Grapefruit

Jacqueline K. Burns
Citrus Research and Education Center, IFAS
University of Florida, Lake Alfred, FL

Scientific Name and Introduction: *Citrus paradisi* Macf., a member of the Rutaceae family, originated in the Carribean and was introduced in Florida in the early 19th century (Gmitter 1995). The grapefruit is classified as a hesperidium, a kind of berry with a leathery rind that is divided into segments. Each segment contains hundreds of individual juice vesicles that comprise the majority of the edible portion of the fruit. Florida is the largest producer of grapefruit in the U.S., followed by Texas, California and Arizona. White and red pigmented cultivars are grown. Marsh is the predominant white cultivar. Ruby Red, Star Ruby, Henderson, Ray Ruby, and Flame are the most popular red pigmented varieties (Saunt, 2000).

Quality Characteristics: A high quality fresh-market grapefruit will have a turgid, smooth peel and be relatively blemish-free. The fruit should be elliptical and firm. An appropriate balance of SSC:TA within the edible portion should be achieved, and bitterness should be at a minimum.

Maturity Standards, Grade Standards and Packing: Marketable fresh grapefruit generally range from size 23 (23 fruit/carton) through 56 (56 fruit/carton). Grade standards for fresh grapefruit rely on color-break, texture, peel blemishes, shape and firmness. In markets that emphasize processing, grapefruit must achieve a minimum juice content and SSC/TA ratio before harvest. Grapefruit are commonly packed, stored and shipped in 4/5 bushel cardboard cartons (Soule and Grierson, 1986).

Ethylene Production and Respiration: Grapefruit is a non-climacteric fruit and does not exhibit a classic ripening pattern of increased respiration and ethylene production. The rate of ethylene production is typically < 0.1 µL kg^{-1} h^{-1} at 20 °C. Respiration rates at optimum storage temperature are generally < 10 mg CO_2 kg^{-1} h^{-1} (Arpaia and Kader, 2000).

Degreening: Degreening is necessary for marketing early-season fresh grapefruit in areas where night temperatures remain high. In these cases, 1 to 5 µL L^{-1} ethylene for periods of 12 h to 3 days is used to cause the destruction of peel chlorophyll. The recommended temperature for degreening is 28 to 29 °C (82.4 to 84.2 °F) in Florida and 21 to 22 °C (69.8 to 71.6 °F) in California, each reflecting the physiological state of the fruit grown under different climactic conditions. High RH of 90 to 95% must be maintained to avoid softening and accentuation of existing peel injuries or blemishes. One complete air change per h should enter the degreening room to avoid unnecessary buildup of CO_2 and to assist in uniform temperature and ethylene distribution (Wardowski, 1996).

Storage: Grapefruit are typically stored at 12 to 15 °C (53.6 to 59.0 °F) with 95% RH. Coatings are applied in the packinghouse to reduce water loss from the peel. However, to minimize postharvest pitting, grapefruit should be cooled immediately below 10 °C (50 °F) with 95% RH after harvest and maintained at 5 to 8 °C (41 to 46.4 °F) during transit and storage until distribution at retail outlets. High shine water waxes will minimize chilling injury and incorporated fungicides should control decay at these temperatures. At optimum storage temperatures, fruit respiration rates will be reduced and quality will be maintained up to 6 weeks (1998 ASHRAE Handbook on Refrigeration, 1998). Although some benefit of increased firmness and delayed senescence can be gained from controlled atmosphere storage, commercial use of controlled atmosphere storage for grapefruit is very limited or non-existent (Arpaia and Kader, 2000).

Physiological Disorders: The rigors of harvesting and handling grapefruit can result in development of conditions grouped under the category of physiological disorders. Other conditions can appear as a result of the interaction of fruit physiology and environmental conditions. Postharvest pitting is a peel disorder that affects waxed grapefruit stored at higher temperatures. Postharvest pitting can be reduced or eliminated by reducing fruit pulp temperature to 10 °C or less and coating fruit with high gas permeable coatings (Florida Department of Citrus, 1996; Petracek et al., 1995). Chilling injury can occur with low temperature storage, typically 5 °C (41 °F) or below. Chilling injury is characterized by peel pitting. Pitting associated with postharvest pitting is targeted to areas of the peel surrounding oil glands, whereas pitting associated with chilling injury is not targeted to oil glands (Petracek et al., 1995). Coating grapefruit with high shine water waxes reduces the incidence of chilling injury. Conditioning fruit by intermittent warming or stepwise lowering of temperature can also reduce chilling injury. Granulation, or section-drying, affects late-season grapefruit predominantly on the stem or stylar end of the segment. Granulation can be severe in larger fruit stored for extended durations (Burns and Albrigo, 1998). Granulation can be avoided by harvesting large fruit early in the season. Oleocellosis can occur during harvest when excessive squeezing force is used to remove fruit from the stem. Grapefruit harvested in the morning, when RH is high, are most susceptible because oil glands are easily broken in turgid peel. Symptoms of oleocellosis appear in the packinghouse or in storage, and can be exacerbated by degreening. Stem-end rind breakdown (SERB) is characterized by collapse and sinking of the peel in irregularly-shaped regions near the stem end. SERB is closely associated with excessive water loss. Late-season grapefruit are most susceptible to SERB. Blossom-end clearing is most commonly found in late harvested, thin-peeled red-pigmented grapefruit. The wet, translucent area that develops predominantly on the blossom end results from the leaking of juice from the segments to the peel. Blossom-end clearing can be reduced by reducing pulp temperatures < 21 °C (69.8 °F) after harvest and eliminated by avoiding high-impact handling procedures (Echeverria et al., 1999). Green ring is a physiological disorder that has recently appeared on early season grapefruit in Florida. The disorder is characterized by failure of the peel to degreen in circular areas around fruit-to-fruit contact points. The remaining green ring can become necrotic as fruit remain in storage. The incidence of green ring disappears as the fruit peel matures. Recently, interest for long-term storage of grapefruit has developed for the purposes of extending market availability. Grapefruit stored longer than 6 weeks at 3 °C (37.4 °F) may develop physiological collapse of juice vesicles (Brown et al., 1998).

Postharvest Pathology and Control: Postharvest decay can result in significant losses of grapefruit. Postharvest grapefruit decays generally fall into two categories: those that develop as a result of colonization or infection on the fruit before harvest (stem end rots, anthracnose and brown rot) and those that develop by inoculations made through wounds made during harvest or subsequent handling (blue and green mold and sour rot). Stem end rots develop as latent infections on the fruit button (calyx + disc) and begin growth through the core after harvest. The decay develops unevenly at the stem and stylar ends resulting in wavy margins. Stem end rots are a problem with grapefruit grown in warm humid climates such as Florida, but are rare in Mediterranean climates. *Diplodia natalensis* is prevalent in early season fruit when temperatures are high and degreening is used. Development of *Phomopsis citri* is favored during the Winter months when temperatures are low and degreening is no longer necessary. *Alternaria citri* is a less aggressive fungus that can be problematic in over-mature grapefruit and those in extended storage. Often the symptoms of Alternaria, internal black discoloration generally towards the stem end, are not visible until the fruit are cut. Anthracnose, *Colletotrichum gloesporioides*, is a minor problem that can appear on late-season fruit. Brown rot, caused by *Phytophthora citrophthora*, appears more frequently in mature fruit and fruit stored for longer durations at low temperatures. Green and blue mold, caused by *Penicillium digitatum* and *italicum*, respectively, invade fruit through wounds made during harvesting handling. Growth of P. digitatum is more favorable at temperatures above 10 °C (50 °F), whereas growth of *P. italicum* occurs more readily at lower temperatures. Immature fruit are resistant to sour rot (*Geotrichum candidum*) infection, but as the fruit mature, the disease can become a problem. Consequently, late-season grapefruit can become infected, especially since the disease develops more readily at temperatures above

15 °C (59 °F) (Florida Dept. of Citrus, 1996; Eckert and Brown, 1986; Compendium of Citrus Diseases, 1988).

Drenching harvested grapefruit with thiabendazole (TBZ) before packinghouse arrival is recommended for *Diplodia*, *Phomopsis*, anthracnose and *Penicillium* control. In addition, application of aqueous imazalil or TBZ in the wax treatment aids in control. Minimizing degreening time by delaying harvest will assist in controlling stem end rot caused by *Diplodia* and anthracnose. Careful harvesting and handling can reduce injuries that allow wound pathogens to enter grapefruit. Good sanitation of packinghouse equipment and storage areas will help control diseases that lack effective chemical control, such as sour rot. Generally, pre-cooling or storing fruit after packing ≤ 10 °C (50 ºF) will help control growth of postharvest pathogens.

Quarantine Issues: In areas infested with a number of tropical fruit flies, cold treatment is an approved quarantine treatment. However, grapefruit must first be preconditioned at 10 to 15 °C (50 to 59 °F) to increase resistance to chilling injury. After 1 week, temperatures can be reduced to 0.6 to 2.2 °C (33 to 36 °F) for 14 to 24 days. In areas of low fly infestation, a less stringent temp/duration schedule can be used (Florida Dept. of Citrus, 1996). The recent appearance of citrus canker (*Xanthomonas axonopodis* pv. citri) has restricted movement of grapefruit grown in affected areas in Florida. Compliance with the Citrus Canker Eradication Program (2000) is required for harvesting, packing and shipping fruit from quarantined areas.

Suitability as a Fresh-cut Product: The potential for grapefruit as a fresh-cut product is great. Peeled and sectioned grapefruit packaged in hard plastic containers have recently appeared in refrigerated shelves of Southeastern U.S. retail markets. Technological developments have overcome various postharvest problems with fresh-cut citrus. However, further development of automated systems for efficient and economical peeling is essential (Pao et al., 1997).

References:

1998 ASHRAE Handbook on Refrigeration. 1998. Citrus fruit, bananas, and subtropical fruit. Chapt. 22, Amer. Soc. Heating, Refrig. Air-Conditioning Eng., Atlanta GA.

Arpaia, M.L. and A.A. Kader. 2000. Grapefruit. Recommendations for Maintaining Postharvest Quality. http://postharvest.ucdavis.edu/produce/producefacts/fruit/grapefruit.html.

Brown, G.E., P.D. Petracek, M. Chambers, H. Dou, and S. Pao. 1998. Attempts to extend the market availability of 'Marsh' grapefruit with storage at 2 to 3 ºC. Proc. Fla. State Hort. Soc. 111:268-273.

Burns, J.K. and L.G. Albrigo. 1998. Time of harvest and method of storage affect granulation in grapefruit. HortScience 33:728-730.

Citrus Canker Eradication Program. 2000. http://doacs.state.fl.us/~pi/canker/menu1.

Compendium of Citrus Diseases. 1988. J. Whiteside, S. Garnsey, and L. Timmer (eds) APS Press, St. Paul MN.

Echeverria, E., J.K. Burns and W.M. Miller. 1999. Fruit temperature and maturity affect development of blossom end clearing in grapefruit. HortScience 34:1249-1250.

Eckert, J.W. and G.E. Brown. 1986. Postharvest diseases and their control. In: Fresh Citrus Fruits. W.F Wardowski, S. Nagy, and W. Grierson (eds) AVI Pub. Co., pp. 315-360.

Florida Dept. of Citrus. 1996. Fact sheets on postharvest diseases of citrus. www.fred.ifas.ufl.edu/citrus/srd.

Gmitter, F.G. 1995. Origin, Evolution, and Breeding of the Grapefruit. In: Plant Breeding Reveiws, Vol. 13, J. Janick (ed) John Wiley and Sons, NY, pp. 345-363.

Pao, S., P.D. Petracek and M.A Ismail. 1997. Advances in preparing peeled fresh-cut citrus. Food Tech. Int., pp. 39-42.

Petracek, P.D., W.F. Wardowski and G.E. Brown. 1995. Pitting of grapefruit that resembles chilling injury. HortScience 30:1422-1426.

Saunt, J. 2000. Citrus varieties of the world. Sinclair Intl. Ltd., Norwich, England.

Soule, J. and W. Grierson. 1986. Maturity and grade standards. In: Fresh Citrus Fruits. W.F. Wardowski, S. Nagy, and W. Grierson (eds) AVI Pub. Co., CT, pp. 23-48.

Wardowski, W.F. 1996. Recommendations for degreening Florida fresh citrus fruit. Univ. Florida Cir. 1170.