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) 227-1630
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
www.agrinetguyana.org.gy

Postharvest Handling
Technical Bulletin

MANGO

Postharvest Care and Market Preparation

Technical Bulletin No. 3

June 2003

POSTHARVEST HANDLING TECHNICAL SERIES

MANGO

Postharvest Care and Market Preparation

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

Technical Bulletin No. 3

June 2003

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 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 postharvest handling problems, to packaging and transportation, to final market.

Introduction

The mango (*Mangifera indica*) is one of the most important fruit crops grown in Guyana. However, it is not cultivated in large-scale plantings or managed intensively. Almost the entire production comes from landowners who have several trees planted near their residences. Mango fruit is available year round, but the main harvest periods are mid-October to January and May through June. The fruit is widely distributed in the domestic market and small volumes are exported to Canada.

Two principal mango cultivars constitute almost the entire nationwide production, Buxton Spice and Long. They are selections of material originally introduced from India, but have been produced in Guyana for decades. Buxton Spice is the leading cultivar grown and produces medium-sized fruit (~240 to360 gm) with a golden-yellow skin color when ripe. The fruits are sweet in flavor and have a relatively low fiber content. The fruits of Long are slightly larger, more elongated, less sweet, and more fibrous than Buxton Spice.

Harvesting

Harvest Maturity

Various non-destructive indices can be used to determine mango fruit harvest maturity for the fresh market, including external color, size, changes in appearance in the fruit shoulder area, and waxiness of the skin. Destructive indices used for determining harvest maturity include internal pulp color and % soluble solids content. Grower experience, which uses a combination of these indices, is also a reliable way to determine when to harvest.

The most obvious index of fruit maturity is external skin color. As the fruit matures, the skin color will change from green to yellow. Normally sized fruits which have started to turn yellow are ripe and ready for immediate harvest. However, fruits showing some yellow color on the tree are generally too ripe for long distance marketing. They will bruise easily and soften during transport and distribution. Yellow fruits typically have a shelf life of only a few days and must be sold in the local market. If the intended market is for export, the fruit should be picked when firm and at the mature green color stage, using a combination of fruit size and appearance to determine maturity. The fruit should arrive at the destination market at some predetermined stage of color development (usually more yellow than green). There is a range of maturity levels within which green fruit will develop acceptable ripe fruit attributes. The rate at which ripening occurs depends upon the degree of maturity at the time of harvest. More mature fruit will ripen sooner than less mature fruit. Fruits harvested too immature green will not ripen properly, will not taste good, and will shrivel prematurely. The Buxton Spice mango ripens quite rapidly after harvest and if picked at the mature green stage will begin to turn yellow within 3 to 5 days at ambient temperature.

Mango fruit is ready for harvest when the shoulder area swells or broadens and rises above the stem end. This is accompanied by the stem end sinking and forming a small pit around the pedicel (stem). Another external characteristic which is correlated to harvest maturity is the appearance of the skin. A dulling in the shine or waxiness of the fruit surface occurs when mangoes become mature and are ready for harvest.

Internal pulp color and % soluble solids (sugar content) are additional indices for determining harvest maturity, but both involve cutting the fruit open with a knife and therefore are destructive tests. However, they are often used on a few randomly selected fruit to establish a correlation between fruit size and maturity. The pulp of Buxton Spice fruit at maturity changes in color from light yellow to deep yellow or yellowish-red (Figure 1).

The soluble solids content of mature fruit will be at least 10%, and can be determined by placing several drops of juice on a hand-held refractometer (Figure 2).

In addition to the fresh market, mango fruit may be harvested at an immature stage and used as a component of processed foods (i.e. chutney, achar, preserves, etc.). In this case, the above indices of fresh market harvest maturity do not apply.

Figure 1. Immature fruits with light yellow pulp (left) versus mature fruits with deep yellow pulp (right).

Figure 2. Hand-held refractometer for determining fruits maturity.

Harvest Procedure

Harvesting the fruit is the most labor intensive operation in mango cultivation. The fruit does not mature at the same time and therefore the tree requires multiple pickings. Mango trees should be harvested several times per week once the initial fruit becomes mature. Harvest should be done during the coolest part of the day, as more fruit bruising will

occur with increasing pulp temperatures. Mangoes should not be picked during rain as postharvest decay will be significantly higher.

Mangoes are harvested manually and should be cut or clipped from the tree leaving at least 2 cm or longer of the pedicel attached. This is necessary to prevent latex flow from the point of detachment. Latex does not usually exude from stems $\geq$ 2 cm in length because there is no continuity between the fruit and stem resin ducts and the fruit lactifers are not severed. The fruit should be handled gently (like eggs) at all times to avoid bruising. Fruits should not be allowed to drop to the ground, as it will result in severe impact bruising, mechanical injury, and surface scarring. Postharvest deterioration of dropped fruits will be rapid, lowering the market quality and reducing the shelf life.

Harvest Tools

The recommended harvest tools include knives, clippers, or poles (cali) with a sharp-edged cutting blade attached at the end. Fruit which can be reached from the ground is easily harvested using a knife or clippers, while fruit higher up in the tree is removed with the special poles. A canvas pouch or nylon net bag is attached to a metal ring below the sharp-edged cutting blade at the end of the pole to catch the detached fruits. The pouch should be large enough to hold several fruits (Figure 3).

Harvest Trays

After detachment, the fruit should be carefully lowered to the ground and placed in a single-layer tray with the pedicel oriented upwards (Figure 4). The fruit-filled tray should be put in a shaded area to avoid sunburn.

Figure 3. Pole with cutting blade and pouch used for mango harvest.

Figure 4. Mango fruits placed on harvest tray

After a short period, the pedicels should be re-cut to a length of several millimeters extending past the shoulder of the fruit. The cut area should be oriented downward to prevent latex exudation onto the fruit surface. A tray with individual cells perforated at the bottom allow for latex drainage without staining of the skin. After about an hour, the latex flow will cease and the fruit can be transferred to a field container which is transported to the packinghouse or consolidation site.

Field Sorting

The initial sorting of marketable versus unmarketable fruit should be made in the field. Severely damaged or defective fruit should be put into a separate container and discarded in a location away from the mango trees to minimize the build-up of anthracnose inoculum in the area. The remaining marketable fruit, whether intended for local or export destinations, should be put in a strong, well-ventilated, stackable field containers kept in a shaded location.

Field Containers

Several different types of field containers can be used for mangoes. No more than 18 kg (40 lb) of fruit should be put in the container, regardless of the one chosen. This is necessary to avoid compression bruising of the fruit. The containers should be lined with a soft material, such as straw or polyfoam padding. Woven synthetic bags should not be used since they do not have adequate ventilation and usually contain in excess of 15.88 kg (35 lbs.) of fruit.

The least expensive field container is a reed basket. However, the uneven inside surface of the basket often results in fruit scarring and skin abrasions when there is movement or vibration of the basket. Also, this type of field container is not strong enough to be stacked without causing some damage to the fruit. A better field container is a wooden crate, which is much stronger and can be stacked without damaging the fruit.

The ideal type of field container is a durable plastic crate which is well ventilated and has a smooth inside finish. Plastic crates can be easily cleaned, are stackable, and do not damage the fruit (Figure 5).

Figure 5. Well-ventilated plastic field container ideal for mango harvest.

Field Transport

The field crates of mango fruit should be transported to a nearby collection or consolidation site the same day of harvest. The crates should be carefully loaded and stacked in the transport vehicle in order to minimize handling damage to the fruit. There should be adequate ventilation through the field containers and the transport vehicle should have a protective cover over the crates of mangoes. Ideally, the fruit should be transported during the coolest time of the day in order to minimize heat build-up inside the transport vehicle. Mangoes are very sensitive to heat stress and bruise easily during transport when the fruit temperature is above 32°C (90°F). Bruised pulp becomes soft and deteriorates quickly. Upon arrival at the consolidation facility, the crates should be unloaded with care and never dropped. They should be handled as little as possible to avoid unnecessary damage. The crates should be stacked in a shaded well ventilated area.

Preparation for Market

Various steps should be followed in preparing the mango fruit for market. These involve grading, cleaning, packing, storing, and transport. These operations should be carried out in an easily accessible, shaded area which is protected from rain.

Grading

The first step in market preparation involves making a final selection of the fruit according to the standards required of the market. The quality standards of export grade fruit are considerably more stringent than domestic grade fruit. Regardless of the market destination, the fruit should be sorted according to size, shape, firmness, external color, insect damage, and decay. Visibly damaged fruit should be rejected. Different markets have different quality requirements and the fruit should be graded to conform to the individual market standards. However, there are certain minimal requirements for mango fruit intended for any market. The fruit should :

- be clean and free of dirt and latex stains
- be mature and firm
- be well shaped
- be free of punctures, wounds, and cuts
- be free of sunburn, insect damage and decay
- be free of black necrotic spots or stains (i.e. anthracnose)
- have a well-trimmed peduncle with a length of ≤ 1 cm

In addition to the above general requirements, domestic market fruit quality standards have been established by the Guyana National Bureau of Standards. Although they are not rigidly enforced, they establish a fruit quality guideline all marketers should strive for. There are three domestic grades for mangoes, namely Grade I, II, and III. Grade I mango fruit should possess the characteristics listed above. Grade II mangoes must meet the requirements for Grade I, except for defects in shape and latex burn. The total defects must not exceed 10% of the fruit. Grade III mangoes must meet the requirements for

Grade II, except total defects must not exceed 15% of the fruit. The minimum weight of the fruit must not be less than 240 gm. Mangoes are classified into three size groups, based on fruit weight. The weight range for each size group is:

Size Group	Weight Range (gm)
A	320-360
B	280-320
C	240-280

Export quality fruit must be free of insect damage, physical injury, and disease (i.e. anthracnose). The fruit must also be carefully sorted for uniformity of size and shape. The fruit should be firm and mature green in order to withstand the rigors of air transport and in-land distribution in the destination country. Competition for the export market is intense and importers will only accept consistent supplies of high quality uniform fruit (Figure 6).

Figure 6. High quality mango fruits in the Toronto wholesale market.

Cleaning

The fruit surface should be cleaned by washing in a very mild detergent and using a soft cloth to remove any dirt or latex. The water used for cleaning should be sanitized with 150 ppm free chlorine and maintained at a pH of 6.7.

Waxing

Waxes help to extend the shelf life of the fruit by reducing internal water loss and preserving the turgidity and freshness of the skin. Waxes also extend shelf life by creating a modified atmosphere of lower O_2 and higher CO_2 inside the fruit, which slows down metabolic processes and ripening. Aqueous wax emulsions, consisting of vegetable waxes, paraffin, and shellac have all been used successfully to increase the storage life of mangoes. In addition, several polysaccharide-based coatings have shown some benefits for prolonging the shelf life of mangoes (i.e. Nature Seal). Application of waxes or surface coatings will depend on the market requirements and buyer preference. Nevertheless, mango fruit intended for export will usually benefit from an application of a surface wax during packing. However, care must be taken to avoid over application of the

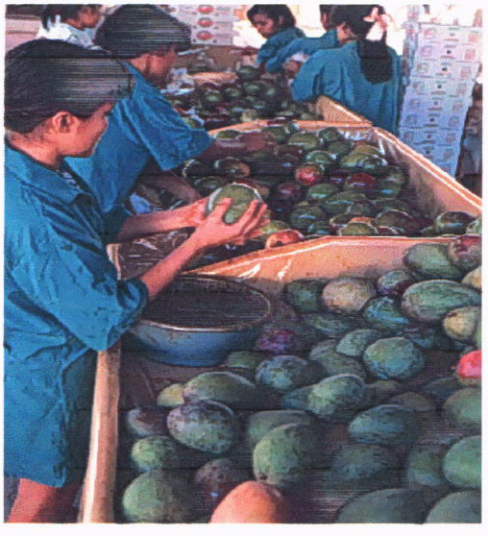

Figure 7. Manual rubbing of wax onto mango fruits surface.

wax, as too thick a coat may result in fruit asphyxiation and off-flavor development. Waxes are commonly applied by roller brushes in a wax applicator, or by very light hand application (Figure 7). Complete coverage of the entire fruit surface is essential. The fruit should be thoroughly dried before packing.

Packing

After cleaning and/or waxing of the fruit, it is left to dry prior to packing. The packaging material used for mangoes depends on the intended market destination. The package should be strong, well-ventilated, and stackable. Individual mangoes can be wrapped in tissue paper or foam sleeves to cushion the fruit and minimize surface abrasions during transport. The durable plastic containers used for transporting the fruit from the field can also be used as the final domestic market container (Figure 8). Since they are expensive, a means should be in place for returning these containers to the person who packed the fruit for sale.

Figure 8. Packing mangoes in single-layer export cartons.

The standard export package for mangoes is a single-layer corrugated carton which contains 4 kg (9 lb) of fruit (Figure 9). This carton is well-ventilated, attractive, and stackable on a pallet to 12 high. It is not recommended to pack mango fruit for export in more than a single layer carton. Multiple-layered fruit suffer too much bruise damage during transport and distribution. The carton should have a minimum bursting strength of 275 lb/in^2. The carton should be properly labeled to include the following: name of product, variety, net weight, grade, size, place of origin, name and address of consignee.

Figure 9. Standard 4 kg export carton for mangoes.

Storage Conditions

Temperature

The ideal storage temperature for maximum shelf life of mangoes is between 53°F to 55°F (11.5°C to 12.5°C). At these temperatures, a mature green harvested mango will have a potential storage life of about 3 weeks. Below these temperatures the fruit will not ripen properly and break down due to the physiological disorder known as chilling injury. Above these temperatures, the fruit will ripen more quickly and become soft. Under

ambient tropical conditions in Guyana, mature green harvested fruit will ripen within 6 days and become overripe and spoiled within 10-12 days.

Relative Humidity

Water loss from mango fruit increases with decreasing relative humidity (RH). This represents a loss of saleable weight and a reduction in fruit quality. The ideal storage (RH) for mangoes is between 90 to95%. This will minimize postharvest weight loss and peel shriveling.

Transport

Mangoes destined for either the domestic market or the airport for export should be transported in a well-ventilated vehicle that has some sort of cover to minimize heat build-up from direct sunlight hitting the fruit. In the absence of refrigeration, transport should occur during the cooler times of the day.

Recent innovations in marine container technology will allow mango exporters to ship their fresh fruit to distant North American and European markets. Shipment by sea may take several weeks, but product arrival quality will be good if the temperature is maintained at 12°C ±1°C (54°F ±34°F) with 90 to95% relative humidity and a controlled atmosphere of between 3 to5% O_2 and 5 to10% CO_2 during transit.

Principal Postharvest Diseases

Anthracnose

Anthracnose, caused by the fungus *Colletotrichum gloeosporioides*, is the worst postharvest disease of mangoes. It makes the fruit unsightly and in many cases unmarketable. Typical symptoms include small black spots and/or larger black lesions on the surface of the skin (Figure 10). The lesions may coalesce and penetrate deep into fruit, resulting in extensive fruit rotting.

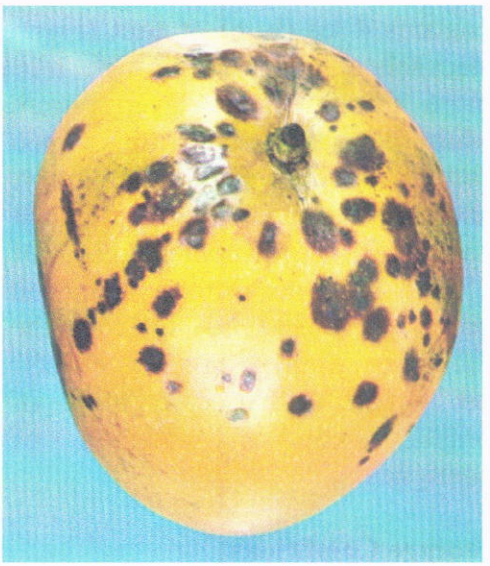

Figure 10. Mango fruit with anthracnose lesions.

Mature fruit may also exhibit tear stains, in which the anthracnose spores wash along in spore-laden water droplets falling from infected twigs and panicles above the fruit. This results in a vertical spotting pattern (Figure 11).

Figure 11. Tear staining symptoms of anthracnose infected mango fruits.

Ripe yellow colored fruits are much more susceptible to anthracnose than mature green fruits. However, the infection process generally begins on the tree when the fruits are green. The fungal spores often remain dormant on the surface of the mature green stage fruit, but rapidly develop and penetrate the surface of the weaker and softer yellow skin as the fruit ripens. Anthracnose is always more severe during the rainy season. Buxton Spice fruit is highly susceptible to anthracnose. Long fruits are also susceptible, but are generally less severely affected because of their tougher skin.

Management and control of anthracnose decay begins in the field. Proper cultural practices are necessary to avoid the build-up of high levels of inoculum responsible for postharvest decay. These practices include proper tree spacing to avoid crowding, periodic pruning to allow more air movement through the canopy, monthly foliar fungicide applications (i.e. mancozeb, benomyl, iprodione, propiconazole, and/or copper fungicides), and removal of fallen leaves under the tree. Manipulation of the time of flowering (i.e. using KNO_3 foliar sprays) so the fruit ripens during the drier months is another way to reduce anthracnose decay.

Several postharvest decay control methods are useful in reducing the severity of anthracnose fruit rot. They are 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 first decay control method involves submerging the fruit for 2 to 5 minutes in 50°C to 55°C (122° F to132° F) water or 5 minutes at 48° C to50°C (118° F to122° F) water. Control of the water temperature and the length of submergence are critical for effective anthracnose control. If either the temperature or duration of submergence is exceeded, fruit injury will result. On the other hand, if the temperature is too low and/or the duration of submergence inadequate, the treatment will be ineffective. The second method

involves the same hot water submergence treatment with 500 ppm thiabendazole or imazalil fungicide added to the hot water. This provides a more effective level of anthracnose control than just the hot water alone, but would not be appropriate for use if the intended market was the organic trade. Also, before use, it is necessary to determine the acceptability of any postharvest pesticide in the final market destination.

Stem End Rot

Stem end rot, caused by several different fungi (*Dothiorella* spp., *Lasiodiplodia theobromae, Phomopsis mangiferae*), is another principal postharvest disease of mangoes. This disease usually begins with the fungus attacking the stem of the fruit prior to harvest, where it remains quiescent until the fruit ripens. The initial symptom of stem end rot on harvested mature fruit is a darkening of the skin around the base of the pedicel. The infected area may enlarge rapidly to form circular brownish-black areas of water-soaked tissue which can extend over the whole fruit within several days (Figure 12). Once the fungus enters the stem end of the fruit, the whole fruit will rot within several days.

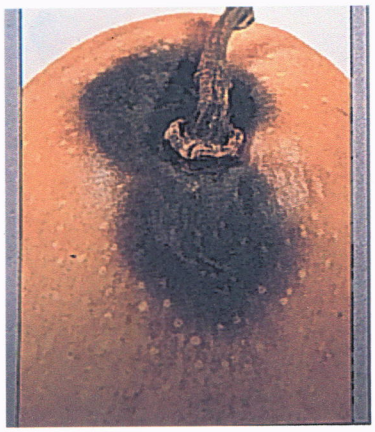

Figure 12. Stem end rot of mango fruits.

Control of stem end rot can be obtained by following several different pre- and postharvest sanitation practices. First of all, the inoculum level of the fungus on the tree prior to harvest can be reduced by removing the contaminated leaves and debris on the ground, coupled with regular foliar fungicide sprays. Postharvest control is obtained using the same hot water submergence protocol as described above for combating anthracnose.

Alternaria Rot

Alternaria rot, caused by the fungus *Alternaria alternata*, can become serious when anthracnose and stem-end rot are well controlled. Alternaria infects the mango fruit through the lenticels on the skin. After infection on the tree, the fungal hyphae remain dormant until fruit ripening, when it starts to grow intercellularly. The symptoms include small black circular spots, 0.5 to1.0 mm in diameter, which develop around the lenticels. The fungus develops in the lenticels and penetrates the fruit, resulting in a darkening of the intercellular spaces and cell collapse. Initially, spots are concentrated around the stem end of the fruit where high numbers of lenticels are present. The spots grow and coalesce to become a single spot that can cover half the fruit. Later, the disease progresses into the flesh which darkens and becomes partially soft.

Postharvest Disorders

Latex Burn (Staining)

Mango fruit exudes a latex resin (sap) from the pedicel area near the fruit. If allowed to drop onto the fruit surface, this resin will result in an undesirable blemish or burn to the skin. It may also accentuate the spreading of anthracnose decay. Therefore, it is important to avoid this type of skin damage by harvesting the fruit with at least 2 cm (.8 inches) of pedicel remaining attached. If the pedicel is cut too short, the turgor pressure inside the fruit will result in a spurting of latex out from the pedicel and onto the fruit surface. Little or no latex exudes from pedicels in excess of 2 cm. However, if the pedicel breaks in transit to the packing area, latex will leak out and skin burn is possible. The pedicel must be cut back to near the shoulder of the fruits prior to packing. This should be done soon after harvest. In order to avoid exudation of latex onto the fruit, the pedicel should be pointed downward at the time of removal and the fruit placed stem down while allowing the oozing sap to cease flowing.

Soft Nose

Soft nose is a type of internal fruit breakdown common to mangoes grown on acid sandy soils low in calcium. The degree of severity varies from season to season. Symptoms include softening and water soaking of the fruit flesh at the distal end while the flesh around the shoulders remains unripe. In addition, the flesh next to the seed is usually over-ripe and/or there are areas of varying size in the flesh which are spongy with a grayish-black color. This disorder is aggravated by high nitrogen fertilization. Increased calcium fertilization may help alleviate this problem in acid soils. Fruits harvested mature-green are less affected than those allowed to ripen on the tree.

Chilling Injury

Mango fruits are highly sensitive to chilling injury, which is a physiological disorder occurring at storage temperatures below 11°C (52°F). Symptoms of chilling injury include pitting and sunken lesions on the skin, uneven skin coloration, internal darkening of the pulp, off-flavor development, and decay (Figure 13). The amount of chilling injury is a function of temperature and time, with lower temperatures and longer durations of exposure causing more injury.

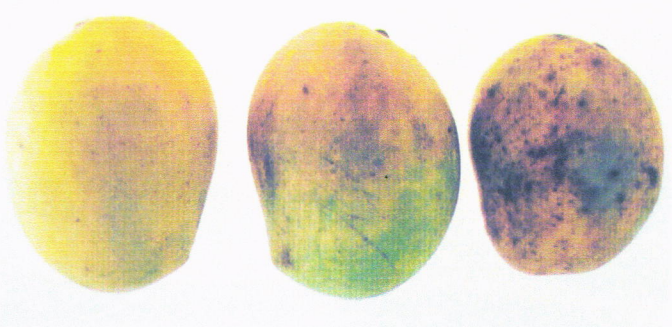

Figure 13. External chilling injury symptoms on mango fruits.

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.