HANDLING OF FRESH FRUITS, VEGETABLES AND ROOT CROPS
-A TRAINING MANUAL-
FOR GRENADA

TCP/GRN/2901

Agricultural Marketing Improvement

Prepared By
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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
# HANDLE OF FRESH FRUITS, VEGETABLES AND ROOT CROPS

## A TRAINING MANUAL FOR GRENADA

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INTRODUCTION

The “Agricultural Marketing Improvement” Project TCP/GRN/2901 is being implemented by the Grenada Government and FAO with the objective of improving incomes for fruit, vegetable and root crop growers through a more efficient agricultural marketing system. The project would enhance the capacity of the Ministry of Agriculture to help farmers, extension staff and inter-island traffickers to provide appropriate agricultural marketing advice and support services on post-harvest handling. This document has been prepared based on the need to improve harvesting, handling and produce distribution in the Country and to increase exports. The document gives emphasis to specific crops produced in significant quantities or with a potential for increased production and marketing.

CHAPTER 1. GENERAL POSTHARVEST CONSIDERATIONS

All fruits, vegetables and root crops are living biological organisms, having a respiratory system, similar to that of humans. They continue their living processes after harvest. Respiration is the process by which plants take in oxygen and give out carbon dioxide. On the basis of their respiration rate and ethylene production patterns during maturation and ripening, fruits can be classified in two groups: climacteric fruits (they exhibit a large increase in carbon dioxide and ethylene production rates coincident with their ripening) and non-climacteric fruits (which exhibit no changes in their generally low carbon dioxide and ethylene production rates during ripening). In accordance with the respiration rate most horticultural commodities can be classified as follows:

- Low respiration rate. Nuts, dates, dried fruits and vegetables, apples, citrus, grape, garlic, onion and sweet potato.
- Moderate respiration rate. Banana, cherry, plum, cabbage, carrot, lettuce, pepper and tomato.
- High respiration rate. Cauliflower, avocado, berries and green onion.
- Extremely high respiration rate. Broccoli, peas, spinach and sweet corn.

Ethylene is a natural product of plant metabolism and is produced by all tissues of higher plants. It is considered the natural aging and ripening hormone and is active even at small traces. Horticultural commodities can be classified as follows, based on the amount of ethylene they produce:

- Low ethylene production. Cauliflower, cherry, citrus, leafy vegetables, root vegetables, potato, cucumber, eggplant, pepper, pineapple, pumpkins and watermelon.
- Moderate ethylene production. Banana, guava, honey dew melon, mango, plantain and tomato.
- High and very high ethylene production. Apples, avocado, cantaloupe, papaya, kiwi, pear, plum, passion fruit, sapote and cherimoya.
Fruits, vegetables and root crops contain 65 to 95 percent of water and their post-harvest life depends on the rate at which they use up their stored food reserves and their rate of water losses. When food and water reserves are exhausted the produce dies and decays.

1.1. Objective of post-harvest handling

Both quantitative and qualitative losses occur at all stages in the post-harvest handling system of the distribution chain of perishables (from harvesting, through handling, packing, storage and transportation to final delivery of the fresh produce to the consumer). Factors affecting post-harvest losses vary widely from place to place and are more and more difficult. A farmer growing fruits for his family's consumption does not mind too much if his produce has a few bruises and scars and if it is not packed for a suitable transportation to a market at a certain distance. Meantime if he is producing for the market at any distance from his own farm he must have a different attitude if he wants to get the best return from his produce: he must know about the quality requirements wanted by the consumers and the proper containers needed for the transport.

Two examples below help to explain the importance of post-harvest handling.

Example 1. By knowing the market and its needs, the grower can and must judge how important are the requirements of appearance, maturity and flavor of his produce for the consumer. Those requirements are strictly related with maturity indexes, which are influenced by a proper harvesting time. A farmer must, therefore, know the proper harvesting time for his produce.

Example 2. The farmer must decide whether the investment in packaging will increase his revenue from the crop. It will be of no value to buy expensive containers for his produce if the harvesting is not properly done and bruises and scars damage the content before packaging. It is more important for the grower to change his attitude toward reducing post-harvest losses, through improving harvesting, than to think that the purchase of expensive packages will automatically solve his problem and increase his income.

The objective of post-harvest handling is, therefore, the creation of an understanding of all the operations concerned from harvesting to distribution so as to enable people to apply the proper technology in each step and in such a way to minimize losses and maintain quality as high as possible during the distribution chain. The farmer must give, among others, special and careful attention to the following steps of the post-harvest chain:

- Market demand for the produce they are planning to grow;
- Market requirements and buyers;
- Knowledge of the fresh produce;
The first part of this manual was prepared as an overview of the general principles and operations involved in the post-harvest handling and storage of fresh fruits, vegetables and root crops. The second part of the manual is centered to the specific handling and distribution operations of fruits, vegetables and root crops grown in Grenada. This document has been produced for use, along with other material, as a training component for concerned government and private sector persons interested to understand the principles of post-harvest and its applications to the fresh commodities marketed within the country and overseas.

1.2. Post-harvest technology procedures

Temperature and humidity are used to control shelf-life of commodities in refrigerated cold stores.

1.2.1. Temperature management practices

Temperature management is the most important tool that we have to extend shelf-life of fresh horticultural commodities after harvesting the produce. Temperature management begins with a rapid removal of the field heat by using one of the following cooling methods:

- Hydro cooling;
- In package ice;
- Top icing;
- Evaporative cooling;
- Room cooling;
- Forced air cooling;
- Serpentine forced air cooling;
- Vacuum cooling; and
- Hydro-vacuum cooling.

Cold storage facilities should be well constructed and adequately equipped. They should have:
• Good construction, and insulation and vapor barrier;
• Strong floor;
• Adequate doors for loading and unloading;
• Effective distribution of refrigerated air;
• Properly located controls;
• Enough refrigerated coil surface;
• Capacity adequate to expected needs;
• Appropriate stacking of the produce.

1.2.2. Control of relative humidity

Appropriate relative humidity is important to control the following:

• Water losses;
• Decay development;

• Incidence of some physiological disorders;
• Uniformity of ripening.

Proper relative humidity should be 85-95% for the majority of the fruits, 95-98% for vegetables (except dry onions and pumpkins at 70-75%) and 95-100% for some root vegetables. Relative humidity can be controlled by the following methods:

• Addition of moisture to air by humidifiers;
• Regulation of air movement in relation to produce;
• Maintaining coil temperature to 1°C difference to air temperature;
• Wetting the floor in the storage room; and
• Addition of crushed ice.

1.2.3. Controlled atmosphere

Controlled atmosphere means the addition or removal of gases resulting in an atmospheric composition surrounding the commodity that is different from that of the air 79% of nitrogen, 21% of oxygen and traces of carbon dioxide). Usually this involves reduction of oxygen and elevation of carbon dioxide, in a perfectly sealed room. The use of controlled atmosphere can be considered only as a supplement to the proper temperature and humidity procedures. Controlled atmosphere is used for a certain number of crops to extend shelf-life, reduce disorders such as chilling injuries, reduction of pathogens and some insect control.

1.2.4. Supplemental procedures

The following treatments may be applied to horticultural commodities:

• Curing of certain roots, tubers and bulbs vegetables (see details on specific chapter);
• Sorting for defect elimination;
• Waxing and other surface coatings;
• Hot water treatment;
• Treatment with post-harvest fungicides or bactericides;
• Use of sprout inhibitors;
• Special post harvest chemical treatment;
• Fumigation for insect control;
• Films wrapping; and
• Ethylene treatment for de-greening and ripening certain fruits, such as citrus, bananas and mangos.

Details are given in the specific chapters.

1.2.5. Ripening fruits with ethylene gas

In the post harvest physiology of most horticultural crops, ethylene plays an important role, sometime beneficial (improving quality of the produce by faster and more uniform ripening prior to retail distribution) and often deleterious (increasing the rate of senescence and reducing shelf-life).

**Systems for ethylene treatments.** Handlers can equip existing rooms for use as ripening chambers or they can install specially built ones. Both need automatic control of temperature (for heating and cooling), humidity and ventilation. The room should be as tight as possible, to prevent leakage of gas, but not essentially hermetically sealed.

Amount of gas needed. It is recommended 100 ppm of gas. Higher concentration will not speed up the ripening process. Too much gas may result an explosive air-gas mixture. Safety precautions have to be followed.

**Temperature and humidity.** Optimum temperature varies from 18 to 25°C. At lower temperature ripening is slowed, from 25 to 30°C ripening may be inhibited and decay accelerated. Relative humidity should be as high as possible.

**Other technologies for using ethylene.** Fruits ripening could also be induced with the following methods:

• Explosion-proof ethylene mixed with an inert gas.
• Ethylene generators, widely used in developed countries;
• Ethephon;
• Calcium carbide which, in a furnace, releases acetylene (which has an ethylene like response) when combined with water;
• Fruits already ripe (included in the high ethylene producing category) can be used in very small commercial operations, or at home, to ripen other fruits.
Deleterious effect of ethylene. The potent effect of ethylene on senescence of perishables commodities can greatly reduce the shelf-life of product sensitive to it. Techniques to remove it (such as the utilization of potassium permanganate, ozone, hypobaric storage and oxidizers) or reduce its effect (such as loss of green color in certain vegetables, accelerate ripening, sprouting and decreased shelf-life) are of considerable importance. Storage of perishables sensitive to the gas should not be done in the same room where products which have a high or very high production of ethylene are kept. See more details in the first part of this chapter.

1.3. Postharvest deteriorations

The interaction of metabolic and environmental factors are responsible for many post-harvest deteriorations. Among the main causes of wastage are the following:

- General senescence;
- Water loss;
- Diseases and pests;
- Physical damages (mechanical injury);
- Injuries from temperature effects (chilling injuries); and
- Other causes.

1.4. Standardization, quality factors, quality standards and quality control

Almost all agricultural commodities in developed countries are now marketed on the basis of official standards established under national or international laws. The role of the official standards is particularly important in the case of perishable commodities such as fresh fruits vegetables and root crops.

Standardization, as applied to fresh commodities can be described as “common acceptance of the practice of classifying produce and offering it for sale, in term of quality characteristics that have been precisely defined and are constant over the time and distance”. Time and distance are important parameters since produce quality deteriorates with increased time and/or handling. Products that leaves the farm or the packinghouse as Grade 1 may be Grade 2 on arrival at the wholesale or retail market as a result of improper harvesting and handling, bad packaging, rough transport, excessive delays and other malpractices.

Definition of quality. The word quality is used in various ways in reference to fresh fruits, vegetables and root crops, such as market quality, edible quality, dessert quality, shipping quality, table quality, nutritional quality, internal quality, and appearance quality. Quality of fresh horticultural commodities is a combination of characteristics, attributes, and properties that give to the commodity value to humans for food (fruits, vegetables and root crops). Producers should be concerned that their commodities have good appearance and few visual defects, but for them a useful cultivar must have high yield, disease resistance, easy to harvest and shipping quality. To receivers and market distributors, appearance quality is most important, followed by firmness and shelf-life. Consumers consider
good quality, fruits and vegetables which look good, are firm, and offer good flavor, good edible quality and nutritive value.

**Quality components.** The various components of quality are used to evaluate commodities in relation with specifications for grades and standards, and evaluation of responses to various environmental factors and post-harvest treatments. The relative importance of each factor depends upon the commodity and its intended use, fresh or processed. The main components are:

- Appearance. Many defects can influence the quality appearance of horticultural crops. Morphological defects are sprouting of potatoes, onions and garlic, rooting of onions, germination inside tomatoes and peppers, floret opening in broccoli, etc. Physical defects include shriveling and wilting of all commodities, internal drying of some fruits, mechanical damage such punctures, cuts and scratches, spitting and crushing, skin abrasions, deformation and bruising. Temperature related disorders (such as sunburn, chilling, sunscald), blossom end rot. Pathological defects include decay provoked by fungi and bacteria.
- Texture. It is important for eating and cooking quality.
- Flavor. Evaluating flavor quality involves perception of taste and aroma.
- Nutritive value. Fresh fruits and vegetables play an important role in human nutrition, especially as a source of vitamins, minerals and dietary fibers. Physical damage may reduce the nutritive value of a commodity.
- Safety. Safety factors include the presence of toxicants such as the greening of potatoes, chemical residues and mycotoxine produced by fungi.

**Factors influencing quality.** Many pre and post-harvest factors influence the composition and quality of fresh horticultural crops. They may include:

- Genetic factors: cultivar selection and rootstocks;
- Pre-harvest environmental factors: climatic conditions, cultural conditions and time and method of harvesting;
- Harvesting: maturity, ripeness, physiological age;
- Post-harvest treatments: handling methods, storage time between harvesting and consumption; and
- Interaction among the above detailed factors.

Some form of grading and quality control is always carried out whenever fruits, vegetables and root crops are traded. The most basic quality standard is that the produce must be edible, so severely diseased or badly damaged produce is not accepted even in the simplest market. Other quality requirements vary depending on the stage of development of the market and personal preferences of the consumers and become more and more complex as the economic prosperity of the community where the produce is traded increases.
1.4.1. Important quality components

Attributes of produce, which are important to consumers and therefore could be incorporated into grading or quality standards, can be grouped under:

- **Appearance characteristics.** The most important quality attributes of fresh fruits and vegetables appearance are:

  - **Size.** For most commodities consumers have a definite preference as to the desirable size, which is the most widely used quality parameter. This preference must be expressed as weight, diameter, circumference, length or width. Where produce is graded according to size, it is a normal practice to package those of similar size together. The uniformity of size allows produce to be placed into a container in a regular packing array, with the result firstly to have a more efficient use of packing space so that either more produce can be placed in the container or the size of the container reduced which means a reduction of the cost of packaging per unit of produce.

  - **Shape.** While shape differs greatly between commodities, it one of the major recognition factors used by consumers who will place a lower value on a commodity, which lacks the expected characteristic shape.

  - **Color.** Many produce show distinctive color changes during maturation which have been correlated by the consumers with the development of other desirable quality attribute so that the correct color of the skin is often the basis for a decision to purchase the commodity displayed on the shelves of the supermarkets.

  - **Conditions.** It is a quality attribute usually referring to freshness and stage of senescence or ripeness of a commodity. Factors which detract from the desirability of a commodity include, among others:

    - Wilting of leafy vegetables;
    - Shrivelying of fruits;
    - Skin blemishes such as bruises, scratch marks and cuts;
    - Surface contamination by soil, birds or insects secretions, plant secretions such as latex straining; and
    - Residues from chemicals applied during the growing season.

  - **Texture and flavor.** Texture is the feeling a food gives in the mouth. It is a combination of sensation derived from the lips, tongue, walls of the mouth, teeth and even the ears. Flavor comprises two factors: taste provoked by sugar and acidity of the produce and aroma provoked by volatile organic compound detected by the nose.
1.4.2. Objective quality standards

The ideal quality standard is one which can be related to a numerical value derived from a simple test conducted quickly in the field, packing house or market with minimum equipment to establish with a certain accuracy when to harvest, store or consume a produce. The test would mainly be used by farmers to determine when to harvest produce. It could also be used during storage or in the market to ensure that the produce being sold has retained an acceptable eating quality or has a predetermined self-life. Main objective quality standards are:

- **Color.** Research has developed charts for apple, pears and stone fruits. Similar ones are for bananas and tomatoes.
- **Flesh firmness.** The measurement of the texture of the flesh is applied mostly in apples and pears with a penetrometer to establish the proper harvesting time suitable for a long cold storage of the produce.
- **Soluble solids.** The sugar content measured with a refractometer is a suitable maturity index for a number of fruits, such as grapes, melons, pineapples and citrus.
- **Titratable acidity.** With the approach of maturity we assist in the reduction of the acidity in the majority of fruits. It is useful for a number of fruits but correct measurement can be done only in a laboratory.
- **Sugar/acid ratio.** The ratio between sugar and acidity is used to assess the acceptability of citrus, pineapple and grapes.

1.4.3. Development of grading standards

Developed countries have comprehensive sets of regulations for fruits, vegetables and root crops marketed in the countries themselves or for export. An increasing number of developing countries have developed the same regulations to export their produce to developed ones. The regulations stipulate the market grade classifications which must be used and define in detail the physical characteristics and quality parameters of produce in each grade. They also often specify the type and size of the containers (packages) that can be used, labeling requirements, recommended storage and transport conditions and permitted post-harvest treatments. In most of the countries the regulations are mandatory and in a few of them they are merely guidelines.

The regulations usually categorize produce into three or four classes, with the lowest class being considered only just acceptable for marketing. The appearance of the produce in each class is decided on the basis of shape and color, the type and extent of blemishes that can be present and physical characteristic specific to that commodity. Apart from an applicability for export trading, the grading standards used in developing countries are unrealistic for the marketing of fruits, vegetables and roots crops within Grenada. The international standards severely downgrade
commodities which show slight cosmetic blemishes and the lowest defined grade excludes a lot of produce that is still of good eating quality. Grading regulations to be used in Grenada for marketing the produce within the country should be established to allow the marketing of the produce at the quality required by the different consumer groups in the country. For example:

- Produce sold to the large hotels, restaurants and special tourist stores can benefit by grading to a uniform maturity and size with a low level of blemishes and will require a set of grading standards not necessarily inferior to the international ones.

- Produce destined for cheaper priced markets can be of mixed size and maturity and a higher level of blemishes and will require a completely different set of grading standards, allowing the marketing of lower quality produce.

Starting grade standards at the farm. The first simple grading which could be introduced at farm level for marketing produce within the country should merely be to codify the informal market practices that are currently in use. Future refinements should be gradual and with the aim at eliminating undesirables and inefficient practices. When a set of regulations have been gradually introduced, it is necessary to conduct an intensive education campaign to ensure that everyone is fully aware of what the changes are and how farmers will benefit from the changes.

Starting grade standards for export. Grade standards for export can be introduced only after the introduction of simple but clear grades standards for marketing the produce within the country. The grades standards to be introduced will have to be those established and implemented in the country where the export is planned. Standards should be introduced at trade level or at farm level in case this is well organized. Few exporting countries have established standards, which are even stricter than those prevailing in the importing country. This ensures that only top quality produce is exported.

1.4.4. Quality control

Fresh produce is highly perishable and it is natural that some deterioration of quality will occur during the marketing process. The rate of deterioration will depend on the care or abuse exerted on the produce during harvesting, handling, transport and storage. The development of marketing practices and strategies become more important and refined with the development of marketing practices, standardization, market information service and increased competition. Quality control is one of the most important features in achieving consistency and reliability of products, like all aspects of marketing quality control demands good planning, research, and management together with regular training and reviewing of procedures. When standardization practices have been implemented and there
is a degree of policy in the market place, there will also be an elementary form of quality control.

In the developed countries and also in those developing countries, which operate a regular export service to sophisticated markets, the practice of quality control has become a fundamental part of the production and marketing programme. Monitoring and testing of production practices, for maximum production of produce, which conforms to market demand, is one area where institutional research particularly in Grenada can be of great assistance to the producer, but the producer has the obligation of adhering to guidelines, such as:

- At harvest time, the producer must keep a careful check on harvest maturity to ensure that the produce conforms to market and/or storage requirements.
- In field packing and transport, the producer must carefully check that the operation is properly conducted to ensure that the produce arrives at the packinghouse or to the market in good condition.
- In the packinghouse, the packer needs to keep a close eye on the performance of his staff to ensure that selection and grading practices are adhered to.

One of the biggest problems concerning implementation of standardization and quality control in developing countries is the lack of personnel with suitable qualification and experience. There is a big scope for countries to send promising staff abroad for training. In addition, there is a need for dissemination and training to middle level staff who are already active by organizing practical workshops at the national, district, institutional and school levels.

2. HARVESTING AND FIELD HANDLING

Farm management is generally aimed at maximizing the yield of a crop from the area of land under cultivation while at the same time maximizing the return. The time, labor and capital expended in bringing the crop to maturity is rewarded by the financial return obtained by the grower during marketing. For fruits and vegetables, the magnitude of this return mainly depends on:

- quantity of fresh produce harvested and marketed, which mostly depends on production planning, crop selection, varietal selection, production practices (which include among other irrigation, cultural practices, fertilization and chemical treatments).
- quality attributes to satisfy market and consumer requirements. The overall quality of fresh produce cannot be improved after harvest, there are a few exceptions like controlled ripening to improve color and flavor and
refrigerated and controlled cold storage to extend shelf-life. These exceptions are however limited by pre-harvest conditions.

**Size.** It is the major quality factor and farmers through varietal selection followed by production practices, should try to control it. The aim is to produce a crop of an average desirable size which is not necessarily the largest possible size.

**Mechanical defects.** The need to reduce surface defects is an inevitable consequence of market development. These defects can be physical damages which can be controlled pre-harvest by better plant management to protect the produce from wind, sun, hail, chemical residues, etc.

**Pest and diseases.** A better control with appropriate and controlled application of chemicals and field sanitations practices to control fungal, bacteria and insect attacks and avoid the presence of unsightly marks.

**VARIETAL SELECTION.** The desired market characteristics of a commodity can often only be obtained by changing the variety being grown. This will often means that growers have the difficult task of adapting to new varieties which may have very different growing characteristics compared to traditional ones. However a resistance to change may mean a major loss of income as the traditional varieties become less popular on the market.

### 2.1. Harvesting factors

The quality and conditions of produce sent to market and their consequent selling price are directly affected by the care taken during harvesting and field handling. Whatever the scale of operations or the resources of labor and equipment available, the planning and carrying out of harvesting operations must observe basic principles.

The objective of the grower should be:

- to harvest a good quality crop in good condition;
- to keep the harvested produce in good condition (protected from rain, sun or animals) until it is consumed or sold; and
- to dispose of the crop to a buyer or through a market as soon as possible after harvest.

To meet these objectives, success for the harvesting, field handling and marketing must depend on planning from the earliest stages of production, with particular regard to:

- crop selection and timing to meet expected market requirements;
- contact with buyers so that the crop can be sold at a good price when ready for harvest;
- planning harvest operations in good time, arranging for labor, equipment, material, cover space to protect the inputs and the harvested crop and transport;
- it is economically sound in terms of returns on investment to improve grading, packing and handling of the produce before it leaves the farm;
- considering the above the grower must ensure that all those working on the farm are properly trained;
- provide full supervision at all stages of harvesting and field handling.

2.1.1. Maturity at harvest

Fruits and vegetables are considered to be commercially mature when at the stage of physiological development that consumers consider to be the most desirable. However the stage, at which a commodity reaches commercial maturity, varies greatly. Many leafy vegetables are commercially mature at an early stage of plant development while fruits are often ready for harvest at a fully developed stage. For details on maturity standards see the following Tables 1 and 2.

Maturity standards have been determined for many fruits and vegetables. Harvesting crops at the proper maturity allows handlers to begin their work with the best possible quality produce. Produce harvested too early may lack flavor and may not ripen properly, while produce harvested too late may be fibrous or overripe and have a shorter shelf-life. Pickers can be trained in methods of identifying produce that are ready for harvest. Table 1, from Reid (in Kader, 1992) provides some examples of maturity indices.

Table 1. Maturity indexes for fruits

<table>
<thead>
<tr>
<th>Index</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elapsed days from full bloom to harvest</td>
<td>Apples, pears</td>
</tr>
<tr>
<td>Mean heat units during development</td>
<td>Peas, apples, sweet corn</td>
</tr>
<tr>
<td>Development of abscission layer</td>
<td>Some melons, apples, feijoas</td>
</tr>
<tr>
<td>Surface morphology and structure</td>
<td>Cuticle formation on grapes, tomatoes</td>
</tr>
<tr>
<td></td>
<td>Netting of some melons</td>
</tr>
<tr>
<td></td>
<td>Gloss of some fruits (development of wax)</td>
</tr>
<tr>
<td>Size</td>
<td>All fruits and many vegetables</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>Cherries, watermelons, potatoes</td>
</tr>
<tr>
<td>Shape</td>
<td>Angularity of banana fingers</td>
</tr>
<tr>
<td></td>
<td>Full cheeks of mangos</td>
</tr>
<tr>
<td>Textural properties</td>
<td>Compactness of broccoli and cauliflower</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>-----------------------------------------</td>
</tr>
<tr>
<td>Solidity</td>
<td>Lettuce, cabbage, Brussels sprouts</td>
</tr>
</tbody>
</table>

**Textural properties**

<table>
<thead>
<tr>
<th>Property</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firmness</td>
<td>Apples, pears, stone fruits</td>
</tr>
<tr>
<td>Tenderness</td>
<td>Peas</td>
</tr>
<tr>
<td>Color, external</td>
<td>All fruits and most vegetables</td>
</tr>
<tr>
<td>Internal color and structure</td>
<td>Formation of jelly-like material in tomato fruits</td>
</tr>
<tr>
<td></td>
<td>Flesh color of some fruits</td>
</tr>
</tbody>
</table>

**Compositional factors**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starch content</td>
<td>Apples, pears</td>
</tr>
<tr>
<td>Sugar content</td>
<td>Apples, pears, stone fruits, grapes</td>
</tr>
<tr>
<td>Acid content, sugar/acid ratio</td>
<td>Pomegranates, citrus, papaya, melons, kiwifruit</td>
</tr>
<tr>
<td>Juice content</td>
<td>Citrus fruits</td>
</tr>
<tr>
<td>Oil content</td>
<td>Avocados</td>
</tr>
<tr>
<td>Astringency (tannin content)</td>
<td>Persimmons, dates</td>
</tr>
<tr>
<td>Internal ethylene concentration</td>
<td>Apples, pears</td>
</tr>
</tbody>
</table>


Vegetables are harvested over a wide range of maturities, depending upon the part of the plant used as food. Table 2 provides some examples of maturity indices of vegetable crops.

### Table 2. Maturity indexes for vegetables and root crops.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Root, bulb and tuber crops</strong></td>
<td></td>
</tr>
<tr>
<td>Radish and carrot</td>
<td>Large enough and crispy (over-mature if pithy)</td>
</tr>
<tr>
<td>Potato, onion, and garlic</td>
<td>Tops beginning to dry out and topple down</td>
</tr>
<tr>
<td>Yam, bean and ginger</td>
<td>Large enough (over-mature if tough and fibrous)</td>
</tr>
<tr>
<td>Green onion</td>
<td>Leaves at their broadest and longest</td>
</tr>
<tr>
<td><strong>Fruit vegetables</strong></td>
<td></td>
</tr>
<tr>
<td>Cowpea, yard-long bean, snap bean, sweet pea, and winged bean</td>
<td>Well-filled pods that snap readily</td>
</tr>
<tr>
<td>Lima bean and pigeon pea</td>
<td>Well-filled pods that are beginning to lose their greenness</td>
</tr>
<tr>
<td>Okra</td>
<td>Desirable size reached and the tips of which can be snapped readily</td>
</tr>
<tr>
<td>Snake gourd, and dishrag gourd</td>
<td>Desirable size reached and thumbnail can still penetrate</td>
</tr>
<tr>
<td>Vegetable</td>
<td>Maturity Stage</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Eggplant, bitter gourd, chistophine or slicing cucumber</td>
<td>Desirable size reached but still tender (over mature if color dulls or changes and seeds are tough)</td>
</tr>
<tr>
<td>Sweet corn</td>
<td>Exudes milky sap when thumbnail penetrates kernel</td>
</tr>
<tr>
<td>Tomato</td>
<td>Seeds slipping when fruit is cut, or green color turning pink</td>
</tr>
<tr>
<td>Sweet pepper</td>
<td>Deep green color turning dull or red</td>
</tr>
<tr>
<td>Muskmelon</td>
<td>Easily separated from vine with a slight twist leaving clean cavity</td>
</tr>
<tr>
<td>Honeydew melon</td>
<td>Change in fruit color from a slight greenish white to cream; aroma noticeable</td>
</tr>
<tr>
<td>Watermelon</td>
<td>Color of lower part turning creamy yellow, dull hollow sound when thumped</td>
</tr>
</tbody>
</table>

**Flower vegetables**

<table>
<thead>
<tr>
<th>Vegetable</th>
<th>Maturity Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cauliflower</td>
<td>Curd compact (over mature if flower cluster elongates and become loose)</td>
</tr>
<tr>
<td>Broccoli</td>
<td>Bud cluster compact (over mature if loose)</td>
</tr>
</tbody>
</table>

**Leafy vegetables**

<table>
<thead>
<tr>
<th>Vegetable</th>
<th>Maturity Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lettuce</td>
<td>Big enough before flowering</td>
</tr>
<tr>
<td>Cabbage</td>
<td>Head compact (over mature if head cracks)</td>
</tr>
<tr>
<td>Celery</td>
<td>Big enough before it becomes pithy</td>
</tr>
</tbody>
</table>


This variation in physiological development means that there is no single factor that can be used to determine the optimum harvest date for all commodities and much research is still needed to find simple objective tests to reliably indicate when produce is at commercial maturity.

In addition to eating quality, the effect of maturity on the ability of a commodity to be stored or transported can influence the preferred harvest stage. Climacteric fruits (see Chapter 1) are generally harvested prior to the onset of natural ripening so they can be transported in a hard green stage and then ripened in the market. Some other fruits and vegetables are harvested slightly immature as they are then less susceptible to attack by microorganisms. In contrast, apples required for a long cold or controlled atmosphere storage are harvested slightly overripe if we do not want the development of “superficial scald”, unless we want to control the disorder with a post-harvest chemical treatment.

### 2.1.2. Training field workers

This training should cover general aspects of produce harvesting and handling for all workers and specific training for those engaged in tasks requiring greater skill, like grading, sizing and packing.
Harvesting operations are simple and will permit the maintenance of produce quality if people know what to do and how to do it. Never forget that field workers should always be trained before starting the harvesting operations in using the correct techniques. They should be fully supervised during the harvesting operations. Aspects which need to be covered in a training program includes:

- quality criteria for selecting the items to be harvested;
- desirable methods of detaching and the correct use of any harvesting aids;
- degree of care required during harvesting and any additional operation like introducing produce in the container and handling the same; and
- proper field hygiene to prevent unnecessary contamination of the produce with soil, infected tools and human bacteria.

**General training** for everyone concerned with harvesting and field handling should include:

1. Demonstrations of the causes and effects of damages to produce, emphasizing the need for careful handling at all time to avoid mechanical injuries from such causes as:
   - Wooden containers with rough edges, splinters, protruding nails or staples.
   - Over packing containers which are to be stacked one over the other;
   - Damaging produce with long fingernails, rings and jewelry;
   - Dropping or throwing produce into containers at a distance; and
   - Throwing, dropping, rough handling or sitting on field containers.

2. An explanation of the need to avoid the contamination of harvested produce from causes such as:
   - Placing the produce directly on the soil, especially when wet;
   - Using dirty harvesting or field containers contaminated with soil, crops residues or decaying produce: containers must always be kept clean; and
   - Contact with oil gasoline or any chemical than those used specifically for authorized post-harvest treatments.

**Specific training.** Specific training should be given to workers allocated to specialized tasks, such as crop harvesting and selection, and the post-harvest selection, grading, sizing and packing. This kind of training will include demonstration and explanation of:
• The methods of evaluating the readiness of the crop for harvesting;
• The rejection of unsuitable produce at harvest, according to market requirements;
• The actual technique to be employed in harvesting produce e.g. breaking the stem with the fingers in the suitable place or plucking with the end, clipping and cutting with scissors;
• The use of harvesting sacks, containers, the transfer of the produce to field or marketing containers and eventual grading when emptying the sacks, by introducing different grades in different containers; this operation is important when a field assembly point does not exist for filling with the produce ready for the market;
• The selection of marketable produce at the field assembly point and grading for color, size and quality, if applicable;
• The correct application of post-harvest treatments when necessary; and
• The method of packing market packages or other containers.

2.1.3. Harvesting time

When the decision to harvest has been taken the preferred time for harvest varies from crop to crop. However the preferred time is the coolest part of the day, usually in the early morning or late afternoon. This is particularly so for leafy vegetables.

Other factors such as the availability of labor and transport and the distance to a packing house or temporary storage area may dictate that some other harvesting time is more suitable or necessary.

The selected time should be that which minimize the time between harvest and transport to a packing shade. For example, if night transportation is used it is not advisable to harvest early morning unless produce can be placed under cover and a well ventilated place during the daytime.

Local weather conditions could affect the harvesting time:

• It is not desirable to harvest produce when it is wet from dew or rain as this greatly increases the risk of post-harvest spoilage and the tissue is more prone to physical damage.
• It is also not advisable to harvest during a hot and sunny day if the produce is left in the field and cannot be protected by the sunrays and the heat.
• Protect harvested produce in the field by putting it under open-sided shade when transport is not immediately available. Produce left exposed to tropical sunlight will get very hot. Leafy green vegetables such as spinach and salad lose water quickly because they have a thin waxy skin with many pores.
2.1.4. Harvesting technique and operations

In developing countries most of the produce for internal rural and urban markets is harvested by hand. Larger commercial producers may find a degree of mechanization an advantage, but the use of sophisticated harvesting machinery will be limited for the most part to agro-industrial production of cash crop for processing or export. In most circumstances, if harvesting properly is done by hand by trained and experienced workers, will result in less damage than if produce is machine harvested. Hand-harvesting is usually preferred when fruits, such as peaches, and other produce, such as green vegetables, are at different stages of maturity and there is need on repeated visits to harvest the crop over a period of time.

When the crop is ready for harvesting, labor and transport available and harvesting operations organized, the decision as to when to start harvesting will depend largely on:

- the weather conditions; and
- the state of the market.

Possible flexibility of the harvesting date will depend on the crop. Some, such as root crops, can be harvested and sold over a long period, or stored on the farm awaiting for favorable prices. Others such as berries and peaches must be harvested when ready and marketed as soon as possible or they will be spoiled.

**Fruits.** Many ripe fruits such as apples and some immature seed-bearing structures such as legumes pods have a natural breakpoint of the fruit stalk, which can be easily broken by twisting and lifting the stalk taken between the thumb and index. Fruits and other seed-bearing structure harvested in the immature or unripe green stage are more difficult to pick without causing damage.
Plucking methods vary according to the kind of produce being harvested:

- **Ripe fruits with a natural break – point, which leave the stalk attached to the fruit** are best removed by a “lift, twist and pull” series of movements, e.g. tomato and passion fruit.
- **Mature green or ripe fruits with woody stalks which break at the junction of the fruit and the stalk** are best clipped from the tree, leaving up to a centimeter of fruit stalk attached. If the stem is broken off at the fruit itself, diseases may enter the stem scar and give rise to stem end rot, e.g. mango, citrus, avocado.
- **Immature fruits with fleshy stem** can be cut with a sharp and clean knife, e.g. zucchini, okra, papaya, capsicum; these can also be harvested by breaking the stem by hand, with the risk of damaging the plant or the fruit and the rough cut will make the produce and the plant more susceptible of decay.

Harvesting is basically a simple operation involving the removal of the produce from the parent plant and placing it in containers for removal from the field to the market, or to the packing shade in the farm itself or to the packing – house.

**Vegetables.** Either the whole or a part of vegetative growth can be harvested by hand only or sharp knife. Knives may be kept sharp and clean at all times to avoid spreading of virus diseases from plant to plant.

Harvesting methods varies in accordance with the plant part harvested:

- **Leaves only (spinach, rape, etc.) and lateral buds (Brussels sprouts, etc.):** the stem is snapped off by hand;
- **Above–ground part of the plant (cabbage, lettuce, etc.):** the main stem is cut through with a heavy knife, and trimming (roots and external unsuitable leaves are discarded) is done in the field. Do not forget that the cut stem must not be placed in the soil;
- **Immature green onions** can usually be pulled from the soil by hand; leek, garlic and mature bulb onions are loosened by using a digging fork as for root crops such as carrots and lifted by hand. Simple tractor implements are available for undermining bulbs and bringing them to the surface.

**Flower structure vegetables.** Immature flower heads (cauliflowers, broccoli) can be cut with a sharp knife and trimmed in the field. Mature flowers (squash,
chayote, pumpkins) are plucked individually by hand or shoot bearing flowers are harvested as a vegetable.

**Root and tuber crops.** Most roots and tubers that live beneath the soil are likely to suffer mechanical damage at harvest because of digging tools, which may be wooden sticks, machetes, hoes or forks. Harvesting of those crops is easier if they are grown on raised beds or mounds, or “earthed up” as is common with potato growing. This enables the digging tool to be pushed into the soil under the roots or tubers, which then can be levered upward, loosening the soil and decreasing the possibility of damage to the crop. Other root crops, such as taro, carrots, turnips, radishes, etc. can be loosened from the soil at an angle and leaving the root upward. This method can be used also for celery if it has been earthed up or buried to blanch the stem.

Following the harvesting, other field operations, which may vary or have a different sequence (given below) according to the produce, may include:

- inspection;
- trimming;
- cleaning;
- washing;
- sorting;
- grading;
- sizing;
- packing in field crates;
- transport to a cover shade which may protect from rain or sun and may permit packing in the final container for the market; and
- transport to the packinghouse and packing in the final container for the market.

For details see Chapter 5.

All operations should be carried out to minimize any damage or loss of quality. Key elements in the maintenance of quality are to;

- Keep the handling operations to a minimum, but ensure that each operation is carried out with maximum care;
- Minimize the time between harvest and transport from the harvesting place to the packing place; and
- The detrimental effects of poor harvesting practices are often not evident at harvest but will be greatly magnified during storage and marketing.

**2.1.5. Harvesting tools**

Because the supply of fresh produce to domestic markets in Grenada comes mainly from relatively small-scale producers, mechanical systems for crop harvesting are likely to be rare. There is scope, however, for the use of mechanical aids in modest
commercial operations where a tractor can be used in harvesting potatoes, sweet potatoes, onions, and other root crops by lifting up the crops and leaving them on the soil surface.

Many fruits (for example mangoes and avocados) and vegetables (for example tomatoes) are adequately harvested by hand, without mechanical aids. However, the provision of simple harvesting tools such as knife-edge or scissors will invariably increase the speed of harvesting for crops such as grapes, lemons and oranges. A neat cut of the stem will also eliminate rough edges created when the stem is hard with produce, which does not break easily. This will also have the advantage of reducing the incidence of mechanical post-harvest damages. Sharp knifes are indispensable for harvesting of commodities like lettuce, cabbage and broccoli.

Most tools are specifically designed for each commodity and have to be as practical as possible to facilitate its utilizations by the workers. At the end of the harvesting day they have to be cleaned and sharpened to prevent them being a source of microorganism contamination and have them ready for the following harvest. The desirability and need of harvesting tools increases as the size of the plant increases. Many fruit trees, like new grafted varieties of mango and avocado, and old varieties of golden apples, are too large to allow manual harvesting from the ground and it is more efficient to use a suitable harvesting tool from the ground rather than have to harvest by climbing the tree.

Figure 5. Harvesting tools: plastic field box (a), knife (b), spade (c), rake (d), bucket (e), fork (f), glove (g), ladder (h), sizer (i), scissor (j), bag (k), fork sticks (l) and pole with collection bag (m). Source: FAO, 1989
It is almost compulsory that the harvesting of roots and tubers be carried out with some digging implement if damage has to be reduced or avoided. The device should gently locate the roots and lever them to the surface causing as few injuries as possible, freeing the tubers from most of the soil.

Figure 6. Harvesting tools: basket, bag, bucket for hand picking. Source: Friend Manufacturing Corporation, New York.

Figure 7. Manual sizers for round produce such as citrus. Source: FAO, 1989.
2.1.6. Harvesting and field containers

The packing of produce directly into marketing packages in the field at harvest reduces the damage caused by multiple handling and is used increasingly by commercial growers in developed countries. It is not a common practice in rural areas, where produce is sent to nearby markets and elaborate packaging cannot be justified, but commercial growers can view it as cost-effective if the packaging takes produce in better conditions to market, where it can command a higher price.

The field containers for harvesting must be of a size that can be conveniently carried by the harvest workers while moving through the field. The following are suitable according to the produce harvested:

- Harvesting bags with shoulder or waist slings can be used for fruits with firm skins like citrus and avocados. They are easy to carry and leave both hands free. They should be designed for opening at the base to allow produce to be emptied through the bottom into a field container without tipping the bag.
- Plastic buckets or other containers are suitable for fruits that are more easily crushed, such as tomatoes. The containers should be smooth with no sharp edges or projections to damage the produce;
- Baskets are often used for harvesting once they do not have sharp edges or splinters that can provoke an injury to the produce. If they are not sturdy, they may bend out of shape when lifted or tipped – especially if they are large-and crush or otherwise may damage the content. The inner part of the basket is often filled with a sack cloth.

![Figure 8. Harvesting poles with collection bags for fruits, factory made (a) and home made (b). Source: adapted from MALF, Trinidad and Tobago, 1986](image-url)
woven on the top to reduce the damage to the content not properly deposited by the worker and reduce bruises.

- Bulk bins, usually of 250-300 kg capacity, are used for commercial operations by big growers.
- Jute and/or woven sacks.

### 2.1.7. Post-harvest transport

Transport of the produce can be effected as follows:

**Field and farm transport.** Routes for the movement of produce within farm fields should be planned before crops are planted. Farm roads should be kept in good conditions because great damage can be inflicted on produce carried over rough roads in unsuitable vehicles. Containers must be loaded in the transport vehicle carefully and stacked in such a way that they cannot shift or collapse, damaging the content. Vehicles need good shock absorbers and low-pressure tires and must move with care.

**Transport from the farm.** The destination of the produce leaving the farm will usually be one of the following:

- A local market. Produce is usually in small containers carried sometimes by animals or in animal drawn carts; public transport is sometime used. Usually produce is graded and packed in the field.
- A commercial packing house. Produce may be in palletized field containers or in hand loaded sacks or wooden or plastic boxes. In the packing-house the produce is graded and packed in suitable containers for the market.
- A city market. This applies only where produce is graded and packed in marketing containers on the farm or the packinghouse.

For more details see Chapter 7.

### 3 PACKAGING

The principal benefit of packaging is to provide protection against physical damages through inadequacies in handling and transport of a fresh produce. There are additional benefits, which can be derived from packaging:

- Barrier protection, to prevent contamination of produce by undesirable environmental agents such as dust and micro-organisms;
- No utilization of produce, to create relatively small units of produce, which are easier and quicker to handle than unpacked goods. It also gives better utilization of space during storage and transport.
• Trading aid, to provide a standard size unit for market trading and thereby eliminating the need to weigh or count all items of produce being traded.
• Marketing aid, through the display of basic market information and attractive designs on the package.

3.1. Damages suffered by packed produce.

Fruits, vegetables and roots vary widely in their susceptibility to physical damage and in the type of damage that is likely to be sustained. Some commodities are more susceptible to impact bruising, whereas others are more prone to compression or vibration bruising. Susceptibility to the different types of damage will require a different type of protection to be incorporated into the package. The choice of packaging material will also be influenced by factors such as susceptibility to water losses and microbial infections or heat accumulation and may be the primary consideration in the type of package required.

The physical damage suffered by the packaged fresh produce are caused mainly from the following:

• Injuries caused by sharp objects piercing the packages. This results in deep puncture, leading to water loss and rapid decay.
• Impact caused by throwing or dropping the packages. This results in bruising the content and / or bursting the package.
• Compression caused by overfilling the container or stacking them too high. This result in bruising or crushing the content.
• Vibration of the vehicle from rough roads: bursting the packages and bruising and crushing the contents.
• Heat damage caused by exposure of packages to direct sunlight or poor ventilation within the package: this results in fruits becoming overripe or soft and decay develops rapidly.
• Freezing damages caused by subzero ambient temperature: the result is the damage to chilling-sensitive produce. Most produce is affected by break-down after thawing.
• Moisture damages caused by exposition to rains, dew or high humidity: this results in softening and collapse of the containers, crushing the produce and decay.
• Insects, or/and animal damages: these results in rejection of the produce by the buyer.
• Damage from light: this results in disintegration of plastic sacks.

3.2. Prevention of injuries to the produce

Suitable packages and handling techniques can reduce the amount of damage to which fresh produce is exposed during marketing:
• To keep the packaging itself from damaging the produce during handling and transport, wooden boxes and/or cardboard cartons must be properly assembled; nails, staples and splinters are always a danger in wooden boxes and should be used carefully and properly;
• Individual items of produce should be packed to avoid rubbing against each other during handling and transport; loose fill packs are particularly susceptible to vibration damages;
• Much bruising results from overfilling containers or from the collapse of boxes; collapse may be caused by weak walls of boxes, by the softening of cardboards walls because of moisture or by failing to stack boxes so that the side or the walls support those above; stack of boxes should never exceed the height recommended by the manufacturer or the experience.
• Produce in woven jute sacks or nets is especially susceptible to shock damage; sacks of 25 or 50 kg capacity are normally used for relatively low valued produce, such as roots, tuber crops, cabbages, etc. and are often roughly handled on account of their weight. Whenever possible, handling of bagged produce should be minimized by stacking sacks in unit loads on pallets and avoiding over stacking.

3.3. Package selection.

The most appropriate package for a commodity can only be determined following a thorough examination of the current marketing system. Never forget that packaging can be the major item of expense in produce marketing, so the selection of suitable containers especially for commercial-scale marketing requires a careful consideration.

The steps involved in package selection are:

• Understand the need of the commodity, particularly in terms of physical protection;
• Select the packaging material that will economically satisfy the above needs; and
• Select a package that offers the greatest protection to produce and is acceptable to the intended market.

Besides providing a uniform-size package to protect the produce, there are other requirements for a container:

• It should be easily transported when empty and occupy less space than when full, e.g. plastic or wooden boxes which nest in each other when empty collapsible cardboard boxes, fiber or paper or plastic sacks;
• It must be easy to assemble, fill and closes either by hand or by use of a simple machine;
• It must be easy and cheap to repair;
• It must provide adequate ventilation for the content during transport and storage;
• Its capacity should be suitable for market demands;
• Its dimensions and design must be suited to the available transport in order to load neatly and firmly; and
• It must be cost-effective in relation to the market value of the commodity for which will be used and the sophistication of the market;
• It must be readily available, preferably from more than one supplier.

3.4. Packaging material and types of packages

Packaging for fresh produce is of several types:

1. **Natural material.** Baskets and other traditional containers are made from raw material locally available such as bamboo, rattan, straw and palm leaves. Both raw material and labor costs for the manufacture of the containers are normally low, and if the containers are well made, they can be reused for several times. They are mostly used for handling the produce in the field, at farm level and seldom for the local market.

   Disadvantages are:
   • They are difficult to clean and easily contaminated;
   • They lack rigidity and easily bend out of shape when stacked;
   • They load badly for their shape;
   • They cause pressure damage if tightly filled; and
   • They often have sharp edges or splinters and cause damage unless they internally lined with sacks, cotton or other materials.

2. **Wood.** Sawn wood is used to manufacture reusable boxes or crates, but less so recently because of cost. Veneers of various thicknesses are used to make various boxes or trays. Wooden boxes are rigid and reusable and if made to a standard size, it will stack well on trucks and in storage. They are used for produce handling at farm and packing – house levels.

   Disadvantages are:
   • Difficult to clean adequately for multiple uses;
   • Heavy and costly to transport for the reutilization; and
   • They have sharp edges, requiring some form of liner to protect the content.
3. **Cardboard and fiberboard.** Containers are made from solid or corrugated cardboard. The types closing with either fold-over or telescopic tops are called boxes or cases. Shallower and open-topped ones are called trays. Boxes are supplied in a collapsible form and are set up by the users. The setting up and closing often requires taping, gluing or stapling. Cardboard boxes are lightweight and clean and in some cases are reusable because they may be easily collapsible when empty.

![Diagram of cardboard box types](image)

(a) Slotted, one-piece box must be stapled or glued shut

(b) Telescopic box has top and bottom to be glued or stapled in assembly

(c) Deeper telescopic box takes bigger load of less fragile produce

(d) (e) These are one-piece trays made rigid by engaging tabs in slots

Figure 9. Samples of cardboard cartoons. Source: FAO, 1989
Disadvantages are:

- They may, if used only once, prove an expensive recurring cost;
- They are easily damaged by careless handling and stacking;
- They are seriously weakened if exposed to moisture, unless they are wax–coated;
- They can be ordered economically only in large quantities; and
- Many small countries do not manufacture their own boxes and imports are expensive.

3. **Molded plastics.** Reusable boxes molded from high-density polythene are widely used for transporting produce in many countries they can be made to almost any specifications. They are strong, rigid, smooth, easily cleaned and made to stack and nest when empty in order to conserve space. In spite of the cost, however, their capacity for reuse can make them an economical investment.

Disadvantages are:

- They can be produced economically only in large quantities, but are still expensive;
- They have to be imported in most of the developing countries, adding to the cost of foreign currency;
- They are attractive and have many alternative uses and are subject to high pilferage;
- They require a very tight organization and control for use in a regular go-and-return service; and
- They deteriorate rapidly when exposed to the sunlight, unless treated with ultraviolet inhibitor.

4. **Natural and synthetic fibers.** Sacks or bags for fresh produce can be made from natural fibers like jute or sisal or from synthetic polypropylene. Bags usually refers to small containers of up to about 5 to 10 kg capacity, woven to a close texture or made in a net form of about 15 kg bags or sacks are mostly used for less easily damaged product such as potatoes, onions and roots avoiding in any case to damage the produce with a careful handling.

Disadvantages are:

- Lack of rigidity;
- Rough handling may damage the content;
- They are often too large for careful handling and for the weight they are easily dropped with result of damage;
- The reduced ventilation when stacked if they are finely woven; and
- They are difficult to stack and may be unstable and collapse.
5. **Paper or plastic films.** They are often used to line packing boxes in order to reduce water losses or to prevent friction damage. Paper sacks may have a capacity of about 25 kg and are mostly used for produce of low value. Closure is done by machine – stitching or in the field by twisting wires ties around the top.

Disadvantages are:
- Walls of papers are permeable by water, vapor or gases;
- Heat can be slow to disperse from stacks of sacked produce; and
- Mishandling provokes damage to the content.

4. **POST-HARVEST HANDLING OPERATIONS**

Post-harvest handling operations encompass those steps required for harvested produce to be selected or modified to meet market quality standards and to be packaged in a form suitable for storage or marketing.

4.1. **Field operations**

The simplest operation is where produce is placed into a container in the field directly after harvest, which is then placed into storage or transported to a market without additional sorting or packing. A common variation is to trim off excess leaves or stems before placing into the field container. These simple packing operations are adequate where there is only a small distance between farm and market and produce is sold directly to consumers. This is commonly the case for vegetables grown close to the towns and/or consuming areas.

Figure 10. Handling produce in a field packing station.
Source: Grierson, W. 1987
Field sorting is also recommended for produce, which is highly sensitive to repeated handling. All sorting and grading should be conducted in the field in one operation and the produce packed directly into containers suitable for retailing. For most produce, sorting and trimming of excess plant material in the field is desirable only to minimize the volume of produce transported from the farm.

### 4.2. Field curing root, tuber and bulb crops

Curing roots and tuber crops such as potatoes, sweet potatoes, cassava and yams is an important practice if these crops are to be stored for sometime. Curing is accomplished by holding the produce at high temperature and high relative humidity for several days after harvesting with the objective to heal the wounds and form a new protective layer of cells. While curing can be initially costly, the extended length of storage life makes the practice economically worthwhile. Best conditions for curing vary among crops as follows: potato at 15-20°C, 90-95 % R.H., for 5-10 days; sweet potato at 30-32°C, 85-90 % R.H., for 4-7 days; yam at 32-40°C, 90-100 % R.H., for 1-4 days; cassava at 30-40°C, 90-95 % R.H., for 2-5 days.

It is common practice to cure onion and garlic bulbs, directly following harvest, by allowing the external layers of skin and neck tissue to dry out prior to handling and storage. Onions and garlic can be cured in the field in regions where harvesting coincides with the dry season. These crops can be undercut in the field, windrowed and left in the soil to dry for five to eight days, depending on the air temperature and moisture. The separated dry tops of the plants can be arranged to cover and shade the bulbs during the curing process to protect the produce from excessive heat and sunburn. The dried layer of skin will protect the produce from further water loss during storage and reduce mould and bacteria attacks. The crops can be cured also after packing into 15 to 25 kg fiber or net sacks.
In regions where solar radiation is limited, relative humidity high and natural air movement low curing can be done with the produce packed in sacks, covered under sheds and ventilated with ceiling fans. Curing can be done also with heated air, positioning the heaters on the floor near to the packed produce.

5. PACKINGHOUSE

In many situations it is necessary to establish a specific site for packing operations.

5.1. Need for a packinghouse

The site for the packing operations may simply be the provision of a portable or temporary shelter in the field adjacent to the harvesting area to protect the produce and workers from the weather during field handling. This is of considerable importance for produce harvested in hot, sunny conditions where exposure to the weather for only a few hours can markedly accelerate senescence or in rainy periods where the chance of microbial
infection is greatly enhanced if the produce becomes wet.

The need for a more permanent structure increases as the complexity of grading, sizing and sorting operations increases and where the volume of production or the lengths of the period of harvesting is substantial.

The structure of a packinghouse should only be as elaborate as necessary. A packing place constructed with a bamboo frame and grass thatched roof without water or electricity services is satisfactory for a low manual sorting and packing operations.

The complexity of packing house operations increase, as market requirements for quality and uniform grading become more demanding. The standards of the required building will also increase along with more sophisticated equipment and a larger and more skilled work force.

Figure 14. Handling operations in a packinghouse. Source: FAO, 1986
Dumping (Dry or in Water)

Initial Sorting (to remove culls and foreign materials) → Cull Accumulation Bin

Presizing (small size eliminator)

Wash #1 (to remove most of the organic materials)

Wash #2 (to clean commodity and water + detergent + 100 - 150 ppm chlorine)

Rinsing with chlorinated water

Removal of surface moisture (sponge rollers + air draft)

Sorting to remove No. 3 grade and over ripe fruits

Waxing (if used)

Sorting by color (if needed)

Partially ripe → Accumulation of commodities for processing

Mature Green

Ripe

Sorting by weight or dimension

Small

Medium

Large

Extra Large

Sorting by Quality Grades

Fancy

No. 1

No. 2

Individual unit wrapping in polymeric film or packaging in retail units

Volume fill in shipping container + vibration settling

Place in master container

Continuous USDA Inspection

Figure 15. Flow diagram on handling fruits in a modern packinghouse. Source: Kader, A. 1993
5.2. Packing house operations

The actual operations to be carried out will be determined by the market system and volume of produce passing through the packing place. A packinghouse can fulfill a variety of functions. It may, for example, accept produce from the field and prepare it for the market or act as a preliminary quality control operation to ensure that only quality produce is placed into storage. A packing house may also be used to repack produce after storage for retail marketing.

Packing houses for small-scale operations can be utilized for:

- Receiving produce where, the quantity and quality are checked on arrival before being transferred to a temporary storage area;
- Treatment, where excess part plants are trimmed off, surface contaminants removed by washing or brushing, and chemicals applied to extend storage or market life;
- Grading, where substandard items are removed, produce is graded for factors such as maturity, color and the separated grades are sized and packed; and
- Temporary shelter for produce waiting for being loaded for dispatch.

All packinghouse operations can be executed manually, mostly small scale, or with a range of mechanical devices of varying sophistication, mostly for larger operations. For packinghouses with small throughput, economics will favor manual operations with workers performing more or all the tasks. The advantage of human labor is that it provides flexibility of operation since it can perform a variety of tasks with equal efficiency.

5.2.1. Receipt

On arrival to the packinghouse produce is usually unloaded, weighed, sampled shlegt down for quality and recorded.

5.2.2. Sorting

A preliminary sorting of produce should remove unmarketable pieces and foreign matters, such as plant debris, soil and stones, before the produce passes on to further operations. All discarded material should be quickly hauled away from the packing place.

5.2.3. Cleaning and washing

The removal of soil and stones mentioned above can be done by hand-picking or by sieving. Some type of produce can be washed, brushed or cleaned with a soft cloth. Washing is required to clean produce which has acquired latex stains from injuries from bad harvesting or handling, such as mango, papaya, breadfruit and
most of the root crops. It is important to note that washing should be carried out only when absolutely essential. If it is necessary to wash produce, a fungicide should be normally applied immediately afterward. Use only clean water. The washing of produce in recirculated water should be avoided because it can quickly become heavily contaminated with decay organisms, leading to rotting of the washed produce. Hypochlorites or chlorine may be added to washing water but its use is not recommended for small-scale operations, because they are quickly inactivated by the organic material present in the dirty water. Washed produce to be treated with fungicide should first be drained after washing to reduce the danger of reducing the concentration of the fungicide. When washing is not followed by chemical treatment, the washed produce should be spread out in a single layer on racks of mesh, in the shade but exposed to good ventilation to aid rapid drying.

5.2.4. Fungicide treatment

Decay caused by molds or bacteria is one of the major causes of loss of fresh produce during storage and marketing. Infection may occur before or after harvest, either through injuries or direct penetration of the intact skin of the produce. Post harvest application of fungicide is usual in crops such as apples, bananas and citrus fruits which have to be stored for a long period or those which undergo long periods of transport. Fungicide is normally applied only after the produce has been washed and drained. In small-scale packinghouse operations, fungicide can be applied by:

- **Dipping.** Treatment is normally carried out by hand operation using a suspension of fungicide agitated using stick. Wire-mesh baskets are used to dip the fruits. After dipping produce should be drained and dried.

- **Spraying.** This can be done using a hand-operated sprayer while the produce is still in trays or racks after washing and drying. It is often done on bananas following the de-handing of bunches.

5.2.5. Quality selection and size-grading

Although produce will have to be sorted on the
farm or on its arrival at the packinghouse there may be a further selection for quality and size immediately before it is packed. The scope of these operations depends on the market. Will the buyer be ready to pay premium prices for quality-graded produce? Many urban costumers are more demanding of quality than are rural markets. See more details on quality in Chapter 1. Selection and grading in a small packinghouse are best done by the human eye and by hand, with the produce on a table, assisted by sizing rings.

5.2.6. Waxing

The application of wax or similar coating to enhance appearance and limit water losses from produce such as citrus requires specialized equipment and has little relevance to small-scale packing. Waxing is normally preceded by fungicide treatment.

5.2.7. Packaging

Packaging in small-scale operations means the filling of marketing containers by hand, often using a packing stand or a table. There are various methods of packing:

- Loose-fill jumble pack is used where there is no advantage to size-grading: weighing is necessary;
- Multi-layer pattern pack has size-graded produce normally sold by count of the produce such as citrus and apples;
- Multi-layer size-graded pack mostly used in mechanical packing has separator trays between layers; it is normally sold on per-box basis; and
- Single-layer packs for high value produce may have each piece wrapped in tissue (often chemically treated) or placed in a divider holding it alone.

For more details on packages and packing see the Chapter 3.

5.2.8. Special treatments after packing

Special post-packing treatments applied to certain produce are more common in large operations for urban and export markets. They are:

- Fumigation. The treatment is to control insect pests.
- Initiation of fruits ripening. See details in Chapter 1.
- Degreening of citrus fruits. See details in Chapter 1.
6. STORAGE

The term “storage” as now applied to fresh produce is almost automatically assumed to mean the holding of fresh fruit and vegetables under controlled conditions. Although this includes the large-scale storage of some major crops, such as carrots and potatoes, to meet a regular continuous demand and provide a degree of price stabilization it also meets the demands of populations of developed countries and of the richer consumers of developing countries, providing year round availability of various local and exotic fruits and vegetables of acceptable quality.

In many developing countries, however, where seasonally produced plant foods are held back from sale and released gradually, storage in a controlled environment is not possible because of the cost and the lack of infrastructure development and maintenance and managerial skill. Even in developed countries, however, there are still many peoples who, for their own consumption, preserve and store fresh produce by traditional methods.

6.1. Storage potential

Much fresh produce (i.e. that which is most perishable) cannot be stored without refrigeration, but the possibilities of extending the storage life of even the most durable fresh produce under ambient conditions are limited.

**Organs of survival.** The organs of survival which forms the edible parts of many crops such as potatoes, yams, beets, carrots and onions have a definite period of dormancy after harvest and before they resume growth, at which time their food value declines. This period of dormancy can usually be extended to give the longest possible storage if appropriate conditions are provided. This factor is called the storage potential. It is important to recognize the variation in the storage potential of different cultivars of the same crop. Experienced local growers and seed suppliers can usually provide information on this subject.

**Edible reproductive parts.** These are largely confined to the fruits or seeds of leguminous plants (peas and beans). In their fresh condition these products have brief storage life which can be only slightly extended by refrigeration. They can also be dried and then are called pulses. Pulses have a long storage life, provided they are kept dry, and do not present a storage problem as is the case of fresh produce.

**Fresh fruits and vegetables.** These include the leafy green vegetables, fleshy fruits and modified flower plants (e.g. cauliflower and pineapple). The storage potential of these, particularly tropical fruits in tropical countries, is very limited under ambient conditions. They quickly deteriorate because of their fast respiration rates, which cause rapid heat build-up and depletion of their high moisture content.
Most fresh fruits and vegetables have a storage life of only a few days under even the best environmental conditions.

6.2. Factors affecting storage life

The natural limits to the post-harvest life of all types of fresh produce are severely affected by other biological and environmental conditions.

**Temperature.** An increase in temperature causes an increase in the rate of natural respiration of all produce and food reserves and water content become depleted. The cooling of produce will extend shelf-life by slowing the rate of respiration.

**Transpiration and water losses.** High temperature, low humidity in the store and injuries to produce can greatly increase the loss of water from stored produce beyond that unavoidable lost from natural causes. Maximum storage life can be achieved by storing only undamaged produce at the lowest temperature tolerable by the crop and at the Relative Humidity appropriate for the produce.

**Mechanical damage.** Damage caused during harvesting and subsequent handling (i.e. injuries, impact bruising) increase the rate of deterioration of produce and renders it liable to attacks by decay organisms even under refrigerated storage. Mechanical damage to root crops will cause heavy losses owing to bacterial decay and must be remedied by curing the roots or tubers before storage. Curing is a wound–healing process.

**Decay in storage.** Decay of fresh produce during storage is mostly caused by the infection of mechanical injuries provoked by micro organisms, mostly bacteria and fungi. Furthermore, many fruits and vegetables are attacked by decay organisms which penetrate through natural openings or even through the intact skin. These infections may be established during the growth of the plant in the field but lie dormant until after harvest, often becoming visible only during storage or ripening.

6.3. Storage structures

**Ventilated stores.** Naturally ventilated structures can be used for the storage of produce with a long storage potential, such as roots and tubers, pumpkins, onions and hard white cabbage. Such stores must be designed and built specifically for each intended location. Any type of building can be used, provided that it allows the free circulation of air through the structure and its contents.

**Clamps.** These are simple, inexpensive structures used to store root crops, particularly potatoes.

**Other simple storage methods.** Windbreaks are narrow, wire mesh, basket-like structures about 1 m wide and 2 m high, of any convenient length, on a raised wooden base, and are used for short term storage of dried onions in the field. The
onions are covered on top with any convenient length, on a raised wooden base. The onions are covered on top with a 30cm layer of straw, which is in turn held down by a polythene sheet fastened to the wire mesh. The windbreak is built at right angles to the prevailing wind to obtain maximum drying and ventilation.

**Refrigeration and controlled – atmosphere storage.** For large –scale commercial operations, refrigeration storage may be used in a cold –chain operation to carry regular consignments from production areas to urban markets and retailers. This can be highly complex operation requiring expert organization and management.

Cold storage can also be used for long, medium and short-term storage of seasonal crops.

The objective of refrigeration is to extend the shelf-life of the produce.

The storage life of some fruits, such as apples and pears and flowers, can be extended by combining refrigeration with a controlled environment consisting of a mixture of oxygen and carbon dioxide in an airtight room. This last storage mechanism is an expensive operation with high maintenance and running costs, and demand skilled and experienced management. They have relatively little application to small-scale production in developing countries. For more details see Chapter 1.

**7. TRANSPORTATION TO THE MARKET**

Transportation is often the most important and most costly factor in the marketing channel of fresh produce. The method of transport of the fresh fruits and vegetables is determined by distance, perishability and value of the produce, all these factors being regulated by time.

Whatever the method used the principle of transport are the same:

- Loading and unloading should be as careful as possible;
- Transit time should be as short as possible;
- The product should be well protected in relation to its suitability to physical injuries;
- Overheating should not be permitted;
- Water losses by the produce should be restricted to the minimum;
- Whenever possible the transport vehicle should not stop under the sun and the produce protected with a cover; and
- Providing shelter from sun and rain at loading and unloading areas.

The method of stowage of the produce in the transport vehicle will depend on the package, commodity and type and size of the vehicle. Useful guidelines are the following:
• Load the package tightly to reduce movement and make best use of space;
• Distribute weight evenly;
• Only stack to a load height which the lower container can withstand the weight without crushing or damaging the content;
• Use rope whenever needed to avoid shaking of the containers on the higher side. If the container shakes most probably the content will get bruised; and
• Cover the top boxes with tarpaulin to avoid sun damages and overheating to the produce. The cover will, also, reduce shaking of the containers.

7.1. Causes of losses

The damage and losses incurred during non-refrigerated transport are caused primarily by mechanical damage and overheating.

7.1.1. Mechanical damage

Damage of this type occurs for many reasons, including:

• Careless handling of packed produce during loading and unloading;
• Vibration (shaking) of the vehicle, especially on bad roads;
• Fast driving and poor condition of the vehicle; and
• Poor stowage, which allows packages in transit to sway; the stow may collapse.
• Packages stacked too high. Vibration of produce within a package increases in relation to its height in the stack, provoking bruising.

Figure 18: Bulk loads of yams carefully loaded in vehicle lined with straw. Source: Wilson. IITA, London.

7.1.2. Overheating
This can occur not only from external sources but also from heat generated by the produce within the package itself. Overheating promotes natural breakdown and decay and increases the rate of water loss from the produce: remember water loss means shriveling and shrinkage.

The causes of overheating include:

- The utilization of closed vehicles without ventilation;
- Close-stow stacking patterns blocking the movement of air between and trough the packages, hindering the disposal of air;
- Lack of adequate ventilation of the packages themselves; and
- Exposure of the packages to the sun waiting for transport, when trucks stop underway or awaiting unloading.

8. HARVEST AND POST-HARVEST HANDLING FOR SELECTED FRUITS

Some fruits, although not produced in significant quantities, are well established in Grenada. Others have a good potential for increased cultivation. Details on harvest and post-harvest handling for selected fruits are given in this chapter.

8.1. Avocado

Latin name: Persea spp.

The fruit is pear shaped, oval or nearly round. It has a skin which may be yellow-green, deep green or reddish-purple, depending on the variety. Avocados will not ripen while they are still attached to the tree; flesh rancidity and browning may develop if they are left too long on the trees. Homeowners usually consider the crop pickable when a few mature (fully grown) fruits have fallen. This is not a dependable guide because the prolonged flowering of the avocado results in fruits in varying stages of development on the tree and at the same time.

8.1.1. Harvesting

**Harvesting maturity.** Avocados ripen only after they are picked and may need up to 10 days to ripen at room temperature. Indication of maturity, depending on variety, is a combination of size, smoothness of the skin and loss of sheen. Determining the proper harvest maturity is difficult: experience is necessary. Fruits grown on the same tree vary in expected maturity dates. Ready fruits are usually picked at weekly intervals for a month or more, the largest fruits being selected each time. Harvested immature fruits will fail to ripen, shrivel rapidly and show rapid decay.
**Harvesting method.** Harvest carefully as even small cuts, scratches and abrasions can spoil appearance and lead to decay. Harvest with the stalk attached, preferably by hand and place in a bag or pouch worn on the body for lowering to the ground at intervals. Many varieties have big size trees and when the fruit cannot be reached by climbing or positioning a ladder for hand picking, picking poles (preferably with cutter bars or clippers) with attached pouches to catch the fruit, should be used.

**Field assembly.** Place the fruits in lined field crates or baskets. Position the latter in a shaded area of the field, because exposure to the sun will raise the temperature of the fruits and cause earlier ripening and shorter self life.

**8.1.2. Post-harvest**

**Treatment.** Trim stalk to approximately 1 cm in length to reduce the risk of injuries (punctures and scratches) among the fruits after ripening. If the stalk is completely removed at the mature green stage it predisposes the fruit to stem-end rot.

**Selection/Grading.** Remove soil or field debris with clean soft cloth, containing a mild solution of bleach. Select out damaged, malformed, immature and scarred (e.g. fruit with growth cracks and healed abrasions injuries) fruit. Grade, according to size. A post-harvest dip treatment in a solution of 0.05 % Thiabendazole may assist in reducing disease development.

**Packaging.** Place large fruits in single layers in strong cardboard cartons with separators. Smaller fruit should be placed in cardboard cartons with or without separators in two or three layers as indicated. Lined wooden crates may also be used.

**8.1.3. Storage**

Most varieties ripen between 2 to 10 days after harvesting, depending on variety and the storage temperature; ripe fruits have a shelf life of 1 to 2 days. Avocados are susceptible to bruising and disease incidence, but if handled correctly and stored under the appropriate conditions, a storage life of up to four weeks, depending from the variety, can be achieved. Storage refrigeration can be the following:

- 5 to 13°C, depending on the variety and duration, for mature-green fruits;
- 2 to 4°C for ripe avocados; and
- 90-95 % is the optimum relative humidity.

**8.1.4. Post-harvest losses.**
• Chilling injury. Skin pitting, scalding and blackening develop on mature-green avocados kept at low temperature (0-2˚ C) for more than 7 days; internal flesh browning develop when fruits are stored to 3-5˚ C for more than 2 weeks.
• Anthracnose. Provoked by a fungus, this consists of circular black spots on the skin, which can penetrate into the flesh when the fruits begin to soften. Can be partially controlled or delayed with prompt cooling; and
• Stem-end rot. Provoked by a fungus and appears as dark-brown-black discolorations starting at the stem and advancing toward the blossom. Control method includes good orchard sanitation and careful handling to minimize physical injuries and prompt cooling.

8.2. Papaya

Latin name: Carica papaya L.

8.2.1. Harvesting

Papaya is one of the most susceptible fruits to skin damage. Papaya handlers can minimize fruit damage by taking protective measures throughout all handling stages: use the harvesting tools properly, and avoid dropping fruits into the boxes and overfilling, latex stains should be avoided and the fruits transported carefully.

**Harvesting maturity.** Papayas are ready for harvesting when most of the skin is yellow-green, called the “one yellow stripe” If harvested before this stage papayas will fail to ripe completely. For the local market, particularly in the winter months, papaya should be allowed to color fairly well, before picking; in this case the fruits are more susceptible to damage and bruising during handling.

**Harvesting method.** Home growers usually twist the fruit to break the stem. In commercial operations it is preferable to use a sharp knife to cut the stem and then trim it to the base of the fruit. Harvesting of high fruits can be done with a harvesting pole with a small hoop and a small mesh bag at the end. Above the hoop is a horizontal blade, which cuts the fruit which will fall into the bag below. Another system consists of a harvesting pole with a cup attached held against the lower end of the fruit and twisting it. In this case the picker will then need to catch the falling fruits. Latex can irritate the skin of the pickers: protection with gloves is advisable.

**Field assembly.** The fruit must be handled with extreme care to avoid scratching and licking of latex which provokes stain on the fruit which may burn the skin.
After harvest fruits are placed gently in plastic or wooden field crates, preferably with a foam layer as cushioning.

**8.2.2. Post-harvest handling**

Post-harvest handling of papaya requires care and attention to detail. The fruit is susceptible to several factors (fluctuating temperature, moisture, diseases and mechanical damage) which reduce its commercialization.

**Treatments.** Fruits could be held at 30º C and high humidity for 48 hours to enhance coloring before packing. The standard decay control consists of 20 minutes submersion of the fruits in water at 49º C, followed by a cool rinse. Application of fungicide as thiabendazole (TBZ) or a similar one has proven to be satisfactory also to control the pathological diseases. Heat treatment can help to control insects present on the skin of the fruit.

**Selection/Grading/Packing.** Grading and packing should be carried out as soon as possible after harvest. Fruits, after separation of broken or heavily diseased ones, are graded according to size and stage of ripeness. Papaya should be packed in single layer cartons. Internally, packaging material could include shredded paper. Papayas are best packed on their sides in rows with the stem end at an angle.

**8.2.3. Storage**

Fruits harvested at the proper harvesting stage (one yellow stripe) will ripen to 60-70% yellow within 4 to 6 days under ambient tropical conditions (25-28º C). Fruits harvested at “one strip stage” and stored at low temperature (10 to12º C) will last from 14 to 21 days, if post-harvest disease incidence can be controlled.

**8.2.4. Post-harvest losses**

They may include:

- Chilling injuries. They include pitting, uneven ripening, skin scald, hard core and increased susceptibility to diseases; and
- Anthracnose. It is the major cause of post-harvest losses. It can be partially controlled with the heat treatment.

**8.3. Mango**

Latin name: Mangifera indica L.

Mango is considered the apple of the tropics and one of the most
commonly eaten fruits in tropical countries around the world.

8.3.1. Harvesting

Harvesting maturity. Mangoes normally reach maturity in 4 to 5 months after flowering. When the first large fruits start showing a yellow-pink color on the tree, all the fruits of the same size or larger are ready and have to be picked. Harvesting must be repeated when the remaining fruits, which in the meantime have grown in size, start coloring. When the fruit is fully grown and ready for picking, the stem will snap easily with a slight pull. If a stronger pull should be needed, it means that the fruit is still immature and should not be harvested. In the red varieties an additional indicator of maturity is the development of a purplish-red blush at the base of the fruit.

Harvesting method. When harvesting by hand from the ground is not possible the picker should use a long pole with a cutting blade and a small bag under the blade which holds only a few fruits. For bigger trees the pickers should climb the branches with cotton or fiber bags that they fill and lower to the ground. Fully mature fruits will detach easily at the natural abscission point, whereas half-mature fruits will not. Optimum picking should be done with shears and cutting the stem 1 to 2 cm away from the fruit. This technique permits the reduction of latex exudation and staining of the skin and the entrance of fungus diseases.

The quantity of latex flow depends on:

- Fruit maturity: younger fruits exude more latex;
- Time of the day of harvest: in early morning harvest more exudes;
- Level of rainfall: more latex flows when harvesting after rain;
- Length of stem at harvest: if fruit is picked with the stem, latex flow is minimal.

Unfortunately many pickers harvest mangoes by simply knocking them from the tree, dropping or throwing to the ground; this causes bruises, punctures and cracks and later the fruits spoil. When low fruits are harvested with clippers, it is desirable to leave aprox. 1 to 2 cm of stem to avoid the spurt of the milky sap that exudes if initially the stem is cut close.

Field assembly. Place the field crates with no more than two to three layers of fruits (separating each layer with sponges to avoid bruises and scratches) and baskets with liners in a sheltered or shaded area of the field or under the shade of the tree. Exposure to the sun of fruits with stains provoked by the latex may be corrosive for the skin. After harvest, latex should be allowed to drain away from the fruit by placing the mangoes with the stem downward on grass below the tree, cutting the stem 1 to 2 cm away from the fruit.
When quality of the harvested fruits is very good, in field selection, grading, sizing and packing can be done. Fruits should be freed from debris, and cleaned of soil and eventual leaked latex separated with a clean and soft cloth.

8.3.2. Post-harvest

_Treatments_. Wash/clean the fruits or use a clean soft cloth if latex stains and/or residues of chemical treatments are present on the surface of the fruit. In India, it is a habit at the beginning of the harvesting season to artificially ripen mangoes. In the south of the country mangoes are picked at a quite green stage to avoid bird damage and reduce damage during long transport of badly packed produce, on roads which are in a bad condition. On arrival in the final market dealers layer them with paddy straw, covered with plastic, often burning calcium carbide to increase underneath the quantity of acetylene and induce surface color and ripening, which will take place within 5 to 7 days at 15 to 20°C Celsius. In developed countries ripening of mangoes prior to shipment is conducted in ripening rooms with controlled atmosphere, temperature and humidity. Treatments with chemicals (such as ethephon which produces ethylene and calcium carbide which produces acetylene) are used in a air tight rooms for 24 hour at 20 to 25°C C and 90 - 95% of relative humidity and an adequate air circulation. The treatment causes green mangoes to develop full color in 7 to 10 days, depending on the degree of maturity, whereas untreated fruits require 10 to 15 days.

_Selection/Grading_. Select out all immature, ripe, damaged, scarred or otherwise damaged fruits. In accordance with quality specifications required by the purchaser fruits should be graded in each carton according to variety, size and maturity.

_Packaging_. Mangoes for export or sophisticated internal markets such as supermarkets should be packed in cardboard boxes in single layer and the stem end facing downward or slightly on one side to avoid the latex contamination and with separators. Ventilation holes are recommended to improve air circulation.

8.3.3. Storage

Mangoes ripen within 4 to 6 days, after harvest at the mature green stage. The ripe fruits have a shelf life of 2 to 4 days. Storage at 10 to 12°C and 85 to 90 % of relative humidity, will maintain fruits in acceptable conditions for up to 4 weeks and fruits will then ripe satisfactorily at higher temperature. These conditions will however depend on the variety, maturity at harvest and tome of harvest.

8.3.4. Post-harvest losses

- Chilling injuries. Storage below 10°C C for a few days will result in this damage.
- Anthracnose. Consists of small, black, circular spots on the skin which increases with the ripening of the fruits. Post-harvest
applications of specific fungicides (imazalil or thiabendazole) may assist in disease control. Dipping in hot water (at 50° C for 5-10 minutes, depending from the fruit size in combination with the fungicide) is also utilized.

8.4. Breadfruit

Latin name: Artocarpus altilis.

8.4.1. Harvesting

Harvesting should be conducted, possibly the same day of dispatch, in the early part of the day to avoid the field heat.

**Harvesting maturity.** Harvest at mature green stage using as indicators size, color surface, texture (stretching of segments) and, perhaps most important, appearance of small drops of latex on the surface. Fully mature fruits show a dark-green color of the skin and lack of sheers.

**Harvesting method.** Harvesters climb the tree and break the fruit stalk with a forked stick so that the fruit will fall. This harvesting system may cause some bruising, splitting and cracks and cause early ripening. Although controversial it is considered better than catching the fruit by hand because the broken pedicel leaks much latex.

Manual harvest can be performed using a picking pole with cutting bars for inaccessible fruits. Try to harvest fruits with stalk intact avoiding impact injuries by lowering them gently or by dropping into a catching net.

**Field assembly.** Cut the stem at up to 1.5cm long and let stand for some time with the stem downwards to allow latex drainage. Place breadfruit in field crates or bags or baskets and keep them in a shaded area while in the field.

8.4.2. Post-harvest handling

**Treatments.** Trim the stalk and wash off excess latex with a wet cloth. Breadfruits should be packed and shipped as soon as possible (hours) after harvest to allow maximum time for marketing. If shipment is delayed, place the harvested produce under cool conditions if available (not below 13° C) to avoid chilling injuries. Otherwise submerge the fruits in clean water, outdoors and in a well ventilated shaded area.
**Selection/grading.** Separate immature, over-mature, scarred and damaged fruits. Grade according to size.

**Packaging.** Breadfruits should be packed in wooden crates or strong cardboard boxes, 2 to 3 layers thicks, according to size, with dividers.

### 8.4.3. Storage

The storage life of breadfruits harvested at the green mature stage varies from 2 to 4 days. Surplus breadfruits are kept under water until needed. Fully ripe fruits which have fallen from the tree can be wrapped in polyethylene or put into polyethylene bags, and kept for 10 days in refrigerated storage at 12°C. At lower temperature the fruit shows chilling injuries. Unripe fruits can be kept for 15 days under the same conditions.

### 8.5. Watermelon

Latin name: Citrullus Lanatus T.

#### 8.5.1. Harvesting

**Harvesting maturity.** Ripeness in watermelons is difficult to determine because the fruit remain attached to the vine, rather then ’slipping off“. Harvesting generally begins about 30 days after full bloom and continues with periodical cuts at 3 to 5 days intervals. The most recommended method for timing the harvest of watermelons is to cut a few representative fruits in the field. However, also the following indicators of ripeness will help:

- The tendrils of the leaf closest to the fruit attachment become dry;
- Change in ground spot colour from greenish-white to pale yellow;
- The rind becomes hard to pierce with the fingernails;
- Blossom end “fill out”; and
- The sound of a fruit, when thumped with a finger, is a muffled, dull tone if it is ripe.

**Harvesting method.** Watermelons are harvested in the afternoon by cutting the stem with a sharp knife rather than pulling the fruit out. Afternoon harvest may reduce the risk of cracking if the field has received abundant water during the previous night. If plants are not too turgid field heat can be minimized by harvesting in the morning. Watermelons do not ripen off the vine. However holding them for 7 days and over at room temperature will improve flavour and colour in seeded varieties. Take care of the wet and dirty soil; if watermelons get dirty clean them with a wet and clean cloth.
Field assembly and packaging. After harvesting, watermelons are stacked in the field itself, on the side rather than on end to reduce the risk of cracking. Placing them in a shaded area will allow to minimize the build up of heat and avoid quality reductions. Packaging in fibreboard boxes or bulk loaded in bins in the field itself taking care to load only dried rather than dew-covered fruits.

8.5.2. Post-harvest

Cleaning and packing is done in the field itself, when the field is easily accessible.

8.5.3. Storage

At 10 to 15° C and 90% relative humidity the fruits can be kept for 2 to 3 weeks after harvest. Prolonged storage will be responsible for reduction in crispness and colour.

8.5.4. Post-harvest losses

Chilling injuries (the pit in the ring will be invaded by micro organisms) will take place after storage below 5° C.

8.6. Bananas and plantains

Latin name: Muse spp.

Include: Plantains ; traditionally grown for cooking as part of the staple diet, or for processing into more durable products, such as flour, which can be stored for later food use. Bluggoe ; uses are similar to plantains as a locally consumed staple food. Dessert; includes Gros Michel and Cavendish types, widely grown for export to temperate countries. The ripe fruit is also eaten where it grows, but in some countries it is cooked in the immature stage or in the mature green but unripe stage as a starchy staple.

8.6.1. Harvesting

Harvesting maturity. Published recommendations of maturity standards for export dessert bananas do not generally apply to bananas grown for local consumption. Many types of bananas are grown for local use in different countries. When bananas are to be sent to distant urban markets they are best harvested in hard mature but unripe green state, which reduces the risk of deterioration during transport.
**Harvesting method.** The method of harvesting will depend on the height of the plant. Low-growing varieties can be harvested by cutting through the bunch stalk about 30 to 35 cm above the top hand. With taller varieties, the stem of the plant will be partly cut through to bring the bunch down within the harvester’s reach, and then the bunch stalk can be cut through. Harvested bunches are best carried on a foam-padded tray to reduce damage during carrying.

**Field assembly.** It is customary in most banana-growing countries to transport the fruit to market on the bunch. This practice injures the fruit during handling and transport, and it is not recommended. Bananas for urban markets will suffer less damage and look better if they are de-handled and packed in suitable boxes.

8.6.2. Post-harvest

**Selection and grading** Bananas which are very immature and small, badly damaged or decaying should be discarded. Size and quality grading will depend on the demands of the market. In the more sophisticated urban markets (e.g. supermarkets), size-graded and good-looking fruit may command a higher price.

**Packing.** All harvested bananas should be kept dry and in the shade before and after packing. Packing is best done in or as near to the field as possible. There must be facilities for keeping the fruit and packaging dry.

As soon as the hands of bananas are cut from the stem, they should be laid, curved side uppermost, across the midribs of fresh banana leaves. This will prevent latex from the cut crown contaminating the fruit. Latex flow should stop in 12-15 minutes, after which the banana may be packed into wooden or, preferably, cardboard boxes, which can be of the slotted or telescopic type. Whole hands of bananas can be divided into clusters of four or more fruit which can be packed more compactly to give a greater weight of fruit per box.

The hands or clusters should be packed in the boxes with the curved side uppermost, making sure that the crowns of the upper hands do not damage the bananas underneath. Boxes should be full but not over-packed, otherwise the bananas will be damaged because the fruit itself and not the walls of the boxes will be supporting the upper boxes of the stack.

**Post-harvest treatments**. No special post-harvest treatments should be necessary for bananas sold locally or for those which will be sold to consumers in urban markets within four or five days. If sales are to be delayed for a greater time and the fruit sold in a ripening condition, it may be necessary to wash and then dip or spray them with a fungicide before packing.

8.6.3. Storage

Bananas have a very short post-harvest life at ambient conditions. This is four to ten days when mature green and two to four days when ripe. Both green and ripe
bananas are sensitive to cold and are damaged by temperatures less than 13° Celsius.

8.6.4. Ripening

Bananas harvested in the mature green stage will normally ripen under the local ambient conditions in which they are grown, but some types will not develop their full ripe skin color. Where urban high-value markets demand fully colored fruit, ripening under controlled conditions is best carried out on a large scale at the urban distribution point. The operation requires special equipment, good management and technical skills. Where the ripening operation is to be undertaken locally, advice should be sought from specialists.

8.7. Citrus

Latin name: *Citrus spp.*

**Includes:** Oranges, grapefruit, mandarins; used ripe as fresh fruit and for juice. Lemons and limes; used mature green or ripe for culinary purposes and for drinks.

8.7.1. Harvesting

**Harvesting maturity.** The assessment of the readiness of citrus fruit for harvest presents some problems for small-scale producers because:

- citrus fruits do not ripen further after harvest. To reach their full flavour and sweetness they must be left on the tree to ripen;
- in the tropics citrus often remain green when they are fully ripe internally and do not develop an orange-yellow colour on the tree. The development of the orange-yellow skin colour can be artificially induced after harvest (degreening).

These facts make it very difficult to assess harvest maturity just from the appearance of the fruit on the tree. Small-scale producers marketing their own fruit will be able to assess the readiness of their fruit on several counts, which will vary in different situations, for example:

- **Skin colour:** where it develops normally, this will be a good guide to ripeness; if normal skin colour does not develop, maturity may be indicated by a change in the shade of green shown by the skin; lemons change from dark green to a silvery-green appearance at maturity;
- **Size:** experienced growers may evaluate maturity by considering size as well as with other characteristics, such as slight changes in skin colour; and
• **Internal condition of fruit**: if a few typical fruit thought to be mature are cut in two, they can be considered ripe if:

1. The juice has developed full flavour and is sweet;
2. The fruit pulp has developed to the normal colour; and
3. Juice drips from the half-fruit when the cut surface is held vertically.

**Harvesting method.** Although the skin of citrus fruit is relatively tough and can tolerate some degree of pressure, it is easily cut or punctured, providing access to the serious post-harvest decay diseases: blue and green mould. Every care must be taken to avoid cutting or puncturing the skin of citrus fruits at all times. Clippers or secateurs should be used to remove the fruit from the tree. Fruit may be pulled by hand, but there is danger that the stem may be pulled out of the fruit, damaging the skin, or of damage to the tree providing an entry point for field diseases. Not more than 0.5 cm of stem should be left attached to the fruit. If the fruit is mature or ripe this piece of stem will dry up and fall off, leaving only the flower calyx (button) attached to the fruit. As it is harvested, citrus fruit should be placed in picking bags worn by the harvester or in plastic buckets.

**Field handling.** Harvested fruit is taken in the harvesting container either directly to the packing facility or to the field assembly point, where it is emptied into field containers. At either point the fruit should be protected from exposure to sunlight and rain while awaiting packing or movement to the packing house.

8.7.2. Post-harvest

**Selection.** Before it is packed the fruit should be sorted to eliminate all foreign material, such as leaves and twigs. The fruit is then inspected and pieces which are unripe, immature, undersized, damaged or decaying should be discarded. The extent to which superficial skin damage can be tolerated will depend upon the market. Local consumers may be more concerned about the eating quality of produce than its external appearance.

**Size grading** Where citrus fruits are to be pattern-packed in custom-made cardboard boxes it is usually an advantage to grading it into size categories. The differences between categories will depend on the type of fruit. Suggested minimum sizes and grade category differences for different commodities are:

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Minimum (mm)</th>
<th>Grade difference (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oranges, lemons, mandarins</td>
<td>50</td>
<td>5-10</td>
</tr>
<tr>
<td>Grapefruit</td>
<td>70</td>
<td>15-20</td>
</tr>
</tbody>
</table>

Limes are not normally size-graded. Citrus sent to local markets in wooden crates will usually be size-graded by the retailer at the point of sale.
**Packing.** Citrus for sale in local and internal urban markets is packed in a variety of containers. Baskets, wooden boxes, sacks, bags, factory-made wooden crates and cardboard boxes are all used. Most citrus from large scale commercial production are now packed in telescopic cardboard boxes. The recommended outside dimensions for the boxes are 50x 30x 30 cm. These can be stacked eight boxes per layer on standard 1 x 1.2 m pallets. The capacity of these boxes is about 18-20 kg. Wooden crates can also be used for citrus provided they do not have sharp edges or splinters which will damage the skin of the fruit. Wooden crates should not exceed 25 kg capacity. Larger crates are difficult to handle and if dropped can severely damage the contents. Citrus fruits can be packed a little above the top of the box so that they are under slight pressure when the box is closed. This prevents movement of fruit within the box during transport and handling and allows for natural shrinkage.

**Post-harvest treatments.** Citrus produced for local and other internal markets should not require specific post-harvest treatments provided it is handled carefully and packed properly. Commercially grown citrus for export is normally washed, treated with fungicide and wax-coated on highly automated packing lines. There may be occasions where citrus for internal urban markets requires fungicide treatment. Where this is necessary, the fruit should be washed and dried after sorting, then treated with fungicide and dried before packing. In those countries where some types of citrus remain green when ripe it is not usually necessary to de-green them for market. De-greening will only change the color of the skin of citrus fruits. It will not ripen them internally. De-greening is carried out by exposing the fruit to ethylene gas under controlled environmental conditions. It can only add to the cost of the fruit to the consumer, without any compensation in eating quality. However, we are aware that most consumers purchase with the eyes, therefore yellow/orange color is preferable to the green one.

**8.7.3. Storage**

Citrus fruits can be held up to three weeks under ambient conditions, depending upon the temperature and moisture content of the air. In dry air they may lose moisture and shrink after a few days. Damaged fruit may become infected and decay quickly after harvest. Depending on the variety citrus can be stored in refrigerated rooms as follows:

- **Grapefruits:** at 10 to 15° C, 85-90% Relative Humidity, for 6 to 8 weeks.
- **Lemons:** at 10 to 13° C, 85-90% Relative Humidity, for 1-6 months.
- **Limes:** at 9 to 10° C, 90-9656% Relative Humidity, for 6 to 8 weeks.
- **Oranges:** at 0 to 9° C, 90-95% Relative Humidity, for 3 to 8 weeks.

**8.8. Minors fruits crops**
8.8.1. Pineapple

Latin name: Ananas comosis sp.

**Harvesting maturity.** It is difficult to tell when pineapples are ready to be harvested. Some people judge ripeness and quality by snapping a finger against the side of the fruit. A good, ripe fruit has a dull, solid sound. Immaturity and poor quality are indicated by a hollow thud. However harvesting should be started when the base of the fruit has changed from green to yellow or light brown. An acceptable quality may also develop before color changes may occur. Often pickers select fruits by size.

**Harvesting method and handling.** Fruits are harvested manually by cutting the stalk using a sharp knife or twisting the fruits from the stalk. The harvested fruits are put inside gunny bags, bamboo or other kind of baskets or field crates and sent to the collecting point for grading. Grading and packing can also be done in the field itself. Fruits, after separation of broken and heavily diseased or defective ones, are graded according to size and stage of ripeness and packed in single layer cardboard boxes, on their side.

**Storage.** The fruits should be stored, depending from the variety, at 7 to 13°C (45 to 55°F), 85-95% Relative Humidity for up to 24 weeks. However it is advisable to store pineapples for no more than 4-6 weeks, because the fruit is chilling injury sensitive, like most of the tropical fruits.

8.8.2. Carambola.

Latin name: Averrhoa carambola L.

**Harvesting.** Fruits best when ripen on the tree, but will ripen slowly if picked before fully ripe. The fruit naturally fall on the ground when fully ripe. For fresh marketing they should be hand-picked while pale-green with just a touch of yellow. The fruits should be harvested carefully and arranged in a basket or plastic field crates with the wrappers still intact.

**Handling.** The fruits are then carried to the shaded area. It is not necessary to get rid of the wrappers because this will prevent damages and bruising to the fruits. At the packing place the fruit is graded according to size, color and quality, avoiding rough handling.
**Packaging.** The fruits are packed solidly, stem end down, at a 45° angle, the flange of one fruit fitting into the “V” grove of another.

**Storage.** Carambolas picked when showing the first signs of yellowing are kept in good condition if stored at 10° C, 85-90% Relative Humidity, for 4 weeks. If kept at 15.5° C may be kept for 3 weeks and for two weeks if stored at 21° C.

**Post-harvest losses.** The carambola fruit is relatively pest-free except for fruit flies.

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### 8.8.3. Soursop

Latin name: Annona muricata.

The skin is dark green in the immature fruits, becoming slightly yellowish-green before the mature fruit is soft to the touch.

**Harvesting.** The soursop flowers more or less continuously but in every growing region there is usually one principal harvesting period. The fruit is picked when fully grown and still firm but slightly yellow-green. If it is allowed to soften on the tree, it will fall to the ground and splatter. It is harvested by hand using a large bamboo pole with an attached pouch.

**Handling.** Firm fruits are kept a few days at room temperature. The skin will blacken and become unsightly while the flesh is still unspoiled and usable. Studies of the ripening process have determined that the optimum stage for heating is 5 to 6 days after harvest, at the peak of ethylene production. Thereafter, the flavor is less pronounced and some off-odor may develop. The fruit is very sensitive to packing if harvested at the proper maturity stage. One single layer should be packed in cardboard boxes with cushioning material.

**Storage.** The soursop can be stored under refrigeration at 13° C, 85-90% Relative Humidity for 1 to 2 weeks.

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### 8.8.4. West Indian Cherries

Latin name: Malpighia sp.
**Harvesting.** For home use, as a dessert, the fruits are picked when fully mature. For processing or preserving, they can be harvested when still slightly immature, when they are turning from green-yellow to red. As there is continuous fruiting over long periods, picking is done by hand, in the cool of the early morning, every day or every 3 days to avoid losses by falling. They are extremely short shelf-life and must be handled gently to reduce bruises and oxidation. For immediate processing some growers shake the tree and allow the ripe fruits to fall into sheets spread on the ground.

**Handling.** Fruits should be packed directly in the field into 5 kg cardboard boxes or wooden or plastic trays, often being sorted based on color and size. Harvested produce should be kept in the shade until transferred from the field, which should be done within 2-3 hours. Boxes, if not shaded, should be covered with canvas.

**Storage.** Ripe cherries bruise easily and are highly perishable. They can be stored for no more than 3-4 days at 7° C and 90-95% Relative humidity. Half ripe fruits can be stored for a few more days.

**9. HARVEST AND POST-HARVEST HANDLING FOR SELECTED VEGETABLES**

Some vegetables, although not produced in significant quantities, are well established in Grenada. Others have a good potential for increased cultivation. Details on harvesting and post-harvest handling of fresh vegetables are given in this chapter.

**9.1. Bulb onions and garlic**

**Latin name:** *Allium cepa, A. sativum and other species.*

Onions and garlic of different types are grown worldwide for the flavor they contribute to food. They are also commonly regarded as having medicinal properties. In many countries onions are used in the immature green state. In others, where the crop is seasonal, cultivars which produce bulbs that can be stored in a dry state are grown.

**9.1.1. Harvesting**

**Harvesting maturity.** When the bulbs developing from the leaf bases of both garlic and onions are fully formed, the leafy green tops begin to yellow and eventually collapse at a point a little above the top of the bulb, leaving an upright short neck. When the tops "go down" in this way, the bulbs are ready for harvesting. Because all the onions or garlic in a crop do not mature at the same time, large-scale commercial growers harvest them when about half the tops have gone down. Small-scale growers can, if they wish, harvest their crops progressively
as the tops go down, especially so if they intend to store the dry onions for sale or use at a later date.

**Harvesting method.** Since onion bulbs are normally formed at the soil surface, it is sometimes possible in sandy soils to pull the mature bulbs by hand. Where conditions make hand-pulling impossible, and with garlic where the bulbs develop below ground, harvesting is done by loosening the bulbs with a fork or hoe before lifting them. In dry, sunny weather the harvested crop is left in windrows in the field for a few days until the tops are dry. Where the harvested bulbs are exposed to high-intensity sunlight (e.g. at high altitudes in the tropics), the windrows should be made so that the green tops cover the bulbs to protect them from sunburn.

**9.1.2. Post-harvest**

**Selection and grading.** All damaged or decaying onion and garlic bulbs should be discarded. Onions with thick necks should be put aside for immediate use because they will not store well. Market requirements will determine whether onions need to be size graded or not. Retailers in local markets will normally do their own grading when making up lots for sale. If the onions or garlic are to be made up into strings for storage or sale, as described below, it is an advantage to separate them into sizes so that the bulbs will be more or less uniform in size in any string. This makes the stringing operation easier and gives a better appearance to the finished product.

**Post-harvest treatment.** The only post-harvest treatment required for the long storage of bulb onions is a thorough curing of the bulbs. Curing is a drying process intended to dry off the necks and outer scale leaves of the bulbs to prevent the loss of moisture and the attack by decay during storage. It can be carried out in the field under dry conditions by windrowing the bulbs. The essentials for curing are heat and good ventilation, preferably with low humidity. This dries out the neck and the two or three outer layers of the bulb. The outermost layer, which may be contaminated with soil, usually falls away easily when the bulbs are cured. This results in exposing the dry under-layer, which should have an attractive appearance. If onions cannot be dried in the field, they can be collected in trays, which are then stacked in a warm, covered area with good ventilation. In cool, damp climates, onions in bulk ventilated stores are dried with artificial heat blown through the bulk at a duct temperature of 30° C. Garlic and onions can also be cured by tying the tops of the bulbs in bunches and hanging them on a horizontal pole in a well-ventilated situation.

**Packaging.** For bulk marketing, the tops of onions are removed when they are thoroughly cured and the necks are quite dry. The tops of garlic are cut off one cm above the bulb and only the loose outer skin rubbed off. Both onions and garlic may be made up into strings. These are of 2 kg for garlic or 5 kg to 10 kg for onions. This is, however, a labor-intensive operation suited to small-scale production using family labor. It is not cost-effective on a commercial scale.
9.1.3. Storage

The first requirement for successful storage of dry bulb onions is that the cultivar chosen should have the right characteristics for long-term storage. The principal needs are:

- the cultivar should have a long dormant period;
- it should be a cultivar which forms a strong outer skin when fully cured; brown- and red-skinned cultivars tend to be better in this respect;
- the bulbs put into storage should be disease-free; the most important storage disease is neck rot, which is controlled by dusting the onion seed before planting with benomyl fungicide at the rate of one gram active material per kilogram of seed.

The storage environment must be dry and well-ventilated. Optimum storage temperatures must be the lowest available under ambient tropical conditions. At temperatures between these, onions will sprout in storage. Onions stored in a damp atmosphere will develop roots. Onions can be stored in bulk in insulated stores, with fans for cooling the onions using cold night air. This method is used where large tonnages are to be stored. Small-scale growers can use naturally ventilated stores made from local materials. The onions can be stacked in trays or in layers on slatted shelves.

Where small amounts are to be stored, the stringing of onions in 5 kg to 10 kg lots and the hanging of the strings in a well-ventilated dry location is a very effective storage method. Dried onions can be stored in cold storage at 0° C, 65-70% Relative Humidity for 1 to 8 months.

Garlic may be stored in trays, strings or bunches in the same manner as onions, except that with garlic strings are made by plaiting the dry top leaves of the garlic. Garlic can be stored in cold storage at 0° C, 65-70% Relative Humidity for 6 to 7 months.

9.2. Leafy vegetables and immature flower heads


Include cabbage, Chinese cabbage, kale, rape, mustard, broccoli, chard, spinach beet, spinach, lettuce, celery, green onions.
9.2.1. Harvesting

**Harvesting maturity.** All are harvested in the immature state before the plant has developed to the point of seed production. The older parts of these commodities become fibrous or woody.

**Harvesting method.** The parts of the plant harvested vary with the crop:

- Cabbage, Chinese cabbage, lettuce, celery and green onions form more or less compact heads; the entire head is harvested at one time;
- Kale, rape, mustard. young shoots, with or without immature flower heads, are picked by hand-breaking; can usually be harvested over a period of time as long as new shoots continue to develop; and
- Chard, beet and spinach are harvested as individual young leaves; sometimes young shoots of spinach are harvested; harvesting is repeated as new leaves continue to develop.

Those crops forming a head, such as cabbage, are cut with a sharp knife. Young shoots and leaves are broken off by hand. Celery and green onions are either pulled by hand or dug from the soil. They should be harvested under dry conditions when soil can be readily shaken from the roots. The roots are then trimmed with a sharp knife.

**Field assembly.** All these commodities are damaged easily if subjected to pressure. They should be packed loosely in field containers, which must not be overfilled or the produce will be damaged when the containers are stacked. The harvested produce must be kept free from contamination by soil. Leafy vegetables and immature flower heads deteriorate very quickly after harvest because they lose water fast and produce a great deal of heat. The following care is necessary to keep losses to a minimum:

- They must be packed loosely in well-ventilated plastic field containers; if they are piled in a tight mass, the heat they generate cannot escape.
- They must be kept in the shade and not exposed to direct sunlight.
- They must not be exposed to drying winds or they will lose water quickly and become wilted and soft; at the same time there must be enough ventilation to disperse the natural build-up of heat.
- There must be the shortest possible delay between harvest and sale or consumption because leafy commodities have a very short post-harvest life under ambient conditions.

9.2.2. Post-harvest

**Selection, grading and handling.** All produce which is damaged, decaying wilted or infested by insects or other pests must be discarded. Size-grading is not normally necessary for local and internal marketing. Size-grading may be needed to supply supermarkets.
**Post-harvest treatment.** It is essential to keep these commodities free from contamination by soil or decaying plant material. Do not wash them. Washing them may remove gross soil contamination, but it will also spread any decay through the whole bulk and result in heavy losses. Shading the produce and keeping it in a moist atmosphere helps to keep it cool, reduces water loss, and delays wilting and yellowing of leaves.

Chemical treatments to control decay are not acceptable because they are not very effective and they leave high residue levels because of the characteristic high surface area of these products in relation to their volume.

**Packaging.** For local rural markets traditional containers are likely to remain in use. It is important, however, that containers should not be too large to be carried by one person. Rough handling of heavy packages results in damage to produce. Packaging of leafy vegetables and immature flower heads for urban markets will vary with the type of commodity.

The following are examples:

- Cabbages: woven sacks, net bags or field crates of 20-25 kg capacity are suitable.
- Lettuce: one layer wooden plastic crates or ventilated cardboard boxes each containing 24 heads of lettuce.
- Celery: wooden crates holding 20-30 heads of celery.
- Green onions: normally tied in bunches by the grower; they are best transported in small wooden crates holding 10-15 kg.
- Chard and spinach: crisp, brittle and easily broken by rough handling; they are best packed loosely in cardboard, wooden or plastic field boxes of 5-10 kg capacity; over-packing will cause crushing of leaves and bruising and rapid discoloration of stems.
- Kale, rape and leafy brassicas: may be tied in bunches or packed loose; they can be marketed in nets, cardboard or wooden or plastic field crates of 5-10 kg capacity.

**9.2.3. Storage**

Leafy vegetables and immature flower heads have a very short post-harvest shelf-life, especially under ambient conditions. Even under refrigeration most remain in good condition only up to two weeks. Ideally, they should reach the consumer within two days of harvest. For details on the single commodities see the Annex 3.
9.3. Tomatoes

Latin name: *Lycopersicon esculentum*

9.3.1. Harvesting

**Harvesting maturity.** If tomatoes are to be used in the ripe condition, they should be picked at the earliest when they are at least mature green. Immature tomatoes do not ripen after harvest. The actual stage at which they should be picked depends upon local preference and custom in each country. Tomatoes have reached the mature-green condition when they are fully rounded and have changed from dark to medium or light green, and the skin develops a waxy gloss. As ripening is initiated, the fruit shows a pale pink or yellow tinge, which develops through a definite pink to full red. Most tomatoes are harvested at the early ripening or pink stage, depending on market preference and the time they take to reach the retailer. Tomatoes to be consumed immediately can be harvested when fully ripe.

**Harvesting maturity.** Tomato fruit stalks have a natural break-point. Mature fruit readily breaks away from the cluster when pressure is placed on this point while lifting the fruit upwards. Tomatoes are best harvested into plastic buckets (pails) and transferred if necessary to plastic field crates holding not more than 20 to 25 kg weight.

9.3.2. Post-harvest

**Selection and grading.** All decaying, damaged, undersized and sunburned tomatoes should be discarded. Size-grading for the local market is normally done by retailers. Internal urban markets, including supermarkets, may have differential prices for size grades as against un-graded fruit. Catering and institutional buyers do not normally demand size-graded fruit.

**Post-harvest treatments.** Only those tomatoes which are in good condition are marketed, there should be no need for any post-harvest treatments. Tomatoes produced on a large commercial scale may be subjected to artificial ripening; but in countries where production is mostly on a small scale, this is not necessary since tomatoes are normally harvested at maturity and ripen naturally.

**Packaging.** For local markets tomatoes can be packed in baskets or other traditional containers assuring careful handling, i.e. rigid enough to protect the contents from being crushed. For urban markets cardboard telescopic boxes or wooden or plastic trays with capacities of not more than 10 kg, should be used. Size-graded tomatoes can be pattern-packed in 2 layers for green produce and one layer for ripe red produce to make best use of the box. Un-graded tomatoes are jumble-packed to a given weight.
9.3.3. Storage

Tomatoes have a relatively poor storage capability. Green mature fruit can be held for up to two weeks at 18-20° C and 90-95% Relative Humidity, but for less time under ambient tropical temperatures. Fully ripe tomatoes have only 4 to 7 days' storage life, at 13-15° C and 90-95% Relative Humidity.

9.4. Eggplants

Latin name: Solanum melangela L.

9.4.1. Harvesting.

**Harvesting maturity.** The harvest index is based principally on size and color. The fruits of eggplant should be harvested somewhat before they reach full maturity. The color should be dark purple, firm and glossy, with green calyx and stem. Browning of the calyx and shriveled skin are indication of aging and water loss.

**Harvesting method.** Harvesting should be done once or twice per week, depending on the variety. Secateurs are needed for hand-harvesting, taking care to handle nicely the fruits and leaving 2 to 4 cm long stem above the calyx. The harvesting of wet fruits should be avoided.

**Field assembly.** Ventilated field crates should be placed when full, in a shaded place to avoid over-heating. Sacks and bags should be avoided to reduce development of mechanical damage and heat build-up.

9.4.2. Post-harvest

Clean with a soft cloth to remove soil and residues from the fruits. Fruits showing yellowing of the skin are over-mature and should be separated, along with fruits presenting signs of decay, insect damage, cracks, sunscald and other mechanical damages. After size grading, the fruits of the same size are loose packed in cardboard boxes.

9.4.3. Storage

At optimal storage conditions of 7 to 12° C and 85-90% Relative Humidity, eggplants can be stored for 7 to 10 days. Stored below 7° C the fruits will develop chilling injuries such as surface pitting, decay internal breakdown and shrivelng.

9.4.4. Post-harvest losses
• Stem puncturing;
• Crates overfilling;
• Microbial infections;
• Chilling injuries; and
• Shriveling.

9.5. **Carrots**

Latin name: Daucus carota.

9.5.1. **Harvesting**

**Harvesting maturity.** Carrots are ready to harvest about 90 days or more after seeding, but continue to grow and enlarge them. Size is the best maturity index. Harvest when the roots are of good size, but still tender.

**Harvesting method.** They may be harvested manually or mechanically. The crop is mowed or preferably the roots are pulled out. The root is separated from the green top with a sharp knife.

9.5.2. **Field assembly and handling**

Carrots should be cleaned by immersion in water tanks. Separation of the soil is facilitated by soft scrubbing with a brush. Final washing in clean water may be needed. If it is the case add chlorine at 1%. Carrots should be packed in plastic or wooden field boxes. Sack should be avoided to reduce handling and transport damages.

9.5.3. **Storage**

If carrots are left too long in the soil or allowed to over-mature, the roots become tough, woody and start cracking. At optimal storage conditions mature carrots can be stored at 0° C and 95-98% Relative Humidity up to 6 to 9 months.

9.6. **Pungent and sweet peppers**

Latin name: Capsicum Sp.

9.6.1. **Harvesting.**

**Harvesting maturity.** Sweet pepper fruits usually are picked when they have stopped increasing in size, are firm to the touch and in the green turning
yellow/red stage. Hot varieties are harvested either immature (green) or mature (yellow/red) stage for fresh use or processing.

**Harvesting method and field handling.** All peppers are harvested by hand, with approximately 1 to 2 cm of stem attached, and introduced into baskets that are then emptied into field boxes for delivery to the pack-house or in single layer cardboard boxes for the market. Harvesting of wet peppers should be avoided. Considerable mechanical damage can occur during picking and handling if care is not taken to minimize scuffing and impact.

**9.6.2. Post-harvest handling**

Harvested peppers should be placed in the shade immediately after harvest and cooled, if refrigeration is available, as soon as possible to lower the field-heat. The use of perforated film carton liners or perforated plastic bags increase storage life, although it may inhibit proper cooling and may encourage diseases. Before final packing for market peppers should be selected for uniform maturity, color, shape, size and for freedom from defects (sunscald, mechanical or insect damage or decay).

**9.6.3. Cooling and storage**

Immediately after harvesting, peppers should be cooled to 7° C. If they are allowed to remain at high temperature for more than 1 to 3 hours they will begin to show signs of shriveling, shrinkage, softening, accelerates ripening and color changes. Peppers are also sensitive to chilling injuries. If kept at temperatures below 4° C, they may show signs of softening, pitting and a predisposition to decay. Peppers are sensitive to ethylene gas produced, as a natural by-product of ripening, by some fruits and vegetables (such as tomatoes, apples bananas and avocados) which never should be stored and shipped together with peppers.

**9.6.4. Post-harvest losses**

Peppers in addition to the chilling injuries described above, are subject to a number of problems: diseases, insects, weather and other environmental factors.

**9.7. Sweet corn**

Latin name: Zea mays L.

**9.7.1. Harvesting.**

**Harvesting maturity.** Sweet corn ears are generally ready for harvest approximately three weeks after the first silk emergency, depending
on the temperature. Silk will start to turn brown about two weeks after emergence. Ears should be harvested when the kernels appear to be milky when punctured with a thumbnail. It is called the milky stage. The un-husked ears should feel firm, have full kernel to the top of the ear and have brown dry silk. Fully ripe kernels of super sweet varieties will still posses a clear, watery juice.

**Harvesting method and field assembly.** Ears of standard varieties will remain in prime condition for only a short time in warm weather when compared to cool weather. Harvest in the early morning when both the ears and the weather are cool. High temperature will quickly lower the eating quality of sweet corn. When harvesting, break the stem of the ear as close to the ear as possible without breaking the main stalk. Long shanks and flag leaves should be clipped to reduce moisture losses. Ideally, ears should be cooled to 0°C within an hour of harvesting. Use field plastic or wooden crates to handle the corn.

**9.7.2. Post-harvest handling**

If corn cannot be refrigerated immediately, it should be stored in the shade to reduce heating from the sun. When harvesting for direct market supply, harvest only a one-day supply and keep as cool as possible. Ears can be packed in field-crates topped with ice, and kept at 0°C. Ears, in these conditions will be marketable for 5 to 10 days.

**9.7.3. Storage**

Traditional sweet corn varieties are seldom stored for more than a few days, because of the resulting serious deterioration and loss of tenderness and sweetness. The loss of sugar (which is converted to starch) fastens with the increase of temperature. Prompt cooling at 0°C and high Relative Humidity will extend shelf-life.

**9.8. MINOR VEGETABLES CROPS**

**9.8.1. Broccoli and cauliflowers.**

Latin names:

**9.8.1.1. Harvesting and handling.**

Use a sharp knife and cut keeping the blade aligned with the soil.

**Broccoli.** Harvesting is done by hand while the head is still compact and before the flowers open. The central heads should be dark blue or green. If harvested too late or when the heads are over-mature, woodiness in the stem will develop.
Depending upon marketing requirements, the main head is cut with 3 to 5 cm of the stem. Sometimes a second harvest of side shoots can be obtained. Quality of broccoli is based upon the degree of compactness, leafiness, trimness of heads, damage and freedom from insects and external debris. Broccoli is packed in one layer boxes with the heads upright to avoid scrubbing of the flowers.

**Cauliflowers.** When ready to harvest, the heads should be compact and clear white. Heads become discolored and develop an unpleasant flavor when exposed to sunlight. The longest leaves are normally tied loosely together over the head to “blanch” and prevent the head for being exposed to the sun. Large heads cannot be normally obtained by delaying harvest. Cauliflower is harvested by hand and cut with one or two whorls of leaves to protect the head and permit packing in two layer cardboard boxes.

### 9.8.1.2. Storage

Broccoli can be stored at 0° C, 95-98% Relative Humidity for only 1 to 2 weeks to avoid yellowing. Cauliflowers can be stored at 0° C, 95-98% Relative Humidity for no more than 3 to 4 weeks, or longer with leaves protecting the head, to avoid black spots of fungus diseases.

### 9.8.2. Cucumbers

Latin name: Cucumis sativus.

#### 9.8.2.1. Harvesting

**Harvesting maturity and harvesting method.** For table or slicing cucumbers quality is primarily based on uniform shape, firmness, and a dark green skin color. Additional quality indices are size, freedom from growth or handling defects, decay and absence of yellowing. Cucumbers are harvested at a range of developmental stages. Depending on cultivar and temperature, the time from flowering to harvest may be 55 to 60 days. Cucumbers generally are harvested at a slightly immature stage, near full size but before seeds fully enlarge and harden. Firmness and external glossiness are also indicators of a pre-maturity condition. At the proper harvesting maturity a jellylike material has begun to form in the seed cavity. Harvesting is done by hand by cutting free of the vine with a sharp knife, rather than by tearing. Cucumbers are packed in two layer boxes, cardboard, wooden or plastic.

#### 9.8.2.2. Storage

Storage of cucumbers at 10 to 12° C and 95% Relative Humidity is generally less than 14 days as visual and sensory quality deteriorate rapidly. Short term storage or transit temperature such as 7° C is often used but after 2 to 3 days chilling injuries
will result. Cucumbers are highly sensitive to ethylene present in the storage room or in the transport vehicle. Do not mix bananas, melons, tomatoes and other ethylene producing products with cucumbers.

9.8.2.3. Post-harvest losses

- Chilling injuries;
- Bruising; and
- Yellowing.

10. HARVEST AND POST-HARVEST HANDLING FOR SELECTED ROOT CROPS

Most of the well known root crops are well established in Grenada. Others have a good potential for increased cultivation. Details on harvesting and of root crops are given in this chapter.

10.1. Sweet potato

Latin name: Ipomoea batatas

Sweet potatoes are grown widely throughout the tropics as a basic or subsidiary staple food crop in subsistence economies. They are also widely used as animal feed and in some countries as an industrial raw material.

10.1.1. Harvesting

**Harvesting maturity.** Sweet potatoes are considered ready for harvest when the leaves begin to yellow. A further test of readiness to harvest is said to be that of cutting mature tubers the cut surfaces do not discolor. In some countries experienced growers harvest at a specified time after planting. This has to be based on careful observation and long experience since there is a difference in the maturity period of the various cultivars.

**Harvesting method.** Harvesting is carried out either progressively or all at one time. Subsistence growers tend to harvest progressively, often from the same plants over a long period. Sweet potato crops grown on a commercial scale are usually harvested all at one time.

The preferred harvesting tools for most small-scale producers are pointed wooden sticks or metal bars, or machetes (cutlasses, bolos, pangas), especially where progressive harvesting is practiced. These tools are said to cause less damage to the roots and enable a few roots to be harvested from a plant on each occasion. When the whole crop is harvested at one time, growers tend to use pronged rakes, hoes or digging forks.
**Field assembly.** On no account should the roots be thrown, whether into field and storage containers or at any other time during their handling. Great care must be taken to avoid damage to the skin of sweet potato roots since they are very subject to post-harvest decay under tropical conditions. For this reason it is recommended that the harvested roots be gathered into baskets, boxes or crates in which they can remain throughout their post-harvest life without disturbance, through curing and storage if necessary. Harvested tubers which have damp soil adhering to them at harvest may be left in the field for an hour or so to dry, but not long enough to suffer sun scorch. The soil can then be carefully removed.

**10.1.2. Post-harvest**

**Selection and grading.** All decaying roots should be discarded. Slightly damaged roots can be used for immediate consumption, and those which are undersize or badly damaged may be fed to animals. Tubers which are to be stored should be fully mature and free from visible injury. Most sweet potatoes are size/graded by the retailer if necessary.

**Post-harvest treatments.** Curing of those roots which are to be stored after harvest is the only treatment necessary for sweet potatoes.

The roots should remain in the containers into which they were harvested and in which they will be stored. The containers can be placed in the storage structure and covered with straw. Ventilation should be restricted to allow a buildup of heat and moisture in the store, to give the correct conditions for storage, which are: 27 to 34° C, 85-90% Relative Humidity for a curing time of 15 to 20 days.

Curing is a process of healing by the formation of new skin on damaged areas of sweet potatoes, and also of the maturing and hardening of the whole skin of the roots. The length of time required for curing cannot be forecast since it has been shown to vary even under identical environmental conditions. Indications of maturity are said to be thus: when the skin can no longer be rubbed off easily from a sample root and when small buds appear on the roots.

**10.1.3. Storage**

Sweet potatoes are subject to very rapid deterioration after harvest at ambient tropical temperatures. There are reports in the literature of storage of sweet potatoes for four months or more. In most reported instances of successful storage for such a time the storage temperature has been in the low range of 10-18° C. Even at the higher end of this range sprouting of the roots has been a problem. At temperatures below 10° C sweet potatoes suffer chilling damage.

The storage structures used have been either custom-built ventilated stores, with or without refrigeration, or sunken or underground chambers, protected by a building above. Conditions required for successful storage are as follows:
- The roots must be fully mature and well cured before storage;
- They must be handled carefully at all times and only sound roots should be stored;
- The best temperature range for storage is 10-15°C Celsius; and
- The relative humidity should be 85 to 90 percent.

If there is any indication of free water on the roots or in the store, more ventilation should be provided to remove the excess moisture. If the air gets too dry the floor of the store can be lightly sprinkled with water.

These conditions can be achieved at higher altitudes in the tropics at those times when night temperatures fall to within the required range. In a well-insulated ventilated store, the tubers can be cooled at night by full ventilation and heat rise can be slowed during the day by closing the store. It is unlikely that sweet potatoes can be stored at ambient tropical temperatures for more than three weeks without heavy losses from decay and sprouting.

**Packaging.** The best form of packaging for long transport is either wooden crates or cardboard boxes holding not more than 25 kg. The roots should be packed firmly to prevent movement within the boxes or crates during handling and transport. Sweet potatoes should not be packed in 50 kg sacks, which are difficult to handle and, when dropped, cause heavy damage to the roots.

### 10.2. Yams

**Latin name:** Dioscorea *spp.*

Yams are grown principally as a subsistence crop and for internal marketing.

#### 10.2.1. Harvesting

**Harvesting maturity.** Yams are ready for harvest when the above-ground parts of the plants have died off. The Greater and White Yams can be left in the ground for a time after maturity. Yellow Yams, which have a very short dormant period, should be lifted as soon as mature.

**Harvesting method.** Yams is normally harvested by carefully scraping the soil away from the tubers in order to avoid damaging them. Wooden digging sticks or spades are less likely to cause damage to the tubers than are metal forks or hoes.

#### 10.2.2. Post-harvest
Selection and grading. Heavily damaged or decaying yams should be discarded. Those which are slightly damaged may be consumed immediately or subjected to a curing process before storage. Size-grading is not always practiced. It is mainly done when there is an advantage to be gained in the packaging for marketing.

Post-harvest treatments. Where yams are cut or deeply injured, a new skin can be formed on the damaged surfaces by curing the tubers at high temperature and humidity. Curing has been shown to be effective in Yellow and White Yams, but its effectiveness in other types is not known. Injuries caused by skin abrasion or bruising tend to dry out rather than form replacement skin.

A method recommended in West Africa for curing yams which are to be stored is given below. This provides the necessary conditions for raising the temperature and moisture content of the air to suitable levels by restricting ventilation.

The conditions found to be effective in promoting the curing of Greater and White Yams are: 32 to 40°C, 90-95% Relative Humidity.

Curing, which will be done in 1 to 7 days, should be carried out immediately after harvest at the location where the yams are to be stored.

Yams stacked in this method to cure skin damage should be covered with grass to keep the canvas or jute cover from touching the yams. The curing pile should not be exposed to direct sunlight and the cover should be removed after four days.

In humid areas of West Africa yams may be stored in 'barns” whose side poles have taken root and are growing leaves to provide shade. Inside walls of yam barn are vertical frames to which yams are tied.

Packaging. Yams being sent to local markets may be carried in bulk by vehicle, in ordinary baskets or in plastic or wooden field crates. When they are carried in bulk, the floor and sides of the vehicle should be padded with sacks loosely packed with straw, or with grass mats or plastic foam covered with polythene sheet. Whether the yams are carried in bulk, in crates or in baskets, the vehicle must not be overloaded and should be driven with care. For internal urban markets the tubers are best packed in wooden or plastic field crates or ventilated cardboard boxes. These containers should not be over-packed and must be handled and transported carefully.

10.2.3. Storage

Greater and White Yams in good condition can be stored for several months under appropriate conditions. Yellow yams have poor storage potential due to their very short dormancy period. Although yams may keep in storage for several months, they shrink over such a period owing to water loss and to natural living processes which use up stored dry matter (starch). There may also be additional losses because of decay caused by moulds. There are many different storage practices in
various countries. Owing to the generally non-commercial nature of yam production and limited resources of growers, most storage uses low-cost methods. Yams are generally stored during the hot dry part of the year when the provision of ventilation and other conditions which help to reduce their temperature are key factors. Yams kept in the ground and harvested progressively when needed are subject to attack by insects and other pests. They are also exposed to attack by moulds. Yams kept undug may also tie up limited land resources. The tubers can be piled in small numbers in shaded situations or in well ventilated huts built of local materials, in which case they are best stored on racks or shelves. In West Africa, yam "barns" are a common method of storage. They are vertical frames to which individual yams are tied. The uprights supporting the frames are bush poles up to two or more meters in height. The use of poles which will take root and provide a protective canopy of leaves to shade the yams is of benefit. Such growing poles are also less likely to decay or be attacked by termites. The stored frames of yams may be protected by a fence to keep out rats.

10.3. Dasheen

Latin name: Colocasia esculenta var esculenta.

10.3.1. Harvesting

**Harvesting maturity.** Maturity is based on corm size, harvested 8-12 months after planting, depending mainly on desired corm size and on market conditions. Maturity is also indicated by wilting and drying of the older outer leaves. Length of growth period and senescence of leaves are therefore indicators that the root is fully mature. A few roots should be lifted to ensure that the dasheen is well-formed, evenly shaped, round to oval and brown in color.

**Harvesting method and field handling.** Harvesting is carried out using a fork or a cutlass, and the corm gently removed from the ground. The corms and the roots should be left attached to the corm, the surrounding soil gently broken away from the dasheen, preliminary selection executed (under-sized, damaged, soft, insect damages or infested corms should be removed) and packed into 20-25 kg wooden or plastic field crates. Sacks should be avoided to reduce breakage of the corms, bruising and other damages to the corms. Packing should be executed within the 12 hours of harvest. On arrival at the packing facilities, the dasheen if not cleaned in the field, is cleaned to remove excess soil, preferably by hand and repacked in smaller containers. If handled correctly, dasheen can be stored up to 2-3 weeks. Dipping in water should be avoided in order not to reduce shelf-life. Dasheen for export market could be dipped in a chemical solution (such as Redomil) to control fungal infections. 15 g of chemical should be mixed with 30 liters of water and corms dipped for 5 to 10 seconds. Solution should be changed when water
becomes dirty. Drainage is required to remove excess liquid. Corms are packed in “banana” type boxes before becoming fully dry.

10.3.2. Storage

Dasheen should be stored at 10-12° C and 80-90% Relative Humidity. If handled correctly corms should remain in good conditions for up to 4 weeks.

10.3.3. Post-harvest losses

- Mechanical damages;
- Micro-organism infections; and
- Chilling injuries.

10.4. Cassava

Latin name: Manihot esculenta C.

Cassava is an irreplaceable food security crop in a large part of the developing world. Although in the Americas cassava is slowly evolving from a traditional staple to a market oriented inexpensive row material for the manufacture of human (casabe, farinha, gar, fufu and kuanga are only a few products) livestock and industrial products. This manufactured cassava products have a more elastic market than the fresh cassava, which starts spoiling within 48-72 hours after harvest, unless the root receive a special treatment to extend shelf-life to 3-4 weeks.

10.4.1. Harvesting

**Harvesting maturity.** There is no mature stage for cassava. Plants are ready for harvest as soon as storage roots large enough to meet the requirements of the consumer. Typically harvesting can begin eight months after planting. In the tropics plants can remain un-harvested for more than one growing season, allowing the storage root to enlarge further. However as the root age, the central portion becomes woody and inedible.

**Harvesting method and field handling.** Most cassava is harvested by hand, lifting the lower part of the stem from the base of the plant. The upper part of the stems with the leaves are removed before harvest. Removing the leaves 2 weeks before harvesting lengthens the shelf-life to 2 weeks. Levers, forks or ropes can also be used to assist harvesting. Cassava is very susceptible to damage at harvest.
Harvested roots should be packed in wooden or plastic field crates in a shaded place and sent to the nearest market as soon as possible.

10.4.2. Post-harvest handling and storage

The shelf life of cassava is only a few days unless the roots receive a special treatment. Dipping the roots into a permitted chemical (fungicide), followed by immersion in paraffin or wax and storing them in plastic bags. The treatment reduces the incidence of vascular streaking and extends shelf-life to 3 to 4 weeks. Dipping will permit the supply of fresh roots to overseas markets.

ANNEX 1. Quality Standards for Melons.

Regulation 1093/97 of 16 June 1997 for marketing into the European Community.

0 DEFINITION OF PRODUCE

This standard applies to melons of varieties (cultivars grown from Cucumis melo L. to be supplied fresh to the consumer, melons for industrial processing being excluded.

1 PROVISIONS CONCERNING QUALITY

The purpose of this standard is to define the quality requirements for melons after preparation and packaging.

A. Minimum requirements

In all classes, subject to the special provisions for each class and the tolerances allowed, the melons must be:

- intact, (1)
- sound, produce affected by rotting or deterioration such as to make it unfit for consumption is excluded.
- clean, practically free of any visible foreign matter
- of fresh appearance
- practically free from pests
- practically free from damage caused by pests
- firm
- free of abnormal external moisture
- free of any foreign small and/or taste

The melons must be sufficiently developed and display satisfactory ripeness (2). The development and condition of the melons must be such as to enable them:

- to withstand transport and handling, and
- to arrive in satisfactory condition at the place of destination

A. CLASSIFICATION

Melons are classified into two classes defined below:
Class I
Melons in this class must be of good quality. They must be characteristic of the variety or commercial type.
The following slight defects however may be allowed provided that these do not affect the general appearance or the produce, the keeping quality, and presentation in the package:
− a slight defects of shape
− slight defects of colouring (a pale colouring of the rind at the point where the fruit touched the ground while growing is not regarded as a defect)
− slight skin blemishes due to rubbing or handling
− slight healed cracks around the peduncle of less than 2cm in length that do not reach the pulp
− The length of the peduncle, in the case of fruit belonging to varieties that do not separate at the time of ripening may not exceed 2cm for the varieties of Charentais, Ogen and Galia type melons and 5cm for other melons, but must in any case be present and intact.

Class II
This class includes melons which do not qualify for inclusion in Class I but satisfy the minimum requirements specified above.
The following defects may be allowed provided the melons retain their essential characteristics as regards the quality, the keeping quality and presentation:
− defects of shape
− defects of colouring (a pale colouring of the rind at the point where the fruit touched the ground while growing is not regarded as a defect)
− slight bruising
− slight cracks or deep scratches that do not affect the pulp of the fruit and are dry
− skin blemishes due to rubbing or handling

III PROCVISIONS CONCERNING SIZING
Size is determined by the weight of one unit or by the diameter of the equatorial section.
When the size is expressed in terms of weight, the largest melon in each package may not weigh over 50% more than the smallest.
When the size is expressed in terms of diameter, the diameter of the largest melon may not be over 20% more than the diameter of the smallest.
Sizing is compulsory for both classes.

IV PROCVISIONS CONCERNING TOLERANCES
Tolerances in respect of quality and size are allowed in each package for produce not satisfying the requirements of the class indicated.
A. Quality tolerances

Class I
10% by number or weight of melons not satisfying the requirements of the class but meeting the requirements for Class II, or, exceptionally, coming within the tolerances for that class.

Class II
10% by number or weight of melons satisfying neither the requirements for the class nor the minimum requirements, with the exception of produce affected by rotting, or any other deterioration rendering it unfit for consumption.

B. Size tolerances

For all classes 10% by number or weight of melons not satisfying the size immediately below or above that specified on the package.

V. PROVISIONS CONCERNING PRESENTATION

A. Uniformity

The contents of each package must be uniform and contain only melons of the same origin, variety or commercial type, quality and size and which have reached appreciably the same degree of development and colouring. The visible part of the contents of each package must be representative of the entire contents.

B. Packaging

Melons must be packed in such a way as to ensure proper protection of the produce. The materials used inside the package must be new, clean and of a quality such as to avoid causing any external or internal damage to the produce. The use of materials and particularly of paper or stamps bearing trade specifications is allowed provided that the printing or labelling has been done with a non-toxic ink or glue. The package must be free of all foreign matter.

VI PROVISIONS CONCERNING MARKING

Each package must bear the following particulars in letters grouped on the same side, legibly and indelibly marked and visible from the outside:
A. Identification

Packer and or dispatcher. Name and address or officially issued or accepted code mark

B. Nature of produce

"Melons" if the contents are not visible from the outside. Name of the variety or commercial type (e.g. Charentais)

C. Origin of produce
Country of origin and, optionally district where grown or national, regional or local place name.

D. Commercial specifications

Class
Size expressed either by minimum or maximum weight or minimum and maximum diameter
Number of units (optional)

E. Official control mark (optional)

(1) However, a small healed scar caused by automatic measurement of the refractometric index is not regarded as a defect.
(2) The refractometric index of the pulp must be at least 8% measured at the middle point of the fruit flesh at the equatorial section.

ANNEX 2: Quality Standards for Cucumbers


I. DEFINITION OF PRODUCE
This standard applies to cucumbers grown from varieties (cultivars) of Cucumis sativus L. to be supplied fresh to the consumer, cucumbers for processing and gherkins being excluded.

II. PROVISIONS CONCERNING QUALITY
The purpose of the standard is to define the quality requirements for cucumbers after preparation and packaging.

A. Minimum requirements
In all classes, subject to the special provisions for each class and the tolerances allowed, cucumbers must be:
- intact
- sound, produce affected by rotting or deterioration such as to make it unfit for consumption is excluded
- fresh in appearance
- firm
- clean, practically free of any visible foreign matter
- practically free from pests
- practically free from damage caused by pests
- free of bitter taste (subject to the special provisions for classes II and III under the heading ‘Tolerances’)
- free of abnormal external moisture
- free of foreign smell and/or taste

Cucumbers must be sufficiently developed but their seeds must be soft.
The condition of the produce must be such as to enable it:
- to withstand transport and handling and
- to arrive in satisfactory condition at the place of destination

A. Classification
Cucumbers are classed into four classes defined below:

(i) ‘Extra’ class
Cucumbers in this class must be of superior quality. They must have all the characteristics of the variety.
They must:
- be well developed
- be well shaped and practically straight (maximum height of the arc: 10mm per 10cm of length of the cucumber)
- have a typical colouring for the variety
- be free of defects, including all deformations and particularly those caused by seed formation

(ii) Class I
Cucumbers in this class must be of good quality. They must:
- be reasonably developed, be reasonably well shaped and practically straight (maximum height of the arc: 10mm per 10cm of the length of cucumber).

The following defects are allowed:
- a slight deformation, but excluding that caused by seed formation
- a slight defect in colouring, especially the light coloured part of the cucumber where it touched the ground during growth
- slight skin blemishes due to rubbing and handling or low temperatures, provided that such blemishes have healed and do not affect the keeping quality

(iii) Class II

This class includes cucumbers which do not qualify for inclusion in the higher classes but satisfy the minimum requirements specified above. However, they may have the following defects:
- deformations other than serious seed development
- defects in colouring up to one-third of the surface; in the case of cucumbers grown under protection, considerable defects in colouring in the affect part are not allowed
- healed cracks
- slight damage caused by rubbing and handling which does not seriously affect the keeping quality and appearance
- All the defects listed above are allowed for straight and slightly crooked cucumbers.

On the other hand, crooked cucumbers are allowed only if they have no more than slight defects in colouring and have no defects or deformation other than crookedness.

Slightly crooked cucumbers may have a maximum height of the arc of 20 mm per 10cm of length of the cucumber.

Crooked cucumbers may have a greater arc and must be packed separately.

(iv) Class III

This class includes cucumbers which do not qualify for inclusion in the higher classes but satisfy the requirements specified for Class II. However, crooked cucumbers may have all the defects allowed in Class II for straight and slightly crooked cucumbers and they must be packed separately.

III. PROVISIONS CONCERNING SIZING

Sizing is determined by the weight of the cucumber.

(i) Cucumbers grown in the open must weight 180g or more. Cucumbers grown under protection must weigh 250g or more.

(ii) Moreover ‘Extra’ Class and Class I cucumbers grown under protection weighing

- 500g or more must be not less than 30cm long
- between 250 and 500g must be not less than 25cm long

(iii) Sizing is compulsory for classes ‘Extra’ and I.

The difference in weight between the heaviest and lightest cucumbers in the same package must not exceed:
- 100 grams where the lightest piece weighs between 180 and 400 grams
- 150 grams where the lightest piece weighs 400 grams or more

(iv) The provisions concerning sizing are not applicable to ‘short cucumbers’
IV. PROVISIONS CONCERNING TOLERANCES

Tolerances in respect of quality and size are allowed in each package for produce not satisfying the requirements for the class indicated.

A. Quality tolerances:

(i) ‘Extra’ Class:
5% by number of cucumbers not satisfying the requirements for the class but meeting the requirements for Class I, or exceptionally coming within the tolerances for that class.

(ii) Class I:
10% by number of cucumbers not satisfying the requirements for the class but meeting the requirements for Class II, of exceptionally coming within the tolerances for that class.

(iii) Class II:
10% by number of cucumbers satisfying neither the requirements for the class nor the minimum requirements, to the exclusion of produce affected by rotting or deterioration such as to make it unfit for consumption. Within this tolerance a maximum of 2% by number of cucumbers may have tips with a bitter taste.

(iv) Class III:
15% by number of cucumbers satisfying neither the requirements for the class nor the minimum requirements to the exclusion of produce affected by rotting or deterioration such as to make it unfit for consumption. Within this tolerance a maximum of 4% by number of cucumbers may have tips with a bitter taste.

A. Size tolerances

For all classes 10% by number of cucumbers not satisfying the size requirements. However, this tolerance is applicable to produce which differs by not more than 10% from the size and weight limits specified.

V. PROVISIONS CONCERNING PRESENTATION

A. Uniformity:

The contents of each package must be uniform and contain only cucumbers of the same origin, variety or type, quality and size (where required). For cucumbers in Class III, uniformity may be limited to origin and variety or type. The visible part of each package must be representative of the entire contents.

B. Packaging:
The cucumbers must be packed in such a way as to protect them properly. The cucumber must be packed sufficiently tightly as to avoid damage during transport. The materials used inside the package must be new, clean and of a quality such as to avoid causing any external or internal damage to the produce. The use of materials and particularly of paper or stamps bearing trade specifications is allowed provided that the printing or labelling has been done with a non-toxic ink or glue. The packages must be free of any foreign matter.

V. PROVISIONS CONCERNING MARKING

Each package must bear the following particulars in letter grouped on the same side, legibly and indelibly marked and visible from the outside:

A. Identification:
Packer and/or dispatcher / Name and address or officially issued or accepted code mark

B. Nature of produce
- ‘Cucumbers’ if the contents are not visible from the outside
- ‘under protection’ where appropriate, or an equivalent expression
- ‘short’ cucumbers’ or ‘mini-cucumbers’ as appropriate

A. Origin of produce:
Country of origin and, optionally, district where grown, or national, regional or local trade name.

B. Commercial specifications:
- Class and, as appropriate, for Classes II and III ‘crooked cucumber’
- Size (if the produce is sized) expressed in minimum and maximum weight of the cucumbers
- Numbers of units (optional)

A. Official control marking (optional).

(1) The use of this class is under review.
ANNEX 3. RECOMMENDED STORAGE TEMPERATURES

Recommended temperature and relevant humidity and storage life for fruits, vegetables and root crops.

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>TEMPERATURE</th>
<th>RELATIVE HUMIDITY</th>
<th>APPROXIMATE STORAGE LIFE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C</td>
<td>F</td>
<td>(PERCENT)</td>
</tr>
<tr>
<td>Apples</td>
<td>1-4</td>
<td>30-40</td>
<td>90-95</td>
</tr>
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<td>Apricots</td>
<td>-0.5-0</td>
<td>31-32</td>
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<td>Asian Pear</td>
<td>1</td>
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<td>85-90</td>
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<td>4</td>
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<td>85-90</td>
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<td>Bananas, green</td>
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<td>Barbados Cherry</td>
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<td>32</td>
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<td>Bean sprouts</td>
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<td>95-100</td>
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<td>Beans, green or snap</td>
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<td>40-45</td>
<td>95</td>
</tr>
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<td>Beans, Lima, in pods</td>
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<td>41-43</td>
<td>95</td>
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<td>Beans, bunched</td>
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<td>Custard apples</td>
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<td>Eggplants</td>
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<td>RELATIVE HUMIDITY (%)</td>
<td>APPROXIMATE STORAGE LIFE</td>
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<tr>
<td></td>
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<td>Yams</td>
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</table>

**RECOMMENDED REFERENCES**


8. **MEDLICOTT, A.** “Products specification and post –harvest handling for fruits, vegetables and root crops export from the Caribbean” Fintrac.