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PACKINGHOUSE OPERATIONS AND SHIPPING CONDITIONS OF CITRUS FOR EXPORT[1]

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Abstract. **The greatest positive influence packinghouse management can have on citrus fruit quality is to secure careful harvesting, and with the exception of lemons, assure prompt movement to the packinghouse. Degreening with no more than 5 ppm ethylene, high relative humidity, fresh air ventilation and adequate air movement assures an optimum degreening rate with minimal risk to quality. In the packinghouse, prompt handling of fruit at high relative humidity especially until it is waxed, will retard moisture loss. Application of an approved benzimidazole fungicide, alone or with other approved fungicides, is essential to control decay. Application of fungicides and waxes must be consistent and thorough to assure good decay control and minimal loss of moisture. Shipping temperatures should be varied with the type of citrus fruit, and, for grapefruit, with the time of year and growing conditions. Citrus should not be cooled to a potential sweating temperature prior to fumigation. Overpacking citrus cartons should be avoided as this common practice, sometimes requested by fruit buyers, is especially harmful to citrus destined for the longer term export market. High humidity through the long export transit is important to maintaining citrus fruit quality. Generally, common sense and attention to details in the packinghouse and during transit will keep citrus fruits fresh and viable for the overseas consumer.**

A citrus fruit never has better quality than the instant it is removed from the tree. Citrus fruits can be made to appear better, but never taste better after harvest. The greatest influence management can have on quality of citrus fruit is to provide very careful harvesting as described in the previous paper (12). If a fruit has the skin broken, the injury is frequently fatal, due to fungal decay, as it may not be controlled by the fungicide treatment. It would be better to prevent injury rather than use "band-aid treatments" to attempt to repair damage.

The quality of citrus fruit exported from Florida is greatly influenced by the maturity and grade standards which are rigidly enforced through the Florida Department of Citrus rules and the State of Florida Statutes (6, 7). The internal quality of Florida citrus fruit is higher than for most other growing areas in the world (15) while the external appearance is lower due to such factors as green or pale color, wind scar, rust mite damage, etc. (27). To take best advantage of these characteristics, Florida shippers should take great care to select only the crop grown for optimum external quality, which usually assures good internal quality.

The influence of packinghouse management on quality of export citrus can be discussed in relation to major changes in Florida citrus packinghouse operations. Such changes were limited to either end but not the middle of the packingline from the late 1950's through the 1970's. We are beginning to see energy cost inspired changes in the center of the line in the 1980's. These changes can affect the quality of citrus for the export market, and will be discussed in this paper. Much of this information can be found in an excellent review by Brown (2).

With the exception of lemons, where handling should be delayed 24 hours after harvest to reduce oleocellosis (25), citrus should be moved promptly to the packinghouse. Pallet bin (also called pallet box) handling is recognized as being much more efficient and less damaging to citrus frut than the old nearly outdated standard 90 lb. (for oranges) Florida field box (3, 16, 26).

Modern degreening rooms generally adopted in the 1970's are superior to older designs (9, 11, 19, 24). These degreening rooms feature positive flow air circulation, very high humidity, low (1-5ppm) ethylene concentration, and controlled fresh air ventilation. Such rooms increase the speed of degreening and result in better fruit quality, particularly lower decay and less dehydration.

Trash elimination is a continuing and increasing problem for Florida citrus packers (5, 10). The elegant solution to trash would be to simply eliminate the vast majority of it at the time of harvesting. However, this is not always possible, or expected to happen, so packers are beginning to install systems to remove sand, leaves, limbs, bottles, cans and other trash. Once trash is delivered to the packinghouse, the ideal situation is to get it off the line immediately after dumping so that fruit and machinery are not damaged further by the trash. The best trash elimination systems deliver the refuse to pallet boxes or trucks for efficient removal.

Fruit quality can be lowered in the packinghouse by brushes. Generally speaking, dry fruit should not be allowed on dry brushes as this can cause peel injuries. Brushes are used in the washer and in a water wax application. Brushes should rotate at a relatively slow speed of not over 100 rpm, and in the wax applicator they should be horse hair or horse hair grade. It is advisable to avoid installing new stiff brushes in a washer at the beginning of the season while the fruit peel is still very tender. New brushes can be more safely installed during the Christmas break. Brushes are sometimes found in dryers to "polish" the fruit for a better shine and to remove sooty mold. This practice is not recommended due to the risk of putting dry fruit on dry brushes and causing injury. (14). However, it is done commercially with slowly rotating very soft brushes.

The packinghouse manager can improve packed quality

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by making the grading operation efficient and the graders as comfortable as possible. Some of the considerations that would help graders do a better job include: good lighting, a minimum of lifting, neither too few nor too many graders for the crop being run, adequate supervision, a reverse-roll grading table, proper sequence of the individual graders with the most experienced grader being last, and a separate air-conditioned room to eliminate noise, dust, and distractions (14).

Color-adding is not commonly applied to export Florida citrus because grapefruit is our most commonly exported crop. Only oranges, temples, and tangelos may be color-added (6) and of these, only the early season fruit is commonly color-added. Naturally colored oranges, temples, and tangelos should be shipped whenever the markets will accept them in order to avoid the potential injury from treating with a hot, color-add solution that must be maintained at a rather exact pH (17).

Fungicides are an integral part of a good quality program for export citrus fruit in Florida. State regulations mandate that one of the approved fungicides must be applied (6) and this rule is enforced by systematic sampling and analysis for minimum residues. The benzimadazole fungicides (benomyl and thibendazole) are superior to other postharvest approved fungicides for decay control of Florida citrus (18). Only three fungicides (diphenyl, sodium-o-phenylphenol, and thiabendazole) are generally approved by *all* our overseas markets, and more than one are sometimes used to advantage on export shipments. The packinghouse managers can improve decay control by immediate and careful application of fungicides in the packinghouse. Some fungicides may be applied in water waxes, but separate application results in better decay control (1). Testing and approval of an additional fungicide requires many years, millions of dollars, and approval is usually only in one country at a time, so that improvements are both slow and expensive.

Water emulsion waxes are being adopted in the 1980's by Florida citrus packers because the cost of petroleum based solvent wax continues to increase. Both types of wax can provide good shrinkage control and a cosmetic shine. Water waxes may "chalk" by reemulsification when they get wet due to sweating, inadvertenly sprinkling with water in the marketing channels, or especially by contact with a decayed fruit (13). This chalking makes the fruit difficult or impossible to market due to poor external cosmetic appearance.

Another change during the 1980's on Florida citrus packinglines is the partial recirculation of warm moist dryer air to reduce escalating fuel costs. Present installations of recirculating dryer air have controls to adjust the amounts of recirculation according to humidity conditions in the dryer. Fruit quality should not be affected by these changes in drying methods as long as overheating dry fruit can be avoided. Dryer temperatures of 43-49°C (110-120°F) for 2-3 minutes are commonly used and adequate in Florida, and temperatures over 54°C (130°F) are not recommended (14) although damp 'Valencia' oranges dried in (66°C) 150°F air showed no increase in pulp temperature (8). Dehumidification of dryer air may result in cooler dryer temperatures (20).

Precooling can be detrimental if the fruit is to then be fumigated. Water on the surface of the fruit from condensation or any other source usually causes peel injuries during fumigation (21). Rapid precooling of grapefruit and oranges before containerization or loading in ships hold gives no known advantage. More perishable mandarins and zipper skin types benefit from precooling if fumigation is not required. Shipping temperatures for oranges and mandarins are fairly standard at 1°C (34°F) and 4.4°C (40°F) respectively, whereas lemons and limes are normally shipped at 10°C (50°F). Grapefruit temperatures vary between 10° and 15.5°C (50 and 60°F) depending on the time of the year and conditions of the trees at harvest (18). In the spring and fall the trees are actively growing and the fruit are more susceptible to chilling injury at 4.4°C (22). Late season grapefruit shipping temperature recommendations are not consistent in that they range from 10°C (4) to 15.5°C (18). The cooler temperature provides better decay control while the warmer protects against chilling injury.

Relative humidity (RH) should be as high as possible without percipitation. Degreening RH is recommended at 90 to 96% (19, 24) while ships hold humidity is best kept down to 85 to 90% in order to maintain carton strength (18). Over 90% RH could be used during shipping if the fruit were shipped in pallet bins rather than fiberboard containers and the pallet bin shipping concept should enhance citrus quality, not only for the physical reasons of fruit deformation (16) but also because more favorable high humidity conditions may be maintained aboard ship.

Innovations at the packing end of the citrus packinghouse include: packing aids and automatic packaging machines of various designs. Opportunities for employees to discard damaged fruit becomes less, however, when packing becomes mechanized.

All container sizes, packs and board weights used for Florida citrus must be approved by the Florida Department of Citrus (6). Fruit damage from overfilling these containers continues to be a problem (16, 23), although more buyers and packers are cooperating to fill containers to "water level" (level full) to reduce damage. One of the most expensive changes in citrus packinghouses in the 1970's and continuing in the 1980's is the use of automatic palletizers. This innovation does not harm fruit quality, and in cases where previously rough handling by offset men is prevented, original quality is better maintained. The main reason for this change, however, is related to unreliable labor to palletize containers. Lift-trucks and palletized semi-truck loads can maintain quality for the same handling damage reasons, when damage from rough hand stacking is avoided.

Common sense, a knowledge of experimental results, and practical commercial experience will ensure maintenance of citrus quality through the packinghouse. Citrus fruit is alive and its quality cannot be improved after harvest. The best handling practices will only ensure that good quality fruit will retain that quality.

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FACTORS TO BE CONSIDERED FOR EXPORTING GRAPEFRUIT TO DISTANT MARKETS

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Abstract. **Fresh grapefruit continue to be the most important fresh citrus fruit exported from Florida. In 1981, the market value, upon arrival, of fresh grapefruit is estimated at $100 million, and it will probably exceed $150 mililon by 1985. Consequently, the delivery of grapefruit in the best possible condition at its overseas destination is of great importance. This paper presents specific and practical recommendations for the Florida grapefruit shippers to use on quality, pretransit treatments, shipping containers, packing, temperature control, and stacking and handling for export of grapefruit.**

It is my pleasure to participate in the Florida State Horticultural Society's first symposium on "Citrus Exports from Florida." The transportation of fresh grapefruit from Florida in both refrigerated van containers and in the refrigerated holds of ships has increased rapidly in recent years, and fresh grapefruit is now Florida's No. 1 exported citrus fruit (4). By 1985, the market value, upon arrival, of fresh grapefruit delivered to overseas markets probably will exceed $150 million, assuming that a good job is done in getting fruit to the markets. Consequently, proper packaging, temperature and humidity control, handling, stacking, unitizing, and loading, are of great importance to ensure that grapefruit will arrive at destination in the best possible condition.

In domestic marketing, after harvest, 3 to 10 days are required for the fruit to reach the consumer. In contrast, overseas export can require as long as 6 weeks to reach destination, and additional storage time may be required at the terminal market.

The purpose of this paper is to identify several factors that should be considered when exporting grapefruit to distant markets. These factors should not be considered absolute or final; they may change from time to time as we gain more information and accumulate data from our experiments and observations.

Quality. In all reports concerned with the export of citrus, the maximum transit and shelf-life after arrival can be attained only by selecting high-quality grapefruit (10, 20). Quality cannot be improved after harvest. Thus, the first consideration is always to ship the highest quality, U.S. No. 1 fruit. To obtain extended transit and shelf-life, the fruit must be free from skin breaks, mechanical injuries, bruises, and decay. It should also be remembered that early fruit havested in October and November is especially susceptible to low-temperature injury, and that late-season fruit harvested in May is more susceptible to decay (18). In addition, fruit harvested during October and November that are exposed to more than 48 hours of degreening with ethylene often develop excessive amounts of decay, and fruit undergoing this treatment are not recommended for export.

Pretransit treatments. Shippers should be aware of the approved fungicides and allowable tolerances by the country receiving the grapefruit (16). Fungicides should be applied and monitored closely. Fungicides applied during pregrading or during packing can be detected and, unless they are approved, the entire shipment can be confiscated on arrival and dumped or rejected for entry into that market. Results of our export shipping tests conducted during the last several years clearly indicate that the best decay control has been obtained when thiabendazole (TBZ) and sodium *o*-phenylphenate (SOPP) were applied to the fruit (19). Benomyl may be used in place of TBZ if approved by the importing country. To control additional decay and green mold sporulation in storage and in transit, one biphenyl pad should be placed over the bottom layer of fruit and one pad placed between the upper layers (17). For early shipments prior to January, use only one biphenyl pad to ensure the biphenyl residues will be within accepted tolerance levels, since early grapefruit tend to absorb more biphenyl than more mature fruit (21). All fruit should receive an approved wax application before being packed into shipping containers, so that moisture loss during transit will be minimized, and consumer appeal will be enhanced. Also, mois-

[1]This paper reports the results of research only. Mention of a pesticide in this paper does not constitute a recommendation for use by the U.S. Department of Agriculture nor does it imply registration under FIFRA as amended.