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Postharvest Handling
Technical Bulletin

WATERMELON

Postharvest Care and Market Preparation

Technical Bulletin No. 6

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POSTHARVEST HANDLING TECHNICAL SERIES

WATERMELON

Postharvest Care and Market Preparation

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

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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 post harvest handling problems, to packaging and transportation, to final market.

Introduction

Watermelon (*Citrullus lanatus*) is a popular dessert vegetable in Guyana, with year-round availability. Fruit vary in shape from globular to oblong. External rind color varies from light to dark green and may be solid, striped, or marbled. Pulp color of most commercial varieties is red. The leading cultivar grown is Mickylee, which has a round shape, solid light-green skin color, and typically weighs between 2.3 to 3.6 kg (5 to 8 lbs). Lesser amounts of the large elongated light-green skinned Charleston Gray are also grown. Postharvest handling recommendations are identical for all watermelon cultivars.

Watermelon harvesting and handling systems are relatively simple in comparison to the procedures used for many other fruits and vegetables. Nevertheless, attention to management in all steps in the system is needed to restrict postharvest losses, maintain quality, and increase profitability. Watermelon harvest quality is retained by careful handling and transport, proper grading, and cool temperature storage.

Harvest Maturity Indices

Several different maturity indicators can be used to determine when to harvest watermelon fruit. Watermelons should be harvested at full maturity to ensure that good quality fruit are delivered to the market. The fruit do not develop internal color or increase in sugar content after being removed from the vine.

Commonly used non-destructive maturity indicators include fruit size, skin color, the amount of surface shine or waxiness, the color of the ground spot, the sound of the fruit when tapped, and the condition of the tendril at the first node above the fruit. Each of these individual indicators by themselves is not a foolproof determinant of fruit ripeness. It is advisable to use at least 3 or more of the above indicators to have more confidence in the harvest maturity state. Growers should also become familiar with the changes in external appearance of the fruit of the particular cultivar grown as it nears maturity in order to develop more confidence in the best stage for harvesting.

Each cultivar has a known average fruit size, controlled by the genetic make-up of the cultivar and influenced by environmental conditions. Based on this previously established average fruit size, the timing of harvest can be approximated. As the fruit approaches harvest maturity the surface may become a bit irregular and dull rather than glossy.

The ground spot (the portion of the melon resting on the soil) changes from pale white to a creamy yellow at the proper harvest maturity. The ground spot color is easily revealed by gently rolling the fruit over to one side while still attached to the vine. Very experienced workers can determine ripeness stage based on the sound produced when the fruit is thumped or rapped with the knuckles. Immature fruit will give off a metallic ringing sound whereas mature fruit will sound dull or hollow. Another reliable indicator of fruit ripeness is the condition of the tendril (small curly appendage attached to the fruit stem slightly above the fruit). As the fruit become mature, the tendril will wilt and change from a healthy green color to a partially desiccated brown color.

Several destructive indices can be used on randomly selected fruit to predict harvest maturity of the remaining fruit in the field of similar size. When the fruit is cut in half longitudinally, the entire flesh should be well-colored and uniform red (unless it is a yellow-flesh type). Immature melons have pink flesh, mature melons have red to dark red flesh, and over-mature fruit have reddish-orange flesh. For seeded cultivars, maturity is reached when the gelatinous covering around the seed is no longer apparent and the seed coat is hard and either black or brown in color. Melon fruit that have an abundance of white seeds are not mature. The soluble solids content of the juice is another commonly used index of harvest maturity. Soluble solids in watermelon consist mostly of sugars. A soluble solids content in the center of the fruit of at least 10% is an indicator of proper maturity. Soluble solids is determined by squeezing a few drops of juice on a hand-held refractometer (Figure 1). In addition, the flesh of mature fruit should be firm, crisp, and free of hollow heart.

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

Harvest Methods

The harvest operation is a manual process which is the most labor-intensive part of producing watermelons. Due to their large size and susceptibility to splitting or cracking under mechanical stress, watermelons should not be harvested in the early morning when they are most turgid.

Avoid picking wet fruit, as the dirt on the watermelon surface will be smeared during handling. This will result in an unattractive appearance. The surface of the watermelon fruit should be cleaned with a soft cloth or cotton gloves to remove any stains or adhering dirt. Typically, the ground spot will have soil attached. If the fruit surface is dry, it is easy to manually rub off the surface dirt. In some cases, it may be necessary to use a damp cloth to rub off the dirt particles. When the fruit surface is very dirty, it will be necessary to put it in a wash tank and scrub it with a soft bristled brush or by hand.

Watermelon stems do not separate freely from the fruit, therefore they should be cut off with a sharp knife. A short length of stem, about 2.5 cm (1 inch) should be left attached to the fruit when it is cut from the vine to deter against stem end rot. The fruit should not be pulled, twisted, or broken off the vine, which can result in the removal of a small piece, or plug, of rind tissue. A plugged fruit is likely to decay around the damaged area. Bacterial soft rot is a common postharvest rot of watermelons with open wounds.

Large sized watermelons are usually put in rows in the field prior to being picked up with a transport vehicle. Alternately, a group of workers can go through the field and toss the melons from one worker to the next, eventually arriving to a person on the transport vehicle. Fruit of small sized cultivars (i.e. less than 5 kg [11 pounds] per fruit) can be put in strong wooden field containers and carried out of the field. Usually 3 to 5 fruit are put

in a field container. Field sacks should not be used for transporting the fruit out of the field, since they do not provide protection against bruising injury.

Watermelons should be handled gently to avoid bruising. Any fruit that is dropped during handling should not be loaded, even if it did not break when it was dropped. Watermelons are easily bruised and flesh softening occurs soon after impact. Also, people should not walk or ride on top of a load of watermelons.

Harvested watermelons should be removed from the field as quickly as possible. Exposure to direct sunlight in the heat of the afternoon can result in sunburn of the fruit surface within a few hours. The damage is more evident in varieties with dark rinds (Figure 2). Field application of a sun protectant about a week prior to harvest can help reduce the incidence of sunburn. Materials used as sun protectants include a slurry of calcium carbonate (whitewash) or a suspension of clay powder. During harvesting and handling the whitewash or clay powder can be wiped or washed off the fruit. This does not create a marketing problem unless a surfactant is used when the protectant is applied, which makes the powder stick to the fruit surface. Buyers may object to the presence of residue or rind staining.

Figure 2. Sunburn of unprotected watermelon fruit.

Preliminary grading of market quality fruit should be done in the field at the time of harvest. Deformed, insect damaged, partially decayed, or cracked fruit should not be loaded for transport to market.

Watermelons should not be stacked on the stem end or blossom end during transport. The internal flesh is more susceptible to vibrational damage if the fruit are stacked in this manner. They should be loaded on their sides. Fruit bruising during transport can also be minimized by keeping the depth of the stack to less than 1 meter (3.3 feet), (Figure 3). Depending on market destination, watermelons may be loaded directly for transport to a domestic market destination, or brought to a packinghouse to be graded for export. Watermelons are generally transported in open trucks or inside un-refrigerated vans. However, neither of these transport methods is ideal for maintaining fruit quality. The fruit on top of the load in open trucks are subject to sunburn. Fruit loaded inside enclosed vans are subject to overheating if transport occurs during hot sunny afternoons.

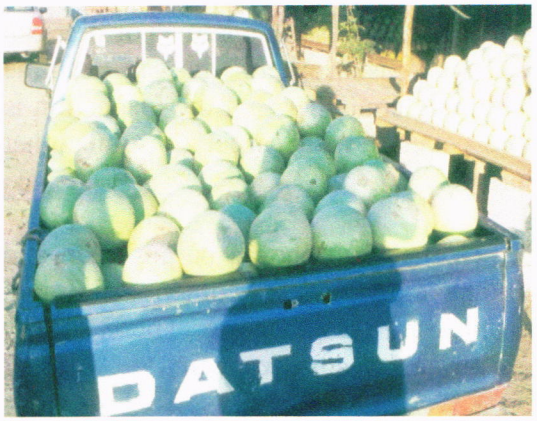

Figure 3. Load height of watermelon fruit should not exceed 1 meter.

Preparation for Market

Cleaning

Watermelon should be picked when the fruit surface is dry. Any adhering soil in the ground spot area or other surface stains should be removed at the time of harvest with a soft cloth or cotton gloves. Watermelons are usually not washed. However, if washing is required to remove excess soil or to enhance the appearance for a particular market, the wash water should be clean and properly sanitized to reduce the potential for spread of disease. Sodium hypochlorite (household bleach) is commonly used since it is an inexpensive and readily available wash water sanitizing agent. It is effective against decay organisms when added to the wash water at a concentration of 150 ppm and a water pH of 6.5. As the wash water becomes contaminated with soil and organic matter, the sanitizing ability of the hypochlorous acid is diminished. Therefore, the wash water tank should be changed when necessary and filled with clean water with 150 ppm hypochlorous acid.

Grading

Watermelons are graded according to external appearance. Fruit shape should be symmetrical and uniform in size within the same container. The surface should be clean, bright, and waxy. There should be an absence of scars, bruising, sunburn, transit abrasions, decay, or other surface defects.

Watermelons destined for export must meet the quality standards established by the receiver. Typically, the fruit are more carefully inspected than those intended to be marketed domestically. Freight costs constitute the greatest single expense when shipping to an offshore market and it is critical that all fruit of inferior quality be excluded from the shipment. Also, the presence of disease, insects, or soil can result in failure to meet phytosanitary requirements at the destination and lead to rejection of the entire shipment.

Inspection areas should be kept clean and surfaces should be disinfected periodically with chlorine solutions to reduce the risk of spreading pathogens. A simple conveyor belt can be utilized to transport the watermelons in a single row past workers who can examine each fruit individually before they are placed in shipping containers. If the inspection is done on a stationary table, the surface should be covered with carpet or some other material that will prevent scratching of the fruit surface.

In addition to the external appearance, randomly selected fruit should be cut open and checked for internal quality. The edible flesh should have a high sugar content (minimum of 10% soluble solids), a deep red color, and a pleasant crisp texture. These quality characteristics are dependent on fruit maturity, cultivar, and postharvest care.

Packing

Watermelons may be loaded directly from the field into the bed of a truck or trailer and transported to market. This is essentially a form of field packing.

Watermelons destined for export are generally taken in bulk from the field to a collection site for grading and packing. Workers should unload the fruit with care and place them on a packing table where other workers sort them into more precise size groups and pack them. Table surfaces should be covered with a nonabrasive material, such as carpet, to help avoid scratching the fruit. Large packing operations can improve packing efficiency and increase product throughput by using a conveyor belt to move the fruit past stationary workers trained in grading and packing. Watermelons packed for export should be put in strong double-walled corrugated cartons containing from three to five watermelons, depending on fruit size and shape (Figure 4). The cartons typically weigh between 25 to 35 kg (55 to 77 lb). Since watermelon fruit are so heavy, inserts should be used inside the carton to help support the weight. Smaller sized round fruit may be packed 6 to 8 fruit per carton (Figure 5). The cartons should be stacked properly to permit adequate air flow through the load during transport.

Figure 4. Three large elongated watermelons packed in cartons destined for the U.S.

Figure 5. Small round fruit packed for export to the U.K.

Temperature Management

The optimum temperature for storage and transport of watermelon is 10° C (50° F). Watermelons should not be held at temperatures below 10°C because they are susceptible to chilling injury. Market life is up to 21 days at 10°C. With increasing storage temperature, market life is diminished and the fruit lose their sweetness. Watermelon market life is usually 14 days at 15°C (59°F). Watermelons held at ambient temperatures of around 29°C (85°F) should be marketed promptly, as quality declines quickly (Figure

6). If they don't succumb to decay, watermelons held for more than 2 weeks at ambient temperature will have poor flavor and the texture will lose its crispness.

Relative Humidity

Watermelons should be held at 90-95% relative humidity (RH). Storage at low RH will result in shriveling of the rind and a loss of external shine. Mechanical injuries incurred during harvesting and handling become more noticeable at a low RH.

Figure 6. Watermelons should be marketed soon after harvest to avoid quality loss at high temperatures.

Principal Postharvest Diseases

Postharvest diseases are important sources of postharvest loss of watermelons in Guyana. The amount of disease pressure depends on cultural practices used during production and the local climatic conditions at harvest. Disease pressure is greater in areas with high rainfall and humidity during production and harvest.

A number of pathogens may cause postharvest decay of watermelon. The primary defense against the occurrence of decay is the exclusion of diseased fruit from the marketing chain through careful selection at harvest and appropriate grading before shipment. Also, holding the fruit at 10°C (50°F) will slow the rate of disease development, compared to ambient temperature storage. There are no postharvest fungicide treatments for watermelon.

Common fungal diseases that cause rind decay after harvest include black rot, anthracnose, Phytophthora fruit rot, Fusarium, and stem-end rot. The most common postharvest bacterial disease is soft rot.

Black Rot

Black rot, also known as gummy stem blight, is caused by the fungus *Didymella bryoniae*. Fruit lesions appear as small water-soaked areas and are nearly circular in shape. They rapidly enlarge to an indefinite size, up to 10 cm to 15 cm (4-6 inches) in diameter. Mature lesions are sunken, may show a pattern of concentric rings, and turn black. Lesions in stems and fruit may ooze or bleed an amber plant fluid, hence the name gummy stem blight. A brown streak may also appear at the blossom end of the fruit.

The pathogen is transmitted from contaminated seed and is spread from plant to plant by splashing rain or wind. Inoculum is also found on old plant debris. The disease is controlled by planting clean seed in soils free of watermelon crop debris.

Anthracnose

Anthracnose, caused by the fungus *Colletotrichum orbiculare*, is a common postharvest watermelon disease. Dormant infections may exist at the time of harvest, with no external evidence of the disease. During storage, the latent infections may become active at high temperatures or after exposure to chilling injury inducing conditions. Disease development is rapid at temperatures between 20°C to 30°C (68°F to 86°F). The fungus can penetrate the fruit surface and wounding is not necessary for infection. Symptoms of anthracnose include sunken spots on the rind, which eventual become black (Figure 7). Red or orange colored spores may appear in the decayed areas.

Figure 7. Anthracnose decay of watermelon fruit.

Anthracnose spores are spread by water, insects, or pickers' hands. Infection is particularly severe after prolonged wet periods. A combination of seed treatment, crop rotation, removal of infected debris, and fungicide applications are necessary for controlling this disease. Protective spray applications of the fungicide chlorothalonil should be made when vines start to run and should be continued at 7 to 10 day intervals during periods of humid or rainy weather. Also, storage of the fruit at 10°C (50°F) will retard the growth of this fungus.

Phytophthora Fruit Rot

Phytophthora fruit rot is caused by the soil-borne fungus, *Phytophthora capsici.* The fruit rot will appear as greasy blotches on the outer rind. A whitish mold is likely to be present on the greasy tissue (Figure 8). This disease is most likely to occur during or after periods of excessive rains where water remained in the field. Control of Phytophthora may be obtained by avoiding planting in low areas. In addition, foliar sprays of the systemic fungicide Ridomil provide some protection against this disease.

Figure 8. Greasy spot and associated whitish mold growth of Phytophthora infected fruit.

Fusarium

Fusarium is a soil-borne fungus that attacks the roots, stems, and fruit of watermelons. The fungus can attack both sound and wounded tissue. Fruit symptoms first appear as spots on the underside of the fruit, and eventually spread to the upper surface. Infected tissue is usually spongy or corky. Under humid conditions, the fruit may become covered with a white or pinkish mold (Figure 9). Decay may be shallow or it may extend deep into the flesh of the fruit. There is usually a sharp separation between healthy and rotted tissue. The temperature range which favors Fusarium growth is 22° to 29°C (72°F to 84°F).

Figure 9. Fusarium rot on 'Sugar Baby' watermelon.

Use of resistant varieties can minimize the risk of Fusarium. Rotating the planting site and removing and destroying all plant debris at the end of each growing season will also reduce the incidence of the disease. For watermelon, a minimum eight-year planting site rotation is recommended to avoid Fusarium. This disease may also be spread by planting previously saved seed that came from contaminated fruit.

Stem-end Rot

Stem end rot is caused by the fungus *Lasiodiplodia theobromae*. The disease is first seen as a shriveling and drying of the stem followed by browning of the area around the stem, which progressively enlarges as the disease develops (Figure 10). The cut flesh is noticeably softened and lightly browned. If the cut melon is exposed to the air for a few hours, the diseased areas become black. The disease develops rapidly in the fruit at temperatures greater than or equal to 25°C (77°F) but slowly or not at all at 10°C (50°F). In order to minimize the incidence of this disease, at least 2.5 cm of stem should remain attached to the fruit at harvest.

Figure 10. Symptoms of stem-end rot.

Bacterial Soft Rot

Bacterial soft rot, caused by *Erwinia carotovora*, is the principal postharvest bacterial disease of watermelons. It is a secondary decay organism, requiring openings in the skin or wounded areas of the rind to enter. Insect damage, fungal decay, and mechanical injuries predispose fruits to infection. The disease causes rapid fruit rot and rancidity. Foul odors develop within a few days at ambient temperatures. The disease can be avoided by careful handling of the fruit to minimize rind damage.

Postharvest Disorders

Mechanical Injury

Rough handling during harvest, loading, and unloading of watermelons will result in fruit bruising, cracking, and high amounts of postharvest loss. Internal bruising leads to premature flesh breakdown and mealiness. Watermelons should not be dropped, thrown, or walked on, as internal bruising and flesh breakdown will occur.

Chilling Injury

Watermelons develop chilling injury (CI) when stored below 10°C (50°F) for more than a few days. Damage becomes greater as the temperature decreases and the length of storage time at CI-inducing temperatures increase. Symptoms of CI include sunken depressions on the fruit surface (pitting), brown-staining of the rind, loss of flesh color, loss of flavor, and increased decay when returned to ambient temperature. Conditioning fruit at 30°C (86°F) for about 4 days before cooling will induce some tolerance to CI, but will not alleviate the problem completely. Fruit may sustain chilling injury in cold storage without exhibiting symptoms until the fruit is returned to warm temperatures.

Ethylene Damage

Watermelon are adversely affected by exposure to ethylene. Exposure to as little as 5 ppm ethylene for 7 days at 18°C (64°F) results in tissue softening and rind thinning. Flesh color fades and has the appearance of being overripe. Higher concentrations of ethylene result in more rapid injury to the fruit. The ethylene absorbent potassium permanganate may be used to inactivate ethylene in enclosed areas. Avoiding exposure to ethylene by keeping watermelons away from other commodities that emit high amounts of ethylene is the simplest way to avoid injury.

Hollow Heart

Hollow heart is a fruit disorder of preharvest origin, in which the internal flesh separates, creating an open cavity or hollow area. It is more problematic on crown-set fruit than lateral-set fruit. Cultivars differ in susceptibility and the severity of the disorder varies among growing locations and seasons. The exact cause of this disorder is unknown. It is also very difficult to externally distinguish fruits with hollow heart.

ANNEX I

PUBLICATION IN THE POSTHARVEST HANDLING TECHNICAL BULLITIN 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.