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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

Mangoes are one of the main fruits exported from Guyana to Canada, covering nearly a 9 month period each year. There is an established market in the Toronto area for the 'Buxton Spice' mango, especially among the Guyanese community. In addition, there are market opportunities in the U.K. for the Buxton Spice mango among the large Guyanese diaspora and consumers of other nationalities. Importers are looking for consistent supplies of high quality mango fruit. However, inadequate postharvest handling practices in Guyana often lead to less than optimal arrival quality of the mango fruit in Canada. The principal concern among Canadian importers is the high incidence of mango fruit fungal decay.

Anthracnose

Anthracnose (*Colletotrichum gleosporiodes)* is the worst postharvest disease of mangoes in Guyana and is the fungal organism responsible for the vast majority of rejected fruit. Initial symptoms of this disease include sunken black spots on the surface of the fruit (Figure 1) which enlarge to form huge black lesions as the fruit ripens (Figure 2).

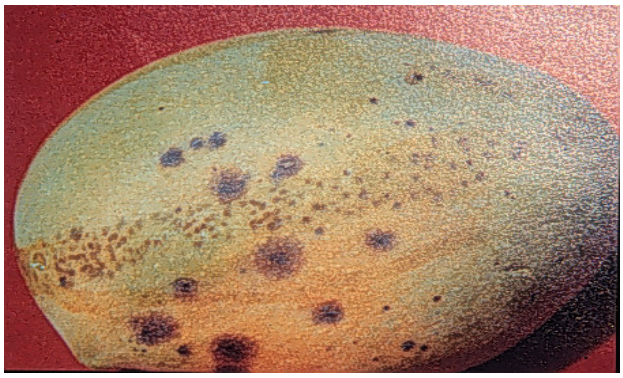

Figure 1. Sunken black spots on surface of mango fruit characteristic of anthracnose.

Figure 2. Large black anthracnose lesions on ripe mango fruit.

A tear-drop pattern of black spots running length-wise down the fruit is common due to dispersion of the fungal spores by raindrops (Figure. 3).

Figure 3. Tear-drop pattern of anthracnose development on mango fruit.

This microorganism is present year round, but it is especially problematic during the rainy season. Anthracnose inoculum is present on leaves, stems, and flowers so control in the field is important in reducing postharvest losses. Growers and exporters experience huge losses in marketable fruit due to this disease. It is a serious constraint to exporters, as the decay often manifests itself after arrival in the destination market and results in significant losses in market value. This situation is particularly expensive because the costs for packaging and air transport have already been paid. Importers in Toronto have rejected up to 60% of some mango shipments due to postharvest anthracnose decay.

Anthracnose is dispersed by tiny dust-like spores formed by the actively growing pathogen. Spores have adaptations that allow them to survive in hot, cold, or very dry conditions. They may be carried great distances by wind or water and can cover the surface of the mango fruit in high numbers. Spores may remain dormant for long periods until the correct conditions exist for their germination and growth. These conditions include the presence of water (in liquid form or as high relative humidity), warm temperatures, and nutrient solutes from the fruit (i.e. sugars). Immature mango fruit maintain physical barriers or contain chemical compounds that inhibit the growth of anthracnose. However, these mechanisms of resistance are slowly lost during ripening. As the mango fruit softens, it becomes much more susceptible to anthracnose. Small openings in the skin or wounded areas on the fruit surface are ideal sites for anthracnose spores to colonize. Postharvest decay symptoms can develop very quickly, particularly under warm temperatures and humid conditions. Gentle handling to prevent wounding and lowering the fruit temperature (ideally to 13°C or 55°F) will help to reduce the severity of anthracnose decay.

Hot Water Treatment

A simple and effective treatment exists to reduce anthracnose decay in mature green harvested mangoes. Basically, it consists of dipping the fruit in a hot water bath, with or without fungicide, at temperatures between 50° to 55°C (122°F to 131°F) for 2 to 5 minutes. This treatment also partially controls stem end rot (*Dothiorella dominicana*), but the immersion time required is up to 7 minutes. The effectiveness of the treatment will be reduced if the water temperature falls below 50°C (122°F). On the other hand, the fruit may be scalded if the water temperature rises above 55°C (131°F). The exact combination of temperature and time varies with cultivar and growing location. The optimal hot water bath conditions for Buxton Spice and Long mangoes produced in Guyana has not been determined.

The hot water treatment is being used successfully in many of the major mango producing countries of the world. It is effective in eradicating quiescent infections of the fungi that have become established on and beneath the cuticle and within the pedicel. Treatment effectiveness varies with infection level and storage temperature. The treatment should be done as soon as possible after harvest, but no later than 2 days following harvest.

The temperature of the water bath must be carefully controlled to within 0.5°C (33°F) to prevent fruit damage. An accurate thermometer is needed to monitor water temperature in various areas of the bath, especially near the heat source. Growers in other countries use specially designed tanks heated by gas or electricity with manual or thermostatic temperature control. No appreciable drop in the water temperature will occur if mango fruit are added in the ratio of 1 kg (2.2 lb) fruit per 3 liters (6.3 pints) of water.

Addition of certain fungicides to the hot water will provide improved control of anthracnose and stem end rot. Specifically, benomyl, imazalil, prochloraz, and thiabenbazole have all shown some degree of disease control activity. Benomyl is the most effective, followed by imazalil and prochloraz. The recommended rate of application for each of these fungicides is in the range of 500-1000 ppm of active ingredient. The concentration of the fungicide in commercial tanks may decline rapidly as more mangoes are treated because of fruit stripping and chemical interactions between the fungicide and mango latex.

In the case of benomyl, it is necessary to maintain a slightly acid or neutral pH of the water (i.e 6.5-7.0). Under alkaline conditions, benomyl will lose its anti-fungal activity within a few hours. The accumulation of latex in the treatment tank may raise the water pH and interfere with the efficacy of benomyl in controlling anthracnose and stem end rot. Dipping mango fruit in dirty, latex-contaminated hot water can increase the incidence of phytotoxicity and lenticel damage during ripening.

The permissible use and maximum residue level (MRL) tolerated for specific fungicides on mango fruit varies between countries. Before use in the hot water tank, it is very important to verify the acceptability and MRL of the fungicide on mango fruit in the

intended destination market. Individual fungicide tolerances on mango fruit differ between countries. When fungicides are used, the spent water in the tank must be properly disposed of using safe handling practices and government-approved methods. The water should be pumped or drained into a sealed collection tank or trench filled with gravel, sand, and activated charcoal. Runoff must be avoided.

Design of Hot Water Bath

Various designs and construction materials can be used for a hot water treatment facility. They range from inexpensive installations piece-mealed together from locally available components to expensive turn-key systems using factory designed and constructed components. Several options for hot water treatment facilities are available for Guyanese produce exporters. The design, construction materials, and costs for the different options are described below. The advantages and disadvantages of each option are also discussed.

The hot water tank should be made of a non-corrosive material, such as polyethylene, fiberglass, ceramic tile, or stainless steel. Accuracy in temperature control, efficiency of the heating unit, and timing of fruit submergence in the bath are critical for success. Thorough and uniform water circulation is essential inside the tank to avoid temperature gradients from forming. The water in the tank should be vigorously agitated during dipping to uniformly distribute the heat and keep all fungicides properly suspended. A sensitive thermostat and accurate thermometers are important to regulate and monitor the water temperature. A re-circulating pump with sufficient flow rate and tolerance to hot water is essential. In-line filters in the inlet and pump circulation systems should be installed and cleaned regularly. Impurities (i.e. sediment, debris) in the dip water can affect fungicide performance and stain or damage the fruit.

Inexpensive Option

One of the quickest and least expensive ways to construct a hot water treatment facility in Guyana is to use a large polyethylene tank [Tuf-Tank (Figure X)] with the top cut off, or a ceramic-lined cement trough. The Tuf-Tank is imported from Trinidad and available from a number of vendors in Georgetown (Figure 4). Polyethylene is less expensive than other types of plastic polymers. Polyethylene is stable up to 65°C (150°F), which is above the hot water temperature needed to treat mangoes. Other relatively inexpensive materials amenable to fabrication as hot water tanks include concrete and bricks lined with ceramic tiles.

The water must be heated with either electric or gas heating elements. The least complicated and most uniform heating elements are electric. They can be installed in the hot water tank along the bottom and perimeter, or external to the tank, in the form of a commercial hot water heater (Figure 5). If the electric heating elements are installed inside the tank, it will be essential to protect and shield them from directly contacting the containers of mango fruit. Also, an experienced electrician and/or plumber will be needed to be hired to ensure the reliability and safety of the system. If a self-enclosed hot water

heater is used for the hot water source, it can be obtained from at least one plumbing/irrigation company in Georgetown who stocks these imported items.

Figure 4. Polyethylene tank commonly used for water storage.

Figure 5. Commercial hot water heater used to heat the water tank.

The hot water must be circulated in the tank with a sufficiently high flow to ensure uniformity of temperature. Therefore, a water pump of adequate flow rate capacity and tolerance to at least 52°C (126°F) water is needed. Several commercial hardware stores in Georgetown sell these types of water pumps (Figure 6). Additional accessories which will be needed to complete the hot water treatment unit include high-temperature resistant PVC pipe, shut-off valves, silicon sealant, and an in-line water filter.

Figure 6. Water pump used for circulating water from the hot water heater to the tank.

A prototype of this inexpensive hot water treatment unit was constructed at the NGMC packinghouse in the Sophia Exhibition Center Complex (Figures 7 and 8). It is capable of treating approximately 90 kg (200 lb) of mangoes at one time. An ideal container to use for submerging the fruit is made of smooth, rigid plastic and is well ventilated (Figure 9). This type of unit can be constructed within a day. The cost and availability of all the components is indicated below. The cost of labor for the plumbing and electrical wiring is not included, since it will vary according to the individual site and technician capability.

Figure 7. Front view (without water) of hot water treatment unit at the NGMC packinghouse. Note: plumbing of PVC pipe inside the tank is not completed.

Figure 8. Side view (with water) of hot water treatment unit at the NGMC packinghouse.

Figure 9. Rigid plastic container ideal for hot water treatment of mango fruit.

Cost and Source of Materials for an Inexpensive Hot Water Treatment Unit

Polyethylene tank (460 gallon or 1740 l size)
Cost: G$15,000

Anral Shipping Co. Ltd.
18 Broad & Lyng Streets
Charlestown, Georgetown
Phone: 227-2702
Fax: 225-7204
(polyethylene tanks are also available from McDonalds Hardware, Royal Woodworking General Store and R & R International Ltd.)

Hot water heater (65 gallon or 246 l)
Cost: G$74,000

Spads Inc.
267 New Market Street
Georgetown
Phone: 225-4672
Fax: 225-4653
Contact: Stewart Stevenson, Managing Director

Water pump (65 liters/min. flow)
Cost: G$14,500

Silvie's Variety Store
31 High & Hadfield Streets
Georgetown
Phone: 227-6243
(water pumps are also available from Farfan & Mendes Ltd.)

Plumbing supplies: 2 cm and 1.3 cm (¾ in and ½ in) PVC pipe, 2 cm (¾ in) ball valves, 2 cm (¾ in) PVC unions, foot valve, reducers, tees, knees, plugs, adopters, couplings, tape and paste
Cost: G$23,000

National Hardware
17A Water Street
Georgetown
Phone: 227-1961

(plumbing supplies also available from Silvie's Variety Store, McDonalds Hardware, Farfan & Mendes, Royal Woodworking General Store, R & R International Ltd. and Guyana Stores Ltd.)

Electrical materials: panel, cables, wiring, switch, outlet, copper rod and tower clips
Cost: G$35,000
Available from the various hardware stores listed above.

Polyethylene containers for mangoes (6 needed per 460-gallon or 1740 liter tank)
Cost: G$17,500

Len's
136 Sheriff & 4th Streets
Campbellville, Georgetown
Phone: 224-1717
Fax: 226-3750

TOTAL COST (labor not included): G$179,000

Expensive Option

A more permanent hot water treatment tank may be built out of fiberglass and the water circulated through Jacuzzi-type pressure inlets. The entire turn-key unit, including a rectangular-shaped 500 gallon (1893 liter) tank, pump, heating elements, thermostats, 6 Jacuzzi jets (pressure inlets), and plumbing can be fabricated by a local firm in Mon Repos.

Cost and Source of Materials for an Expensive Hot Water Treatment Unit

500 gallon (1893 liter) rectangular fiberglass tank
Cost: G$280,000

Fibre-Tech Industrial Plastics
105-106 Triumph Village
Agricultural Road
East Coast Demerara
Phone: 220-6907
Fax: 220-7406

Water pump, heater, 6 Jacuzzi jets
Cost: G$132,000

Fibre-Tech Industrial Plastics

TOTAL COST (complete turn-key hot water treatment unit): G$412,000

In addition, more sophisticated and expensive units are available in the U.S. for delivery and installation in Guyana. However, these units require significantly more mango export volume than is currently present in order to justify their costs.

ANNEX I

PUBLICATIONS IN THE POSTHARVEST HANDLING TECHNICAL BULLETIN SERIES

PH Bulletin No. 1	Pineapple: Postharvest Care and Market Preparation, November 2002.
PH Bulletin No. 2	Plantain : Postharvest Care and Market Preparation, November 2002.
PH Bulletin No. 3	Mango: Postharvest Care and Market Preparation, November 2002.
PH Bulletin No. 4	Bunch Covers for Improving Plantain and Banana Peel Quality, November 2002.
PH Bulletin No. 5	Packaging Materials for Export of Fruits and Vegetables, November 2002.
PH Bulletin No. 6	Hot Water Treatment for Reducing Anthracnose Decay of Mangoes, November 2002.

PLANNED PUBLICATIONS - 2003

Cassava: Postharvest Care and Market Preparation.

Eggplant (Boulanger): Postharvest Care and Market Preparation.

Papaya: Postharvest Care and Market Preparation.

Sweet Potato: Postharvest Care and Market Preparation.

Wash Water Sanitation: Recommendations for the NGMC Packing House.

Watermelon: Postharvest Care and Market Preparation.

Peppers: Postharvest Care and Market Preparation.

Yam: Postharvest Care and Market Preparation.

Okra: Postharvest Care and Market Preparation.

Tomato: Postharvest Care and Market Preparation.

Orange: Postharvest Care and Market Preparation.