Ministry of Fisheries, Crops and Livestock
Regent Road, Bourda
Georgetown
Tel. (592) 226-1565
Fax (592) 227-2978
e-mail:
minfcl@sdnp.org.gy
www.agrinetguyana.org.gy
/moa mfcl

New Guyana Marketing Corporation
87 Robb Street
Georgetown
Tel. (592) 226-8255
Fax (592) 227-4114
e-mail:
newgmc@networksgy.com

National Agricultural Research Institute
Mon Repos
East Coast Demerara
Tel. (592) 220-2049
Fax (592) 220-2841-3
e-mail:
nari@networksgy.com

Postharvest Handling
Technical Bulletin

GRAPEFRUIT

Postharvest Care and Market Preparation

Technical Bulletin No. 13

January 2004

POSTHARVEST HANDLING TECHNICAL SERIES

GRAPEFRUIT

Postharvest Care and Market Preparation

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

Technical Bulletin No. 13

January 2004

With the assistance of the United States Agency for International Development

Table of Contents

Preface

This publication is part of a series of technical bulletins that seek to provide specific recommendations for improvements in postharvesting 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

Grapefruit (*Citrus paradisi*) is a minor citrus in Guyana and essentially all the fruit is consumed in the domestic market. Almost all the grapefruit produced in the country have seeded fruit and consist of the cultivars White Marsh, Duncan, and Ruby. Market demand in many countries has shifted in preference to red-fleshed cultivars (Figure 1). Grapefruit have an intermediate storage life in comparison to other types of citrus. The postharvest recommendations are similar for all cultivars. The quality of grapefruit does not improve in storage.

Figure 1. Red-fleshed grapefruit are preferred in most export markets.

Harvest Maturity Indices

Since grapefruit do not continue to ripen after harvest, it is important to pick the fruit at the optimal maturity stage. Several different indices may be used to determine harvest maturity. The most commonly used indices are external appearance and juice quality.

The grapefruit peel will gradually lose its green colour and start to yellow as the fruit matures. Grapefruit should be harvested when at least 50% of the peel surface area has started to turn yellow.

Juice quality should also be determined prior to the beginning of harvest. Random samples of fruit from various trees should be picked and separated into different size categories. Quality of the juice should be determined for each size category. Specifically, the percent soluble solids (%SS) and percent acidity should be measured. Flavour is related to the soluble solids : acidity ratio and the concentration of compounds that impart bitter flavour. Soluble solids content is determined by squeezing a few drops of juice on a hand-held refractometer. The juice should have a minimum percent SS of 7.5 percent and a minimum percent SS : percent acidity ratio of 7:1 for the fruit to be considered mature and of acceptable eating quality. Grapefruit from the size categories meeting these minimum measurements are mature enough for harvest. The juice sample should be obtained from a total of 10 randomly selected fruit. Each fruit should be cut in half, 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 percent acidity.

Harvest Methods

Grapefruit should be picked with a combination pull-twist-snap motion that leaves the woody stem and button (calyx) attached to the fruit. The fruit that have protruding stems remaining should be clipped close to the button to shorten the stem to prevent wounding

and puncture damage of adjacent fruits in the container. Careless picking that results in fruit plugging, in which part of the rind pulls loose from the fruit, is unacceptable. Avoid rough harvesting practices that result in fruit bruising. Never shake the tree to harvest the fruit. Fruits on low branches are picked by hand from the ground. The harvested fruit should be carefully placed into well-ventilated, smooth-walled wooden or plastic field crates. Ladders may be needed to facilitate harvesting of fruit borne on tall trees. The fruit are put into picking baskets or sacks equipped with a quick-opening bottom. These harvest containers can be made by fitting fabric over the open bottom of ready-made baskets or by simply adding some carrying straps to a small basket. When filled, the worker descends to the ground and empties the contents of the picking sack into a field container. Any grapefruit that falls to the ground is likely to be severely bruised and subject to postharvest decay. It is a popular misconception that grapefruit can withstand rough handling. Grapefruit may be more durable than many other fruit, but they do bruise easily. However, symptoms may take several days to become apparent. Grapefruit should not be picked in large field sacks, as they provide limited protection to the fruit and overstuffing can result in considerable compression bruising.

Preparation for Market

De-greening

Grapefruit produced in Guyana is often mature and of acceptable eating quality when the rind is still green. However, many consumers associate external skin colour with internal flavour and believe a green-coloured grapefruit is not ready to eat. Grapefruit that are mature but not fully coloured can be de-greened by exposure to ethylene. Ethylene breaks down the green chlorophyll pigment in the peel surface and allows the yellow carotenoid pigments to be expressed. This treatment is solely cosmetic in effect and does not alter the flavour of the fruit (Figure 2).

Figure 2. Properly de-greened grapefruit with a nearly uniform yellow peel colour.

The de-greening protocol involves exposing green-skinned grapefruit to low concentrations of ethylene (usually between 1 to 5 ppm) at 28°C to 30°C (83°F to 87°F), 90% to 95% relative humidity for several days. The optimal ethylene concentration and treatment duration varies by cultivar and growing conditions. Excess ethylene can cause stem end rot and 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 several minutes. Ventilation of the atmosphere inside the treatment chamber is important to prevent a build-up of CO_2. High CO_2 (above 2000 ppm) will inhibit the effect of ethylene.

A liquid ethylene-releasing compound, called ethephon [(2-chloroethyl) phosphonic acid], is also an effective de-greening agent. 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 hypochlorous acid (i.e. 150 ppm bleach at a pH of 6.5) and treated with a fungicide (i.e. 500 ppm benomyl, or 1000 ppm thiabendazole or imazalil) in order to prevent postharvest decay.

Cleaning

The peel of grapefruit at the time of harvest is often covered with varying amounts of dirt, sooty mould, scale, and spray residue. The first step in preparation of the fruit for market involves cleaning the fruit surface. This can be done manually by rubbing the fruit with a damp cloth or in larger scale operations by passing the fruit under spray wash nozzles while revolving on a series of slowly moving brush rollers. The water should be properly sanitized with hypochlorous acid (150 ppm bleach at a pH of 6.5). 150 ppm is equal to 2 oz of household bleach (such as Marvex) per 5 gallons of water, or .3 liters of bleach per 100 liters of water. A dilute soap or detergent spray applied to the fruit will enhance cleaning as the fruit continues across the brushes. Adequate cleaning usually requires about 30 seconds on the brushes. Brushes should be horsehair grade, rotating at about 100 rpm. The fruit is then rinsed and treated with a fungicide (i.e. 500 ppm benomyl, 1000 ppm thiabendazole, or 1000 ppm imazalil) as it passes over the last of the brushes or on a roller conveyor just beyond the brushes. Excess water on the fruit can be eliminated with sponge rollers.

Grading

Grading of the fruit is done immediately after washing. The fruit is sorted into different grades based on size, colour, peel blemishes, and over-all appearance. Only fruit of uniform appearance should be packed into each container. Fruit that is seriously damaged by insects, decay, or below market standards should not be packed for sale. Export market destined grapefruit should have a minimum diameter of 10 cm (4 inches) to satisfy importer requirements. Individual fruit should have an average minimum weight of about 450 gm (1 lb). Premium prices are typically received for larger sized fruit. Grapefruit of slightly smaller minimum size may be acceptable in the domestic Guyanese market, but larger sized fruit will typically have a better edible quality.

Grading can be done manually in small-scale operations or semi-automatically in larger volume operations. The fruit is easily sorted by size based on fruit diameter using sizing rings made from wire, wood, or plastic (Figure 3). Examples of the smallest and largest acceptable sizes can be placed within view of the workers for easy reference.

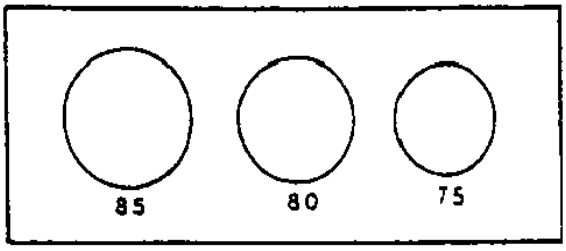


Figure 3. Rings of different diameters used as guides to manually size grapefruit.

Large-scale operations typically use a series of perforated conveyor belts, roller bars, or drum rollers with different sized openings to mechanically size grapefruit. One type of mechanical sizer is composed of a long slanted tray with a series of openings which converge (largest at the top, smallest at the bottom). Another type consists of a set of diverging bar rollers where the smallest sized grapefruit falls through the rollers first, onto a sorting belt or into a bin, and larger sized grapefruit falls between successively more divergent rollers.

Waxing

Much of the surface wax on the peel of the grapefruit is removed during the cleaning process. Grapefruit will benefit from the post-cleaning application of a carnauba-based wax (Figure 4). Waxing slows the rate of shrivel, thereby extending market life. In order to retard moisture loss and improve appearance, grapefruit intended for export should be waxed as soon as possible after harvest. Water-emulsion waxes do not require completely dry fruit, so the wax can be applied right after washing and grading. In small volume operations, the wax can be applied manually by rubbing individual grapefruit with a water-emulsion wax soaked cloth. Larger volume operations will find it more efficient to apply the wax automatically from overhead spray jets as the fruit is moving underneath on a series of slowly rotating (not more than 100 rpm) horsehair grade roller brushes.

Figure 4. Waxing improves grapefruit appearance and reduces postharvest shrivel.

Care must be taken to avoid over-application of the wax. Too thick a coat may restrict gas exchange through the peel and create an internal oxygen deficiency. This may result in the development of off-flavours. A carnauba water-emulsion wax is preferred over a shellac-based wax because of better gas exchange and less likelihood of juice fermentation. A fungicide can be incorporated in the wax to prevent postharvest decay. Recommended fungicides are thiabendazole or imazalil (2000 ppm) or benomyl (1000 ppm). The fungicide concentration incorporated in the wax is double the amount recommended in wash or spray water.

De-greening should always be done prior to waxing. The wax coating will partially restrict gas exchange through the peel and inhibit the action of ethylene.

Packing

Grapefruit should be packed in strong well-ventilated containers that can be stacked without collapsing. The most commonly used container for domestic market sales is a

large sack, often filled with more than 30 kg (66 lb) of fruit. However, sacks do not provide protection against bruise damage. In addition, they cannot be stacked without causing serious injury to the fruit. Wooden crates provide much better protection to the fruit.

The preferred containers for export marketing are full-telescope fiberboard cartons (Figure 5), typically holding 18 kg (40 lb) of fruit. All fruit within the carton should have a uniform appearance. The fiberboard cartons should have a minimum test strength of 275 psi. Diphenyl-treated pads should be put inside the cartons or crates before closing to reduce postharvest fungal decay.

Figure 5. Inspection of exported grapefruit packed in 18-kg fiberboard cartons.

Temperature Control

The recommended storage temperature for grapefruit is 12°C (54°F). At this temperature, grapefruit will have a potential storage life of 8 to 12 weeks. For short-term storage of several weeks 16°C (61°F) is adequate. However, storage at ambient temperature will result in rapid deterioration. Grapefruit should not be held for more than a week under non-refrigerated conditions. The first signs of breakdown are dehydration and collapse of the stem-end, followed by surface pitting and postharvest decay. Holding grapefruit at cold temperatures is also undesirable. Grapefruit is subject to chilling injury at a temperature of 10º C (50º F) or below.

Relative Humidity

The recommended relative humidity (RH) for holding grapefruit is 90% to 95%. A lower RH will accelerate fruit dehydration and softening and favor rind breakdown.

Principal Postharvest Diseases

Grapefruit is susceptible to a number of different bacterial and fungal pathogens during storage. Some of these postharvest microorganisms attack the fruit prior to harvest, but exist in a resting or dormant state until the conditions are right for infection. Others are only problematic after harvest. Grapefruit must be harvested and handled gently to avoid wounding of the fruit that predisposes it to postharvest decay. In addition, adequate ventilation during storage is necessary to remove ethylene and other volatiles. High concentrations of ethylene in the storage room increase the occurrence of various moulds.

Control of postharvest decay is obtained by a combination of treatments, including proper sanitation of the wash water, the use of appropriate fungicides, and proper temperature and RH control. Dipping the fruit in a tank of hot water dip (50°C to 53°C; 120°F to 125°F) for 2 to 3 minutes is also effective in reducing postharvest decay. In addition, pads impregnated with the fungistat diphenyl (at the rate of 4.7 gm/23 kg fruit) can be

placed in shipping cartons to limit the development of postharvest decay during transport and distribution to market.

Green Mould

Green mould, caused by the fungus *Penicillium digitatum*, is generally the worst postharvest disease of grapefruit. The fungus causes a rapid breakdown of fruit injured or bruised during harvesting and packing. The initial symptom appears as a soft, watery, discoloured spot on the rind. The spot enlarges and the decay soon penetrates into the fruit. A white fungal growth appears on the fruit surface and olive-green spores are produced (Figure 6). The sporulating area is surrounded by a broad zone of white fungal growth and an outer zone of softened rind. The entire fruit becomes covered with a mass of dusty olive-green spores. 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. The decay spreads very little in packed cartons, but masses of spores produced on one infected fruit can soil surfaces of healthy fruit with green-coloured spores.

Figure 6. Green mould on grapefruit.

Green mould develops rapidly at ambient temperature. It is suppressed by holding the fruit at 12°C (54°F). Adequate ventilation of the storage room is important because high concentrations of ethylene will increase the incidence of green mould. Also, a postharvest application of a benzimidazole fungicide (500 ppm benlate, 1000 ppm thiabendazole, or 1000 ppm imazalil) will reduce the amount of green mould.

Blue Mould

Blue mould, caused by the fungus *Penicillium italicum*, is a common postharvest disease of grapefruit during long term cool storage. Like green mould, blue mould develops rapidly at ambient temperatures. It attacks injured areas of the peel and first appears as soft, watery, de-colourized spots on the rind. Soon afterwards, a blue mould growth begins, surrounded by a zone of white mycelium (Figure 7). Healthy fruit in packed containers become soiled by spores shed from the diseased fruit. Unlike green mould, blue mould spreads in packed containers and results in nests or pockets of diseased fruit.

Blue mould can be minimized by timely pre-harvest fungicide applications (i.e. benlate, thiabendazole) and careful harvesting practices to avoid wounding. Immediately after harvest, the fruit should be submerged in a fungicide solution (500 ppm benomyl, or 1000 ppm thiabendazole, or 1000 ppm imazalil).

Figure 7. Considerable blue mould growth surrounded by white mycelium.

Brown Rot

This fruit disease is caused by the same species of *Phytophthora* that causes foot rot. The fungus can attack fruit on the tree during periods of excessive rains or during irrigation. The fruit must be wet for some time before infection by the brown rot fungus occurs. Since the fungus is commonly found in the soil, fruit hanging low on the tree is often infected by rain-splashed soil. Winds can spread the actively growing fungus to fruit in the upper tree.

Decay initially occurs as a light brown discolouration of the rind at any location on the fruit surface within 3 to 4 days of infection. The affected area is firm and leathery, and it retains the same degree of firmness and elevation as the adjacent healthy rind. Under humid storage conditions, delicate white mycelium forms on the lesion surface. Decay will spread from infected to healthy fruit in packed cartons during transit and storage, particularly during conditions of export. Fruit with brown rot have a characteristic pungent, rancid odour, which distinguishes the disease from the stem-end rots.

Control of brown rot is obtained by a combination of field sanitation, pre-harvest sprays of copper or fosetyl-Al (Aliette) fungicides, disinfection of the harvest containers, wash water sanitation, and holding the fruit at 12°C (54°F).

Anthracnose

Anthracnose, caused by the fungus *Collectotrichum gloeosporioides*, is generally associated with fruit which has been stored for more than several weeks. Symptoms generally appear as brown to black circular sunken spots on the peel. 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 may be pink or salmon-coloured, instead of their normal brown or black colour (Figure 8). Ethylene stimulates anthracnose growth and increases the susceptibility of the rind to further fungal invasion.

Figure 8. Severe anthracnose infection of grapefruit.

Control of anthracnose is obtained by using timely pre-harvest fungicide applications to lower the inoculum level, avoiding injury to the fruit during harvest and handling, application of a postharvest fungicide application (i.e. either benomyl, thiabendazole, or imazalil), and holding the fruit at temperatures 12°C (54°F) instead of at ambient temperature.

Black Rot

Black rot, caused by the fungus *Alternaria citri*, occurs as a stem-end rot on grapefruit, but usually only after they have been stored for a month or more (Figure 9). The fungus becomes established on the fruit in dead tissue of the button (calyx and disk) surface and at incomplete closures of the stylar-end. As the button deteriorates during storage, the fungus grows from the surface into the fruit. Lesions developing from infections of the button become light brown to black in colour, and gradually progress over the fruit surface from the blackened button towards the stylar-end. Stylar-end infections proceed through growth cracks. In some cases there are no external symptoms of black rot, only an internal black rot of the center tissue. The decay does not spread from infected to healthy fruit in packed containers.

Control of black rot is obtained by pre-harvest fungicide sprays to lower the inoculum level, careful harvesting to avoid wounding of the tissue, applying the herbicide 2,4-dichlorophenoxy acetic acid as a 500 ppm dip to delay button senescence, and storage of the fruit at 12°C (54°F).

Figure 9. External (left) and internal (right) symptoms of black rot on grapefruit.

Diplodia stem-end rot

Stem-end rot, caused by the fungi *Diplodia natalensis*, is a common postharvest disease of grapefruit in Guyana. Fungal spores lodge beneath the calyx at the time of flowering and remain dormant until harvest. The fungus becomes active at the stem end of the fruit and symptoms appear within several weeks after harvest at ambient temperatures. 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. Decayed tissue is initially firm, but later becomes wet and mushy. There usually is a sour, fermented odour and sometimes the fruit will become quite black. The decay does not spread from infected to healthy fruit in packed containers.

Control of stem-end rot is obtained by pre-harvest fungicide sprays, postharvest application of imazalil (1000 ppm), and storage of the fruit at 12°C (54°F). Diplodia stem-end rot can also be retarded by postharvest applications of 2,4-dichlorophenoxy acetic acid at a dose of 500 ppm, which retards senescence of the button and therefore the entry of the pathogen into the fruit.

Phomopsis Stem-end Rot

Stem-end rot, caused by the fungus *Phomopsis citri*, is a serious postharvest disease of grapefruit grown in humid coastal production areas. The fungus becomes established in dead tissue of the button (calyx and disk) surface, where it lays dormant until harvest. As the button deteriorates during storage, the fungus grows from the surface into the base of the fruit through natural openings. Decay begins at the stem end of the fruit and spreads evenly down the peel. There is some shriveling of the decayed tissue causing a line of separation between decayed and sound tissue. Eventually the rot will penetrate the rind and enter the juice sacs. Surface mycelial growth is occasionally observed on Phomopsis-infected fruit. The disease does not spread from decayed to healthy fruit in packed cartons. The incidence of stem-end rot can be reduced by pre-harvest fungicide sprays to lower the inoculum level and postharvest application of imazalil (1000 ppm active ingredient).

Sour Rot

Grapefruit are very susceptible to sour rot, caused by the fungus, *Geotrichum candidum*. Sour rot is more likely to be a problem in fruit with high amounts of rind moisture, such as fruit harvested in the early morning or following irrigation or rainfall. The disease organism is present in debris on the fruit surface and in the button area. Over-mature fruit and fruit which have been de-greened with ethylene are the most susceptible to sour rot. Infection originates through wounds in the peel. The initial symptoms of sour rot may be confused with those of green or blue mould. Sour rot begins as a water-soaked lesion, light to dark yellow and slightly elevated, with radiating cracks in the cuticle. A sparse amount of white mycelium develops slowly on the lesion surface. The disease develops rapidly at ambient temperature. As the infection spreads, the fruit becomes a slimy watery mass that is very attractive to fruit flies. The decaying fruit gives off a sour smelling odour, hence the name sour rot. Sour rot can spread by contact from one fruit to another. Decayed fruit that are dumped onto a packinghouse line will contaminate brushes and belts, thus increasing the potential for decay. An effective material for control of sour rot is a postharvest dip or spray with sodium ortho-phenylphenate (0.9 kg/380 liters or 2 lb/100 gal). The benzimidazole fungicides are not effective against sour rot.

Postharvest Disorders

Chilling Injury

Grapefruit is very susceptible to low temperature injury, commonly known as chilling injury (CI). It is a physiological disorder which adversely affects the appearance and quality of the grapefruit and occurs at temperatures of 10°C (50°F) or below. Fruit symptoms include pitting and sunken lesions on the peel surface (Figure 10), surface scald, secondary decay, and off-flavour of the juice. Damage is a function of temperature and time, with more CI incurred at lower temperatures and longer exposure durations. The amount of CI depends on cultivar, production area, harvest maturity, and location of the fruit on the tree. The use of pre-harvest applications of the growth regulator gibberellic acid reduces susceptibility to CI, as does maintenance of a 100% RH storage environment. Preconditioning the fruit at 16ºC (61°F) for 7 days before storing at chilling temperatures will also reduce injury. Waxing the fruit or wrapping in a thin plastic film will also lower the amount of damage from CI. In addition, a postharvest fungicide application will lower the amount of decay resulting from CI.

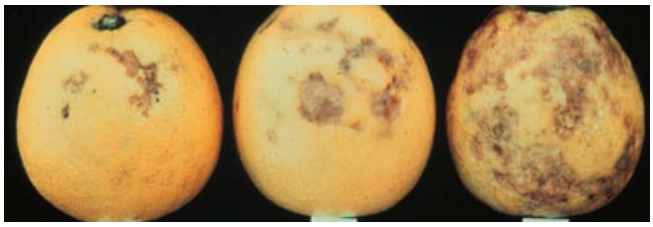


Figure 10. Pitting and sunken lesions on grapefruit peel caused by chilling injury.

Blossom-end Clearing

Blossom-end clearing (BEC), also known as stylar-end clearing, appears as translucent, water-soaked spots at the blossom-end of fruit (Figure 11). The inside of the grapefruit appears wet, as juice vesicles protruding into the core are ruptured under pressure from rough handling during harvesting and packing. BEC usually affects mature seedless grapefruit with a thin peel. Rough handling results in impact damage which leads to the development of BEC. The incidence of BEC increases with elevated temperatures. This disorder varies between growing locations and from season to season.

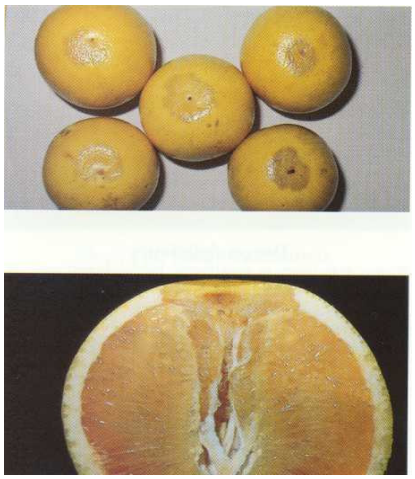


Figure 11. External and internal symptoms of blossom-end clearing in grapefruit.

Control of BEC is obtained by careful harvesting and handling practices to avoid dropping or squeezing of the fruit. Cooling of the grapefruit to 12°C (54°F)

prior to packing will help reduce the incidence of BEC. Also, the cartons should not be over-filled with fruit.

Oleocellosis

Oleocellosis, or oil spotting, is a handling problem which normally does not appear until several days after harvest. Oleocellosis results from physical stress which forces oil from the epidermal oil glands in the peel. The oil kills adjacent cells in the peel and also can damage other fruit that it contacts. Wet fruits are most likely to develop oleocellosis because the oil glands of wet fruit are more easily ruptured. The oil spots may vary from less than 1 cm in diameter to large, irregular areas involving much of the fruit's surface. The spots remain brown in contrast to the yellow colour of the normal rind.

Fruit wetness, or 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. Fruit should be picked after it has been dry for at least several hours. Harvest should be delayed for several days after a heavy rain or irrigation. Oleocellosis can be reduced by having pickers wear cotton gloves and using padding inside the harvest container to cushion the fruit. Grapefruit should always be handled carefully so the oil glands are not punctured or ruptured.

Stem-end Rind Breakdown

Stem-end rind breakdown (SERB) is due to the collapse of tissue around the stem. The affected area is irregular in shape and becomes dark and sunken (Figure 12). A (2 to 5 mm) ring (button) of unaffected tissue immediately around the stem is a distinctive symptom of SERB. Symptoms usually develop during storage and within 2 to 7 days after packing. SERB is more common and severe on small fruit and on well-coloured fruit. Thinner-skinned fruit produced in humid growing environments tend to be more prone to SERB than thicker-skinned fruit grown in drier locations. Fruit with SERB are more susceptible to decay. Development of SERB is mostly due to holding the fruit at a low RH and/or ambient temperature.

Figure 12. Symptoms of stem-end rind breakdown of grapefruit.

Waxing the fruit as soon as possible after harvest will reduce the incidence of SERB. Storing the harvested fruit in the shade will also reduce postharvest SERB. If delays in packing of more than several days are unavoidable, the fruit should be held at a high RH (i.e. 90% to 95%) and 12°C (54°F). Excessive brushing during packing results in increased water loss and a higher incidence of SERB. In automatic brushing operations, the rotation should be kept less than 100 rpm. A good even coat of wax applied to the grapefruit will also reduce the development of SERB.

Fruit Distortion

Grapefruit are susceptible to distortion in the shape of the fruit due to adverse handling and packing procedures. Rough handling, dropping, and holding the fruit at a low RH will increase the amount of fruit distortion. In addition, over-filling or packing grapefruit in weak containers will result in considerable fruit deformation. Misshapen grapefruit are unattractive and develop dry unpalatable flesh under the distorted areas. In order to minimize this problem, grapefruit should be handled very carefully during packing, avoiding dropping of the fruit and exposure to a RH below 80%. The fruit should also be packed in strong containers which are not over-filled.

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, June 2003.
PH Bulletin No. 3	Mango: Postharvest Care and Market Preparation, June 2003.
PH Bulletin No. 4	Bunch Covers for Improving Plantain and Banana Peel Quality, June 2003.
PH Bulletin No. 5	Papaya: Postharvest Care and Market Preparation, June 2003.
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.
PH Bulletin No. 11	Pumpkin: Postharvest Care and Market Preparation, January 2004.
PH Bulletin No. 12	Lime: Postharvest Care and Market Preparation, January 2004.
PH Bulletin No. 13	Grapefruit: Postharvest Care and Market Preparation, January 2004.
PH Bulletin No. 14	Passion Fruit: Postharvest Care and Market Preparation, January 2004.
PH Bulletin No. 15	Green Onions: Postharvest Care and Market Preparation, January 2004.
PH Bulletin No. 16	Sweet Potato: Postharvest Care and Market Preparation, January 2004.

PLANNED PUBLICATIONS - 2004

Cassava: Postharvest Care and Market Preparation.

Eggplant (Boulanger): Postharvest Care and Market Preparation.

Yam: Postharvest Care and Market Preparation.

Ginger: Postharvest Care and Market Preparation.

Harvest Maturity

The grapefruit peel will gradually lose its green colour and start to yellow as the fruit matures. Grapefruit should be harvested when at least 50% of the peel surface area has started to turn yellow.

Juice quality should also be measured to determine harvest maturity. Random samples of fruit from various trees should be picked and separated into different size categories. The percent of soluble solids (%SS) should be measured on a combined sample of 10 randomly selected fruit in each size category. Soluble solids content is determined by squeezing a few drops of juice on a hand-held refractometer. The juice should have a minimum SS of 7.5 % and a minimum SS: percent acidity ratio of 7:1 for the fruit to be considered mature and of acceptable eating quality.

Harvest Methods

Grapefruit should be picked with a combination pull-twist-snap motion that leaves the woody stem and button (calyx) attached to the fruit. The fruit that have stems remaining should be clipped close to the button to shorten the stem to prevent wounding and puncture damage of nearby fruits in the container. Never shake the tree to harvest the fruit. The harvested fruit should be carefully placed into well ventilated, smooth-walled wooden or plastic field crates or picking sacks equipped with a quick-opening bottom. Grapefruit should not be picked in large field sacks, as they provide limited protection to the fruit and overstuffing can result in bruising.

Preparation for Market

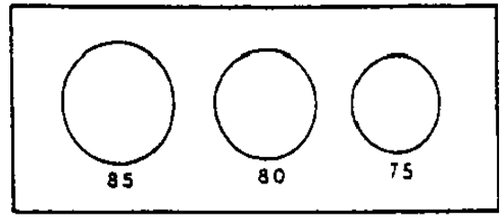
Cleaning
Cleaning can be done manually by rubbing the fruit with a damp cloth or in larger scale operations by passing the fruit under spray wash nozzles while revolving on a series of slowly moving brush rollers. The wash water should be sanitized with 150 ppm hypochlorous acid (household bleach) maintained at a pH of 6.5. This is equal to 2 oz of household bleach (such as Marvex) per 5 gallons of water, or .3 liters of bleach per 100 liters of water. A dilute soap or detergent in the wash water will enhance cleaning. The fruit is then rinsed and treated with a fungicide (i.e. 500 ppm benomyl, 1000 ppm thiabendazole, or 1000 ppm imazalil) prior to grading.

De-greening
Grapefruit that are mature but not fully coloured can be de-greened by exposure to ethylene. This treatment is solely cosmetic in effect and does not alter the flavour of the fruit. The de-greening process involves exposing green-skinned grapefruit to low concentrations of ethylene (usually between 1 to 5 ppm) at 28-30°C (83-87°F), 90 to 95% relative humidity for several days. The optimal ethylene concentration and treatment duration varies by cultivar and growing conditions. Excess ethylene can cause stem end rot.

The de-greening process required keeping green-skinned grapefruit to low concentrations of ethylene (usually between 1 to 5 ppm) at 28°C to 30°C (83°F to 87°F), 90% to 95% relative humidity for several days. The ethylene concentration and treatment durations can vary. Excess ethylene can cause stem end rot.

A liquid ethylene-releasing compound, called ethephon is also an effective de-greening agent. It is applied by dipping the fruit in a tank of clean, sanitized water treated with ethephone (500 ppm) for 1 minute at room temperature. Ethephone (500 ppm) should be measured at 6.6 oz to 5 gl water (0.2 l ethephon to 19 l of water).

Grading
The fruit should be sorted into different grades based on size, colour, peel blemishes, and over-all appearance. Only fruit even in appearance should be packed into the same container. Fruit that is seriously damaged by insects, decay, or below market standards should not be packed for sale. Export market destined grapefruit should have a minimum diameter of 10 cm (4 inches) to satisfy importer requirements. Individual fruit should have an average minimum weight of about 450 gm (1 lb). Grapefruit of slightly smaller minimum size may be sold in the domestic Guyanese market.



Grading by size or fruit diameter can be done manually in small-scale operations using sizing rings, which are placed within view of the workers for easy reference. Large-scale operations typically use more automated equipment to mechanically size grapefruit.

Waxing
Grapefruit will benefit from a postharvest application of a carnauba-based wax. Waxing slows the rate of shrivel and extends market life. Water-emulsion waxes do not require completely dry fruit, so the wax can be applied right after washing and grading. In small volume operations, the wax can be applied manually by rubbing individual grapefruit with a cloth soaked in a water-emulsion wax. Larger volume operations will find it easier to apply the wax from overhead spray jets, as the fruit is moving underneath on a series of slowly rotating brushes.

Packing
Grapefruit should be packed in strong well-ventilated containers that can be stacked without breaking. The large sacks commonly used for domestic marketing do not provide enough protection against bruise damage. In addition, they cannot be stacked without causing serious injury to the fruit. Wooden crates provide better protection to the fruit. The preferred containers for export marketing are strong fiberboard cartons, typically holding 18 kg (40 lb) of fruit. All fruit within the carton should have the same appearance.

Temperature Control

The recommended storage temperature for grapefruit is 12°C (54°F). At this temperature, grapefruit will have a storage life of 8 to 12 weeks. Storage at ambient temperature will result in rapid deterioration. Storing grapefruit at temperatures below 10º C (50º F) can cause chilling injury (CI). Fruit symptoms of CI include pitting and sunken spots on the peel surface, surface scald, decay, and off-flavour of the juice. The recommended relative humidity

(RH) for storing grapefruit is 90% to 95%. A lower RH will increase fruit dehydration and softening and foster rind breakdown.

Principal Postharvest Diseases

Grapefruit is vulnerable to a number of fungal and bacterial postharvest diseases. The fruit must be harvested and handled gently to avoid wounding, which can cause postharvest decay. Good ventilation during storage is necessary to remove ethylene and other volatiles. Postharvest decay is controlled through a combination of treatments, including good sanitation of the wash water (150 ppm hypochlorous acid at a pH of 6.5); the use of appropriate fungicide (500 ppm benomyl, or 1000 ppm thiabendazole or imazalil); and proper temperature (12°C) and RH (90%). Benomyl (500 ppm) should be measured at 6.6 oz to 5 gl water (0.2 l benomyl to 19 l of water). Thiabendazole or imazalil (1000ppm) should be measured as 13.2 oz. to 5 gl waters (390 ml to 19 l). Dipping the fruit in a tank of hot water (50°C to 53°C; 120°F to 125°F) for 2 to 3 minutes can also reduce postharvest decay. In addition, pads with the fungistat diphenyl (at the rate of 4.7 gm/23 kg fruit) can be placed in shipping cartons to limit the postharvest decay during transport market.

Green Mould

Green mould is one of the worst postharvest diseases. The first signs appear as a soft, watery, discoloured spot on the rind that grows into a mass of white fungal growth on the fruit surface. The entire fruit may eventually become covered with a mass of dusty olive-green spores.

Blue Mould

Like green mould, blue mould develops rapidly at room temperatures. It attacks injured areas of the peel and first appears as soft, watery, de-colourized spots on the rind. Soon afterwards, a blue mould growth begins, surrounded by a zone of white fungal growth. Unlike green mould, blue mould spreads in packed containers and results in nests or pockets of diseased fruit.

Brown Rot

This fruit disease is common during the rainy season. The fruit must be wet for some time before infection occurs. Decay signs begin as a light brown discolouration of the rind. The affected area is firm and leathery. In humid storage conditions, a white fungal growth forms on the lesion surface. Decay will spread to healthy fruit in packed cartons. The fruit will have a bad, rancid odour. Brown rot is controlled through pre-harvest sprays of copper or fosetyl-Al (Aliette) fungicides.

Anthracnose

Anthracnose occurs with fruit that has been stored for more than several weeks. Symptoms are brown to black circular sunken spots on the peel. The decay may be firm and dry and cause fruit to soften.

Black Rot

Black rot occurs as a stem-end rot on grapefruit, but usually only after they have been stored for a month or more. Spots developing from infections of the button become light brown to black in colour, and gradually progress over the fruit surface from the blackened button towards the blossom end. Control of black rot is obtained by applying 2, 4-D as a 500 ppm dip to delay button aging. 2,4-D (500 ppm) should be measured at 6.6 oz to 5 gl water (0.2 l benomyl to 19 l of water).

Technical bulletins are also available on waxing fruits and vegetables, hot bath treatment and de-greening procedurings. Contact:
New Guyana Marketing Corporation (NGMC) 87 Robb & Alexander Sts., Georgetown, Guyana
Tel: 226-8255, 226-2219

National Agricultural Research Institute (NARI)
Mon Repos, East Coast Demerara, Guyana
Tel: 220-2950

With the assistance of
The United States Agency for International Development

New Guyana Marketing Corporation

GRAPEFRUIT

Postharvest Handling and Market Preparation Information Sheet

This information sheet provides growers and agriculture extension personnel a summary of the recommended harvesting and postharvest handling practices for grapefruit. A more technical and detailed bulletin is available from the New Guyana Marketing Corporation (NGMC) and the National Agricultural Research Institute (NARI).