JULIE MANGO
IN THE EASTERN CARIBBEAN

A comprehensive manual

Caribbean Agricultural Research and Development Institute (CARDI)
The Technical Centre for Agricultural and Rural Cooperation (CTA)

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JULIE MANGO MANUAL
Sapburn
When the sap or latex exuded from the cut or snapped stalk of a Julie mango spreads over the surface of the fruit and dries, unsightly patchy areas develop, which lead to an uneven colour when the fruit ripens. Effects of sapburn can be commonly seen on fruit displayed in domestic markets. This must be avoided especially on fruit destined for export. Sap exudation effects are more marked on younger fruit and when fruit are picked in the early morning when water pressure in the fruit cells (turgor) is high.

Two practical approaches are used to control and prevent sapburn:

a) harvest fruit with long stalks or
b) wash off exudate in the packhouse.

The first approach, which is the better one, is applicable in orchards with short (well managed) trees, which allows fruit to be harvested by hand or with short picking poles with cutting blades. To prevent latex flow from mangoes in the field, leave stalks of 1–2 cm (0.4–0.8 in). On tall trees this is best done with a bladed picking pole. When the stalks are trimmed in the packhouse this is done over a tank of water, in which the fruit remain for up to 30 minutes to ensure latex flow has ceased.

More commonly in the Eastern Caribbean the sap is washed off in the packhouse. This may require the use of soaps, especially if there is a delay of several hours between harvest and reaching the packhouse, during which time the sap dries to a gluey texture. The use of soaps also removes some of the mango’s natural waxes which, if not replaced by an artificial coating, will lead to excessive weight loss and possibly shrivelling.

Mechanical damage
The main sources of mechanical damage during postharvest handling are:

- cracking of hard fruit on impact
- bruising of ripening fruit from impact
- bruising of ripening fruit from compression
- cuts and scratches from soil, fingernails, tools, and packhouse equipment

Since the postharvest system aims to supply fruit to import markets in the hard to 50% ripe stage, handling in the country of export is solely with hard mature fruit. Drops of 30–36 cm (12–14 in) onto hard surfaces are known to cause cracking of firm, mature Julie mangoes. Therefore during harvest, avoid dropping fruit into field crates, or dumping fruit onto conveyors during postharvest operations in the packhouse.

As fruit mature and soften, cracking is replaced by bruising when fruit are dropped. Bruised areas of ripening fruit appear lighter in colour than surrounding tissues, and sometimes the bruised tissues separate to form air pockets.

Ripe mangoes are bruised by drops from heights of
10–15 cm (4–6 in) with the bruises appearing watery and translucent.

Compression damage occurs where fruit are packed in multiple layers, when cartons are of insufficient strength or are overpacked. The severity of the damage will be heightened by softer fruit and long shipping periods. Firm fruit undergoing relatively short shipment periods can be packed in multiple layers without fear of compression providing that the boxes are not overpacked.

Contact with soil, sand and grit, can cause skin scratch marks, which are unsightly and can lead to rotting. Piling of fruit on the ground should be avoided and field crates should be washed between use.

Heat injury
The introduction of hot water treatment for the control of fruit fly and anthracnose has added the postharvest concern of heat injury. Incorrect temperature settings, overexposure to otherwise safe temperatures, or poor water circulation – may result in ‘hot spots’.

Hot water injury manifests itself differently in different varieties. At a water temperature of 48°C, Julie mango suffers no ill effects from dip durations of up to 55 minutes. However, at 50°C and dip durations of 45 minutes and above, peel yellowing is hastened and flesh colouration, softening and the development of aroma and flavour is delayed. Other mango varieties, particularly of the Florida type ripen more rapidly after hot water treatment.

Wax injury
Some waxes and fruit coatings recommended for mango may not be suitable for all varieties. Damage can occur due to incompatibility or because of too high concentrations. Work by CARDI has shown that Semperfresh and NuCoat Flo, both recommended for mango in some countries, disrupt ripening, resulting in poor flavour, uneven softening and skin blackening when used on Julie.

Chilling injury
Chilling injury is caused by exposure of mangoes to temperatures below their ideal storage temperatures. This may happen as a result of inappropriate temperature setting on precoolers or reefer containers, breakdown of reefer container temperature control, or inadequate protection in northern markets during winter.

Chilling injury in Julie mango appears as a greyish scalding of the skin, pitting, uneven and incomplete ripening, poor colour and flavour development, and surface decay. The symptoms may not appear during the exposure to cold but later, on returning to warmer temperatures. The severity of chilling is related not only to temperature but to the duration of the exposure.

Chilling injury of mango is prevented by avoiding exposure of the fruit to temperatures below 10°C during June to October and 12°C between November and May.

Physiological disorders
Julie mango is not prone to physiological disorders such as stem end breakdown, stem end cavity, jelly seed, soft-nose and sunburn, which are experienced in the larger Florida-type mangoes.
11 Harvesting and postharvest handling

Planning harvest and handling of Julie mango

There is no single best way to harvest and handle mangoes. Every country, every farm, every variety, every market and every mode of transport, may influence the specific way in which fruits are handled. However, there are some guiding principles and common procedures which should be applied to ensure that the quality supplied meets market requirements.

Although it may be perfectly acceptable and profitable to pick unselected mangoes off a tree and take them to the local town market, this is only possible because the local consumers are familiar with the product and competing fruit of better quality is not available.

On other markets, whether regional or extraregional, this approach may also be acceptable and profitable if competing fruit are absent or of worse quality. However, as a product is moved outside of the domestic market into regional, and especially into extraregional markets, competition from other suppliers becomes more and more intense. In addition, as the exporter engages in marketing to more distant countries, the technical and managerial demands become greater, and so does the potential for more serious financial loss. Detailed planning of the harvest and postharvest operations is essential.

The basic quality requirements for mango have been presented in section 2. The postharvest handling procedures employed to achieve these requirements depends to a large extent on:

- the production system
- the markets targeted
- the modes of transport available.

Production system: The absence of large orchards in the Eastern Caribbean means that harvest and assembly of fruit is an arduous and expensive task. Sufficient fruit to fill a 6 m (20 ft) container may take two days to assemble, and delivery time from the field to the packhouse is often uncertain. This means that fruit may have to be stored temporarily either before or after preparation and packing. These are longer than ideal times from harvest to actual shipment.

Distance to market and mode of transport: Whereas fully mature and even ripe fruit may be harvested, transported by road and sold on the local market the same day or the day after; these fruit would clearly be overripe if they were shipped to a more distant market. The time between harvest and sale at the market, and the conditions under which fruits will be held during that period, influences the stage of maturity at which the fruit are harvested.

Market influences: Most buyers will wish to see some sign of ripening (up to as much as 50% yellowing) when the fruit reaches the market. This varies with the type of market, the
day of arrival on the market, the market demand, and the seasonal temperature. For example, under hot summer temperatures in London and conditions of slow demand, importers will prefer fruit that are less ripe, to allow them more time to sell.

**Harvest and postharvest operations**
Workers involved in mango production and handling need to appreciate the sequence of operations that are required to ensure that the quality of the fruit is maintained through to the final market.

Fruit harvest initiates the immediate process of realising cash from production. The decision to harvest for a market may or may not be taken by the farmer. (For the farmer the decision to harvest should be based solely on whether the cost of harvest and handling will be covered by the price offered, since at this time all other production costs have been incurred and cannot be reversed – they are ‘sunk’ – and should not enter into the immediate decision of whether to harvest the crop.)

Once harvested, mango begins to deteriorate in quality. Fruit should be moved to the market as rapidly as possible, in order to provide the longest possible shelf life to the marketing agent and consumer.

Harvesting fruit is a skilled job, requiring well-trained labour. Pickers should be briefed on the quality requirements and should be paid on the basis of volume and quality of fruit picked. Written quality specifications should be provided by the exporter for the farmers and pickers before the start of the season, to ensure complete understanding and to avoid arguments over what was expected.

An example of a quality specification is presented in Section 2. This should form part of a contract between farmer and exporter, specifying price, payment, handling instructions and delivery arrangements.

**Timing of harvest:** In any postharvest handling system, the best quality product is provided when the time between harvest and consumption is as short as possible. This is the approach used by most Eastern Caribbean exporters at present. Most Caribbean, North American and European markets, are readily accessible from the Eastern Caribbean by air within 12–24 hours of shipment. Small aircraft pallet loads of mangoes may be harvested early one morning, shipped by lunchtime and on the market in Canada the next morning.

If it is not possible that there is a short time between harvest and consumption, rapid cooling after harvest is desirable. Most Eastern Caribbean mango handling systems do not incorporate this approach at present, but it will increase as facilities become available and the advantages are realized. Many large importers will not consider purchase of mango if precolling is not performed. (see more on ‘precolling and cold storage’ below).

Timing of harvest therefore should be governed by the subsequent handling system. Preshipment cooling facilities provide flexibility in handling, allow assembly of a much larger shipment volume and a product of better quality. It is best to harvest mango in the cool of the morning when fruit temperatures are at their lowest. However, this may not always be practical. Fruit harvested at midday may have internal temperatures 10–15°C higher than those picked in the early morning. This extra heat hastens ripening if the fruits are not cooled before shipment. Even when fruit can
be cooled, the additional heat load necessitates longer cooling runs and higher cost.

Typically it takes 12–18 hr for all the operations from harvest through to shipment, when there is no precooling. Precooling can add a further 24–30 hr from harvesting up to the point of shipment.

**Harvest maturity:** Optimum fruit flavour is achieved when mangoes remain on the tree to full maturity and start to ripen. Fruit harvested at this stage will be overripe within a short period (1–2 days). For export markets, fruit should be harvested when they have reached a stage of physiological maturity (mature stage II) without showing signs of ripening.

The mango is a climacteric fruit. This means that once it has attained a certain stage of maturity, it will undergo ripening changes involving colour development, flesh softening, sugar level increases and acid level decreases, even after it has been detached from the tree.

Harvesting the fruit before it is physiologically mature will result in poor flavour development. Rapid water loss also occurs from immature fruit in storage, due to the incomplete development of surface waxes.

Traditionally mango farmers harvest fruit using their judgement, based on appearance of the fruit and their experience over past seasons. There is a perception that farmers are often unable to correctly identify fruit at the
appropriate stage of maturity. However, field experience shows that when the desired stage of maturity is carefully described to farmers and they are aware that appropriate controls are in place to reject immature and over mature fruit, farmers do demonstrate a high level of skill in fruit selection. The problem is therefore not lack of expertise on the part of the farmer, but poor management of the export operation.

No nondestructive, objective and practical field method of determining mango maturity, has yet been developed despite many attempts. Farmers therefore have to rely on a combination of visual characters such as fruit shape, skin lustre and, to a lesser extent, colour.

The maturity guide for Julie mango depicted in Figure 11.1 has been found to be reliable in the Eastern Caribbean and is recommended.

The internal colour of mango offers the best guide to fruit maturity. For this reason a random sample of fruit should be cut in the field before harvest commences, to ensure the pickers equate external appearance with the appropriate level of maturity. This is particularly important early in the season. Many export market specifications will require a minimum sugar content of 10% (see Industry standards in Section 2). This can be checked in the field with a hand held refractometer.

**Harvest operations:** The techniques and equipment available for harvesting mango are governed by the scale of the operation, orchard layout, field slope, tree size and the degree of intercropping and/or undergrowth.

The method of removing fruit from the field should be considered at the preproduction stage when selecting orchard location. Flat or gently sloping land will allow some level of mechanization either in allowing access to the fruit, or in removing fruit from the field by tractor. Given that the cost of harvesting tree crops in the Eastern Caribbean may represent as much as 80% of production costs, consideration of these factors at the appropriate planning stage is essential. However, since most of the land available for planting mangoes in the Eastern Caribbean is sloping, handling activities will most probably be by hand.

Tree size also has a major impact on the accessibility of fruit and the cost of harvesting. Currently the cost of harvesting and the level of damage is increased substantially because the majority of trees are 12 m (40 ft) high and more. The lack of concentrations of trees as orchards also adds significantly to the cost of harvest.

The aim should be to be able to harvest all fruit from the ground either by hand or with a picking pole. Tree height should therefore not exceed 5 m (16 ft) (see Pruning). Production and handling of mangoes for export from trees exceeding this height is unlikely to be sustainable in the long term.

**Picking technique:** Mangoes can be picked most efficiently by hand with minimal damage and negligible latex contamination. The fruit should not be pulled downwards but twisted forwards or sideways, to snap the stalk with a quick wrist movement. If the stalk is held rather than the fruit alone the stalk length can be controlled. Stalk lengths of 1 cm (0.5 in) or more will prevent latex flow and contamination of adjacent fruit before arrival at the packhouse.

Where a picking pole becomes necessary, pole length
should not be any more than 3 m (10 ft), and should be light enough to handle with one hand. Numerous variations of a basic design exist. The most common designs used in the Eastern Caribbean today do not include a cutting blade for detachment, but rely on the application of pressure on the fruit shoulders which inevitably results in damage to some fruit.

Field handling: After picking, fruit should be checked in relation to the specifications of acceptability and placed directly into a bucket, or a canvas bag worn either over the shoulder or around the waist. Fruit that clearly do not meet the specification should be rejected immediately. When the buckets or bags are full, they are emptied into field crates or bins, stacked under the tree or standing between the rows of trees.

Field crates normally hold 60 to 100 fruit and weigh 18–30 kg (40–66 lb) when full. Crates that can be stacked or nested on each other offer most flexibility in movement of empties. For mango these crates should not need padding, except when ripening fruit are picked for the local market.

On flat and gently sloping land, pallet bins approximately 1.2 x 1.0 x 0.8 m (47 x 39 x 31 in) (length x width x height) may be used in conjunction with tractors and or fork lifts. These will hold approximately 500–800 kg (1,100–1,750 lb).

Field crates and bins should be removed from the field and taken to the packhouse as quickly as possible. Under current conditions in the Eastern Caribbean, where relatively small amounts of fruit are collected at numerous locations around the island, this requirement is seldom met. Nevertheless, whenever possible, fruit should not be exposed to the sun between harvest and the packhouse.

Precooling soon after harvest, if possible, will greatly assist in extending the shelf-life and quality of the fruit.

The use of refrigerated trucks for fruit collection has been tried in the Eastern Caribbean but shows little benefit unless the fruit are precooled before being placed in the truck. Mobile field cooling equipment has been designed and used in other parts of the world which could be suitable for the Eastern Caribbean.

Management of harvest operations: Assembly of fruit from numerous farmers and locations is characteristic of current mango systems in the Eastern Caribbean. Failure to keep track of fruit origin means that it is virtually impossible to determine the cause of problems that show up either at the packhouse or at the market.

Recent legislation also means that buyers in North American and European markets may be prosecuted if shipments of produce are found not to comply with safety regulations, relating to either microbial contamination or pesticide residues. Due diligence has therefore to be demonstrated through the provision of field records, and the ability to be able to trace the origin of the product back to the farm level. Most large importers incorporate these requirements into their terms of trade agreements with suppliers, and this provision will be increasingly common.

In order to ensure that fruit are harvested carefully but quickly, many exporters prefer to operate their own picking teams who are well trained, have the right tools, and can be paid on a combination of ‘piece rate’ and quality of output.
Packhouse operations
Covered areas where produce is selected, washed, sorted and packed ready for shipment are referred to as packhouses. The function of a packhouse is to take delivery of fruit from the field, sort them, and prepare them for shipping and marketing. Packhouses in the Caribbean are frequently no more than basic improvised areas with a roof, a wash tank and perhaps a few tables. However, as volumes that are handled increase and the need for more efficient operations for producing better quality fruit intensifies, structures containing automated handling facilities are likely to become more commonplace.

Packhouses are areas for handling food and although fresh produce is considered low risk in terms of food safety problems, it is the responsibility of the exporter to ensure basic hygiene measures are applied, and that the packhouse is appropriate for the preparation of safe products. The “due diligence” legislation mentioned in section 2 is an example of recent trends in the fresh produce industry, and exporters must remain aware of these needs.

Design of the packhouse and the layout of the equipment and/or the handling stages is crucial to the efficient handling of mango, whatever the scale of operation. Poor design not only reduces the throughput of the plant, but also reduces quality of the final product. Design depends on the planned throughput of the plant and the sequence of procedures, so it is best to look at the sort of procedures that need to take place in preparing mango for marketing.

Mango packhouses can normally be divided into the following areas:
- reception
- selection and postharvest treatment
- size grading and packing
- labelling
- carton storage and fabrication
- cooling and cold storage
- loading.

Reception: Whether fruit are delivered by the packhouse’s own trucks and picking teams or by farmers themselves, an area of the packhouse should be set aside to receive the mangoes. The main requirements are that the area:
- provides protection from rain and sun
- is well ventilated
- is large enough to temporarily hold the expected volume on a daily basis
- is organized to facilitate recording of weight delivered and perform any quality checks.

If a 6 m (20 ft) reefer container, holding 9.5 pallets, is to be packed in one day, the reception area should be able to hold up to six pallets at any one time.

One person should be in charge of fruit reception and systems should be set up to ensure quick receipt, recording, issue of farmer delivery note, identification of fruit, and stacking on pallets to await processing. No fruit should be held overnight to pack the following day; harvests should be scheduled and packhouse labour organised to ensure that the last fruit is delivered to the packhouse in time to enable treatment and packing.

Packhouse records are essential to facilitate payments to farmers. Records also form an important basis for continuous improvement of the export operation as well as becoming a requirement by importers that all the necessary
measures were taken at the packhouse to ensure the safety of the product for consumption - this is sometimes referred to as ‘due diligence’. The minimum of information required is:

- farmer name
- orchard location
- telephone number
- weight and number of fruit delivered.

The same form can be completed with the weight of fruit accepted and required payment. More advanced operations will want to include information on:

- quality (comments or actual physical inspection)
- temperature of the fruit on receipt
- results of the shelf life of a retained sample.

Transfer of the information onto computer will allow simple sorting and analysis, to assist decision making.

An example of such a delivery record form is provided in Annex 5.

**Selection and postharvest treatment:** In a manual system, washing and selection can be performed as one operation.

The first procedure after delivery is to select out those fruit which are clearly not of export quality, to trim the stalk, and wash the fruit. Selection can best be performed by picking out individual fruit from the field crate, and inspecting them against the quality specification. At this stage fruit are likely to be rejected on the basis of:

- small size
- excessive blemish
- immaturity
- excessive ripening
- deformity.

Reject fruit should be placed in separate field crates for return to the farmer, or for packing later for alternative markets. The selection process can be standardised through training, but more particularly through displaying fruit in clear view of the workers that are at the limit of acceptability. Checks throughout the packing process need to be made by the packhouse manager, or quality control staff.

The stalk of accepted fruit should be trimmed with a secateur or a knife and the fruit placed in the water tank. Latex will exude from the stalk into the water but not on the fruit. The fruit should ideally remain in the water tank for up to 30 minutes to ensure latex flow has stopped. If this duration is not sufficient, fruit should be packed stalk downwards in the carton to ensure no remaining latex exudes onto the packed mangoes.

The water should not contain any soaps as these will remove the natural fruit waxes and enhance water loss during shipping. Soaps will not be required if stalks are left long at harvest. Since under Eastern Caribbean conditions this is not always possible, soap may be required, in which case subsequent waxing (see ‘fruit coatings’ below) of fruit should be considered. The water should however contain 150–200 ppm of chlorine provided by 30–42 ml bleach per 5 L of water to reduce bacterial and fungal contamination.

Where hot water treatment is required against either anthracnose or fruit fly, fruit should be picked out of the wash tank and placed in the crates or baskets of the hot water plant. Where hot water treatment is not required, the fruit can be size graded out of the water tank or removed for waxing.

In semi-automated systems, mangoes may be placed into a chlorinated water tank from pallet bins or field crates. Selectors standing alongside the tank will pick out
unmarketable fruit and those that require stalk trimming, placing reject fruit in a trash chute and returning accepted fruit to the water. An elevator lifts fruit out of the water onto either a short (approx. 10 rollers) length of sponge rollers to dry off excess moisture in readiness for wax application or directly into the hot water treatment tank. The water should be changed when it becomes cloudy.

**Hot water treatment:** The use of hot water treatment (HWT) against fruit fly and anthracnose has been described in Sections 8 and 9. Batch treatment or continuous flow systems have been devised, and are operational in many Caribbean and Latin American countries, though only one exists in the Eastern Caribbean at the time of writing (Grenada). In its simplest form, the critical features of an effective HWT system are:

- a ratio of at least 3 L of water to 1 kg of fruit (1 gal : 3.3 lb) to ensure temperatures remain constant
- forced water circulation to ensure even temperature distribution
- a good temperature controller.

Water temperature needs to be controlled to within 1°C of the target temperature, particularly at the higher temperatures employed for anthracnose control, as there is danger of fruit damage.

For manual systems, batch dipping is recommended using field crates or larger pallet bins. For automated systems, continuous flow HWT fits in well with fruit emerging from the wash tank. Fruit fly treatments of 35 minute duration will require very long tanks, and therefore considerable space. The design of a batch HWT system capable of treating fruit sufficient to fill one 20 ft container in one day is shown in Figure 11.2.

- **Recommended treatments for Julie mango are as follows:**
  - Fruit fly treatment 48°C for 35 minutes
  - Anthracnose treatment 53°C for 5 minutes

  Anthracnose is only slightly reduced by the fruit fly treatment and work is still continuing to determine the best way of combining control in one treatment regime or as a two-stage treatment.

  Hot water treatment under the above conditions does not affect shipping and shelf life or eating quality of Julie mango in any way, but may reduce peel lustre to a noticeable degree. This can be rectified through the use of fruit coatings. However, after hot water treatment, fruit need to be cooled as soon as possible to retard the ripening process.

**Fruit coatings:** Fruit coatings are used to reduce water loss, improve external appearance and in some cases slow ripening rate. The range of coatings, which are both effective and accepted by importing countries, has been investigated by CARDI. The most effective coating for use on Julie mango is Decco Lustr 202, which reduces weight loss under sea shipment by 34% and enhances fruit appearance.

A 6% wax solution applied either as a dip or sprayed over rotating brushes is required. This coating is approved for use on fruit entering the USA but not for Europe. The European Union only accepts coatings for mango based on sucrose esters or microcrystalline wax. CARDI trials on sucrose ester coatings have shown them to provide little benefit and in some cases to be damaging.

After waxing by dipping or in semi-automated brush systems the fruit can proceed to the packing area. Drying is achieved at ambient temperature and no special
Figure 11.2 Design of a mango hot water treatment plant

Plan view - basics

Plan view - hot water inlets

Notes:
1. System to treat equivalent of one 20ft container per 6h day (7500kg)
2. Water temperature to be 53°C with minimal fluctuation (1°C either side max)
3. Suggested system is that main tank is fed by a hot water reserve tank controlled by a solenoid linked to the thermostat. When main tank temp. OK reserve tank supply is switched off. When temp drops in main tank, reserve tank supply is brought on stream.
4. Very good mixing is required. Dip duration will be about 5 minutes. Field crates to be dipped in sequence by two operators.
5. Crates will stand on a raised perforated platform about 12in high.
6. Crate dimensions expected to be about 24in x 15in x 12in and will hold approx 25kg fruit each. 150kg fruit per batch.
7. Unit to be movable with fork lift.
arrangements are necessary.

**Size grading and packing**: Mangoes exported from the Eastern Caribbean are not normally size graded. The majority of competitors however size grade and attempts to expand the market for Julie mango will require Caribbean exporters to do the same. Though automatic weight graders are common in many producing countries, none exists currently in the Eastern Caribbean for mango. Manual sizing, where performed, is done by eye.

Sizing fruit is best performed as a separate activity to packing. Fruit can be selected at any stage after washing, hot water treatment or waxing, and placed into one of up to four size categories on a divided packing table (Figure 11.3).

Sample fruit of the correct weight placed in full view of the sizing team will assist in standardising the work between staff, and between one shipment and the next. Packers then take presized fruit and pack in cartons to a specific count (number per box). Dividing up the job in this way allows each person to concentrate on a specific task and results are invariably better.

If a packer is confronted with a mixed batch of fruit, time to pack a carton will be longer, the chances of mixed sized fruit in a carton are higher and the level of mechanical damage is higher, as the packer handles fruit several times while looking for the appropriate sizes.

Mechanical sizing of mangoes is done with cup graders which are also suitable for avocados and other irregular shaped fruit. Individual fruit are delivered into cups which proceed with their cargo, until the weight of the fruit matches a preset counterbalance weight at a certain point of the line. At that point the fruit is dropped onto a conveyor band for delivery to a specific packing station. Such equipment represents a costly investment and requires high throughput to be justifiable.

An intermediate option is to have workers select fruit from a conveyor belt running at about 0.25 m/second.

**Packing**: Most importers require fruit to be packed in standard sized cartons, although this will depend on the importer and the mango variety. Table 11.1 provides guidelines for packing counts of 12, 14, 16, 18 and 20 in a 5 kg (11 lb) net weight carton, i.e. the range of weight of mangoes for each different size category. These cartons are compatible with the metric pallet.

To avoid fruit being compressed during shipment and storage, they should be packed with the stalk downwards since mangoes tend to ripen from the stem end. Some operations wrap alternate fruit in tissue paper to reduce fruit-to-fruit rubbing.

The effects of inappropriate sizing will show up during packing as under- or overpacked cartons and this should be brought to the attention of the sizing team. A further check is possible at weighing.

<table>
<thead>
<tr>
<th>Count</th>
<th>Av wt</th>
<th>Smallest</th>
<th>Largest</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>416</td>
<td>&gt;375</td>
<td>375</td>
</tr>
<tr>
<td>14</td>
<td>357</td>
<td>335</td>
<td>335</td>
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<tr>
<td>16</td>
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<td>18</td>
<td>277</td>
<td>265</td>
<td>265</td>
</tr>
<tr>
<td>20</td>
<td>250</td>
<td>235</td>
<td>235</td>
</tr>
</tbody>
</table>

**Reject**
Figure 11.3 Divided packing table

Labelling: It is not uncommon to see cartons exported from the Caribbean with only an airway bill number written on the top. Authorities in importing countries can and occasionally do retain such consignments for detailed inspection, which inevitably results in extra charges and delays. The minimum information required on cartons is:
- country of origin
- product
- net weight or count
  Optional information might include:
  - variety name
  - exporter name and address
  - brandname and/or logo
  - importer name
  - ripeness indicator.

Much of this information may be printed on the carton during manufacture. If the carton is not solely to be used for mango, then information may be printed in such a way to allow ticking of possible varieties, products, net weights or counts.

Carton storage and fabrication: Under the minimal investment environment of export operations in the Eastern Caribbean, most exporters opt for the cheapest form of packaging. However the cheapest can turn out to be expensive when the extra spoilage is taken into account.

Until recently mangoes have generally been shipped in banana-type cartons holding 13.5–16 kg (30–35 lb) packed in multiple layers. This has been and still is arguably acceptable for certain varieties supplied to certain markets. The market trend is, however, to supply mangoes in 4, 4.5 or 5 kg (9, 10, 11 lb) net weight cartons. The cost of packaging
is doubled as a result.

Recently, standard 5 kg mango cartons have been made available by Winera with external dimensions of 39.5 x 29.5 x 10.5 cm (15.8 x 11.8 x 4.2 in) (length x width x height), suitable for stacking on the 1.2 x 1.0 m pallet standard in Europe. Carton design (board weight, corrugation design and vent size and positioning) should take into consideration cooling and shipping requirements (see below).

Cartons cost EC$3-4.00 per carton (in 1996), which typically represents 25-40% of the total cost to the exporter, including the contents (i.e. FOB cost). As a result, it pays to treat cartons with considerable care during storage and handling. All packaging materials should be stored in a clean area away from water (ideally on a second floor) and free from sunlight (fades printing), insects, rodents and fungal spores.

The mango carton described above is a one piece die-cut design which is constructed without stapling or glue. Legislation in Europe is introducing the need for minimum recycling requirements on packaging, which will eventually prohibit the use of staples in fibreboard packaging.

Cartons should be provided to packers already built and ready to use. The best system to use is an overhead rail system as this uses space effectively and prevents contact with wet floors and soil.

Other cheaper alternatives are the storage and construction of cartons on a second storey and delivery to packers via a chute or cartons which can be stacked on pallets next to packing stations or delivered along roller conveyors. Packhouse managers should not underestimate the labour requirement for carton construction – one carton maker should be able to supply two to three packers, if using a one piece carton.

**Pre-cooling and cold storage:** To provide buyers with the harvest-fresh fruit they are looking for, rapid cooling after harvest is essential. Delays in cooling will result in premature ripening during transport, increased shrivelling, more severe disease, and short shelf life in the market.

In areas without fruit fly, some mango operations precool or partially precool immediately after arrival at the packhouse, to enhance these benefits. Generally though, precooling is performed after product packing and palletization. It is essential for sea shipment and desirable for air shipments.

Hot water treatment is only carried on in fruit affected by fruit fly and anthracnose. Hot water treatment, therefore, is carried out after the selection process and before packing the product. No cooling is carried out before these treatments. However, fruit need to be cooled as soon as possible to retard the ripening process.

Forced air cooling systems are best suited to mango and with air temperatures of 10-12°C, fruit can reach target temperatures within 4-6 hours. Palletization and carton design must be compatible with cool room design to allow air through the cartons.

The high capacity room coolers introduced by ADCU into Grenada, St Vincent, St Lucia, Dominica, and Antigua in 1995 are suitable for cooling mango. The technical manual written for operators of these coolers explains the precooling operation in detail with specific reference to air and sea shipments (see *Fresh produce precooling in the Eastern Caribbean*).

**Loading area:** Many packhouses in the Eastern Caribbean cannot handle unitised (palletised, containerised) cargo. This
severely reduces the efficiency of the operation, increases overall cost and negatively affects product quality because of the repeated handling of break bulk cargo. Large scale mango shipments will require unitised handling systems. Whether the cargo is shipped by sea or by air the packhouse has to provide improved facilities including:

- pallet handling equipment
- precooler
- extra cool storage (though not always necessary)
- truck and container loading bay.

The loading area of a mango packhouse must be clean and away from sources of dust. Preferably the area should be managed by one person and subject to strict access control. The removal of produce from any carton is undesirable while the addition of any materials (particularly drugs) could be disastrous to the reputation of the exporter.

The loading area should be subject to the same record keeping controls as the reception area at the other end of the packhouse. This is where the cycle at the packhouse ends and where packhouse performance is assessed.

Air shipment: The bulk of Eastern Caribbean mangoes reaching international markets are still shipped by air, although shipment by sea is becoming more common. Air shipment should always provide a better product to consumers and will return better prices, but because of the high cost of air freight, returns to exporters and farmers are not necessarily better.

Fruit harvested and shipped by air should be fully mature and of excellent quality to reach the consumer in the required state. In the absence of precoringing facilities, aircraft pallets should be used. Where precoring is possible, unit containers can be considered, (i.e. LD3 and LD7 types) which can be loaded into the lower decks of the aircraft.

Where transhipment to an international airport is required as in the cases of Dominica and St Vincent, every effort should be made to facilitate the transfer. In all instances of transhipment, the exporter should be fully aware of any quarantine regulations relating to mango pests. Failure to check this may result in loss of fruit fly free status of produce from Grenada and St Vincent as it passes through Antigua or Puerto Rico, or impounding of a shipment from Dominica as it passes through Grenada. Up-to-date information should always be sought from the local Plant Quarantine office.

Sea shipment: Work performed by CARDI and other regional agencies has shown that Julie mangoes can be shipped successfully by sea to Europe with shipment periods of up to 14 days. As the technology described in this manual is more fully applied, sea shipment will overtake air shipment as the dominant means of transport. For the Eastern Caribbean mango industry to expand, sea shipment is essential to enable sufficient volumes to reach the markets. The region's air freight capacity and cost could not sustain the required volumes.

- Successful sea shipment requires:
  - palletisation
  - containerisation
  - precoring at the packhouse
  - container loading bay and reefer plug-in point at the packhouse
  - pallet trucks or fork lifts.
The T-floor of the reefer container should be brushed out and the temperature set to 12°C between November and May and at 10°C between June and October. Ventilation ports should be set at 25% open and all drain plugs opened. Using the 1 x 1.2 m pallet, a 6 m (20 ft) container will hold nine pallets plus another half pallet stowed loose, or 600 cartons in all. A temperature recorder should be included in the container to monitor the holding temperature. This should be set on the wall of the container by the rear doors at the same position for each shipment. A slipsheet which prevents air short circuiting should be positioned at the rear doors as explained in the manual 'Fresh produce precooling in the Eastern Caribbean'.

**Product compatibility:** Mangoes can be shipped with many other tropical commodities with the same temperature requirements. Shipment with less cold tolerant products such as plantain, banana, and ginger at 13°C is acceptable, as long as the consignment is precooled.

**Handling in the market:** Exporters should ensure that handling in the country of import is well taken care of, even though this may appear to be the importers responsibility. The importer will only pay for produce that arrives in good condition at his premises.

Delays at the port of import, hold ups due to inadequate documentation, breaking down of the container and subsequent unrefrigerated transport, are all possible events which can impact negatively on fruit quality and ultimately on financial returns. In conjunction with the importer, the exporter therefore needs to ensure that onward transport of the full container or pallet through to the importer's premises is arranged. Alternatively, a freight forwarder should be hired to take control of the shipment at the port, provide reports on the condition and quality of the fruits at the port of entry, and arrange onward transport.

Controlling the temperature of the fruit in the market is important. Chilling injury is likely in North American and European winters and rapid ripening in the summers. The optimum holding temperature for Julie mango is 12–14°C.

**Ripening:** Mangoes can be artificially ripened and this is a rapidly developing trend amongst the larger retailers and their suppliers. Fruit gassed with ethylene are more predictable in the way they ripen which improves control over marketing. Ideal conditions for ripening mango are 100 ppm ethylene gas for 24 hours at 18–25°C. Under these conditions mangoes will ripen in 2–3 days. At 12°C, ripening is slowed.

Ripening mangoes produce ethylene and therefore should be kept separate from ethylene-sensitive commodities.