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Introduction

Citrus fruit produced in Guyana is often mature and of acceptable eating quality when the rind is still green. High temperatures and humidity interfere with peel coloration, although internal fruit quality characteristics may be acceptable. Regardless of peel color, Guyanese consumers recognize citrus fruit with a green peel color may be perfectly good to eat. Domestic consumers tend to be more concerned about citrus fruit flavor and juiciness, rather than external appearance.



However, many consumers in non-Caribbean export markets associate external skin color with internal flavor and believe oranges, tangerines, grapefruit, and lemons with green-colored peels are immature and not ready to eat. Demand in these markets is only for fully colored citrus fruits.



Purpose of De-greening

In order to improve external skin color and export market acceptance, citrus can be treated with ethylene, which is a naturally produced plant growth hormone effective as a de-greening agent. Ethylene treatment breaks down the green chlorophyll pigment in the exterior part of the peel 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.



Timing of De-greening

Ethylene treatment should be given immediately after harvest. Fruit do not have to be dry before treatment. However, grapefruit will not de-green well if the peel is moist. Ethylene must be applied prior to waxing. Application of a wax coating to the fruit surface will lower the rate of gas exchange through the peel. Less ethylene will be able to penetrate into the fruit, thereby requiring either a higher concentration or a longer duration of

exposure to obtain adequate de-greening.

Ethylene De-greening Methods

Gas Treatment

The general procedure for de-greening citrus with ethylene gas involves exposing green-skinned fruit held at a high temperature and relative humidity to low concentrations of ethylene for several days. The source of ethylene can be a high-pressure gas cylinder or an ethylene generator. Precise control of the temperature, relative humidity (RH), ethylene concentration, ventilation, and internal air flow is critical in obtaining the desired de-greening results.

The ethylene gas treatment procedure for effective de-greening should adhere to the following protocol:

Temperature: 28-29°C (82-85°F) for humid production areas

20-25°C (68-78°F) for arid production areas

Relative Humidity: 90-96%

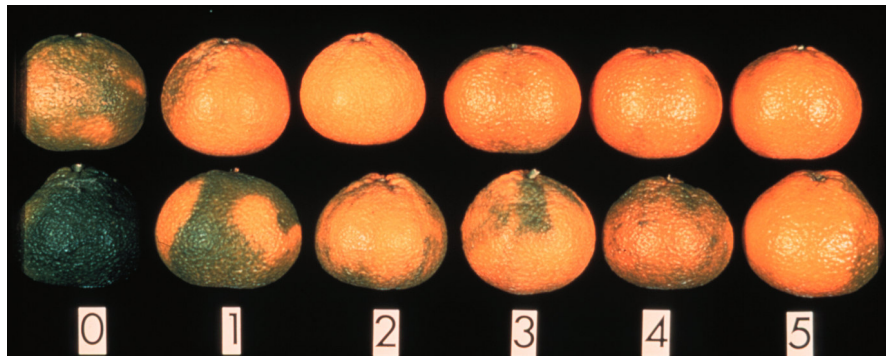
Ethylene Concentration: 3-5 ppm

Duration: ≤ 2 days

Grapefruit: 48 hours

Oranges: 24-36 hours

Tangerines: 6-12 hours



Tangerines de-greened with 0 to 5 ppm ethylene.

Warmer or cooler temperatures slow de-greening. Adequate insulation of the walls and ceiling of the de-greening chamber/room is necessary to avoid over-heating. Good air circulation must be maintained inside the room to ensure uniformity in temperature and ethylene concentration, which is necessary to achieve good de-greening results. The total air volume within the treatment chamber should be circulated every 2 to 3 minutes. The room should be designed so the internal air movement is horizontal.

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, ethylene concentration should never exceed 10 ppm. Higher ethylene concentrations do not speed up the rate of de-greening, but increase postharvest decay.

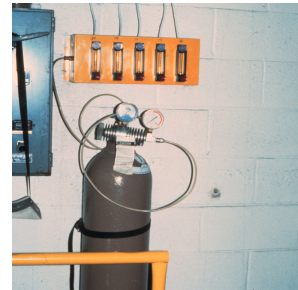
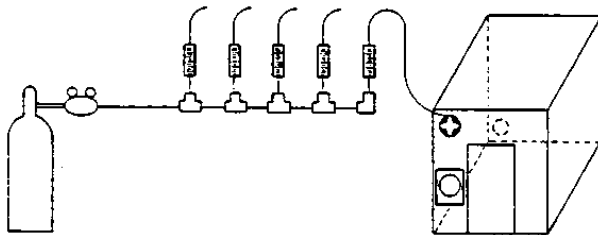
The treatment chamber should be well insulated in order to maintain the desired ethylene concentration. It is important to have a portable ethylene analyzer or disposable detection tubes available to measure the ethylene concentration in the de-greening room, in case any adjustments are needed. Ethylene analyses procedures are simple and reliable.

The de-greening room should be ventilated with fresh outside air to replenish the oxygen (O_2) which is consumed. It eliminates the carbon dioxide (CO_2) which is given off by the treated oranges. 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. Ventilation is best done by having a small, but constant, intake of fresh air into the de-greening room. Ventilation with clean outside air should be done at the rate of one complete room volume change per hour.

A high RH is necessary during de-greening to maintain peel freshness and prevent desiccation. A low RH will increase stem-end rot decay and stem-end rind breakdown.

High Pressure Cylinders

The flow of ethylene from the high pressure cylinder into the de-greening rooms is finely controlled by a two-stage regulator, needle valves and flowmeters.



Ethylene Generator

A commercially available electric ethylene generator is available for de-greening citrus. It converts ethanol, in the presence of heat and a catalyst, to ethylene. The generator is located inside the de-greening room.



Liquid Treatment (Ethephon)

The general procedure for de-greening citrus with liquid ethylene (ethephon) involves dipping green-skinned fruit in a tank of water at ambient temperature to low concentrations of

ethylene for several minutes or less. The source of ethylene is the chemical [(2-chloroethyl) phosphonic acid], which is a liquid ethylene-releasing compound with the chemical name of ethephon. The water should be sanitized with 150 ppm hypochlorous acid (2.4 pints of household bleach in 100 gallons of water) and maintained at a pH of 6.5. The sanitizing strength of the wash water should be frequently tested with the appropriate meters and/or test strips, and adjusted when necessary. A fungicide is usually incorporated in the water (500 ppm benomyl or 1000ppm thiabendazole).

The liquid ethylene treatment procedure for effective de-greening should adhere to the following protocol:

Water Temperature:	ambient (22-29°C) (72-85°F)
Water Sanitation:	potable, 150 ppm hypochlorous acid, pH 6.5, fungicide benomyl (500 ppm) or thiabendazole (1000 ppm)
Ethephon Concentration:	500 ppm
Duration:	1-3 minutes

Undesirable Effects of De-Greening

Postharvest Decay

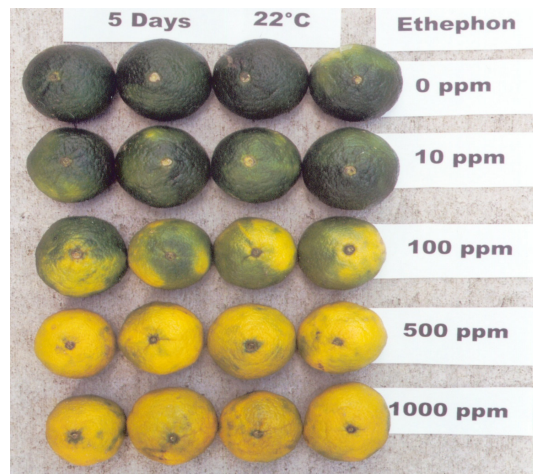
Postharvest decay may be accelerated due to excess ethylene exposure. The two principal diseases which can increase are stem-end rot (*Diplodia natalensis*) and anthracnose (*Colletotrichum gloeosporioides*). Both pathogens can be controlled by a postharvest application of benomyl (500 ppm) or thiabendazole (1000 ppm) after de-greening.

Diplodia Stem-end Rot

Stem-end rot fungus usually infects fruit from the button at the stem-end of the fruit. It proceeds through the core more quickly than the rind, leading a soft brown to black decay to appear at both ends of the fruit. All citrus types are susceptible.



The pathogen usually develops unevenly on the rind, forming finger-like projections of black to brown discolorations on the peel surface. The fungus may also infect fruit through injuries to cause a soft brown to black lesion that enlarges very rapidly.

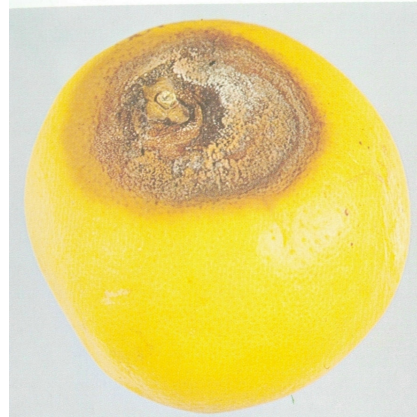


Tangerines 5 days after treatment with various concentrations of ethephon.

Anthracnose

The lesions initially appear silvery gray and leathery, and are similar in firmness and elevation to adjacent healthy rind. The infected rind becomes brown to grayish black and softens as the rot progresses.

Lesion sizes and shapes are irregular. Pink spores may form on the lesion surface in humid environments. Lesions may be tear-dropped in shape due to distribution of the spores at the time of infection. Anthracnose may also develop at rind injuries and produce firm, sunken, dry lesions. Tangerines are particularly susceptible to anthracnose decay if de-greening time exceeds 36 hours.

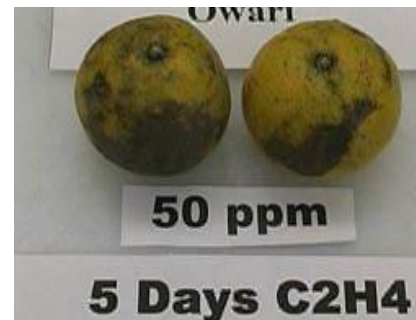


Stem-end Rind Breakdown

Valencia oranges are susceptible to stem-end rind breakdown. After degreening, a holding period is necessary where fresh, cool air is introduced into the room for 12 to 24 hours before packing. If not properly aired and cooled, rind stain may appear after running over the packing line.

Peel Scalding

Irregular, brown lesions develop on skin with an objectionable appearance. Tangerines are particularly susceptible and may have to be treated with only 2-3 ppm ethylene to avoid this disorder.



ANNEX 1

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.
PH Bulletin No. 17	Eggplant (Boulanger): Postharvest Care and Market Preparation, January 2004.
PH Bulletin No. 18	Avocado (Pear): Postharvest Care and Market Preparation, January 2004.
PH Bulletin No. 19	Bitter Melon: Postharvest Care and Market Preparation, January 2004.
PH Bulletin No. 20	Bora: Postharvest Care and Market Preparation, April 2004.
PH Bulletin No. 21	Cassava: Postharvest Care and Market Preparation, April 2004.
PH Bulletin No. 22	Eddoes: Postharvest Care and Market Preparation, April 2004.

- PH Bulletin No. 23 Ginger: Postharvest Care and Market Preparation, May 2004.
- PH Bulletin No. 24 Breadfruit: Postharvest Care and Market Preparation, May 2004.
- PH Bulletin No. 25 Cabbage: Postharvest Care and Market Preparation, May 2004.
- PH Bulletin No. 26 Calaloo: Postharvest Care and Market Preparation, May 2004.
- PH Bulletin No. 27 Coconut: Postharvest Care and Market Preparation, May 2004.
- PH Bulletin No. 28 Cucumber: Postharvest Care and Market Preparation, May 2004.
- PH Bulletin No. 29 Lemon: Postharvest Care and Market Preparation, May 2004.
- PH Bulletin No. 30 Starfruit: Postharvest Care and Market Preparation, May 2004.
- PH Bulletin No. 31 Tangerine: Postharvest Care and Market Preparation, May 2004.
- PH Bulletin No. 32 Yam: Postharvest Care and Market Preparation, May 2004.
- PH Bulletin No. 33 Waxing Fruits and Vegetables: Postharvest Care and Market Preparation,
June 2004.
- PH Bulletin No. 34 De-Greening Citrus: Postharvest Care and Market Preparation, June
2004.
- PH Bulletin No. 35 Curing of Ground Provisions: Postharvest Care and Market Preparation,
June 2004.