Production is only half the battle

A training manual in fresh produce marketing for the Eastern Caribbean

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FOOD AND AGRICULTURE ORGANISATION OF THE UNITED NATIONS
Bridgetown, Barbados
December 1988

Contents

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Foreword

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This Training Manual was prepared and reproduced under FAO Project PFL/RLA/001/PFL "The Reduction of Post-Harvest Losses of Fruits and Vegetables Entering the Inter-Island Trade.", and funded therefore by the FAO Action Programme for the Prevention of Food Losses. It is intended as a source of training material and general information on the subject of post-harvest technology and marketing of fresh produce appropriate to the conditions, commodities and needs of trainers and growers of the Eastern Caribbean.

The Manual is sub-divided into Sections, each of which describes the important principles and considerations of that particular phase or aspect of fresh produce marketing. In this way it is hoped that the complexities which are an everyday part of fresh produce marketing are more easily understood. At the same time it is recognized that not all trainers or trainees need exposure to the whole spectrum of activities from production to consumption and that most extension workers in the region are too busy to select and abstract their training material from a broad and more general text. Accordingly, trainers and extension workers should consider the Training Manual as a 'menu' from which

different 'meals' can be selected to suit different appetites or training needs on different occasions.

Throughout the preparation of this Manual, I have tried to keep to a simple, readable, and I hope, interesting style with the emphasis on the principles concerned and their relevance to real situations in the Eastern Caribbean. However, the subject material is complex and often the use of technical terms is the only way to properly describe the events or operations concerned. The Manual should not be considered anything more than an introduction to the subject of post-harvest technology and marketing of fresh produce and the references given in Section 12 are just a selection from many other possible sources.

Trainers are encouraged to abstract or reproduce the material in the Manual to suit their needs and those of the trainees. However, as with any reference material, the source should always be acknowledged.

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Since my first introduction to the Eastern Caribbean in July 1986 it has been my privilege and pleasure to meet and work with a great many people from all walks of life and from both public and private sectors. Without exception, all

have knowingly or unknowingly contributed to this Training Manual by way of information, advice or debate. I would like to think that this Manual is just the first step towards repaying my debt of gratitude to those concerned.

In particular, I would like to thank those who have worked directly with and for the project, especially Cornelis (Kees) Schuur and his wife Jacqueline for their patient support to the 'boss' over the last two years. Thanks are also due to the Consultants on the project and co-workers in the region, including: Bob Patterson, John Burden, Mike Griffin, Lynda Wickham, David Crucefix, Andy Medlicott, Hannes Bjarnason, Ian Marshall, and all those workers from aid and development organizations in the region who have helped in any way they could.

Finally, I would like to thank Mr. Frederick Zenny for his valuable advice, guidance and patience, and all of his staff at the FAO Representative's Office in Barbados for putting up with me and supporting the project for the best part of three years.

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1. Marketing of fresh produce in the Eastern Caribbean

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1.1. What is marketing?

When we talk about the 'marketing' of fresh produce we describe the entire process of directing the flow of goods and services from producer to consumer. This process includes not only the commercial transactions of buying and selling, but also the physical distribution aspects. For fresh produce, the physical distribution itself includes all the handling

and movement features of harvest, loading and unloading, grading, packaging, storage and subsequent dispersal through the markets to the consumers. In addition, marketing as an entire process also includes the vital auxiliary functions of production planning, production and dissemination of market information, financing of markets and their administration, the activities of marketing intermediaries, the provision of training and extension to individuals and groups involved in marketing, and research activities which seek to improve the marketing system in some way.

All marketing systems evolve to suit the needs of the consumers and the producers, depending who the producers are, who the consumers are, and, where they are in relation to each other in terms of distance, transport and communication links, and what the consumers preferences are and what they can afford.

The marketing process might be fairly simple where producers and consumers live close to each other in a rural reasonably self-sufficient area, and the farmer provides most of his own needs and sells the rest to the immediate community for local consumption. Under these circumstances the producers and the consumers preferences are likely to be almost the same and the consumers spending power not too different from the producer. Accordingly, there will be little delay between harvest and consumption and little need to resort to sophisticated or complex handling and distribution.

Alternatively, a small farmer in St. Vincent and member of a cooperative might be growing fresh ginger for export to England through a regional export agency with various buyers with different variety, grade and packaging requirements. Under these circumstances, the marketing of a single commodity can involve many different individuals and organizations, who are largely unknown to each other and yet mist communicate in a precise fashion if the ginger is to be grown, harvested, graded, packed and transported at the right times in the right way. If any of the people concerned do not do their job the ginger might not reach its destination in the right condition to make a sale and satisfy the consumers wants and needs.

Fresh fruits, vegetables and root crops, collectively called fresh produce, are inherently perishable commodities and their physical distribution through the marketing system often leads to considerable post-harvest losses, as shown in Figure 1.1., through quality downgrading, physiological spoilage (ea. rooting and sprouting), pathological spoilage

from pests and diseases, or simply from over-supply to a market that cannot absorb the volume sent to it. These post-harvest losses frequently occur because of inappropriate or inadequate application of the correct post-harvest practices and considerations, including production planning.

Figure 1.1. Post-harvest losses during fresh produce marketing

This manual was prepared specially for the Eastern Caribbean as a basic guide and training resource for extension workers generally, and for direct use by those groups and individuals active in the marketing and distribution of fresh produce in the region.

1.2. Who is involved in the region?

Figure 1.2 shows the main activities and principal participants involved in the marketing of fresh produce. Even at a glance, it can be seen that many different individuals are potentially involved although not all will be active in every marketing channel.

Figure 1.2. Activities and participants in fresh produce marketing

The Eastern Caribbean countries produce, consume and export many different crops but they also import considerable quantities of produce from elsewhere in order to meet the requirements of the tourist industry as well as supplying the produce needs of the local population during the off-seasons when produce would otherwise be scarce. The list of who is involved in marketing therefore becomes much larger to include import agents and producers and transporters and brokers from outside the region as well.

Many people forget all of the vital ancillary services and functions from financial institutions such as banks and credit unions who supply the credit for production as well as distribution activities. Shipping and insurance agents, customs officials and phytosanitary inspectors, hucksters and traffickers all play their part in the export, import and regional trade in fresh produce.

1.3. Marketing channels in the region

The producer of fresh produce in the Eastern Caribbean is faced with a variety of different options or marketing channels for their crops. Small farmers regularly grow small volumes of many different crops for subsistence purposes and then try to sell any surplus volumes on the domestic market. The consumers in this instance could be other farmers, friends and extended family, or other purchasers in the Public Markets in the capital cities and mayor towns.

The farmer may sell his produce to a wholesaler or trader/transporter who in turn may sell to domestic retailers or to hucksters or traffickers engaged in the inter-island trade. The volumes and quality of the produce to be sold will depend on whether the farmer regularly sells his produce this way or whether the sale is opportunistic as a result of a huckster, for example, taking advantage of a temporary shortage on another island and offering a better price than other buyers.

Figure 1.2 shows typical marketing channels for fresh produce grown in the region but does not of course include the marketing channels for imported commodities which usually involve the intervention of import broker/wholesalers and or statutory marketing boards or agencies supplying retailers.

Figure 1.3. Typical marketing channels for fresh produce

The tourist industry in many of the islands of the Eastern Caribbean offers particularly good opportunities for producers who can supply particular commodities to order for the hotel trade. Most farmers that demonstrate their ability to supply the right volume and quality on a regular basis can usually enter into contract supply for one or more hotels. In St. Lucia for example, there can often be a shortage of some types of produce in the Public Market and retail outlets yet the hotels will have a good supply from local sources provided on a contract basis.

Some farmers are actively engaged in the extra-regional export industry supplying markets in Europe, or Canada, or the USA. These producers, if they are to be at all successful, must plan their marketing strategy often well before they

plant their crops. The extra-regional markets will often demand a particular variety, grade and size of a commodity which is not wanted or needed by the regional and domestic markets. Once a grower has decided on this particular marketing channel, he may be locked into it for good or poor returns because the type or volume cannot be absorbed locally.

The marketing of bananas in the Eastern Caribbean is clearly the most important factor as far as most growers in the Windward Islands are concerned. However, since the production, packaging, assembly, transport and distribution is thoroughly well established through WINBAN and the Geest Organisation, little mention of this particular industry is included in the manual unless it affects marketing activities for other fresh produce.

1.4. Perishability of fresh produce

Fresh fruits, vegetables and root crops grown in the Eastern Caribbean offer the consumer a wide diversity from tropical, subtropical and even temperate commodities depending on the altitude and season in which the crops are grown. However, this diversity of type also means that the post-harvest characteristics are equally diverse. Most fresh produce is highly perishable and if it is to reach the consumer in the right condition it must be marketed properly bearing in mind the most suitable temperature and humidity for each commodity as well as appropriate packaging and handling methods. Failure to address these issues leads to stress to the produce rapidly followed by spoilage and losses.

This manual covers, in a step-wise fashion, the major activities involved in fresh produce marketing in the Eastern Caribbean. At every opportunity, emphasis is placed on the importance of post-harvest losses, how and why they occur, and what practical steps can be taken to prevent them occurring.

Figure 1.4. Causes of post-harvest losses

1.5. The need for extension and training

There are two vitally important factors involved in the post-harvest loss of fresh produce during its marketing and distribution:

i. Economics - If cost were no object then nearly all postharvest losses could theoretically be controlled. The practical reality however is that the production, distribution and sale of fresh produce is a business which demands that any improvements in the marketing must be paid for by the consumer and still allow reasonable profit margins for the growers and distributors.
   Considerable reductions in the post-harvest losses of fresh produce in the inter-island trade could be realized by the introduction of modern refrigerated freight liners and the use of stanadardised and appropriate packaging. However, the inter-island ships owners cannot or will not make such a large capital investment, the current vessels are not appropriate for improved packaging, and the value of much of the produce limits other forms of transport.
ii. Ignorance - or a lack of proper understanding of the need for improvements, and knowledge and experience of practical measures which can be adopted, constitutes a major obstacle to the reduction of post-harvest losses of fresh produce. However, unlike the factor of economics, ignorance can be overcome by a concerted extension and training programme.
   In recent years, there has been considerable attention directed to agricultural diversification in the Eastern Caribbean and particularly towards the production of fruits, vegetables and root crops for export to the extra-regional markets. Various workshops and seminars have been held to sensitive extensionists, exporters and producers to the need for improvement in marketing and distribution skills and practices. Some of these initiatives have resulted in the production of handbooks and guides for particular commodities, whilst other training activities have relied upon standard, but often irrelevant or impractical, international texts for the training of specialists. However, what has been lacking is the production of a specific and practical training manual for the Eastern Caribbean covering all aspects of fresh produce marketing.

The aim of this manual is to supply extensionists, distributors and producers with a practical and relevant guide to

improvements in marketing of fresh produce while focussing on the need for the reduction pf post-harvest losses. The manual emphasises the importance of management skills and the need for all involved to adopt a professional and business like approach to solving problems.

1.6. About this training manual

The manual has been prepared in a modular form so that different extension workers, trainers and direct users of the information and guidance can use all of the manual or just the parts they need. The manual in Just about all of its sections can only be termed an introduction to the subject. It is not intended to be used as a comprehensive manual for the training of specialists. Individuals seeking more detailed information are advised to read some, or all of the literature and references given in Section 12 of the manual. In addition, readers are directed to those individuals and nucleus-groups resident in each island and who have benefitted from specialist training in the past few years.

Section 2 gives an introduction to the natural features of fresh produce and focusses on the main reasons for spoilage and post-harvest losses. Accordingly, Section 2 is recommended to be included in all training programmes.

Section 3 concentrates on all the activities performed on the farm by the producer, beginning with production planning and production practices, before leading on to the questions of maturity, the harvest operation, and getting the produce ready for the market. This Section is particularly appropriate as training material for extension officers in the ministry of agriculture and for use by them in training farmers.

Sections 4 and 5 cover the increasingly important topics of packaging and packhouses. Both sections are fairly basic in terms of technical material and readers are strongly recommended to refer to other sources when contemplating selection of new packaging and/or designing and building packhouses. Section 4 gives an analysis of the packaging needs of the inter-island trade based on the authors experiences with FAO Project PFL/RLA/001/PFL. These two sections should prove useful to extensionists of all types but especially those working through national marketing agencies or boards.

Section 6 gives basic information and advice about transport of fresh produce by land, sea and air with a particular emphasis on the troubles of the inter-island trade.

Section 7 is particularly appropriate for training producers as well as wholesale and retail staff in the scope and purpose of the wholesale and retail industry and includes some practical advice on how to reduce post-harvest losses during distribution and sale and thus maximize profits.

Sections 8 and 9 offer more specialized information about storage and special post-harvest treatments for fresh produce, particularly that produce targetted for extra-regional export. It is hoped that all those expounding the virtues of storing surplus production without first considering the management and economic problems inherent with fresh produce storage will read Section 8 and think again before rushing into purchase of cold stores.

Section 10 is for use by extension workers and trainers involved in, or contemplating, training programmes in fresh produce marketing. Included in this Section is a review of the targets for training and training objectives, together with suggestions for alternatives to the now rather tired but still useful 'workshop' philosophy.

Section 11 lists some practical and often essential postharvest equipment for measuring environmental, chemical and physical parameters in the field - the sort of equipment needed by any organization involved in extra-regional exports. A list of possible suppliers and their addresses is included for guidance only, since many other equally reputable suppliers might be used.

Section 12 gives a bibliography of various texts, references and guides which may also prove useful to the extension worker and specialist reader. Again, the list is not exhaustive but concentrates on practical and relevant texts suitable for the Eastern Caribbean.

Finally, the Appendix gives a brief guide to some individual commodities produced and traded in the Eastern Caribbean with the emphasis on basic harvesting and marketing criteria pertinent to keeping post-harvest losses at a minimum.

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2. Fresh produce

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2.1. The living food

In most societies, starchy staple foods, particularly cereal grains, provide the main energy requirement of human diet. In certain areas, especially the humid tropics, root and tuber crops together with plantains and other cooking bananas are the staple diet, or are used to supplement the cereal staples.

Fruit and vegetables are important sources of minerals and vitamins and when eaten together with some of the root and leguminous crops (pigeon pea, beans etc.) can provide a proportion of human requirements of protein. In addition fruits and vegetables add variety and colour to what might otherwise be a monotonous diet.

Fruits and vegetables are living plant organs which when growing exhibit all the features indicative of plant life, such as respiration, transpiration, synthesis and degradation of chemical constituents, and possibly also photosynthesis as well. When harvested, the produce is at once removed from a source of water, mineral and organic nutrients, but it remains living as shown in Figure 2.1 (see Figure 2.1. Fresh produce remains living after harvest) below. Greening and sprouting of stored onions and root tubers, the sweating of produce in polythene bags as a result of transpiration and water loss, are just a few examples of this retention of living processes.

2.1.1. Energy Requirements

Starches and sugars, formed within the plant for its own use are used as energy foods by people. Starch is the main component of root and tuber crops, also of plantains and green bananas. Fruits and some vegetables contain sugars as an energy source. Oils and fats are also energy foods. Fresh produce contains only very small amounts of these, except avocadoes, which may contain 15-25% oil.

2.1.2. Food for Body Growth and Repair

Proteins are essential to the building and repair of muscles and other organs. They are required in large amounts by growing children.

Fresh produce is low in protein content, although on a dry weight basis some root crops such as sweet potato and Irish potato and leaves of several crops, have protein contents approaching that of animal products. Cassava has a very low protein content.

Minerals - Many minerals are required for healthy living but only in small amounts compared with energy foods and proteins. Sodium, potassium, iron, calcium, phosphorous and many trace elements are essential. Vegetables contain significant amounts of calcium and iron, and of some other minerals.

Vitamins - are essential for the control of chemical reactions in the body. Fruits and vegetables and to a lesser extent root crops, are important sources of Vitamin C and other essential vitamins.

Fibre or "roughage" - Fresh produce contains large amounts of indigestible fibres, known as "roughage". Medical research has shown that a high fibre content in the diet may reduce susceptibility to several diseases in man, notably heart disease. Thus a high level of fresh produce in the diet is considered to have a beneficial effect.

2.1.3. Post-Harvest Effects on Nutritional Value

The preparation of fresh produce after harvest will affect its nutritional value, for example:

i. The dry matter content (energy supply) is reduced with time as the continuation of living processes within the produce uses up stored food reserves.
ii. Vitamin C content decreases with time after harvest, little may be left in green leaves after two or three days.
iii. Cooking partially destroys vitamins C and B1. Raw fruit and vegetables are particularly valuable provided they are grown and handled hygienically.
iv. Peeling may cause significant loss of food value, especially in Irish potatoes and many other root crops where the protein and vitamin content is located immediately under the skin.
v. Minerals, including trade elements are dissolved out in cooking water, which is often thrown away.

Further information on nutritional value of fresh produce can be obtained from your local Nutritional Council.

2.2. Types of fruits and vegetables

Compared with all other foodstuffs, fruits and vegetables are characterized by an extreme diversity of size, form, structure and physiology (see Figure 2.2. diversity of fresh produce types and structures, over page). This diversity is a result of evolution and natural selection but some is of course due to breeding programmes in which the edible parts have been accentuated.

Fruits and vegetables are grown all over the world under many different conditions and thus have inherent structural and physiological features which enable them to function normally under the growing conditions for which they are adapted.

This diversity means that different types of fresh produce will react differently to the environment and its changes. Produce harvested from a farmers plot may endure many changes in temperature, humidity, and physical handling before the consumer prepares it for consumption. Therefore when we think about marketing of fresh produce we should also think about the physical and environmental aspects of marketing as well and remember what might be perfectly alright for one type of produce may be disastrous for another and different type of produce.

2.3. How and why spoilage occurs

2.3.1. What are the Causes of Losses?

All fruit, vegetables and root crops are still alive after harvest. They contain from 65 to 95 percent water, depending on the type of produce. For example, watermelons contain about 95% water, while potatoes, yams and other starchy root crops are from 65 to 70 percent water. They also contain food materials which enable living processes to continue. After harvest the continuation of living processes in the produce uses up both the water and stored food.

i. Water is lost from all produce. When the amount lost is from 3 to 10 percent (depending on the plant parts involved), the produce begins to wilt or shrivel up and cannot be restored to its original condition.
ii. At the same time water is being lost the food materials are also being used up.
iii. Loss of water and food materials means a loss in weight of the produce.
iv. Eventually the food and water reserves are completely used up and the produce breaks down and decays.

AS SOON AS PRODUCE IS HARVESTED THE PROCESSES LEADING TO BREAKDOWN BEGIN, AND CANNOT THEN BE STOPPED: THE RATE AT WHICH BREAKDOWN OCCURS CAN, HOWEVER, BE SLOWED UP AND LOSSES MINIMISED BY EMPLOYING THE CORRECT HANDLING METHODS AFTER HARVEST.

2.3.2. What Affects the Rate of Breakdown ant Loss?

The conditions to which produce is exposed after harvest govern its rate of deterioration. These are:

i. The temperature of the produce, which is related to the temperature of the environment, and the heat of respiration of the produce.
ii. The extent of damage inflicted during market operations, including physical and physiological damage.
iii. The moisture content of the environment.
iv. The effect of infection by decay organisms (e.g. fungi or bacteria).

2.3.3. Temperature Effects

HIGHER TEMPERATURE AFTER HARVEST MEANS QUICKER SPOILAGE.

An increase in temperature increases the:

- Depletion of food reserves necessary for normal living activity.
- Loss of the water essential for continued living activity.
- Breakdown caused by moulds and other rots causing decay.

The post-harvest life of produce is approximately halved for each 10øC rise in its temperature.

i. How does the produce become hot?

   a. Because it generates heat itself as a result of its own living processes. A mass of produce without ventilation will quickly produce a very big rise in temperature at the centre of the mass.

b. Exposure to the sun's heat causes a large temperature rise in produce at any stage after harvest.
c. Through exposure to artificial heat sources, often during transport,. (e.g. heat from ships engines, especially in inter-island vessels like wooden sloops - see Section 6.4.1.).

ii. How can produce be kept cools

a. Harvesting should be carried out during a cool part of the day, and the produce kept cool thereafter.
b. Harvested produce should be protected from the sun at all times. In the field natural shade of trees or simple pole and thatch structures without walls should be used to protect harvested produce. Transport should have a canopy to protect produce from the sun - but ventilation must not be obstructed.
c. Produce must not be stacked in compact piles or masses. Ventilation must be provided to disperse heat, taking advantage of prevailing winds where possible.
d. Use ventilated field and marketing containers, making sure that the ventilation holes are not blocked either by produce or due to an incorrect stacking pattern.
e. Forced air ventilation or refrigeration can be used to lengthen post-harvest life of produce but it is very costly and not recommended for general use.
f. Minimise time between harvest and consumption. It is always better wherever possible to move produce quickly from grower to consumer, avoiding the additional cost of storage.

iii. Chilling injury

Refrigeration is a potent method of keeping fresh produce cool but under excessive refrigeration, fresh produce will freeze at around -2øC and a return to higher temperatures leads to a breakdown of tissues and off-flavours and the produce is not usually marketable. Most tropical fruits and certain vegetables can also be irreversibly damaged by cool temperatures above freezing. This damage, known as 'chilling injury', is very important to the marketing of many fruits which if held below 14øC for any significant period will lead to tissue breakdown,

unsightly blackening and off-flavours. See Table 2.1, below for details

Table 2.1. Lowest safe temperatures and chilling injury symptoms in fruits and melons

Commodity	Lowest safe temperature		Type of injury incurred below safe temperature
	°F	°C	
Avocado	40 - 55	4.5 - 13	Blackening of pulp and peel.
Banana	55 - 60	13 - 15	Dull peel, brown streaking of peel, hardened placenta, off-flavour
Grapefruit	50 - 60	10 - 15.5	Scald, surface pitting, water-logging.
Lime	45 - 50	7 - 10	Pitting
Mango	50 - 55	10 - 13	Pulp and peel blackening, uneven ripening, off-flavour.
Melon	35 - 50	2 - 10	Pitting, decay, failure to ripen.
Orange	35 - 45	2 - 7	Pitting, surface browing.
Pawpaw	40 - 45	4.5 - 7	Pitting, off-flavour, failure to ripen.
Pineapple	45 - 55	7 - 13	Irregular ripening, "glassy spoilage, tendency to Endogenous Brown Spot.

2.3.4. The Effects of Injuries

INJURY TO PRODUCE AFTER HARVEST WILL HASTEN ITS DETERIORATION .

Injuries take many forms, including cuts, punctures, scraping of outer surfaces, internal and surface bruising, sunburn, heat damage and cold damage.

Their effect on harvested produce is to:

- Speed up the rate at which water is lost by as much as five times.
- Provide sites for attack by decay agents such as moulds and bacteria.
- Increase the rate of heat production at injury sites.
- Cause discolouration due to internal damage.
- Cause off-flavours to develop.

i. How are injuries caused?

a. Careless harvesting practices, such as knocking fruit to the ground from trees, damaging stem-end areas when harvesting, cuts from long finger nails or the jewellery of harvesters.
b. Through rough field handling of produce, such as dropping or throwing items into field boxes, dropping or throwing packed field and market containers themselves. (See Figure 2.3)
c. By using unsuitable containers with rough or sharp edges to ventilation holes, made from rough and splintered wood, carelessly made with protruding nails or staples, and containers too large to be handled easily.
d. From overpacking containers causing crushing of contents when they are closed or stacked, or underpacking so that damage is caused by excessive movement within the package. (See Figure 2.3. Causes of injury to fresh produce)
e. By people walking or sitting on produce in containers, or in bulk.
f. From exposure to the sun after harvest, resulting in sunburn.

g. From exposure to excessive artificial heat or cold (chilling and freezing damage).

ii. How can injuries be avoided?

The fragile nature of most fruit and vegetables products makes them very susceptible to injury, and the complete avoidance of such injury is not possible. However, damage may be reduced to a minimum by giving attention to:

a. Care in harvesting, especially with tree fruit, which are severely damaged if they fall or are thrown to the ground.
b. Being careful not to harvest wet produce, especially citrus fruit - because it is more easily damaged in this condition.
c. The selection of suitable field and marketing containers, which should not be too large for careful handling. They should be strong enough to protect produce but should not cause damage to produce due to sharp edges, poor manufacture or assembly.
d. The avoidance of overpacking or underpacking containers, which should be filled to an extent that will exert a slight pressure on the contents when closed. This will prevent movement of produce within the container.
e. The careful handling of produce at all stages, especially when in containers, which must not be rolled, dropped or thrown.
f. Transport conditions. Loads should be stacked in a manner which will prevent either the movement of individual containers or the collapse of the stack during transport. Riders should not be permitted on top of the load, especially when it consists of produce in bulk or in sacks. Vehicles should have a canopy to protect the load from the direct heat of the sun, but it should not restrict ventilation.

2.3.5. The Effect of Surface Water on Harvested Produce

The effect of the loss of internal water from the produce due to natural causes, excessive heat and injuries has been explained, but often the presence of free water on the surface of produce will also lead to problems, such as:

- Increase in post-harvest decay

This often occurs where produce is washed before packing. Most moulds and bacteria causing decay require free water to establish infection, particularly where injuries, even though small, are present on washed produce and the washing water is stagnant or recirculated. It may also be a problem where condensation occurs on the surface of produce when it is moved from cold stores to high ambient temperatures, or when produce is exposed to rain after harvest.

- Increased susceptibility to surface Injury

Produce saturated with water, from rain or other causes may become 'soft' and more easily damaged than when dry. This damage not only provides opportunity for infection by decay agents but may in itself leave unsightly surface damage, leading to down-grading and lower prices. This is often seen in citrus fruits, where fruit harvested when wet develop the skin blemish known as "oleocellosis".

It may not always be possible to keep produce dry but field crews should avoid harvesting freshly wet produce. Do not wash produce after harvest unless it is essential If it has to be washed it is usual to apply an anti-fungal dip immediately afterwards. The produce should then be dried in the shade, preferably on a mesh or slatted rack - this will help to cool it, especially if it is exposed to a breeze.

DO NOT PUT WET PRODUCE DIRECTLY ON TO BARE SOIL.

DO NOT PILE UP WET PRODUCE IN THE SUN TO DRY.

If produce has been in a cold room try not to remove it into a warm, humid and unventilated atmosphere. It should be

held under ventilated ambient conditions in the shade to prevent the accumulation of excessive condensation on its surface.

2.3.6. Ripening of Fruits and the Ethylene Factor

Fruits undergo a natural process of ripening and although this is an attractive and beneficial aspect as far as the consumer is concerned, the ripening process adds several complications to the marketing and distribution process. Many vegetables, such as tomatoes, melons, green peppers and hot peppers, are also fruits in that they undergo a ripening process as part of their development leading to senescence and death of the tissues.

The rate and nature of the ripening process differs significantly between species of fruits, cultivars of the same species, different maturities of the same cultivar (eg.'3/4 full' banana compared with 'full' banana), and also between production areas. Fruits may also differ in their ripening responses to postharvest conditions, Nevertheless, some general features are recognizable in the ripening behaviour of fruits:

i. Changes associated with ripening - these are:

- changes in texture and a reduction in firmness;
- colour changes, usually loss of green colour and an increase in red and yellow colours;
- changes in flavour and smell, usually becoming sweeter as starch is converted to sugars, and with the production of volatile and frequently aromatic compounds.

ii. Climacteric and non-climacteric - Basically there are two distinct patterns of ripening which can be identified and these are termed climacteric and non-climacteric types. (Specialists seeking detailed information are referred to the literature and references in Section 12, since only a brief coverage will be given here.)

In non-climacteric fruits the process of maturation and ripening is a continuous but gradual process. In contrast, the climacteric fruits undergo a rapid ripening phase when triggered by changes in hormonal composition. The onset of climacteric ripening is thus a well defined event marked by rapid increase in the rate of respiration and the natural evolution of ethylene gas by the fruit at a point in its development known as the respiratory climacteric. Figure 2.4 (see Figure 2.4. Respiration of climacteric and non climateric fruits) shows the differences between the two ripening patterns in a graphical form, and Table 2.2 gives listings of common climacteric and non-climacteric fruits and vegetable fruits.

The importance of the respiratory climacteric is that fruits such bananas may be held at a reasonable temperature when in the green state, but as they begin to ripen they will rapidly increase their respiration and generate much more heat. The consequence may be that this heating cannot be controlled and even more respiration will occur in an inflationary spiral rapidly leading to spoilage of the fruit in a very short time. Once climacteric fruits start to ripen, there is very little that can be done except to market them for immediate consumption.

Table 2.2. Classification of fruits and fruit vegetables based on climacteric and non-climacteric ripening patterns

	CLIMACTERIC	NON-CLIMACTERIC
TEMPERATE FRUIT	Apple Pear Peach Apricot Plum	Cherry Grape Strawberry
'VEGETABLE' FRUIT	Melon Tomato Watermelon	Cucumber

COMMON TROPICAL FRUIT	Avocado Banana Mango Papaya Fig Guava Passion fruit Persimmon	Orange Grapefruit Lemon Lime Olive Pineapple Litchi
LESS COMMON TROPICAL FRUIT	Cherimoya Soursop Breadfruit Jackfruit Mamey apple Sapote	Cashew apple Java plum Other Eugenia sp

Ethylene is present in all fruit and is recognized as the central fruit ripening hormone which, in climacteric fruits, can actually initiate ripening when present at concentrations as low as 0.1 to 10 parts per million (ppm). Non-climacteric fruits also respond to ethylene application by increasing their respiration rate but the actual ripening process is only triggered by the fruit itself.

As well as being involved in ripening and increased respiration in fruits, ethylene also plays an important role in all plant materials and is produced in response to stress from wounds and injuries. In other words, ethylene produced by wounding or stressing may also trigger ripening in the damaged fruit as well as the undamaged fruits around it. Damage one green fruit in a box and the the whole box load may ripen prematurely. For this reason, good ventilation of fresh produce with fresh air, refrigerated if necessary, is vital to ensure that ethylene levels do not build up to significant levels during storage and transport.

Ethylene can also adversely affect certain vegetables. Carrots for example develop bitter flavours, and parsley and

other leafy herbs will rapidly wilt when exposed to ethylene in stores and during retail display. It is important therefore not to mix ripening fruits with such sensitive vegetables at any stage in the marketing process. Retailers in particular should be careful about displaying fruits next to carrots and parsley or the vegetables will either spoil rapidly or develop bitterness.

2.3.7. Pests, Diseases and Spoilage

i. Pests - notably insect pests, are a serious problem during production of fresh produce which in the tropics must be controlled by the use of careful cultural practices and controlled application of insecticides provided that no harmful residues remain on the crop at harvest.
Infested produce at harvest is relatively easy to spot and separate from clean produce. The rapid marketing of most fresh produce also means that there is little opportunity for insect pest infestation provided that reasonable precautions are taken and that produce infested prior to harvest is rejected and not mixed with clean produce. Fruit flies are particularly difficult to control and keep away from harvested produce and is the main reason why the USA operates such stringent quarantine regulations.

ii. Diseases - Post-harvest infection of fresh produce by fungi and bacteria may cause physical injury, increased water loss and increased respiration leading to rapid deterioration and spoilage of the produce.
Bacteria multiply by rapid cell division and enter produce mainly through cut surface. or natural abscission points. Bacterial contamination of produce is most commonly by contact with infected water or by contact with soil harbouring the bacteria.
Good phytosanitary practices will help prevent most postharvest infections. Use clean and sharp knives and clippers at harvest and only use clean water for washing, and do not put cut surfaces, of cabbage for example, onto the ground.
Fungi multiply by cell extension and division and by forming spores for dispersal in air or water, or even by

various animal and insect vectors. Fungal infection of produce may result from entry into cut surfaces or natural abscission points as with bacteria, or by pathogenic entry of produce. Pathogenic entry of intact healthy tissue is confined to a few organisms and generally entry is via cut surfaces, or damaged or weakened tissue.
During storage, marketing and distribution, all produce will age and become weaker with a gradual breakdown of cell structure and integrity. The produce is thus stressed and less able to withstand invasion and infection by disease organisms. Alternatively, the produce being a fruit, ripening produces a sweet and readily utilizable food source for fungal growth. Ripening fruits are also weakened and easier to penetrate. Fungal spores present at harvest, but unseen, may thus germinate and spoil the fruit once ripening commences. This "latent infection" is typical of 'Anthracnose' and other similar fungal spoilage diseases.

2.4. Further information

The material as presented in this section is merely by way of an introduction to the various technical terms and considerations adopted by the fruit and vegetable marketing industry on an international basis. Far more information about the physiology of fresh produce, and how and why spoilage occurs, and how it can be avoided or controlled, can be obtained by reading the literature and references included in Section 12. In addition, readers of this manual are strongly urged to contact the postharvest specialists working in the Ministry of Agriculture in each island who have information and experience of the particular local postharvest problems.

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3. On the farm

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3.1. Before the harvest

The farmer or producer, by growing the crop in the first place, has already primed the need for a marketing process. The conditions under which the crop are grown, the cultural practices used, the variety of crop grown and when it was planted, will all determine:

- What the quality of the crop will be;
- When it will be ready for harvest;
- How big the harvest will be;
- How the crop will withstand the post-harvest abuses of the marketing and distribution process

You cannot improve the quality of any fresh produce after harvest. Thus the ultimate market quality of the produce is determined by the grower from the moment he selects the crop, the variety and the production system.

From an economic standpoint, you cannot grow fresh produce without various capital inputs for the purchase of seed, fertilizer and pesticides, Considerable time and labour is spent on land preparation, cultivation, irrigation, crop protection and eventually on the harvest of the produce. All of these inputs must be balanced by a good return from the marketing process, and the only way this can be achieved is by careful planning and management of all aspects of production.

3.1.1. Production Planning

The Gospel of production planning has been, and continues to be preached by all and sundry in the Eastern Caribbean region. Nevertheless, we are still seeing gluts and deficits in produce and farmers incomes depressed as a result. Most

of the farmers in the region have only small production areas, often on scattered lots which are difficult to get to, difficult to work and highly prone to erosion. Under these circumstances, there is clearly little or no scope for mechanization and an immediate limitation placed on the crops that can be successfully grown at a profit (this does not of course preclude crops grown for subsistence).

Yield is a worthy objective and it makes obvious sense to get the most out of your land with each crop, but when every farmer grows the same crop at the same time, high yield is an embarrassment with no market and a tremendous loss economically. Financial yield per acre, or hectare, is and should always be the register of success in production.

Production planning means a lot more than Just selecting the crop and variety to be planted. It means planning:

- the correct time of planting or sowing;
- crop spacing;
- type of inter-crop, if any;
- irrigation requirements;
- cultivation practices and frequency;
- pesticide application and frequency; (buying ahead and not waiting until a pest or disease problem appears)
- fertilization type, application and frequency;
- other cultural practices - pruning/training etc.;
- and of course, the time of harvest.

Failure to include crop marketing requirements as part of production planning can result in crop failure and poor quality for several reasons:

i. Markets can only accept limited quantities of highly perishable produce.
ii. When lack of planning causes the management needs of a growing crop to exceed the resources of the grower, the crop is subjected to various types of stress. Mineral deficiencies, inadequate water management and cultural

neglect eventually detract from product quality and may make it unmarketable.

iii. If a grower has limited resources for harvesting, field handling and marketing, it is necessary to stagger planting of annual crops such as vegetables and melons, so that produce can be harvested at the correct maturity. Okra left in the field for later harvest become fibrous and dry, and cabbage may burst its head under similar conditions, factors which will reduce quality and lower the price of the produce if it can be sold at all.

iv. Weather conditions during the planned harvesting period should be taken into account when planting. Onions cannot be harvested during wet weather unless artificial drying facilities are available, or sprouting and rotting will rapidly result in storage. Sweet potatoes should not be lifted in rainy conditions and from wet soil because they will de damaged, experience stress, and will rot quickly. If irrigation is not available, the absence of rain prior to harvest will result in lower yields or poor quality produce with correspondingly short market life and low value.

3.1.2. Crop Selection

The selection of the type of crop will be governed by several inter-related factors. If a grower has no previous experience of a crop he would be foolish to plant more than a few plants on which to experiment. If there is no domestic market for a particular crop for traditional reasons, and the grower has no facilities for export, again there is no point in growing that crop except for experimental or subsistence purposes.

The grower's soil and fertility will be deciding factors. For example, carrots and sweet potatoes give a higher yield with fewer post-harvest problems if grown on lighter soils that have not received heavy manuring immediately prior to planting whereas bananas require rich fertile loamy soils that have good water absorption properties but which drain freely.

Vegetable crops occupy land space for relatively short periods, but tree-crops are a more permanent investment and it

may be a question of years rather than weeks or months before the first harvest of fruit is obtained. This can present a serious cash-flow problem for the grower with limited credit facilities. Inter-cropping with annual vegetables or fast-growing crops may alleviate the cash flow problem e.g. planting papaw or hot pepper between rows of slower growing young citrus trees.

Seasonal conditions are probably one of the major deciding factors influencing crop selection. Many vegetable crops grow better with fewer pest and disease problems in the dry season provided they have adequate water and overcast skies do not shut out too much sunlight. However, with careful management these same crops may also be grown at other times of the year, and although capital inputs may be greater, this may be balanced by better market prices. (e.g. St. Kitts early potato production).

3.1.3. Varietal Selection

Varietal selection is frequently made on the basis of yield potential, disease resistance, or suitability for local conditions, and often without sufficient consideration of market preferences and post-harvest behaviour. Seed availability of the correct variety is still a very limiting factor in the Eastern Caribbean. For cash cropping purposes, the selection of the variety should follow a clear order of priorities:

i. The variety should be that which the particular market wants. If a suitable variety cannot be obtained which will yield satisfactorily under local conditions, then a different market must be found or an alternative crop grown.
ii. If more than one variety is available which meets market requirements, then the variety should be chosen which has the most favourable post-harvest characteristics.
iii. Yield and other agronomic factors should be taken into account if more than one variety meets the above criteria. It may be possible to grow two or more varieties of the same crop at the same time and perhaps benefit from an extended harvesting period.

Crops grown from poor, stale or diseased seeds or planting material rarely thrive and the resulting produce will be of poor quality.

3.1.4. Production Practices

Production practices require as much planning as other factors because they often involve capital and labour costs, but more importantly because they influence the production quality of the produce and thus the potential post-harvest life and marketability of the crop.

i. Irrigation

Irrigation increases crop turgidity at harvest but depending on commodity, stage of maturity and other factors, may make the crop more susceptible to bruising and splitting. Over-irrigation and under-irrigation are a double-edged sword and either can reduce yield, quality and marketability of the crop.

Over-irrigation of cucumbers and melons increases fruit size but leads to greater losses due to decay, both before and after harvest, and reduces the intensity of the fruit flavour. Under-irrigation of the same crop improves fruit flavour, but yields are reduced and growth cracks are common. Over-irrigation of leafy vegetables prior to harvest may increase their turgidity but will also make the leaves more brittle and susceptible to handling damage.

Un-irrigated grapefruit grown under dry conditions will have a low Juice content and develop a thicker peel. The low Juice content of grapefruit may mean a delay in harvesting due to lack of irrigation and this leads to reduced storage life of the fruit, but also greater rejection rates at harvest because of field blemishes. Conversely, harvesting of all types of citrus immediately after irrigation, when the peel cells are fully turgid, increases the incidence of oil spotting, and prevents their export to extra-regional markets.

ii. Cultural practices

Crops growing in competition with weeds may suffer from both water stress and mineral deficiency leading to lower yields and quality. Weeds may also harbour pests and diseases which attack the crop, detract from its appearance and increase the incidence of postharvest spoilage. Failure to prune out Jagged, dead wood in citrus trees makes harvesting difficult, harbours decay organisms and causes physical injury to the fruit, both before and during harvesting. Such damage and latent disease infection are major causes of quality downgrading and storage losses in citrus and many other tree fruits. Lack of careful land preparation and maintenance of channels in furrow irrigation of crops may cause one end of the crop furrow to be over-irrigated and the other end under-irrigated.

iii. Fertilisation

Soil fertility has a direct effect on all aspects of crop growth and development. In some cases, post-harvest disorders can be linked directly to the deficiency of a particular mineral, but often other environmental factors such as water stress are involved. "Spongy tissue" symptoms in mango have been linked to mineral deficiency, and copper and iron deficiencies cause abnormal peel development in citrus fruits.

In general, fruits and vegetables growing under low fertility conditions are slow to mature, have a greater tendency to develop abnormal shape, do not store well, and ripen irregularly after harvest.

FERTILISER - YOU ONLY GET OUT OF A CROP WHAT YOU PUT IN!

iv. Chemical treatments

All chemicals applied to growing fruits and vegetables have an effect on quality, and in some cases are applied specifically for their effect on post-harvest behaviour.

Chemicals applied to fruit and vegetable crops are of two types:

a. Pesticides -- including insecticides, fungicides, and nematicides, are applied primarily to protect the crop and should therefore improve its quality potential. Their effect is also to reduce insect and fungal damage which detracts from the appearance of the crop and increases storage losses. In some cases, for example the development of 'Anthracnose' spotting in mango, it is necessary to spray with fungicide during growth even though the disease itself may not be seen until after harvest. By removing weed competition, which may impose water stress and mineral stress, herbicides can also have beneficial effects on postharvest behaviour.
   Since all crop protection chemicals are toxic to animals and humans, they must be applied in concentrations which will not allow toxic residues to build-up. A safe period specified by the manufacturers must be left between final application and harvest. Produce exported to developed countries is rejected if tests reveal pesticide residues above the permitted level.
   Careless application of herbicide between rows of crops, and spray mists blown over from neighbouring fields, can cause irreversible damage to a growing crop, usually in the form of external blemishes and discolourations which reduce market value. Severe damage by herbicides may lead to gross deformities of the produce and possibly total crop loss.
   Pesticides are of little use in combating bacterial wilt diseases (e.g. 'Moko' disease in banana) and virus infection. The only solution in these cases is removal and burning of the infected plants and possibly sterilization of surrounding soil. (With Moko disease, the herbicide glyphosate ('Roundup') is used to kill all host plant tissue and not to 'kill' the disease!)

b. Growth regulators -- have a widespread use on fruit crops, causing physiological changes which will improve marketability. For example, "Ethrel", an ethylene releasing compound may be applied to pineapples just before harvest to stimulate uniform ripening. "Gibrel", a gibberellin formulation is sprayed on citrus orchards to delay flowering and thus extend the harvest season. However, the use of

growth regulator chemicals is not straightforward, and incorrect application may either give no effect (and be a waste of money) or a harmful effect, e.g. "Ethrel" can increase acidity and cause excessive softening of pineapple if incorrectly applied.

3.1.5. Maturity for Harvest

Much research has been carried out on determining the correct stage for harvesting a crop. Reliable technical tests have been developed for important commercial crops such as citrus and pineapples grown on a large scale under more or less uniform conditions. These tests are, however, mostly dependent on laboratory and field tests requiring costly equipment and technical skills which are out of the reach of small scale growers with limited resources.

In the Caribbean where multiple cropping on small acreages accounts for a large proportion of fresh produce production, decisions on when to harvest are not made on technical test but on the individual's evaluation of when the crop is in good enough condition to be harvested, and sold to realise the best price.

A major factor influencing this decision is the price which can be obtained at any given time, which frequently leads to crops being harvested before or after they are at their best in order to get a good price. This practice is not confined to the Caribbean, or indeed to less developed countries.

HOW DO WE KNOW WHEN A CROP IS READY FOR HARVEST?

Two characteristics are normally used in deciding crop maturity, both very dependent on the experience and personal opinion of the grower.

Observation, or looking for characteristic signs of readiness such as:

- size and shape
- colour
- texture, hardness and softness.

Sampling of characteristic specimens and testing by:

- smell
- taste

Some crops, such as cabbage and yam, are acceptable for consumption over a wide range of development and selection for harvest is often more dependent upon price and the size preferences of the market.

Other crops, as seen in Figure 3.1 (see Figure 3.1. Commercial maturity for different fresh produce) below, must be harvested at a specific maturity or they will be unmarketable for reasons such as poor flavour, high fibre content, and/or rapid postharvest deterioration.

Pineapple for local consumption and for canning is generally harvested at around the 2530% yellowing stage of the fruit, whereas fruit for export may be either totally green or more normally just showing the first signs of yellowing at the basal end. Mango harvest criteria can vary with local consumption patterns and distance to the market. Time from flowering combined with fullness of mango cheeks are the commonest criteria.

Producers must decide whether to harvest as soon as the market price ensures a reasonable return, or to leave the crop in the field to obtain maximum yield. However, waiting too long for yield increase may drastically shorten the marketable life of the produce and lower the sale price. This balance is a critical factor in determining the growers income from the crop. In practice the total harvest period is very short and the grower has very little time in which to make the correct decision.

With vegetable field crops such as green beans, okra and tomato, the harvest once begun, must be continuous in order

to pick produce at the same stage of maturity to give a consistent supply to the market.

3.2. Managing the harvest

3.2.1. Harvesting Objectives

The objective is to harvest the crop without damage and to get it to the market in the best possible condition. Although the scale of production, availability of labour and type of produce may vary, certain basic factors must be taken into account in the planning of any harvest operation. Equipment must be obtained, labour organized, and marketable produce identified for harvesting, collection and removal from the field. Each of these tasks must be planned, managed and implemented efficiently if the value of the crop is to be fully realised.

Harvest management has four components:

i. Good production planning -- to ensure that crop maturity coincides with market demand.
ii. Continuous communication with buyers -- to identify their exact requirements as harvest time approaches, but also to let the buyers know the best time of harvest and expected quality.
iii. Forward planning -- to coordinate equipment, labour and transportation.
iv. Field supervision -- to apply the most appropriate combination of handling techniques. The efficiency of the harvesting operation itself depends upon the use of experienced or trained staff, and the adoption of methods which will meet the buyers requirements. The central objectives should be:

- to move the crop from field to buyer with the minimum number of handling operations compatible with the quality requirements of the buyer;
- to minimise exposure of the crop to stresses such as extremes of temperature, or of compression pressures caused by over-loading. If harvested clean, the produce should be kept clean and not stacked on the soil, even momentarily.

Good management of the harvest operations is usually reflected in the speed at which produce moves from field to market place, packing station or storage centre, provided that is not at the expense of careful handling and subsequent quality downgrading

3.2.2. Labour

Training and supervision of labour are critical to a successful harvesting operation. Constant supervision is necessary to maintain quality and reduce subsequent spoilage of produce. Training is required in both general principles and crop specific techniques relating to maturity selection, detachment method maintenance of equipment, field hygiene and division of labour. Some of the more important areas are:

i. Division of labour

Teams of workers must work systematically through a plot or field, experienced staff removing the crop and others carrying it to collection points. If crops are relatively inaccessible, as with older mango, avocado and breadfruit trees, great care must be taken by pickers climbing in the trees if fruit is to be harvested free of damage. Whenever possible, planting densities and pruning techniques should be chose which minimise tree size.

ii. Produce selection

It is essential that crops are harvested at the correct size and maturity for the market. The workers must be given strict specifications before entering the field and each worker's performance carefully supervised.

iii. Method of detachment

Careful instructions must be given on the correct method of cutting, twisting or pulling to remove a crop, and the performance of each worker checked.

iv. Mishandling

During long harvesting sessions, some individuals develop habits of slapping, pressing and rubbing produce. Others become tired and start to throw or drop produce into field containers. Such practices can cause damage to the produce and should be controlled by checking performance, by restricting the lengths of shifts worked, and by promoting comfortable working conditions.

v. Jewelry

Sharp edges on rings and bracelets, and long fingernails, are significant cause of postharvest abrasions and should be removed before harvesting starts.

vi. Field hygiene

Unmarketable produce must not be left in the field to rot and contaminate healthy standing crops. Routine collection of waste is an important part of the harvesting operation, and all workers can contribute to this. Cleaning, sterilization or replacement of picking containers must be carried out regularly to prevent the build-up of infection.

vii. Equipment

Each individual should be issued once only with necessary equipment and given clear instruction and training in its maintenance. It should then become that individual's responsibility to keep knives and clippers both clean and sharp, and to keep other equipment such as boxes, poles, nets and bags in a good state of repair. Blunt and dirty knives and clippers are potent sources of bacterial soft-rot contamination of both

fruits and vegetables.

3.2.3. Harvest Maturity

Optimum commercial harvest maturity of fruits and vegetables is covered in Section 3.1.5. of this manual as an essential preharvest consideration. However, it is just as important that the state of maturity is maintained throughout the harvest period. Failure to do so will lead to inconsistency of produce quality and to lowered market prices.

3.2.4. Time of Harvesting

The time of day at which to harvest will depend on the availability of transport and other facilities, weather and environmental conditions and human factors, as well as market demands and quotas. The factor which assumes greatest importance depends upon the crop and the local situation.

i. Environmental -- most crops are coolest, freshest, and therefore in the most favourable condition for handling, early in the morning. In some areas, where markets need night transportation, it may be advisable to avoid harvest during the middle of the day. Produce harvested early in the morning, then stored under ventilated shelter until evening loading. However, this must be balanced against the possibility of local heavy dew or early morning rains which could have detrimental effects. Packing of wet produce often leads to greater post-harvest spoilage and fully turgid tissue can bruise or split more easily.
ii. Transportation -- since harvested produce standing in the field usually starts to deteriorate rapidly unless specialized facilities are available, it is unwise to start harvesting until transportation is assured.
iii. Destination -- if the crop is to be transported to a relatively distant market, storage centre, packing station or

processing facility, harvesting should be timed to allow for delivery at a convenient time.

iv. Labour--harvesting can only take place when sufficient labour of the required skill and strength is available. Thus the distance which workers must travel, their domestic, religious and sometimes social arrangements may have to be considered.

3.2.5. Harvesting Techniques

The method will vary according to the types of commodity described to be harvested. Additional information on specific commodities can be found in the Appendix to this manual.

(i) Root and tubers - like sweet potatoes, yams, cassava and ginger, may be completely buried in the soil, or may be partly visible above the soil surface, as in dasheen, carrots and turnip. Those which develop below soil level, if they are small, are best grown in mounds or raised beds, so that a digging tool can be easily pushed underneath to lift them when they can be freed from the soil without damage. (see Figure 3.2. Harvesting root crops with a fork).

Dasheens, carrots and other partly buried crops can also be lifted in this way or, if soil conditions are right, be pulled by hand.

Larger roots or tubers, such as some types of yams and cassava, are harvested by carefully scraping away the soil from above and around them by hand.

Tools used to lift root crops are a matter of personal choice and/or tradition. As shown in Figure 3.3. (see Figure 3.3. Harvesting tools for root crops) below, they include: digging sticks, cutlasses (machetes), hoes or digging forks. Always use sharp instruments with great care so as not to wound or cut the produce because this will give rise to rapid spoilage by soil-borne pathogens.

(ii) Leafy vegetables. bulbs and flowers - These will include leafy vegetables like callaloo and spinach in which individual leaves are picked by hand, or lettuce and cabbage where the main stalk is cut through with a sharp knife. Cauliflowers are also harvested by cutting the main stalk of the plant, but with broccoli the flowering shoots are usually broken off by hand and then trimmed with a sharp knife if necessary.

Bulbs, such as mature bulb onions and garlic are usually harvested like root crops, by pushing a digging tool under them and levering them up to free the roots from the soil, or again, they may sometimes be pulled by hand.

Tools used are, the hands, sharp knives or digging tools. When knives are used they must be kept sharp, clean and free from soil, or they may contaminate cut surfaces and cause bacterial soft rot.

The cut or broken ends of stems should NEVER BE PLACED IN DIRECT CONTACT WITH THE SOIL, NOR PLACED IN CONTAINERS CONTAMINATED WITH DIRT OR DECAYING PLANT MATERIAL.

(iii) Fruits --Harvesting methods for fruits are variable and depend to some extent upon whether they are immature, mature green or ripe when harvested:

- Mature or ripe fruits with natural stem 'break points'

Some fruit, such as passion fruit and tomatoes have a natural 'break-point' at which they can easily be removed from the parent plant, leaving the fruit stalk attached to the fruit. These are usually harvested by hand using the 'lift, twist or pull method', (see Figure 3.4. Harvesting tomato by the lift and twist method). Passion fruit, however, may be left on the vine until fully ripe and harvested by shaking the trellis on which they grow, causing ripe fruit to fall to the ground, from where they are gathered. They suffer little or no damage due to the hardness of the outer "shell".

- Mature green or ripe fruit not readily detached with the fruit stalk intact

Many tree fruits fall into this category, including mango, citrus and avocado. These fruits are best harvested using

clippers, and placed in harvesting bags carried by the harvester. Figure 3.5. (see Figure 3.5. Harvesting aids and tools for tree fruits) illustrates various aids and tools for harvesting tree fruits.

With large trees, such as mature mangoes and avocadoes, fruits are harvested by the use of picking poles, with or without attached clippers, equipped with bags into which the fruit fall. This method is rather slow and requires considerable experience and skill, but is essential if high quality fruit is required.

Alternatively the fruit is picked by the harvester either on a ladder, or who climbs the trees, and throws the fruit to a skilled 'catcher' on the ground, or into a large net. (A good method for breadfruit!). Pulling out of stems from fruit when harvesting has to be avoided at all costs because broken skin at the point of attachment of the stem is particularly susceptible to a decay condition know as STEM END ROT.

- Immature fruit with soft stems but no natural breakpoint

Many fruits are eaten in the immature state, some as vegetables or salads. They include sweet peppers, papayas, cucumbers, okras, eggplant and christophene (chocho).

Fruits of this type are usually harvested by hand by snapping the stem, or cutting it with a sharp knife. Where knives are used they should be kept sharp and free from contamination with soil.

Breaking off the stem instead of cutting is not recommended because the rough break is more susceptible to the establishment of infection by decay organism than a clean cut.

Immature green legume pods such as green beans and peas have a short fruit stalk which can usually be easily broken away from the plant.

NO MATTER WHAT HARVESTING METHOD IS USED CARE MUST BE TAKEN TO AVOID INJURY TO PRODUCE.

3.3. Getting produce ready for market

Once produce is harvested it should be prepared, sorted and assembled together for transport to the market, packhouse or storage area as soon as possible. This stage of getting the produce ready for the market should be thoroughly planned, as with all aspects of fresh produce production and marketing.

3.3.1. Preparing and Sorting in the Field

Much of the required preparation and sorting of produce can be done during the harvest operation itself. Scarred, pitted, over-ripe or otherwise deficient produce can be placed in separate harvest containers or discarded completely and removed from the field later. More rigorous preparation such as washing and critical size or ripeness/colouration selection may be better performed in a packhouse, as described in Section 5.2. of this manual. However, for most of the crops harvested in the Eastern Caribbean the requirements are generally only for simple sorting and packing in the field, or assembly of the produce prior to collection and transport.

There is a growing tendency towards the practice of packing produce directly into final marketing containers in the field, reducing the number of times the produce is handled with a corresponding reduction in the amount of injury caused. This practice however requires that appropriate selection and packaging facilities are set up for the purpose, together with adequate supervision.

Whatever the process, assembly of the produce is always necessary, and like putting all your eggs in one basket, it is often the point when troubles or problems first arise.

As with all aspects of post-harvest, the objective of assembly should be to develop a system which minimises stress on the produce and keeps handling operations to a minimum but with maximum care and to keep the time between harvest and first destination of the produce as brief as possible.

Clearly, reaching such an objective does not happen by accident, but only by carefully planning the assembly process as carefully as all other operations are planned.

3.3.2. Field Assembly

What do we mean by ASSEMBLY?

An aggregation and bringing together of like commodities for the purpose of transport and/or wholesale marketing.

Unless field plots are very small, it will be necessary to assemble the harvested crop in preparation for transport. Interruptions in the harvesting operation due to rain or other reasons, can and will occur.

Field assembly should be planned bearing in mind the best location and the provision of basic facilities.

i. Shade and shelter - OUT OF THE SUN AND RAIN.
ii. Storage - OFF THE GROUND and NO BULK-PILING.
iii. Distance to assembly - If harvest crews have to walk long distances with the produce they will get tired more quickly and handling damage will increase.

3.3.3. Field Crates and Containers

Harvested produce may be transferred from the harvest containers into field containers, for transport to a packing house, or in some cases for transport direct to local markets.

- Wooden crates made of boards or slats, with a capacity of up to 25 or 50 kg for manual handling. If the wood used in such crates is rough sawn then sharp edges or splinters may cause damage to the contents, especially if the full crates are carelessly handled. Wooden crates are usually returnable or re-usable for local marketing operations. However, rough handling methods usually limit their usage to very few occasions, sometimes as little as three to five return journeys.
- Plastic crates are now in common uses Most are made from high density polyethylene which contains ultra-violent inhibitor (UVI), which extends the life of the container when it is exposed to sunlight.
  CONTAINERS FILLED WITH PRODUCE SHOULD NOT BE LEFT EXPOSED TO SUNLIGHT.
  Plastic returnable crates have a longer life than wooden ones because they are more durable. They are usually made to pack inside each other when empty to save space during transport and storage. Their usefulness as multi-purpose containers makes them liable to heavy losses.
- Sacks and net bags made from natural or synthetic fibres are commonly used where low value or more durable produce, such as root crops or dry bulb- onions are transported direct from grower to market. They are relatively cheap and require little storage space and usually provide good ventilation to their contents. However, they give little protection to their contents and when made from synthetic fibres tend to disintegrate when exposed to sunlight.

3.3.4. Transport Out of the Field

To get the produce from harvest point to a collection point by the roadside may involve passing over one or more kilometers of farm roads. Growers rarely give sufficient attention to the logistics of this operation and then wonder why they get problems. In the Eastern Caribbean, this problem is compounded by the topography. In many cases 'heading-out' or mule are the only alternatives and crates may not be as suitable as sacks.

If you can get a vehicle in close to the field it should not be overloaded (as is often seen with banana pick-ups) and it should have good suspension and with preferably larger wheels and lower tyre pressures to take out some of the jolts.

VEHICLES SHOULD BE DRIVEN SLOWLY!

Packing between vehicles and crates with soft straw or leaves can help cushion the blow but make sure it is clean. Why infect healthy produce with dirty packing material?

DO NOT RIDE ON TOP OF THE PRODUCE!

Is the vehicle shaded from both sun and rain? If the produce is covered with a protective tarpaulin or similar, does it prevent ventilation of the produce?

Often the above points are overlooked because the operators argue that the produce does not have far to travel and the produce is not expected to be on the vehicle for long. Unfortunately, drivers do have the habit of making unscheduled stops during their journeys. They may stop for lunch on the way, or to speak to their friends/girlfriends, and often the fact that the pick-up is parked in the full sun is forgotten.

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4. Fresh produce packaging

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4.1. What is a package?

A package is created when fresh produce is brought together and contained. The package could conceivably contain different types, sizes, grades, or stages of maturity of produce. The important thing to remember is that the reason for bringing the produce together in the first place is to create a more manageable unit for conveying more than one item of produce in one handling step instead of several.

The question is not so much what is a package, but rather what should a package do, what different types of package are there, and how do we choose the right package? These and some other questions are tackled below, but for a more comprehensive coverage of the subject interested parties and extension workers are referred to "Packaging for Fruits, Vegetables and Root Crops" by Cornelis Schuur (see Section 12 for reference details.).

4.2. What Should a Package Do?

4.2.1. It Should Contain the Produce!

A package should above all other things be a container for produce and create a more efficient handling unit which can be easily be handled by one person. Clearly there are some packages in everyday use in the Huckster and Trafficker trades which do not fit this description because they may take two or more people to handle them effectively.

The package should provide a more convenient and efficient unit for the marketing of produce and allow for the weighing of produce as well as handling and transport to be accomplished in fewer steps.

4.2.2. It Should Protect the Produce!

The package should protect the produce at all stages of the marketing process from the producer to the consumer.

Fresh produce is inherently perishable and needs to be protected particularly from mechanical damage inflicted during handling. Mechanical injury to produce, including cuts, compressions, impacts and vibration rubbing, will all lead to wounding and bruising of the produce and will seriously shorten the marketable life of the produce if not totally ruin the produce.

Careful harvesting and subsequent handling of the produce will eliminate most of the risks associated with cutting and wounding of the produce. In addition, the package containing the produce should not have sharp edges or corners, and nails and staples carefully placed so as not to pierce the produce.

Compression bruising of produce can be avoided by packaging in containers strong enough to withstand multiple stacking. Particularly delicate produce such as most fruits should be packaged in shallower containers such that the weight of the upper layers of produce do not crush those below. With any produce, the package should never be overfilled. The practice of many Hucksters/Traffickers is to overload their giant-sized crates and then sit on the lids to cram the produce down while an assistant nails the lid shut. This will cause serious loss of the produce and probable loss of the trade!

Impact damage to the produce is mostly caused by dropping or throwing the package, and by shocks in transport caused by excessive braking and accelerating and by driving too fast over bad roads. Dropping and throwing can be eliminated by using packages which are easily handled by one person. The package should never exceed 50kg and preferably not exceed 25kg and should have built in handles.

Vibration rubbing of produce results from transportation vibration transmitted to the package and causes abrasions ranging from light rub marks to removal of skin and flesh.

To prevent vibration rubbing, the package design should follow two important principles:

- individual produce should not be able to move, once packed, with respect to each other or the wall of the package;

- the package should be full without overfilling, and should not be packed too tightly and with unnecessary force.

This may be achieved by including specially shaped liners in each package which conform to the shape of the produce, or by wrapping each individual item in tissue paper or some other like material. Citrus is often packed loosely and then lightly vibrated on a special rig which settles all the fruit down before the lid is applied with enough pressure on the produce to keep it in its place but without injury.

Packaging also has a role to play in acting as the interface with the environmental conditions experienced during marketing. Fresh produce must be ventilated or it will die from lack of oxygen, fruits such as bananas must be ventilated in the package if they are to be ripened with ethylene. However too much ventilation may cause drying out of the produce, or chilling of the produce in a cold climate or over-cold storeroom. Accordingly, the package design must incorporate ventilation suitable for the marketing and distribution system targetted.

4.2.3. It Should Communicate the Contents!

The package should be labelled in such a way that its contents are clearly understood. For the extra-regional export markets, and ideally for the regional and domestic markets as well, the package label should include the following information:

Communicate the Contents

- country of origin;
- name and address of grower and exporter;
- brand name (if any);
- description of contents (product, variety, size class, quality grade);
- gross weight;

- net weight or count (i.e.. how many units in the package);
- overall dimensions of the package;
- full name and address of the receiver.

The labels, for whatever market, should be printed clearly in waterproof ink on the outside of the container, usually on the short sides of the package. If the labels are hand written they should be in block capitals.

In the highly competitive extra-regional markets, where large volumes of produce and many thousands of packages are being constantly moved, it is vital that each package is properly labelled but equally important that your exports catch the buyers eye when he/she is busy and has a great deal of choice. Many exporters from all over the world have resorted to the use of multicoloured graphics and artwork to decorate their packaging purely to make it stand out from the crowd of rather plain brown Kraft paper packs sent from less marketminded exporters. Locally, the Caribbean Agricultural Trading Company (CATCO) has reported very favourable response from their brightly coloured packs for high value produce.

Clearly, the export marketing of fresh produce has entered a "cosmetic" phase where considerable investment is made in design of appealing logos and graphics none of which offer any physical advantages for the produce but help ensure market attention. Nevertheless, such is quality control in the extra-regional markets that the package must not only look good from the outside, it must contain produce which is up to an acceptable quality standard, or the bright distinctive label will become a signal for rejection by the buyers rather than the intended appeal.

The extra-regional markets now handle most produce in the form of palletised loads where packages of the same produce, pack design and origin are stacked in a tight pattern on a wooden pallet and moved by fork-lift trucks. The buyers and wholesalers are not often dealing with produce or even with individual "boxes", but with labelled stacks on pallets which may not be inspected until they reach a retail outlet.

4.3. Different Types of Package

There are many different types of package in use throughout the world, many of which have been carefully evaluated with respect to produce and market systems, while other types have often been adopted for general use without evaluation. Package types include sacks and nets, wooden crates, cartons or fibreboard boxes, plastic crates, baskets, pallet boxes and other such shipping containers. The uses, advantages and disadvantages of each of these packaging types is described below.

4.3.1. Sacks and Nets

Sacks and nets of various description, sizes and materials are in widespread use in the Eastern Caribbean for the domestic and regional marketing of many root crops such as sweet potato, dasheen, eddoe, yam, carrot, other crops such as pumpkin and fruits including citrus. the material used for the sacks may be woven natural fibres or more commonly nowadays the synthetic materials especially polypropylene or polyethylene. One of the most popular sacks in use in the Eastern Caribbean is the so-called " crocus bag".

Sacks are the cheapest form of packaging available, and are often used several times over, being easy and cheap to return. The sack occupies very little space itself, which gives some advantage to the shipper in the regional trade. However, cheapness is the only advantage that sacks have over other forms of packaging.

The disadvantages of sacks as packing materials are considerable. They are difficult to clean and sterilize and allow the build-up of decay organisms during multiple use. The lack of rigidity of sacks means that they offer no support for the produce, and when stacked do not prevent compression of the produce. Often the sacks used are too large to be conveniently handled and tend to be thrown rather than placed. Most of the sacks in use, particularly the "crocus bags", have a mesh size too small to allow proper ventilation of the produce. Sweet potato shipped in sacks are often broken and rotting by journey's end.

4.3.2. Baskets

Traditional round wicker type baskets have been used in Grenada for many years for exports to Trinidad and are still in common use. The baskets have the advantage that they are relatively cheap and are made from locally available and readily renewable resources. In addition, because of their spherical shape they may be rolled around if they are too heavy to lift. However, this rolling around is one of the worst features of the basket because the weight of the produce inside distorts the shape of the basket and the produce is alternately rubbed against the rough interior and crushed by the produce around it. The basket offers extremely little protection to the produce when several baskets or other containers are stacked on top of each other.

The basket also provides a suitably opaque container for contraband and this factor alone may prove to be its downfall in the Trinidad market because of extra attention from Customs officers, increased handling damage from the inspections and possible future legislation.

4.3.3. Wooden Crates

Wooden crates are widely used by the Hucksters and Traffickers in the inter-island trade in fresh produce. There are no standard sizes and designs in current use except for the wire-bound veneer crates which were obtained in Trinidad (actually used to import Irish potato into Trinidad from the Netherlands) for a short while. The normal procedure is for the traders to make up their own crates, typically from broken down pallets, with the result that the crate may be up to one cubic metre in dimension and weighing many kilograms empty. The size of the crate offers advantages to the traders in that the shipping cost is less on the inter-island schooners than for several smaller containers with the equivalent volume.

Wooden crates are relatively resistant to different weather conditions and to sea-water, and offer good ventilation for the produce. In addition, wooden-crates are often the only suitable container for very large commodities such as water

melon.,/font><-p>

The disadvantages of wooden crates are chiefly concerned with the material itself. Untreated wood can easily become contaminated with decay organisms and may be difficult to wash effectively and keep clean. In addition, the rough surface of the wood may injure the produce unless it is planed down and/or a liner is used with the package. Manufacture of wooden crates from local timber may put extra pressure on valuable but limited resources.

The extra-regional export market will not often accept wooden crates unless they are of a standardized and accepted design. In any case the weight of wooden crates prevents their use for air freighted exports because of the very high cost.

4.3.4. Fibreboard Cartons

Fibreboard boxes or cartons may be of solid or corrugated fibreboard construction of varying thicknesses and resilience depending on the produce to be contained and the market to be supplied. They have the advantages of being light to carry, clean and smooth surfaced, they allow for easy printed application of labels and can be manufactured to a wide range of sizes, shapes and strength specifications.

The disadvantages of fibreboard cartons are particularly pertinent to the regional Huckster and Trafficker trade in the Eastern Caribbean, in that cartons are not reuseable, they are easily damaged by water and rough handling unless impregnated with wax at extra cost, and they cannot be produced economically on a small scale.

4.3.5. Plastic Crates

Plastic crates and containers can be manufactured to a wide variety of specifications, generally from either high

density polyethylene (HDPE) or polypropylene (PP). Usually, plastic crates are more expensive than other forms of packaging, but have a very long lifespan allowing their use on a return basis for many Journeys. Plastic crates are nearly always the container of choice as a field crate where their use can be controlled, but they have few applications for most distribution systems unless transport, wholesale and retail are closely integrated.

Plastic crates are expensive and require a very high capital outlay. Some manufacturers do make plastic crates in the CARICOM region but these are not generally of a suitable design for fresh produce and import from outside the region is the only recommended avenue of supply at present. Occasionally, a Huckster may acquire a small supply of plastic crates for the inter-island trade but their use is far from widespread because they cannot be securely closed and pilferage is common. Plastic crates are not suitable packages for the extraregional export markets.

4.3.6. Paper, Plastic Film and Plastic Bags

Paper or plastic film is widely used as lining material and dividers for other forms of packaging. Tissue paper, shredded paper or plain Kraft paper helps prevent produce rubbing together or against the package walls and is generally only used with high value delicate commodities. Polystyrene foam wraps are very effective but very expensive and only economic on the most high-valued of export fruits.

Multiple layer paper sacks are used successfully for Irish potato in the extra-regional markets but have no practical application in the Eastern Caribbean because of higher ambient temperatures and humidity and the general insufficiency of refrigerated storage space. Large and small polythene bags and sacks are widely used as retail and occasionally as wholesale packages throughout the world and including the Eastern Caribbean, because they are relatively cheap and widely available. However, produce in plastic bags sweats horribly and heats up rapidly giving rise to perfect bacterial and fungal rot conditions. Their use should not be considered unless they are fairly small and properly ventilated with perforations and utilised only as a retail package.

4.4. Choosing the Right Package

The most important criteria for selecting the right package for your needs quickly boil down to the factors of cost and supply. Assuming that you have made the decisions about which market you are going to supply and the cost of the produce and the cost of transport are known, there remains the choice of package materials. The first criterion for any form of packaging is that it must add to the value of the produce handled, sufficient to cover the additional capital outlay and operation, plus a margin for profit.

The best way to cost packaging is as a unit cost per pound or kilogram of produce, and it does not matter what the cost is as long as it can be recovered from the market. In practice this means that the packaging and the produce must be competitive with those marketed by other suppliers. Good packaging of good produce has a clear financial advantage over poor quality produce which is poorly packed and presented.

4.4.1. Packaging for the Extra-Regional Markets

If the market is extra-regional then the only choice is fibreboard cartons, with the possible exception of pumpkin shipped to ethnic extra-regional markets. The next decision is which type of carton, which size and from which source. Several suppliers are located within the Eastern Caribbean:

- WINERA in St. Lucia;
- St. Vincent Packaging;
- Caribbean Packaging Industries (Barbados/Trinidad)
- SAPIL in Guyana.

A limited range of standard box designs are available from these suppliers, such as banana, mango, and 'Kenya' vegetable boxes, but not all suppliers can produce each type of carton. In St. Lucia and St. Vincent, the banana industry

always takes precedence over orders for other produce exports, with the result that the suppliers are often slow and inconsistent. In addition, the regional suppliers are still limited to one or two colour print designs and usually on a brown Kraft paper background. The quality of the fibreboard and the adhesives used may also give cause for concern. Only SAPIL in Guyana has plans to install waxing machinery for cartons.

There are numerous suppliers in the USA and Europe of a very wide range of tested and tried designs of fibreboard carton. Provided a sufficiently large order is placed, these suppliers can construct custom dies for new designs and there are no restriction in printing designs and backgrounds. The quality of the fibreboard must meet stringent specifications and supply is rapid and reliable. Clearly, suppliers outside of the region have much to offer over the regional suppliers but may not be the obvious choice for supply of packaging because of foreign exchange requirements, imposition of local import duties and taxes, and possible application of protective measures. All of these factors may make extra-regional suppliers more expensive.

4.4.2. Packaging for the Regional Markets

A considerable array of different packaging types are in active use in the Eastern Caribbean for the purposes of regional trade of fresh produce. Figure 4.1. (see Figure 4.1. The inter-island trade in fresh produce) illustrates typical packages and conditions prevalent in the inter-island trade in fresh produce. The high percentage of post-harvest losses, estimated to be in excess of 25 per cent and often as high as 50 per cent or more, experienced in the inter-island trade says a great deal about the inadequacies of current handling and transport systems and indicates the very real inadequacy of much of the packaging used.

For the reasons stated in 4.3.2. above, wicker type baskets can not be recommended for the regional trade. Sacks and bags will no doubt continue to be used for many different crops but especially root crops. However, with the recession in Trinidad and the increased production of root crops in that island, it is likely that Traffickers from St. Vincent in particular will have to concentrate on lower export volumes of much better quality root crops if they are to

continue supplying the Trinidad market. Clearly, the use of cartons and crates is favoured over sacks in such an environment.

Plastic crates are likely to prove too expensive because of their necessary import in large numbers from extra-regional sources. In addition, plastic crates do not offer sufficient security from pilfering and may themselves be the targets because of their potentially diverse other uses.

Wood crates and fibreboard cartons offer the most practical and economic choice for packaging for the inter-island trade, but availability of suitable designs at the right price and of consistent supply remains the greatest challenge to improvements.

In Dominica, in 1986, the British Development Division in the Caribbean (BDD) introduced some 250 wood crates for commercial trials with the Dominican Hucksters Association (DHA). The crates, designed and developed by packaging specialists at the Tropical Development and Research Institute (TDRI but now renamed as ODNRI) in England, were made locally at a small workshop from local timbers, principally 'Gommier' (Dacroides excelsa) and Mahot cochon. The design as illustrated in Figure 4.2. (see Figure 4.2. The Dominican collapsible wood crate), is of a lightweight collapsible crate intended to make at least eight return journeys with approximately 25 kg of produce each journey.

The trials were a success and many of the crates lasted for 20 journeys or more if carefully used and properly repaired. In addition, the Hucksters themselves expressed their satisfaction with the crate as being "stronger than it looks and easier to carry if nobody else there to help you". However, the Hucksters as individuals were not in a position to place a large enough order to ensure that the workshop would be sufficiently occupied. Indeed, the workshop has since closed. The FAO Regional Project on inter-island trade is ordering some 2000 of the crates from a small workshop cooperative in Dominica for supply to the Hucksters through the DHA, and possibly also for supply to other inter-island traders in the region if the workshop sees sufficient business.

In Grenada, there is an urgent need to replace the wicker baskets and giant crates which are inappropriate for the

trade, but it is by no means certain that the crates could be economically manufactured in Grenada because of more limited forestry resources and higher labour costs than Dominica.

St. Vincent would clearly have to import timber to manufacture the crates and in any case has a carton factory on the island. St. Lucia also has a carton factory (WINERA) but does not have any significant regional trade in fresh produce which requires wood crates in preference to cartons.

The DHA in Dominica has resolved to introduce the "Hucksters Code of Practice" in which there is a considerable reliance on improved packaging as well as handling of the produce. However, they have met with considerable difficulty in acquiring a regular supply of suitable cartons for the inter-island trade whose requirements differ from the extraregional export trade. Cartons exported regionally must withstand rougher and more frequent handling and are often exposed to the elements with the real risk of collapse when wetted with rain or sea water. Waxed cartons have to be imported from outside the region at greater expense than can be supported by the Huckster trade. In addition, cartons require stapling machinery for assembly and which is usually not available to the Hucksters. The DHA experimented with a special carton obtained from Guyana which did not need staples, but the carton proved too weak for packaging of most produce other than very light commodities.

The inter-island trade will almost certainly continue to need different packaging types appropriate to the handling systems prevalent in different markets and determined by the economic packaging cost which can be borne by the produce.

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5. Packing house

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5.1. Need for a packing house

Field preparation and packaging of produce is possible for only a limited number of crops, and for particular markets. After harvest most horticultural crops must be cleaned, sorted, sized and usually packaged if they are to be sold in the fresh produce market. Usually these procedures take place in packing houses of different types, be it a small thatched shelter on the edge of the field, or a large packing with automated equipment.

Packing houses serve as a sheltered working site for the produce and the packers, and should create an orderly assembly and flow of produce which can be well managed and centrally supervised. They may also provide a storage point for packing equipment and materials and, if large enough, can house office and communications facilities. Packing houses tend to become focal points for the local horticultural industry and centres of information, and if properly designed, can be utilised for packing of different commodities in different seasons. For export of fresh produce, packing houses are an essential part of the operation where selection, grading and quality control must be disciplined.

The packing house design and facilities needed depend very much upon local infrastructure, types and quantities of produce, markets being served and the funds available. It is rare for two packing stations to be identical. The various factors which have to be taken into consideration when planning a packhouse include:

- operations;
- equipment and facilities;
- location;
- design and construction materials;
- management.

5.2. Packing house operations

The operations which are carried out in a packing house include some or all of the following:

- Receival, checking and unloading;
- Packaging, including washing, waxing, fungicide treatment, grading, sizing, packing;
- Despatch, checking and loading;
- Storage, fumigation, ripening, curing, cooling.

(i) Receival

On arrival at the packing house, produce is usually counted or weighed and, in some cases, sampled for quality and labelled to identify the date and source.

Usually, the produce cannot be carried directly to the packing lines. It must be unloaded from the trailer or truck in such a way that it is easy to carry into the packing house and yet avoid damage to the produce. Palletised crates of produce are best unloaded mechanically with a fork-lift. Individual crates can be manually off-loaded onto a conveyor and routed direct to the packing line or to a temporary holding area.

(ii) Packaging

Packaging lines differ greatly according to the type and the quantity of the crop. They may consist of simple sloping tables (an example is shown in Figure 5.1. (see Figure 5.1. Simple inexpensive grading and packing table)) where produce is trimmed, cleaned, graded, sized and packed, and this sort of operation is perfectly acceptable for small quantities. For larger quantities of produce, specialized mechanical handling and preparation lines are more usual. However, even in a large packing house with full mechanization it is necessary to include a small simply equipped packing line for special lots of Produce.

The packing line may include the following operations:

a. Supplying the packaging line --should be carried out so as to avoid damaging the produce. Hand removal onto a conveyor or table, or dumping into a tank of water causes least damage. Where mechanical handling is used, care must be taken to minimise dropheights (and hence bruising), to avoid hard surfaces and not to overload the line.
b. Cleaning -- dry delivery systems, such as for citrus, onion and garlic, larger pieces of debris are removed by passing the produce over a graded griddle. Further cleaning is sometimes carried out with rotating dry brushes. Washing produce with water is more common, and since many types of produce float, the water makes a good transport system (e.g. banana). Some highly perishable produce, notably fruits should not come into contact with water. Orange and mango, however may be soaked and rinsed sufficiently clean, but soft rotating brushes may also be used for high-priced market fruit. For some commodities, the risk of cross-contamination in the washing tank is high (healthy produce infected by bad produce assisted by water), and it is often safer to wipe clean with a cloth (e.g. eggplant, sweet pepper). Produce may be allowed to dry naturally after washing, or dried artificially using air-blowers which are sometimes heated.
c. Special treatments -- after washing, some crops receive special treatments to extend their storage and market life, or to make them more attractive to the consumer. For example, citrus is often waxed to reduce shrivelling and improve the fruits appearance. Mangoes may receive a hot water treatment and fungicide for anthracnose control. (see Section 9 for more details)
d. Selection and grading -- almost all produce is graded and sized in the packing house to meet the quality and size standards of the market being served. Sorting to remove substandard produce and grading into different qualities is largely carried out manually. Sizing, according to weight, length or diameter is more often a mechanized process and for which a wide variety of equipment is available, much of it crop specific.
e. Packing -- packing stations may supply produce to different buyers and markets, each having different quality and packaging requirements. Flexibility in packing methods and materials employed should therefore be built into the system, even though standardization of produce should lead to a reduction of the number of different packages.

(iii) Despatch

At the point of despatch, produce is handled in the condition that it will reach the buyer. It is therefore essential that rough handling, overloading of trucks, infestation and exposure to extreme weather conditions are kept to a minimum.

The despatch area should be cool, clean and spacious to allow for temporary storage of packed produce and permit unrestricted movement of loading staff and their vehicles.

(iv) Storage

Depending on the commodities handled, packing houses may have adjacent facilities for long and short-term storage of packed produce. Some produce may be stored before preparation and/or after packing, as a normal function of the marketing process. Except where storage is a necessary part of the handling chain, the aim should be to move packaged produce out of the packing centre and to the buyer as quickly as possible.

5.3. Packing house equipment and facilities

Before considering the design features of a packhouse it is necessary to take an audit of what facilities and equipment will be needed for the packhouse, and what form and quantity of services will be needed for immediate purposes and any future expansion. The general facilities required for packing stations are described below.

i. Water - all packing stations require large quantities of water for washing produce and possibly also for cooling (hydro-cooling) of produce, and facilities will be necessary for the delivery and disposal of this water. Where public supplies of water are unreliable, wells and storage must be considered. Where water is scarce, possibilities for recirculation and re-utilisation may exist, but it is important that attention be given to the sanitary quality of the water that comes into contact with the produce.
ii. Electricity - where any form of automation is employed and certainly where good lighting is needed, a source of electricity supply from mains or generator must be arranged. Even where there is mains supply, it is sensible to install reserve or emergency generators, and particularly if the packing houses has its own refrigerated store rooms.
iii. Waste disposal - it is important to separate waste and rejected produce from the fresh market line in order to restrict the spreading of post-harvest diseases. Waste, once separated should not be allowed to accumulate inside the packhouse or it will become a physical hindrance as well as a phytosanitary risk. Some of the waste could go

for animal feed to help reduce costs of disposal.

iv. Material handling - good handling equipment and vehicles save much time and effort and can greatly reduce the damage to produce. Provision must be made for hand trolleys and roller conveyors, and, in bigger stations, for powered conveyors and fork-lift trucks. Where pallets are used they should be compatible with box sizes to achieve close to a 100% fit.

v. Produce handling - an immense range of equipment is available for washing, conveying, brushing, waxing, grading, and packaging specific commodities. Suppliers and manufacturers specializing in post-harvest handling equipment in various countries can advise from past experience on complete handling lines to meet specific commodity needs.

vi. Storage facilities - many packing stations include refrigerated facilities for short-term storage of highly perishable commodities. A ventilated temporary storage area may be sufficient, however, for commodities which have a reasonable post-harvest life. The possibility of future expansion of the storage facilities must also be considered.

5.4. Location of the packing house

The location of a packing house depends on several objective criteria:

i. Proximity to production area - a small field packhouse allows for easy supply and transport of produce with minimum delay. However, where a packing house serves a larger production area, it should be sited to allow good and rapid access for the producers. Where road facilities are poor, and production scattered, it is often better to have several smaller packing stations than one large central facility.

ii. Labour - a labour force sufficient for the needs of the packing house must be available in close proximity. Where this is not possible, it may be feasible to supply reliable transport or seasonal dwellings for the work force at peak employment times, but, this extra cost must be balanced by benefit.

iii. Services - the need for water and power facilities has already been mentioned above. In addition, access to communication facilities such as telephone lines is beneficial for rapid contact with producers and buyers.

iv. Site - a sufficient plot of land must be acquired to provide any increase in forecast production, or any change of

commodity types, or market needs. The site should not be exposed unduly to wind, erosion or to periodic flooding.

5.5. Design of the packing houses

The packing house design should accommodate all those factors described above which are relevant to the specific needs of the operation being planned. The overall design should ensure that floor space is adequate for easy movement, doors are wide enough for passage of vehicles and pallets, storage areas are sufficient for packaging materials, all surfaces can be easily washed and drained, there is a relatively clean and quiet administration office and that the workforce have a clean area where they can wash and eat in reasonable comfort.

It is conventional to segregate a packing house into the three main activity areas of reception, preparation/packing, and despatch. Storage for produce and packaging materials has to be provided according to the needs.

i. Crop reception area - this is frequently a dirty area and so should be clearly separated from the despatch point to prevent contamination of packed produce, but also to assist in segregation of incoming and outgoing transport vehicles. Overhead protection from the weather is useful and raised unloading bays may be an advantage if deliveries are from trucks. This can be more economically achieved by sloping down the approach area to below ground level rather than constructing the entire plant at a raised level.
ii. Crop preparation ant packing area - this should be dry, clean, well ventilated and welllit. Handling and packaging lines are traditionally linear in design but many variants are possible.
iii. Despatch area - this should be cool, clean and spacious to allow for temporary storage of packed produce and permit unrestricted movement of loading staff and their vehicles. Where a quality control programme is planned, an area adjacent to the dispatch area should be included in the design to facilitate these operations.

Figure 5.2. (see Figure 5.2. Proposed design and layout for a packhouse in Grenada) shows a proposed design and layout for a packhouse within an existing building in Grenada with initial requirements for a maximum of two packing lines, one for 'wet processing' of crops needing washing and dipping, and one for 'dry processing' of crops where

water is not necessary nor advisable. However because of planned expansion, the design allows for two additional packing lines and supporting infrastructure. Figure 5.3. (see Figure 5.3. Proposed flow of produce through the grenada packhouse) indicates the proposed flow of produce through the packhouse from reception to storage prior to despatch.

Land for completely new packhouse building is scarce and becoming increasingly more difficult to obtain, and many organizations are likely to be faced with plot sizes and shapes which are difficult to adapt to the packing operations intended. Lack of funds may also mean that existing buildings will have to be adapted rather than demolished and a new building erected. It is important that designs for packhouses are kept as flexible as possible in case of changed needs for different crop types.

5.6. Construction of the packing house

A popular design for the larger scale of centralized packing house or station utilises the relatively cheap and easily available materials of concrete flooring and corrugated metal sheeting for walls and roof. For many location these materials prove economic and durable. However, where solar radiation and high ambient temperature combine, packing houses built of these materials rapidly turn into sweat-boxes which are uncomfortable for the work force and a serious hazard to the post-harvest life of the produce. It may be necessary therefore to incorporate into the design such features as sprinkler systems on the roof and electrically powered ventilation fans to dissipate the heat load. Often much of the heat load can be avoided by constructing the roof into tiers with clear spaces between to allow natural ventilation.

For the small-scale packing house, the use of very cheap and readily available natural materials, such as grass and rush thatching, is often over-looked. Although possibly not as durable as concrete and corrugated metal sheeting, these natural materials are much cheaper and easily renewable -- crucial factors to the small-scale producer with limited capital.

5.7. Management of the packing house

It is a sad fact of life that many packing stations, even though well supplied by good quality produce and well designed and located, have failed through lack of good management. In the case of the small producer who does his own packing, any deficiencies in management will be directly reflected in his own personal income. The small producer thus has a particular incentive to work harder at improving the efficiency of his packing operation. However, in the case of the larger packing house jointly owned by a co-operative or producers' association, the manager is more likely to be a salaried employee. Thus it is vital that great selectivity is applied when appointing a manager to ensure that they are capable of handling all the necessary operations, and are experienced in the management of a workforce such as packing house staff. It is equally important that the manager can communicate clearly and respectfully with both producers and buyers.

The job of the packing house manager is to maintain a smooth movement of produce from delivery areas through the handling and packing lines to despatch. Bottlenecks in the system invariably lead to damage and deterioration of the produce and are frequently caused by breakdown of machinery, or by the failure to match labour requirements with anticipated deliveries. Regular maintenance schedules for all equipment and training of staff to handle machinery and produce correctly should also be prepared to a adopt a flexible approach to operations, for example by switching operations to two short packing lines rather than one long single line when delays occur.

The period of operation of a packing house is often limited by the restricted growing season of crops and managers should be constantly looking for out-of-season commodities which can extend the operation and reduce the costs of the packing house.

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6. On the hove - transportation of fresh produce

Transportation is often the most costly factor in the marketing channel, and for airfreighted export crops the cost of transportation may exceed the cost of production. The method of transportation for fresh fruit and vegetables is determined by distance, perishability and the value of the product. Whatever the method used, the principles of transport are the same:

- Loading and unloading should be as careful as possible.
- Transmit times should be as short as possible.
- The product should be well protected in relation to its susceptibility to physical injury.
- Jolting and movement should be reduced as much as possible.
- Overheating should be avoided.
- Water loss by the produce should be restricted.
- The required conditions of preservation should be obtained and maintained constantly, regarding in particular temperature, relative humidity and air circulation.

6.1. Handling and moving short distances

Marketing and physical distribution of fresh produce inherently means moving the produce. The commodities are handled, either manually or mechanically, many times from harvest and through the distribution process before the consumer buys and prepares them to eat.

Handling operations are seldom given much thought by the individuals directly involved in moving the process, particularly when the produce is only moved short distances. Figure 6.1 (see Figure 6.1. Handling steps during fresh produce marketing) gives an indication of the number of handling steps that will probably be endured by the produce. Notice that most of them are movements over very short distances and most probably by direct manual handling. These short moves are usually highly repetitive operations and unless the personnel concerned are properly trained and motivated then the physical handling is likely to be very bad leading to produce injury, spoilage and high losses

(Witness the loading of inter-island vessels with fresh produce!).

Figure 6.2 (see Figure 6.2. Equipment for moving fresh produce short distances) shows some useful equipment for moving produce short distances which would not only make the job much easier for the workers, it would also speed up operations and reduce physical injury to the produce at the same time.

Roller-conveyors, be they motorised or gravity fed are of great assistance in the packing house for moving boxed produce but are equally useful for loading and unloading of pickups, trucks and stores. Hand-trucks can carry up to six or more crates of produce, are very manoeuvrable light and durable, and do not cost a lot of money. Hand-carts with the front wheels steered by the tow-bar can carry a lot more produce but need to be used on more level ground. Pallet-trucks are in everyday use in the Eastern Caribbean but are not yet used with any regularity for fresh produce handling and movement, probably because packaging has yet to be sufficiently standardized to benefit from pallet operations.

6.2. Handling and stowage during transportation

The factors which govern packaging for transportation have already been covered in Section 4. Dropping of packages during loading and unloading is a frequent cause of damage to the produce and to the package, but can be minimised by:

- Using pack weights and designs which are compatible with the handling method.
- Correct supervision and management of loading and unloading to prevent careless handling and to ensure workers are strong enough and tall enough for the Job.
- Using ramped loading bays gives a tremendous advantage when loading trucks with produce.
- Providing shelter from sun and rain at loading and unloading areas.
- Using trolleys, conveyors and fork-lift trucks to reduce the amount of manual handling.

The method of stowage of the produce in the transport vehicle will depend on the pack, the commodity and the type and size of the vehicle but should always be carefully planned and managed to minimise both physical and

environmental damage. The following are some useful guidelines:

- Loading tightly to reduce movement and make best use of space.
- Distribute weight evenly.
- In mixed commodity or dispatch loads, stow goods in reverse order to their unloading sequence.
- Provides gaps for ventilation.
- Only stack to a load height which the lowest containers can withstand without crushing or damage to the pack.
- Do not exceed the capacity of the vehicle.
- Ensure the vehicle is properly maintained, breakdowns are time delaying and may lead to excessive or total spoilage of the produce.
- Be selective as regards the vehicle operator, e.g. band and inexperienced drivers will mean more damage to the produce and to the vehicle.

6.3. Road transportation

For domestic transportation the use of road vehicles offers substantial advantages of convenience, availability, flexibility permitting door-to-door delivery, and reasonable cost of transport. The use of road transportation for fresh produce is increasing and likely to increase in countries all over the world. Produce may be transported by pick-up, enclosed truck, open truck or refrigerated vehicle.

i. Enclosed vehicle - these are only suitable for short journeys, unless provided with a cooling system, since the produce inside heats up rapidly. However, they protect the produce from pilferage and physical injury, and are often used for urban retail delivery.
ii. Open vehicle - pick-ups and open trucks are the commonest type of road transport. They are often fitted, before or after purchase, with frames to ease stacking and covering. Natural ventilation is usually sufficient to prevent overheating of produce over relatively short journeys and the most versatile types have a fixed roof and tarpaulin drapes which can be pulled along the sides and back to allow access for loading and unloading at any point. These loose awnings are not in contact with the produce and so allow for ventilation systems on these types of

vehicles are unnecessary for short journeys, but when transit time are more than a few hours, adjustable louvres and air-scoops may be needed.

iii. Refrigerated vehicle - some highly perishable products may justify the use of refrigerated vehicles. Ice is not generally used to refrigerated trucks because of weight and corrosion constraints and for most refrigerated vehicles a mechanical system is used. Truck-based mechanical refrigeration systems vary in their cooling capacity. Most are only suitable for maintaining the temperature of produce which has been pre-cooled by other means, and they possess fairly weak air-circulation fans sufficient only to allow refrigeration of air heated up by low respiration of the cool produce. Some form of ventilation may be necessary on longer journeys to prevent oxygen depletion and carbon dioxide accumulation.

A few refrigerated vehicle types, usually reefer containers mounted on the back of flatbed trucks, are capable of rapid forced-draught cooling of warm produce, but these are generally an exception because of their expense.

Figure 6.3. Transport needs good management and supervision

There is often a tendency to use the relatively low capacity refrigerated trucks as the precooling system for export produce. The trucks were not designed as pre-coolers and the results are not satisfactory. In other instances, these same trucks may be used as mobile refrigerators to be installed for days or weeks at a time, as a form of refrigerated store. Again the results are far from satisfactory and spoilage levels are very high. In addition, use of the vehicles in this way is a waste of a very expensive transport vehicle.

6.4. Sea transport

6.4.1. Regional Sea Transport - The Inter-Island Vessels

The inter-island trade in fresh produce utilizes a range of small vessels of wooden or steel construction which are independently owned and operated and focus almost exclusively on servicing the transport needs of the trade. The vessels all rely on engines for propulsion, but the wooden sloops regularly use their sails to stabilize and propell

them. The wooden sloops are generally newer (ten years old or less) and carry only about 35 to 40 tonnes of cargo. The steel vessels by comparison are much older and most were bought cheaply and fairly recently second-hand from Europe where they were considered too old or expensive for continued service. Many of the steel vessels are 50 years or older and carry 60 to 100 or more tonnes of cargo.

FIGURE 6.4. INTER-ISLAND TRANSPORT OF FRESH PRODUCE

Some of the larger steel vessels, such as the 'Stella SII' and the 'Louise Kingcraft', carry other types of cargo on a regular or opportunistic schedule between their regular fortnightly huckster route. Several of the small wooden sloops operating out of Dominica also double as fishing boats - fresh produce from Dominica is off-loaded in Antigua then the vessel will fish the waters in the Leewards and sell their catch at the weekend market in Antigua before returning to Dominica for more fresh produce.

All of the rest of the inter-island vessels concentrate solely on the fresh produce trade, but it should be noted that the return journey with dry goods and other consumables ranging from snack foods from Trinidad or cylinders of LPG gas and spare parts etc., is equally important to both the hucksters and traffickers in terms of cargo volume and probably more important in many cases in terms of profits.

Ship

Early in 1987, a Consultant Marine Engineer with the FAO Inter-Island Trade Project (PFL/RLA/001/PFL) conducted a survey of, most of the vessels involved in the inter-island trade in fresh produce at that time. His conclusions may be summarized as follows:

i. General condition - The condition of most of the vessels themselves was found to be reasonably good. Only the 'Bigdin' was found totally unsatisfactory, but then it was built in 1898 and should have been scrapped a long time ago. Many of the vessels regularly experienced engine breakdowns for lack of parts or occasionally lack of maintenance.

ii. Fitness for fresh produce - Not one single vessel of either steel or wooden construction was found to be appropriate for fresh produce transportation because of:

- Poor ventilation - none of the vessels had adequate ventilation of the hold and most had no ventilation at all;
- No insulation of the engine compartment - in most of the wooden vessels the engine compartment is not separated from the cargo hold and heat and fumes from the engine mixes with the cargo, often the engine sucks air from the cargo hold because there is no other air supply for engine operation;
- No cargo liftinb equipment - few of the vessels had equipment to assist with loading/unloading of cargo and much damage was impacted on the produce from rough handling by the crew and stevedores;
- Cargohold shape - Only the larger steel vessels offered a practical shape for loading of crates and boxes and the wooden vessels shape meant that sacks and bags were crammed into the spaces between and under heavy wooden crates.

The FAO Consultant recommended various inexpensive and practical improvements for the vessels and these were presented to the captains and owners for their guidance. The FAO project offered to financially assist with fitting of one or two demonstration vessels with the prescribed improvements, but met with no response and to date none of the vessels has been improved at the owner's or captain's initiative. The improvements recommended were:

i. Improved ventilation - by fitting "cowl-type" ventilators as shown in Figure 6.5. (see Figure 6.5. "Cowl-type" ventilators for inter-island vessels), below. Most of the vessels are not equipped with generators to provide power for electric fans and blowers, so natural airflow and some wind assistance can be used to direct air into the bottom of the cargo and engine holds separately and extract the warm air from the top of the holds. Cost is estimated at approximately US$2, 500 for each vessel assuming only one cargo hold.
ii. Insulation of engine compartment - by construction of a proper barrier between the engine and the cargo hold and fitting an insulating layer to prevent heat from the engine entering the cargo hold. The insulation could be prefabricated polystyrene panels (approximate cost US$500 per vessel), or steel coated polystyrene sandwich panels (approximate cost US$1,500), or polyester foam insulation sprayed into place or onto spercially prepared

plywood panels (approximate cost US$600 if sprayed into place directly or US$800 if sprayed onto plywood panels). All costs include wood, plywood and other materials as well as the insulation material itself.

iii. Cargo lifting equipment - intended only for the wooden sloops. Figure 6.6. (see Figure 6.6. Cargo lifting equipment for inter-island schooners), below, shows a suitable installation which can be fitted to the mast and yet would not interfere with normal sailing operations. At a later stage owners could fit a small diesel powered winch to further improve the design.

Very few of the inter-island vessels carry any form of insurance because the owners claim the premiums are too high. The history of the inter-island trade is characterized by many sinking of wooden vessels with a complete loss of cargo and occasionally the lives of the hucksters accompanying their produce. Today, only a few of the steel vessels carry passengers and most of the traders fly to their destinations and meet the cargo there. The exceptions are still the very small open boats serving Marie Galante and Les Saintes from Dominica which still carry passengers and still experience losses of life and cargo.

Without insurance of their vessels, the owners cannot obtain loans for improvements to the vessels. However, the profits from the trade have been estimated on several occasions to be easily sufficient to support the cost of the above recommended improvements from cashflow alone and loans should not be necessary for any but the most poorly operated vessels. It would appear that the principal barrier to improving the vessels is the intransigence of the captains and owners content to reap their profits without the bother of improving the trade. Hucksters and traffickers generally lack sufficient organization and cooperative spirit to force the owners into making improvements, and some owners are hucksters themselves.

Various reports, recommendations and proposals have been made by different aid organizations in the region to introduce an independent freight service based on modern and possibly purpose built vessels more suited to the transport of fresh produce. To-date, none of these suggested interventions has become a reality, and the inter-island trade will continue to suffer high postharvest losses of fresh produce because of inadequate transport service and conditions. The dilemma is such that some improvements can be made by introducing better forms of packaging (see Section 4.4.2.) but these will be limited until improvements are made in the vessels themselves. In addition, most of

the vessels are really only suited to the use of sacks and bags because of the size and shape of the cargo hold.

6.4.2. Refrigerated Sea Transport

The perishability of fresh produce, allied with its tendency to heat up in confined spaces leading to rapid spoilage and decay, are all reasons why long distance unrefrigerated ship transportation is seldom used and never without high levels of spoilage. It is not likely that any mayor advances will be made in unrefrigerated shipping design to make the transport of fresh produce less risky. In most circumstances sea transportation is by reefer vessel and is largely used for export of fresh produce. Sea transportation, because of the journey times, is effectively a form of refrigerated storage and all the precautions necessary for storage are relevant here also.

i. Reefer vessels - are totally refrigerated, have efficient air circulation systems and controllable rates of air-exchange. Loading is facilitated by side-hatches or by specialized loop-belt continuous conveyors, which transport the individual packages from the loading wharf up above the central hatches of the vessel and down into the holds (they are used in an identical fashion for off-loading). Reefer vessels are generally high capacity (4000 tones or more) and regularly carry fresh produce all over the world. The limiting factors are the journey times, which may exceed the storage-life of most produce, and the considerable amount of handling involved in loading and unloading. Palletisation of produce has reduced much of the handling but break-bulk loading of individual packages is still widely used.
   Reefer vessel transportation usually involves the export of large volumes of fresh produce and necessitates the dedicated activities of full-time personnel employed by a large volume producer. For example in the Eastern Caribbean, the banana operations. Chartering, if to be successful means organising regular large volume supplies of produce over an extended period or charter vessels will not be available.
ii. Reefer containers - are a specialized form of sea transportation which is rapidly growing in international popularity. Each container either has its own independent refrigeration system which can be powered electrically by the container vessel, or has special air ducts are one end which are lined up with conduits on the container

vessel and refrigeration is thus provided entirely by the vessel's own system (this is know as the "ConAir" system). Reefer containers are in standard sizes all of which are 8 x 8 ft. cross section, but which may be 10, 20, 30 or 40 ft. long. The most widely used sizes are the 40ft. followed by the 20ft. size. The container can be bought or leased but they can be very expensive and can vary greatly in quality and performance. Their principal advantages are:

- permit shared use of a reef container vessel by many producers of different commodities, provided they have access to containers and are exporting by the same route.
- greatly reduce handling damage since they are loaded at the packhouse and may not be unloaded until they reach a customer store in the country of export.
- temperature control is independently set and monitored.
- capable of rapid pre-cooling of produce from ambient tropical conditions.

However, their disadvantages are:

- very expensive to own or lease.
- large and heavy and require special lifting equipment.
- need to lease more containers than are in actual fuse because of delayed return and breakdown.
- not all countries have container handling facilities which may limit loading ports and discharge ports, although some vessels are self-loading and unloading.

6.5. Air transportation

Air transportation is very expensive and usually can only be justified for high value export produce such as exotic tropical fruits and vegetables for the extra-regional markets. These markets are very sophisticated and demand top quality produce which is carefully packed in standardized fibre-board cartons and correctly labelled. Any produce not meeting these specifications, or of less than top quality, will either be rejected immediately or will be down-graded to a price level which gives a break-even price for the exporter or very often a loss on the consignment.

Airplane

All air-freighted exports require a high degree of market research, planning, organization and management. Constant communication with identified importers is vital to guage market trend, prices and fluctuations in demand, together with feedback on quality control.

i. Costs - of air freight will vary according to distance carried and whether a charter or scheduled flight is used. If production and package costs are added it can very quickly be seen that profit margins are low. Some countries see export of these commodities less as a profit maker and more as an earner of valuable foreign exchange. Lack of planning and good management will result in poor quality, rejection and possible loss of income.
ii. Airport handling - airports are designed to keep people away from cargo areas, but it is essential that personnel are given clearance for supervising the loading of produce onto the plane. The produce must be at the airport well before the time of flight departure. Delays are common and so facilities for holding the produce at the airport are necessary, and they must either be refrigerated or at the very least shaded. The loading supervisor or another person should have all necessary paperwork processed in good time and details of the consignment should be sent to the importer by telex or telefax.
iii. Air containers - fresh produce may be sent by cargo carrier but more usually in the cargo hold of a passenger aircraft. The quantity that can be sent will vary according to aircraft and space available. Most aircraft servicing the Eastern Caribbean employ unit load containers (ULD), which fit the contours of the hold, as well as carrying goods packed loose. Others may use special thin aluminium pallets which are moved over rollers. These can be leased and a supply kept at the packhouse with the necessary securing nets. By palletising in this way at the packhouse and perhaps using refrigerated trucks the handling of the produce is greatly reduced and loading times for the aircraft become very rapid.
iv. Temperature and pressure - cargo holds are frequently maintained at the same temperature and pressure as passenger areas, but this may not always be the case. Very often chill temperatures at high altitude can cause irreversible damage to the produce and flight conditions should always be checked with the airline.
Of the aircraft currently servicing the Eastern Caribbean the situation tends to be confusing in that some holds may be temperature-controlled but at preset temperatures, and no choice is offered as to the temperature set.

Other holds on the same aeroplane may have no temperature control and operate at ambient (i.e. at altitude they will be around 0-5 C). Exporters must therefore select which produce must go in which hold well ahead of time and book that space with the airline if chilling of the produce is to be avoided.

v. Trans-shipment - of fresh produce from one flight to another at an intermediate country airport is nearly always inviting disaster unless personnel are available to supervise. For example, air transport from Dominica and St. Vincent with only small air-fields must be trans-shipped out of the other islands airports which can accommodate large jets and have regular scheduled services to the extra-regional markets. The exporters must then rely upon the others to make sure that the trans-shipment occurs smoothly. This is clearly one major advantage that CATCO has over other exporters in the Eastern Caribbean. Direct flights should always be aimed for to prevent delays, disasters and economic loss.

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7. In the market - wholesale, retail, and market information

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7.1. Wholesaling of fresh produce

7.1.1. What is Wholesaling?

Wholesaling is the business of selling relatively large quantities of consumables to retailers or other merchants rather than to consumers.

In most countries in the world, a strategic role in fruit and vegetable marketing is played by one or two central wholesale markets. The wholesale market constitutes the basic source of supplies for retailers in the largest cities and their surrounding districts, and for wholesalers supplying retailers in more distant centres. It also serves as the main outlet for nearby growers and, through transporter/traders and commission agents, for those producers further afield. Such a market is also the main centre for the sale of imported produce and that to which exporters in other countries send their produce. At the wholesale market, supply and demand find an equilibrium price and this becomes the mayor determinant of prices throughout the area.

7.1.2. Wholesaling in the Eastern Caribbean

Port-Of-Spain in Trinidad boasts a large central wholesale market which operates generally along the lines described in 7.1.2. above, but no such wholesale markets are in existence in the other English-speaking islands of the Eastern Caribbean. This is largely a reflection of the small land masses, low production volumes, and small consumer populations with a relatively low daily demand volume for fresh produce. However, the absence of a wholesale market in these islands does not mean that wholesaling of fresh produce does not occur, it is just less obvious in its activity.

Wholesaling of imported produce from extra-regional sources generally proceeds with the importers acting as initial wholesalers who either sell to retailers directly or may sell to other wholesale traders that handle domestic and imported produce. In St. Vincent, on the leeward side of the island, there are a number of transporter/traders who buy produce from farmers and sell it onto traffickers and retailers, and who are clearly wholesalers who also supply a transport service.

In the same way the inter-island traders are wholesalers with a more integrated system of marketing and distribution in that they will buy from farmers directly (as well as other sources), pack the produce, arrange for transportation to the dock, complete shipping documentation and arrange for sea transport, travel on the boat themselves or fly to the country of import, then they will clear the produce through Customs and phytosanitary control before arranging transport if necessary to the selling point. All of these activities invoke a tremendous risk for the trafficker or huckster,

but in the absence of improved transport and consignment services, are the only effective means of sustaining the regional export trade at the moment.

Some wholesalers may also become involved in extra-regional export by virtue of the volume of produce handled and a greater appreciation of the requirements of these distant markets. In this sense exporting is really just another form of wholesaling.

In Barbados, there is a considerable amount of by-passing of the wholesale trade in domestic produce because many farmers, both large and small, enter into regular supply contracts directly with supermarkets and shops, and the numerous hotels and restaurants supplying food to the large numbers of tourists present nearly all the year round. Under these circumstances the activities of wholesalers can often be largely confined to importation and wholesaling of imported fresh produce, most of which is from outside the region. Although there is substantial consumer demand for fresh produce, there is no real demand for a specialized wholesale market because there would be very little if any increase in marketing efficiency as a result - which is after all the main reason for having a wholesale market!

In Trinidad, the large wholesale market complex in Port-Of-Spain was established many years ago to increase marketing efficiency and to help ensure that the many small farmers would have a market in which to sell their produce. A large retail market is included in the Port-Of-Spain market complex and which offers an immediate vending point for retailers buying from the wholesale market and which attracts a great many consumers in search of fresh produce, dry goods such as rice and peas, and meat.

The market operates around the clock with regular closing times to ensure that cleaning operations can be performed as well as other administrative functions. Unfortunately, the location of the market has become a restraining factor because of the need to develop more rapid transport and communication between Port-Of-Spain, the ever-expanding urban corridor, and the other cities such as San Fernando.

The wholesale market is successful, but needs to be expanded and to be more accessible, otherwise the wholesaling centre becomes a delaying factor in fresh produce marketing and distribution when farmers cannot reach the market

without queuing for long periods on traffic-jammed highways and then cannot get into the congested market itself.

A new wholesale market is being proposed for the Piarco area so that produce can be marketed more rapidly and wholesalers from San Fernando can buy their produce more quickly and conveniently. At the same time the large number of retail outlets in the urban corridor can obtain their supplies much more efficiently. The existing wholesale and retail market in Port-Of-Spain will the be better able to cope with the marketing needs of the capital itself and its immediate surrounding territory.

The relatively small populations of the Windward and Leeward Islands and the consequently small demand volume for fresh produce means that wholesale markets are not likely to be needed in the forseeable future. However, the absence of a central wholesale market creates special problems relating to market information and intelligence and the maintenance of stable prices for domestic produce. Without proper market information on daily or weekly prices and produce availability, prices obtained by farmers can and do fluctuate considerably with the result that while a few farmers occasionally benefit from high prices, most may only recover production costs or possibly make a loss. Under these circumstances, production planning by the farmers and extension workers is rather hit and miss.

The presence of a central wholesale market might also offer a solution to the serious problem of praedial larceny which is prevalent in the region in that all growers and traders could register with the central market and all sales of produce be documented with the registration number of the grower. Nonregistered sellers of produce would not gain entry to the marketing process. However, the relatively low volume of domestic produce traded is likely to continue throughout the Eastern Caribbean and no matter what particular advantages there may be in establishing a wholesale market facility, if there is not sufficient economic Justification then it will not be successful.

7.1.3. How Can Wholesalers Avoid Post-Harvest Losses?

Wholesalers handle produce which may or may not have been freshly harvested and may be packaged in various types

of container. Depending on how well the farmer and transporter have done their job, the wholesaler must decide on the most appropriate sale and distribution system so that the produce can reach the consumer in the best possible condition.

Above all, the wholesaler must strive to keep post-harvest losses at a minimum or he will have to raise the selling price to counter the losses or bear the financial loss directly himself. Wholesalers in the Eastern Caribbean rarely have specialized storage facilities other than an ordinary warehouse and it is recommended that they concentrate their activities on selling and moving the produce as quickly and carefully as possible in order to avoid losses from spoilage of all kinds.

The general principles of keeping produce cool by stacking it in well shaded and ventilated locations and avoiding exposure to sun and rain at all times are the most important things to remember. Whenever the produce is handled it should be done so carefully and cleanly so as not to inflict cuts and bruises. If the produce is purchased from the farmer in bulk, or 'off the tree', then suitable packaging should be invested in so that multiple handling steps can be avoided and the produce protected from compression and other injuries.

The best way to avoid post-harvest losses is to only buy good quality produce in the first place and to regularly inspect the produce for spoilage if sale is delayed. Re-grading and repacking of produce may be permissible but this will depend on the cost of the process and the value added as a result. Wholesalers are in the business to make money, not as charitable suppliers of fresh produce. All staff employed by the wholesaler should be trained in the basic causes of post-harvest losses and recieve demonstration type training on the importance of careful handling and stowing of fresh produce in preventing such losses.

7.2. Retailing of fresh produce

7.2.1. What is Retailing?

Retailing is selling to the consumer and is the last commercial act before fresh produce is consumed. Consequently,

the fruits and vegetables offered for sale at retail may have passed through many different hands from the time they were harvested. Some of the produce will have come from domestic sources but a significant proportion will have been imported, either from within or outside the Eastern Caribbean region.

Whatever the source of the produce its natural perishability will almost certainly mean that it is nearing the end of its marketable life. Post-harvest losses occur at all stages through marketing and distribution but tend to be greater at retail. A significant proportion of the produce purchased by the retailer may never make a sale due to spoilage soon after reception by the retailer, or during storage at his shop or supermarket.

Retailing fresh produce is undoubtedly 8 risk business and the high price mark-ups made by the retailer are necessary to cover the cost of the post-harvest losses as well as the general overheads for the shop and still give a profitable income. It therefore stands to reason that a smart retailer will make more profit if he or she can reduce post-harvest losses by selling more of what they buy or alternatively they can sell a greater volume of produce at a slightly lower price and attract more customers and a greater market share.

7.2.2. Who are the Retailers in the Region?

There are four principal groups of retailers which can be recognized in the Eastern Caribbean region:

(i) Hawkers, higglers, hucksters, and street vendors

These retailers sell in open public places, often main streets and busy corners where they can attract a passing trade. They are opportunistic salesmen often depending on impulse buying of small quantities by the public. High value or sought after imported fruits are often the main produce sold by these vendors including single fruits such as prepared pineapples, small bunches of imported grapes, or imported mangoes when the local crop is out of season.

Individually, the sales volume of each vendor is relatively small but collectively the volume of produce sold is often very large.

(ii) Market vendors

These retailers are mostly engaged in selling fresh produce at the busy weekend markets in the capital cities or larger towns. Market vendors are more institutionalized in that whether they sell from permanent stalls within the Public Market building or from make-shift and temporary portable stalls in the open outside the market, they must pay a licence or stall fee for the privilege. Market vendors are mostly women and may be related to the producer from whom they bought the produce, or they may be independent in their operations.

Some inter-island traders, also called hucksters or traffickers, are regular market vendors in that they concentrate their selling activities to retail in the Public Market. Often, the bulk of fresh produce vending during the week, when Public Market buildings are often almost empty, is by these inter-island traders.

As with the street vendors, the individual sales volume of the market vendor is frequently very small, but collectively is still significant even though an ever increasing proportion of fresh produce sales is being diverted to the higher volume shops and especially supermarkets.

(iii) Shops

Unlike street or market vendors, the shop keeper sells fresh produce as part of a whole range of consumable items, most of which are not perishable. Both domestic and imported fresh produce is sold. Although some refigeration is often in place in the shop, it is not often used for fresh produce but more commonly for meat and dairy products. Retail volumes of fresh produce may only be small.

Occasionally, a shop may elect to specialism in fresh produce sales only, but the history of such ventures in the region would indicate this is not often profitable and the shops usually close down or convert back to general grocery and

provision sales. The exceptions to this pattern are the many roadside fruit and vegetable 'shops' lining the main highway from PortOf-Spain to Piarco Airport in Trinidad. Here the very high volume of traffic throughout the day, but especially during the evening rush-hours when commuters return home along the urban corridor, affords a useful opportunity for farmers with fruit and vegetable plots close to the road to engage in regular retail activities.

These shops started as temporary structures but today many have become almost permanent and sell quite high volumes of produce. Farmers with a shop may be selling their own or other farmers produce. However, the long-term future of these shops is threatened by legislation designed to prevent traffic from stopping on the highway to purchase produce because of the traffic Jams and accidents resulting. Also, many large and sophisticated supermarkets are opening up in key areas of the urban corridor and offer increasingly large volumes of diverse types of fresh produce as well as a full range of other consumables and hardware. However, the roadside shops presently satisfy a need among consumers by offering a convenient supply of freshly harvested produce.

(iv) Supermarkets

Supermarkets are an increasingly popular retail outlet for fresh produce in the Eastern Caribbean, but they also sell all kinds of other items in their bid to attract the 'one-stop' shopper. Fresh produce volumes sold in supermarkets are often far greater than other retail outlets and collectively, supermarkets are rapidly becoming the principal retail suppliers in many of the islands.

Supermarkets usually have some form of refrigerated retail display for fresh produce and the larger supermarkets also have larger refrigerated stores exclusively for fresh produce. Produce is obtained from small and large farmers, wholesalers and importers. The produce may be delivered in a variety of packages, grades and maturities. Considerable skill is needed by the supermarket manager or buyer in selecting the produce if substantial postharvest losses are to be avoided. Fresh produce is frequently sorted, graded, washed and packed and priced prior to refrigerated retail display, so that the busy shopper can 'grab and go'.

Small farmers are often at a disadvantage when supplying very large supermarkets, such as those in Barbados and

Trinidad, because they cannot consistently supply large enough volumes of fresh produce at a quality demanded by the supermarket for many weeks or months of the year. Often, the supermarket manager prefers to import fresh produce from extra-regional sources because it will often be cheaper, the quality standards and packaging will be guaranteed, and volume supply can be obtained nearly all the year round, with fewer post-harvest losses and consequently less risk and more profit.

7.2.3. How Can Retailers Avoid Post-Harvest Losses?

In the first place, the retailer should be aware of the importance of post-harvest losses and their effect on profits, as well as understanding the basic causes of post-harvest losses and what can and cannot be done to prevent them. The principal concern to the retailer will be the cost of any loss prevention programme and its effectiveness rather than any desire to prevent losses just for the sake of it.

Reduction of post-harvest losses requires an investment in time, planning, management and possibly capital equipment. The level of investment will thus largely be governed by the nature of the retailer and the volumes of fresh produce sold.

(i) The smaller volume retailer - All retailers should be very selective about the produce they buy. Produce with the first signs of wilting, physical damage, or decay should be avoided. Unless storage facilities are available there is no point in buying under-ripe fruit, and over-ripe fruit should never be considered unless they can be sold immediately (ie. on the same day) to consumers prepared to buy them.

Having bought the produce, it should be handled and transported as carefully as possible to avoid physical damage and prepared for retail display in an attractive manner. If it looks good to the consumers it will be sold more rapidly and at a better price. Retailers should try not to mix attractive and unattractive produce together. Grading of produce by quality and maturity helps add value to the produce and for the small volumes sold takes only minutes of the

vendors time.

If the vendor has no covered stall they should try and invest in a portable stall with a canopy or umbrella to shade both the produce and themselves from the sun and rain. Produce in the sun heats up and spoils very quickly, while rain sodden produce may rot.

Vendors should be very selective about what they carry over for sale the next day. It is better to lower prices and make a sale rather than to carry over poor produce that will not be sold the next day and thus thrown away with no income gained.

(ii) The shop and the supermarket - The recommendations for the small volume retailer apply equally well here, but in addition there are a number of problems which relate specifically to storage, preparation and display of fresh produce in shops and supermarkets.

If no refrigeration is available, or there is insufficient space for all storage needs, then the unrefrigerated produce should be sold as soon as possible. Only the best quality produce should go into refrigerated storage because only the best quality will store with fewer postharvest losses and give sufficient returns to warrant the expense of refrigeration. The refrigerated store should only be loaded with amounts of produce that the cooling capacity can cope with at one time. Overloaded refrigerators cannot cool produce properly with the result that the produce will often spoil more rapidly because of confinement in a warm and humid environment with high levels of carbon dioxide (See Section 8.5.3. for more details.). In other words, supervise loading properly such that smaller quantities are added to the store at regular intervals.

Remember, that the store contents should be clearly identifiable with the date the produce was put into the store marked on each package. Do not keep older produce in the store when better quality and fresher produce needs the storage space.

When washing and preparing produce before storage or retail display it is important to do the job thoroughly and to

make sure that the produce is dried sufficiently, with a dry soft cloth or by air-drying, before bagging or wrapping or it will get slimy and rot. Remember that not all produce is suitable for washing and may be better prepared by gentle wiping with a soft dry cloth, as with green peppers, or simply selecting out of very dirty produce, as with green beans.

Polythene bags are a cheap and effective container for retailing of fresh produce but must not be completely sealed or the living produce will suffocate and spoil very rapidly. Make sure that the polythene bags have small holes in, by using ready perforated bags or by perforating them with a paper-punch or similar instrument. A very simple method of ensuring adequate ventilation of plastic bags is to Just snip off the corners with a pair of scissors.

Even if the produce does not suffocate in a polythene bag, it will rapidly sweat and look unsightly and with the real danger of rapid spoiling from bacterial soft rots in the sweaty conditions.

Leafy vegetables can lose water and wilt very rapidly, and if not wrapped may benefit by occasional spraying with clean water. Many of the condiments, seasonings/herbs and other vegetables such as carrots are very sensitive to ethylene gas produced naturally by ripening fruits and fruit vegetables. Celery and parsley will wilt and yellow very quickly, and carrots will get bitter if exposed to ethylene produced from ripening fruits. Wherever possible they should be stored and displayed separately.

Not all produce can be stored at the same temperature. Mango, pineapple and banana should not be held below 14C (56F) or they will be chill damaged and spoil rapidly. Most other commodities will store adequately between 7 and 10 C (45 to 50F) for a short period.

Fresh produce management in a busy supermarket is a very demanding job. Careful planning and preparation are vital if post-harvest losses are to be reduced and profits maximized. All new staff involved in fresh produce handling and sales at the supermarket should be trained properly before they assume responsibility for the produce.

7.3. Market information

Market information includes any aspect of information ranging from production to the final point of sale which improves our ability to market effectively. Some areas of information required on both domestic and export markets are:

- size and location of supplies;
- consumer demand;
- changes in consumer preference and taste;
- seasonal variations in supply and demand;
- historical, current and anticipated prices;
- selection, grading and packaging requirements;
- transport availability and charges;
- trade contacts;
- export/import policies;
- phytosanitary regulations;
- tariff barriers;
- production information for competing countries.

7.3.1. Why Do We Need Market Information?

Market information and intelligence helps producers, traders and consumers balance supply and demand in the marketing system for fresh produce and thus avoid gluts and deficits in supply and corresponding price fluctuations. Farmers need information about probable supplies and prices in order to make decisions when planning their production, harvest and sale of produce. The knowledge that a farmer can compare one price offered by a trader with another price elsewhere, also influences buyers in offering fair prices.

Access to better information enables wholesalers to develop those consumer demands and producer supplies

whiching might otherwise have been neglected. This reduces their business risks and enables them to operate profitably on lower margins. This in turn brings benefits to both producers and consumers. Consumer purchases can also be influenced by market news in that they may choose not to buy expensive produce which is in short supply in favour of more plentiful and cheaper alternatives.

Programmes of price and supply stabilization are more effective when based on reliable estimates of production, storage, internal movements and prices. To collect and broadcast such information is a complex operation and must be performed rapidly if the latest market news is not to become of historical interest only. Market information must be presented in a simple style which can be understood readily by all those that need to use it. This kind of public service is generally sponsored by government or possibly by aid organizations because a permanent staff and budget are fundamental to its operation.

For the local market most farmers are aware of what crops consumers require, how they expect them to be presented, and the time of year when they are required. This information is not usually consciously acquired - it is simply known from a farmers general experience of producing and selling. Thus the average farmer knows a great deal about local market conditions, and, if he intends to be successful, must plan his production accordingly. The difficulty which confronts many market information services in the Eastern Caribbean as regards domestic market information is telling their clients something that is needed and not already known!

For export markets, particularly the extra-regional markets, the necessary information cannot be acquired through everyday experience. There are three principal methods of obtaining information:

i. Observation - by production surveys and visits to the export markets;
ii. Contacts - conversation with importers and exporters and trade and consular representatives, airlines etc.;
iii. Publications - trade reports and journals, reports, research organizations (eg ODNRI).

In the initial stages of planning an export programme, an exporter will rely mainly on published information, but once exports begin, information obtained through market contacts and by visiting the markets will be of primary importance.

This applies particularly to items currently exported from the Eastern Caribbean which, due to their small volumes, are not adequately covered by published sources of information.

7.3.2. Market Information in the Eastern Caribbean

Market information capability in every territory is located in the public sector within either the Ministry of Agriculture or a statutory body with responsibility for marketing. All of these market information units (MIU's) supply domestic price information as well as on other areas, including:

- Production surveys: Antigua, Barbados, Montserrat, and forecasts St. Kitts
- Export/import data: Antigua, Barbados, Dominica, St. Lucia
- Regional prices: Antigua, Barbados and St. Lucia
- Comments on: Barbados, Dominica and St. Lucia market developments
- Exporters needs: Dominica and transport availability

All MIU's use the newsletter/report format to disseminate their information but relatively little use is made of other media such as newspapers, radio, television and notice-boards in strategic places such as public markets. The use of the Extension Officers of the Ministry of Agriculture as disseminators of selected market information for farmers is strongly suggested since they are in regular contact with the people who need to know.

St. Vincent and Grenada continue to struggle without an effective market information service despite efforts in the past to establish them. The GAINS report in Grenada is produced but on an apparently irregular basis and contains very little information of practical and immediate use for the farmers. Admittedly, farmers and rural communities are served with local information on the radio but there is ample room for improvement. In St. Vincent, the only information on farm-gate and retail prices published is in the bi-monthly report of the Statistical Unit of the Ministry of Trade, Industry and Agriculture. The information is largely historical by the time it is released and even then the

report's circulation is fairly limited.

CARDATS produces a weekly radio programme on Radio Antilles covering prices from Grenada, Dominica, St. Lucia, Montserrat and Antigua, and occasionally from Trinidad as well.

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8. Storage of fresh produce

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8.1. The need for storage

In temperate countries much of the production of fruits and vegetables is confined to relatively short growing seasons and thus storage becomes essential for provision of fresh produce out of the harvest season. In tropical countries production is often extended but storage may still be necessary or desirable for extended supply to the consumer. As consumer purchasing power increases, the reasons for storage may cease to be ones of traditional necessity but of satisfying consumer demand. Consumer demand is likely to include improved quality as well as improved availability and pressure is increasing, and will continue to do so, for improvements in storage techniques.

Produce may be stored for a few days or weeks as part of the normal marketing process but some temperate produce may also be stored for periods up to 12 weeks. The reasons for storage are:

- Because there is no immediate buyer.

- Because transportation or some other essential facility is not available.
- To extend the marketing period and increase the volume of sales.
- To wait for a price increase.

There are various different forms of storage, the choice of which will depend on its cost and the produce to be stored. However, before contemplating storage of fresh produce there are other factors which must also be taken into account. The maximum storage life of a harvested crop depends on its production history and quality and maturity at harvest. The actual storage life which can be achieved in practice may be quite different and depends upon harvesting and handling procedures and the storage environment. Not all fresh produce is amenable to storage and some produce may require specific post-harvest treatments such as "curing" or "waxing" prior to successful storage (see Section 9. Some Special Post-Harvest Treatments). There may be features of the market structure or supply which create constraints whereby stored produce may compete at a disadvantage with freshly harvested produce. Encompassing all of these interactions is the question of storage economics.

8.2. Basic pre-treatments before storage and/or marketing

Section 9 describes various "special" post-harvest treatments necessary for specific crops, but there are some basic pre-treatments which must be performed before storage and/or marketing of any fresh produce.

i. Cleaning - all stones, soil clods and plant debris must be removed before storage, particularly if the crop is to be stored in bulk. Stones damage the produce and soil and plant debris compacts and restricts ventilation, leading to localized build-up of heat, but may also carry spoilage pathogens.
ii. Grading and selecting - small, damaged, infected and over-mature produce must be removed. Very small produce loses water more rapidly leading to wilting in storage. Produce which has been bruised or cut loses water and is easily invaded by spoilage pathogens during storage. Infected produce deteriorates rapidly, heats up, and provides a source of infection inoculum for healthy produce. Over-mature produce has less resistance to disease and reduced -storage potential, and in the case of fruits such as banana and mango, may produce ethylene gas which stimulates premature ripening and senescence throughout the store.

iii. Field heat removal - regardless of the type of storage facility employed, it is important to remove the 'field heat' from the produce before bulking up the produce in a store. This field heat removal may be carried out by temporarily stacking the produce in a shaded, cool, ventilated area, or more usually by resorting to refrigeration techniques as described in section 8.5.3. below. Failure to remove field heat can result in rapid temperature rises and accumulation of high concentrations of carbon dioxide, to possibly damaging levels, once the produce in confined in the store.

8.3. Temperature, humidity and commodity considerations

Most rapidly maturing tropical fruits, soft fruits of all kinds, and leafy vegetables with a large surface area tend to have high respiration rates and normally have short storage lives. In contrast, most temperate fruits, cured potatoes and onions, and vegetable root crops often have lower respiration rates and consequently longer storage lives. Respiration of all produce increases with temperature which is why all storage techniques aim for a reduction in temperature of the produce.

Lower storage temperatures offer the additional advantage of greatly reduced water loss from the produce with reduced transpiration. High relative humidity slows down water loss and enhances storage life of the produce. Stores should ideally be maintained at the highest relative humidity (RH) that the crop can tolerate. Humidifiers of various types are generally available, and although 100% RH would totally prevent water loss, this can rarely be maintained because:

- disease organisms often develop rapidly at 100% RH;
- condensation, giving rise to increased spoilage can easily be caused by slight temperature fluctuations at or near 100% RH;
- ventilation with unsaturated air is often necessary to remove heat and volatile gases such as ethylene.

It is important to retain adequate circulation of the air within a store and around the produce to ensure efficient cooling. However, over-rapid air movement can drastically increase water loss by the produce. This is an important

consideration when using forceddraught pre-cooling, as described in Section 8.5.3. below.

In conclusion, the choice of the correct storage technique is governed by:

- the type of produce, its temperature from harvest and its respiration rate as well as produce quality;
- the storage temperature and humidity best suited to the produce and intended storage life, without implicating chill damage or unnecessary microbial spoilage;
- appropriateness to the market place and its requirements;
- and above all, the economics of the whole operation

8.4. Ventilated storage

Before the advent of refrigeration, ventilated storage was the only means available for storage of fresh produce and today is still in wide use all over the world for a variety of crops. Ventilated storage is ambient air storage which makes use of controlled ventilation for cooling of the produce and maintenance of lower temperatures. It requires much lower capital investment and operating costs than refrigerated storage and is perfectly adequate for some crops and conditions where:

- production is being stored for local use;
- the crops to be stored have a relatively long natural storage life;
- regular inspection is possible to remove spoilage centres;
- there is a significant difference between day and night temperatures, for example at altitudes above 1000 meters and most temperate latitudes;
- the need is for relatively short storage periods.

Figure 8.1. (see Figure 8.1. A ventilated store for onions and sweet potatoes) illustrates a ventilated store for use by small farmers and built from readily available local materials. The store may be used for onions, garlic, yams and sweet potato. However, ambient or ventilated storage for most other commodities is not a practical nor an economic

proposition because spoilage rates are simply too high. Some ventilated storage at the retail point may be an everyday reality for small shop keepers but larger shops and supermarkets, and most importers and wholesalers use refrigerated stores.

In the tropical climate of the Eastern Caribbean there is little opportunity for ventilated storage of most commodities beyond a few days. There are a few exceptions in that properly cured onions, garlic, sweet potato and yam may keep for up to two months if all the aspects of harvesting, curing, drying and handling are properly addressed and the store itself is thoroughly clean, well ventilated and protected from the rain, and located in a cool and shaded spot - preferably with some altitude to assist with lower temperature maintenance.

Although there are many islands with altitudes above 1000 metres, these are either too far away from the production zones or are not accessible by a good road, and topography prevents the building of large stores on steeply sloping terrain.

DO NOT FORGET RODENT CONTROL!!

8.5. Refrigerated storage

8.5.1. General Principles ant Considerations

It is now more than 130 years since the Australian James Harrison designed and built the first effective refrigeration equipment and the first icemaking plant in the world. Over 100 years ago regular shipments from Australia to England were commenced for the transport of frozen beef, an event soon followed by the operation of the first mechanically refrigerated cool stores for apple and pear. The most modern refrigeration plants available have changed very little in basic design since those times and accordingly consideration will be restricted to the mechanical functions and nomenclature of the equipment.

A refrigeration plant, as seen in the accompanying figure 8.2. (see Figure 8.2. Typical refrigeration plant for fresh

produce) consists of three basic components:

- a compressor in which the refrigerant gas, commonly 'Freon', is compressed and unavoidably heated;
- the condenser, either air-cooled or water-cooled, in which the hot compressed gas is cooled and condensed to a liquid;
- the evaporator coils in which the liquid is permitted to boil and evaporate and so remove heat from its surroundings.

Fans are usually necessary to circulate air over the cooling coils of the evaporator and through the stacks of produce in the store. The compressor and the condenser are always outside the cold store and usually mounted in tandem. The link between the three units is completed by insulated copper-piping. To increase efficiency the evaporator is fitted with metal fins to improve the heat exchange properties. Air-cooled condensors are fitted with similar fins and air is forced through by an electric fan. More detailed information can easily be obtained from any one of a large number of textbooks on the subject.

MANAGEMENT - MAINTENANCE - MOTIVATION

Refrigerated storage rooms are in common use for many types of fresh produce. Although the technology for designing and installing refrigeration facilities is well established it is a sad fact that many refrigerated stores operate unprofitably because of a number of common problems. The most significant of these problems are:

- Untrained or unmotivated supervision;
- Deterioration of produce quality during storage;
- Irregular maintenance and improper use of equipment and facilities;
- Under-utilisation of refrigeration space.

Each of these problems could be directly attributed to inadequate planning and management performance. Successful operation of cold storage facilities is dependent on some knowledge of costing, specific commodity requirements,

refrigeration technology, and produce marketing for the successful operation of cold storage facilities. The construction and operation costs of refrigerated stores are high and so investment should not be considered until a thorough feasibility study has been carried out.

Too often stores remain in operation at great cost when they are almost empty of produce or when no increase in the selling price of the commodity is expected. A clear appraisal must be made of the commodities planned for storage, which are compatible in storage at specific temperatures and humidities and which commodities are not compatible, the expected storage life of the various commodities and the applicability to the anticipated market situation. Managers should have the confidence and authority to shut-down stores, even, if it means storing some produce at ambient temperature, rather than incur operating losses.

8.5.2. Storage Expectations for Fresh Produce

Table 8.1. lists the approximate storage life expected of different types of fresh produce and the specific temperatures and humidities which must be maintained in order to realise these expectations. It is assumed that the produce is:

- clean and free of infection;
- has been harvested at the correct stage of maturity;
- is free of physical damage;
- is placed under the storage conditions as soon after harvest as possible;
- and has been properly prepared for storage in every way.

Failure to meet these demands will result in a shortening of the expected storage life. To avoid confusion it is assumed that the storage life is the maximum period for which the produce will remain fit for marketing, and not the period to total senescence or spoilage. The list given is for example only and is by no means comprehensive. More extensive information can be found in the texts listed in Section 12.

8.5.3. Pre-Cooling of Fresh Produce

Once produce is placed in the cold-store it will radiate heat to the room by virtue of fieldheat and heat of respiration. The sooner the produce is brought to its optimum storage temperature then the sooner will respiration be brought under control and the maximum storage life of the produce be realized.

The heat from the produce is transmitted to the air which transfers this heat to the evaporator which removes it in the normal mechanical refrigeration cycle. The cooling, of the air and hence the produce is speeded up by the presence of electric fans mounted across the evaporator coils and may be supplemented by circulatory fans placed in the room and directed across the produce.

The time it takes for the produce to reach the optimum storage temperature (sometimes called the pull-down time) will be limited by the overall refrigeration capacity of the equipment and the speed of the air passing over the evaporator and over the produce assuming there are no barriers to air circulation around the produce.

Rapid air movement over produce enhances water loss and so in most refrigerated stores for long-term storage, air circulation is moderated to keep water loss to a minimum over the storage period. Produce temperature reduction under these conditions will be slow and the rate of respiration will only be slowly reduced.

To overcome these problems various pre-cooling methods have been devised for the rapid cooling of produce prior to its placement into long-term cool storage.

i. Forced draught cooling - This method is best described by looking at Figure 8.3. (see Figure 8.3. Forced draught cooling of fresh produce) Produce is stacked in the manner shown in a cold-store with a high refrigeration capacity. A sheet of canvas or other material is placed over the stacked produce and a powerful electric fan sucks cold air rapidly from the room through the packed produce.

Although the rapid air movement creates more water loss from the produce, cooling is much more rapid than otherwise and the respiration rate is reduced very quickly. As soon as the produce has been cooled down to close to the optimum storage temperature it can be transferred to an ordinary cold-store for the rest of its storage life. There are many different types of forced-draught cooling and most depend upon the produce being in appropriate containers - often fibreboard cartons. Ships and containers adapted specially for refrigeration and carriage of fresh produce use a variation of this system.

Forced-draught cooling has the advantages of being a relatively cheap pre-cooling method which is easily operated and maintained and is widely used for many different kinds of produce. Heat transfer from produce to air is less efficient than that from produce to water, but many fruits, especially soft fruits, and some vegetables will spoil rapidly in store following water contact.

ii. Hydrocooling - Water is an excellent medium for transferring heat from produce to a cooling source. With hydrocooling, ice generated by a refrigeration plant is melted and the cold water is allowed to collect in a water bath in which either the produce is dipped, or serves as a reservoir for spray or cascade application to the produce. Alternatively, evaporator coils of a refrigeration plant directly cool the water to the required temperature and the produce is dipped or sprayed as before.

Efficiency of the cooling technique depends upon rapid movement of the cold water over the produce. Rate of cooling is dependent on the surface to volume ratio of the produce. Hydrocooling is only suitable for fruits which can withstand the excess of water but is widely used for rapid cooling of many vegetables.

iii. Vacuum cooling - This method depends upon the fact that water absorbs heat as it evaporates and that evaporation (and hence cooling) is very rapid in a vacuum. In essence the produce is packed, stacked on pallets and placed in a special air-tight chamber. Powerful pumps exert a strong vacuum on the chamber and surface water on the produce as well as some of the produce's own water content rapidly evaporates and directly cools the produce. The amount of water lost from the produce is not sufficient to impair quality and storage life.

Vacuum cooling is only of benefit however for produce with a high surface area to volume ratio, such as cabbage, lettuce, celery and other leafy vegetables, which allow for evaporation and thorough cooling in about 20 minutes.

Full-scale plants are expensive to install, but portable units are available which can be powered by a farm tractor. In recent years a system known as 'Hydrovac' cooling has been initiated which is identical to ordinary vacuum cooling but water is added in a controlled manner before cooling commences. In this way water loss from the produce is restricted and has been shown to be of benefit for some crops in allowing longer treatment time and more intense cooling.

iv. Ice-bank cooling - This is a relatively recent development in which heat is removed by melting a large block of ice which has been built up over a period of days by a small refrigeration unit. The heat is removed from air in the store by passing it through sprays of ice-cold melt water in a chamber separate from the store. In this way cool air of very high relative humidity can rapidly cool the store and the produce within. Units down to fivetonne capacity are now available.

8.5.4. Long-Term Refrigerated Storage

Once the produce has been cooled down to the required temperature it should be transferred as rapidly as possible to a store designed specifically for long term storage. Occasionally this is the same store as was used for pre-cooling but normally is an adjacent and often much larger storeroom.

For long-term storage it is important that the room air is well circulated but at a low velocity so that transpiration and water loss from the produce is kept to a minimum. Temperature of the store, and hence the produce within it, should be carefully monitored and maintained and the humidity should be carefully checked and elevated if necessary. Some form of ventilation is vital to prevent accumulation of carbon dioxide and ethylene gases and depletion of oxygen to

harmful levels.

Produce should be stacked so as not to hinder circulation and thus permit the creation of localized "hot-spots" and subsequent premature spoilage. Packed produce should not be stacked against the side-walls nor directly against the evaporators. Stacking produce in regularly spaced 'corridors' will permit inspection of the produce at intervals during storage and hence removal, if necessary, of infected, over-ripe or otherwise spoiled produce.

8.6. Design, construction and management of refrigerated stores

Refrigerated stores are important components of the marketing process for fresh fruits and vegetables. They also demand careful planning in their design, construction, management and day-to-day operation if the substantial capital invested in them is to be protected and if they are to serve their function in the marketing structure.

8.6.1. Design and Construction

Before anything else it is important to determine the needs of the cold store and the environmental conditions. The products to be stored, their types, quantities and periods of production have to be weighed against the storage conditions demanded by the produce and the market place. Inherent factors, such as the local environment, the availability of labour and its skills and experiences, also have to be considered.

The size of the store will be determined by economic and technical factors. Small rooms are more expensive per unit volume for building and operation than large ones, but stock control and management of large cold stores is more complex and difficult. The volume of the cold store will depend upon the stacking patterns necessary for air circulation and heat dissipation, and the height of the rooms will depend on the handling and stacking methods to be used, 2.5 to 3 meters for manual handling, and 6 or even 9 meters if mechanical handling and pallet boxes are used.

Once all the above factors are accounted for then calculation of the refrigeration load can be made and hence the required refrigeration capacity and room insulation determined. These calculations are based on assessment of:

- heat gain/loss through the walls;
- heat gain/loss by air removal and replacement;
- heat of respiration of the products;
- rate of refrigeration/removal of field heat;
- heat gain from electric fans, lights, labour, etc.

Finally, the type of refrigeration machinery, with a power rating sufficient for all refrigeration needs plus a safety margin, can be selected. The usual frigorific power for long-term cold storage, as opposed to pre-cooling, of fruit and vegetables is of the order of 30 to 50 watts per cubic meter.

With regards to construction, many types of building can be used for cold stores. Where the produce will be handled manually the height of the building will allow the use of relatively cheap local materials. For large stores however, specific systems must be designed with metal structures to support insulation or prefabricated walls and ceilings. The limitations are principally economic. The insulation properties must be sufficient to prevent excessive heat leakage and moisture transmission through the walls and ceiling and must constitute on effective vapour barrier.

The elements of refrigeration capacity and insulation of the store room can have considerable bearing on its construction and operating costs. It is recommended that an expert in refrigeration of fruits and vegetables is consulted before investment in the facilities begins.

8.6.2. Management and Maintenance of the Store

Good management of cold stores needs knowledge and experience of:

- storage conditions of the commodities;
- directions for loading of the rooms and maintaining a clean and hygienic state;
- management, control and maintenance of refrigeration equipment;
- staff training in store operation.

The loading of a room should be as rapid as possible if there is no pre-cooling process but should be monitored carefully so as not to over-load the refrigeration plant, or cooling of the produce will take much longer leading to reduced storage life.

POOR MANAGEMENT AND POOR MAINTENANCE - POOR STORAGE!

The stacking of the produce must allow for quick removal of some products, especially with mixed commodity storage, and also not impede air circulation. Opening of doors is an important heat leakage point and must be controlled by disciplined management. If doors need to be beekept open for extended periods, doorways can be fitted with a curtain of wide transparent plastic strips to prevent excessive heat leakage. Store rooms need regular disinfecting to prevent contamination and spoilage of healthy produce and this should be properly supervised.

When loaded, the store room temperature must be checked daily and the thermostat regularly examined to ensure it has not been tampered with. Recording thermometers should be used in large commercial cold stores. The relative humidity of the store room should also be checked regularly to prevent undue water loss by the produce. Evaporator coils should be checked daily for icing and defrosted when necessary. Maintenance and repair of the refrigeration equipment must be done by specialized, well-trained technicians.

One of the most important aspects of store management is the careful and accurate keeping of records. Records of produce type and volume, daily temperatures and humidities, produce losses during storage and when they were first observed and removed, are all essential historical documents assisting in overall store management and auditing of operating costs and profits, but they are also frequently the first indicators of faults and troubles.

CONSEQUENCES OF POOR STORE MANAGEMENT - SPOILAGE AND LOSSES !!

8.7. Economics of storage

Storage adds to the cost of a product and the more elaborate the storage method, the higher the added cost. It is not usually worthwhile storing fresh produce if the price increase resulting from storage does not exceed the costs of storage and show a profit on the operation. Sometimes it is acceptable to break-even on the cost/return ratio if this means that a greater volume of produce is sold overall or that the storage facility is being used more efficiently.

In certain marketing avenues the pre-cooling and/or storage of fresh produce is a standard requirement, and its cost is assumed as an accepted part of the production and marketing strategy. Provided that the storage is accomplished successfully then the price increase resulting from storage can be forecast from previous seasons and in any case will be known exactly in retrospect.

The costs of storage of fresh produce are often difficult to assess precisely and must take into account:

- Operating costs - labour, utilities and administrative costs;
- Fixed costs - the costs of financing and constructing the store discounted over a reasonable period, rent and overheads;
- Financing - the cost of financing the crop while it is in store, whether it be by the party who has stored the product, or other parties on an interest basis. In either case, each day of storage adds cost to the product other than direct storage costs.

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9. Some special post-harvest treatments

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9.1. Why special treatments are needed!

Sections 3.3., 5.2., and 8.2. of this manual describe various basic treatments applied to fresh produce in the field, at the packing house, and prior to storage. In addition, some fresh produce commodities may require special treatments in order to slow down their rate of deterioration and minimize losses. The crops involved are for the most part those which are seasonal and subjected to long-term storage, or which are highly perishable and are transported over long distances to market. Some of the special treatments, such as hot water dipping of mango and degreening of citrus, are often used Just to make the produce acceptable for a given market rather than for any great need to prevent their spoilage.

These special treatments may be applied before, during or after packing of the produce and are supplements to the normal and basic practices of grading, selecting, cleaning, and temperature and humidity management and should never be considered as replacements for such practices. Fruits, because of their generally higher value, seasonality and greater perishability are the most common commodities to be given special post-harvest treatments, and these are summarized in Table 9.1., below.

Root crops are often 'cured' to prolong their storage life and minimise losses, while crops such as onions and potatoes may also be treated with sprout suppressants prior to long-term storage. Fungicides are now in widespread use for decay control in many fruits, vegetables and root crops. These and other treatments are described in more detail below.

9.2. Ripening and degreening of fruits

Oranges and grapefruit grown in the Eastern Caribbean remain green, partly green, or will reach full colouration depending on various environmental factors but especially night-time temperatures. Regardless of colour, the local markets recognize that the fruits are perfectly good to eat and consumers worry more about fullness of flavour, juiciness and sweetness than appearance of the fruits. The export markets demand full-coloured fruits and so a degreening process is necessary.

Degreening is the process where the green chlorophyll pigments in the peel are broken down and the yellow and orange xanthophyll and carotenoid pigments are formed. In citrus, this natural process is stimulated by exposing the fruits to 10 to 20 parts per million (ppm) of ethylene gas under controlled conditions of temperature, humidity and ventilation, in special degreening rooms operated by skilled management. Degreening is generally considered uneconomic unless large quantities of fruit can be treated at one time. The Citrus Growers Cooperative in Dominica uses large degreening rooms in Roseau to initiate colouring of their export citrus prior to sea shipment in refrigerated vessels.

Ripening of fruits is a perfectly natural and highly desirable phenomonen leading to increased sweetness, flavour development and softening of the edible tissue. However, ripening of certain fruits presents a dilemma to the export industry because the very act of ripening clearly marks the onset of senescence rapidly leading to decay and spoilage. The socalled 'climacteric' fruits such as banana, avocado and mango are harvested and shipped for export in the green state while still hard and capable of surviving the physical handling with minimum damage and spoilage during transit. This is a very familiar operation in the Eastern Caribbean where large volumes of bananas are shipped green every week on the Geest boats to England, where they are held in store until just before they are needed by the consumer. The transformation from green unripe to yellow ripe bananas is achieved by stacking the boxed fruit in special airtight rooms where they are exposed to 1,000 ppm of ethylene gas under controlled temperature and high humidity. The ripening process is described in the text to Table 9.2..

TABLE 9.2. RIPENING OF BANANAS

Number of Days to	**Fruit Temperature (pulp) in F**

Ripen	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
4	64	64	62	60	-	-	-
5	62	62	62	62	60	-	-
6	62	62	60	60	60	58	-
7	60	60	60	60	60	58	58

PLEASE NOTE:

a. **The temperatures indicated are for pulp temperature NOT air temperature.**
b. **Air temperatures will usually be lower than pulp temperatures.**
c. **Do not start ripening with ethylene until pulp temperatures stable at desired temperature.**
d. **Seal ripening room and gas with 1000 ppm ethylene for 12 to 15 hours.**
e. **After initial gassing thoroughly ventilate ripening roam with fresh air for 20 to 30 minutes every 12 hours.**
f. **Inspect fruit regularly and adjust air temperatures to control pulp temperature in desired range.**
g. **Ripening time given is time from hard green to Colour Stage 4 (green-yellow with dark green tips)**
h. **Always use a proper pulp thermometer.**

In the tropics, banana ripening is traditionally achieved by harvesting of fuller fruit and simply waiting for it to ripen at ambient. On occasion, some traders may resort to triggering ripening in the same way as with ethylene but using acetylene generated from small quantities of calcium carbide and water in an enclosed room. This practice tends to give fruit which are overly soft for their appearance and with a short market life. In addition, it is very dangerous to use acetylene because of its explosive properties.

In Barbados, quite large quantities of bananas from local growers and from imported sources are now regularly ripened under reasonably controlled conditions using ethylene gas in the same way as Geest, in order to supply

the increased consumer demand for "properly ripened" bananas, but also to enable the high volume retailers, especially supermarkets, to better supply their customers and control their post-harvest losses.

Ripening of avocado and mango can also be achieved using controlled ethylene exposure but its use in the tropical exporting countries will depend upon the market to be supplied and individual importers/buyers requirements.

9.3. Curing of root crops and onions

One of the most important methods of reducing post-harvest losses in many root crops such as yam and sweet potato and also for onions, is the use of surface drying and curing processes.

Curing is a natural wound healing process which in sweet potato and Irish potato replaces and stengthens damaged areas by forming a corky layerwhich protects against water loss and infection by decay organisms.

In contrast, the curing of onions is mainly a drying process where excess moisture is removed from the outer skin and neck of the onion. At the same time, by exposing the onion to higher temperatures the colour of the skin darkens and natural fungicidal compounds accumulate in the skin. Both processes together ensure the formation of protecting layer which greatly reduces water loss and serves as a physical and chemical barrier to infection.

9.3.1. Root Crop Curing

Table 9.3. summarizes the specific details for the curing of different root crops, but regardless of which root crop is to be cured, the following conditions should be established for all:

- **the roots and tubers must be kept at the right temperature to stimulate skin growth, and this is normally above ambient temperature;**
- **the air around the roots or tubers must be moist but without free moisture on the surface dry air will cause injured surfaces to dry out quickly but free moisture will allow spoilage organisms entry into the tuber before the protective layer forms;**
- **skin growth needs oxygen so ventilation is needed but not too much or the produce will dry out and temperatures are also likely to drop.**

All root and tuber crops suffer some damage during harvest and handling so curing should be carried out as soon as possible after harvest. Sweet potato in the Eastern Caribbean is still largely traded both domestically and regionally without a proper curing treatment. Often the uncured tubers are bundled straight into crocus bags with damp soil still attached to the surface and the poorly ventilated bags roughly handled and loaded into unventilated ships holds. It should not be surprising that postharvest losses are often very high. Considering that sweet potato is indigenous to the area it is a pity that most farmers and exporters have very little understanding of how best to harvest and handle the crop.

The most simple curing practice for sweet potato in the Eastern Caribbean involves firstly careful harvest (not when the soil is too wet) and simple stacking of the produce in field crates or in small heaps, off the ground in a shaded, sheltered and well ventilated spot under ambient conditions. The curing process should be completed in 3 to 5 days after which the tubers can be washed if necessary, graded, packed and distributed.

9.3.2. Onion Curing

Curing of onions is most coveniently performed in the field by the 'windrowing' method. Windrowing of onions is performed by carefully pulling or lifting the onions at harvest and simply laying them in their places to dry with

the leaves of one row covering the bulbs of the next row in order to promote thorough drying of the tops while protecting the bulbs from undue sunburn. the bulbs should be turned regularly to ensure even drying and curing and should always be turned after a rain shower to make sure they are not touching wet soil continuously. If rainfall persists, then the onions must be dried and cured on special racks as shown in Figure 9.1. (See FIGURE 9.1. DRYING AND CURING RACKS FOR ONIONS) which can be easily and cheaply constructed from locally available materials. Polythene sheets should be fixed to the edge of the roof to let down quickly in the event of heavy rain showers and removed afterwards.

Curing is considered complete when the outer scales and neck are sufficiently dry to 'rustle' when handled and they form a tight cover over the bulb. Development of skin colour is also completed at this stage, some 10 to 12 days after harvest.

Unfortunately, most onions grown in the Eastern Caribbean are not sufficiently adapted to the local conditions and many of the 'Texas Grano' types are seldom cured sufficiently, in the field or otherwise, before marketing and post-harvest losses due to rots and sprouting tend to be high. The introduction of more suitable red-skinned short day onion varieties with better postharvest characteristics is strongly recommended.

9.4. Sprout inhibition

When crops such as onion and potato are placed in long-term storage in temperate countries they tend to sprout and eventually rot. Sprouting can be avoided under such conditions by using varieties with long dormancy periods, proper curing (see above) and the use of chemical sprout suppressants such as 'Tecnazene' (TNCB), 'Chlorpropham' (CIPC), or other proprietary chemicals.

In the Eastern Caribbean storage is seldom for long enough periods to worry about sprout control, but nevertheless some sprouting of onions and potatoes does occur during distribution and home storage before consumption. The best remedy is avoidance by making sure that these commodities are not stored under high

humidity, such as in unventilated plastic bags, and not exposed to light for significant periods.

9.5. Fungicide application

9.5.1. Why Fungicides Are Necessary!

Most post-harvest losses eventually result from invasion and breakdown of the produce by micro-organisms, although physical injury and stress caused by poor handling may predispose the produce to such attacks. In the spoilage of vegetables, bacteria can be the most important spoilage organisms, but since bactericides are not suitable for application to fresh produce, control must be largely by other methods. Chlorinated disinfectants are beneficial in cooling and washing water but are difficult to use effectively because the chlorine tends to combine readily with dirt and debris and ceases to be effective.

Fungi are usually the primary agents in the spoilage of fresh produce and control is possible by the application of fungicides at dose rates which do not harm the produce nor the consumer of the produce. If the produce is to be marketed and consumed rapidly after harvest then fungicides may not be necessary or their use may be uneconomic if the value of the produce is low or the effect of the fungicide is not sufficiently significant.

Fruits in particular suffer from fungal infection. Often infections established in the field may remain dormant until after harvest and decay only develops during post-harvest ripening. These so-called 'latent' infections are of great importance to crops such as bananas, mangoes and avocadoes, where anthracnose infections are not seen by the exporter but may totally prevent their purchase in the export market if not controlled.

9.5.2. Application Methods for Fungicides

Fungicides are nearly always applied in the form of an aqueous solution or suspension and thus only to produce which is normally washed before packing.

Washed produce should be drained of excess water before the fungicide is applied or dilution will occur and the fungicide may not work properly - a waste of money and time.

Almost all fungicides used for post-harvest application are in the form of wettable powders (WP) or emulsifiable concentrates (EC), and when mixed with water form suspensions, not solutions. They are both liable to settle out from the suspensions so it is ESSENTIAL THAT THE TANK MIX BE CONTINUOUSLY AGITATED TO KEEP THE FUNGICIDE IN SUSPENSION. Failure to do this will mean that the fungicide will collect at the bottom of the tank instead of going on to the produce - no fungicide application means no effect and a waste of time and money.

The most common application methods are:

i. **Spray or mist - when application is by a hand-held knapsack sprayer for small-scale operations, or a mechanical spray set up on a moving belt or roller-conveyor for large-scale commercial operations. Both systems normally include provision for agitation of the spray mixture. Spraying should be done to the point of run-oof to ensure a complete cover of fungicide.**
ii. **Drenching - is a simple mechanical re-circulating system in which the fungicide is pumped in a cascade over produce passing beneath it on a belt or roller-conveyor. It has the advantage that there are no spray nozzles to wear away or become blocked. The combination of reservoir design and a high flow-rate pump keep the mixture agitated. A disadvantage of the system is that the high flow-rate and agitation may cause the fungicide to be dragged out of suspension and float on the foam generated by the agitation. It may be necessary to add a non-toxic anti-foam agent to prevent this happening.**
iii. **Dipping - is normally used where small quantities are to be treated. The fungicide mixture is made up in a small bath and produce dipped by hand. Excess fungicide is allowed to drain back into the bath. The**

fungicide mixture must of course be agitated frequently by hand. It is advisable to wear rubber gloves because some people develop allergic skin reactions to the fungicide mixture.

iv. **Smoke or fumigant - is rarely used as an application method for fungicides. Tecnazene, which is a fungicide as well as a sprout suppressant, is applied in the form of volatile granules in long-term Irish potato stores, and 'diphenyl' wraps or pads may be used for citrus.**

9.5.3. Caution When Using Post-Harvest Fungicides!

Pesticides used in the field are subject to removal from the crop by rain, wind, solar degradation and physical removal by rubbing of leaves etc. by handling of produce at harvest, and the produce may also be washed after harvest. However, fungicides applied post-harvest in the packhouse, or wherever, are not subject to these factors, and what is applied will largely remain until the produce is purchased by the consumer. The fungicide will thus remain on the produce and help to control fungal infection but it will also be there as a possibly toxic chemical at the time of consumption.

For these reasons only a small number of chemicals is available for post-harvest treatment of fresh produce and is limited to those chemicals with a very low toxicity. The manufacturers specify strict limitations on the concentrations to be used so that residues do not exceed the permitted levels for human consumption. Extra-regional export markets regularly check on fungicide and other pesticide residue levels on imported produce and if the permitted levels are exceeded, the produce is rejected and a warning given that all produce from that source must in future comply with the legislation or a total ban will be implemented. It makes good sense from an economic as well as an ethical standpoint to use fungicides carefully and accurately.

9.6. Hot water treatment

Although not used for treatment of vegetables and delicate fruits, hot water immersion of mango and pawpaw has been shown to help control latent 'Anthracuose' development. The hot water treatment is usually combined with fungicide application to promote the most effective control and save additional handling and equipment.

In the Eastern Caribbean, hot-water treatment is recommended for mangoes exported to the extra-regional markets. The details of the process have still to be optimized with regard to water temperature and duration of the dip, and the requirements of different varieties from different growing areas, and possibly also from different harvest times. Experiments are being conducted by post-harvest technologists in Dominica at the Government's Produce Chemist's Laboratory, and at the CENTENO Post-Harvest Research Unit of the Ministry of Food Production in Trinidad, as well as individual experimentation by independent exporters including CATCO.

Generally, there are two main variants of the hot water treatment:

i. **Dip in hot water at 55C for 5 minutes. Heat injury can develop when the mangoes are placed in cold storage after treatment - do not therefore dip in hot water when fruits are to be stored.**
ii. **Dip in hot water at 52C with Benomyl (Benlate) at 0.1% concentration, for 1 to 3 minutes.**

Hot water treatment requires a lot more management and supervision to ensure that the water temperature and dipping time are strictly adhered to because there is little margin for error. Commercial scale equipment for treating larger volumes of fruit have yet to be acquired in the region and even in more developed countries the apparatus is still undergoing further development.

9.7. Fumigation and vapour-heat

Fumigation of fruits was traditionally for control of disease, as in the case of sulphur dioxide fumigation of grapes to control Botrytis and other fungus diseases, or for control of insect pests for quarantine purposes,

principly against fruit flies.

Quarantine regulations in the USA and Japan require that certain produce from areas where fruit fly is endemic must be disinfested on or during importation, by approved and controlled methods. This was formerly achieved by fumigation with ethylene dibromide (EDB) or methyl bromide (MB). These chemicals have since been banned by many countries fo fear of toxic residues on the treated fruits. For the present, there are no suitable alternatives and areas with fruit fly in the Eastern Caribbean have no opportunity to export fruits such as mango to the USA unless, like Grenada recently, they are cleared as fruit fly free by USDA inspectors.

Vapour heat treatment may be used where other fumigants may damage the produce. The treatment consists of circulating saturated water vapour at high temperature around the produce in an enclosed store until the produce reaches the required temperature, usually in about eight hours, and the produce is then held at that temperature for a further six hours. Clearly most fruits such as avocado, lemon and most vegetables would injured by this treatment, but other kinds of citrus may be treated with vapour heat without serious Injury. The method is not in widespread use on account of its cost and impracticality. The method is not considered a viable alternative to EDB fumigation for the Eastern Caribbean.

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10. Getting the message across - training

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10.1. Training goals

Training goals should have the objective of meeting specific training needs in the marketing of fruits and vegetables, and these fall broadly into two camps:

- **direct training of operatives involved in the manual handling, transport and distribution and storage of produce by demonstration and close supervision;**
- **management training of executives and technicians involved in decision making and extension work.**

Good training can increase manual workers' and management personnel's awareness of their responsibilities and roles in the marketing process and the impact of their contribution in -improving overall marketing efficiency.

Let us look a little more closely at the priority cases for training and what they need specific training in :

i. **Producers - Since marketing begins with the producer and he is also the first to handle the produce, training in his area of influence is a major goal. Advice and demonstration about production planning, harvesting, on-farm handling, field assembly, transport and packing should be directed through agricultural extension services.**
ii. **Transporters - Transporters of fresh produce may be handicapped in many cases by the types of containers and vehicles which they are currently obliged to use and will certainly be handicapped by poor roads and other infrastructural deficiencies. Nevertheless, instructing porters in the need to treat fresh produce carefully and to avoid rough handling can go a long way in alleviating these problems.**
Transporters need to be sensitized to the advantages of removable covers on vehicles to keep off sun, rain and dust, and the importance of careful driving on bad roads as well as proper maintenance of their vehicles. Special demonstration training is required to show real benefits of improved transport.
iii. **Distributors - Included in this category are the wholesalers, retailers, Nigglers, hawkers, traffickers and**

hucksters since all play a vital role in the distribution of fresh produce.
The most important element of the training is clear demonstration of the correct way to lift, carry and handle produce so as to reduce damage and post-harvest losses. Other specifics for training include: product knowledge; receipt, storage and stock control of produce; produce display; and, general business administration.

iv. **Extension workers - Extension workers are usually generalists with a broad knowledge and experience of many areas. The objective of training extension staff (trainer training!) is not to convert them into specialists, but to sensitize them to the subject and expose them to training and resource materials which they can incorporate into their regular programme. The extension worker can then offer better support to the real target audience, the trainees, be they farmers or whoever.**

v. **Planning personnel and policy makers - To many senior government officers, politicians and management personnel, marketing, particularly of fresh produce is a complex area in which many would rather leave alone because they do not sufficiently understand the systems and their importance. Clearly, these individuals do not require a structured training course so much as an introduction to the subject and sensitization to the problems and the possible solutions.**
Sufficiently well-informed policy makers and management personnel can make a significant contribution to overall agricultural marketing development. On the other hand, insufficiently informed managers and policy makers can condemn a programme before it even gets started.

vi. **Consumers - Any improvements or changes in marketing and distribution patterns and in the post-harvest systems in operation, may be unsuccessful without the benefit of an informed public sensitized to the need for change in the first place. Many post-harvest losses are caused by the consumers lack of understanding of perishability of fresh produce and how to handle and store correctly at home.**
Training of the consumer may be by media campaigns in newspapers or radio and television programmes or by point*-of-sale posters and other educational materials, or by inclusion in the regular curriculum of primary and secondary schools.

10.2. Training coordination and support

It is relatively straightforward to identify those individuals or groups in need of training in post-harvest and marketing of fresh produce but it is not so easy to identify appropriate support mechanisms for that training and to coordinate the different training courses within a broader programme. When that broader programme is in reality a combination of many different programmes, each with often quite different end objectives and methods even though the target audience is the same, then the biggest problem is coordination in order to prevent repetition and dilution of effort.

The islands of the Eastern Caribbean are frequent if not constant hosts to a very large number of aid and development agencies, many of which concentrate on agriculture, and most of these focus particularly on technical assistance and training. Each of these agencies identifies specific target groups or individuals for training relative to the particular interests or commitments of the agency concerned. The type of training envisaged and the level of that training is subject to many possible permutations depending on the abilities and experiences of the consultants and trainers, many of whom may only be in the region for a short while and may or may not have had previous relevant experience in the Eastern Caribbean.

Staff of the Ministries of Agriculture in each island are frequent targets for training and attendance at training workshops, and often the government has very real difficulties in identifying participants for a training course or workshop because they are understaffed, and perhaps because too many Ministry staff are already attending another workshop elsewhere at the same time.

Each of the island states in the English-speaking Eastern Caribbean has identified agricultural diversification as its major strategy with a concentration on extra-regional exports of fresh produce as its mayor goal in the push for greater foreign exchange earnings and reduced fresh produce imports. Training, sensitization and education are seen by all governments as necessary if this push is to be sustained. Training in postharvest and marketing features prominently in all of the national agricultural plans but few countries if any have a cohesive

programme prepared at the national level, let alone the regional level.

10.3. Training materials

Any intended training programmes will need training materials prepared specially for the Eastern Caribbean and more particularly for the commodities to be covered and targetted for one or more particular group of trainees, be they farmers or stevedores, or whatever. Very little training material of this degree of specificity is currently available, although special interest groups like the Dominican Hucksters Association (DHA) and CATCO are producing training materials specific to their needs. However, these materials once prepared are not yet shared with other groups sufficiently to avoid some duplication of efforts.

One of the mayor aims of this manual is to provide specific training materials for direct use by extensionists and technicians in the Eastern Caribbean. However, even with the best will in the world, this manual cannot be considered the answer to all extension workers' and trainers needs. Many groups of trainees will need a simpler and more general approach while others will need more detailed coverage of highly specific areas of marketing and distribution, perhaps for one or two commodities only. For these reasons, users of this manual should feel free to adapt and amend the material to suit their own or their trainees needs, provided of course that the principles involved are not misinterpreted. As with any publication, its use in whole, part, adapted or amended form should always be acknowledged.

10.4. Training techniques

Many people in the Eastern Caribbean are familiar with a few training techniques such as the workshop system, demonstrations and field visits. These methods undoubtedly have their uses, but they also have their limitations depending on the material used, the abilities and experience of the trainers, and the needs and abilities of the trainees.

Occasionally, some so-called workshops may offer little more than a series of lectures followed by questions from the floor. If the lectures were not properly prepared, or the lecturer was not a good communicator, and the audience not receptive or too nervous to ask important questions about what they did not understand, then the whole exercise may have been an expensive waste of time. People who attend training usually have jobs to do. If they are not receiving adequate training but are kept away from their job then the exercise is doubly expensive.

The following is a brief guide to various forms of training that can be used on their own or in conjunction at workshops and other such training meetings:

(i) Demonstration - An expert (trainer or someone else) shows how to do something in the correct (or incorrect) way and which the trainee is meant to imitate (or avoid). This method is useful for training in nearly all of the practical skills necessary in harvesting, marketing and distribution of fresh produce. It is particularly suited to training of farmers, transporters, hucksters and stevedores.

Hints:

- **Allow enough time for trainees to practice;**
- **Let the trainees, rather than the trainer, analyse the good and bad points;**
- **Often the method being demonstrated is better exaggerated to emphasis the technique.**

(ii) Field visits - planned visits to farms, cold stores and commercial enterprises are extremely effective because they allow trainees to see real-Life situations where the skills and operations are in everyday use. In addition, the trainees get the opportunity to ask questions of the people working on the site and will very often get exactly the information they need to improve their own operations.

Hints:

- **Visit the site well before the planned visit and brief the managers/farmers etc on what you want to see;**
- **Confirm the time and date of the visit and reconfirm on the preceding day - these operations are usually commercial and plans may have to be changed at short notice;**
- **Arrive on time and depart on time;**
- **Brief the trainees in advance on what to look for, questions to ask, etc.;**
- **Best included later in a course when trainees have acquired some basic knowledge and concepts;**
- **Debrief the trainees fully on what was learned, possible applications in own situation, etc..**

(iii) Slide or film shows - Films are good at showing movement when training in handling and packaging, but very few films relevant to the Eastern Caribbean exist or are available. Video offers excellent possibilities for the future but equipment and trained operators with experience in recording training material are not present or are fully engaged in other commercial activities. Trainers should contemplate using video as a major training tool and try to get the equipment and training in its use as soon as possible.

For the moment, slides represent the best opportunity for visual training and demonstration as accompaniment to lectures and talks (see below), but there is a shortage of suitable slide materials in the region. CARIRI have developed a slide series recently for use in the region which is particularly recommended for use with this manual, but the slide series is relatively expensive and has only just started to be disseminated in the region (see Section 12 for details). Other slide materials from outside the region may have limited application for techniques but may prove useful in emphasizing principles (ea. slide sets from University of Davis, California.).

Hints:

- **Make sure the projector, or other equipment, works and you know how to use it;**
- **Make sure the material shown is appropriate and relevant to the situation you want to demonstrate (a film might be in the wrong language or only demonstrates temperate country experience);**
- **Brief the trainees on what to watch for on a film and repeat that section if necessary;**

- **When using slides make sure that everybody can recognize the significance of what is being shown, and describe it by other means if necessary at the same time.**

(iv) Lecture - This is quite a good method of imparting specific information to a large audience but often is not sufficiently interactive with the trainees by way of discussion and resolving individuals problems and doubts. A lecture should be well supported by visual aids to illustrate the main points if the audience is to stay awake.

Hints:

- **Keep it short, preferably 30 minutes or less;**
- **Summarise the main points and make few points;**
- **Make sure the "level" of the audience is matched by the technical content of the lecture;**
- **Watch carefully for boredom and sleepiness;**
- **Use humour and practical examples;**
- **Make sure everyone can hear the lecturer;**
- **Hand-outs of diagrams and the main issues are useful.**

(v) Group discussion - led by the trainer or a chosen group leader is more effective with groups of around 10 trainees. A topic of interest is selected (perhaps from earlier training material or lectures or from current marketing operations) and discussed informally among the group who venture suggestions and ideas for improvement or amendment.

Hints:

- **Be very clear on the objective of the discussion and where possible keep attention focussed on that objective;**
- **Prepare key questions in advance to stimulate the group if ideas temporarily run dry;**

- **Don't let one or a small band dominate the discussions and keep everybody involved by asking questions of the "quiet" ones;**
- **Set a time limit but be flexible if the discussion is particularly valuable; - Summarise the outcome.**

(vi) Panel discussion - A group of experts answer questions from the trainees and/or make short presentations on a particular topic. The experts can be drawn from many different sources depending on the topics and operations to be discussed.

Hints:

- **Don't allow panel members or questioners to hog the proceedings - keep strictly to prepared ground rules (ea. speeches limited to 2 minutes, etc.);**
- **Not every panel member should necessarily have a comment on every question - so don't ask them every time;**
- **Make sure you have a very "strong" chairperson who has the respect of panel members and questioners.**

(vii) Case studies and management games - A case study is where a particular situation or operation is examined in detail by the group such that the reasons for the operations and techniques can be thoroughly analysed and alternatives realized. Case studies are an excellent way of reinforcing trainees knowledge and giving them the confidence to analyse the situation for themselves and act accordingly. The trainer will need to guide the trainees but should keep a low profile. This is a widely used technique in workshops but is often hurried through because not enough time is allowed for detailed examination and analysis.

Management games are a useful exercise for trainees familiar with a particular operation or system but who need training in decision-making and evaluation. For example, the group of trainees is given a particular problem to solve within an organization (fictitious or otherwise) and at the same time they are assigned operational titles and responsibilities. The trainees make decisions about the running of the organization and

the resolution of the problem.

During the management game, the trainees can swap roles and further information about changes in the situation and consequences of their decisions can be introduced. Games of this nature take a lot of time to prepare and to play. Trainers/directors shouts ensure that the trainees experience some success or they might reject the game as being unrealistic and "a waste of time".

Many other possible forms of training exist, such as projects for individuals and/or groups and group tasks to be completed without the aid of the trainer. Many organizations train their staff by apprenticing them with an experienced hand or staff member, and although this is very practical and effective for the training of new recruits, it often ignores the importance of trainees learning alternative ways of doing things which are not used or have not yet been considered by the organization. Training should seek to extend the horizons of the trainees knowledge beyond that of their current exposure.

Trainers and extension workers are by necessity generalists with a broad scope of knowledge and experience, and who are good communicators and they can teach. Experts, research workers, commercial people, and others are extremely useful when included in support of a training programme as lecturers, panellists or guest speakers, but trainers should never expect these specialists to be good teachers. When putting together any training programme the trainer should always discuss the material with the specialist concerned, and edit it if necessary, to make sure that it fits in with the rest of the programme and doesn't miss the target.

Training programmes, like marketing programmes, should have a built-in flexibility to cover eventualities such as transport and power failures, extended discussion periods which are perhaps more valuable than an optional lecture or presentation, and the possibility of backup material and ideas if a gap appears in the programme. For example, a lecturer or speaker may not make it on time because of delayed/cancelled flights, or a 'management game' doesn't work out as planned and has to be cut short. there is no substitute for thorough planning and preparation.

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11. Post-harvest equipment

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11.1. Basic equipment for practical field use and troubleshooting

Specialists and extension workers are often required to assist growers and marketing organizations by making decisions about crop maturity and produce storage or distribution. At other times, these same workers will need to conduct investigations into how and why various problems have occurred in the field or during preparation and distribution of the produce.

These advisory and troubleshooting activities are a vital part of the development of the fresh produce industry in the Eastern Caribbean, but seldom do the extension workers and specialists have any tools other than their own experience and intuition to come up with the answers so badly needed and needed immediately as far as the farmer is concerned.

Recently, the FAO Inter-Island Trade Project (PFL/RLA/001/PFL) obtained 15 portable post-harvest equipment kits for use by trained individuals in each of the eight independent countries in the Eastern Caribbean. The portable kits are intended for use by extension workers and specialists working in the field measure produce temperature, humidity and temperature of air in stores or ambient conditions, sugar concentrations in fruits approaching maturity, as well as monitoring temperatures during storage and

distribution.

Below, is a list of such equipment and possible suppliers together with their names, addresses and other contact details. It must be stressed that the particular suppliers listed are not in any way recommended and others exist which may also be appropriate. Whenever considering purchase of any equipment, it is advisable to request quotations from as many suppliers as possible because fluctuating currency exchange rates and varying rates for freight and insurance for delivery will significantly alter the final price. Many suppliers may consider discounts of as much as 10 per cent or more on purchases of ten or more units at a time.

11.2. Equipment and possible suppliers

(i) Hand-held Refractometers

These are durable and very reliable (when used properly) field instruments for measuring sugars or soluble solids in fruits such as melons, citrus, pineapple and others. Some refractometers measure per cent sugars directly, while others measure soluble solids in Brix units which need conversion to per cent sugars.

The 'Atago' type refractometer is self-compensating for temperature differences (but for a higher price of course!) but other units need to refer to temperature compensation tables. In practice, readings taken at ambient in the Eastern Caribbean region will be approximately 0.5 to 0.75 per cent low than actual sugar per cent.

Possible suppliers include:

Bellingham and Stanley Ltd., Longfield Road, North Farm Industrial Estate, Tunbridge Wells, Kent. TN2 3EY. England. Telephone: 892-36444 Telex: 95453 (REFRAC G) Fax: 892-43115

McCormick Fruit Tech., 6111-A Englewood Avenue, Yakima, Washington 98908 USA. Telephone: 966-3999 No telex/fax details!

(ii) Humidity Measurement

Humidity measurement in stores or of ambient air can be made either electronically or by the wet and dry bulb thermometer principle. Static wet and dry bulb thermometers are far too slow in measuring humidity but in the form of a whirling hygrometer or sling psychrometer are a very reliable, cheap and rapid method for humidity measurement. Whirling hygrometers come in several designs and makes and choice should be based on price and durability for field use. Do not forget when ordering, to request spare thermometers (they get broken when misused!) and wicks for the wet bulb.

Possible suppliers include:

McCormick Fruit Tech. (see above for details) ELK International Ltd.,. Eastman Way, Hemel Hempstead, Hertfordshire HP2 7HB England. Telephone: 442-218355 Telex: 825239 (ELELTD G) Fax: 442-52474

There are various types of portable electrical equipment capable of rapid measurement of humidity but these are generally more expensive than the whirling hygrometer and often take longer to equilibrate to ambient conditions which are changing in humidity. Most electronic humidity measurement devices also give air temperature measurement at the flick of a switch, thus giving two pieces of equipment for the price. However, the same instrument cannot be used for measuring produce temperature which is a far more important indicator of produce condition and market or store life.

Possible suppliers include:

ELE International Ltd. (see above for details) McCormick Fruit Tech. (see above for details) Kane-May Ltd.,

Swallowfield, Welwyn Garden City, Hertfordshire, AL7 1JP England. Telephone: 707-331051 Telex: 25724 (KAMAY G) Fax: 707-331202

(iii) Temperature Measurement

Air temperature measurement can often be reliably measured using an accurate mercury thermometer such as the dry bulb thermometer in a whirling hygrometer, or a static Maximum/Minimum thermometer of the 'Taylor' type which is usually only seen in a Stephenson Screen with other weather recording instruments.

Max/Min thermometers are also very useful in registering the extremes of air temperature experienced in a store and will thus give a good indication of when things go wrong with refrigeration. Many different suppliers exist, including all of those already listed except for Bellingham and Stanley, and Kane and May.

Measurement of produce temperature is actually far more crucial when storing, ripening, or distributing produce and requires insertion of a reinforced glass pulp thermometer or a thermister type metal probe linked to an electronic metering device. For nearly all purposes, the electronic type with a solid chisel-type thermister probe are preferred, and can usually be obtained relatively cheaply. The electronic types usually have a digital display and run off of small batteries. They are very durable and generally very fast and accurate in their response. The advantage of the probe is that produce temperatures, hydrocooling or dip-tank temperatures and even air temperatures can all be measured with one piece of equipment.

Possible suppliers include:

Kane-May Ltd.
ELK International Ltd.
McCormick Fruit Tech. (see above for details)

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12. Literature, references and training supports

12.1. List of practical guides, tests and references on post-harvest technology and marketing of fresh produce

The following list is not intended to be an exhaustive bibliography of literature and references on the very diverse and complex field of post-harvest technology and marketing of fresh produce. On the other hand, the contents of the manual can not supply all the information needs for all crops and marketing situations in the Eastern Caribbean.

The references given below are reasonably upto-date and encompass, in the author's opinion, a good selection of practical and essential information to suit the needs of trainers and specialists alike. The texts covering predominantly temperate agriculture are included because of their good coverage of the principles of post-harvest technology rather than for their immediate relevance to the Eastern Caribbean.

1. **ABBOTT, J. C., (1970) - Marketing fruit and vegetables. FAO Marketing Guide No. 2, 2nd edition. FAO, Rome 181 pp. (available through FAO Office in Barbados).**
2. **ABBOTT, J. C., (1979). Agricultural economics and marketing in the tropics. Intermediate Tropical Agriculture Series. Longman Group Ltd., London 168 pp.**
3. **BURTON, W. G., (1982). Post-harvest physiology of food crops. Longman Group Ltd., London 339 pp.**

4. **DIXIE, G., (1988). Horticultural marketing. A resource and training manual for extension officers. FAO. 110 pp.**
5. **GIULIANO, M. A., (1987). Fresh and freign : A complete guide to marketing produce from the Caribbean and Latin America. Walker A. Williams and Company, Inc., Washington DC 76 pp.**
6. **HAARD, N. F. and SALUNKE, D. K., (1975). Symposium: Post-harvest biology and handling of fruits and vegetables. AVI Publishing Co. Inc., Westport, Connecticut. 193 pp.**
7. **HARRIS, S. R., (1986). Improvement of post-harvest fresh fruits and vegetables handling. A manual. FAO Regional Office for Asia and the Pacific, and Association of Food Marketing Agencies in Asia and the Pacific. 229 pp.**
8. **HORTON, D., (1987). Potatoes. Production, marketing and programs for developing countries. Westview Press. 243 pp.**
9. **INTERNATIONAL INSTITUTE OF REFRIGERATION (various) (1976) Guide to refrigerated storage. 190 pp. (1976) Refrigeration techniques in developing countries, 2nd Edition. 170 pp. (1976) Current trends in the refrigerated storage and transport of perishable foodstuffs. 241 pp. (1976) Towards an ideal refrigerated food chain. 193pp. (1979) Recommended conditions for chilled storage of perishable produce. 148 pp.**
10. **KADER, A. A., MORRIS, L. L. and CANTWELL, M., (1979). Post-harvest handling and physiology of horticultural crops. A list of selected references. Vegetable Crops Series No.169 (revised edition). Division of Agricultural Sciences, University of California, Davis, California. 44 pp.**
11. **KADER, A. A., KASMIRE, R. F., MITCHELL, F. G., REID, M. S., SOMMER, N. F. and THOMPSON, J. F., (1985). Postharvest Technology of Horticultural Crops. Cooperative Extension, University of California, Division of Agriculture and Natural Resources. 192 pp.**
12. **LUTZ, J. M. and HARDENBURG, R. E., (1968). The commercial storage of fruits, vegetables and florist and nursery stocks. Agriculture Handbook No. 66, US Dept. Agriculture, Washington, D. C. 94 pp.**
13. **McGREGOR, B. M., (1987). Tropical products transport handbook. Agriculture Handbook No. 668, Office of Transportation, US Dept. Agriculture, Washington DC. 148 pp.**

14. **MAFF (1979). Refrigerated storage of fruit and vegetables. Reference Book No. 324, Ministry of Agriculture, Fisheries and Food (MAFF), HMSO Stationary Office, London. 148 pp.**
15. **MENDOZA, D. B. and WILLS, R. B. H. (Editors), (1984). Mango. Fruit development, postharvest physiology and marketing in ASEAN. ASEAN Food Handling Bureau, 8th Floor, Syed Kechik Foundation Building, Bangsar, Kuala Lumpur, Malaysia.**
16. **MOLINE, H. E. (Editor), (1984). Postharvest pathology of fruits and vegetables : Postharvest losses in perishable crops. Agricultural Experiment Station, Division of Agriculture and Natural Resources, University of California, Berkeley, California. 80 pp.**
17. **NATIONAL ACADEMY OF SCIENCES,(1978). Postharvest food losses in developing countries. National Academy of Sciences, Washington, D.C. 206 pp.**
18. **OAKLEY, P. and GARFORTH, C.,(1985). Guide to extension training. FAO Training Series No. 11, FAD/UN. 144 pp.**
19. **PANTASTICO, Er. B., (1975). Post-harvest physiology, handling and utilization of tropical and sub-tropical fruits and vegetables. AVI Publishing Co. Inc., Westport, Connecticut. 587 pp.**
20. **PURSEGLOVE, J. W.,(1968). Tropical crops : Dicotyledons. Longman Scientific and Technical Press, Harlow, England. 719 pp.**
21. **PURSEGLOVE. J. U., (1972). Tropical crops : Monocotyledons. Volumes 1 and 2. Longman Scientific and Technical Press, Harlow, England. 607 pp.**
22. **RYALL, A. L. and LIPTON, W. J.,(1979). Handling, transportation and storage of fruits and vegetables. Volume 1. Vegetables and melons. 2nd. Edition, AVI Publishing Co. Inc.,, Westport, Connecticut. 587 pp.**
23. **RYALL, A. L. and PENTZER, W.T.,(1974). Handling, transportation and storage of fruits and vegetables. Volume 2. Fruits. AVI Publishing Co. Inc., Westport, Connecticut. 436 pp.**
24. **SAMSON, J. A.,(1980). Tropical fruits. Tropical Agriculture Series, Longman Press, London and New York. 250 pp.**
25. **SCHUUR, C. C. M., (1988) Packaging for fruits, vegetables and root crops. FAO Project PFL/RLA/001/PFL, FAO Representative Office in Barbados, FAD/UN. 58 pp.**

26. **SCHUUR-CASTENMILLER, J.,(1988). Trade of fresh produce in the Eastern Caribbean. FAO Project PFL/RLA/001/PFL, FAO Representative Office in Barbados, FAD/UN. 242 pp.**
27. **STOVER, R. H. and SIMMONDS, N. W., (1987). Bananas. 3rd Edition, Tropical Agriculture Series, Longman Scientific and Technical Press, Harlow, England. 468 pp.**
28. **UNIDO,(1972). Wood as a packaging material in the developing countries. ID/72. UNIDO, Vienna. 111 pp.**
29. **WARDOWSKI, W. F., NAGY, S. and GRIERSON, W.(Editors),(1983). Citrus fruits. AVI Publishing Co. Inc., Westport, Connecticut.**
30. **WILLS, R., LEE, T., GRAHAM, D., McGLASSON, B. and HALL, E., (1981). Postharvest: An introduction to the physiology and handling of fruit and vegetables. New South Wales University Press, Kensington, New South Wales, Australia. 176 pp.**

12.2. List of slide sets/visual aids and suppliers addresses

There are a considerable quantity available internationally of slide sets and series covering post-harvest technology and marketing of fresh produce. Unfortunately, most are inappropriate or indeed irrelevant to the needs of trainers and trainees in the developing countries, including the Eastern Caribbean.

The list below indicates those slide sets are considered useful by the author when organising training sessions for extension workers, farmers, and in some circumstances specialists or policy makers. Attention is drawn in particular to the slide series created by CARIRI/IICA especially for the Eastern Caribbean. This four volume series, complete with audio cassettes, combines original slides with other reproductions from various texts and sources.

The CARIRI/IICA slide sets are beyond the economic range of many if not all trainers and government institutes in the region. However, one complete set is possessed by each of the CARDI/CARDATS offices in the Eastern Caribbean, another with the Ministry of Agriculture in Barbados, and yet another with the FAO Representatives Office in Barbados. Provided that enquiries are made well in advance, it should be possible to

borrow the slides and cassettes for official training programmes.

1. Postharvest Handling of Tropical Produce.

- **Volume 1. Overview.**
- **Volume 2. Harvesting and Field Handling.**
- **Volume 3. Cooling, Storage and Postharvest Treatments.**
- **Volume 4. Packaging, Transport and Handling.**

Series available through Caribbean Industrial Research Institute (CARIRI) in Trinidad, and Inter-American Institute for Cooperation in Agriculture (IICA) offices throughout the region.

2. A Guide to Quality Requirements for Fruits and Vegetables in Western Europe.

50 slide set produced by and available from Overseas Development and Natural Resources Institute (ODNRI), 56 -62, Grays Inn Road, London, WC1X 8LU, England. (Formerly known as TPI or TORI, the address will change later in 1989, consult British Commission for details.)

3. Postharvest Cooling Methods.

80 slide set produced by University of California at Davis, and available from Eugene Memmler, 3287 Dunsmere Road, Glendale, California, CA 91206, USA.

Many other slide sets are available through Eugene Memmler, and although most are not suitable for the Eastern Cartibbean, some may be of specialist interest. Write to Eugene Memmler for an updated listing of available slide sets.

Some slide sets have been prepared in the region, or are being prepared at the moment, but may have a very

limited distribution. For example, the slide set on post-harvest handling and marketing produced by the CENTENO Post-Harvest Research Unit of the Ministry of Food Production in Trinidad, or the slide set being prepared between Dr. Michael Griffin at CARDATS in Grenada and Dr. David Crucefix at the Ministry of Agriculture Produce Chemist's Laboratory in Dominica. The trainer should try to stay in touch with such developments wherever possible and persuade other institutions to share their visual aid resources at every opportunity.

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Appendix

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Basic Advice for Handling and Marketing of Fresh Produce Commodities Regularly Grown and Traded in the Eastern Caribbean.

COMMON NAME: AVOCADO

Latin Name: (Persea americana)

Principal Varieties: Pollock, Lula, large range of local types

HARVEST

Maturity: Depending on variety, a combination of size, smoothness of the skin and loss of sheen indicates maturity.

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 bag or pouch worn on the body for lowering to the ground at intervals. Where fruit cannot be reached by climbing, picking poles with attached pouches (preferably with cutter bars) should be used.

Field Assembly: Place in field crates or baskets in a shaded area of the field. Exposure to the sun will raise temperature of the fruit causing earlier ripening and shorter shelf life.

POST-HARVEST

Treatment: Trim stalks to 1.0 - 1.5 cm in length to reduce the risk of injury among fruit after ripening. If the stalk is removed at the mature green stage it predisposes the fruit to stem end rot.

Selection/Grade: Remove soil or field debris with clean soft cloth. Hake sure fruit is dry. Select out damaged, malformed, immature and scarred (e.g. fruit with growth cracks and healed abrasion injuries) fruit. Grade according to size.

Packaging: Place large fruit in single layers in strong cardboard cartons with separators. Smeller 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.

Ambient Storage Life: Host varieties ripen in 2 to 4 days after harvest and ripe fruit has a shelf life of 1 to 2 days.

COMMON NAME: MANGO

Latin Name: (Mangifera indica)

Principal Varieties: Julie, Graham, PaLouis, Long, Ceylon, Imperial

HARVEST

Maturity: Harvest at mature green stage. Maturity indicators ray be variety specific. Size, fullness of cheeks, colour and sheen are useful indicators.

Method: Harvest by hand or with a picking pole and attached pouch. Mechanical in jury should be avoided at all cost, especially impact injury from fruit falling or being thrown about. Injury also hastens ripening and shortens storage live. Punctures and bruises, even small ones, may lead to severe losses from rotting.

Field Assembly: Place in field crates or baskets in a sheltered area of the field. For specific markets and when the quality of the harvested fruit is very good, infield selection and packing for shipment can be done. Ensure that such mangoes are mature with a well developed abscission layer and no leaking sap. They should be of marketable size and free from blemishes. For field packing, mangoes should be wiped free of soil and other debris with a clean soft cloth.

POST-HARVEST

Treatment: Wash mangoes if contaminated with sap and if a fungicide treatment is used.

Selection/Grade: Select out all immature, ripening, damaged, scarred or otherwise blemished fruit. Grade

according to size.

Packaging: Pack mangoes in cardboard boxes or lined wooden crates for shipment.

Ambient Storage Life: Mangoes ripen within four (4) days after harvest at the mature green stage. The ripe fruit has a shelf life of 2 to 4 days.

COMMON NAME: MAMMEY APPLE

Latin Name: (Mammea americana)

Principal Varieties: A range of local types exist

HARVEST

Maturity: Harvest when mature, but unripe as indicated by size and general appearance.

Method: By hand or by picking pole as with other tree fruits.

Field Assembly: Pack fruit in field crates or baskets in a shaded area of the field.

POST-HARVEST

Treatment: Trim fruit stalks to 1-2 cm. No specific post-harvest treatment is necessary if fruit is harvested carefully.

Selection/Grade: Remove malformed and damaged fruit. Grade fruit by size.

Packaging: Small wooden crates or fibreboard cartons.

Ambient Storage Life: Marked for immediate consumption.

COMMON NAME: BREADFRUIT

Latin Name: (Artocarpus altilis)

Principal Varieties: A range of local types exist

HARVEST

Maturity: Harvest at mature green stage using indicators of size, colour surface texture (stretching of segments).

Method: Harvest manually as far as possible. Use picking poles with cutting bars for inaccessible fruit. Harvest with stalk intact. Avoid impact injury by lowering fruit gently or by dropping into a catching net. Injury reduced the quality of the fruit and causes early ripening.

Field Assembly: Place breadfruit in field crates or bags or baskets in shaded area of field

POST-HARVEST

Treatment: Trim stalks and wash off excess latex. Package and ship breadfruit as soon as possible (hours) after

harvest to allow maximum time for marketing. If shipment is delayed, place harvested fruit under cool conditions (but above 13C to avoid chilling injury) if available. Otherwise submerge in clean water, outdoors in well ventilated sheltered area.

Selection/Grade: Select out immature postmature, scarred and damaged fruit. Grade according to size.

Packaging: Package breadfruit 2 to 3 layers thick according to size, in wooden crates or strong cardboard boxes.

Ambient Storage Life: The storage life of breadfruit harvested at the green mature stage varies from 2 to 4 days.

COMMON NAME: GOLDEN APPLE

Latin Name: (Spondias cytherea)

Principal Varieties: A range of local types exist

HARVEST

Maturity: Harvest at mature green or turning stage depending on intended market.

Method: Harvest by hand or use picking pole with pouch attached. Fruit have a tendency to crack on impact resulting in loss of quality, uneven ripening and post-harvest rotting.

Field Assembly: Place fruit in field crates or baskets in shaded area of field.

POST-HARVEST

Treatment: Wash off excess latex to prevent stickiness for handling. Drain and air dry thoroughly in well ventilated shaded area. Select out damaged, rotting, malformed, scarred and ripe fruit. Grade according to size and according to market - immature and mature green for unripe consumption and use, and mature green and turning for ripe consumption and use.

Selection/Grade:

Packaging: Package fruit in wood crates or cardboard boxes.

Ambient Storage Life: Mature green fruit ripen or show signs of ripening in about 4 days. Ripe fruit have a shelf life of 2 to 4 days.

COMMON NAME: SAPODILLA

Latin Name: (Achras sapote)

Principal Varieties: Various local types exist

HARVEST

Maturity: Harvest at mature green stage. Harvest by size and general appearance especially with respect to external skin texture.

Method: By hand or using picking pole with bag or pouch attached. Bag should be place over fruit clusters and

fruit detached with a shaking twisting action. Mature fruit become detached more readily than immature ones. Fruit crack very readily on impact and should be handled very carefully.

Field Assembly: Place fruit with head-end down to drain sap for several minutes. Fruit should be placed in shaded area in the field. Pack fruit in field crates for removal from the field.

POST-HARVEST

Treatment: Clean fruit only if the market demands it. Use clean abrasive material e.g. coconut husks for cleaning fruit.

Selection/Grade: Select out damaged, malformed, latex stained soft and soft fruit. Grade according to size.

Packaging: Pack in wooden crates for shipment.

Ambient Storage Life: Generally, mature green sapodilla ripen in 2-7 days. The shelf life of ripe sapodilla is 1-2 days.

COMMON NAME: SOURSOP

Latin Name: (Annona muricata)

Principal Varieties: A range of local types exist

HARVEST

Maturity: Harvest at mature green stage indicated when fruit turn lighter green colour and smooth wide spaces have developed between surface spines, especially at the head end.

Method: Harvest extremely carefully. Harvest manually and lower to the ground in small amounts in a pouch or bag. Inacessible fruit should be picked by a pole with an attached pouch.

Field Assembly: Pack in field crates or baskets in a shaded area in the field. Soursop can be field packed directly into cardboard boxes or wooden crates for shipment.

POST-HARVEST

Treatment: If fruit are harvested carefully and at the correct stage, no specific post-harvest treatment is necessary.

Selection/Grade: Discard all fruit that are damaged, malformed, have severe abrasion scars and have mealy bugs. Grade fruit according to size.

Packaging: Package fruit in wooden crates or cardboard boxes for shipment.

Ambient Storage Life: Mature green fruit ripen in 2 to 4 days. The shelf life of ripe soursop is 2 to 4 days.

COMMON NAME: TAMARIND

Latin Name: (Tamarindus indica)

Principal Varieties: Many different types exist locally.

HARVEST

Maturity: Harvest by size and general appearance. It is useful to use the season and the time of normal bearing of the given tree as a guide. Pods should be harvested when ripe. Pods harvested too early hew very poor keeping quality and flavour. Pods harvested too late tend to be too dry with greater tendency to insect infestation.

Method: By hand or by using picking pole with bag which can be placed over clusters and shaken to dislodge pods. Pods may also be quickly harvested by shaking the tree if an appropriate collector or net is used.

Field Assembly: Place pods in field crate for removal from field.

POST -HARVEST

Treatment: Generally no specific post-harvest treatment are necessary.

Selection/Grade: Remove immature, broken, rotting pods and pods with evidence of insect infestation e.g. holes. If grading is required by the market, also remove discoloured pods and pods with less than four seeds.

Packaging: Packaging in cardboard boxes or light wooden crates for shipment.

Ambient Storage Life: Carefully harvested and selected pods sometimes store well at ambient for several weeks. Long-term storage should not be planned unless reduced temperature storage is available since fungal growth on the seeds of stored pods is common problem.

COMMON NAME: PLUM

Latin Name: (Flacourtia ramontchi)

Principal Varieties: Known variously as Governor's Plum or Ramomtchi

HARVEST

Maturity: Harvest at mature green and hard turning stages as indicated by size and hint of reddish brown colour.

Method: By hand as far as possible.

Field Assembly: Place in field crates in shaded area of field.

POST-HARVEST

Treatment: No specific treatment is generally necessary. Plums may be washed if necessary but they must be thoroughly dried before packaging.

Selection/Grade: Discard any soft ripe, malformed or damaged fruit or fruit with mealy bugs or scale insects or scabbing. Rotting may begins in the field and this is not easily spotted during the rapid picking process. If necessary, fruit may be graded by size or into mature green and turning.

Packaging: Package plums in cardboard cartons or wooden crates.

Ambient Storage Life: Generally plums take 3-5 days to ripen from the mature green stage. Ripe plums have a shelf life of about 2 days.

COMMON NAME: SUGAR APPLE & DUSTARD APPLE

Latin Name: (Annona squamosa & A. reticulate)

Principal Varieties: Many different types exist

HARVEST

Maturity: Harvest at mature green stage. This stage is indicated by a combination of size, colour and general appearance, especially spread of the fruit segments.

Method: By hand as far as possible. Picking poles with attached bags may also be used.

Field Assembly: Place fruit in field crates or baskets in shaded area.

POST-HARVEST

Treatment: No specific post-harvest treatment is necessary.

Selection/Grade: Discard all fruit that are damaged, malformed, scarred or ripe. Look specifically for mealy bugs on fruit and discard infested fruit. Grade fruit according to size.

Packaging: Package fruit in cardboard boxes or wooden crates.

Ambient Storage Life: Mature green fruit ripen in 3 to 6 days. Shelf life of the ripe fruit is about three (3) days.

COMMON NAME: SWEET POTATO

Latin Name: (Ipomea batatas)

Principal Varieties:

HARVEST

Maturity:

Method: Harvest carefully to avoid mechanical injury. Any digging implement suited to the soil type can be used as long as it gives good soil separation and lifting of the tubers without injury.

Select our rotted, infested, malformed and damaged sweet potatoes during the harvesting process. Pile produce in small heaps or place in field crates, baskets or similar containers to facilitate pick-up and removal from field. Remove harvested wet potatoes from the field as soon as possible and provide shade in the field if the harvesting process or waiting time before removal is more than two (2) hours.

Field Assembly:

POST-HARVEST

Treatment: Wash sweet potatoes to remove soil and place in single layer on perforated racks in well ventilated area to drain and air dry. Fungicide treatment may be applied after washing.

Selection/Grade: Select out sweet potatoes which are badly bruised, and those which have cracks, cuts or puncture wounds. Grade sweet potatoes into sizes suitable for the particular market.

Packaging: Pack sweet potatoes in wooden crates or cardboard cartons. Potatoes should be packed firmly to prevent movement of the tubers relative to each other and to the sides of the container.

Ambient Storage Life: Depends on thoroughness of curing, but may keep for two or more weeks if kept well ventilated and in the dark to prevent sprouting.

COMMON NAME: YAMS

Latin Name: (Dioscorea spp)

Principal Varieties: Various local cultivars

HARVEST

Maturity: Harvest when fully mature as usually indicated by senescene of the vines. In some types of D. cayenensis where the vines do not senesce markedly, tubers should be harvested based on time from establishment of the crop.

Method: Harvest carefully using tools suited to the soil type and paying attention to the depth to which the tubers penetrate.

Field Assembly: Pile harvested yams in small heaps in the field or place directly into field crates, baskets or similar field containers to facilitate the removal of produce from the field.

POST - HARVEST

Treatment: Wash yams if heavily contaminated with soil and if the market demands it, but do not leave soaking in wash bins or troughs. Wash and remove tubers ad quickly as possible. Very large yams should be cut into pieces with a clean sharp knife. Damaged areas on large yams should also be removed by clean cut. Cut yams should be treated with recommended fungicide. Yams should be thoroughly air dried after washing or treatment and before shipping.

Selection/Grade: Removed all badly damaged, cut, crushed or punctured tubers. Grade according to size where intact tubers are being handled.

Packaging: Pack yams in cardboard box" or wooden crates for shipment.

Ambient Storage Life: Sound tubers keep for several weeks at ambient. However, the storage life varies with cultivar. The major post-harvest problem is sprouting.

COMMON NAME: EDDOE AND TANNIA

Latin Name: (Colocasia esculenta var antiquorum sagittifoliu.)

Principal Varieties: Various local types exist

HARVEST

Maturity: Cormels should be harvested when mature as indicated by period of growth and senescence of the foliage.

Method: Harvest cormels carefully. Use lifting shaking motion using tools suited to the soil type. Cormels should be removed carefully from the main corn so that the 'necks' are not broken.

Field Assembly: Place cormels directly into field crates or baskets in the shade.

POST-HARVEST

Treatment: Wash only if the market requires it or if the produce is heavily contaminated with soil. Otherwise excess soil should be brushed from cormels if soil type is friable. Rub fibres off surface of eddoes and wash for extra-regional export. If produce is washed, cormels should be removed quickly from the water and treated with fungicide or antimicrobial agent. Drain produce and place in single layers in well ventilated area to allow for thorough air drying before packing.

Selection/Grade: Select out badly damaged or broken cormels.

Packaging: Pack snugly in wooden crates or cardboard boxes to avoid abrasion damage from movement of contents.

Ambient Storage Life: Best marketed for immediate consumption but may keep for two or more weeks if properly cleaned and prepared and stored in dark well ventilated store.

COMMON NAME: CASSAVA

Latin Name: (Manihot esculenta)

Principal Varieties:

HARVEST

Maturity: Harvest roots when mature. Immature roots do not have the best cooking quality and they do not have sufficient starch to make good quality processed products like farine. Roots may be harvested post-mature for processing.

Method: By any method which gives the minimum damage to the roots. Types with roots borne near the surface and grown on mounds in friable soil types can be harvested by grasping the main stem and lifting with a pulling, shaking motion to loosen roots. Other types may be harvested with a fork or cutlass or both. Mechanical harvesters can be used if they do not damage root significantly.

Field Assembly: Place roots immediately after harvest into covered field containers or into ventilated plastic bags. Avoid totally, exposure to the sun or drying winds.

POST-HARVEST

Treatment: Wash root and use directly for marketing or processor. If roots cannot be utilized immediately, place into plastic bags, crates or boxes with moist media e.g. coconut coir, sand. Roots may also be reburied in moist soil. If root are to be kept for more than three (3) days in this way a fungicide dip should be used before storage.

Selection/Grade: Discard small and badly damaged roots if stored or retailed as a fresh staple. All roots can be utilized for immediate processing.

Packaging: Package roots in plastic bags for sale. Bags can be transported in wooden crates.

Ambient Storage Life: Cassava roots store from 1 to 7 days at dry ambient conditions (i.e. without any protection packaging). With appropriate post-harvest treatments roots may be stored at ambient for 2 to 3

weeks.

COMMON NAME: DASHEEN

Latin Name: (Colocasia esculenta var esculenta)

Principal Varieties: There are several local types

HARVEST

Maturity: When fully mature using length of growth period and senescence of the leaves as indicators.

Method: Harvest very carefully. Trim excess roots making sure that the body of the corm is not damaged. Trim cabbage and leaves close to base using clean cutlass or knife. Final trimming may be left for later after removal from field.

Field Assembly: Select out small corms to be used as planting material. Remove all rotting or damaged corms during harvesting. Place harvested corms in field crates, bags or baskets in the shade.

POST-HARVEST

Treatment: Wash corms carefully removing all traces of soil. Do not leave soaking in water but remove quickly. Use fungicide dip or antimicrobial agent after washing. Allow to drain and air dry or cure completely before packaging. Dasheen corms should be kept dry and in a well ventilated area until packaged.

Selection/Grade: All rotting corms should be removed along with badly damaged corms. Grade according to size.

Packaging: Package as close to shipment time as possible. Corms should be checked during packing for rots, evidence of softening or external evidence of fungal infections. Use wooden crates or cardboard cartons for shipping dasheen.

Ambient Storage Life: Should be marketed for immediate consumption.

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