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Postharvest Handling Technical Bulletin

PLANTAIN

Postharvest Care and Market Preparation



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POSTHARVEST HANDLING TECHNICAL SERIES

PLANTAIN

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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 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

The plantain (*Musa paradisiaca*) is one of the major fruit crops grown in Guyana. It is generally planted in larger tracts of land than most fruit crops, although it is not uncommon to see small plantings of only a few plants. Several types of plantain are grown, including "Horse", "Creole", and "Horn". The types differ in fruit shape, size, skin color, and flavor. Plantain fruits are typically higher in starch content and lower in sugar than bananas. Plantains are sometimes called cooking bananas, and are larger and firmer than dessert bananas. Plantains are rarely eaten raw, unless completely black to ensure ripeness. They are usually baked or fried and served like a root crop. Fruit is available for harvest year round. Plantains are very important to the diet of the domestic population and are also exported to several Caribbean and North American market destinations. The purpose of this bulletin is to provide sufficient technical information on plantains to improve product quality and shelf life for both the domestic and export markets.

Harvesting

Plantains require about 3 months from the beginning of flowering until harvest. Multiple fruits are produced on a large bunch, weighing between 30 to 100 lbs. Within the bunch are clusters of double rows of fruit called 'hands', and individual fruit called 'fingers'.

Crop Maturity Indices

Maturity standards for plantains are less precise than they are for bananas. Several different external and internal fruit characteristics can be used to determine plantain maturity. These include fruit diameter, age of the bunch, angularity of the fruit, length of the fruit, and peel color. The stage of maturity for harvest depends on the intended market destination. Locally marketed plantains can be harvested at a more advanced maturity stage compared to export market fruit. Export market destined fruit should be harvested the day before or the same day of shipment.

Plantain maturity is related to the diameter of the fingers. This is determined by measuring the diameter of the fruit at its midpoint with a pair of calipers (Figure 1).



Figure 1. Caliper used to measure plantain fruit maturity.

Another method for estimating plantain maturity is to record the age of the bunch. The time from when the fruit bunch first becomes visible ('shooting') is recorded. Bunches can be tagged with different colored ribbons at the time of shooting, and subsequently harvested after the appropriate time for the particular cultivar, based on the season of the year and experience. The color of the ribbons is changed weekly to coincide with the time of shooting and subsequently the age of the bunch.

A third method used to determine harvest maturity is to observe the shape (fullness) and angularity of the fruit. Immature fruit is angular in cross-sectional shape and has distinct ridges. As the fruit matures, it becomes less angular and more rounded or full. The degree of roundness differs between cultivars and location of the hand on the bunch. Typically, the fullness of the fruit on the middle hand is measured. The appropriate shape to harvest the fruit depends on the market destination. Fruit intended for the domestic market should be harvested when the fruit shape is nearly round. Export market fruit intended for the Caribbean market should be harvested when the fruit shape is slightly angular, while fruit intended for long distant export markets (i.e. Canada, U.K.) should be harvested when the fruit shape is more noticeably angular.

A fourth way of estimating plantain bunch maturity is to measure the length of the edible pulp portion of the fruit from the fingers in the middle hand. The length should be a minimum of 15 cm for the domestic market and 18 cm for the export market.

Finally peel color is another frequently used method of assessing fruit maturity. The peel remains green throughout growth and development of the fruit until it reaches physiological maturity. It then changes to a yellow color during ripening.

However, plantain fruit should be harvested when the peel is green in color to withstand the rigors of handling and distribution. Internal fruit composition changes dramatically during plantain fruit ripening. At physiological maturity, the fruit is fully developed in size, green in peel color, and at its highest level of starch. The starch will progressively be converted to sugar as ripening progresses.

The stage of harvest maturity of plantains will depend on the target market. Plantains for local markets are harvested at a more advanced stage of maturity than those for exportation. However, if the fruit is too mature at harvest, particularly following irrigation or rainfall, fruit splitting can occur during handling. Also, mature fruit may ripen prematurely during transport or storage (Figure 2).



Figure 2. Splitting of mature fruit (bunch at right) after heavy rainfall.

Harvest Methods

The usual method of harvesting plantains is to partly cut through the pseudostem approximately 2 m from the ground. This allows the plant to bend over under the weight of the bunch. The bunch is then cut off and carried away by hand to a nearby collection site or packing area.

Preparation for Market

Transportation to Collection Area

After harvest, the plantain bunches are taken from the field to a collection area or consolidation site, where they are often piled up on one another (Figure 3). Piling should be avoided, as it results in considerable bruising injury and mechanical damage to the fruit. Rudimentary grading at this point should be done to eliminate diseased, damaged, or over-ripe fruit. The fruit should not be exposed to sun, rain, or wind. Fruit temperature of plantains exposed to the sun may be up to 10°C higher than shaded fruit. Collection points for the harvested fruit should be shaded and easily accessible to vehicles for transportation.



Figure 3. Plantain bunches piled together at collection site near Parika.

Transportation to Packing Area

The bunches of plantains from the collection sites are normally loaded in bulk in trucks (Figure 4) or vans for travel to Georgetown or other domestic market destinations. The bunches are piled on top of each other to maximize the load capacity and often over several hundred bunches are stuffed in the truck bed. No specific measures are taken to protect the fruit from physical damage during transport. Considerable peel damage is incurred during loading and unloading and injuries such as bruising from compaction during the journey are common. In addition, many fingers may twist and fall off the bunch. Significant losses occur during transport in fruit intended for the export market, as there is less tolerance for damaged fruit in these markets.



Figure 4. Loading of plantains in bulk for transport to Georgetown.

Suggested changes for reducing mechanical injury and damage to the bunches during transport include:

- use of foam padding along the bottom and side walls of the truck
- placement of foam padding between the bunches
- creating several levels in the truck bed with horizontal boards to stack the bunches
- de-handing the bunches and transport in stackable field containers
- driving the transport vehicle at a low speed

De-handing plantains in the field and packing in stackable plastic field containers is highly recommended for export market fruit. Plastic field containers are easy to clean, widely adapted for use on a number of crops, and very durable (Figure 5). They also impart significantly less damage to the fruit compared to wooden crates or reed baskets.



Figure 5. Stackable plastic field containers for packaging and transportation of plantain hands.

Cleaning

The cleaning step differs depending on whether the fruit is intended for the domestic or export market. If the plantains are to be sold domestically, usually they can be cleaned with cotton gloves or a moist cloth to remove surface dirt once the hands have been cut from the main stalk (peduncle). Export market fruit must be subject to a more rigorous cleaning procedure.

Once the export market fruit arrives at the packing area it must be properly cleaned and sanitized to maximize its potential market life (Figure 6). If the fruit arrives on intact bunches, the hands need to be cut smoothly from the main stalk using a sharp curved knife or blade. A portion of the crown is left attached to the hand. After de-handing, the hand should be moved by grasping the crown area. Moving the entire hand by lifting one or two fingers will cause pedicel bruising and possible severing of the individual fruit from the hand.



Figure 6. Cleaning of plantain fruit destined for Barbados.

When the hands are cut off, sap (latex) oozes from the severed crown. This substance oxidizes and causes a dark stain or blemish on the peel. In order to avoid latex burn, the hands can either be left to drain for 2 minutes on de-latexing trays or floated in water tanks to wash the latex off the fruit surface. If de-latexing trays are used, absorbent cellulose crown pads impregnated with thiabendazole should be applied to the cut crown area after the latex has stopped exuding. Crown pads are commonly used by small-scale growers.

Large-scale plantain growers float the plantain bunches in a water tank to remove any adhering dirt from the peel surface and to coagulate the exuded latex (Figure 7). The water tank should be filled with clean flowing water sanitized with 150 ppm free chlorine, 1% aluminum potassium sulphate (alum) to coagulate the latex, and an appropriate fungicide (except for bananas marketed as 'organic'). The fruit should remain in the water tank at least 15 minutes or until all oozing of latex ceases.



Figure 7. Cleaning and de-latexing of plantain fruit in water tank.

In some packinghouses, separate washing and de-latexing tanks are used. The fruit is first washed for about 5 minutes, followed by de-latexing for about 10 minutes. The fungicide can be included in the de-latexing tank, or sprayed onto the crowns with a hand sprayer while on the drying tray. Alum may also be applied at the same time and serves as an anti-oxidant to prevent subsequent latex exudations from staining the peel.

The recommended fungicides for postharvest disease control in plantains are thiabendazole (500 ppm) and/or imazalil (1000 ppm). It is very important to keep the fungicides agitated to prevent the active ingredient from settling out. Relatively large amounts of the fungicide are usually required because the wash water becomes dirty and must be changed from time to time.

The water flow transports the hands from the de-handing side of the tank to the opposite side where the hands are separated into clusters of 4 to 8 joined fingers, and small or defective fingers are removed. Some markets require each finger to be separated from the bunch. The clusters are removed from the tank, placed on trays, dried, and graded (Figure 8).



Figure 8. Plantain fruit in drying trays after de-handing and washing.

The packing area should be located in an easily accessible area that is shaded, covered, and has good air flow.

Grading

Quality standards vary for different markets. They are the most stringent for the North American and European export market and the least stringent for the domestic Guyanese market. However, the following grade standards apply to green plantain fruit on the bunch for both domestic and export markets:

- fruit must be clean and free of adhering dirt on the peel
- fruit must be well developed, without pronounced ribs or marked angles
- fruit must be similar in shape, color (pale green), and skin typical of the variety
- fruit must be free from visible decay
- bunches must be well trimmed
- the neck, which hold the stems of the fingers together, must be between 1 to 2.5 cm from the pulp
- fruit must be free of damage, or defects caused by malformation, which detract from appearance or edibility

In addition to meeting the above requirements, the Guyana National Bureau of Standards has three grade classifications for plantains based on size. Size is determined by weight and length of individual fruit.

	Minimum weight (gm)	Minimum length (cm)
Grade I	70-110	18
Grade II	250	15
Grade III	140	10

The U.K. market requires a minimum finger length of 22 cm (9 in) and the fruit must arrive with a green peel color. In addition to minimum finger length, the fruit must be free of objectionable blemishes. A small amount of healed scar tissue or superficial insect damage may be tolerated in certain markets. Mechanical scarring of the peel is the single most important fruit defect and can be caused by poor plantation management and harvesting procedures or during transport to the packing area (Figure 9).



Figure 9. Significant scarring and mechanical damage to the peel occurs during transport and handling.

Packing

Plantains sold in the domestic market are usually not packaged. They are transported to market as intact bunches and de-handled at the market site (Figure 10). However, the external fruit appearance would benefit by de-handing the fruit from the bunch and packing the hands with the finger tips pointed down in padded cartons prior to loading in the transport vehicle.



Figure 10. Plantains sold from intact bunches in the Bourda market.

Plantains exported to Barbados or North American market destinations by air should be packed in strong, well-ventilated cartons, typically containing 18 kg (40 lb) of fruit. The cartons must be strong enough to withstand the forces of palletization and well ventilated to maintain an even fruit temperature during transport. An additional 2 lbs of fruit should be added to the 40 lb carton to account for weight loss during storage and transport.

A commonly used package in the international trade of plantains is a full-telescopic two-piece corrugated fiberboard carton with a bursting strength of 275 lb/in² (Figure 11). Top and bottom ventilation, in addition to side vents are required, particularly where sea-shipments are used. A double-walled bottom is preferred. Typical carton internal dimensions are 20 cm x 51 cm x 34 cm (7.9 in x 20 in x 13.4 in).



Figure 11. Typical export carton used for plantains.

Hands or clusters should be packed in a neat, regular pattern to minimize movement and chaffing of the peel. The cartons may be lined with a thin polyethylene film to prevent scuffing of the fruit against the fiberboard. The hands in the bottom of the carton should be placed in the center and overlapped with the adjacent hands. The crowns should face the base of the carton. A thin divider should be used to separate the two layers of fruit. Fruit should never be forced into the carton. Also, the fruit should never be overpacked so it forces the top of the carton to bulge out. This will result in considerable abrasion and mechanical damage to the plantains. Mechanical damage will result in blackened areas of the peel which will soften and often succumb to fungal infection.

Marine container transport is an option if transit time is less than 2 weeks and sufficient cooling capacity is available to maintain storage conditions between 12°C to 14°C (54°F – 57°F), 90% RH during transit. If this mode of transport is used the fruit should be packed in cartons lined with perforated plastic film or enclosed in semi to permeable sealed plastic bags and the transport temperature should be maintained between 12°C to 14°C. The modified atmosphere of low O₂ and high CO₂ established inside the sealed bags from respiration of the fruit will significantly extend the shelf life of the plantains. The plastic film or bags will reduce moisture loss during transport and provide some protection from chafing damage. The fruit should also be harvested at the proper maturity stage to avoid ripening during transport.

Temperature Management

The optimal storage and transport temperature for maximizing plantain shelf life is between 12°C to 14°C. This temperature will delay ripening, but avoid low temperature chilling injury. The average shelf life of mature green harvested plantains stored at 12°C is between 4 to 5 weeks. If the fruit is harvested at a more advanced stage of ripening and/or the storage temperature is higher, the shelf life will be less. Green harvested plantains that are stored under ambient temperatures in Guyana will have a shelf life of about 7 to 10 days. At temperatures above 30°C, the pulp will soften but the peel will remain green. However, shelf life of green mature plantains can be extended at ambient temperatures by storing the fruit in polyethylene bags with an ethylene absorbent (potassium permanganate) wrapped in porous paper. In this microenvironment, plantain shelf life can be extended up to 4 weeks at 29.4°C (85°F) and up to 7 weeks at 12.7°C (55°F). To obtain maximum shelf life from plantains, ethylene must be removed from the atmosphere and the fruit must be kept at 12°C.

Humidity Management

The optimal postharvest relative humidity (RH) for plantains is between 90 to 95%. Storage of fruit at < 90%RH will result in peel desiccation and shriveling. The amount of dehydration will increase with decreasing RH. Water loss from localized skin abrasions and chafed areas of the peel will be accelerated with decreasing RH, and the damaged areas will turn brown to black in color. Traditional methods for increasing the storage humidity include spraying fruit intermittently with water, storing fruit on wet sacking, and storing fruit in boxes filled with moist coir or sawdust. Although effective, these methods can cause excessive wetting, which leads to fruit splitting and reduces market quality.

Artificial Ripening

Plantains may be consumed at different stages of ripeness. They are commonly prepared as fried sections or chips when the peel is still green and the pulp is high in starch. They are also consumed in the baked or fried form as a sweeter dessert fruit. Starch declines from > 30 % in green fruit at harvest to < 2 % in fully ripe yellow-brown fruit. Ripening is accomplished by holding the green harvested fruit at ambient temperatures and/or artificially ripening the fruit with ethylene gas. At ambient temperatures, the pulp of mature green harvested plantain fruit will soften and the peel will turn yellow to brown in color. A much faster rate of ripening can be obtained by putting the mature green fruit inside a sealed chamber and exposing it to ethylene gas at precisely controlled temperatures. Most commercial cultivars of plantains require 100 to 150 ppm ethylene for 24 to 48 hours at 15°C to 20°C (59°F to 68°F) and 90 to 95% relative humidity to induce uniform ripening. The exact temperature chosen depends on the desired degree of ripening and the peel color. Carbon dioxide concentration should be kept below 1% to avoid its effect on delaying ethylene action. Use of a forced-air system in ripening rooms assures more uniform cooling or warming of plantains as needed and more uniform ethylene concentration throughout the ripening. After the ethylene gas treatment, the chamber is ventilated and the temperatures are gradually reduced. Ripening to a soft textured pulp high in sugars takes about 9 days at 18°C and 12 days at 14°C. If ripening temperatures are too high (>25°C), the pulp may become undesirably soft. The fruit must be kept cool (13.3° to 15.6°C) and at 90% RH after removal from the ripening chamber and during delivery to the destination market to avoid rapid spoilage.

Principal Diseases

Crown Rot

Crown rot is a major postharvest disease of plantain fruit throughout the world. It is especially problematic in packinghouses that do not follow strict sanitation practices. Crown rot is a disease complex involving several different fungi, including *Colletotrichum musae*, *Fusarium* spp., and *Verticillium theobromae*. Infection occurs from plantain trash in the field, or from inoculum build-up in the packinghouse and during de-handing. Fungal spores colonize the wounded area where the hand is removed

from the stalk (peduncle). Symptoms begin as a softening and blackening of the cut crown surface. Decay typically spreads from the cut surface into the crown area of the hand of plantains during transport. In severe cases, the decay may extend to the top part of the fruit (Figure 12).



Figure 12. Severe crown rot symptoms in ripe fruit.

Control of crown rot is achieved by dipping the hands of fruit in a fungicide-treated wash tank and/or applying fungicide-impregnated cellulose crown pads to the cut surface of the hand. The most commonly used fungicides are thiabendazole, imazalil, and benomyl. Dipping the fruit in 50°C (122°F) water for 5 minutes is also effective in reducing deterioration from crown rot.

The manner of severing the hand from the stalk also influences the amount of crown rot. Breaking the stalk near the crown rather than neatly trimming it with a knife will increase the amount of crown rot. The action of breaking will leave fragments of stalk tissue attached to the crown which are suitable microenvironments for crown rot infection. In addition, fungicide-impregnated pads will adhere better to smooth than to rough crown surfaces, allowing for more effective fungicide transfer and disease control.

Good field hygiene and elimination of sources of crown rot inoculum are additional steps useful in reducing this disease. Also, storage of the fruit at 12°C 54°F will minimize the growth of the fungi responsible for crown rot.

Anthraxnose

Anthraxnose peel blemish, caused by the fungus *Colletotrichum musae*, is another important postharvest plantain disease. Infection originates on immature fruit in the field, but lesions typically do not develop until the fruit ripens and the fungus can penetrate the peel. Anthracnose lesions on green fruit are generally dark brown to black with a pale margin, oval in shape, and slightly sunken. On ripening fruits the typical symptoms are numerous small dark circular spots which enlarge, coalesce, and become sunken. Salmon-pink spore masses are eventually produced (Figure 13). Diseased fingers mature more rapidly than healthy fingers. Anthracnose control is achieved by the same packinghouse sanitation practices, fungicide treatments, and postharvest temperature control as recommended for crown rot.



Figure 13. Salmon-pink spores of anthracnose on fruit.

Finger Rot

Finger rot, caused by the fungus *Lasiodiplodia theobromae*, is prevalent in Guyana and is most serious following heavy rains. Decay usually begins at the flower end of the fruit or in a wounded area of the peel. The decay spreads uniformly causing a brownish-black discoloration of the peel and a softening of the pulp. The affected area of the peel becomes wrinkled and covered with fungal growth. The pulp is reduced to a soft rotten mass. The disease attacks fruit of all development stages, but is more common on ripe fruit.

This disease can be controlled by minimizing injury to the fruit, removing decaying banana trash in the field, spraying the plants with systemic fungicides, and maintaining a storage temperature below 20°C (68°F).

Postharvest Disorders

Chilling Injury

Plantains are very sensitive to chilling injury (CI), which is a physiological disorder caused by exposure of the fruit to temperatures below 12°C (54°F). Symptoms include peel discoloration (dull or grayish-brown color), flesh darkening, uneven ripening, and off-flavor development. The amount of chilling injury a plantain receives depends on the temperature and the length of time exposed to the chilling temperature. Damage from chilling injury may occur after a few hours to a few days, depending on cultivar, maturity, and temperature. For example, moderate chilling injury will result from exposing mature-green plantains to several days at 10°C (50°F), but severe chilling injury will occur at 4°C (39°F). Chilled fruits are also more sensitive to mechanical injury and microbial decay.

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.

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.

