MODULE 1 POST-HARVEST LOSSES AND PREVENTION

UNIT1 DEFINITION OF POST-HARVEST LOSSES, BRIEF ON POST-HARVEST PHYSIOLOGY: WHAT HAPPENS TO FARM PRODUCE AFTER HARVEST?

CONTENTS

1.0 INTRODUCTION

A problem that cannot be defined can hardly be solved; furthermore, solving any problem must start with understanding the circumstances surrounding the situation, as that will enable us to prevent events that could start the problem. In this unit therefore we shall as simple as possible define what we mean by post-harvest losses and have a brief on post-harvest physiology that is simply put what happens to farm produce after harvest, or common activities that go on in the **life** of harvested produce? Note the word “life”, does that interest you? Not to worry, we shall soon understand that harvested produce are living.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- discuss the scope of post-harvest losses
- explain the fact that harvested produce are living tissues

3.0 MAIN CONTENT

3.1 Definition of Post-Harvest Losses

Post-Harvest, Physiology, Produce, Storage

* The word **Pos**t means **after**
* The word **harvest** refers to the process of harvesting; gathering the ripened crop or the produce obtained from a farm, **"Post-harvest"** therefore refers to events after harvest, when the harvested produce had been cut off from the source of nutrition from the parent plant.
* The word **Physiology** is a branch of biology (study of all life or living matter), physiology deals with the functions and activities of life or of living matter (as organs, tissues, or cells) and of the physical and chemical phenomena involved.
* **Produce**- these are plants parts that are of economic importance to man.
* **Storage**-the act of storing goods or keeping safe

Post-harvest losses refer to all forms of reduction- which may generally be in quantity or quality of harvested produce, from the point of harvest to the point of consumption of such produce. In other words any form of reduction that occurs in the quality or quantity of harvested produce between the points of harvest till the time of consumption.

In order to have a good grasp of what we want to discuss, we should have an idea of the processes going on in harvested produce. Yes that banana, plantain, tomato, guava, oranges, yam tuber, carrot etc. that you have just harvested or given to you by a friend or relative that has just arrived from a long journey. In other words let us start by briefly discussing post-harvest physiology.

3.2 Brief on Post-harvest Physiology: What Happens to Farm Produce After Harvest?

Harvested produce are made up of living cells and tissues in other words they are alive. Before such produce are harvested they are nourished by the parent plant through the process of photosynthesis. Briefly let us evaluate how true it is that harvested produce are alive. The best thing to do here is to examine harvested produce using the characteristics of living things. I remember in my elementary biology that I was thought that I could easily remember these characteristics by an acronym: "Mr. D. Niger" Decoded as

Movement: living things move, this is obvious in animals, however plants roots move towards water, they also move when blown by winds and so on.
Respiration: the process whereby oxygen is taken in and carbon (IV) oxide (CO_2) is given out.

Death: plant and animals also experience death.
Nutrition: this means that all living take in food for their nourishment, plants manufacture their food through the process of photosynthesis using energy from sunlight, water and other mineral nutrients from the soil; animals on the other hand take preformed food by feeding on plants and other animals.

Irritability or response to stimuli: animals respond to touch, the eyes also respond to light, skin respond to cold, heat and so on; in the same vein plant move in response to light (photosynthesis); some respond to touch, gravity.

Growth: is also another prove that both plants and animals are alive. Growth is the irreversible increase in height, volume, weight, area and so on; this is experienced by plants and animals.

Excretion: this has to do with removal or elimination of wastes from the body. Plants take in carbon (IV) oxide and give out oxygen. Animals sweat, pass out feces.

Reproduction: this has to do with regeneration or giving birth to young ones in order to avoid extinction and ensure continuity.

Never mind the order, it is just to enable us remember the characteristics of living things.

Don't forget what we are discussing any way the physiology of harvested produce and the fact that we claim that harvested produce are alive.

When a fruit is initiated it will continue to grow until maturity. A growing fruit is nourished by the food provided by the mother plant in the process of photosynthesis, the cells in the fruit takes in oxygen i.e. **respires**, in many fruits you have seeds for reproduction and the fruit can die. Now we can go ahead to discuss physiology of harvested produce.

One major activity that takes place in plants and harvested produce is **Respiration**. I am sure you are familiar with this term. Never mind if you can't remember. Respiration is defined as the process whereby oxygen is taken in and carbon (IV) oxide (CO_2) is given out. Can you remember the equation to represent this? Here we are:
$C_6H_{12}O_6 + 6O_2 = 6CO_2 + 6H_2O$+ Heat energy

Respiration leads to break down of harvested produce. Carbohydrate or sugar in the harvested produce is used without any means of replacement; remember that green leaves continue to make more carbohydrate through the process of photosynthesis to replace that lost in respiration. On the other hand harvested produce continually use carbohydrate and lose water without any replacement. This eventually leads to ageing, death and decay. I am sure you can understand this, just imagine a person carrying out all his daily routine without eating, he will eventually emaciate, look old and then die.

Air must be supplied adequately for normal respiration to take place. When air is in short supply to the extent that the oxygen level reduced from 20 per cent to two per cent, it has been reported that fermentation instead of respiration will take place. **(**www.**fao**.org/docrep/t0073e/t0073e02.htm**)** Fermentation leads to the production of alcohol and carbon (IV) oxide from sugar, the effects are production of unpleasant flavors and premature ageing **(**www.**fao**.org/docrep/t0073e/t0073e02.htm**).** Lack of good ventilation will increase Carbon (IV) oxide concentration in the produce and if it rises from oneto about five per cent, production of bad flavors occurs as well as internal break down of and failure of fruit to ripen.

Another other major activity that also takes place in growing plants and harvested produce is transpiration or loss of water. **Transpiration** is the passage of water through the plant. This process maintains the high water content as well as the pressure needed for support.

In fresh produce loss of water also occur, but this time without replacement. When there is up to 5-10 per cent reduction in fresh weight, harvested produce wilts and may become unusable **(**www.**fao**.org/docrep/t0073e/t0073e02.htm). In other words, usable life of

harvested produce can be extended by minimising the rate of water loss. This can be achieved by keeping the harvested produce in a moist atmosphere.

Secondly, although good ventilation through the harvested produce is necessary to remove the heat of respiration, movement of air through the produce must be gentle because the faster the movement of air over the produce, the quicker the water loss. Good packaging material will reduce the rate of air movement over the produce. It should also be noted that rate of loss of water differs from produce to produce. One main factor that plays a role here is the ratio of the surface area to the volume of the produce. Produce with high surface area to volume ratio lose more water than those with lower surface area to volume ratio. That is the reason why produce like vegetable amaranth and other leafy vegetables readily lose water compared to tubers like sweet potatoes, yam and others

SELF-ASSESSMENT EXERCISE

Mention two main physiological activities that take place in growing plants and harvested produce which have implication on how long they can be kept?

4.0 CONCLUSION

A brief on post-harvest physiology that is simply put what happens to farm produce after harvest was discussed

5.0 SUMMARY

In this unit we have defined post-harvest physiology as the study of the functions and activities of life in harvested produce and post-harvest losses refer to any form of reduction that occurs in the quality or quantity of harvested produce between the points of harvest till the time of consumption.

6.0 TUTOR-MARKED ASSIGNMENT

1. What are post-harvest losses

7.0 REFERENCES/FURTHER READING

Jingtair, S. (2002). Post-harvest physiology of tropical fruits. Proceedings on tropical and subtropical fruits. In R. draw editor. Acta Hort. 575.

Respiration- Food and Agricultural Organization www.**fao**.org/docrep/t0073e/t0073e02.htm

UNIT 2 TYPES OF POST-HARVEST LOSSES: QUANTITATIVE, QUALITATIVE, NUTRITIONAL, ECONOMIC, OTHER LOSSES

CONTENTS

1.0 INTRODUCTION

Having defined post harvested losses coupled with having a shot on post-harvest physiology, we shall at this point explain the different categories of post-harvest losses that can occur; we must also stress here that one form of loss may lead to another or some other ones.

2.0 OBJECTIVES

At the end of this unit, you shouldbe able to:

- distinguish between different types of post-harvest losses
- explain how one form of loss can lead to other(s)
- appreciate the fact that not all forms of losses are visible

3.0 MAIN CONTENT

3.1 Quantitative Losses

This is a measurable reduction in harvested produce. This reduction might be in terms of weight or volume. This type of losses can occur through different means; for example moisture which is a substantial part of harvested produce can be lost between harvest and consumption. This will

lead to reduction in weight or volume. Freshly harvested tubers have more weight than that which has been transported and stored over a period of time. Weight of grains of maize might reduce in storage due to moisture loss this will also amount to quantitative post-harvest loss. Shrinkage in oranges, tomatoes and potatoes due to moisture loss in transit or storage for example during the harmattan will also reduce the weight. The effect of moisture loss might transcend or go beyond reduction in quantity as it sometimes leads to quality reduction. For example moisture loss in vegetable amaranth will reduce the consumer appeal, the same goes for tomato and potato. Reduction in quantity of harvested produce can also occur during threshing, winnowing and transporting. In transit leakages in bags will lead to quantitative reduction in harvested produce. Pest infestation during storage can also reduce the weight of harvested produce. Rodents attack on stored yam, banana, plantain, grains like maize, cowpea and others cause measurable reduction in these harvested produce. I am sure you are familiar with some of the examples listed. Can you give other relevant examples?

A distinction can be made between loss of weight and food loss. In the example given above, the fact that there is reduction in weight due to loss of moisture does not make the produce to be unfit for consumption or used as food. **What then is food loss?** Food loss implies that the produce has been rendered unfit for consumption and this is often associated with loss in quality.

3.2 Qualitative losses

I am sure that you are familiar with situations where grains are purchased and excreta of rats are found inside. When such happens I am sure sorting became compulsory before further processing for consumption. The disposition of the consumer is quite different when the grains look so clean and smell nicely. This is also common with cowpea, I mean incidence of cowpea beetle (*Callosobruchusmaculatus*) which often bore holes in the grains, produce an offensive odour and reduces palatability. These are examples of losses in quality. *Quality of harvested produce is assessed visually by observing the shape, the size, the colour and general cleanness of the produce including absence of insects. Other parameters of quality include moisture content, taste, odour and firmness.* Moldy grains have repulsive odor, the same goes for other harvested farm produce. Many will not go for over-ripped plantain, banana, mango, pawpaw, cucumber and other fruits all because of reduction in quality. We shall discuss this in detail as we proceed.

3.3 Nutritional Losses

These are reduction in the nutritional values of harvested produce. We eat food whether cereals, pulses, fruits, vegetables etc. not just to fill our stomach but to derive nourishment for our bodies. Grains have in them food reserves made up of proteins and other nutrient. When rodents and insects attack such produce their targets are these portions of the grains. You would have noticed that many times when either rodents or insects attack a cowpea or maize store they often eat what we can refer to as the heart of seed and not the whole grain. Such eventually lead to reduction in nutrition quality even if such are fed to poultry, because some vital nutrients would have been consumed by the pests. Respiration which is a major characteristic of harvested produce leads to break down of the food and nutritive value of harvested produce.

3.4 Economic Losses

Qualitative, quantitative and nutritional losses eventually lead to reduction in economic value of a farm produce. The farmer's income is thus reduced on one hand and there is also reduction in the amount of food available to the masses and national economic loss on the other hand. Apart from economic losses that can result directly from pests damage there are other form of economic loss due to factors like market glut, poor road network, inadequate storage conditions. When more produce are taken to the market than are demanded the result is glut and of course when such produce are not purchased for consumption, loss is inevitable. You can better understand this when you visit a popular orange or tomato market at the peak of the season for such crop. You often see a huge heap of spoilt produce this is an example of economic loss.

3.5 Viability Losses

Seeds are stored with the primary aim of using such as planting material in the following cropping season. Activities of insect pests may destroy the embryo and render the seeds unfit for planting. At other times, high temperature, inadequate storage moisture and relative humidity as well as poor ventilation may induce reactions or activity that lead to loss of the viability of stored seed. This is also a post-harvest loss.

SELF-ASSESSMENT EXERCISE

In a tabular form classify the following into different types of post-harvest losses or losses that can result: Holes made by insects on grains, rodent attack in a yam barn, shrinkage of tomato due to moisture loss, shrinkage of tomato due to excessive respiration, failure of stored seed to germinate. Hint: Some of these may fall under two or more types of losses.

4.0 CONCLUSION

While you were familiar with some of the post-harvest losses discussed in this unit, it is important to ponder upon those you have not really considered until now, then you would have increased in knowledge. Several factors are responsible for various forms of losses ensure you remember them.

5.0 SUMMARY

Post-harvest losses occur in various forms: quantitative, qualitative, nutritional, and economic and viability losses. One form of loss can lead to some other.

6.0 TUTOR-MARKED ASSIGNMENT

1. Mention five types of post-harvest losses
2. Using a named fruit , vegetable or seeds explain the inter relationship between three types of post-harvest losses

7.0 REFERENCE/FURTHER READING

Klaya, V. (2014). Post harvest losses and strategies to reduce them www.actioncontrelafaim.org/sites/default/.../technical_paper_phl__.pdf

UNIT 3 CAUSES OF POST-HARVEST LOSSES

CONTENTS

1.0 INTRODUCTION

We have discussed the various forms of post-harvest losses and it is obvious that such losses are undesirable especially in the developing countries where production technology has not produced the amount of food needed to feed the populace. It is therefore pertinent, I mean very crucial to understand the causes of the losses identified in order to prevent or reduce such as much as possible. Thus in this unit we shall be studying the causes of various post-harvest losses that we discussed in the last unit.

2.0 OBJECTIVE

At the end of this unit, you should be able to:
identify some of the causes of post-harvest losses.

3.0 MAIN CONTENT

3.1 Injury

Injury sustained by produce especially mechanical injury at harvest is one of the causes of post-harvest losses. **Mechanical injury** occurs when tools used for harvest pierce or cut part of the produce, exposing the produce to higher moisture loss and infestation with disease. Mechanical injury can also occur as a result of crude methods of harvesting. Sometimes long poles

are used to pluck off fruits from a tall tree while allowing the fruit to fall freely on the ground causing both external and internal injury which could kick start other forms of losses. Similarly, shaking-off fruits off a tree when many fruits are harvested will also result in mechanical injury.

3.2 Chilling Injury

Chilling injury is a disorder that occurs in especially tropical fruits and vegetables when they are stored in cold storage at temperature above the freezing point most times between 10^0C -15^0C. You know that water freezes at 0^0C, but for these produce injury or damage occur before the freezing point. This is quite interesting and important and should be of interest to you because you would have been aware that one of the ways of preserving fruits and vegetables is to store them in the refrigerators, it is therefore necessary to know how cold should the temperature in the cold store be for safe keeping of your produce. Produce are kept in cold storage primarily to reduce the rate of their metabolic activities and slow down ripening and extend their shelf life. In other words like we have mentioned severally these food items are alive even though they have been detached from the parent plant. For produce that are injured at the chilling temperature, the tissues become weak because they are not able to carry out their normal functions. The seriousness of chilling injury a produce can sustain depends on how low the temperature is and how long the produce is exposed to the low temperature.

How you will recognise that a produce has been injured: Some of the symptoms of chilling injury include surface lesions, the colour inside the produce would be different from normal, the tissues becomes water soaked and the produce will fail to ripe as it should. These signs are usually noticed after the produce are removed from the cold store and expose to a warm environment. Produce injured by chilling temperature are equally easily attacked by microorganisms.

There is also what is known as **freezing injury;** in this case ice crystals are formed in the tissues of produce when allowed to freeze. Produce that are not susceptible to chilling temperature are affected by freeing injury. You then be sure that produce affected by chilling injury are also much more affected by freezing injury. I remember sometimes ago that someone purchased some fresh tomatoes and kept them in a deep freezer. The frozen tomatoes look so healthy until they were brought out and allowed to warm up by the surrounding air. Guess what? The tomatoes have completely lose form and could only be good for tomato paste and even at that you will need to convince yourself that they were still safe for consumption. That

was even fair enough; of recent some cucumber were also kept on some other stuff in a freezer. This time when brought out the tissues also completely collapsed and was only fit to be used as organic manure.

Injured produce are not usually fit for sale, so you see that this also constitute a post-harvest loss.

3.3 Loss of Water

You are quite familiar with this as it has been discussed under transpiration. Loss of moisture directly reduces the weight of harvested produce and reduces the quality.

3.4 Decay

This occurs as a result of entry of pathogenic microorganisms into the harvested produce or on the surface of the produce. These microbes like bacteria, fungi and viruses can cause different types of diseases in the commodity. The disease causing microorganism could come in contact with the produce before harvest, from the soil that is through tiny holes on the tubers, they could also come in through wounds and bruises during harvest, injury during transportation or in storage if the store or storage materials are not properly disinfected.

3.5 Improper Curing

Curing is done especially in tuber crops to encourage new cells to form to cover up bruises and injuries sustained during harvest, before storage. If this is not properly done, post-harvest losses can be encouraged.

3.6 Sprouting and Rooting

Root and tuber crops are peculiar in their own right. These crops are propagated using the economic portion of the crops, e.g. yam and potatoes. Yam and potatoes undergo a period of dormancy after harvest. During this period once the general principles of safe storage is maintained the produce are kept intact. After the period of dormancy is expired, these produce begin to sprout and produce new shoot. This new shoot will make use of the carbohydrate and water stored in the tubers for its growth and by so doing leading to both moisture loss and food loss. Loss of moisture also paves way to entry of disease causing organisms into the produce.

You must note here that sprouting and rooting are not the only or major cause of pathogenic attack of tubers and root crops as we have mentioned above.
How long a tuber crop will remain dormant is therefore affected by whether it is wounded or not or the degree of injury, the temperature in the store house (high temperature favour high respiration); the moisture content in the store, the air flow i.e. the ventilation of the store and the carbon (IV) oxide in the store.

SELF-ASSESSMENT EXERCISE

i. What is mechanical injury?
ii. Distinguish between chilling injury and freezing injury

4.0 CONCLUSION

Post-harvest losses have their root causes in injury, chilling injury, water loss, decay, sprouting and improper curing. It is therefore obvious that avoidance or reducing occurrence of these conditions is not beyond what you can handle.

5.0 SUMMARY

In this unit you learnt the causes of the losses identified in order to prevent or reduce such as much as possible

6.0 TUTOR-MARKED ASSIGNMENT

What are the causes of post-harvest losses?

7.0 REFERENCES/FURTHER READING

Chilling and freezing injury. www.ba.ars.usda.gov/hb66/chilling.pdf

Wang, C.Y. (1982). Physiological and biochemical responses of plants to chilling stress. HortScience 17:173-186.

Wang, C.Y. (1993). Approaches to reduce chilling injury of fruits and vegetables. Hort. Rev. 15:63-95.

UNIT 4 PREVENTION OF POST-HARVEST LOSSES

CONTENTS

1.0 INTRODUCTION

We had identified avenue through which harvested produce are reduced in physical, nutritional and economic value. In this sub-section we shall be considering things to be done or efforts to be put in place to reduce or prevent these losses.Preventing post-harvest losses can be as simple as not doing or avoiding things that will cause deterioration and losses as we have discussed above.

2.0 OBJECTIVES

At the end of this unit, you shouldbe able to:

- prepare adequately for proper harvest of fruits and vegetable
- take precautionary measures during harvest and while handling harvested produce to reduce post-harvest losses

3.0 MAIN CONTENT

3.1 Harvesting Operations and Field Handling

Maintenance of fruits and vegetables in the best quality from the point of harvest to time of consumption is one of the main objectives in studying post-harvest physiology. The first step towards achieving this is proper harvesting and field handling.

The farmer should aim to harvest a good quality produce in good condition; keep the harvested produce in good condition until it is sold or consumed and hand over the farm produce to a buyer or dispose it in the market as soon as possible. This aspect is foundational and we shall spend more time

to discuss. The importance of this is seen in the fact that the quality of a produce cannot be improved beyond what is brought into the store. The following points must therefore be noted:

* Care must be taken at the time of harvest to **prevent bruises and injuries**, this is of utmost importance.

  A successful harvest must be preceded by **careful planning.**The plan should include:
  - Provision of appropriate and adequate supervision at all stages of harvesting and handling
  - Crop selection and timing to meet expected market requirements;
  - Appropriate contacts with buyers in order to get a good selling price at harvest
  - Adequate provision for sufficient labour, appropriate equipment and adequate means of transportation.

When appropriate plan has been put in place ask the following questions:

When is it appropriate to harvest?

* Harvesting should be done in the coolest part of the day; very early in the morning or late in the afternoon. This is advisable in order to keep the harvested produce as cool as possible. The harvested produce should be conveyed immediately to the market or be put under a shade prior to the time it will be transported. Produce left exposed to direct sunlight will get very hot and will deteriorate very fast. We shall discuss more on this as we progress in this course.

  If harvesting is done in the hot sun the difference between the harvest temperature and the optimum storage temperature will be high and the pre cooling energy cost will be high, deterioration will also be faster under high temperature.

* Another precaution to take here is that produce should not be harvested when it is wet from dew or rain. Overheating occur in wet produce if not well ventilated, this will also pave way for multiplication of microorganisms which will eventually lead to decay.

* The market condition is also an important factor to be considered. For example for tubers like cassava, farmers would have concluded with the buyers before uplifting the root tubers from the soil. This is

because the tubers deteriorate very fast and their uses may be limited if unprocessed immediately. Produce for local markets can be harvested early in the morning. For more distant markets it may be an advantage-if suitable transport can be arranged-to harvest in the late afternoon and transport to market at night or early the next morning. This is also commonly practiced by farmers not only to meet the quality desired by the buyers but also to get to the market as early as possible and disposed of their produce in good time and in good shape.

What time or stage should I harvest what?

This is another important question to be asked and answered in order to prevent post-harvest losses. Fruits like banana, plantain and guava should be harvested when mature but unripe otherwise they will deteriorate fast and decay before they are taken to their final destination especially if they are meant for a distant market. When produce are harvested immature, they shrink and this will lead to a loss. Fruits like citrus must also be harvested mature otherwise they will not ripe further and they will become sour when tasted. We shall discuss more on this as we proceed in the course.

How should I harvest?

Harvesting is commonly done manually by hand in Nigeria and most part of the developing countries. Even though manual harvesting is the general practice there could be some variation in the actual operation depending of what type of produce is harvested.

Tubers and root crops require lifting from the soil. Examples are sweet potato, carrot, Irish potato, yam, cassava and so on. Mechanical injury from the tools used for harvest can be minimized by planting of such crops on beds, mounds or ridges.

Vegetable crops are those whose economic parts are vegetative. Such might be harvested by uprooting of the plant or by cutting from time to time using a very sharp and clean knife. Examples include telfairia, amaranth, celosia, cochorus and so on.

For vegetables like cabbage and lettuce the above-ground parts of the plant from the main stem is cut and trimmed in the field avoid placing the cut stem on the soil.

In the case of bulbs which include immature green onions, leeks, mature bulb onions and garlic; harvesting is by hand-pulling of

immature green onions; leeks, garlic and mature bulb onions are loosened by using a digging fork.

Fruits

A fruit can be defined as a structure in plants that is formed after successful pollination and fertilisation of the flower; after this process the fertilised ovule developed into a seed while the ovary covering the seed developed into a fruit. In other words a fruit is the seed bearing structure of flowering plants which is formed from the ovary after pollination and fertilisation. There are different kinds of fruits: simple, aggregate, multiple and accessory fruits. You can read more about this; I guess you must have treated this topic in your biology classes and related courses like botany.

Fruits and vegetables feature prominently in human's balanced diet. They supply man with vitamins and minerals needed for a healthy living; some provide us with roughages for proper digestion and make our digestive system to be in good condition. Vegetables are also necessary for our blood formation, hence the circulatory system. For instance the structure of chlorophyll is has something in common with that of hemoglobin in red blood cells.

Many ripe fruits and some immature seed-bearing structures such as legume pods have a natural break-point of the fruit stalk, which can easily be broken at harvest. Harvesting immature or unripe fruit and other seed-bearing structures is best done by cutting them from the plant, using clippers, secateurs or sharp knives.

Plucking methods vary according to the kind of produce being harvested:

- Ripe fruits with a natural break-point, which leaves the stalk attached to the fruit, are best removed by a "lift, twist and pull" series of movements, e.g. apple, passion fruit, tomato
- Mature green or ripe fruits with woody stalks which break at the junction of the fruit and the stalk are best clipped from the tree, leaving up to a centimeter of fruit stalk attached. If the stems are broken off at the fruit itself. disease may enter the stem scar and give rise to stem end rot, e.g. mango, citrus, avocado
- Immature fruits with fleshy stems can be cut with a sharp knife, e.g. okra, papaya, capsicum; these can also be harvested by breaking the stem by hand, but this method may damage the plant or fruit and the rough break will be more susceptible to decay than would a clean cut.

What do I require and what capacity do I have?

Labour is an essential part of successful harvesting and quality maintenance. Labourers must be well informed about the fact that harvested produce are prone to mechanical injury and must be taught to exercise caution. Mechanical injury may result from sharp finger nails, exposed nails in containers, throwing of fruits into a container from a distance, rough edges of containers, crude method of harvesting such vigorous shaking-off of fruits from trees, allowing free fall of fruits at harvest without using a harvesting bag, overstocking of container meant for stacking.

Apart from avoidance of mechanical injury, all storage containers should be thoroughly cleaned to remove any particles or left over of previous harvest; such residues will provide medium for growth of microorganisms that can eventually lead to spoilage of the fresh fruit if not removed. The containers should also be well dried. Harvested fruits should also not be allowed to make contact with wet soil as microorganisms can also be contacted through that. Caution must also be exercised to avoid contact with all un-authorized chemicals that are not directly involved in the storage procedure.

At all stages of harvesting and handling, methods should aim at avoiding damage to produce and providing ventilation to prevent temperature rises.

3.2 Other Precautions that Will PreventPost-harvestLosses

Once all necessary precautions have been put in place at harvest and in handling of harvested produce, other general measures to be put in place include storing of harvested produce at the right temperature to prevent both chilling and freezing injuries. Rate of loss of water from the produce should also be reduced by not exposing the produce to direct heat of the sun, keep the harvested produce under shade and allow only gentle and not fast blowing air into the produce. Avoid activities that will bring the produce in contact with disease causing organisms. Store produce in proper condition to prevent sprouting and rooting. The produced to be stored like tubers, root crops and onion should be properly cured to seal up injury incurred during harvesting.

SELF-ASSESSMENT EXERCISE

Highlight two reasons why shaking off fruits from the tree is a bad method of harvesting.
Do you think harvesting of fruits immediately after a rainfall is ideal? Give reasons for your answer.

A fruit merchant wanted to buy a truck load of fruits from an orchard at about 1pm on a sunny day, would you advise the farmer to go ahead and quickly pluck off the fruits for the merchant? Give reason(s) for your answers.

4.0 CONCLUSION

Quality of harvested produce cannot be improved beyond what they are at the time they are brought into the store, hence injuries, bruises, exposure to direct heat, direct contact with the soil and abnormal storage conditions should be avoided.

5.0 SUMMARY

Prevention of post-harvest losses begins with proper time and methods of harvesting as well as proper handling of harvested produce; and disposing off harvested produce as soon as possible by making good contact with buyers before harvest. Keeping of harvested produce in right container, avoidance of injury and bruises at time of harvest and transportation, keeping harvested produce away from direct heat of the sun, storage under the right temperature, humidity and proper curing of produce before storage all help in preventing post-harvest losses.

6.0 TUTOR-MARKED ASSIGNMENT

What are the necessary precautionary measures during harvest?

7.0 REFERENCE/FURTHER READING

Prevention of post-harvest food losses fruits, vegetables and root crops www.fao.org/docrep/t0073e/t0073e00.htm

MODULE 2 EFFECT OF ENVIRONMENT ON MATURITY, RIPENING AND SENESCENCE

Unit 1 Maturity, Ripeness and Senescence
Unit 2 Environmental Factors Affecting Maturity, Ripening and Senescence
Unit 3 Uniqueness of Tropical Environment

UNIT1 MATURITY, RIPENESS AND SENESCENCE

CONTENTS

1.0 INTRODUCTION

In this unit we shall take time to explain what maturity, ripening and senescence of farm produce mean before we proceed to discuss how the environment affect them in the next unit.

2.0 OBJECTIVES

At the end of this unit, you shouldbe able to:

- distinguish between different farm produce especially with regard to their maturity
- harvest different farm produce at the proper time for proper ripening and reduction of post-harvest losses.

3.0 MAIN CONTENT

3.1 Maturity

With respect to post harvest physiology should be well clarified:
Maturation is said to be a stage of development leading to physiological and horticultural maturity.

Physiological maturity: A fruit for example is said to be physiologically mature when it is at a stage of development where it will continue development even when detached from the mother plant. A fruit is said to be physiologically mature when it has attained its maximum size and this takes place before the fruit is detach from the mother plant at harvest. I am sure you are quite aware that a fruit starts small and continues to increase in size. The size increases as the growing fruit obtain and stores up water, carbohydrate, protein and other substances.

Horticultural maturity on the other hand refers to a stage of development when a plant part possesses the required characteristics for use by consumers.
Many fruits that are transported and stored for sometime before consumption are harvested when they have attained physiological maturity; such fruits attain horticultural maturity during handling and storage processes. Produce that have not attain physiological maturity shrink and are rendered unusable. You must however note that many vegetables are harvested immature, that is they are acceptable to consumers (have attained horticultural maturity) at a stage when they are physiologically immature. Think of okra, green peas etc

3.2 What is Ripeness?

Ripening describes a period or a phase or a transition between physiological maturity and senescence or death. When the fruit is detached at harvest the fruit at this stage is still alive as it contains living tissues. One major function that continues at this phase of the life of the fruit is respiration. I am sure you still remember what respiration is and its function. It is a process where complex molecules are oxidized, that is combined with oxygen to release energy, carbon dioxide and water. Since the fruit has been detached it depends on the substances stored before harvest for respiration and to obtain the energy required during ripening. As ripening progresses more and more food reserve is consumed until it is used up leading to death and rottenness you are certainly familiar with some changes that take place as the fruit ripens. These include:

a)changing of the skin colour from green to yellow, orange, red etc.
b)the fruit also becomes softer
c)sweeter as carbohydrates are broken down to simple sugars, you are aware that ripe plantain is sweeter and softer than unripe plantain. and
d) flavour/aroma develops as the fruit ripens.

One gas that is given off by ripening fruit is **ETHYLENE.** You can easily get this; when you leave an over ripe orange in a box of oranges everything will soon become ripe, also putting ripe plantain in a box of plantain makes all to ripe fast due to release of ethylene by the ripe fruit. It therefore follows that restricting exposure of fruits to ethylene will extend the shelf life.

Climacteric and non-climacteric fruits
Based on the rate of respiration, harvested fruits have been classified as climacteric and non-climacteric fruits. Climacteric fruits enter what is known as climacteric phase after harvest that is they continue to ripen. These fruits continue to produce more and more ethylene and also have increased respiration rate. Examples include guava, mango, banana, plantain, pawpaw, pear, water melon, tomato, breadfruit, passion fruit and apple. Non climacteric fruits on the other hand once harvested do not ripen further; they produce small amounts of ethylene. Examples include orange, grape fruit, lime, lemon, cacao, cucumber, eggplant.

3.3 Explaining Senescence

Senescence has been defined as the final phase in **ontogeny** of the organ in which a series of normally irreversible event is initiated that leads to cellular breakdown and death of organs. According to www.encyclopedia.com. it refers to all the changes that take place in a plant that will finally lead to death of cells, tissues and eventually the whole plant body. For example the green pigment chlorophyll is removed and other pigments like yellow carotenes and red anthocyanin replace such.

SELF-ASSESSMENT EXERCISE

Distinguish between horticultural maturity and physiological maturity. Give two examples of produce that attain horticultural maturity before they are physiologically mature.

4.0 CONCLUSION

Agricultural produce differ in their behaviour after harvest, climacteric fruits enter into climacteric phase after they are detached from the parent plant and should be harvested mature but unripe, non-climacteric fruits do not continue to ripe after harvest and must be harvested ripe.

5.0 SUMMARY

Agricultural produce are said to have attained physiological maturity when they can proceed into the next stage of development if harvested or detached from the parent plant at that point, horticultural maturity however is the stage where those qualities that make the harvested produce acceptable to the consumer are developed. Climacteric fruit continue to ripen after harvest, while non-climacteric fruits have very slow rate of respiration after harvest and do not ripen further. This should be considered for proper harvest. Ethylene is one main gas that is emitted by ripening fruit.

6.0 TUTOR-MARKED ASSIGNMENT

What is maturity, ripening and senescence of farm produce?

7.0 REFERENCES/FURTHER READING

Cantwell, M. &Davis, U.C. Maturation and maturity indices.http://postharvest.ucdavis.edu

Kader, A.A. (1999). Fruit maturity, ripening and quality relationships. Proceedings of post harvest factors on storage of fruit. In L. Michadzzuk editor. ActaHort, 485: 203-208

Senescence: www.encyclopedia.com.

UNIT 2 ENVIRONMENTAL FACTORS AFFECTING MATURITY, RIPENING AND SENESCENCE

CONTENTS

1.0 INTRODUCTION

In this unit you will learn about factors that affect maturity, ripening and senescence.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- identify and control some environmental factors in order to favour or retard maturity and ripening
- identify and control some environmental factors in order to retard senescence

3.0 MAIN CONTENT

3.1 Factors Affecting Maturity

Maturity of most agricultural produce is controlled by the genetic makeup of the crop and some environmental factors. The genetic factor is an innate quality which is only modified by the environment. For example a variety

of a crop may mature in 60 days another variety of the same crop may mature in 75 days, while another one in 90 days given all necessary environmental conditions. However the maturity date might be delayed by some environmental parameters. Some of these environmental factors are soil nutrient availability, availability of water and drought and sunshine hours.

3.1.1 Nutrient Availability

Plants require nutrient for growth and development. Adequate nutrient availability encourages plants to grow well, flower and produce fruit which mature at the right time. On the other hand lack of adequate nutrients will retard growth, development and maturity of fruits or harvestable organ. You can mediate here by ensuring that you know and supply the right amount of nutrient required for proper growth of the crop you are handling, follow the prescribed fertiliser recommendation. If you are using organic fertilisers you ensure this is also applied at the appropriate time.

3.1.2 Water Availability and Drought

Plants take up nutrient in solution; this implies that even when adequate nutrient is present in the soil,there must be enough moisture to dissolve the nutrients before plants can take up such nutrients. During drought soil nutrients are not available to plants and this will delay maturity, you mediate here by planting at the correct time if you want to depend solely on rains or you do supplementary irrigation.

3.1.3 Sunshine Hours

Plants vary in their response to day length. Many plants are day neutral that is to say they grow normally, flower and produce fruits no matter whether the day is short or long, whether we have more or fewer hours of day light, others are long day plants and the last category are the short day plants. For those that are day sensitive the plant will only flower when the appropriate hours of light and darkness is provided. You must know the requirement of the crop you are handling and grow them at the appropriate time when adequate growth environment are provided.

3.2 Factors Affecting Ripening and Senescence

Ripening is affected by three major factors; these are physical, physiological and biotic factors.

3.2.1 Physical Factors

Refer to issues that have to do with the body of the harvested produce. One important factor here is **the ratio of the surface to volume**. Produce with high surface to volume ratio will ripen faster than those with low surface to volume ratio. What we mean here can be understood when you compare the surface area of say vegetable amaranth to its volume. You will realise that the surface area is quite large compare to the volume. This means that rate of loss of moisture will be high leading to wilting and senescence. It has been reported that increased rate of ripening is associated with increased moisture loss. Smaller fruits also have larger surface area to volume ratio and lose more water than bigger ones.

Another physical parameter has to do with **mechanical damage**. Injury inflicted during harvest through the use of crude method of harvest, like shaking-off fruits from the tree, injury from harvesting tools could also hasten ripening. Openings created on the produce make more moisture to be lost; fruit damage also generates ethylene production and hastens ripening.

Peel thickness is another physical attribute that can increase the rate of ripening or otherwise; the thicker the peel, the lower the rate of moisture loss and the slower the rate of ripening; and vice versa. In other words, thin skin loses more water. The implication of this is that if the consumer does not so much discriminate against some varieties of produce, you can decide to choose between those with thin skin or thicker ones depending on whether you desire early ripening or delay ripening as a producer or marketer.

3.2.2 Physiological factors

The physiological parameter is made up of the level of maturity of the fruit as well as some environmental factors which affect metabolic activities in the produce.

You will easily understand that the level of maturity of the produce at harvest will determine how soon it will ripe and how early it will be from harvest to senescence. It has been reported that for the same variety of banana, ripening took 11, 15 or 22 days when it was harvested 100, 90 or 80 days after flowering respectively. It must however be emphasised that too early harvest will lead to yield reduction since the plantain or banana would not have been fully filled.

3.2.3 Environmental Factors

Now let us discuss some environmental parameters that affect ripening and of course senescence. Can you make a guess? Yes, temperature, relative humidity, sunlight and altitude are very important.

Temperature

The storage temperature is very important and together with the relative humidity goes a long way to determine ripeness and senescence. When temperature increases the shelf life of a produce decreases because increase temperature increases metabolic activities especially rate of respiration of stored produce; as the rate of respiration increases, produce ripens faster and deteriorates faster. It has been shown that rate of respiration doubles for every 10^0C rise in temperature over the range of 5^0C to 25^0C. It has also been reported that ripe fruits respire as much as four times the rate at which unripe fruits respire.

Relative humidity

This refers to the amount of water vapour present in the atmosphere and it usually expressed in percentage. In other words the amount of water vapour in the atmosphere relative to the amount of water vapour the air can hold multiplied by 100 gives you the relative humidity. This environmental attribute also affect ripening and senescence. You remember that the harvested produce contain water and like we said earlier, faster rate of water from harvested produce hastens ripening and deterioration. Another important point here is that when a produce is brought into an atmosphere (say a store) with high amount of moisture compare with the produce, the produce will take in more moisture, while in another environment with low relative humidity compared with the moisture content in the fruit the fruit or vegetable tend to lose moisture. It has been observed that at saturation or near saturation when the relative humidity is 95% to 100% fruits rarely loses moisture and ripening period is unaffected, this is important because you know that faster rate of ripening and senescence is what we try to prevent in the study of post-harvest physiology. Excess amount of moisture in the storage environment could also be damaging to the stored produce. The important point to note here is that the right relative humidity must be maintained.

Sunlight

This is also an environmental condition that affects ripening. When produce are exposed to direct heat from the sun, the temperature of such produce rises above the temperature in the atmosphere, this leads to increase rate of respiration and causes ripening to occur faster. The extent

to which the sunlight causes this is dependent on the intensity of the sun that is how hot, it also depend on how long the produce is exposed to direct heating of the sun, the season of the year which of course determines the quality of sunlight also affects this as well as cloud cover. You will agree with me that in Nigeria, the intensity of radiation is very high in the dry season shortly before the rains begin. Also during the rainy season, days with high cloud cover have low sunlight intensity. The lesson you must learn here is that you do not expose harvested produce to direct heat of the sun. When displayed for sale ensure you keep them under a shade with thatched roof for example this is better than storing under a roof made of plastic or polythene which can absorb more heat and transmit same to the produce. Yes I think I should share this also with you to drive home the point. I had long ago learnt not to put my banana on the dash board while travelling in a commercial bus, because from experience I had realised that banana bought fresh and attractive at a point, would have severely deteriorated about two hours later because the direct heat of the sun that is transmitted from the wind shield to the fruit. This also depends on the time of the day when you are journeying and may not occur if you are travelling in the rains. The effect of exposure to sunlight on ripening is however exploited locally; barely 24 hours ago I peeped through the window of my apartment and observed some unripe plantain spread out in the sun to hasten ripening. Now you know the scientific basis increased temperature leads to increased rate of respiration and ripening.

Altitude

The altitude of a location refers to the height of that location relative to the sea level. You must have been familiar with the saying "the higher you go the cooler it becomes." You must have encountered this in geography, can you remember the "lapse rate?" The air temperature decreases as the altitude increases, for every 100 m rise in altitude, the air temperature decreases by 0.5^0C. Therefore fruits and vegetables have longer shelf life in higher altitude if all other rules are kept compared to those stored in lower altitude.

SELF-ASSESSMENT EXERCISE

For proper post-harvest handling, early harvest of plantain and banana is desirable once physiological maturity is attained- True or False?
What if the harvest is too early what will be the effect?

4.0 CONCLUSION

In this unit various environmental factor affecting maturity, ripening and senescence have been discussed. Some of these environmental factors can be controlled, while careful planning of farm activities could help in overcoming some of these constraints.

5.0 SUMMARY

In this unit you have learnt that various physical, physiological and environmental factors affect maturity, ripening and senescence. Choice of the right variety, avoidance of mechanical injury, choice of proper size of material for storage, harvesting at the right time, good cultural practices, and keeping of harvested produce from direct sunlight will all help reduce negative environmental impact on harvested produce.

6.0 TUTOR-MARKED ASSIGNMENT

Locally people sometimes place plantain out in the sun for quick ripening, why do you think that they will achieve their objective?

7.0 REFERENCE/FURTHER READING

Cantwell, M. &Davis, U.C. Maturation and maturity indices.http://postharvest.ucdavis.edu

UNIT 3 UNIQUENESS OF TROPICAL ENVIRONMENT

CONTENTS

1.0 INTRODUCTION

Temperature and relative humidity have been identified as two environmental parameters that are important in storage of harvested produce. High temperature and high relative humidity increased the rate of deterioration. In this unit we shall be discussing how these two attributes make storage in the tropics to be more challenging,

2.0 OBJECTIVE

At the end of this unit, you shouldbe able to:
explain why deterioration could be very fast in the tropical environment.

3.0 MAIN CONTENT

3.1 Temperature and Humidity in the Tropics

The tropical environment is such a unique one in that both the temperatures as well as the relative humidity are always high. In other words tropical climate is hot and wet for most part of the year. This often shortens the shelf life of most produce. High temperature increases rate of respiration in harvested produce leading to faster rate of tissue break down. High relative humidity on the other hand favors multiplication of pathogenic organisms which could further reduce the shelf life of the produce. Rate of chemical reactions increase with rise in temperature and lots of reactions are taking place in harvested produce since they are still alive, enzymes are involved in these reactions and they are affected by changes in temperature.

SELF-ASSESSMENT EXERCISE

Do you think the tropical environment is better than the temperate environment when we want to reduce the rate of ripening? Give reason(s) for your answer.

4.0 CONCLUSION

Tropical environment is unique for having factors that will naturally increase ripening and reduce the shelf life of farm produce proper handling of produce is very important to reduce post-harvest losses in Nigeria being a tropical environment.

5.0 SUMMARY

The tropical environment is unique in the sense that it has high temperature and high relative humidity; both which favor increase rate of respiration, multiplication of pathogenic organisms, faster rate of ripening and senescence. Post-harvest intervention must therefore be very decisive to prolong shelf life of harvested produce.

6.0 TUTOR-MARKED ASSIGNMENT

Why is deterioration very fast in the tropical environment?

7.0 REFERENCES/FURTHER READING

Cantwell, M. & Davis, U.C. Maturation and maturity indices.http://postharvest.ucdavis.edu

MODULE 3 PHYSICAL AND CHEMICAL INDICES OF QUALITY

UNIT 1 PHYSICAL AND CHEMICAL INDICES OF QUALITY IN FRUITS, VEGETABLES AND FLOWERS

CONTENTS

1.0 INTRODUCTION

Quality characteristics in fruits, vegetables and other produce are those attributes that make buyers or users want to buy them. These attributes may be physical that is they can be seen or observed or by the fingers, others attributes are chemical and cannot be seen with the eyes or felt between the fingers.

When you want to buy fruits like mango, tomato, guava, pawpaw, banana, plantain (for immediate consumption), apple and vegetables, what do you often look out for in them? I am sure the attractiveness is a factor, sometimes it is the size; at other times may be the bright red color of tomato, or the firmness. Now what about vegetable amaranth, telfairia and cochorus? You will prefer the green and fresh looking ones I guess. Good. These and other attributes we shall be discussing in this section.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- differentiate between the physical and chemical indices of quality in harvested produce.
- handle these produce to bring out and preserve some of the desired qualities

3.0 MAIN CONTENT

3.1 Physical Indices of Quality in Fruits, Vegetables and Flowers

In fruits and vegetables, the physical or external attributes are: size, shape, colour, texture compactness, uniformity, absence of defects, freshness and ripeness, gloss, firmness, flavor and juiciness.

Size I am sure that before you purchase certain produce, you have your mind fixed on acceptable average size below which you will not go for such produce, yes that is what we are talking about. For example large sized citrus are preferred to smaller ones, same goes for tomato, guava and others. Fruits are not only purchased by immediate consumers some are purchased by food manufacturer for his industry, whosoever is doing the purchase, size is often a major physical attribute considered and while producing you must have that behind your mind.

For most fruits and vegetables intermediate or average size is preferred. In vegetables like okra, the size of the fruit indicates the quality; that is whether it was harvested late or at the right time. Big fruits are often avoided as they would have become fibrous and such are rejected by consumers. You can make the size of produce uniform by proper sorting.

Shape of the fruit is also a factor; sure you will turn down an orange fruit with oblong shape, since naturally oranges are known to be roundish. Thus you will not want to do a thing that will negatively affect the shape of the produce intended for marketing; say packaging in a tight container. The natural shape of harvested produce can be maintained by proper packaging using the ideal packaging material as well as not over stocking the container.

ColourAnother physical attribute that is considered buy buyer is the colour. Fruits come in different colours like red (e.g. some apple, tomato, and cashew), others are yellow examples pawpaw, some oranges, plantain, and some have golden yellow colour. Whatever the case may be, the consumer or buyer have an idea of what the acceptable colour is and he goes for produce that meet his expectations. You must remember here that colour may also vary from variety to variety of the same fruit, in that case the market demand or the target market must be considered and the consumer preference while producing or sending a commodity to the market. Colour is also an important attribute in vegetables. For example in leafy vegetables like telfairia, amaranth and cochorus greenness is very important as compared to yellowness, cucumber is also valued green as yellowness indicates over mature for consumption in other words it has gone past horticultural maturity, I am sure you still remember that. The desired colour can be achieved by timely harvesting and handling as well as choosing the desired variety.

Texture of a fruit describes how the fruit feels when examined by the fingers, the hand or the mouth. It describes how soft, hard, tough, crispy, or meaty. Other attributes associated with texture include smoothness, hairiness or dryness.

CompactnessThis attribute is very important to the consumer when evaluating the quality of flowers and vegetables that form heads like cabbage, lettuce or cauliflower. Loose head could be interpreted by consumer to mean that the commodity was harvested prematurely. Also it is used to evaluate freshness. Dehydration resulting from loss of moisture during display for sale will make the heads to be loose and to the consumer that shows that the commodity has been harvested for long and not really fresh. Dehydration or moisture loss must be controlled to make the produce as compact as possible.

Uniformity The importance of uniformity as a quality parameter cannot be over emphasised. Consumers generally preferred evenly ripped fruit with uniform colour, uniform size, and uniform compactness and so on. This is important whether you are purchasing tomatoes, potatoes, oranges, carrots etc. Buyers repose more confident in the marketer if he observes uniformity in the produce displayed for sale. Proper sorting and grading will ensure uniformity of produce and increase consumer appeal.

Gloss This refers to surface shine of the harvested produce. Can you imagine a shining reddish tomato displayed under a shade in contrast to a dull looking unripe one, I am sure you are beginning to imagine having

some slices of the brightly shining one in your salad if you love that. That underscores the importance of this attribute. Glossiness is also related to freshness.

JuicinessThis refers to the attribute of having a lot of juice. I remember buying oranges that scarcely produced any juice and how discouraging it was. You can be sure that if a consumer samples your oranges and tangerine and the tissues found as hard as if eating a slice of yam, he wouldn't need any preaching to move away from you.

Flavour: The flavour of fruits is produce by aromatic compounds in them. This has to do with the taste. Have you had an experience when in order to persuade you to buy a fruit like citrus the merchant offered a knife and agreed to give you a sample to taste at no cost? This is because a commodity might be very attractive but the desired flavour is not guaranteed. Flavour is a combination of taste and aroma implying that both the tongue and the nose assess this quality.

3.2 Chemical Attributes in Fruits

Unlike physical attributes chemical attributes determining quality in fruit cannot be seen by the eyes or felt between the fingers or the taste bud. The chemical attributes refers to the nutritional qualities of the produce. Specialised instruments will have to be used mostly to evaluate these attributes. These attributes are also affected by the variety of fruit as well as the degree of ripeness.

The chemical quality attributes include the N-containing compounds which are about 0.1% to 1.5% and about 35% -75% of these is proteins.

Carbohydrate is a major chemical index and this include glucose, fructose, arabinose and xylose, some fruits have maltose. All fruits contain cellulose, hemicelluloses and pectin. Starch is present mainly in unripe fruits and it decreases to a negligible level as the fruit ripens in majority of the fruits. The pectin content is also affected by ripening. You must understand here that chemical quality indices are very important in the industrialized world especially when the fruits are purchased as raw materials for industries. Also a producer who aims at exporting his produce must also strive to meet the required standard.

3.3 Safety Factor

Just like for any other food items, eating of fruits and vegetables should not pose a health hazard to the consumer. Safety issue is more pertinent in fruits and vegetables since most are eaten raw and at best after peeling or slight cooking. It is therefore very important not to betray the trust repose on individuals involved in the production and handling chain before it gets to the consumer. Food safety has been defined as the absence of dangerous substances in fruit and vegetables, that is substances that can negatively affect health must be absent in the fruit and vegetables displayed for purchase and consumption. Harmful substances could get into the produce during any stage of the production and handling. Can you think of anything in this line? Let us quickly consider the stages involved from production (pre-harvest) to post harvest and the likely health related issues:

Site selection Soils with high concentration of heavy metals and other pollutants will produce fruits and vegetables contaminated with such.

Use of agrochemicalsAgrochemicals like herbicides, fertilisers, insecticides, fungicides, fumigants, disinfectants if not well handled and if not used in the right rate, time as well as for the right operation could eventually find their way as residues into the harvested produce and be a great threat to the health of the consumer.

Irrigation waterThis could contain some microorganisms that are harmful to man especially in the developing countries where the sanctity of rivers and other bodies of water is not maintained. The water could be messed up by contaminated feces and urine upstream and be used as irrigation as well as for washing of vegetables and fruits downstream.

During harvest Contact with contaminated soil during harvest could also introduce pathogenic organism into the commodity.

The golden rule here is that care should be taken at all stages of production, harvesting, and down the distribution chain to avoid activities that could contaminate fruits and vegetables.

Since safety factor cannot be compromised as a man should not be seen to be “digging his grave” with his cutleries; a buyer must as much as possible purchase his produce from a reliable source.

SELF-ASSESSMENT EXERCISE

In a tabular form highlight some quality attributes in fruits, vegetables and flowers that can be positively enhanced by your intervention as well as the likely intervention.

4.0 CONCLUSION

In this unit various quality attributes have been discussed. Timely harvest, proper sorting, use of proper container, avoidance of dehydration are some of the physical intervention that can be put in place to preserve some of these attributes. Safety standard should also be ensured to put safe and acceptable fruits and vegetables in the hand of the consumer.

5.0 SUMMARY

In this unit we have discussed the physical and chemical attributes of fruits and vegetables; we have also considered some safety factors. Proper site selection, choice of the right variety, good cultural practices, timely harvest, choice of right container, proper sorting, and avoidance of excessive dehydration and keeping of produce in the right environment are all issues to be consider in achieving a desirable quality attributes in fruits and vegetables.

6.0 TUTOR=MARKED ASSIGNMENT

What are the physical and chemical indices of quality in fruits, vegetables and flowers?

7.0 REFERENCES/FURTHER READING

Abbott, J.A. (1999). Quality measurement of fruits and vegetables. Postharvest Biology and Technology 15: 207–225

Manual for the preparation and sale of fruit and vegetables: www.fao.org.docrep

UNIT 2 PHYSICAL AND CHEMICAL INDICES OF QUALITY IN SEEDS

CONTENTS

1.0 INTRODUCTION

In the preceding unit we discussed the quality indices of fruits and vegetables. Seeds are different from fruits and vegetables and in this unit we shall briefly discuss quality attributes that pertain to seed.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- keep your seeds safe and viable till the next growing season
- distinguish between a grain and a seed.

3.0 MAIN CONTENT

3.1 Physical and Chemical Quality Attributes of Seeds

Seeds are fertilised ovules formed after successful pollination and fertilisation. Sure you are familiar with that in your elementary biology. In the seed is the embryo, which we can call a miniature plant. In other words the next generation lies right there in the seed. Proper handling of seeds is therefore very important. Seeds are stored with the sole aim of continuity, they are not meant for consumption, grains are meant for that; that is apart from looking clean to the eyes they must be able to germinate and produce a good field of crop when planted. It then follows that you will want to know how best to handle the seeds in order to make them keep for a long time without reducing their viability or ability to germinate. Grains are stored for the primary reason of consumption, in other words extra care

given to seeds to retain their viability might be unnecessary in preservation of grains. This does not rule out the fact that many grains sold in various markets are viable.

Now what attributes do we look for in a seed that we want to plant? There are both physical and chemical attributes that determine the quality of a seed. You should remember here that you are not interested in eating those seeds but to plant them. What a buyer looks for in seeds are:

a. High viability
b. Good vigour
c. Integrity of the seed

High viability simply put means most or all of the seeds germinate and emerge from the soil when sown. You remember that when you are sowing seeds say of maize many times you are told to sow three seeds and later go and thin to two at two weeks after planting. I know you will be wandering why not sow just two seeds? Remember that sometimes out of the three seed sown only one may emerge from the soil. This happens if the seed is low in viability. To ascertain the viability of a seed lot, the viability or germination test is often carried out.

Germination test: You take a sample of the seeds, say 20 seeds. Place the seeds on moist cotton wool, keep it moist for some days threeor fourand later count the number that has germinated. If 20 out of 20 have germinated then your germination percentage is $20/20 \times 100 = 100\%$. If 18 germinated out of 20 you have $18/20 \times 100 = 90\%$.

The vigour of the seed is defined as the ability of the seed to emerge rapidly and completely under a wide range of environmental conditions. It has also been defined as the seed properties that determine potential for fast and uniform emergence and development of seedlings under a wide range of field conditions. Methods used to measure vigor include: Field emergence of seedling, accelerated aging, conductivity, protein, respiration, seedling growth rates, cold test and rapid germination.

You could read up the details of these methods if you so desire to know more.

Seed integrity: this is a quality index that defines how free the seeds lot is from contaminants. For example cowpea with a brown seed coat in all white variety is a contaminant. You must know here that it may not be as straight forward as that, for example the seed coat might be the same but the growth habit or maturity date may vary. The main point to note here is

that as much as possible the seed lot must be kept free of contaminants. Some contaminants that are organic in nature might absorb moisture and attract microscopic substances that can cause the seeds to deteriorate. Broken seeds, feces of rodents etc. must not be found in the seed lot.

SELF-ASSESSMENT EXERCISE

What is the difference between grains and seeds?
Describe how you can carry out a simple viability test for maize seeds.

4.0 CONCLUSION

Seed viability, good vigour and integrity are key quality attributes that must be preserved in seeds. Proper processing, handling and preservation must therefore maintain these attributes.

5.0 SUMMARY

You have learnt that grains are different from seeds, while the primary aim of grain production is for consumption, seeds are produced for propagation; seeds meant for propagation must have high viability and vigour indices as well as high purity; proper processing, handling and storage must therefore be ensured.

6.0 TUTOR-MARKED ASSIGNMENT

1. Differentiate between respiration and transpiration in fruits and vegetables
2. Briefly explain how respiration and transpiration affect fruits and vegetables after harvest.

7.0 REFERENCES/FURTHER READING

Abbott, J.A. (1999). Quality measurement of fruits and vegetables. Postharvest Biology and Technology 15: 207–225

MODULE 4 FUNDAMENTAL OF CROP STORAGE AND TRANSPORTATION

UNIT 1 SEED STORAGE AND FACTORS AFFECTING SHELF LIFE

CONTENTS

1.0 INTRODUCTION

We had discussed the importance of seeds earlier on, and if you can remember, keeping seeds alive and preserving their vigour are some key attributes that must be preserved. In this unit we shall discuss how to safely store seeds and factors that determine how long seeds can be successfully stored.

2.0 OBJECTIVES

At the end of this unit, you shouldbe able to:

- identify both pre storage and post storage factors that determine how long seeds are stored
- adopt best practices that will elongate shelf life of seeds

3.0 MAIN CONTENT

3.1 Storage and Shelf Life in Brief

Storage can be simply defined as the act of keeping or holding something (in this context seed) safe for future use.

Reasons why we store harvested produce:

Amongst several reasons, we store agricultural produce in order to:

1. Ensure all year round availability of especially seasonal produce
2. Reduce loses especially during harvest when supply is beyond demand
3. Reduce scarcity and attendant high market price
4. Get the best price for harvested produce since price always fall when there is glut in the market.
5. Make quality seeds available for future propagation.

Shelf life: This is the length of time that a commodity may be stored without becoming unfit for use, consumption or sale (Wikipedia free encyclopedia) https://en.wikipedia.org/wiki/**Shelf_life**

What are the things that we store? These include seeds, grains, fruits, vegetables, stem tubers and root tubers.

3.2 Factors Affecting Shelf Life

We need to understand the importance of proper storage of seed because not all seeds can easily be purchased, losing some seeds may be very costly, so you must as much as possible curtail activities that will reduce shelf life of seeds.

There are several factors that determine how long seeds can be stored. You surely can mention some, because you know them. For example you know

that corn harvested fresh for consumption cannot be dried and use as seeds- the grains are not mature and will shrink when dried. You also know that seeds that are not properly dried will get spoilt when stored. That is very good. What we therefore want to briefly discuss are things that you are somehow familiar with.

Pre storage factors

Shelf life of seeds in other words, how long seeds can be stored is determined not only by conditions in the store but by several other factors before you put them in the store. These include condition of seed at harvest. The following factors are related to harvest condition. These are:

1. The **type or species** of the seed stored. Seeds that are high in oil for example groundnut or soybean easily lose viability when compared with cowpea or maize. This is the reason why seeds of soybeans are better stored in air-conditioned room, while maize seeds can be safely stored in a well-ventilated room even in the absence of air-condition facility.

2. The **level of maturity** of the seed at the time harvest cannot be improved in the store; therefore ensure that the seeds to be stored are fully mature. Immature seeds shrink in the store.

3. Proper **time of harvest** Harvesting should be done at the right time; delay harvest will expose the seed to environmental and biological factors, such as excessive heat and infestation by insects.

4. **Mechanical damage**ensure that seeds meant for the store are those free from bruises and injury during threshing and winnowing. Mechanical damage can also be reduced by ensuring proper moisture condition before threshing.

Storage factors

Apart from those factors associated with harvesting which affect shelf life, there are other factors which are associated or related to the condition in or of the store. These include:

1. **Fumigation as well as treatment against rodents, insect pests and moulds**. If fumigation and other use of chemicals are not properly handled in the store deterioration might be hastened.

2. **The volume of seed stored** might also determine how long it will stay viable. The volume of seed stored must not exceed the carrying

capacity of the store to maintain the right conditions for proper storage. When the carrying capacity of the store is exceeded, proper air circulation and ventilation amongst other things cannot be maintained.

3. The initial moisture content of the seed

It has been documented that in order to store seed effectively for a period of up to one year you should keep the initial moisture content of the seeds at the point of storage at 5 per centto 14 per cent. Can you guess why we have a range? Did I hear you say because we have different varieties of seeds? Yes you are smart and correct. The moisture content will vary from seed variety to seed variety, smaller seeds will be expected to be drier at the point of storage.

4. Storage relative humidity

This is related to the moisture content in the seed because it is also moisture content, however, this time it is the percentage moisture content in the atmosphere where the seeds are stored that we are referring to. Did you get that? While the relative humidity in the store refers to percentage moisture content in the store, the initial seed moisture content refers to the percentage moisture content in the seed. You must also know the relationship between the two. If you bring in seeds with appropriate moisture content into a store with high relative humidity, the seeds will absorb moisture from the store and be prone to lose their viability quickly, thus reducing the shelf life.

5. Storage temperature

This is also another factor of great importance you must pay attention to, in order to store your seeds for long; that is to extend the shelf life. It has been reported that appropriate storage temperature can be derived using the formula: $^0F + RH \leq 100$

Do you understand this? Don't worry I will try to explain. That is the sum of the storage temperature (in degree Fahrenheit) and the relative humidity must be less than or equal to 100.

You are familiar with degree Celsius (^0C), you know that water boils at 100^0C and freezes at 0^0C, good. $0^0C = 32^0F$

To convert from degree Celsius to degree Fahrenheit: T (^0C) = (T (^0F) ─32)/1.8

I hope that calculation is simple enough?

Below is a Table showing the appropriate combinations of seed moisture content and relative humidity that will guarantee storage of different seeds for up to a year:

Table1.1: Recommendations of Safe Storage Moisture for a Period of One Year

CROP	SEED MOISTURE CONTENT (%)	RELATIVE HUMIDITY (%)
BEAN	**12**	**65**
BRASSICA	**8**	**70**
CARROT	**10**	**67**
PEA	**14**	**63**
RADDISH	**9**	**65**
SWEET CORN	**12**	**74**
TOMATO	**9**	**60**

Source: Hill Murray, 1999 (www.seedquest.com)

You should note that routine check of the seed must be made. For example you can be carrying out the germination test say once in three months as well as the seedling vigour assessment. Simply put when you take random sample of 100 seeds how many actually germinated? If 99 germinated that means that the germination percentage is 99 per cent. If 95, the germination percentage is 95 per centand so on (this has been treated earlier). The seedling vigor refers to how big or robust the seedlings look when they germinate. The big, robust and healthy are preferred to the small, fragile looking ones.

SELF-ASSESSMENT EXERCISE

A farmer interested in storing some seeds complained of low level of viability of his stored seeds. When examined closely you observed that a good percentage of the seeds have shrunk, others have some parts slightly broken off and the seed store was filled to the door step. How will you advise the farmer in order to extend the shelf life of his stored seeds?

4.0 CONCLUSION

Quality seeds are needed for propagation from season to season. Understanding the seed we are handling, harvesting at the right time, avoidance of mechanical damage as well as maintaining proper storage environment will work together to extend the shelf life stored seeds.

5.0 SUMMARY

Maintenance of seeds in their in good conditions for a long time after harvest is important. Proper time of harvest, avoidance of mechanical injury and maintenance of appropriate storage temperature, moisture of the environment and the seed, not exceeding the carrying capacity of the store will all prolong shelf life of seeds.

6.0 TUTOR-MARKED ASSIGNMENT

How can we safely store seeds and what are the factors that determine how long seeds can be successfully stored.

7.0 REFERENCES/FURTHER READING

Dilip, G. (2009). Post-harvest seed storage/ handling. Syngenta foundation for sustainable agriculture. www.syngentafoundation.org/db/1/808.pdf

Food quality and shelf life: www.ift.org/media/packaging-quality

UNIT 2 TRADITIONAL METHODS OF VEGETABLE PROCESSING AND STORAGE

CONTENTS

1.0 INTRODUCTION

We have been talking about some modern ways based on scientific principles by which fruits and vegetables are stored. In this unit we shall be discussing traditional method of preservation of fruits and vegetables.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- appraise traditional methods of processing fruits and vegetables
- improve on this method of processing and storage.

3.0 MAIN CONTENT

3.1 Drying Most Common Traditional Method of Storage

As a young boy in town in the northern part of Nigeria one method I observed which was used especially by leafy vegetable merchants (mostly women) is to use a wet jute bag to cover these vegetables in order to preserve their freshness at least for a day or two.

Sometimes, tomatoes, pepper are harvested fresh, ground, boiled to reduce moisture content and then dried .Other methods have also been used to process and store vegetables traditionally one of such methods is drying.

Drying is the most popular and the most commonly used of fruits and vegetables preservation methods among the farmers in Nigeria. As you are

aware and also from our discussion so far, one of the major factor leading to rapid deterioration in fruits and vegetables is that they are very high in moisture content, respiration also continues after harvest. It has also been understood traditionally that dry food keeps longer; this knowledge is therefore employed in the preservation of vegetables especially those that can still be acceptable even in the dried form. Drying is done primarily to reduce the moisture content in the commodity in order to achieve the goal of storage which is to keep the produce in a form of minimal respiratory activity and so extend the shelf life. Commodities that have been so preserved and still found acceptable to the consumer include tomato, different varieties of pepper, ginger, telfairia, bitter leaf, okra and so on. Sun drying is majorly employed which makes it cheap especially in the tropics since sun shines for most part of the year. The precaution that is taken in this method of processing and storage is to ensure that such dried commodities are kept in a dry environment to prevent re-absorption of moisture and spoilage. Also the store should be kept free of both insect and rodents.

This method of storage has been very useful in preserving such commodities during the peak period and for augmenting supply during the lean period. One major disadvantage of this method is that the quality indices of some commodities would have been negatively affected such as the colour, the taste, the aroma and the texture and sometimes the nutritional quality. Their uses is also limited in some cases, for example even after soaking in hot water before grinding, dried tomato cannot be eaten as when it is fresh. One other disadvantage of this method of preservation is that during the drying process, especially sun drying high hygienic standard is seldom maintained making produce preserved in this way to pose some health hazard. Some are contaminated by rat feces leading to diseases like Lasa fever.

It is therefore necessary to maintain safety standard while sun drying produce for storage. Flies and other organisms that could cause health hazard should be kept away from the dying produce.

SELF-ASSESSMENT EXERCISE

Highlight five quality attributes of fruits and vegetables that may be affected when drying is used as a method of preservation.
Briefly discuss safety standard in traditional processing and storage of fruits and vegetables

4.0 CONCLUSION

Drying is a traditional method used in processing of fruits and vegetables to extend the shelf life. In the modern times effort should be made to use this method in the most hygienic way in other to fully achieve the goals of storage of which safety factor is a part.

5.0 SUMMARY

Fruits and vegetables have been processed and stored in the traditional ways before the introduction of modern ways of processing and storage of fruits and vegetables. Drying is the most common method in this regard. Some qualities indices are traded off when foods are dried. Traditional methods must be improved on by ensuring safety standard in modern days.

6.0 TUTOR-MARKED ASSIGNMENT

What are the traditional method of preservation of fruits and vegetables?

7.0 REFERENCES/FURTHER READING

Food preservation - Wikipedia, the free encyclopedia: https://en.wikipedia.org/wiki/Food_preservation

Storage of Fruits and Vegetables-Missouri botanical garden: https://www.missouribotanicalgarden.org/.../**Storage**%20of%20**Fruits**%20.

UNIT 3 IDEAL ATMOSPHERE FOR STORING FRUITS, VEGETABLES FLOWERS AND OTHER CROP PRODUCE

CONTENTS

1.0 INTRODUCTION

So far we have considered the basic requirements necessary for storing our seeds for a long time or for extending the shelf life of our seeds. Can you mention them? Good. Yes, the quality of seed brought into the store, the relative humidity and the temperature in the store house are important factors you must consider. Now we want to consider requirements for storing our fruits and vegetable. Remember fruits and vegetables have high moisture content, so you cannot keep their moisture content as low as the 5-14 per cent without destroying them. So in this case what should you do?

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- mention the temperature and humidity required for storage of some common fruits and vegetables
- explain the likely shelf life of some fruits and vegetables under a given storage condition.

3.0 MAIN CONTENT

3.1 Ideal Atmosphere for Storage

To start with, you should note that just like we discussed in storage of seeds, **temperature** and **relative humidity** are the major environmental conditions that are of prime importance in storage of fruits and vegetables.

General tips for successful storage of fruits and vegetables

Furthermore, there are general rules or guide lines you ought to follow in order to successfully store your fruits and vegetables. These include the following:

a. Ensure that fruits and vegetables meant for storage are in the best condition- no bruises, no sign of pest, disease or insect damage. This is because fruits and vegetables that are damaged will deteriorate fast is storage.
b. Leave a small part of stem about two to three cm on the fruit or vegetable to reduce loss of water and entry of disease causing microorganisms.
c. Keep all fruits and vegetables in DARK and AERATED environment.
d. Avoid storing of produce in excessively low temperature, this will lead to chilling and freezing injury and render the produce unacceptable for consumption.
e. Keep off pests like rats and mice.
f. Finally remember that both fruits and vegetables are still alive and you must strive as much as possible to keep them in a state of inactivity (reduced respiration) if you will ever extend their shelf life and thus achieve the goal of storage.

Do not store fruits and vegetables together because on one hand fruits will produce ethylene that will hasten the ripening of the vegetables, on the other hand, vegetables will contaminate the taste of the fruits as the fruits will pick up their taste.

Classification of fruits and vegetables based on required storage environment

Fruits and vegetables have been classified into four groups based on the kind of environment they require to extend their shelf life. This classification is as follows:

1. Those that will store well in cold and moist environment
2. Those that will store well in cool and moist environment
3. Those requiring cold and dry environment and
4. Those requiring warm and dry environment

Below is a table showing the classification of fruits and vegetables based on the combinations of environmental conditions required for their proper storage.

Table 3.1: Environmental requirements and storage period for some fruits and Vegetables

Vegetables RequiringCold and Moist Environment			
Fruit/Vegetable	**Temperature(^{0}F)**	**Relative humidity(%)**	**Length of storage**
Apples	32-36	90	2-6 months
Cabbages (Early)	32	95	3-6 weeks
Cabbages(Late)	32	95	3-4 months
Carrot mature	32	95	4-5 months
Carrot immature	32	95	4-6 weeks
Corn(Sweet)	32	95	4-8 days
Lettuce	32	95	2-3 weeks
Potatoes (early)	50	90	1-3 weeks
Potatoes (late)	39	90	4-9 months
Vegetables Requiring Cool Moist Conditions			
Cucumbers	40-50	95	10-14 days
Egg plant	45-50	90	1 week
Water melon	40-50	80-85	2-3 weeks
Pepper(sweet)	45-40	95	2-3 weeks
Tomato (green)	50-70	90	1-3 weeks
Tomato (ripe)	45-50	90	4-7 days
Vegetables Requiring Cool Dry Conditions			
Garlic	32	65-70	6-7 months
Onion	32	65-70	6-7 months
Vegetables Requiring Warm and Dry Conditions			
Pepper (hot)	50	60-65	6 months
Sweet potato	55-60	80-85	4-6 months
Source: Storage Guide Lines for Fruits and Vegetables www.gardening.cornell.edu			

SELF-ASSESSMENT EXERCISE

Mention two environmental attributes/factors that are important in the storage of fruits and vegetables.

Highlight five important tips to consider for successful storage of fruits and vegetables.

4.0 CONCLUSION

We want to conclude by saying here that based on the knowledge that storage conditions differ between fruits and vegetables, only fruits and vegetables requiring similar storage conditions should be stored together and fruits and vegetables should not be stored together.

5.0 SUMMARY

In this we have learnt that produce meant for storage must be in the best condition and that fruits and vegetables ideally can be grouped into four based on the environmental requirement for their storage and effective storage can be achieved by storing similar fruits and vegetables together based on the classification.

6.0 TUTOR-MARKED ASSIGNMENT

1. Obtain 30 fresh and firm tomato fruits of about average sizes, keep 10 fruits in the freezer of a refrigerator, another 10 fruits in compartment meant for keeping fruits and vegetables still in the refrigerator and the last 10 on the shelf in a room. Ensure those kept in the refrigerator are kept under constant power supply. Bring out five samples out from both the cooling and freezing compartment after 14 days and immediately record your observation. Allow the fruits to remain outside the fridge for 6 hours and record your observations.

2. Give an appropriate title to this practical exercise

7.0 REFERENCES/FURTHER READING

Basediya, A. L., Samuel, D.V.K. &Beera, V. (2013). Evaporative cooling system for storage of fruits and vegetables - a review**.** J Food Sci Technol. 2013 Jun; 50(3): 429–442.doi: 10.1007/s13197-011-0311-6PMCID: PMC3602570

Storage guidelines for fruits and vegetables from Cornell Cooperative Extension. www.gardening.cornell.edu.

UNIT 4 CONTROLLED ENVIRONMENT FOR TRANSIT – LONG TERM STORAGE

CONTENTS

1.0 INTRODUCTION

Most fruits and vegetables are produced at a location and consumed at other locations much further than the point of production. Interestingly, some produce are transported several hundreds of kilometer from the place of production. This make the issue of post-harvest handling and safe keeping very critical.

Locally, you would have observed that harvested produce are not usually handled and transported properly, the results being heaps and heaps of spoilt and damaged produce especially of fruits and vegetables at the commodity market.

2.0 OBJECTIVES

At the end of this unit, you shouldbe able to:

- identify some precautions to put in place when fruits and vegetables are to be transported over a long distance
- explain what it means to transport produce in a controlled environment.

3.0 MAIN CONTENT

3.1 Tips for Maintaining Produce Qualities for Long Distance Transit Storage

Maintaining high quality of produce from the point of production through the period of transportation and finally till such produce is placed in the hand of the consumer is very important as we have discussed so far. Realising this when the producer and consumer are miles apart however requires first, understanding and observing some rules. Hence, we shall briefly have some tips that should be followed to maintain the qualities of produce transported over such long distance. These dos and don'ts include:

1. Do not harvest immature fruits as they will shrink in transit and become unmarketable.
2. Climacteric fruits (I am sure you know what I mean by that) meant for long distance market must be harvested mature but unripe, so that they get ripe at the desired destination.
3. Do not transport infected or bruised produce.
4. Proper packaging materials like crates should be used and the crates should not be stocked beyond capacity, this is because over filled crates will lead to compressing of and bruising and injury of produced when crates are stacked.
5. You must not stack crates on bare floor of the vehicle, but arrange some raised platform on the floor then put the crates on such to facilitate proper air circulation through the transported produce.
6. Transportation of fruits and vegetables is best done using a refrigerated van with the temperature and humidity set as appropriate for the transported produce.
7. Fruits and vegetables must not be transported in the same container, remember the reasons being that the fruits can take on the flavour of the vegetable and the vegetable might deteriorate faster from ethylene oozing out from the fruits.
8. While in transit avoid rain falling on the transported produce.
9. Avoid over heating of the vessels being transported by painting the container with paint that will reflect light and keep the container cool.
10. Proper air circulation must be ensured through the produce to prevent buildup of heat and deposition of moisture on the produce. This is why it is advisable to transport the harvested produce in crates and other appropriate packaging materials, unlike the polythene bags that are often used in some parts of the developing countries.

3.2 Controlled Environment

You must always remember that fruits and vegetables are still alive after harvest and if the rate of respiration is not reduced, deterioration will be fast and shelf life will be reduced as we have discussed earlier. What is therefore aimed at when horticultural crops are being transported is to create an optimum environment that will retard deterioration. Two terms are generally used:

Controlled Atmosphere: here the gas mixture around the transported produce is controlled and kept at desired composition.

Modified Atmosphere: this involves addition or removal of gases in order to create air composition different from that which is around the commodity.

Controlled atmosphere is the enclosure of food in a gas impermeable package inside which the gaseous environment with respect to CO_2, O_2, N_2, water vapour and trace gases has been changed and is selectively controlled to increase shelf life. O_2 scavengers and ethylene absorbers with CO_2 release agents could be classified as CAP during the early stages of the storage life of packaged product.

Modified atmosphere is the enclosure of food in a package in which the atmosphere inside the package is modified so that its composition is other than that of air. Modification can be achieved by removing air and replacing it with a controlled mixture of gases. Nitrogen is frequently used in MAP to reduce the concentration of other gases in the package. (https://answers.yahoo.com/question/index?qid=20130903082317AA5zKQL)

The general idea in both is to keep the produce in the required temperature as well as in an atmosphere with the best percentage combination of oxygen, carbon (IV) oxide and nitrogen.

Creating either a controlled or modified environment require more training which would be handled in more detail for those intending to specialise in this aspect. It is however important that you know that the container used in transporting these produce have cooling or refrigerated systems with other equipment to regulate air, relative humidity, and of course temperature and maintain the desired air composition .

SELF-ASSESSMENT EXERCISE

Differentiate between controlled atmosphere and modified storage atmosphere

4.0 CONCLUSION

Controlled environment implies controlled or modified atmosphere around the stored produce. Careful observance of safety tips is the first insurance against losses in transit.

5.0 SUMMARY

Maintaining high quality produce from the farm gate until such produce are placed in the hand of the consumer especially in a far distance is an enormous task that may require creating a different environment in the transported produce. Being a rookie, you may not be able to practically do this; however understanding and practicing the safety tips in this study will go a long way in extending shelf life of produce in long distance transit storage.

6.0 TUTOR-MARKED ASSIGNMENT

What are the precautions to put in place when fruits and vegetables are to be transported over a long distance?

7.0 REFERENCES/FURTHER READING

Basediya, A. L., Samuel, D.V.K. &Beera, V. (2013) Evaporative cooling system for storage of fruits and vegetables - a review**.** J Food Sci Technol. 2013 Jun; 50(3): 429–442.doi: 10.1007/s13197-011-0311-6PMCID: PMC3602570

Code of practice for handling fresh fruit and vegetables in refrigerated shipping containers for Australian exports. 2007 edition. https://shippingaustralia.com.au/wp.../Code-of-Practice-Draft-2007.pdf

Food Packaging, Principles and Practice by Gordon L.Robertson: https://answers.yahoo.com/question/index?qid=20130903082317AA5zKQL

https://quizlet.com/15860879/10-controlled-and-modified-atmosphere-packaged-foods-flash-cards/

UNIT5 PROTECTIVE TREATMENTS

CONTENTS

1.0 INTRODUCTION

So far we have discussed some principles that must be kept in order to retard the rate of deterioration and extend the shelf life of harvested commodities. Remember that irrespective of the fruit or vegetable the **temperature** and **relative humidity** must be well maintained as required for safe keep of each crop. Proper handling during harvest, packaging and transport are amongst safety measures that can also extend shelf life. In this unit we shall discuss additional treatment that can be carried out on harvested produce which also extend shelf life

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- explain what curing of produce means and how it is done in yam
- list some additional chemical treatments that can be carried out where applicable on harvested produce in order to extend their shelf life.

3.0 MAIN CONTENT

3.1 Curing

When harvesting farm produce like root tubers and stem tubers mostly yam and Irish potato, sometimes the skins of these commodities are scratched/wounded and could serve as entry points to disease causing organisms if left unhealed and taken to the store; this of course will shorten the shelf life. I am sure you are aware that these two crops are important

tuber crops in Nigeria. Incidentally both are stem tubers. Do you remember the difference between stem tubers and root tubers? If you don't, read that up. Okay, in order to keep focused, the principle of curing involves treating the produce with **high relative humidity** and **high temperature** for some days before storage. This process will encourage healing of the bruises as new cells will be formed to cover up the wound. You would have observed such in potatoes before, as greenish skin on part of the tuber. For yam it has been reported that curing can be achieved on the field by heaping tubers under a shaded area and covering the heap with woven grass matting. The curing process will be accomplished in four days. The heat produced through the respiration of the tubers as well as the moisture loss will create the required temperature as well as the relative humidity.

Field curing for yam (adapted from http://www.fao.org/wairdocs/x5403e/x5403e04.htm)

Yams and other tropical root and tuber crops can be cured outdoors if piled in a partially shaded area. Cut grasses or straw can be used as insulating materials and the pile should be covered with canvas, burlap or woven grass mats. Curing requires high temperature and high relative humidity, and this covering will trap self-generated heat and moisture. The stack should be left for about four days.

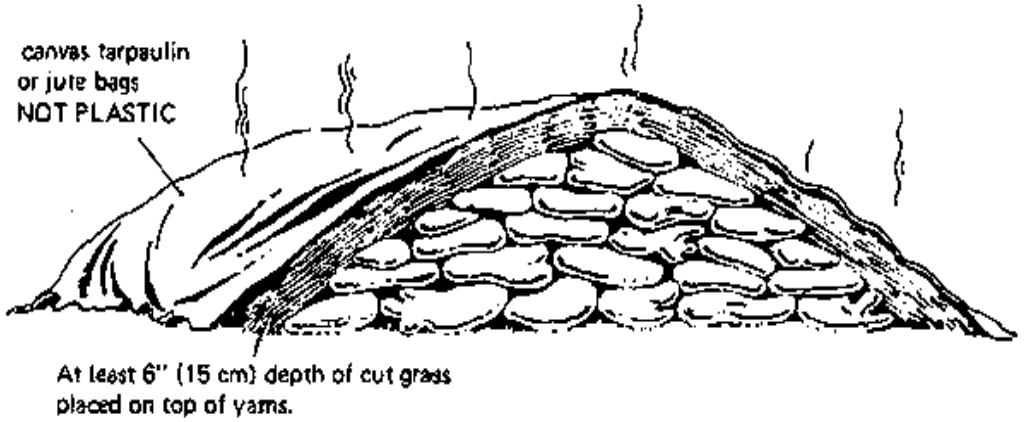

Fig.5.1: Cut-Away View of Yam Curing

Source: Wilson, J. (n.d.). Careful Storage of Yams: Some Basic Principles to Reduce Losses. London: Commonwealth Secretariat/International Institute of Tropical Agriculture. (IITA, Ibadan, Nigeria.)

3.2 Waxing

This involves application of artificial wax to fruits and vegetables after washing before storage. Waxing is not done for the fun of it; rather it has the following advantages: it restores the shine of the produce and makes it attractive, in order words it enhances its quality; remember consumer appeal is very important. Waxing also protects the fruits and vegetables by sealing off scars at the point where the fruit or vegetable was attached to the stem, as well as the cracks or dents on the skin. Waxing also reduces moisture loss and eventually extends the shelf life.

Non-organic fruits and vegetables that are commonly waxed include:

- Cucumbers
- Bell peppers
- Eggplant
- Potatoes
- Apples
- Lemons and Limes
- Oranges
  (http://www.whfoods.com/genpage.php?tname=george&dbid=175)

Natural wax on the produce is removed first by washing before coating with the artificial wax, this artificial wax may be petroleum based or from other natural means.

3.3 Other Chemicals Treatments

Chemicals including fungicides, anti-sprouting agents and disinfectants are also applied to prevent fungi attack, break or discontinue cycle of diseases as well as retard sprouting.

Fungal attack causes different kind of diseases in harvested produce e.g. citrus and plantain. This can be prevented by treating with fungicides. You must however remember that fungicides as well as any chemical must be applied strictly according to the prescription or direction of the manufacturer and must not leave harmful residue on the commodity. This is because although you want to make more profit through proper post-harvest storage and extension of shelf life, the health of the consumer must not be compromised and the trust he reposes on you to provide him with safe food must not be betrayed. Use of fungicides is more common in the field than on harvested produce.

Low concentration of chlorine has been used as a disinfectant and has been found to be advantageous in that it does not leave chemical residue on the commodity.

Use of chemical sprouting suppressant has been found useful in extending the shelf life of potatoes and onion especially in the temperate countries. This is important because once these commodities sprout, they deteriorate faster as they utilise the food reserve in the produce for vegetative growth.

SELF-ASSESSMENT EXERCISE

Highlight three protective treatments given to harvested produce to extend their shelf life.
Briefly describe how you will carry out curing on yam
Mention one advantage each of curing, waxing and treatment with fungicides

4.0 CONCLUSION

Additional treatment of harvested produce should be carried out where necessary and applicable, curing, waxing, application of chemicals must be done to seal up openings that could be used as entrance of agents of deterioration, retard sprouting sometimes and extend shelf life.

5.0 SUMMARY

In this unit we have discusses some treatments that can be carried out on harvested produce ranging from curing which does not require external inputs to waxing, application of sprouting retardant and fungicides. All chemical treatments must however be carried out strictly as prescribed and leaving of residues on produce must be avoided.

6.0 TUTOR-MARKED ASSIGNMENT

What is curing of produce and how is it done in yam.

7.0 REFERENCES/FURTHER READING

Field curing was adapted fromhttp://www.fao.org/wairdocs/x5403e/x5403e04.htm)

Wax coating on fruits and vegetable: http://www.whfoods.com/genpage.php?tname=george&dbid=175

MODULE 5 DESIGN AND OPERATION OF EQUIPMENT FOR STORAGE AND PRESERVATION

Unit 1 Bulk Storage and Palletized Storage
Unit 2 Local Storage Equipment

UNIT 1 BULK STORAGE AND PALLETIZED STORAGE

CONTENTS

1.0 INTRODUCTION

I am sure that so far, you have acquired more knowledge in the area of handling and safe storage of harvested fruits and vegetables. As we draw the curtain in this course, we shall briefly consider the basic guide lines in designing and operation of equipment's for storage and preservation.

2.0 OBJECTIVES

At the end of this unit,you should be able to:

- list the general requirement for a good store
- list the two common types of stores
- explain how to apply the principle of a good store to your local environment even in situations where all the equipment's are not available

3.0 MAIN CONTENT

It is important to state that the operations of some equipment used in storage may be a little bit technical but I bet you we can comprehend a

great deal. You are quite familiar with a refrigerator and I am sure you would have visited one or more cold rooms, so you can comprehend what we are about to discuss.

3.1 Common Storage Systems

There are generally two types of storage systems. These are the bulk storage types and the pelletized storage type.

In the **bulk storage type** just as the name suggests commodities to be stored are piled up in the store as a heap. A duct system is placed under the pile to circulate conditioned air through the pile of the produce a fan is also installed for the same purpose. This type of storage is used for crops like potatoes and onions. In designing this kind of storage system, the walls of the store must be constructed such that they can withstand the force that the produce will exert on them. A space should also be allowed between the pile produce and the door; say about 50 cm. This space will allow you to freely enter into the store for proper monitoring. A thermostat is installed (this is a device made using two types of metal that expands at different temperature, this regulates temperature, the same device is put in a pressing iron that makes it trips off based on the control indicated, that is it trips off once the temperature is reached in order not to exceed it). A humifier is also installed to allow enough humidity for produce requiring such

In **palletized storage,** produce are placed in boxes or pallet bins which in turn are stacked in the store room. In the design for the palletized storage, there is no provision for exertion of force on the walls since such is absent. We use this for crops that cannot be easily piled up in a heap or for crops that can be easily bruised. Examples of these crops include most fruits, cabbage, carrot and many vegetables. Here crops of different varieties can be stored but be sure not to store fruits and vegetables together. Different bins can be handled independently either for marketing or for prompt disposal of problem bins without affecting or contaminating other bins. Ventilation is also controlled here as well as the temperature and relative humidity.

General considerations for a good store include:

1. Irrespective of the material used in constructing the storage, it must be resistant to moisture
2. The store must be insulated.
3. The store must also be air tight
4. The foundation must be insulated on the exterior

5. The store should be such that it will last for a long time.
6. The store should be such that it can easily be sanitised.
7. The store should be provided with a means to control the air temperature, humidity and air flow.
8. For controlled atmosphere storage, the carbon (IV) oxide and the oxygen must be regulated.
9. Storage may be either air cooled, refrigerated or both.

SELF ASSESSMENT ASSIGNMENT

i. Highlight the differences between bulk storage system and palletized storage system.
ii. Itemise at least five things to be considered while designing a good store.

4.0 CONCLUSION

In conclusion a good storage should be well insulated, should serve the function for which it is build, and must have good environmental control (temperature control, relative humidity control, CO_2 and O_2).

You must however remember that the quality of produce cannot be improved in the store, so make sure you store high quality produce, free off disease, bruises etc.

5.0 SUMMARY

In this section, we have briefly considered the requirements for a good store. We have also considered two types of stores: the bulk storage system and the palletized stores.

6.0 TUTOR-MARKED ASSIGNMENT

What are the guide lines in designing and operation of equipment for storage and preservation?

7.0 REFERENCES/FURTHER READING

Handling and preservation of fruits and vegetables: https://books.google.com.ng/books?isbn=9251048614

Processing of fruits and vegetables www.agrivi.com/processing-of-fruits-and-vegetables/

UNIT 2 LOCAL STORAGE EQUIPMENT

CONTENTS

1.0 INTRODUCTION

We shall briefly consider some local storage equipment's that can be constructed and used for small scale storage. This type of storage becomes useful in rural areas and under local conditions where there is erratic or absence of electricity.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- explain the principle behind some local storage equipment's
- construct simple storage equipment.

3.0 MAIN CONTENT

3.1 Local Storage Equipment

Storage equipment have developed over time however the fundamental goal has remained to prolong the shelf life of harvested produce by reducing the rate of respiration, by controlling the temperature and the relative humidity.

Earthen wears have been used to store water and food items traditionally. Clay/ earthen pots are often used to store water in the villages. Such pots are placed on wet sand in a shaded part of the compound, and interestingly the water fetched from such pots is often refreshingly cold relative to water kept in plastic or iron jars and container in the same environment.

Cooling by evaporation

The principle involved that is what makes the water so stored in the pot to have lower temperature is the principle of cooling by evaporation. The earthen pot have tiny holes which will keep its body moist without allowing the liquid to leak out, similarly it pick up moisture from the wet sand. From time to time the moisture on the body of the earthen ware will evaporate, as this happens, the container becomes cooler. This effect is transferred to the content as well; in other words, the water becomes colder over time. The same effect is produced on you when you had a shower in a hot weather, when you leave the water particles on your skin as evaporation of these water particles take place you feel cool. This is because for the water particle to escape heat required is taken from your skin.

Application of this in storage equipment

This principle is being used locally to achieve short time storage of fruits and vegetables.

A bigger pot can be obtained; in this bigger pot some wet fine sand can be poured, then place a smaller pot in the bigger pot, line the inner part of the bigger pot, that is outside the smaller pot with more wet fine sand and then store your fruits or vegetables in the smaller pot. Don't forget to put your storage equipment in a cool place. With the shelf life of your produce can be extended. The advantages of equipment using this principle are that it is cheap, require low inputs which are locally available and does not require electricity. It is however limited in capacity and useful for only short period of storage

There has been various modification of this simple storage equipment, but the principle is the same.

A **pot-in-pot refrigerator**, **clay pot cooler**[1] or **zeer** (Arabic: زير) is an evaporative cooling refrigeration device which does not use electricity. It uses a porous outer earthenwarepot, lined with wet sand, contains an inner pot (which can be glazed to prevent penetration by the liquid) within which the food is placed - the evaporation of the outer liquid draws heat from the inner pot. The device can be used to cool any substance. This simple

technology requires only a flow of relatively dry air and a source of water. (https://en.wikipedia.org/wiki/Pot-in-pot_refrigerator)

SELF-ASSESSMENT ASSIGNMENT

Briefly explain how the 'pot- in pot' evaporative refrigerator works.
Highlight two advantages of this kind of storage system.

4.0 CONCLUSION

Using of earthen wears of different designs employs the principle of cooling by evaporation which is a natural physical principle. This is also found to be useful to extend the shelf life for a short time till date.

5.0 SUMMARY

Cooling by evaporation is natural physical principle that has been employed and found useful to extend the shelf life for a short time till date. The advantage of equipment using this principle is that it is cheap, required low inputs which are locally available and does not require electricity. It is however limited in capacity and useful for only short period of storage

6.0 TUTOR-MARKED ASSIGNMENT

1. Differentiate between climacteric and non climacteric fruits
2. Mention four pre storage and fourpost storage factors that affect shelf life
3. What effect will harvesting plantain before attainment of physiological maturity have on:
   a) The yield
   b) The shelf life under room temperature?

7.0 REFERENCES/FURTHER READING

Pot in pot refrigerator: https://en.wikipedia.org/wiki/Pot-in-pot_refrigerator

Basediya , A., Samuel , D.V.K. &Beera, V. (2013). Evaporative cooling system for storage of fruits and vegetables - a review. J Food Sci Technol. 50(3): 429–442.

General summary and conclusion
This course has presented us with the opportunity of knowing and fine tuning our knowledge of post-harvest physiology. We have realised that

harvested produce are alive and must be handled properly with that consciousness in order to extend their shelf life. Proper management or control of moisture loss as well as rate of respiration will extend shelf life. We have also learnt that several pre-storage factors right from the time of harvest and harvest conditions affect the shelf life. All effort directed at proper storage is to preserve both visible and hidden qualities of harvested produce. Proper storage condition has also been discussed.