped fruit appears to be special, when compared to other fruit. For this reason many gift fruit shippers use tissue wraps in their shipments.

Finally, the packed fruit should be placed into refrigerated storage without delay. The cooler environment will greatly retard the growth of any decay organism.

Materials

The packer that meets the standards of the NOP and has been certified by an accredited certifying agency, may use the USDA's Organic seal on their packaging. Accredited certifiers are listed on the NOP web site (Table 1).

All materials that come into contact with the fruit must be approved by an accredited certifying agency. Under the NOP all others must accept the approval granted by one accredited agency. Two organizations publish a list of the materials they have approved, the Organic Materials Review Institute (OMRI) and the State of Washington Organic Program (Table 1). OMRI is a private company that reviews materials for a fee and is not itself accredited. Certifiers relying on OMRI, in effect, are doing the certifying themselves. The State of Washington program is accredited by the NOP. Each list includes the name and contact information for manufacturers on their lists. For the fresh fruit packer these two are major sources of information on materials meeting NOP standards. Others may be found in the listings of the Organic Trade Association (Table 1).

Cleaners and coatings (waxes) meeting NOP standards are available from most suppliers of processing materials for citrus packers. The number and variety of decay fighting materials are limited. Some of these are physical and others are biological or chemical. None of these are ideal, but on the principle that something is better than nothing, some of these are described.

Sodium carbonate or bicarbonate. Exposing citrus to a 3% solution of these salts heated to 110-120°F for about three minutes has proven effective in reducing 'green mold' and 'sour rot' (Smilanick and Sorenson, 1999). While this process is common in California because of resistant mold problems, it is not being used commercially in Florida. Its largest drawbacks are that there are more effective fungicides available and disposal of spent solutions can be a problem. Another consideration for Florida is there is no track record for this treatment against the stem-end rots. However, there is a patent claiming such efficacy (Fulton and Bowman, 1925).

Lime-sulfur (calcium polysulfide). In tests conducted in California, immersion in a 3% solution of Lime-Sulfur for 3 min at 110°F, significantly reduced 'green mold' and 'sour rot' in lemons and oranges without significant phytotoxicity (Smilanick and Sorenson, 1999). Tests against other postharvest decay organisms have not been reported. The advantages of this treatment are that a formulation is currently available that has been approved by the US EPA and it conforms to the

Table 1. Useful Web Sites.

Site Name	Address
National Organic Program Main	http://ams.usda.gov/nop/indexIE.htm
NOP Accredited Certifiers	http://ams.usda.gov/nop/CeritfyingAgents/Accredited.html
National Organic Standards Board (NSOB)	http://ams.usda.gov/nosb/index.htm
Code of Federal Regulations National Organic Program 7CFR	http://www.access.gpo.gov/nara/cfr-table-search.htm (Follow links to current Title 7 Part 205)
OMRI Organic Materials Review Institute	http://www.omri.org
Washington State Organic Program	http://agr.wa.gov/FoodAnimal/Organic/default.htm

NOP. Lime-Sulfur is also approved as an organic fungicide/ insecticide for preharvest use, therefore the disposal of spent solutions may not be a significant problem.

Biologicals. The yeast *Candida oleophila* and the bacterium *Pseudomonas syringae* have been approved by the US EPA for use as postharvest treatments of citrus. These work by competing with decay organisms for nutrients and space. A third organism *Muscador albus* is in the process of approval. When growing it releases a gas that suppresses the growth of many decay organisms. Its main usefulness would be in degreening or storage rooms. The biologicals currently available have a mixed record for decay control. However, under ideal conditions they work well.

Sanitizers. By keeping the packline clean new infections can be greatly reduced. This especially true of 'sour rot'. Three products are available to the organic packer, with limitations. These are chlorine (sodium hypochlorite), hydrogen peroxide and chlorine dioxide. When used properly each is an effective sanitizer, but all are corrosive and hard on equipment.

Among the physical methods available heat and ultraviolet light have demonstrated some value. Exposure to either short wave ultraviolet or heat has been demonstrated to stimulate a natural resistance to decay (Rodov et al., 1994). Several heat treatments have been devised to take advantage of this property including hot water brushing, drenching and vapor heat (Hall, 2006).

Beside stimulation resistance to decay, ultraviolet light at 254 nm is germicidal and will destroy bacteria, yeast, and molds. *In vitro* tests with 254 nm irradiation against 'green mold' and 'sour rot' have shown promise (Fernandez and Hall, 2004)

In summary one might say there are 10 "Commandments" for the packer of fresh organic citrus in Florida. Each one attacks or weakens one or more legs of the loss triangle. They are (from Hall, 2006):

1. Harvest only fruit that do not require excessive degreening time (Host, Environment).
2. Transport the fruit to the packinghouse as quickly as possible and protect the fruit from over heating by direct sun (Environment).
3. Process the fruit (degreening or packing) with minimal delay (Host).
4. Keep the fruit in the optimum environment for the variety at all stages under the packers control (Environment).
5. Protect the fruit from injury (Host, Pathogen).
6. Keep the packinghouse as clean of decaying fruit as possible and do not allow spores from decaying fruit to drift onto sound fruit (Pathogen).
7. Keep the process line clean (Pathogen).
8. Regularly inspect the packing line for places that might cause injury (Host).
9. Do not overfill cartons (Host).

10. Cool packed fruit to the proper temperature for the variety as quickly as possible after packing (Host, Pathogen, Environment)

By applying these simple rules, the packer of fresh organic citrus can offer their customers an attractive product with the minimum of problems.

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