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Postharvest Handling
Technical Bulletin

ORANGES

Postharvest Care and Market Preparation

Technical Bulletin No. 8

October 2003

POSTHARVEST HANDLING TECHNICAL SERIES

ORANGES

Postharvest Care and Market Preparation

Ministry of Fisheries, Crops and Livestock
New Guyana Marketing Corporation
National Agricultural Research Institute

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With the assistance of the United States Agency for International Development

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Preface

This publication is part of a series of technical bulletins that seeks to provide specific recommendations for improvements in postharvest care and market preparation for selected non-traditional agricultural products. The intended audience for this series is primarily extension agents.

Initial market assessments in current export markets and visits with producers and exporters in Guyana have shown the quality of fresh produce currently exported is uneven and in some instances very poor. Stages all along the export chain from harvest and pre-harvest to transportation and final export are all in need of improvement. Pre-harvest practices, sanitation at the packinghouse, packaging, bacterial and fungal problems, and transportation were all identified as areas where improvement could benefit the quality and increase the shelf life of Guyana's fresh produce exports. The technical bulletins address these issues specific to each product. Harvesting techniques and crop maturity indices are provided. Preparation for market, including cleaning, sorting, packing and transportation are covered. The bulletins address and recommend specific storage conditions, covering temperature and humidity controls. Finally the bulletins address postharvest diseases and insect damage.

The undertaking of these technical bulletins is a joint effort of the Ministry of Fisheries, Crops and Livestock; the New Guyana Marketing Corporation (NGMC) and the National Agricultural Research Institute (NARI) to improve quality, increase production and promote exports. As a team, the three agencies are working on the problems, limitations, and constraints identified in the initial reconnaissance surveys, from production and postharvest handling problems, to packaging and transportation, to final market.

Introduction

Oranges (*Citrus sinensis*) are a popular citrus fruit grown along the entire Atlantic coast of Guyana. The vast majority of oranges produced in the country are seeded Valencia, Pineapple, and Hamlin types, used for both fresh market and juice. Only a limited amount of seedless Navel oranges are grown. Nearly all of the orange crop is marketed domestically, although minor volumes are exported to Barbados.

Harvest Maturity Indices

A combination of external and internal indices is used to determine orange harvest maturity. The most commonly used external index is peel colour. Fruit are considered mature if they have a yellow-orange colour on 25% or greater of the fruit surface.

Figure 1. Hand-held refractometer for determining juice % soluble solids content.

Internal harvest maturity indices include measuring the soluble solids content (i.e. sugars) and acidity of the juice. Flavor quality in oranges is related to the soluble solids: acid ratio and absence of off-flavor-causing compounds. The juice should have a % soluble solids of 8.5 or higher. Soluble solids content is determined by squeezing a few drops of juice on a hand-held refractometer (Figure 1).

The juice should also have a soluble solids to acid ratio of 10:1 for the fruit to be considered mature and of good quality. This ratio is determined by dividing the % soluble solids content by the % acidity. In order to reduce fruit to fruit variability, the juice sample should be obtained from a total of 10 randomly selected fruit. Each fruit should be cut in half (Figure 2), squeezed, and filtered to clarify the juice. A 10 ml sample of filtered juice is titrated with 0.1 N sodium hydroxide to an end point of 8.1. The volume of 0.1 N sodium hydroxide required to reach the pH end point of 8.1 is then multiplied by the factor of 0.0064 to obtain % acidity (i.e. % citric acid).

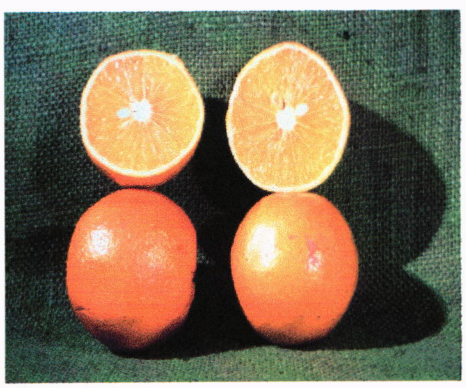


Figure 2. A total of 10 randomly selected oranges should be cut in half, squeezed, and the juice filtered to determine % soluble solids:acidity ratio.

Acidity is a more complex determination that requires a few simple laboratory supplies (i.e. biuret and pH meter).

Harvest Methods

Oranges should be harvested using a pair of clippers or by carefully twisting and pulling the fruit from the tree so the button (calyx and disk) remains attached to the fruit (Figure 3). Stems left on the fruit at picking should be removed because they can puncture other fruit, causing postharvest decay and fruit spoilage. Careless picking that results in plugging (part of the rind pulls loose from the fruit) is unacceptable. All oranges are susceptible to plugging, but some cultivars are more likely to plug than others, especially 'Pineapple' oranges.

Figure 3. The button (calyx and disk) should remain attached to the fruit at harvest.

Never shake the tree to harvest the fruit. Any fruit which falls to the ground is likely to be severely bruised and subject to postharvest decay. Ladders may be needed to facilitate harvesting of fruit borne on tall trees. Avoid rough harvesting practices which result in fruit bruising. It is a popular misconception that citrus fruit can withstand rough handling. Citrus is more durable than many other fruits, but it does bruise easily.

The harvested fruit should be carefully put into padded field crates, well ventilated plastic containers, or picking bags. Picking bags are either strapped around the waist or put over the shoulder and made with a quick-opening bottom. These harvesting containers can be made by sewing bags with openings on both ends, fitting fabric over the open bottom of ready-made baskets, fitting bags with adjustable harnesses, or by simply adding some carrying straps to a small basket (Figure 4).

When filled with fruit, the bags of oranges are typically emptied into larger field crates. Picking sacks are designed to empty from the bottom so that fruit can roll out of the sack onto the bottom of a larger field container or atop fruit already present, rather than being dropped. A strong wooden or plastic field container is preferred (Figure 5).

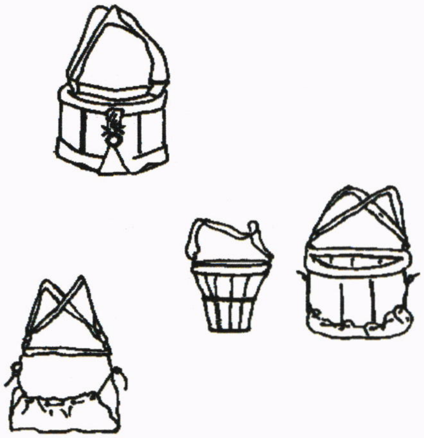


Figure 4. Various styles of picking bags used for harvesting oranges.

Figure 5. Strong wooden field crates that are stackable are ideal field containers.

Preparation for Market

When unloading or transferring oranges from field containers or from transport vehicles into the packinghouse, dry or wet dumping can be practiced. When using dry dumping practices, the filled container should be emptied slowly and gently onto a tilted ramp with padded edges (Figure 6). A conveyor belt can also be used to move the fruit in the packinghouse.

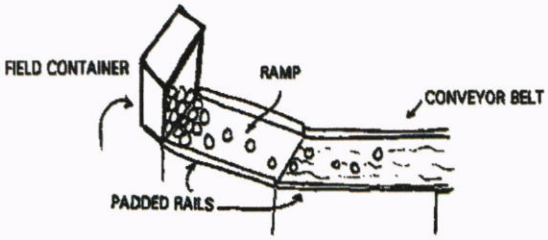


Figure 6. Transfer of fruit from field container onto a ramp and conveyor belt for sorting.

Cleaning

Washing will improve the appearance of oranges by removing dirt, sooty mold, scale insects, and spray residues. Fruit can be cleaned manually by hand rubbing individual fruit dumped in a tank of sanitized water with detergent. Either sodium hypochlorite or sodium o-phenylphenate (SOPP) can be used as sanitizing agents for the wash water, or they can be used in the rinse water. The effectiveness of sodium hypochlorite is optimal at a 150 ppm concentration and water pH of 6.5.

Fruit can also be cleaned mechanically by passing the oranges over a series of roller brushes. The fruit is thoroughly wetted as it passes under a series of spray nozzles. Initial rotating brushes will remove most debris, after which foamed soap or detergent is dribbled onto the fruit to enhance cleaning as the fruit continues across the brushes. Adequate cleaning usually requires about 20 seconds on the brushes, but particularly dirty fruit should be exposed for 30 seconds. Brushes should be horsehair grade, rotating at about 100 rpm. Fruit is then thoroughly rinsed as it passes over the last of the brushes or a roller conveyor just beyond the brushes. Excess water on the fruit can be eliminated with sponge rubber rollers (donuts).

Thiabendazole (TBZ), imazalil, and benomyl are the most effective postharvest fungicides for oranges and can be applied as high pressure sprays after washing. They are typically applied at a dose of 1000 ppm active ingredient in water. These fungicides can also be applied in water-emulsion waxes.

Grading/Sorting

Oranges should be graded according to size, appearance and colour of the peel, and uniformity. This is typically done manually in small volume operations, or semi-automatically in larger volume packinghouses as the fruit is passing down a slow moving conveyor (Figure 7). Grading should be done immediately after washing. Fruit that does not meet fresh market

Figure 7. Manual sorting of orange fruit as it passes over a roller conveyor.

grade standards should be removed, and if the quality is still acceptable it can be sold for juice. The remaining fruit should be sorted into different size classes and graded according to various characteristics. The quality parameters used to classify the fruit include peel colour, smoothness, and uniformity; fruit firmness and shape; freedom from decay and defects, including physical damage (abrasions and bruising), skin blemishes, discolouration, and insect damage.

Sizing

Grading oranges according to size is important because certain sizes (typically large and extra large) receive a higher price. In low-input packinghouses, sizing of the fruit is done manually. Workers should be trained to grade the fruit according to size and to pack only uniform sized fruit in the same container. Sizing can be done by using hand-held rings of different diameters or visually with the use of standard size hole gauges (Figure 8). Examples of the smallest and largest acceptable sizes should be placed within view of the workers for easy reference.

Several types of mechanical sizers are also available for small-scale orange packinghouses. One type is composed of a long slanted tray with a series of openings which converge (largest at the top, smallest at the bottom). This type of sizer works well with round shaped fruit such as oranges. Other sizers are designed as conveyors fitted with chain or plastic belts with various sized openings. Another simple method for mechanical sizing of orange fruit is to use a set of diverging bar rollers. The smallest sized fruit falls through the rollers first and onto a sorting belt or bin. The larger sized fruit falls between successively more divergent rollers.

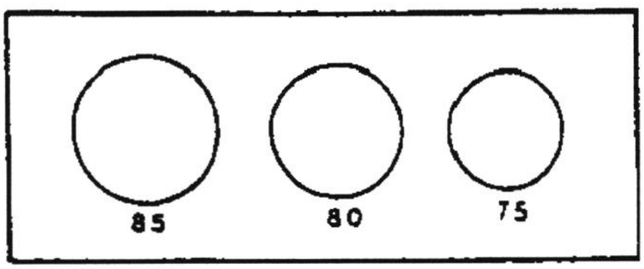


Figure 8. Multiple size rings for sizing oranges.

Waxing

Most of the natural wax on the peel surface is removed during washing. It should be replaced to impart a shine to the fruit surface and to reduce moisture loss. Most consumers prefer oranges with a shiny peel. Wax is usually applied as a water-emulsion wax spray using a pair of traveling nozzles (wig-wag) over a bed of slowly rotating (not more than 100 rpm) horsehair brushes. Water-emulsion waxes do not require a completely dry fruit surface. Orange waxes are typically carnauba or shellac based. In addition to improving the appearance, coating oranges with a thin wax will reduce shrivel and significantly extend fruit market life.

Packing

Oranges should be packed in strong well-ventilated containers that can be stacked without collapsing. The most commonly used containers for domestic market sales are large sacks often filled with more than 30 kg (66 lbs) of fruit (Figure 9). They do not provide adequate protection to the fruit against bruise damage. In addition, they cannot be stacked without causing compression injury to the fruit. Wooden crates provide much better protection to the fruit.

Figure 9. Large sacks used for domestic marketing do not protect against fruit bruising.

The preferred containers for export marketing are full-telescope fiberboard cartons (Figure 10) or wire-bound crates, typically holding 18 kg (40 lbs) of fruit. The fiberboard cartons should have a minimum test strength of 275 psi. Biphenyl-treated pads should be put inside the cartons or crates before closing to reduce postharvest fungal decay.

Figure 10. Full-telescope fiberboard carton (without top half) used for exporting oranges.

Wire-bound crates used for exporting oranges.

Temperature Management

The optimal postharvest temperature to store oranges is between 2°C to 3°C (36°F to 38°F). Market life at this temperature range will be up to 4 months, depending on cultivar and maturity stage at harvest. For short-term storage of several weeks and during transit, 10°C (50°F) is adequate. Storage at ambient temperature will result in rapid deterioration and decay. Loss in market quality is due to a loss of moisture in the peel and pulp along with postharvest rot. Oranges may lose up to 10% of the moisture in the peel after 3 weeks at ambient temperature and relative humidity (RH).

Relative Humidity Management

Oranges are high in moisture content and susceptible to peel shrivel after harvest. In order to minimize postharvest water loss and preserve postharvest quality, oranges should be stored at their optimum RH of 90 to 95%. At a low RH, the peel becomes thin, dry, and shriveled and adversely affects the appearance of the fruit.

Peel De-Greening

Orange fruit produced in Guyana is often mature and of acceptable eating quality when the rind is still green. High temperatures and humidity result in internal fruit maturation, but the colouration of fruit peel usually is not fully developed. Many consumers, especially in export markets, associate external skin colour with internal flavor and believe oranges with a green-coloured peel is immature and not ready to eat. In order to improve external skin colour and market acceptance, oranges can be treated with ethylene, which is an effective de-greening agent. Ethylene treatment breaks down the green chlorophyll pigment in the peel surface and allows the yellow or orange carotenoid pigments to be expressed. This treatment is solely cosmetic in effect and does not alter the flavor of the fruit.

The general de-greening protocol involves exposing the green-skinned orange fruit to low concentrations of ethylene (usually between 1 to 10 ppm) at 20°C to 25°C (68°F to 78°F), 90% RH for several days. The optimal ethylene concentration and treatment duration varies by cultivar and growing conditions. Fruit which develops under high night temperatures usually needs a higher concentration of ethylene to de-green the peel. However, excess ethylene can cause stem end rot and accelerate decay.

In order to achieve good de-greening results, adequate internal air movement is needed so the entire air volume within the treatment chamber is circulated every 2 to 3 minutes. The CO_2 levels inside the treatment chamber should not be allowed to rise above 2000 ppm, as high CO_2 will inhibit the effect of ethylene. The treatment chamber should be well insulated in order to maintain the desired ethylene concentration. Washing the fruit before de-greening is not advisable because it interferes with the de-greening process and increases the time of exposure to ethylene needed to colour the fruit.

A liquid ethylene-releasing compound, called ethephon [(2-chloroethyl) phosphonic acid], may be an effective alternative de-greening material. It is applied by dipping the fruit in a tank of clean water at room temperature with 500 ppm ethephon for 1 minute. It is important the water be properly sanitized with sodium hypochlorite (i.e. 150 ppm at a pH of 6.5) and a fungicide (i.e. 500 ppm benomyl, thiabendazole, or imazalil) to prevent postharvest decay.

Valencia oranges are susceptible to stem-end rind breakdown. After de-greening, it is important to maintain a high RH ($\geq$ 90%) and a temperature near 16°C (60°F) while temporarily holding the fruit before waxing or packing. A holding period is necessary for 12 to 24 hours before packing in which fresh, cool air is introduced into the room. If not properly aired and cooled, stem-end rind breakdown may appear on the oranges after running over the packing line.

Principal Postharvest Diseases

Due to Guyana's warm climate and high rainfall, postharvest diseases of oranges can be quite high and cause significant fruit loss. Postharvest decays may also limit export opportunities for Guyanese growers. Therefore, it is economically important to control postharvest diseases and maintain the quality of the fruit.

Postharvest decays are caused by latent (resting) or wound-induced fungal infections. Latent infections typically become established on the fruit prior to harvest, but exist in a resting or dormant state until the conditions are right for fungal growth after harvest. Wound-induced microbial infections usually take place after harvest, and begin in areas of the fruit which were injured during picking and/or handling. Oranges must be harvested and handled gently to avoid bruising and skin injury, which greatly accelerates postharvest microbial decay. Postharvest decay is also reduced by the use of appropriate pre-harvest and postharvest fungicides, proper sanitation of the wash water, and appropriate storage temperature and RH conditions.

Green Mold

Green mold, caused by the fungus *Penicillium digitatum*, is generally the worst postharvest disease of oranges. The fungus enters the fruit only through wounded areas and causes a rapid breakdown of fruit punctured or bruised during harvesting and packing. The initial symptom appears as a soft, watery, slightly discoloured spot (6-12 mm [0.2-0.5 in] in diameter) on the rind. The spot enlarges to 2-4 cm (0.8-1.6 in) in diameter within 24-36 hours at 24°C (75°F), and the rot soon penetrates into the juice vesicles. White fungal growth appears on the fruit surface, and after the spot enlarges to a diameter of about 2.5 cm, (1 inch) olive-green spores are produced (Figure 11). The sporulating area is surrounded by a broad zone of white fungal growth and an outer zone of softened rind. The entire fruit is soon covered with a mass of olive-green spores, which are easily dispersed by air currents or movement of the fruit. If the storage RH is low, the fruit shrinks to a wrinkled, dry mummy. If the RH is high, the fruit collapses into a soft, decomposing mass.

Green mold develops most rapidly at about 24°C. The rot can be almost completely inhibited by storing oranges at 0°C -1°C (32°F - 34°C). Adequate ventilation of the storage room is important because high concentrations of ethylene will increase the incidence of green mold. Also, preharvest and postharvest sprays of benzimidazole fungicides will reduce the amount of green mold.

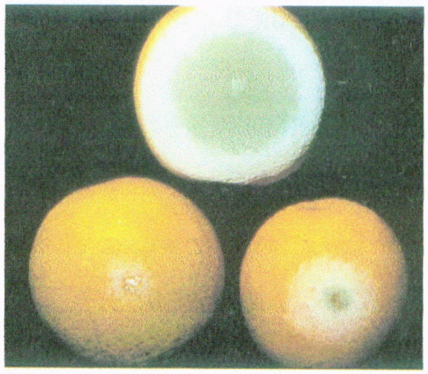
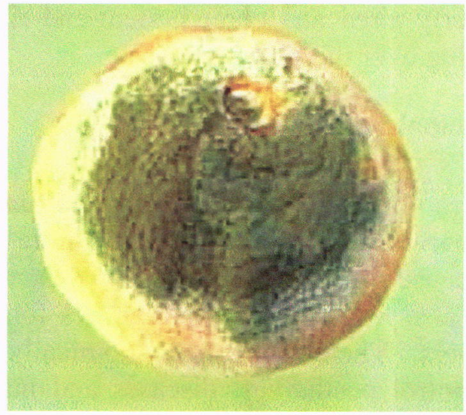


Figure 11. Different stages of green mold decay on orange fruit.



Blue Mold

Blue mold, caused by the fungus *Penicillium italicum*, is another common postharvest mold of orange fruit. Early symptoms are similar to green mold. It attacks injured areas of the peel and first appears as a soft, watery, slightly discoloured spot on the rind. Soon afterwards, a blue mold growth begins, surrounded by a zone of white fungal growth (Figure 12). The lesion enlarges more slowly than green mold. A pronounced halo of water-soaked, faded tissue surrounds the lesion between the fringe of fungal growth and the sound tissue. The blue spores covering the fruit may become brownish-olive with age.

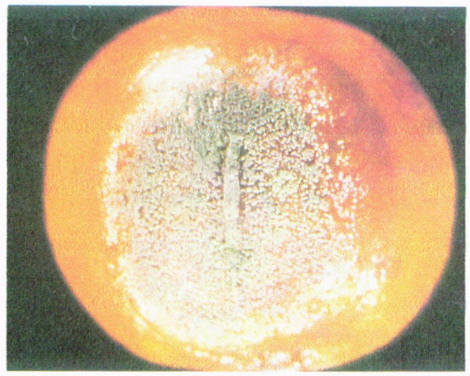


Figure 12. Blue mold decay of orange fruit.

Like green mold, blue mold develops most rapidly at about 24°C (75°F). However, blue mold grows better than green mold below 10°C (50°F) and may predominate over green mold in fruit held in cold storage. Healthy fruit in packed containers become soiled by spores shed from the diseased fruit. Unlike green mold, blue mold spreads in packed containers and results in nests or pockets of diseased fruit.

The incidence of blue mold can be reduced by following the same recommendations as described for control of green mold. Immediate cooling after packing significantly delays development of blue mold, especially if combined with effective fungicide treatments. Adequate ventilation of the storage room is important because high concentrations of ethylene will increase the growth of blue mold.

Black Rot

Black rot, caused by the fungus *Alternaria citri*, is a common postharvest orange disease. Navel oranges are particularly susceptible. Black rot usually occurs as a stem-end rot in oranges that have been stored for extended periods. However, in some cases there are no external symptoms of black rot, only an internal black rot of the center tissue (Figure 13). This is a problem for juicing, since only a small amount of rot will impart a bitter flavor to the juice.

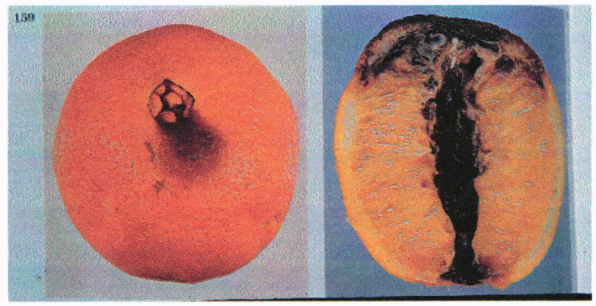


Figure 13. Black rot internal decay of Navel orange fruit.

Anthracnose

Anthracnose, caused by the fungus *Collectotrichum gloeosporioides*, usually appears on fruit previously injured or held too long in storage. Also, fruit which need a higher concentration of ethylene to de-green the peel will have a higher incidence of anthracnose. Ethylene triggers the growth of the dormant fungus and it also increases the susceptibility of the rind to further invasion.

Symptoms generally appear as brown to black spots on the peel, 1.5 cm (.6 in) or more in diameter (Figure 14). The decay may be firm and dry, but if sufficiently deep it may cause the fruit to soften. Under humid storage conditions, the fungal spores associated with the peel lesions are pink or salmon-coloured, while under drier conditions they appear brown or black.

Phomopsis Stem-end Rot

Stem-end rot, caused by the fungus *Phomopsis citri*, is a serious type of decay on all orange cultivars. It is more prevalent in the humid coastal production areas than in drier in-land zones. Decay begins at the stem end of the fruit and will penetrate the rind and juice sacs. The infected tissue shrinks and a clear line of demarcation is formed at the junction between diseased and healthy rind (Figure 15). The disease does not spread from decayed to healthy fruit in packed cartons.

Figure 14. Anthracnose decay of Hamlin orange fruit.

Figure 15. Phomopsis stem-end rot of orange fruit.

Diplodia Stem-end Rot

Stem-end rot, caused by the fungi *Diplodia natalensis*, is a serious postharvest disease of oranges in Guyana. Spores lodge beneath the calyx at the time of flowering and remain dormant until the fruits are harvested. The fungus becomes active at the stem end of the fruit and symptoms appear within several weeks after harvest at ambient temperature. Symptoms include the formation of water-soaked spots near the stem end of the fruit, which turn blackish-brown. Fungal growth progresses rapidly through the spongy central axis of the fruit. The decay proceeds unevenly through the rind, producing finger-like projections of brown tissue (Figure 16). Decayed tissue is initially firm, but later becomes wet and mushy. Decay usually does not spread from infected to healthy fruit in packed containers.

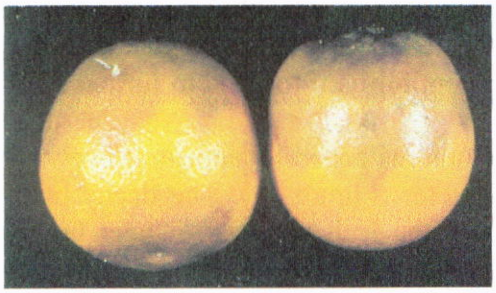


Figure 16. Diplodia stem-end rot of oranges.

The incidence of stem end rot will be greater on fruit which requires a high concentration of ethylene to de-green the peel. Control of stem-end rot is obtained by preharvest fungicide sprays, postharvest application of imazalil, and low temperature storage. The decay is almost completely inhibited at temperatures below 10°C (50°F). Diplodia rot in oranges can also be retarded by postharvest applications of 2,4-dichlorophenoxy acetic acid at a dose of 500ppm, which retards senescence of the button and therefore the entry of the pathogen.

Brown Rot

Brown rot, caused by the fungus *Phytophthora*, is typically a postharvest problem on oranges when high amounts of rainfall occur during the later stages of growth. All cultivars are susceptible. Symptoms first appear as a light brown discolouration of the peel. The affected area is firm and leathery. White fungal growth appears on the fruit surface under humid conditions (Figure 17). Infected fruit have a characteristic pungent, rancid odour, which distinguishes this disease from other rots. Cool storage of the fruit will significantly retard the development of brown rot.

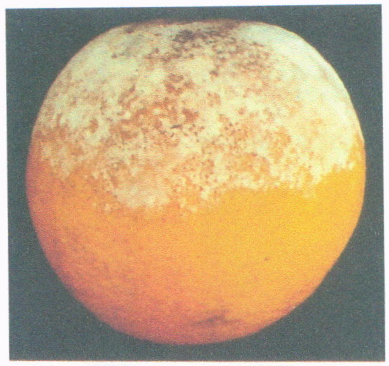


Figure 17. Brown rot with white fungal growth on the peel of an orange fruit.

Postharvest Disorders

Rind Staining

Soft-skinned oranges are susceptible to peel discolouration due to mechanical abrasion incurred during harvesting or packing. The disorder is termed rind staining and the symptoms are brown or reddish-brown discolouration of the damaged areas of the peel. Fruit which are harvested over-mature are more likely to suffer from rind staining. Navel oranges are particularly susceptible to this disorder. Rind staining can be controlled by careful handling of the fruit during harvesting, transport and packing. Pre-harvest foliar applications of gibberellic acid may also reduce rind staining.

Oleocellosis (Oil Spotting)

Oleocellosis, or oil spotting, is a handling problem which normally does not appear until several days after harvest. It results from mechanical damage to the fruit which ruptures the oil glands in the peel. The extruded oil kills rind cells, causing them to turn brown. The spots may vary from less than 1.3 cm (0.5 in) in diameter to large, irregular areas involving much of the fruit's surface (Figure 18). The oil glands of the skin stand out prominently because of slight sinking of the tissues between them.

Turgid fruits are most likely to develop oleocellosis because the oil glands in peels high in moisture content are more easily ruptured. Fruit turgidity is greatest in the early morning and under foggy, wet conditions. Harvesting under such conditions or while dew is on the fruit should be avoided. Oleocellosis is also more severe in orange fruit harvested before it has lost its green colour. Navel oranges are particularly susceptible to oil spotting. Oil spotting can be prevented or reduced by picking fruit when the surface is completely dry, waiting to pick 2 or 3 days after a rain, using foam-lined or padded field containers, and having pickers wear cotton gloves.

Figure 18. Oleocellosis spots on the rind of a Valencia orange.

Stem-end Rind Breakdown

Stem-end rind breakdown (SERB) is a collapse and subsequent darkening of the rind around the stem end of oranges (Figure 19). A narrow band of rind around the stem usually remains undamaged. The collapse of tissue develops within a week of harvest and is due to excessive moisture loss from the rind prior to harvest and continued moisture loss and shriveling of the peel after harvest. Valencia oranges are particularly susceptible.

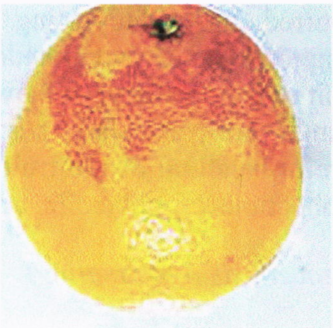


Figure 19. Stem-end rind breakdown symptoms on Navel orange.

During hot weather, water moves from the citrus rind back into the tree causing the fruit to wilt. Fruit which feels soft when harvested is more likely to develop SERB. Oranges borne on trees with a heavy crop of small fruit with thin rinds are more likely to develop SERB. Growers can reduce the incidence of SERB by irrigating Valencia oranges prior to harvest during hot dry weather conditions. If this is not possible, wet the fruit in the field containers bins and place them in the shade. Harvest and handle the fruit carefully, since bruised fruit with a damaged rind can lose moisture and shrivel at twice the rate of non-bruised fruit. Transport the fruit to the packing shed as soon as possible after harvest, followed by a wax treatment to prevent further moisture loss. The fruit should also be kept cool.

ANNEX I

PUBLICATIONS IN THE POSTHARVEST HANDLING TECHNICAL BULLETIN SERIES

PH Bulletin No. 1	Pineapple: Postharvest Care and Market Preparation, November 2002.
PH Bulletin No. 2	Plantain: Postharvest Care and Market Preparation, November 2002.
PH Bulletin No. 3	Mango: Postharvest Care and Market Preparation, November 2002.
PH Bulletin No. 4	Bunch Covers for Improving Plantain and Banana Peel Quality, November 2002.
PH Bulletin No. 5	Papaya: Postharvest Care and Market Preparation, November 2002.
PH Bulletin No. 6	Watermelon: Postharvest Care and Market Preparation, October 2003.
PH Bulletin No. 7	Peppers: Postharvest Care and Market Preparation, October 2003.
PH Bulletin No. 8	Oranges: Postharvest Care and Market Preparation, October 2003.
PH Bulletin No. 9	Tomato: Postharvest Care and Market Preparation, October 2003.
PH Bulletin No. 10	Okra: Postharvest Care and Market Preparation, October 2003.

PLANNED PUBLICATIONS - 2004

Cassava: Postharvest Care and Market Preparation.

Eggplant (Boulanger): Postharvest Care and Market Preparation.

Lime: Postharvest Care and Market Preparation.

Sweet Potato: Postharvest Care and Market Preparation.

Yam: Postharvest Care and Market Preparation.

Ginger: Postharvest Care and Market Preparation.

Pumpkin: Postharvest Care and Market Preparation.