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A Post Harvest Handling System for

SWEET PEPPERS

(Capsicum annuum)

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004

RESEARCH DIVISION
MINISTRY OF FOOD PRODUCTION AND MARINE EXPLOITATION

INTER-AMERICAN INSTITUTE FOR COOPERATION ON AGRICULTURE
IICA OFFICE IN TRINIDAD & TOBAGO PORT OF SPAIN, TRINIDAD & TOBAGO

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The Inter-American Institute for Cooperation on Agriculture (IICA) is the specialised agency for agriculture of the inter-American system. the Institute was founded on October 7, 1942 when the Council of Directors of the Pam American Union approved the creation of the Inter-Americam Institute of Agricultural Sciences.

IICA was founded as an institution for agricultural research and graduate training in tropical agriculture. In response to changing needs in the hemisphere, the Institute gradually evolved into an agency for technical cooperation and institutiuonal strengthening in the field of agriculture. These changes were officially recognised through the ratification of a new Convention on December 8, 1980. The Institute's purposes under the new Convention are to encourage, facilitate and support cooperation among the 31 Member States, so as to better promote agricultural development and rural well–being.

With its broader and more flexible mandate and a new structure to facilitate direct participation by the Member States in activities of the Inter–American Board of Agriculture and the Executive Committee, the Institute now has a geographic reach that allows it to respond to needs for technical cooperation in all of its Member States.

The contribution provided by the Member States and the ties IICA maintains with its twelve Permanent Observer Countries and numerous international organizations provide the Institute with channels to direct its human and financial resources in support of agricultural development throughout the Americas.

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In order to attain these goals, the Institute is concentrating its actions on the following five programmes: Agricultural Policy Analysis and Planning; Technology Generation and Transfer; Organisation and Management for Rural Development; Marketing and Agroindustry; and Animal Health and Plant Protection.

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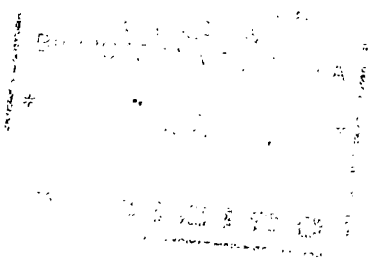

A POST HARVEST HANDLING SYSTEM FOR SWEET PEPPERS

Corrections to this Manual

Foreword - Page iii

5th Paragraph

... there is limited information on tropical **vegetable** crops.

Preface - Page iv

8th Paragraph

... in other developing countries where **Sweet Pepper** assumes importance.

Page 8 - Sorting

Details of the portable sorting is described in detail in Manual **004** on Melongene.

Page 15 - Plate 12

1 - no **chilling**

IICA - CIDIA

FOREWORD

Improvement in food self-sufficiency and food security in Trinidad and Tobago will depend, to some extent, on improvements in the marketing system for food crops. In 1985, the Government of Trinidad and Tobago requested IICA's assistance in the preparation of project proposals for establishment of a marketing system for food crops which would embrace aspects of packaging, handling and postharvest technology.

A mission visited Trinidad and Tobago from August 25th to 31st, 1985 and prepared proposals for the improvement of domestic marketing of fruits and vegetables in Trinidad and Tobago.

On the subject of Research and Training the mission observed that "a national course in postharvest technology and marketing seems necessary."

In pursuing the implementation of the proposed national course in postharvest technology, it became clear that local materials for use in postharvest training were extremely limited. In view of this, IICA sought to assist in the preparation of local training material for use in a national course in postharvest technology and marketing. This publication on the postharvest technology of sweet peppers *(Capsicum annuum)* is the result of joint efforts by IICA and scientists of the Ministry of Food Production and Marine Exploitation to prepare local materials which can be utilized in training programmes designed to improve the marketing systems and reduce postharvest losses in food crops.

This publication is timely and important because, while there is abundant literature on postharvest technology of temperate fruit crops, there is limited information on tropical root crops.

I hope that this continues a series on the postharvest technology of tropical crops which will have application not only in Trinidad and Tobago, but throughout the tropical world. Our Institute is pleased to have collaborated with the Ministry of Food Production and Marine Exploitation in this venture and looks forward to co-operating in future initiatives which will contribute to reducing postharvest losses in tropical crops.

"The responsibility for the opinions expressed in this publication rests solely on the author."

Representative
IICA Office in Trinidad and Tobago

PREFACE

Developing countries often find themselves in the situation where locally grown produce arrives on domestic markets in less than excellent condition and attempts at marketing in the potentially lucrative markets of North America and Europe encounter problems of quality, both from the quarantine viewpoint and overall quality standards.

The goal of achieving a developed marketing system which satisfies both domestic and foreign requirements has remained somewhat elusive for many a tropical developing country.

The reasons for the above condition are varied, amongst them being the lack of a well informed farming community highly sensitive to the need to produce a quality product and willing to engage in the steps necessary to ensure good product life and final consumer acceptance.

It is towards the fulfilment of this condition that this series of manuals directs attention. They attempt to put together the various techniques (generally grouped together as "post harvest technology") that must be applied to a particular commodity not only to ensure quality but minimize total product loss.

The series treats the problems of perishables, more particularly the commodity groupings (1) Fruits, (2) Vegetables, (3) Roots and Tubers, and (4) Ornamentals. The approach consists of an examination of the operations that occur between harvest and market, identification of common problem areas and practical recommendations to the grower/handler.

Although intended for the grower and Extension Officer mainly, it is hoped that it can also be a useful source of information for administrators, entrepreneurs, etc., and even our colleagues in temperate countries with an interest in the post harvest technology of tropical perishables.

This manual is one in the series resulting from the joint efforts of IICA, Trinidad and Tobago Office and the Post Harvest Unit of the Ministry of Agriculture (MOA), Trinidad and Tobago.

It is hoped that the package of technical information provided is supportive not only of the Government of Trinidad and Tobago's efforts in the area of improved marketing but attempts in other developing countries where cassava assumes importance.

It is hoped that critical comments and suggestions especially in the area of new and improved post harvest techniques for the small to medium sized grower would be part of a constant feedback from users throughout this series.

Correspondence concerning this publication should be addressed either to:

The Research Division
Ministry of Food Production and
Marine Exploitation
Trinidad and Tobago

or

Representative
IICA Office in Trinidad and Tobago

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C.E.S. - Central Experimental Station

M.O.A. - Ministry of Food Production and Marine Exploitation

Majeed Mohammed
Post Harvest Unit
Crop Research Sub-Division

A POSTHARVEST HANDLING SYSTEM FOR SWEET PEPPERS (*Capsicum annuum*)

Table of Contents

1.0 INTRODUCTION

The requirements of sweet peppers destined for both local as well as export markets demand careful attention at every stage from harvest to consumption, if quality is to be achieved and maintained. To effectively maintain quality throughout the market chain and ensure that the required quality is delivered to the recipient market requires an integrated approach where each part of the post-harvest system, be it sorting, grading, packaging, transportation or storage, must be appropriate to the system as a whole.

This manual discusses recent research on methods for the maintenance of sweet pepper quality from the point of harvest to consumption with emphasis on the implications of handling practices adopted at each stage and the effect of such on the final product quality.

2.0 VARIETAL SUITABILITY AND QUALITY

There are many commercial varieties of sweet peppers currently grown in Trinidad and Tobago, e.g. 'California Wonder', 'Yolo Wonder', 'Blue Star', 'Keystone Resistant Giant' and 'Bell Boy'.

High quality sweet peppers consumed green are dark green shiny, waxy and firm. They spring back into shape when lightly compressed. Their calyx and stem end should be green and turgid. Irregular shaped sweet peppers reduces eye-appeal and may affect certain uses.

3.0 HARVEST

3.1 Maturity

Sweet peppers of varying maturity are marketed. However, there is a particular point at which a fruit reaches what is described as the 'mature green' stage. While the fruit is developing, the surface has a slightly wrinkled, matt appearance. At this stage it is still immature and should not be picked, because it losses water rapidly and softens (Plate 1). Once the sweet pepper gets to its final size, it becomes glossy and this is called the 'mature green' stage (Plate 1). If the fruit is not picked at this stage it will eventually turn red. Once this change has started, the fruit has to remain on the plant for another six weeks to attain a uniform red colour.

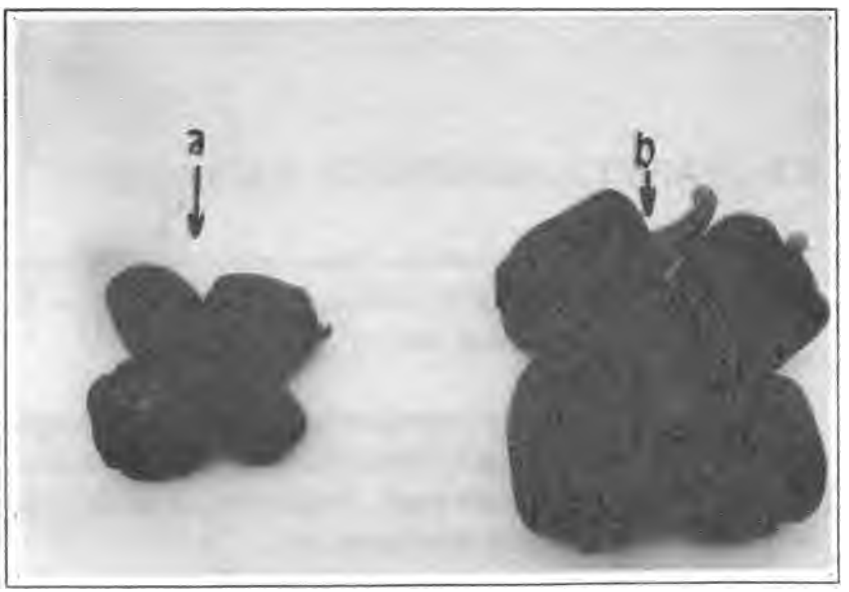


Plate 1 -*a. Immature fruits; b. Mature fruits*

3.2 Harvesting Method

The most common method of harvesting sweet peppers is to break the fruit away from the plant by hand. There is a natural fracture line (Plate 2) where the stalk joins the stem, and it is important that the stalk remains attached to the fruit after harvesting sweet peppers. Whatever method is used to pick, care must be taken to avoid twisting or breaking stems, as this causes the stem to split and this provides an ideal site for the establishment of decay (Plate 3) afterwards.

Plate 2 - *Arrows show where the natural fracture line exist for detaching fruit from plant.*

Plate 3 - *Decay at stem end due to splitting of stem because of poor harvesting technique.*

3.3 Harvesting Containers

Sacks or feed bags should not be used since these are poorly ventilated, encourages overfilling and cannot be stacked and incur damages readily. Field crates are ideal but expensive. Field crates offer several advantages to outweigh the cost since they are durable, reusable, washable, can be used from field packing and transportation to markets, they are also stackable and ventilated. It is desirable to use field crates that are light in colour and shallow.

3.4 Temperature Management in Field

Sweet peppers packed in containers,eg, plastic crates should be protected from the sun rays and therefore covered with banana leaves or a damp cloth or taken promptly under a shady tree or shed. Field crates or containers should be covered to allow enough ventilation to reduce the build-up of heat.

4.0 PRECOOLING

The two methods used to remove field heat in sweet peppers are hydro-cooling and forced air cooling. The main problem with hydrocooling (dipping fruits in cold water) is the incidence of decay. Decay can be lessened by ensuring that fruits are air-dried particularly the stem end and calyx following hydrocooling. With forced air-cooling, sweet peppers stacked in plastic crates, allows the cool air to push through, thereby providing greater air circulation around the fruits, resulting in faster cooling. If quantities of sweet peppers are not sufficient to justify quick-cooling, cooling can also be achieved by placing fruits in a standard chill room at 7-8°C. In the absence of refrigeration, rapid removal of field heat can be obtained by harvesting in the coolest period of the day, followed by exposing produce to overnight cool temperatures.

5.0 GRADING AND STANDARDIZATION

There can be two grades for sweet peppers. Grade A for sweet peppers of good quality and Grade B for those of reasonable good quality.

The minimum requirements for both grades are:

Sweet peppers should be:
- Whole
- Fresh in appearance
- Sound-produce made unfit for consumption by rotting or deterioration is excluded
- Clean, practically free of foreign matter
- Well- developed
- With stalks attached
- Free from unhealed injuries, sunburn, abnormal external moisture
- Free from foreign smell or taste

Grade A (Plate 4)

Must be
- of good quality
- of the normal shape, development and colouring for the variety
- diameter not less than 9 cm
- length not less than 9 cm
- firm
- virtually free of blemishes
- with their stalk, which may be slightly damaged or cut provided that the calyx is intact.

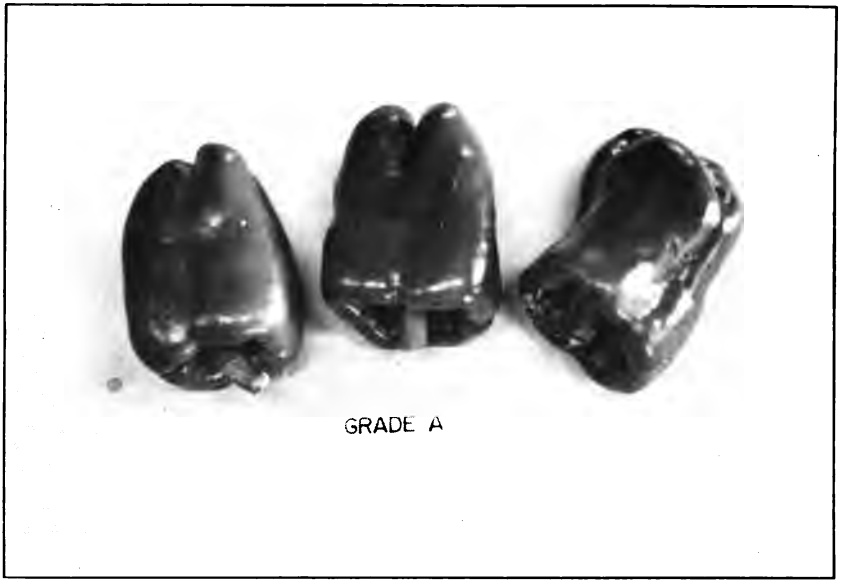


Plate 4 - *Grade A sweet peppers.*

Grade B (Plate 5)

Provided the essential characteristics of quality and presentation are retained sweet peppers may:

- show defects in shape and development
- be less firm without being withered
- show sunburn or slightly healed injuries not exceeding 1 cm^2 per pepper if superficial and 2 cm long if the injury is elongated
- show slight superficial cracks altogether not exceeding 3 cm in length
- slightly damaged stalk, provided it is cut no less than 1 cm from the calyx.

Plate 5 - *Grade B sweet peppers.*

Quality Tolerances

Up to a 10% by number or weight of sweet peppers is allowed for both grades.

6.0 PACKING HOUSE OPERATIONS

6.1 Washing

Dirt adhered to the skin surface of sweet peppers can be very unattractive on display shelves (Plate 6). For repeat sales, sweet peppers harvested on a rainy day, must be washed to remove dirt.

Plate 6 - *Display of sweet peppers with dirt as a result of harvesting on a rainy day.*

6.2 Sorting

Sorting operation can be very time consuming. The use of a portable sorting table as shown in Figure 1 can make sorting faster and less labour intensive. Details of the portable sorting table is described in detail in Manual 002 on melongene.

6.3 Sizing

Size of fruits is determined by the diameter or width across the shoulder. The minimum size requirements for both classes are as follows:

(1)	elongated sweet peppers	-	30 mm
(2)	square blunt sweet peppers	-	50mm
(3)	square tapering sweet peppers	-	40 mm
(4)	flattened sweet peppers	-	55 mm

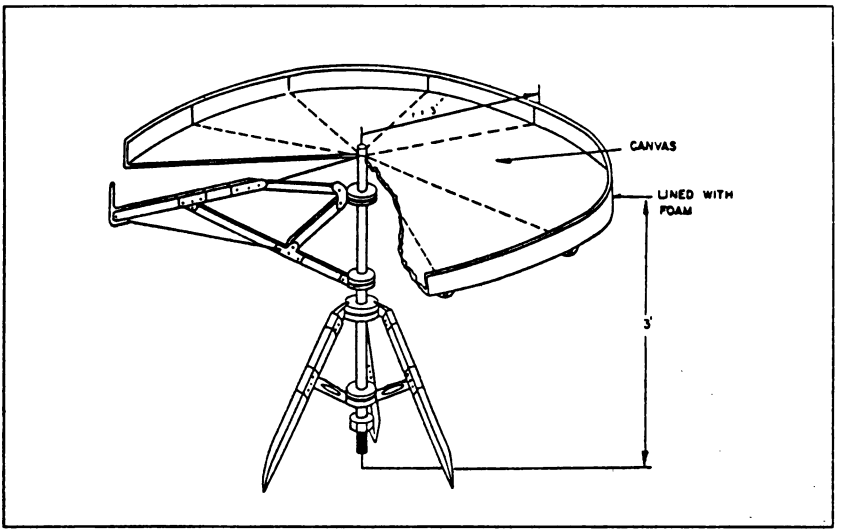


Figure I: Portable Sorting Table

Sizing is compulsory for Grade A but is not compulsory for Grade B provided that the minimum sizes are observed.

6.4 Packing and Packaging

There are a number of containers suitable for transporting and marketing sweet peppers, ranging from open returnable wooden crates for local marketing to disposable cardboard boxes with lids for long distances. Small boxes are most suitable, for example the 4-5 kg box. Containers must be strong enough to prevent physical damage, and also large enough to take the required weight of the fruit without squashing. Ventilation should be provided to prevent excessive build-up of humidity in the container, and the consequent risk of decay. Handholds are necessary during loading and unloading. All holes must be designed and placed in a manner not to substantially weaken the box. In supermarkets sweet peppers are shrink-

wrapped over a tray as shown in Plate 7 with a maximum weight of 1 kg and displayed on refrigerated shelves. Apart from protecting the fruit these shrink-wrapped fruit which have less moisture losses are firmer, less shrivelled, lasts longer and makes a better presentation.

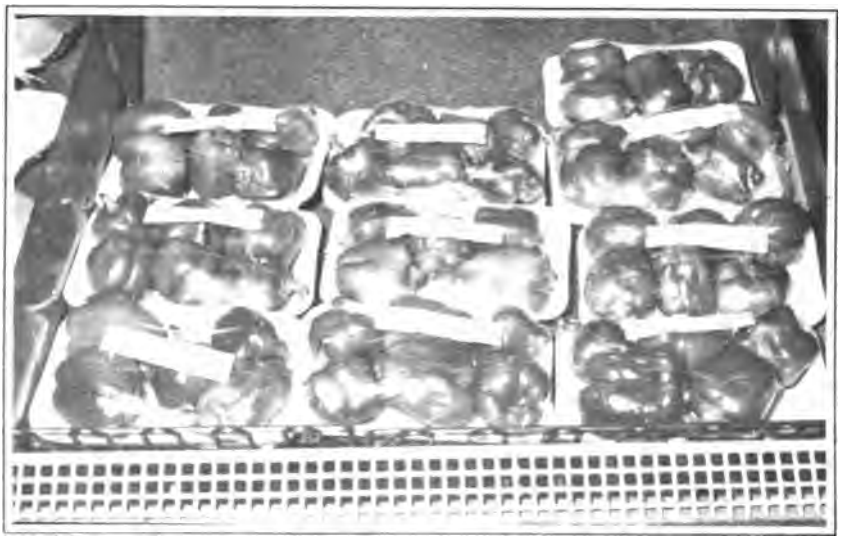


Plate 7 - *Display of shrink-wrappedsweet peppers on refridgerated shelf in supermarket.*

7.0 TRANSPORTATION

Vehicles commonly used to transport sweet peppers may range from pick-up to refrigerated trucks. Whatever the type of transport used it should obviously be as free as possible from impacts and vibrations. Reducing tyre pressures and using air suspension systems on vehicles can reduce shock absorbance by the produce on bumpy roads. Sun shining on a load of sweet peppers in an open vehicle is harmful, as is dry air blowing through the load.

Therefore, a light-coloured wetted cloth suspended over the loaded containers is desirable for air flow during transit. If refrigerated vehicles are available sweet peppers should be cooled before it is loaded. Vehicle refrigeration is usually designed to keep the load cool rather than to cool it, there is seldom enough air movement within the load for cooling. Damages to sweet peppers during transport can be reduced if containers are lined with newspaper or fresh banana leaves. It is also important to stack containers of produce in a vehicle in such a manner that will allow free air circulation. Containers stacked too tightly under condition of high transit temperature will lead to heating of fruit within the pack, thus, enhancing produce decay. If non-sturdy baskets or cardboard boxes are used, provide horizontal platform dividers during loading and stacking in trucks. These horizontal platform dividers will provide protection against impact during transport. Without these dividers, the containers at the bottom of the vehicle will carry the load on top, thus incurring greater damage to fruit.

8.0 STORAGE

At all times only clean, mature, disease-free and injury-free sweet peppers should be chosen for storage. Plate 8 shows where sweet peppers can be stored for seven (7) days at 7°, 14° or 30°C and still be marketed. However, the advent of shrivelling and fruit softening reduce the quality of those at 30°C in comparison to those at 7° or 14°C. Upon longer storage, i.e. up to 15 days as seen in Plate 9 one can hardly notice any major differences in fruit quality at 7° or 14° C but at 30°C severe shrivelling, softening of fruit is prevalent.

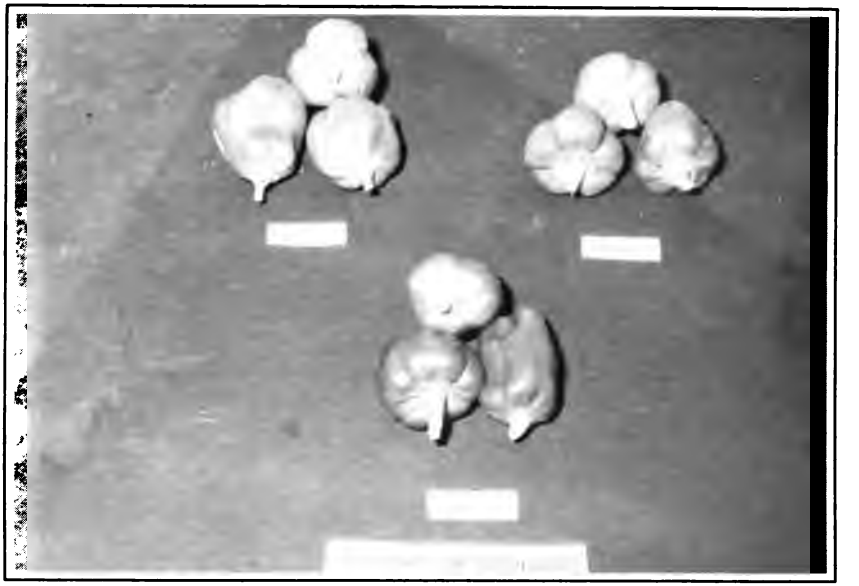


Plate 8 - *Minimal difference in quality of sweet peppers after 7 days at 7°, 14° or 30° C.*

Plate 10 shows the importance of low temperature storage in maintaining fruit quality, if extended storage is required. After 24 days fruit kept at 7°C were of the best quality. Although those kept at 14°C were still saleable, there was some shrivelling and softening. The most shrivelling, softening and colour development took place at 30°C.

To maximise the benefits of extended storage at lower temperatures, a relative humidity of 90-95% is essential. This can be easily achieved by

(1) periodic wetting of the floor and walls of storage room

(2) placement of containers of water in the room

(3) hanging of wet bags on the room walls

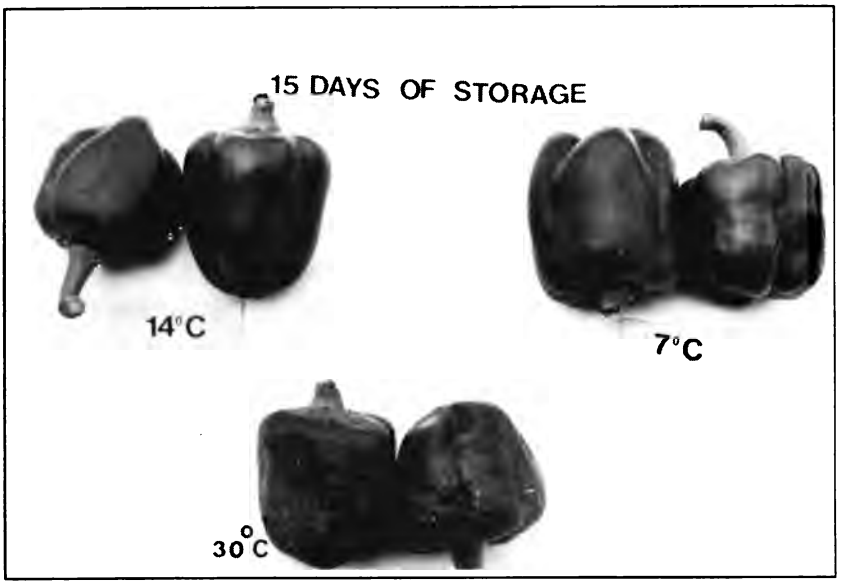


Plate 9 - After 15 days fruits stored at 7°C and 14°C were superior in quality when compared to those at 30°C.

Packaging fruits in low density polyethylene (LDPE) or in high density polyethylene bags (HDPE) can ensure that fruits are kept at a high relative humidity. This helps to reduce moisture loss and maintain firmness of fruits. Within these package, the modified atmosphere delays the "ageing" processes. (Plate 11) shows where fruits stored in both packages up to 24 days at 14°C were firmer, had less weight loss and shrivelling than those shown in Plate 10 where polyethylene bags were not used.

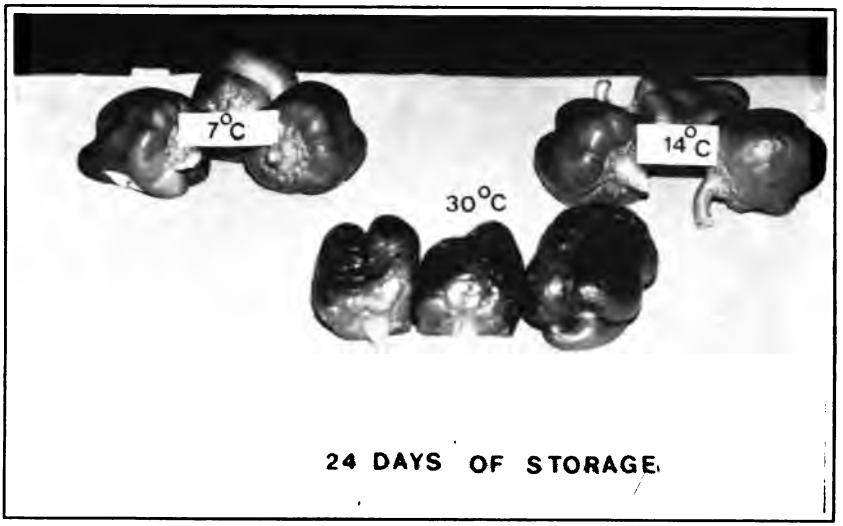


Plate 10 - *Sweet pepper quality after 24 days at 7, 14 and 30°C. Note the absence of shrivelling at the lowest temperature and the advent of colour development and severe shrivelling at the highest temperature.*

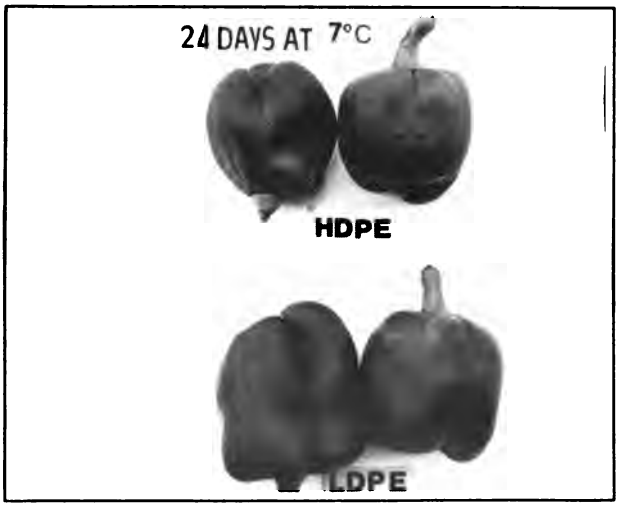


Plate 11 - *Quality of sweet peppers after 14 days at 14°C when sealed-packaged in low density polyethylene(LDPE) and high density polythylene (HDPE) films.*

9.0 STORAGE PROBLEMS

9.1 Disorders

9.1.0 Chilling Injury

This disorder of sweet peppers is caused by exposure to temperatures between 0°-7°C. The most visible symptom of chilling injury in sweet pepper is pitting. In Plate 12 the varying degrees of sheet pitting from none to severe is shown. Discolouration of calyx and a dull fruit surface instead of the normal glossy appearance are further symptoms of chilling injury. An internal symptom of chilling injury is the browning of seeds (Plate 13). Symptoms of chilling injury develop more rapidly at non-chilling temperatures following chilling exposures.

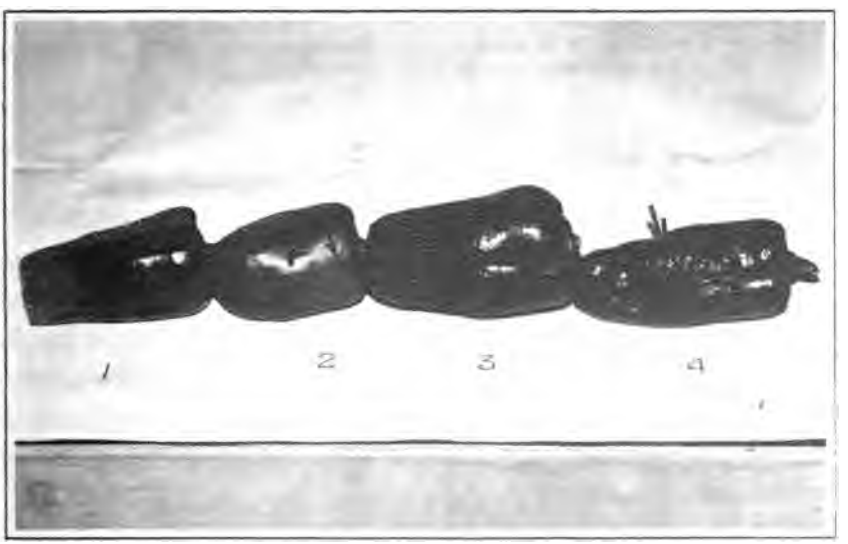


Plate 12 - *Sweet peppers showing varying degrees of chilling injury. 1- no chillind, 2 - slight, 3 - moderate, 4 - severe.*

Plate 13 - *The browning of the seeds in (a) is indicative of chilling injury. In (b) seeds are not brown indicating the absence of chilling injury.*

9.1.1 Ripening

Some consumers do not favour ripe sweet peppers. Storage of fruits at 7°-10°C and 90-95% r.h. will limit ripening up to 24 days. At higher temperatures ripening cannot be avoided. However, at temperatures below ambient for example in an air-conditioned room (15°-20°C) fruit ripening can be initiated if sweet peppers are damaged or injured. Similarly, if sweet peppers are exposed in the same storage room with other ripening fruit, such as tomatoes, or mangoes, the ethylene that is given off from these produce can initiate ripening (Plate 14).

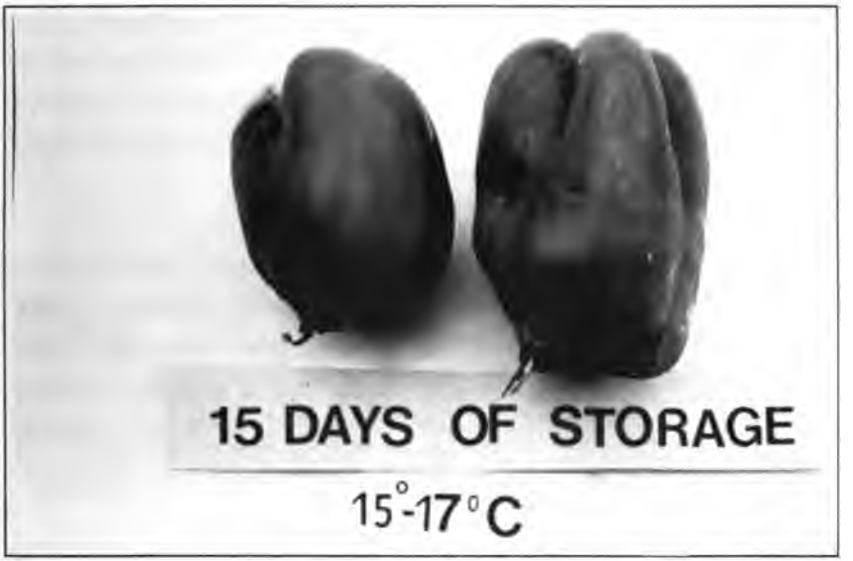


Plate 14 - *The problem of storing sweet peppers with other ripening fruits, e.g. mangoes. Mangoes produce ethylene and can stimulate ripening of sweet peppers at 15-17°C*

9.1.2 Wilting

Sweet peppers readily become soft and shrivelled when held for over 3-5 days at ambient temperature and below 90% r.h., inspite of their natural waxy surface. Sealing in polyethylene bags or waxing can reduce moisture loss. Nevertheless, low humidity, i.e. below 80% r.h. and temperature above 14°-15°C should be avoided.

9.2 Diseases

9.2.0 Bacterial Soft Rot

Plate 3 shows that poor harvesting technique causing split ends on stem of fruit can lead to bacterial infection caused by Erwinia species. Note in Plate

15 the spread of the disease to the calyx and then extending to the shoulders of the fruit. The bacteria can also enter on any other part of the fruit via wounds either before or after harvest e.g., in Plate 16 at arrow (c). In all three instances there is a visible liquefaction of the tissues making a darkened moistured appearance.

Reducing physical injury can limit the incidence of soft rot. Immersing fruit for 1 or 11/2 minutes in hot water (52-53°C) can substantially reduce soft rot. The time and temperature are critical: too short an exposure or too low a temperature has no value, whereas excessive treatment can seriously injure the fruits. After treating, the fruits should be air-cooled to 7°-10°C as rapidly as possible.

Plate 15 - *Sweet peppers fruit that was initally infected by Erwinia species bacteria and which upon prolong storage infection spread from stem to calyx to shoulders of fruit.*

Plate 16 - *(a) Anthracnose caused by Colletotrichum species*
(b) Chilling injury symptoms eg pitting. (c) Bacterial soft rot caused by Erwinia species
(d) Drying up of calyx.

9.2.1 Anthracnose

Plate 16 arrow (a) shows an infection from a fungus called the *Colletotrichum* species. This is usually identified as depressed, circular areas on the fruit surface.

Anthracnose disease is a pre-harvest problem on sweet peppers especially during the rainy season and which can also cause serious losses during post-harvest storage. Proper cultural practices and field sanitation as well as careful handling can ensure a lower incidence of this disease. Good control of Anthracnose as indicated by the Plant Pathology Section of C.E.S., M.O.A., is obtained by the following spray programme:

1st application : Benomyl and Dithane M45

2nd application : Daconil
3rd application : Benomyl and Dithane M45

Fungicide rates are as follows:

Benomyl	:	1-2 ml/1 litre water
Dithane M45	:	2-3 ml/1 litre water

Use sprays with a sticker such or Agral (0.25-0.50 ml litre) particularly during rainy season.

10.0 IMPORTANT REMINDERS

The purchaser of your sweet peppers may be some miles away and your produce may not be consumed for sometime. How to handle, grade, pack and store can definitely affect how well your fruit satisfies the market and how readily it leads to repeat sales. The following is a list of important points to consider.

1. Reduce shrivelling by minimising moisture loss. This can be done by paying attention to:

   (a) Harvesting at proper stage of maturity. Immature fruits have a thinner skin coating than mature ones, allowing faster evaporation of water from the cells.

   (b) Do not expose fruits to high wind velocities.

   (c) Keep fruits in shade or coolest place possible.

(d) Be careful in handling during harvesting, packing, loading, unloading and storage. Injured portions are avenues for the exit of water and the entrance of micro-organisms. Rubbing or abrasion not only removes or weakens the protective outer layers but also increases the rate of water loss.

(e) Line containers with leaves or paper or plastic sheets, as such liners act as barriers against high water loss.

(f) Keep fruits in a humid environment 90-95% r.h. Dry air increases moisture loss.

2. Proper Packaging

(a) Use rigid containers, e.g., plastic crates that are light in colour and shallow. These will withstand the impact of loading, unloading and stacking during storage hence preventing bruising and abrasion of the fruits.

(b) Avoid overpacking or under packing. Poor packing leads to movement of contents and to easy bruising. Tight packing on the other hand results in compressed fruits.

(c) When transporting, stack containers properly to prevent movement or fall while in transit over bad roads and sharp curves.

3. Delay the Ageing Process

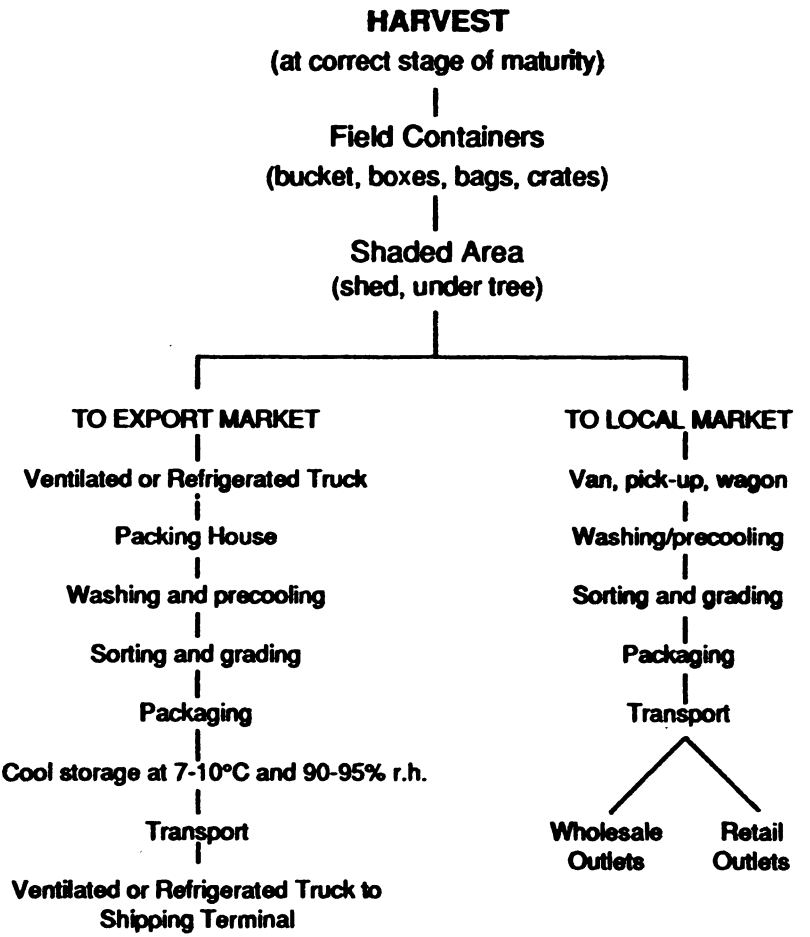
(a) Do not mix diseased or damaged fruits with healthy ones since disease from infected fruits will spread.

(b) Store at 7-10°C. This will avoid damage due to chilling injury.

(c) Keep fruits away from engine exhaust, as this contains ethylene which hastens ageing.

FIGURE 2

HANDLING SYSTEM FOR SWEET PEPPERS



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