PHM 311 POST HARVEST MANAGEMENT OF HORTICULTURAL CROPS (2 + 1)

Dr. S.VINODH

College of Horticulture
CENTRAL AGRICULTURAL UNIVERSITY, IMPHAL
Bermiok, South Sikkim-737134

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Practical Manual

Dr. S. VINODH

Asst. Prof. (Hort.)

College of Horticulture

CENTRAL AGRICULTURAL UNIVERSITY, IMPHAL

Bermiok, South Sikkim-737134

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Technical Support:

Dr A. K. Pandey

Dean, College of Horticulture

Bermiok, Sikkim

Prepared by:

Dr. S.Vinodh

Asst. Professor (Horticulture)

Designed and processed by:

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Central Agricultural University,

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Prof. Anupam Mishra
Vice Chancellor

केंद्रीय कृषि विश्वविद्यालय
CENTRAL AGRICULTURAL UNIVERSITY
इंफाल-795004, मणिपुर
Imphal-795004, Manipur

Phone: 0385-2415933(O)
Email: vc@cau.ac.in
vcofficecau@yahoo.in

FOREWORD

Horticulture plays a significant role in Indian Agriculture. It contributes 30% GDP from 11.73 % of its arable land area. India is the second largest producer of both fruits and vegetables in the world (52.85 Mt and 108.20 Mt respectively). Fruits and vegetables are of immense significance to man. In India, the fruits have been given a place of honour on being offered to God at every festival and have also been mentioned in our epics like Mahabharata, Ramayana and writings of Sushrutha and Charaka. Being rich source of carbohydrates, minerals, vitamins and dietary fibres, these constitute an important part of our daily diet. The dietary fibres have several direct and indirect advantages. Post-harvest losses in fruits and vegetables are very high (20-40%). About 10-15% fresh fruits and vegetables shrivel and decay, lowering their market value and consumer acceptability. Minimizing these losses can increase their supply without bringing additional land under cultivation. Improper handling and storage cause physical damage due to tissue breakdown. Mechanical losses include bruising, cracking, cuts, microbial spoilage by fungi and bacteria, whereas physiological losses include changes in respiration, transpiration, pigments, organic acids and flavour.. The practical manual on '**Post Harvest Management of Horticultural Crops"** prepared by College of Horticulture, Central Agricultural University, Bermiok, Sikkim according to syllabus of 5th Deans' Committee is a very timely and relevant initiative towards improving practical skills of undergraduate students. I am confident that the practical skills acquired by the students would be helpful to them in their professional career.

I hope that the manual would be of great help not only to the students but also to all those dealing with the field/laboratory exercises in post-harvest management of horticultural/agricultural commodities. I congratulate the author for his concerted efforts in preparation of this manual.

(Anupam Mishra)

PREFACE

This practical manual entitled **"Post-Harvest Management of Horticultural Crops"** based on maturity indices, physiological disorder, different storage and packaging methods for various horticultural crops. There is total sixteen practical exercises in this book to impart practical knowledge to the students which will help to their skill development. The manuscript gives an overview of Post harvest practices viz., harvesting, cleaning, grading, physical and chemical treatment, suitable packaging methods, diffent kinds of storage etc. Further, exercises listed on educational visits to cold storage unit of the region may be arranged for developing better understanding about the subject.

(S. Vinodh)

CONTENTS

Ex. 1 Maturity indices of fruits Date:

Introduction

- Maturation is the stage of development leading to the physiological maturity (when a plant or plant parts will continue ontogeny even if detached) or horticultural maturity (when a plant or plant parts possesses the pre-requisites for utilization by the consumer for a particular purpose).
- Maturity indices help in deciding that when a given commodity should be harvested to provide some marketing and to ensure the attainment of acceptable eating quality to the consumer.
- Fruits are picked at the wrong stage of maturity may develop physiological disorders in Storage and may exhibit poor dessert quality.
- For selecting the harvest maturity of fruits or vegetables it should be kept in mind that harvested commodity should have its peak acceptable quality (nontoxic, size, appearance, and flavor with adequate shelf life) (Thompson, 1996).
- Quality indices consist of a combination of visual appearance, texture & flavor.

Mango

Maturity indices:

- Tapka stage (Dropping of 1 or 2 ripe fruits from tree)
- Specific gravity (1.0-1.02 for Alphonso & less than 1.0 for dashehari).
- White powdery like appearance on skin of mature mango.
- Change in fruit shape (fullness of the cheeks)
- Days to fruit set (110-125 days for Alphonso and Pairi).
- Change in skin color from dark-green to light-green to yellow (in some cultivars). Red color on the skin of some cultivars is not a dependable maturity index.
- TSS 12-15 %
- Change in flesh color from greenish-yellow to yellow to orange.

Quality characteristic

- Uniformity of shape and size; skin color (depending on cultivar); flesh firmness.
- Freedom from decay and defects, including sunburn, sap burn, skin abrasions, stem-end cavity, hot water scald, chilling injury, and insect damage.
- Changes associated with ripening include starch to sugar conversion (increased sweetness), decreased acidity and increased carotenoids and aroma volatiles.
- There are large differences in flavor quality (sweetness, sourness, and aroma) and textural

quality (fiber content) among cultivars.

2) Banana

Maturity indices

- Degree of fullness of the fingers i.e., disappearance of angularity in a cross section.
- Skin and pulp ratio (1.20:1.40 for Dwarf Cavendish).
- Drying of plant parts.
- Acid content 0.25%
- Starch index.
- Days to fruit set (90 days for Dwarf Cavendish).
- Bananas are harvested mature-green and ripened upon arrival at destination markets.

Quality characteristic

- Maturity (the more mature the better the quality when ripe)
- Finger length (depending on intended use and demand for various sizes).
- Freedom from defects, such as insect injury, physical damage, scars, and decay.
- As bananas ripen their starch content is converted into sugars (increased sweetness). Other constituents that influence flavor include acids and volatiles.

3) Citrus

Maturity indices :

- All citrus are non-climacteric fruit, meaning that they ripen gradually over weeks or months and are slow to abscise from the tree.
- External color changes during ripening, but is a function of climate more than ripeness, and a poor indicator of maturity.
- Juice content (35-50%)
- TSS 12-14% for mandarin and for sweet orange 10-12%
- By acidity (mandarin 0.4%, sweet orange 0.3%)
- The best indices of maturity for citrus are internal: o Brix (sugar), acid content, and the o Brix/acid ratio (mandarin 12-14o brix, sweet orange 12o brix).

4) Papaya

Maturity indices

- Change of skin color from dark-green to light-green with some yellow at the blossom end (color break).
- Papayas are usually harvested at color break to 1/4 yellow for export or at 1/2 to 3/4

yellow for local markets.

- TSS 7-11%
- A minimum soluble solids of 11.5% is required
- Quality characteristic
- Papayas picked 1/4 to full yellow taste better than those picked mature - green to 1/4 yellow because they do not increase in sweetness after harvest.
- Uniformity of size and color; firmness; freedom from defects such as sunburn, skin abrasions, pitting, insect injury, and blotchy coloration; freedom from decay.

5) Guava

Maturity indices

- Guava fruits are picked at the mature-green stage (color change from dark- to light-green).
- Specific gravity 1.01-1.02
- TSS 12-14 %
- Quality characteristic
- Color is a good indicator of ripeness stage
- Size and shape may be important in some markets
- Freedom from defects, insects, and decay
- Firmness and extent of gritty texture due to the presence of stone cells (sclereids)
- Flesh color depends on cultivar and can be white, yellow, pink, or red
- Amount of seeds in the flesh (the fewer the better)
- Aroma intensity
- Soluble solids and acidity
- Guava is one of the richest sources of vitamin C (200 to 400 mg per 100g fresh weight) and some cultivars are also rich in vitamin A

6) Sapota

Maturity indices

- Fruit with 80% maturity
- Skin color change from light-brown with a tinge of green to light-brown to dark-brown.
- Weight of fruit 65-70 gms
- Flesh yellow streak when scrached with finger nail
- Specific gravity 1.025-1.057.
- Quality characteristic

- Appearance: size, shape (oval), color, freedom from defects, and freedom from decay.
- Firmness (firm-ripe sapotes are preferred).
- Flavor is related to soluble solids content (13-26%) and acidity (0.2-0.3%).

7) Jackfruit

Maturity indices

- Jackfruits can reach very large size (as much as 90 cm long, 50 cm wide, and 25 kg in weight), depending on the cultivar, production area, and the fruit load on the tree.
- Color change from green to yellow to brown is used as an indication of maturity and ripeness stages.
- Optimum harvest for long-distance transport is when the fruit changes color from green to yellowish-green.
- Quality characteristic
- Fruit size
- Shape
- Color
- Freedom from defects (sunburn, cracks, bruises) and decay
- Jackfruits contain 25-30% carbohydrates (fresh weight basis) including about 15-20% starch in unripe fruits that is converted to sugars (sucrose + glucose + fructose) in ripe fruits.
- The unripe fruit is used as a starchy vegetable, either boiled or roasted, and when ripe it is used as a dessert fruit. Average acidity is 0.25% citric acid.
- Jackfruit fruitlets are commonly sold in producing countries as a fresh-cut product.

8) Pineapple

Maturity indices

- Flattening of eyes with slight hollowness at the centre
- Change of shell color from green to yellow at the base of the fruit.
- Specific gravity 0.98-1.02%
- A minimum soluble solids content of 12-14% and a maximum acidity of 1% will assure minimum flavor acceptability by most consumers.
- Quality characteristic
- Uniformity of size and shape, firmness
- Freedom from sunburn, sunscald, cracks, bruising, internal breakdown, endogenous brown spot, gummosis, and insect damage.

• Tops (crown leaves): green color, medium length, and straightness.

• Range of soluble solids = 11-18%; titratable acidity (mainly citric acid) = 0.5-1.6%; and ascorbic acid = 20-65mg/100g fresh weight, depending on cultivar and ripeness stage.

9) Annona

Maturity indices

• Change in skin color from dark-green to light-green or greenish-yellow.

• Days to full bloom (100-115 days).

• Other indicators include appearance of cream color between segments on the skin and increased surface smoothness of the separate fruit carpals.

• Quality characteristic

• Fruit size, color, absence of defects and decay, firmness (annona fruits are relatively soft fruits and must be handled with care to minimize bruising).

• *Cherimoya, atemoya* and sweetsop have high concentrations of sugars (14-15% when ripe) and moderate acidity (0.4-0.7% when ripe). They are good sources of vitamin C (45-60mg/100g) and potassium (250-500mg/100g edible portion).

10) Aonla

• There are number of factors affect the maturity of fruits such as location, variety, climate, and season, nutrition, soil type and moisture, etc.

• The maturity indices of aonla fruits are change of seed colour from creamy white to brown black.

11) Pomegranate

Maturity indices

• External red colour (depending on cultivar)

• Red colour of juice

• Acidity of juice below 1.85%

Quality characteristic

• Freedom from growth cracks, cuts, bruises, and decay.

• Skin colour and smoothness.

• Flavor depends on sugar/acid ratio which varies aming cultivars. A suitable solid content above 17% is desirable.

• Tannin content below 0.25% is desirable.

12) Ber

Maturity indices:

- Ber mature 150-175 days after flowering.
- Green to golden yellow colour
- Seed/stone ratio: 12 to 18
- TSS 15-18%

Ex.2 MATURITY INDICES FOR IMPORTANT VEGETABLES Date :

1. Tomato:

a) **Immature green:** It is the stage of fruit, before the development of seeds fully and before surrounding the seeds by a jelly like substance. The fruits are harvested at this stage only for frying purpose.

b) **Mature green:** It is the stage of fruit when it is fully grown, and show brownish ring at the stem scare on removal of calyx and light green color at blossom end changes to yellowish green and seeds are surrounded by jelly substances filing seed cavity. The fruits at this stage are harvested for shipment to long distance and for long storage too.

c) **Turning (breaker stage):** It is the stage of fruit when one-fourth of the surface at blossom end shows pink colour. The fruits at this stage are harvested for local market.

d) **Pink stage:** It is the stage of fruit when three-fourth of the fruit surface shows the pink color. The fruit at this stage are also harvested for local markets.

e) **Hard ripe stage:** It is the stage of fruit when nearly the whole fruit skin shows red or pink color but flesh is still firm. The fruits at this stage are harvested for table purpose, processing and for the extraction of seed too.

f) **Over ripe stage:** It is the stage of fruit when the fruit is fully red colored and soft. At this stage, the fruits can be used only for the extraction of seeds, not for table purpose and processing since the fruits onward start decaying.

2. Capsicum:

a) **Green pepper varieties:** Fully mature green fruits should be harvested before ripening.

b) **Red and yellow varieties:** Fully mature green fruits should be harvested at the onset of color change.

c) Pepper fruits at the time of harvest should be firm and crisp not tender and immature.

3. Onion:

Bulbs are considered mature when the neck tissues begin to soften and tops are about to abscise and decolorizes. Maturity can be judge by the neck of the plants drying up, tops falling over while the leaves are still green (Rana, 2008).

4. Sweet Potato:

When the leaves turn yellow and begin to shed, tubers can be harvested. Immature tuber, the cut surface shows dark greenish colour while the color will be milky white in fully mature tubers.

5. Okra:

Immature green tender fruits should be picked 3rd to 5th day from the time of first pod formation or 3 to 7 day after flowering. Okra should be harvested when the fruits are bright green, the pods are fleshy and seeds are small.

6. Moringa:

Fruits of sufficient length and girth are harvested before they develop fiber.

7. Cucumber:

Fruits can be harvested from 45 days after sowing. The tender fruits (for salad) can be harvested on 8th to 10th day of flowering.

8. Bottle Gourd:

Fruits should be light green, 30-35 cm long, tender with little pubescence persisting on the skin.

9. Muskmelon:

a) Fruits are generally harvested 60-70 days after sowing, 30-40 days after anthesis and 25-30 days after setting, observing other changes of outer color of the skin.

b) Muskmelon is generally picked at 'half-slip' stages for commercial marketing (part of the pedicle remains attached to the fruit, i.e., abscission layer is not fully developed). Sugar and flavor are not found optimum, at this stage. Full slip is stage at which the pedicle separates easily from the fruit with little or no pulling. Fruits for distance market should be harvested when mature but before full ripeness to minimize to breakdown in texture and damage during transport.

10. Watermelon:

a) The fruits are ready for consumption in about 30-40 days after anthesis.

b) The portion of fruit resting on ground starts turing color from creamy white to yellow.

c) On ripening, the rind become hard enough that resists penetration of thumbnail.

d) The sugar content of fruit measured as soluble solids using hand refractometer is reached 10 % or more in flesh near center of fruit.

e) On thumbing, the immature fruits give out metallic ringing sound and the ripened dull hollow sound.

11. Garden pea:

a) Early cultivars require as few as 1000 heat units to achieve maturity, whereas, late sowing cultivars may require more than 1600 heat units.

b) The pods are harvested when they are filled, tender, having high sugar content and changing color from dark green to light green. Any delay in harvesting turns the pods to poor quality due to conservation of sugar into starch, and this conversion takes place more rapid at high temperature.

12. Chilli:

Chilli should be harvested at fully mature and before change from green to red whereas on approaching the ripe stage.

13. Potato: Yellowish and drying of haulms

14.Cabbage: Solidity, firmness, squeaking of heads indicates maturity.

15. Cauliflower:

Curd size and colour are deciding factors. Snow white or creamy white, compact curds surrounded by turgid green leaves .

16. Knol- khol:

Harvest when the knobs are light green, tender and with delicate flavor having 5 – 8 cm dm.

Ex.3 & 4 MATURITY INDICES FOR FLOWERS AND SPICES Date

Harvesting at right stage of growth of flower crop is an art as well as science. The correct harvest maturity judgment is essential irrespective of the aim of using the harvested flower, flowers whether being used for decoration, adornment, drying or aesthetic purposes should be harvested at right maturity to avoid its quality deterioration. India exports 22485 metric tons worth rupees 45591 lakhs (A.P.E.D.A. Jan 2015). Although there is an increase in floriculture production over last years but postharvest loss of flowers always remained a prime concern of the researchers and entrepreneurs. Harvesting is not just an agricultural operation but far more than that. Good quality flowers are obtained only when harvesting is done at proper stage of maturity.

Flower cultivation in India contributes to a significant share in its horticultural production. 1754000 metric tons of loose flowers and 543 lakh numbers of cut flowers are produced annually in India (N.H.B. 2014-15). Being a very delicate horticultural commodity flower crops require lot of care during harvesting and handling. As the grade and quality of flowers is highly affected by its appearance thus it is must to manage properly the factors which reduces their postharvest life. There are several factors which affects their quality but this sequence of deterioration starts from the point of harvesting. Improper harvesting stage should be avoided and this can be only done when farmers knows about the right stage of harvesting.

Principles behind harvesting at proper harvest maturity:

- Product should retain peak acceptable quality when it reaches the consumer.
- Product should be in a good sensory characteristics, acceptable flavor or appearance.
- Appropriate grade of the commodity suitable to the consumer
- Give maximum shelf life to the consumer.

Maturity indices of commercial cut flower:

Rose:

- harvested differently at various levels of maturity as it is not only variety but the type of market demand also determine the same, like for distant market roses should be harvested at sepals reflexed stage as early to that will make the flower succeptible to bent neck disorder can cause loss of economic value.
- Some yellows as well as white roses can also be harvested at stage when sepals begins to get apart from the bud.
- Bud size vary according to the market demand and knowhow, like in case of international market bud size of 6.5 cm retained along with one or two petal as per their requirement.

• Shears are used for harvesting considered as the best equipment. Stem length of the cut rose varies generally 50 to 80 cm which should be in accordance to the demanding authority and not be our own.

Gladiolus:

• Harvested when 2 - 3 base florets start showing their tremendous colour
• Colour visibility of the 1-3 florets will help consumer to determine the quality of flower thereby increasing the sale of produce giving better returns to farmers.
• While harvesting one should be again careful about the distance of the destiny, as for distant market earlier stage of harvesting is preferred and sugar pulsing may be given further to reduce any quality and wilting loss.
• First floret open stage is best suitable for the local and nearby market.
• Here using knife with pulling upwards the stem considered as a better way of harvest, stem length is again important here for e.g. International market prefers the stem length of 60 to 100 cm as their recommendation strategy.

Carnation:

• Star-stage buds considered as the initial and immature stage which can be used for all purposes marketing but should not be stored for long time.
• 'paint-brush' is suitable harvesting stage and results in quick opening of flower.
• Half bloomed stage accompanied with size of 5.5 cm diameter also stage of open bloomed with 6 cm diameter is generally asked by the international authorities for sale at their venues.
• Here the harvesting equipment is secateurs and stem length can be retained about 50 to 80 cm.

Gerbera:

• Harvested at 2 outer rows disk floret begin to open stage except some which close florets at late evening and night.
• Method of harvesting is twisting and pulling the stems from the junction of the rhizome.
• Stem length should be retained not less than 60 cm if international market is the objective of the grower.
• Harvested flowers should be kept from the base of stem in 40 ppm solution of hypochlorite.
• It is recommended that at least 1-2 row of disk flowers which are tubular flowers located in the center of flower head should show pollen.

Chrysanthemum:

• Cultivars are classified in various groups in this the Standard group of chrysanthemums are

harvested at fully open stage whereas another group namely pompons best suited to be harvested with criteria of most mature flowers at fully open stage.
• Early harvesting is not preferred as it will lead to inability of opening of flowers and cause economical loss, rather than this harvesting at tight buds followed by opening it with bud-opening solutions will be considered as better option.
• Inflorescence size of about 5 cm and a stem length of 60 to 70 cm length considered to be better option of harvesting.
• Spray varieties preferred to be harvested when most of the petals on the most mature flower found to be upright normally. Here we can use the advantage that the flowers can be opened during transportation and storage.
• Cutting stem with knife and shears found to be better. Leaves should be removed totally from the lower third portion of stems.

Anthurium:

• Generally opened spathe are harvested, spathe size varies from variety to variety.
• Angle between the spathe and spadix should be 45° C.
• The color of the spathe should be fully developed and heart shape occurrence at the petiolar end i.e. at the bottom side of spathe towards the point of attachment of flower considered to be one of the best indicator of maturity.

Bird of paradise:

• Harvested generally at bud stage or slightly open stage of flower.
• Flower portion starts bending downward with maturity, which makes 90 degree angle with respect to stem. When orange flower start emerging and can be seen barely stems are to be pulled gently at this stage.
• Harvesting can be done at tight bud stage prior to flowers emergence, as this stage of harvest is an acceptable event for flower longitivity in transport and handling.
• Method of harvesting in this flower is pulling is preferred instead of cutting, the stem retrained with flower generally varies from 30 to 130 cm in length.

Tuberose:

• Harvested at the stage when 2- 4 blooms tends to be open on spike. Earlier stage harvesting is recommended when spike resistance to transportation is needed pretreatment technique can be opted to decrease the chances of bud opening during transport.
• For local market flowers should be more open on the spike. Straight stems with quality florets are always preferred in this case.

Gypsophila common name baby's breath

• Stems to be cut with the length of 20 to 40 cm. flowers here should be harvested keeping the point in mind that this flower is used for both dry and fresh flower purpose.
• 50% of overall flowers should be opened to ensure harvesting, 24 hours from harvest are very much crucial for this flower, farmer should be careful about that.
• For dry flower stems to be cut when 20 to 30% of the flowers are open and thus they even can be retained for long transport event.
• Lot of unopened bud in an arrangement, no water stress to the flowers and no browning of flowers are preferred by the market authorities.

Calla Lilly

• Spathe opening with visible spadix considered as one of the best maturity index.
• Method of harvesting is pulling rhizome from the base and recutting it, generally followed.
• Spadix visibility is considered by the consumer while purchasing this flower, so farmer should take care of it.

Daffodil

• "goose-neck" stage (gooseneck bending downwards for 45 degree angle) considered best, Jonquils harvested at peculiar "one bell" i.e. only single flower open on spike, is considered as harvesting stage,.
• Method of harvesting is cutting flower.
• Flowers should be purchased in the pencil to gooseneck stages.

Helliconia

• Fully mature stage flowers are harvested.

Maturity indices for Seed spices

- Closing of flower initiation: At the time of maturity flower initiation stops.
- Type of the umbel : It depends on the type of umbel to be harvested.
- Color of the leaves: At time of maturity the color of leaf changes fromgreen to yellow or brown.
- Color of the pods: At the time of maturity the color of pods changes from green to yellow or brown.
- Color of seeds: Color of seed changes from green to brown or yellow or black.
- Color of fruits: At time of maturity the color of fruits change from green to yellow or brown.

- Stage of harvest: The stage of harvest depends on the targeted market/ consumer's choice.

1. Ajowan : The small white flowers bloom in November and December in the plains and mid summer in the hills. The harvesting is usually done from February to May. Flower production ceases when the seeds start maturing and become greyish brown in colour. The crop of Ajowain matures in 130-170 days. Mature crop should be harvested with sharp sickle in the morning hours to avoid shattering.

2. Anise : The crop matures in 120-140 days. At the time of maturity, tips of fruit turn greyish green and then fruiting umbels are cut off, tied in bundle and stacked for 4-5 days dried and then threshed out.

3. Caraway : The annual crop of caraway matures in 130-150 days whereas biennial crop in 15 months. Plants should be harvested when the umbels turn brown, over mature crop is prone to shattering and therefore, it should be harvested well before this stage. The harvested plants should be properly stacked and cured or dried till the harvest is completed. The fully dried plants are then threshed with the help of beating sticks in a well-protected place.

4. Celery: Celery crop matures in 150 days after transplanting. There is a problem of seed shattering in celery.

5. Coriander: Coriander crop matures in about 100-150 days of sowing depending upon varieties and climate. The coriander crop grown exclusively for green leaves is harvested after 35-40 days of sowing. The coriander compound leaves with stem are prepared in bunches of desirable size for marketing. The stage of harvest depends upon the market requirement. For green coriander seeds, the crop is harvested when seeds are green and have attained full size. The green seed crop is dried under shade for retaining the green colour. Keeping in view the market requirement, the crop can be harvested at yellow or brown colour of seeds. Delay in harvesting should be avoided, otherwise shattering and splitting of seeds may occur. Harvesting is done by pulling or cutting the whole plant and piled into small stacks in field to dry for 2-3 days. The seeds are separated by beating plants on threshing floor and there after cleaned, winnowed and dried in sun before storing.

6. Cumin: Cumin is harvested in about 100-110 days. The right time of harvesting is usually done in the morning hours to avoid shattering losses.

7. Dill : When dill is grown for vegetable purposes it can be harvested at 4-5 leaves stage. Dill crop takes about 70-80 days for flowering. Flowering starts by the end of December and continues till 2nd week of January. It is pollinated mostly by bees and other insects. The duration

of crop varies from 130 to 150 days and *rabi* crop becomes ready for harvest by end of March.

8. Fennel : Fennel takes 170-175 days to mature. Harvesting is done before the fruits are fully ripe. At this stage, the umbel attains a slight greenish yellow colour. At this stage volatile oil content was found to be the highest and fruit fetches better prices in the market. Over maturity produces poor quality seeds.

9**. Fenugreek:** Fenugreek comes to harvest with in three months after planting. The harvesting time is judged when the colour of leaves and pods turn yellow. Timely harvest is very important so that there is no loss of seed due to shattering.

1**0. Nigella :** The Nigella crop takes 140-160 days to reach maturity. The crop should be harvested when the seed attained full maturity in capsule and have turned to full black colour. Delay in harvesting may cause shattering of seeds.

Ex.5 DETERMINATION OF PHYSIOLOGICAL LOSS IN WEIGHT

Date :

Postharvest physical loss (PPL) comprised of fruit loss due to physical bruising injury, abrasion, cuts and induced lesions which occurred while harvesting/handling and appeared during storage. Physical loss was calculated on percentage basis, i.e. by identifying the good fruits than those fruits which were physically injured/unfit, asper given formula:

Postharvest physical loss (%) = Fruit affected by physical loss / Total number of fruits × 100.

Physiological loss in weight was calculated by marking individual mango fruit of each lot. High precision electronic balance was used to weigh the fruits, during storage and the cumulative PLW was calculated by using the following formula and expressed in percentage (%).

PLW (%) = (Initial weight–Final weight)/Initial weight × 100

Observations

S.No.	No. of Day	Weight in gm
1.	**1st**	
2.	**2nd**	
3.	**4th**	
4.	**6th**	
5.	**8th**	
6.	**10th**	
7.	**12th**	

EX. 6 GRADING OF FRUITS AND VEGETABLES Date:

Grading of fruits and vegetables after harvesting is an essential step in post-harvest management. Grading of fruits and vegetables on the basis of physical characteristics like weight, size, colour, shape, specific gravity, and freedom from diseases depending upon agrocliamatic conditions. The known methods of grading of fruits and vegetables are manual grading , size grading.

Grading of fruits and vegetables in the fresh form for quality is essential, as the people are becoming quality conscious day by day. Further, upon arrival of fruits and vegetables at the processing centres, they should be graded strictly for quality. The immature properly mature and over mature fruits and vegetable should be sorted out for the best attributes.

Definition of Grading:

Grading is sorting of vegetables and fruits into different grades according to the size, shape, colour, and volume to fetch high price in market.

For International market three general grades are considered as:

1. Extra class 2. Class 1st 3. Class 2nd.

1. Extra Class:

The extra class is of superior quality posses the shapes and colour of the variety and without internal defect likely to affect the inherent texture and flavour. A 5% tolerance is allowed for errors. It must be carefully presented taking into accounts the uniformity of the produces in size colour, condition arrangement of the produce in the package quality and appearances of the packing or pre-packing material.

2. Class I:

Almost having a same quality is like the Extra Class except that a 10% tolerance is allowed. Individual fruit is allowed a slight defect in shape, colour and miner skin defect which do not affect the general appearance for keeping qualities. In packing the size range may be wider and product need not always be arranged in the package.

3. Class II:

This class product may exhibit some external or internal defects provided they are fit for consumption while fresh. This class is best fitted for local or short distance market. This category will satisfy the needs of customers who are not too demanding and for whom price is more important than quality.

Advantages of Grading:

1. Losses the selling price due to presence of substandard products or specimen can be easily avoided.
2. It increased marketing efficiency by facilitating buying and selling a produce without personal selection.
3. Grading enhanced to set good price for graded products.
4. Heavy marketing cost in packing and transportation can be avoided by grading.
5. In grading diseased and defected specimen are not damaged due to contact of diseased specimens and thus gets high price in market.
6. By grading there is fairness to both Buyers and Sellers.
7. Properly graded vegetables and fruits are purchased by the consumer easily without inspection.

Grading of Fruits:

Generally, the fruits are graded on the basis of size, weight , sp. gravity, colour, variety, etc. Size grading is predominantly followed in almost all types of fruits on the basis of size. The fruits are graded as a small, medium, large and extra large. On the basis of maturity, the fruits are graded as immature , properly mature and over mature. Grading on the basis of maturity decides both quality and shelf life. The Alphonsoa and Pairi mango fruits are graded on the basis of weight as less than 200 g , 200-249 g, 250-299 g, 300-349 g and more than 350 g. out of these grades the weight grade 250-299 g account for about 30% of the fruits. The mango fruits are also graded on the basis of Sp. gravity (3 grades on the basis of sp. Gravity as less than 1.0 sp.gr, 1.0-1.02 and more than 1.02. The sp.gr Grade 1.0-1.02 accounts for about 50% of the Alphonso and Pairi mango fruits.

Grading of Vegetables:

The fruit vegetables such as bitter gourd, okra, bell pepper, brinjal, green chill, etc. also graded on the basis of size into three grades as small medium and large. The vegetables like tomato are graded on the basis of colour.

EX. 7 **Date:**

Application of different types of packaging containers for shelf life extension

The increased production of fruits and vegetables will have significance only when which they reach the consumer in good condition at a reasonable price. The existing post-harvest losses of fruits and vegetables could be considerably reduced by adopting improved packaging.

Packaging of fruits and vegetables is undertaken primarily to assemble the produce in convenient units for marketing and distribution.

Objects of packaging

1. To protect the produce from hazards of transport
2. Preventing microbial and insect damage
3. Minimizing the physiological loss in weight

Characteristics of packages

a) The package must have sufficient mechanical strength to protect the contents during handling, transporting and staking.

b) The packaging material must be free of chemical substances that could transfer to the produce and become toxic to man.

c) The package must meet handling and marketing requirements in terms to weight, size and shape.

d) The package should allow rapid cooling of the contents. Furthermore, the permeability of plastic films to respiratory gases could also be important..

e) Mechanical strength of the package should be largely unaffected by moisture content (when wet) or high humidity conditions.

f) The security of the package or ease of opening and closing might be important in some marketing situations.

g) The package must either exclude light or be transparent.

h) The package should be appropriate for retail presentations. The package should be designed for ease of disposal, re-use, or recycling.

j) Cost of the package in relation to value and the extent of contents protection required should be as low as possible.

Different packaging for important frits and vegetables

Sr. No.	Types of packing	Commodity packed
1.	Flexible sacks (gunny bags)	Ber, lemon, lime, mango (raw), pear, sweet orange and different vegetables
2.	Bamboo baskets	Grape, guava, mango, papaya, tomato
3.	Earthen pots	custard apples, grapes
4.	Wooden boxes	Apple, apricots, cherry, litchi, mango, mandarin, pear, plum, sapota, capsicum
5.	Corrugated fibre box (CFB)	Apple, cherry, grape, pomegranate, all fruits and vegetables for export.
6.	Rigid plastic crates	Loose fruits and vegetables for cold storage, processing plants, nearby local markets and public distribution system.

New Packaging Material

Sr. No.	Types of packing	Speciality
1.	Corrugated fibre board (CFB) boxes	These are light in weight, easy to handle, hygienic and recyclable. These can be turned water resistant by the use of a suitable adhesive or was coating or a plastic film.
2.	Combination boxes	These are mad with plywood and CFB and give a high stack load capacity
3.	Corrugated polypropylene board boxes	These are light in weight, hygienic, water resistant, sturdy and have a light busting strength. These are useful in the multi-trip packaging.
4.	Plastic trays or crates	These are hygienic, light in weight, sturdy and recyclable and useful in the multi-trip packaging.
5.	Plastic woven sacks	These bags are made of high density polyethylene or polypropylene, light in weight and can be reused. These are used for packaging hard fruits to transport them over short distances.
6.	Moulded pulp trays or thermoformed plastic trays	These trays have the facility of cavities to hold individual apple fruit which prevents the fruit from rubbing against each other that often leads to bruising or surface cracks.
7.	Stretch wrapping	It is used for retail marketing of fresh produce in the form of cling plastic films for stretch wrapping
8.	Modified atmospheric packaging	In this packaging, the internal atmosphere can be manipulated with a combination of certain gases (O_2 & CO_2)and selection of suitable packaging material

Ventilation

Adequate ventilation should be given to the boxes which used to pack the fruits and vegetables. Holes should be provided on the surface (top and sides). This prevent the heat generation which can cause rapid product deterioration.

EX. 8 **Date:**

Effect of temperature on shelf life and quality of produce

Temperature is the characteristic of the postharvest environment that has the greatest impact on the storage life of vegetables. All vegetable deteriorate after they are harvested; only the rate at which the deterioration occurs can be changed. It is well established that the deterioration of most agricultural products is a direct unction of temperature. Within the rage of temperatures bounded on the lower end by chilling injury or freezing and on the upper by heat injury. Deterioration of vegetables caused by physiological, pathological, or physical factors is a function of time and environment.

Postharvest losses of horticultural crops are estimated to be as high as 25% to 50% of the production due to poor postharvest handling techniques, mainly poor temperature management. Especially in some region of the globe such as tropical and subtropical regions and where refrigeration facilities are not available. A large quantity of onions (*Allium cepa* L.) is lost between the field and the consumer in India due to lack of adequate postharvest handling procedures. Good temperature management is, in fact, the most important and simplest procedure for delaying product deterioration. In addition.

Optimum temperature storage retards the aging of vegetables. Softening, and textural and colorchanges as well as slowing undesirable metabolic charges, moisture loss, and losses due to pathogen invasion. Temperature is also the factor that can be most easily and promptly controlled. Optimum preservation of vegetable quality can only be achieved when the produce is promptly cooled to its optimum temperature as soon as possible after harvest.

Low temperature during the storage of fresh vegetables depress both the physiological activity of vegetable tissue and the activity of micro-organisms capable of causing spoilage of the product. In general, the lower the storage temperature, within the limits acceptable for each type of commodity (above the freezing point or chilling injury threshold,) the longer the storage life. For each horticultural commodity there is presumed to be an optimal postharvest storage temperature at which the rate of product deterioration is minimized. Vegetables are, in fact highly perishable products and losses due to inadequate temperature management are found to be mainly due to water loss and decay carrots (*Dacus carota*L.) should be stored at 0 to 1^0 C in order to maintain quality during long-term storage (between 150 and 190 days.) They also added that the carrot

temperature should be reduced to about 0^0 C as soon as possible after harvest. And that the temperature should be maintained constant during the storage period. The optimum temperature for reducing decay of beets (*Beta vulgaries*) was 4 to 5^0 C rather that 0 to 1^0 C of 2^0 C to 3^0 C the storage life of cabbage is limited to 4 to 5 months when storage temperature is maintained at 7 to 8^0 C.

Effects of Storage Temperature on the Quality of Vegetables

The visible quality of the product that is the appearance of the product is perhaps the most important factor that determines the market value of fresh vegetables. When consumers were asked about fresh fruits and vegetables, ripeness, freshness, and taste were named by 96% as the most important selection criteria. While appearance and condition of the product came in second in order of importance.

1) Appearance and Texture of Vegetables

Colour, one of the major factor of product appearance, is a primary indicator of maturity or ripeness and is due to the presence of particular pigments in the product. Undesirable changes in the uniformity and intensity of colour can be observed when fruits and vegetables are not stored at recommended temperatures. Temperature can therefore have a direct effect on colour changes during storage of fruits and vegetables. For example, loss of chlorophyll in mango and tomato, yellowing of green vegetables such as broccoli is considered undesirable.

2) Compositional Characteristics of Vegetables; nutritional Value

Fruits and vegetables are rich sources of vitamins, particularly, Vitamin C and Vitamin A required in the human diet. However, the nutritional value of fruits and vegetables can also be greatly affected by storage temperature. In general, Vitamin C degradation is very rapid after harvest and increases as the storage time and temperature increases. The concentration of carbohydrates, sugars as well as organic acids in fruits and vegetables can also decrease when temperature increases. It is due to fact that, when temperature increases, the respiration rate of the product increases and complex carbohydrates and organic acids are transformed into glucose to provide substrate for respiratory processes. In conclusion, good temperature management is recommended for fresh fruits and vegetables since it retards aging due to ripening, softening, textural and colour changes, undesirable metabolic changes and respiratory heat production that results from moisture loss, spoilage due to invasion by bacteria, fungi and yeast.

Optimum cold storage conditions & approximate storage life of fruits and vegetables

Fruits	Temp (°C)	RH (%)	Approx. storage life (weeks)
Apple	0-2	85-90	20-30
Avocado			
Chilling tolerant varieties	4.4	85-90	4
Chilling sensitive varieties	12.5	85-90	2
Banana			
Cavendish green	13	85-90	3-4
Cavnedish ripe	12	85-90	1-5
Ney Poovan green	12	85-90	2-3
Ney poovan ripe	8	85-90	1
Ber	5-6	85-90	4
Citrus			
Coorg mandarin (main crop)	8	85-90	8
Coorg mandarin (rainy season)	8	85-90	6
Sathgudi orange (Moosambi)	8	85-90	16
Lime yellow	12-13	85-90	8
Lime green	12-13	85-90	7
Grape fruit	13-14	85-90	12
Custard apple	15	85-90	1.5
Date	6-7	85-90	2
Fig	1-2	85-90	6
Guava	10	85-90	2-5
Jackfruit	11-12	85-90	6
Litchi	2	85-90	8-10
Alphonso	12-13	85-90	4
Banganapalli	12	85-90	5-6
Papaya green	10	85-90	3-4
Papaya turning	9	85-90	2-3
Passion fruit	6-7	85-90	3
Pineapple all green	9-10	85-90	4-6
Pineapple 25% Yellow	6-7	85-90	1-2
Strawberry	0	85-90	1
Vegetables			
Beans			
Snap beans	8-10	85-90	3-4
Winged beans	10	85-90	8-10
Beetroot	0-1	90-95	8-10
Brinjal	10	90-95	2
Cabbage(wet season)	0-2	90-95	4-6
Cabbage(dry season)	0-2	90-95	12
Capsicum(green)	7-8	85-90	3-5
Carrot topped	0-2	90-95	20-24

Cauliflower	0-2	90-95	7
Coriander leaves	0-2	90-95	4-5
Chow chow	12-13	90-95	3
Cucumber	10-11	90-95	2
Garlic(bulbs) dry	0	65	28-36
Ginger	8-10	75	16-20
Gourd, bottle	8-9	85-90	4-6
Gourd, snake	18-20	85-90	2
Muskmelon, Honey dew	7-8	85	4-5
Okra	10	90	1.5
Onion, Red	0	65-70	20-24
Onion, white	0	65-70	16-20
Pea, green	0	90-95	2-3
Poato	4	85	30-34
Pumpkin	12-15	70-75	24-36
Radish, topped	0	90-95	3-5
Squash	12-15	70-75	8-24
Sweet Potato	10-12	80-90	13-20
Spinach	0	90-95	10-14
Tomato			
Mature green	12-13	85-90	4-5
Red ripe	5-6	85-90	2
Turnip	0	90-95	8-16
Watermelon	12-15	80-90	2
Yam	16-20	60-70	3-5

EX. 9 **Date:**

DEMONSTRATION OF CHILLING AND FREEZING INJURY IN FRUITS AND VEGETABLES

Chilling injury typically results from "exposure of susceptible produce, especially that of tropical or sub-tropical origin, to temperatures below 10- 15 C". However, the critical temperature at which chilling injury occurs varies among commodities. Chilling injury is completely different to freezing injury (which results when ice crystals form in plant tissues at temperatures below their freezing point). Both susceptibility and symptoms of chilling injury are product and even cultivar-specific. Moreover, the same commodity grown in different areas may behave differently in response to similar temperature conditions.

Symptoms of Chilling Injury

1. Skin pitting: is a common chilling injury symptom that is due to collapse of cells beneath the surface. The pits are often discoloured. High rates of water loss from damaged areas may occur, which accentuates the extent of pitting.

2. Browning or blackening of flesh tissues: is another common feature of chilling injury (e.g. avocado; Chilling-induced browning in fruit typically appears first around the vascular (transport) strands. Browning can result from the action of the polyphenoloxidase (PPO) enzyme on phenolic compounds released from the vacuole during chilling, but this mechanism has not been proven in all cases.

3. Water-soaking: in leafy vegetables and some fruits (e.g. papaya)

4. De-greening of citrus fruit is slowed by even mild chilling.

5. Fruit that has been picked immature may fail to ripen or ripen unevenly or slowly after chilling (e.g. tomato).

6. Development of off-flavour or odour (low O2 levels)

7. Rotting: chilling injury causes the release of metabolities (e.g. amino acids, sugars) and mineral salts from cells. Leakage of metabolites and ions, together with degradation of cell membranes, provides substrates for growth of pathogenic organisms, especially fungi. Such pathogens are often present as latent infections or may contaminate produce during harvesting and postharvest operation. Thus, rots is another common symptom of chilling injury, particularly upon removal from low-temperature storage. Symptoms of chilling injury normally occur while the produce is at low temperature. However, they sometimes chilling injury appear when the produce is removed to a higher temperature and deterioration may then be quite rapid, often within a matter of hours.

Chilling injury symptoms of some fruits

Produce	Lowest safe storage temperature (^oC)	Symptoms
Avocado	5-12	Pitting, browning of pulp and vascular strands
Banana	12	Brown streaking on skin
Cucumber	7	Dark-coloured, water-soaked areas
Eggplant	7	Surface scald
Lemon	10	Pitting of flavedo, membrane staining, red blotches
Lime	7	Pitting
Mango	12-13	Dull skin, brown areas
Melon	7-10	Pitting, surface rots
Papaya	7-15	Pitting, water-soaked areas
Pineapple	6-15	Brown or black flesh
Tomato	10-12	Pitting, Alternaria rots

Management of Chilling Injury

i. Maintaining critical temperature - The safest way to manage chilling injury is to determine the critical temperature for its development in a particular produce and then not expose the commodity to temperatures below that critical temperature (Eg. Safe storage temperature for apple is 0-20C and care should to taken to not to store apple below this critical temperature to avoid chilling injury). However, it has been found that exposure for a short period to chilling temperatures with subsequent storage at higher temperatures may prevent the development of injury. This conditioning process has been effective in managing

- Black heart in pineapple
- Woolliness in peach
- Flesh browning in plum.

ii. MAS - Modified atmosphere storage may also reduce chilling injury in some commodities.

iii. Maintaining high RH - both in storage at low temperature and after storage can minimize expression of chilling injury symptoms, particularly pitting (e.g. film-wrapped cucumbers).

EX.10 **Date:**

PRINCIPLES FOR PROLONGING STORAGE LIFE

The main method used to prolong the storage life of fruit is through reducing the fruit temperature to slow metabolism. Refrigerated storage slows the rate of ripening and senescence of the fruit, and also slows the development of any rots. The way in which temperature management is implemented after harvest can significantly affect the quality of the fruit at the end of storage, both in the amount of ripening retardation and also the presence or absence of disorders. The basic effect of refrigerated storage on fruit can be supplemented by modification of the atmosphere in the cool store, by reducing oxygen and increasing carbon dioxide concentrations. More recently, the application of the inhibitor of ethylene action 1-methylcyclopropene (1-MCP) has become common to slow the ripening of a range of fruit, and in particular certain cultivars of apple. The way in which all these technologies impact on the fruit is dependent on the physiological state, or maturity, of the fruit at harvest. What may be described as a „correct" physiological state at harvest is not fixed, but may differ dependent on the commercial requirements of the fruit, i.e. a short or long storage period. Ultimately, the target for good storage is for the fruit to remain in good condition, to ripen properly, have an acceptable flavour and not have any disorders at the end of storage and when it reaches the consumer.

1. **Temperature**

   To obtain the maximum benefit from cold temperatures, the temperature must be as low as possible without causing damage to the fruit; this is termed the lowest safe temperature. Below the lowest safe temperature, but at non-freezing temperatures, the fruit may develop symptoms of chilling injury. At even lower temperatures, generally in the range –0.5°C to –1.5°C, freezing occurs which irreversibly damages a living product. Because of this, –0.5°C is usually the lowest temperature used for storage of fruit, including some apple cultivars, berries or 'Hayward' kiwifruit. Temperatures at which chilling symptoms occur are around 8oC for subtropical species and may be anything up to 14°C for some tropical fruit: for example unripe banana and mango need to be shipped at 13–14°C. However, it is not only tropical and sub-tropical fruit that are susceptible to chilling injury; even 'Hayward' kiwifruit, which is stored at 0°C or just below, may develop chilling injury.

2. Relative humidity

Once harvested, fruit will continuously lose water to a point where quality will be affected. In some species, a small amount of water loss may accelerate ripening (e.g. avocado), but in all fruit there eventually comes a point at which loss of water, usually first seen as shrivelling, results in the fruit becoming unacceptable. Water loss from the fruit is driven by the vapour pressure gradient between the fruit and the surrounding environment. While the capacity for air to hold water is reduced at low temperatures, there is always a gradient driving water from the fruit into the cool store atmosphere. The less fruit there is in a cool store, the greater the water loss from each fruit before an equilibrium relative humidity is reached. Water may be lost from the cool store atmosphere by condensation on the refrigeration coils that are colder than the room atmosphere, and the greater the temperature differential between the coils and atmosphere the greater the loss of water. When storage is at about 0°C, this can be seen by ice developing on the coils that must be removed by defrosting. In preventing quality loss of harvested fruit, the relative humidity of the storage environment is one of the first aspects considered, since fruit will lose water more rapidly at lower relative humidity. This is mostly an issue where fruit are held unpacked or in bulk in a cool store, and water loss is exacerbated where there is only a small volume of fruit in the store, air flow is high and there is a large temperature differential on the refrigeration coil. In other circumstances, such as for kiwifruit that may be stored for months, the fruit is packed into fibreboard packs with a polyethylene liner or bag. In these circumstances, it is the bag that creates a high humidity environment for the fruit and limits the fruit‟s water loss. A very high relative humidity in the store environment where packed fruit are held may be detrimental to the integrity of the fibreboard packaging, which would soften and lose its strength.

3. Controlled and Modified Atmospheres

The storage life achievable by refrigerated storage can be extended by modifying the store atmosphere by reducing the oxygen and increasing the carbon dioxide concentrations. Elevated CO_2 and reduced O_2, used either separately or together, can delay ripening and slow the onset of senescence. When both high CO_2 and low O_2 concentrations are combined then the beneficial effects may be additive. These methods were originally developed on a commercial scale for apple, but have been progressively applied to many other fruit. Container shipping helped their introduction because a sealed container made it easier to maintain the required temperature and atmosphere regimes.

4. Blocking ethylene action

With ethylene having a pivotal role in the ripening of many (but not all) fruit, the use of the ethylene action inhibitor 1-MCP has been investigated for prolonging the storage life of a wide range of species through retarding fruit ripening and softening (Watkins 2008). 1-MCP is usually applied after harvest as a gas treatment in a sealed store, container or tent, with the active ingredient released from a powder by dissolving in water. Successful use of 1-MCP to delay ripening depends on the physiology of the fruit, most likely on the natural rate of replacement of the ethylene receptors that are blocked by 1-MCP. Since binding of 1-MCP to existing ethylene receptors is irreversible, a single period of exposure can delay ripening for several to many days, depending on the rate of synthesis of new receptors. For all cultivars, careful optimisation of maturity stage, 1-MCP concentration, exposure frequency and duration and storage temperature is required.

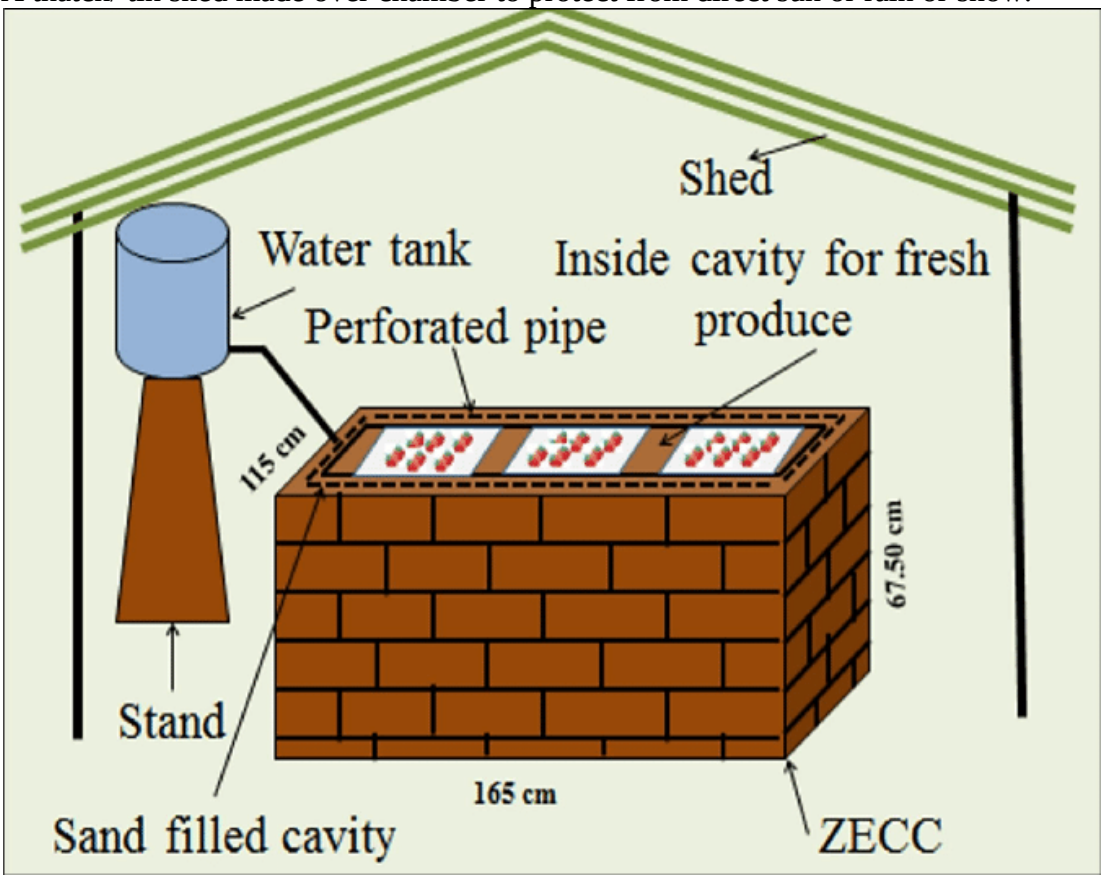
EX.11 **Date:**

CONSERVATION OF ZERO ENERGY COOL CHAMBERS FOR ON FARM STORAGE

In India quality deterioration of horticultural produce takes place immediately after harvest due to lack of on-farm storage. Maintenance of low temperature is a great problem in a tropical country. Refrigeration is energy intensive, expensive, not so easy to install and run in remote areas and not always environment friendly. Due to lack of cold/cool storage space a substantial amount of fruits and vegetables are lost after production. Considering acute energy crisis and lack of cool storage facility efforts made to develop low cost/low energy cool chambers.

Construction:

- Select an-upland having a nearby source of water supply.
- Make floor with brick 165 cm x 115 cm.
- Erect the double wall to a height of 67.5 cm leaving a cavity of 7.5 cm.
- Drench the chamber with water. Soak the fine river bed sand with water.
- Fill the 7.5 cm cavity between the double walls with this wet sand.
- Make top cover with bamboo (165 cm x115 cm) frame and 'sirki' straw or dry grass.
- A thatch/ tin shed made over chamber to protect from direct sun or rain or snow.



EX.12 **Date:**

IDENTIFICATION AND DESCRIPTION OF POST HARVEST DISORDERS OF FRUIT AND VEGETABLE CROPS

EX.13 **Date:**

IDENTIFICATION OF STORAGE PESTS AND DISEASES IN SPICES

EX.14 **Date:**

PLANNING AND LAYOUT OF PACK HOUSE

Need of packhouse

After harvest, fruits and vegetables need to be prepared for sale. This can be undertaken on the farm or at the level of retail, wholesale or supermarket chain. Regardless of the destination, preparation for the fresh market comprises four basic key operations:

1. Removal of unmarketable material,
2. Sorting by maturity and/or size,
3. Grading,
4. Packaging.

Any working arrangement that reduces handling will lead to lower costs and will assist in reducing quality losses. Market preparation is therefore preferably carried out in the field. However, this is only really possible with tender or perishable products or small volumes for nearby markets. Products need to be transported to a packinghouse or packing shed in the following cases: for large operations, distant or demanding markets or products requiring special operations like washing, brushing, waxing, controlled ripening, refrigeration, storage or any specific type of treatment or packaging.

These two systems (field vs. packinghouse preparation) are not mutually exclusive. In many cases part field preparation is completed later in the packing shed. Because it is a waste of time and money to handle unmarketable units, primary selection of fruits and vegetables is always carried out in the field. In this way products with severe defects, injuries or diseases are removed.

General considerations about design

A packinghouse needs to be located close to the production area and within easy access to main roads or highways. It also needs to have one entrance to facilitate and control supply and delivery. Moreover, it needs to be large enough for future expansion or additional new facilities. Sufficient space outside is also required to avoid congestion of vehicles entering and leaving. Buildings should be designed to ensure sufficient shade during most of the day in the loading and unloading areas. They also need good ventilation in summer and protection in winter.

Packinghouses are usually built with cheap materials. However, it is important to create a comfortable environment both for produce and workers. This is because product exposed

to unfavorable conditions can lead to rapid deterioration in quality. Also, uncomfortable working conditions for staff can lead to unnecessary rough handling.

A packinghouse should have adequate room for easy circulation with ramps to facilitate loading and unloading. Doors and spaces should be sufficiently large to allow the use of forklifts. The reception area should be large enough to hold product equivalent to one working day. The main reason for this is to keep the packinghouse in operation in the event of an interruption in the flow of product from the field (rain, machine breakdown, etc).

Electricity is critical for equipment, refrigeration and particularly lighting. Because packhouses usually work extended hours or even continuously during harvest time, lighting (both, intensity and quality) is critical in identifying defects on inspection tables. Lights should be below eye level to prevent glare and eyestrain. Light intensity should be around 2 000 -2 500 lx for light coloured products but 4 000-5 000 for darker ones. The working area together with the whole building should have lighting.

This is in order to avoid the contrasts caused by shaded areas, resulting in temporary blindness when the eyes are raised. Dull colours and non-glossy surfaces are a requirement for equipment, conveyor belts and outfits. In this way, defects are not masked because of the reflection of light. It also helps to reduce eye fatigue.

A good supply of water is important for washing product, trucks, bins and equipment, as well as for dumping. In some cases it may also be necessary for hydro cooling. Provision of an adequate waste water disposal system is as important as a good source.

Administration offices should be located on clean and quiet areas and if possible elevated. This is so that the entire operation is visible. Packinghouses should have facilities or laboratories for quality analysis.

General considerations about operations

- Reception
- Removal of rejects
- Sizing
- Grading
- Waxing
- Degreening
- Controlled ripening
- Pest and disease control & Temperature treatment.

EX.15 **Date:**

VISIT TO PACKAGING UNIT

EX.16 **Date:**

VISIT TO COLD STORAGE UNIT