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PACKINGHOUSE NEWSLETTER

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Impacts of the 2004 Florida Hurricanes on Postharvest Handling of Fresh Citrus

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Hurricanes Charley, Frances, and Jeanne caused significant losses to Florida's citrus industry. In many locations, the storms knocked over trees (Fig. 1), ripped fruit from the trees (Fig. 2), injured fruit left on the tree, and damaged packinghouses (Fig. 3). Packinghouse damage was widespread, but houses in the center of the state generally experienced less damage than those on the east cost. Packing in the center of the state was generally delayed a couple of weeks as repairs were made and power was restored. Packing on the east cost was often delayed a month or more even in those houses that were not severely damaged. While orange and tangerine production are each anticipated to drop about 27% compared to last year, red grapefruit is projected to drop by 56%, and white grapefruit by 75% (Florida Agricultural Statistics Service, http://www.nass.usda.gov/fl/rtoc0ci.htm). The fruit that is left should be worth considerably more this year than in recent years.

Maintenance of Fruit Quality this Season:

As is often the case immediately following heavy rainfall leading to turgid fruit, problems with oil spotting have been reported in a few cases. This disorder is easily prevented using recommendations found in the UF IFAS extension publication, "Oil Spotting (Oleocellosis) of Citrus Fruit" that can be found on the Internet at http://edis.ifas.ufl.edu/CH119. Please contact the newsletter editor if you have trouble accessing any of the publications referred to in this update.

Fig. 1. Navel orange trees blown over by hurricane Frances. Note some fell to the south as the storm approached, and others fell to the north as the hurricane passed by and the wind shifted direction.

Though excessive water was a problem immediately after the storms, the resulting potential root damage and fall vegetative flush competing with developing fruit for water may result in greater fruit dehydration, especially as we move into the drier winter months. Careful attention to irrigation practices will be important as problems with soft fruit and stem-end rind breakdown (SERB) may become a problem in the spring. For more information on SERB, see "Stem-End Rind Breakdown of Citrus Fruit" at http://edis.ifas.ufl.edu/HS193.

Fig. 2. Fruit knocked from the trees after hurricanes Frances and Jeanne.

Fig. 3. Packinghouse Damage in the Indian River region from hurricanes Frances and Jeanne.

Reports of fruit decay have been numerous. Common early season decays due to stem-end rot (*Lasiodiplodia theobromae*), brown rot (*Phytophthora*), and anthracnose (*Colletotrichum gloeosporioides*) have been reported, in addition to wound-pathogens such as green mold (*Penicillium digitatum*) and sour rot (*Galactomyces citri-aurantii*). Excessive ethylene degreening of early season fruit can greatly increase the occurrence of stem-end rot and anthracnose. However, most packers have been paying closer attention to their decay control practices this season and so losses after packing and shipping have been relatively light. All should keep in mind the following points for maintaining optimum fruit quality.

Preharvest Fungicide Application: Thiophanate-methyl (Topsin) can be sprayed on trees 2 days to 2 weeks before harvest for good residual postharvest decay control similar to previously used benomyl. Topsin has a Section 18 registration for preharvest application to control postharvest stem-end rot in citrus. Research conducted last season suggests it also reduces postharvest decay due to anthracnose, which can be a severe problem on certain early season citrus cultivars such as 'Fallglo' tangerines. If thiophanate-methyl is applied preharvest, do not use thiabendazole (TBZ) postharvest because both fungicides break down to the same active ingredient (carbendazim) and development of resistance to TBZ is possible. For more information, see "Preharvest Fungicides to Reduce Postharvest Decay of Fresh Citrus" at http://postharvest.ifas.ufl.edu/Reprints/Preharvest%20Fungicides%202004.pdf.

Fungicide Drench: Postharvest fungicide drenches are only necessary if thiophanate-methyl was not applied preharvest and if the fruit will not be packed within 24 hours of harvest. Fungicide and free chlorine (if used) levels and drench pH must be checked often to assure proper levels. For more information, see "Postharvest Decay Control Recommendations for Florida Citrus Fruit" at http://edis.ifas.ufl.edu/CH081.

Degreening*:* If fruit must be degreened, keep degreening time and ethylene concentration at minimal levels. Whenever possible, tangerines, oranges, and grapefruit should be degreened for less than 12, 24, and 48 hrs, respectively. Ethylene concentration in degreening rooms should be kept between 3 to 5 ppm. For detailed recommendations and more information, see "Recommendations for Degreening Florida Fresh Citrus Fruits" at http://edis.ifas.ufl.edu/HS195.

Packinghouse Operations*:* Because fruit blemishes and injuries are often masked by dirt, sooty mold, etc., grading is necessary after washing to thoroughly eliminate unmarketable / injured fruit even if pre-grading was conducted before washing. Use of optimum brush and belt speeds will reduce fruit injury during the packing process. For more information, see "Packingline Machinery for Florida Citrus Packinghouses" on the Internet at http://edis.ifas.ufl.edu/AE184. Wherever possible, waxes with good gas-permeability (i.e., carnauba or polyethylene) should be used to ensure fruit do not develop postharvest pitting or off-flavors (due to anaerobic respiration). These waxes may also reduce water loss better than shellac waxes. Imazalil or TBZ fungicide (1,000 ppm in water or 2,000 ppm in wax) can be used to help control molds and stem-end rot.

***Storage and Shipping Temperature**:* After packing, tangerines, oranges, and grapefruit should be immediately cooled and shipped at their lowest safe temperature (40, 34, and 50 ^{o}F, respectively). Fruit cooled below their lowest safe temperature may develop chilling injury, while fruit held at higher temperatures will deteriorate more rapidly. For more information, see "Chilling Injury of Grapefruit and its Control" at http://edis.ifas.ufl.edu/HS191. Maximum postharvest quality and shipping life will be achieved only if fruit are not allowed to warm for even brief periods during transit and marketing.

Fresh citrus (especially grapefruit) will be scarcer this year, so make every effort to protect and care for your product. With the correct harvest and postharvest handling practices, successful shipments can bring top-dollar returns for your efforts.

Granulation of Florida Citrus

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What is granulation? Granulation (also called crystallization or section drying) is a physiological disorder of citrus resulting in reduced extractable juice ("juiciness") and sometimes vesicle shriveling (Fig. 1). While segments appear dry, the disorder is not caused by drying, but by gel formation within the vesicles. Freezing and sunburn injury can be mistaken for granulation; however, these do not result in gel formation, but in immediate cell death and actual water loss from the entire section. Freezing- or sunburn-injured fruit can be separated from sound fruit based on fruit density and water content using sizers/graders that calculate density, or by the use of near infrared (NIR) sensors. In practice, granulated fruit often contain a mixture of granulated vesicles and desiccated vesicles that make confident distinctions between granulation and vesicle desiccation difficult. This mixture of cell disorders, however, does allow separation of granulated, unmarketable fruit based on fruit density.


Fig. 1. Granulation of navel orange.

Granulated vesicles within sections are discolored with a tough texture. Individual parenchyma cells within granulated vesicles have thickened walls with secondary wall formation in severe cases. Such changes involve increased concentrations of various cell wall components (cellulose, hemicellulose, pectin, and lignin). Granulated vesicles also have elevated respiration, increased juice pH, and less soluble sugars and acids compared with non-granulated vesicles. Increased respiration is thought to fuel the various metabolic changes, especially changes in the cell wall. Other compositional changes are also evident within granulated tissue, with granulated juice vesicles containing 1.7 times the magnesium and more than twice the calcium of normal vesicles (dry weight basis). It is thought that elevated levels of pectin and calcium result in the gel formation characteristic of granulated tissue.

Many citrus cultivars such as ‘Valencia’ and navel oranges, tangerines, and grapefruit develop granulation. However, the disorder develops differently depending on the citrus species: in navel oranges, granulation often extends through the center of the fruit; in grapefruit, it develops most extensively at the stylar-end of the fruit; and in the other types, it develops first at the stem end.

Possible causes of granulation. Though granulation has been shown to develop during storage in some citrus producing regions of the world, in the United States it is considered to be a preharvest disorder. However, even in the United States, the severity of the disorder can increase during postharvest storage. For example, granulation was found to develop faster in harvested ‘Ruby Red’ grapefruit stored at 21 ^{o}C, than in fruit left on the tree. Postharvest waxing, fungicide treatments, or storage temperatures did not influence the development of granulation.

Many preharvest factors have been associated with the development of granulation in citrus. The disorder is most commonly associated with large fruit and/or advanced fruit maturity. Therefore, delayed harvest increases the risk of granulation. Production of large fruit is often caused by low fruit set which makes more plant resources (e.g., carbohydrates) available to each fruit for growth. Comparing alternate bearing cycles of citrus, more granulation has been reported during the light-bearing (“off”) years, compared to the heavy-bearing (“on”) years. Young trees often also experience greater levels of granulation, possibly due to their rapid growth (vigor) and production of fewer, but larger fruit. To reduce granulation, trees producing large fruit should be harvested early.

Growing region and rootstock have been reported to influence the development of granulation, but results vary. Granulation has also been reported to be more severe in shaded fruit, being highest in interior-canopy fruit and in tests when fruit were covered with black bags. In addition, granulation is associated more with late-bloom fruit than fruit from the main bloom.

Tree water status has been reported to affect granulation with researchers reporting less granulation with less irrigation. This effect appears to be independent of fruit size. In one block of severely granulated Florida ‘Valencia’ orange, 90% of fruit from trees receiving irrigation during drought periods developed at least some granulation, compared to only 72% of the fruit from unirrigated trees. Furthermore, in South African navel oranges, researchers reported that heavy late-summer rains enhanced granulation. Severe mite damage, and cool, dry, windy weather conditions have also been mentioned as possibly related to granulation.

As mentioned earlier, granulation is associated with lower sugar and acid levels within the fruit. Because many of the factors related to granulation also result in reduced internal sugar and/or acid content (e.g., late-bloom fruit, large fruit, high temperatures, increased fruit water content through irrigation or rain, shaded conditions, etc.), unusually low sugar and acid content may somehow provide a unifying mechanism for the development of granulation.

Removing granulated fruit in the packinghouse. Removing granulated fruit at the packinghouse can be difficult since there are no external signs of the disorder. Gel formation associated with granulation does not in itself result in measurable decreased fruit density compared to non-granulated fruit, rather, collapsed desiccated vesicles which are often intermixed with granulated vesicles do result in lower fruit density that can sometimes be used to separate severely granulated vs. healthy fruit.

In an evaluation in Florida, fruit were harvested in Oct. 2003 from two commercial navel orange blocks and run through an optical grader at a speed of five cups per second. The grader was set to separate fruit into five density classes (<0.72, 0.72-0.77, 0.77-0.82, and >0.82 g/cm^3). After the separated fruit were collected, they were cut at 0.64 cm (¼ inch) depths from the stem and categorized on the basis of granulation on a 0 (none) to 3 (severe) scale. Navel oranges from one block (Fig. 2A) all had moderately severe to severe granulation (score of 2.25 to 2.95). Though fruit grouped in the lowest density classification (<0.72 g/cm^3) were more granulated than the rest of the fruit, separation on a commercial scale would not be practical because of the severity of granulation even in the densest fruit. Granulation in the second block of navel oranges was less severe (Fig. 2B). While fruit in the least dense classifications still had moderately high granulation (score of 2.1 to 2.2), the densest fruit (>0.82 g/cm^3) had only slight granulation (score of 1.3) and may have been commercially salvageable for the fresh market.

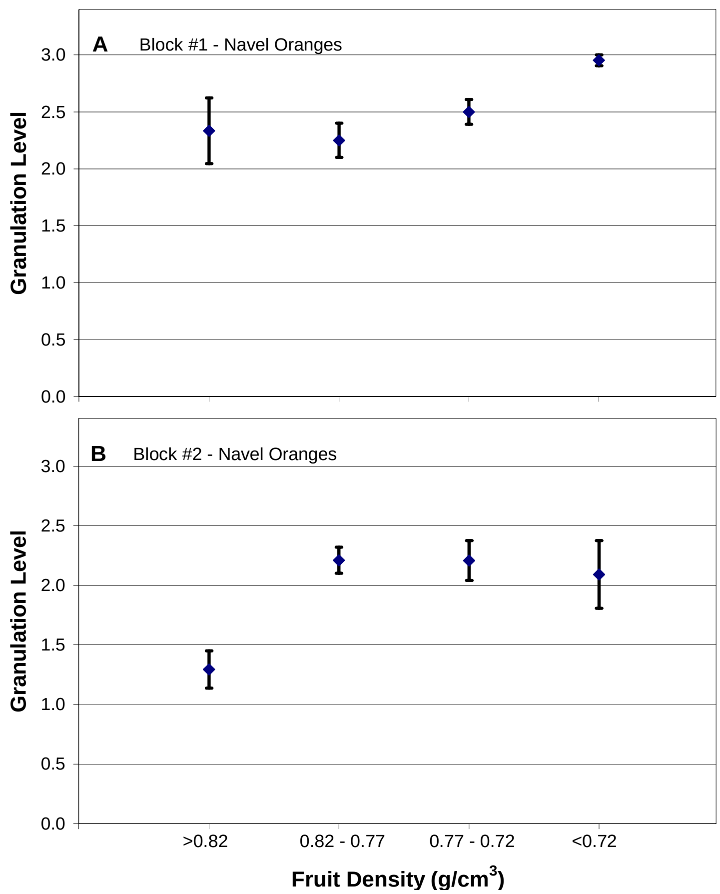

Fig. 2. Fruit density (g/cm^3) verses level of granulation ¼ inch from the stem end in navel orange from two commercial blocks ("A" and "B"). Granulation was rated on a scale from 0 = none, to 3 = severe. Vertical bars represent $\pm$ standard error.

Separation of fruit by size also serves as a useful grading criterion in removing granulated fruit, since large fruit are often more granulated than small fruit. Using automatic sizing and grading equipment to sort for small, high density fruit will result in the greatest chance of recovering non-granulated, packable fruit.

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