RWANDA POLYTECHNIC

TVET LEVEL II

AGRICULTURE

Small Scale Post-Harvest Operations

TRAINEE MANUAL

RWANDA POLYTECHNIC

Approved by: Workforce Development Authority

USAID FROM THE AMERICAN PEOPLE

EDC Education Development Center

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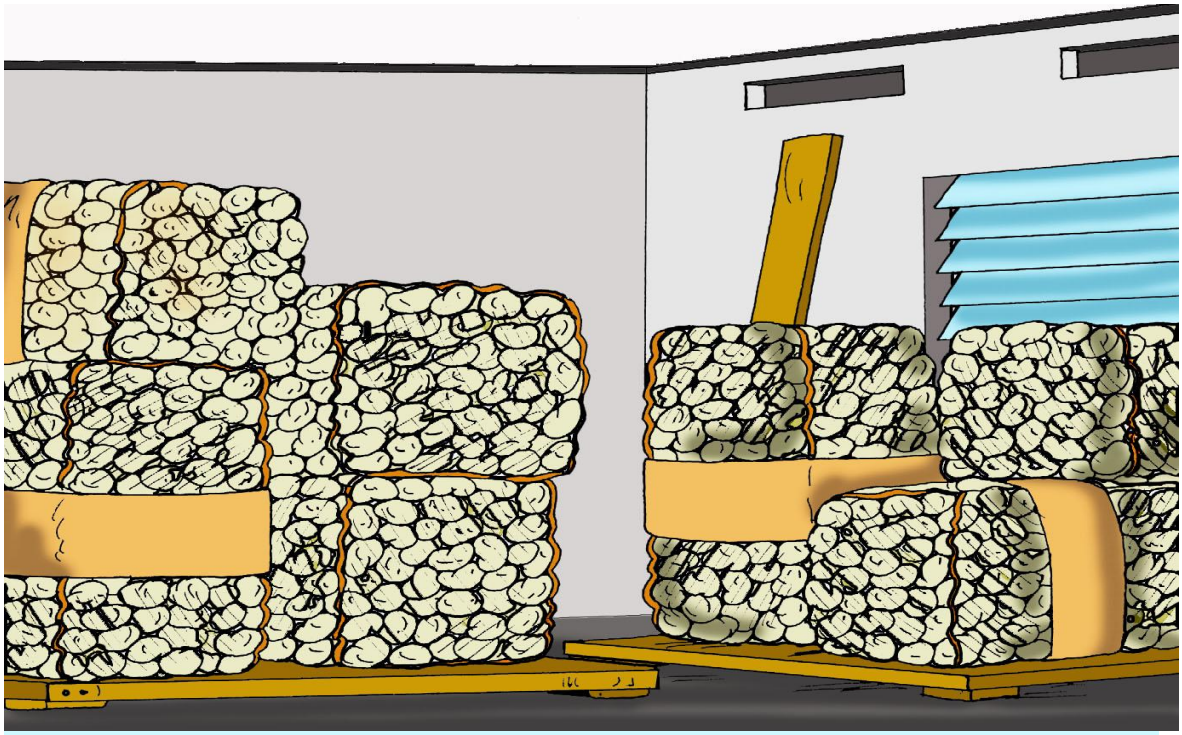
SMALL SCALE POST-HARVEST OPERATIONS

Unit 1: Post-harvest handling

Unit 2: Packaging

Unit 3: Storage

Unit 1: Post-harvest handling



Topics

1.1 Curing roots, tubers, and bulb crops following requirements

1.2 Post-harvest handling operations prior to packaging following requirements

1.3 Sorting and grading of produce considering market requirements

Unit Summary:

This unit describes the knowledge, skills, and attitudes required to perform post-harvest handling. At the end of this unit, learners will be able to cure roots, tubers and bulb crops following requirements, perform postharvest handling operations prior to packaging, and sort and grade produce considering market requirements.

Self-Assessment: Unit 1

1. Observe the unit illustration above. What do you see? What do you think this unit will be about?

2. Fill in the self-assessment below.

There are no right or wrong ways to answer this assessment. It is for your own use during this unit. Think about yourself: Do you think you can do this? How well? Read the statements across the top. Put a check in column that best represents your situation. At the end of this unit, you will take this assessment again.

My experience **Knowledge, skills, and attitudes**	**I don't have any experience doing this.**	**I know a little about this.**	**I have some experience doing this.**	**I have a lot of experience with this.**	**I am confident in my ability to do this.**
Define the curing process					
Identify crops that can be cured and those that cannot					
Describe the requirements and conditions for curing					
Perform curing of roots, tubers, and bulb crops					
Select the crops to be cured					
Choose the appropriate methods for curing					
Describe postharvest handling operations for cereals					
Explain grain drying testing methods					

My experience Knowledge, skills, and attitudes	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Explain how to clean cereals and utilize dumped produce					
Plan for and perform drying of cereals on various drying systems					
Test maize to ensure sufficiently dryness					
Clean cereals by dehusking maize or threshing grain					
Describe sorting techniques					
Identify grading methods					
Define grading standards/ attributes according to market standards					
Sort produce with sieve and hand pick grains					

Topic 1.1: Curing roots, tubers, and bulb crops

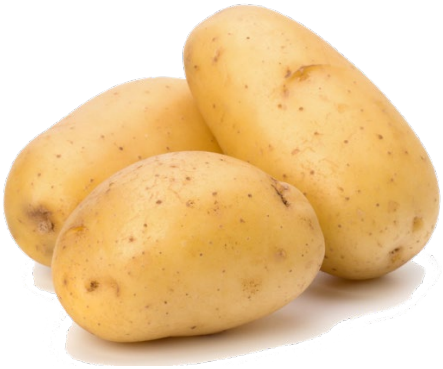
Key Competencies:

Knowledge	Skills	Attitudes
1. Define the curing process	**1.** Perform curing of roots, tubers, and bulb crops	**1.** Willing to try
2. Identify crops that can be cured and those that cannot	**2.** Select the crops to be cured	**2.** Self-confidence
3. Describe the requirements and conditions for curing	**3.** Choose the appropriate methods for curing	**3.** Attention to detail

Getting Started: What do we know and where are we going?

Topic 1.1 Task 1:

A.



1

B.

2

C.

3

D.

4

1. Look at the images and reflect upon the following:

a. Do you recognize the crops and are they grown in your area?

b. What do you think has happened to the crops in images B. and D.?

c. Has this ever happened to crops that you have grown?

d. What steps do you need to take to prevent this situation from happening?

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[1] *Potato* [Photograph]. (n.d.). PngImg. https://pngimg.com/download/2391

[2] United States Department of Agriculture. (2005, July 20). *Phytophtora infestans-effects* [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Phytophtora_infestans-effects.jpg

[3] *Onion* [Photograph]. (n.d.). PngImg. https://pngimg.com/download/3817

[4] Monto, T. (2016, March 5). *Mold on onion* [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Mold_on_onion.jpg; License: https://creativecommons.org/licenses/by-sa/4.0/legalcode

2. Share your thoughts with the rest of the class. Then, refer to the Key Competencies table.

Problem Solving Activity

Task: 1.1 Task 2:

1. Read the following situation and respond to related questions with the person sitting next to you.

Bagabo is a potato farmer in Nyamagabe district, in May, he harvested 500 kg of potatoes. Three days later, he found that half of his produce was rotten.

a. What do you think caused the potatoes to rot?

b. What do you think Bagabo could have done to prevent the potatoes from rotting?

c. Why might this be an important problem to solve for farmers in your area?

2. Volunteer to share your responses with the rest of the class.

3. Refer to **1.1 Key Facts** and review them together.

4. Before the next lesson, you must find a produce item and bring it to class.

1.1 Key Facts

- **Curing:** The process of preparing certain crops for long periods of storage. Curing occurs immediately after harvesting and differs according to the type of crops.

- **Crops that *can* be cured:**
  - Bulb crops (e.g. Onions, garlic)
  - Root crops (e.g. Sweet potatoes, cassava root)
  - Tuber crops (e.g. Potatoes)

- **Crops that *cannot* be cured:**
  - Leafy vegetables (e.g. lettuce, cabbage)
  - Cucumbers
  - peppers

- Fruits (e.g. tomatoes, mangoes, avocados)

- **Curing roots and tubers: sweet potatoes, potatoes and cassava roots**
  - Should occur in a warm, moist environment.
  - Allows wounds, cuts and surface damages to heal.

- **Curing Bulb Crops: Onions and Garlic**
  - Before curing, the neck of the onion or garlic should be fat and moist when first harvested.
  - After being fully cured, the neck will be tight, dry, and thin.

- **Temperature and relative humidity:** The table below shows the conditions and time needed for curing for each crop.[5]

Crop	Temperature	Relative humidity	Days
Potatoes	15 - 20°C	90 - 95%	5 - 10
Sweet potatoes	30 - 32°C	85 - 90 %	4 - 7
Cassava	30 - 40°C	90 - 95%	2 - 5

- **Importance of curing:**
  - Increase storage life
  - Improve quality and appearance
    - Less sprouting and decay
    - Heals wounds
    - Firms the peel
  - Creates barriers against infection

- **Storage life:**
  - 7 months at 15°C for sweet potatoes
  - 10 months at 5 to 12°C for potatoes
  - 4 months for onions

[5] Food and Agriculture Organization of the United Nations. (n.d.). *Chapter 4 - Handling and storage methods for fresh roots and tubers*. https://www.fao.org/3/x5415e/x5415e04.htm

Guided Practice Activity

Topic 1.1 Task 3:

1. Prior to the lesson you will need to bring an item of produce which grows in your area. At the beginning of the lesson, your trainer will ask you to present your produce.
   a. Divide the produce/vegetables into ones you think are curable and ones which are not.

2. Discuss the following questions with a group that your trainer assigns.

   a. Can the item of produce that you brought be cured? Why or why not?

   b. If the item of produce can be cured what are conditions and time needed for curing it?

   c. What might happen if your item was not cured?

3. With your group, share your findings and the responses to the questions.

4. Refer to **1.2 Key Facts** and review them together.

5. Your task for the next activity is to prepare for an upcoming field visit by interviewing a farmer in their neighbourhood who grows and cures crops. You should use the "Interview questionnaire" found under **Topic 1.1 Task 4** to guide your interviews and record your findings to the questions.

1.2 Key Facts

- **Curing methods:**
  - Field curing
  - Shed curing
  - Controlled curing

- **Field curing in windrows or sacks:**
  - Cover to prevent sun damage
  - Takes four to five days in warm, sunny weather
  - Crops should be checked each day to assess progress

- **Curing bulb crops in windrows:** Windrows are loose piles of harvested produce, or in sacks, covered with some light vegetation (e.g. dried leaves).
  - Protects the curing produce from too much sun.

- **Curing with burlap sacks:**
  - Takes 5 to 7 days in warm, sunny weather.
  - Crops should be checked each day to assess progress

- **Shed curing:** Occurs in simple outdoor sheds
  - Protects the drying crop from rain
  - Added fans can speed up drying

- **Controlled curing:** Happens indoors with heated air and fans to move warmer air down through the curing crops.
  - Large bins under controlled conditions
  - Speeds up curing and provides optimal curing conditions
  - Root and tubers crops can be cured in a room with added heat and ventilation.

Application Activity

Topic 1.1 Task 4:

1. Your trainer will arrange a visit to a local farm which is in the process of post-harvest curing. This is an opportunity for you to gain practical experience in post-harvest curing procedures.

2. Before the field visit, prepare by interviewing a farmer in your neighbourhood who grows and cures crops. Use the following “Interview questionnaire” to guide your interview. After you have gathered your findings, bring the completed questionnaire to class and share with your fellow trainees and trainer.

3. After you have completed the interview you are ready for the practical field visit with the rest of your class. Your trainer will instruct you on how to proceed.

4. Compare your practical experience with the findings you recorded in your interview. Does your practical experience match the situation described by the farmer?

Interview questionnaire:

How does the farmer describe the curing process?	
Which crops are being cured?	
What methods of curing are used?	
When did the curing crops start to be cured and when will they be ready?	
How does the farmer check the temperature and humidity of his curing crops?	
What problems can happen during the process, and how should they be avoided?	
How long will the crops last after they have been cured?	
Look back at **1.1 and 1.2 Key Facts** Do your answers match them? If not discuss why this might be.	

Points to Remember

- Curing occurs immediately after harvesting and differs according to the type of crops.
- Curing times depends on humidity, the types of plant involved and the water content of plant.
- Curing is important because it helps crops last longer during storage.

Formative Assessment

1. List three kinds of crops that are curable.

a.

b.

c.

Answer the following True/False questions. If true, write “true”. If false, write in the correct answer:

2. Crops are usually cured to make them taste better.

3. Curing crops is a way to quickly sell your crops after harvest.

4. Potatoes should cure at a lower temperature than other crops.

5. All crops cure at a high (i.e. close to 100%) relative humidity.

Topic 1.2: Postharvest handling operations prior to packaging

Key Competencies:

Knowledge	Skills	Attitudes
1. Describe postharvest handling operations for cereals	**1.** Plan for and perform drying of cereals on various drying systems	**1.** Proactive
2. Explain grain drying testing methods	**2.** Test maize to ensure sufficiently dryness	**2.** Attention to detail
3. Explain how to clean cereals and utilize dumped produce	**3.** Clean cereals by dehusking maize or threshing grain	**3.** Methodical

Getting Started: What do we know and where are we going?

Topic 1.2 Task 1:

1. Look at the illustrations above and brainstorm with a partner about the following:
   a. What does each illustration represent?

   b. Together, what process do these illustrations show happening?

   c. Has this ever occurred to you or someone you know?

2. Volunteer to share your thoughts. Then, refer to the Key Competencies table and read them together.

Problem Solving Activity

Topic 1.2 Task 2:

1. Read the following scenario with a partner:

   Kagabo is a maize farmer in your district and is preparing to harvest his maize crop. What are some things he can do now to ensure he is prepared to handle his crops after harvesting?

2. Make a list of problems he might encounter after harvesting his maize as well as what actions he could take in order to avoid or overcome them. Be prepared to share your list with the rest of the class.

3. Share your responses with the large group and discuss.

4. Ask questions as needed and the trainer will provide clarification. Refer to **1.3 Key Facts** for information and clarification.

1.3 Key Facts

- **Drying maize and grains:**
  - During harvest crops should be placed on a mat, tarpaulin, or in burlap sacks.
  - If rain delays the maize harvest, then you should prevent water from entering the maize cobs by turning them upside down.
  - Transport crops from the field to a storage facility as soon as possible for further drying.
  - Keep farm animals away from drying crops or use a maize drying crib for protected drying.
  - Dump any maize cobs that are substandard. These may be used as feed for livestock.
  - In the case of unexpected rain, cover the drying grains with a tarpaulin. Do not let drying grains get wet.
  - Grains are sufficiently dry when the crop has a moisture content of: 13.5% for cereals, and 12% for beans.
  - Maize drying is most effective in drying racks where maize cobs are hung and suspended to allow for natural drying after they have been picked from the field.
  - Ethephon is used to ripen fruit and is applied to cereals (maize, wheat) to increase resistance during storage.
  - Drying can take up to four to eight weeks and depends heavily on climate and temperature and method.
  - Cooperatives in Rwanda have lost up 60% of their total maize production due to poor post- harvest drying.

- **Cleaning maize-dehusking:**
  - Use your hands or a mechanical dehusker to separate the husk from the maize.
  - If any grains of maize are damaged or unfit for consumption, they can be fed to animals.

- **Cleaning grain:**
  - Thresh and winnow grain to remove chaff, foreign matter, and broken grains.
  - Be careful to remove any insect-damaged or mouldy grain, along with the chaff, and burn it afterwards to avoid spreading crop infection.

- **Warning:**
  - Do not place damaged grain in storage.
  - Do not beat the grain while shelling with sticks.[6]

Guided Practice Activity

Topic 1.2 Task 3:

1. In a small group, read the following scenario carefully and follow the instructions below:

Kagabo, the maize farmer mentioned in the previous **Problem Solving Activity**, is looking for help. After he harvested his crop, he delivered it to a nearby mill a few days later because he really needed the money. Surprisingly to Kagabo, his produce was deemed substandard and rejected by the procurement department of the mill. When Kagabo asked why this was the case, the mill inspector answered that his maize was not sufficiently dry and therefore was unacceptable. Now he wants to make sure that the next season's crops do not get rejected by the mill again. He has brought some of the maize still on the husks and wants your help to dry them.

2. Make a list of recommendations for Kagabo to follow after harvesting his maize. Refer to **1.3 Key Facts** to supplement your answers.

3. Share your thoughts and discuss them with the rest of the class.

4. Preform maize drying according to the procedures demonstrated by your trainer**.**

5. Observe as the trainer or another professional demonstrates how to dry maize using the available system(s).

6. Receive dried maize cobbs from the trainer. Perform maize drying through various methods. Ask the trainer for help as needed.

[6] African Postharvest Losses Information System (APHLIS). (n.d.). *Cereal grain quality losses in Sub-Saharan Africa: Part 2 reducing on-farm postharvest losses*. https://archive.aphlis.net/downloads/PHL_reduction_tips.pdf

1.4 Key Facts

- **Testing moisture content for maize:** Most farmers do not have moisture meters or a grading laboratory facility. However, simple and unsophisticated tests can be used to estimate the dryness of maize or grain. To do this:

  - **Method 1**
    1. Pick 10 grains at random.
    2. Crush each grain between the teeth.
    3. A reasonably dry grain will crush without leaving a pasty feel in the mouth.

  - **Method 2**
    1. Select a random sample of maize.
    2. Fill a clean glass half-way with the maize sample (the glass must be dry).
    3. Add 2 teaspoons of dried salt (the salt should be previously dried in a pan over a fire for 15 minutes).
    4. Shake the mixture for 2 minutes.
    5. Leave to settle for 20 minutes.
    6. Pour out the mixture.
    7. Check for any salt clinging on the walls of the glass.
    8. If any salt is found on the walls of the glass, then the moisture content is greater than 14%.[7]

Application Activity

Topic 1.2 Task 4:

1. Your class will now perform the applied tasks related to proper post-harvest processing of crops. In your groups, read the situation carefully and follow the instructions below:

Kagabo has now handled his harvested crop according to your recommendations and received a premium price at the market. However, he has a friend Bigubi, who also grows maize crops and needs help. Bigubi was in a hurry after harvesting his maize and left most of his in burlap sacks lying in the field. Compare Bigubi crops to Bigubi's crops that you have helped dry in the previous activity.

[7] Eastern Africa Grain Institute (EAGI). (n.d.). *Farmers' training manual: Understanding structured trading systems*. https://ecdpm.org/wp-content/uploads/EAFF-Farmers-training-manual-on-structured-trade.pdf

2. Prepare two samples by dehusking the maize from Bigubi's and Kagabo harvest, keep the cobs and samples separate.

3. Each person in the group should get a chance to try dehusking.

4. Label one sample A and the other B at random.

5. On a separate piece of paper, record which samples belong to who, and do not reveal the answers to other groups.

6. Once both samples are prepared, inform your trainer and then move to another group's samples to perform the moisture tests outlined in the **1.4 Key Facts** for both samples of maize.

7. Everyone in the group should get a chance to try the different testing methods.

8. Once the moisture tests have been performed by every member in your group, discuss which maize might be from Kagabos crops and which ones might be from Bigubi's and why.

9. After you have come to a conclusion, the answers for each group's samples will be shared and discussed with the entire class.

10. Finally think about your own home and possible places where you could store grain for drying after harvest in the future.

Points to Remember

- Keeping cereals dry immediately after harvest is essential for ensuring their quality.
- Damaged grains should be burnt or fed to livestock.
- You can test the dryness of a maize by chewing it in your mouth. A reasonably dry grain of maize will crush without leaving a pasty feel in the mouth.

Formative Assessment

1. Answer the following True/False questions. If true, write "true." If false, write in the correct answer:

a. Harvesting grains should happen on a rainy day so the grains do not get too much sun.

b. Damaged or mouldy grains should be removed with the chaff and burned.

c. Beating the grains with sticks during the shelling process will improve the quality of the grains.

2. Explain one simple way to test the dryness of maize.

3. Describe a good place where grain can be stored for drying. What makes this place good for grain drying?

Topic 1.3: Sorting and grading produce according to market standards

Key Competencies:

Knowledge	Skills	Attitudes
1. Describe sorting techniques	**1.** Sort produce with sieve and hand pick grains	**1.** Proactive
2. Identify grading methods	**2.** Identifies foreign matter and defects in produce.	**2.** Methodical, detail oriented
3. Define grading standards/ attributes according to market standards	**3.** Assess produce according to market standards and test for quality assurance	**3.** Results-oriented

Getting Started: What do we know and where are we going?

Topic 1.3 Task 1:

1. Join your assigned groups, have a look at the illustration above and brainstorm answers to following questions:

a. What are the workers doing in the illustration above and why?

b. What is the difference between the coffee on the table and the coffee entering the sac?

c. In general, what helps us determine the quality of a product?

2. Share your answers with the rest of the class. Ask other groups questions and add your own observations.

3. Review the Key Competencies table together.

Problem Solving Activity

Topic 1.3 Task 2:

1. With your partner, carefully read the following scenario and respond to questions below:

KOPACA is the cooperative operating in Kirehe district, it has over 4 ha cultivated maize, and it has received an order from MAITECH Flour Processing Co. to supply four metric tons of maize. However, upon deliver to the processing plant, inspectors were not pleased with the product. They claimed that the cooperative provided an uneven and poor-quality grade of maize that would not make good flour. In the end the company paid KOPACA a lower price compared to one they had hoped for.

a. What might the cooperative have done wrong that caused the maize to fetch a lower price than expected?

b. Brainstorm some characterises of grain that are desirable.

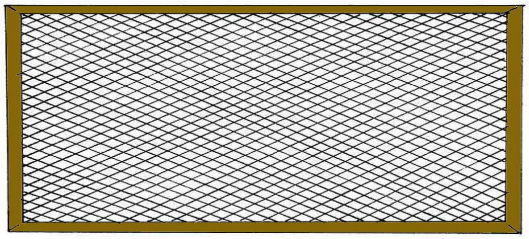
c. Have you ever seen someone sorting grains? Describe how it looked to you.

d. What might be some ways to grade the standards of different grains.

2. Be sure to ask questions for clarification.

1.5 Key Facts

- **Sorting and grading the grain:**



  - Cereal crops like maize and grains always need to be sorted and cleaned to ensure high quality.
  - One way to do this is to pass the grain over an inclined sieve.
  - The calibre of the sieve should be 4.5 mm for grain.
  - It can be operated by one or two people depending on its size.
  - Passing a quantity of grain over the sieve, it is moved across the sieve by hand so that broken grain and dust fall and are collected in a container below the sieve.
  - The grain retained by the sieve should be handpicked to remove discoloured, rotten and diseased grain.
  - The grain is gradually pushed down the sieve into the sack that is suspended at the lower end.

- **Identifying foreign matter:**[8]
  1. Place a clean dry basin (Bottom pan) in place to receive materials that may go through the sieve.
  2. Weigh 200 grams of the representative sample (W1).
  3. Put the maize in the sieve provided (4.5 mm round hole).
  4. Shake the sieve horizontally for 30 times for about 15 seconds.
  5. Collect all the foreign organic matter that has passed through the sieve.
  6. Hand pick all the foreign organic matter retained on top of the sieve.
  7. Weigh all foreign matter collected from the bottom pan and that was handpicked from the top (W2).

Foreign Matter = (Weight 1 / Weight 2) * 100

- **Grading:** Grades are assigned to grain to designate quality based on the quantity of defects a given sample has.

[8] Ali Veterinary Wisdom. (2019, October 26). *Maize notes for poultry feed*. https://aliveterinarywisdom.com/maize-notes-for-poultry-feed/

- Defects are undesirable matter contained in grain.
- Grade 1 is the highest quality of grain i.e. it contains the lowest quantity of undesirable material.
- Grade 3 is given to sub-standard grain.
- See *Table 1.1* below:[9]

Table 1.1

Defect	Maximum limits		
	Grade 1	Grade 2	Grade 3
Foreign matter, %	<0.5	1.0	>1.5
Inorganic matter, %	<0.25	0.5	>0.75
Broken grain, %	<2.0	4.0	>6.0
Pest damaged grain, %	<1.0	3.0	>5.0
Rotten and diseased grain	<2.0	4.0	>5.0
Discoloured grains, %	<0.5	1.0	>1.5
Moisture	<13.5	13.5	>13.5
Immature/shrived grains, %	<1.0	2.0	>3.0

- **Testing for quality- foreign odour:** Quality can be assured following this simple test:
  - Obtain a representative sample
  - Spread out the sample on a flat surface and smell it.
  - If no odour is detected, return the sample into the container and seal it.
  - Leave the sealed container for 24 hours and re-examine the sample.
  - The smell should be typical of maize without other smells e.g. chemicals, mouldiness, earthy, rotten, musty smell, etc.

Guided Practice Activity

Topic 1.3 Task 3:

1. Your trainer will demonstrate how to properly sort cereal crops using a sieve. Pay close attention to the techniques and points to keep in mind during this demonstration.

[9] Uganda National Bureau of Standards. (2011). *Uganda standards template*. Punto Focal. https://www.puntofocal.gov.ar/notific_otros_miembros/uga257_t.pdf

2. Then your trainer will provide your group with 3 kg of substandard grain or maize which you will need to process according to the following steps.
   a. Select appropriate sieve.
   b. Sort grain/maize.
   c. Hand pick for quality assurance.

3. After your group has finished processing your grain/maize with the sieve, inspect another group's grain by determining the amount of foreign matter. Write the percentage next to the sample.

4. After all the groups have had a chance to inspect one another's samples, return to your sample and assign grades to your product based on the determined foreign matter. Refer to the **1.5 Key Facts, Table 1.1.**

5. Be prepared to share your groups experiences with the rest of the class.

Application Activity

Topic 1.3 Task 4:

1. Visit a famer in your neighbourhood who grows cereal crops and discuss with them how they perform post-harvest handling of their produce. Use your previous experience from sorting grains to focus your discussion on any problems or difficulties they have experienced and ways they have overcome them. Specifically ask about methods they use in order to ensure the quality of their grain they plan to sell.

2. Then interview a manager at a local mill about how produce is graded there. Specifically ask about the methods they use to ensure the quality of grain they intend to buy.

3. Compare these results with the points raised in class.

4. Prepare a report after the visit.

5. Present your findings to the class.

Points to Remember

- Grains always need to be sorted and cleaned for high quality.
- A sieve is used to sort grain.
- Removal of discoloured, rotten and diseased grain will always require hand picking.
- The higher the grain quality the better price it usually receives at market.

Formative Assessment

1. Describe two ways which can improve substandard grains.

2. Choose the correct answer by writing true or false. If the answer is true write "true." If the answer is false, fill in the correct answer.

a. Sorting grain often starts with hand picking diseased grain.

b. Defects are undesirable matter contained in grain.

c. The calibre of the grain sieve should be 3.5 mm.

d. Grade 3 grain contains the fewest number of defects.

Self-Reflection

1. You have come to the end of the unit. You are going to do the survey you did at the beginning of the unit again to help you do self-assessment of your knowledge, skills and attitudes.

Again, there are no right or wrong answers to this survey. It is for your own use to gauge your knowledge, skills and attitudes after the unit. Read the Knowledge, Skill or Attitude in the left column. Think about yourself: do you think you can do this? How well? Read the statements across the top. Put a check in column that best represents your situation.

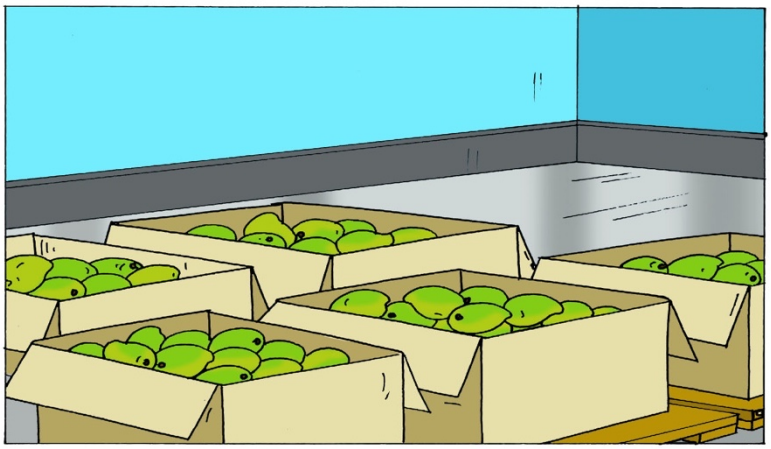
My experience **Knowledge, skills, and attitudes**	**I don't have any experience doing this.**	**I know a little about this.**	**I have some experience doing this.**	**I have a lot of experience with this.**	**I am confident in my ability to do this.**
Define the curing process					
Identify crops that can be cured and those that cannot					
Describe the requirements and conditions for curing					
Perform curing of roots, tubers, and bulb crops					
Select the crops to be cured					
Choose the appropriate methods for curing					
Describe postharvest handling operations for cereals					
Explain grain drying testing methods					
Explain how to clean cereals and utilize dumped produce					

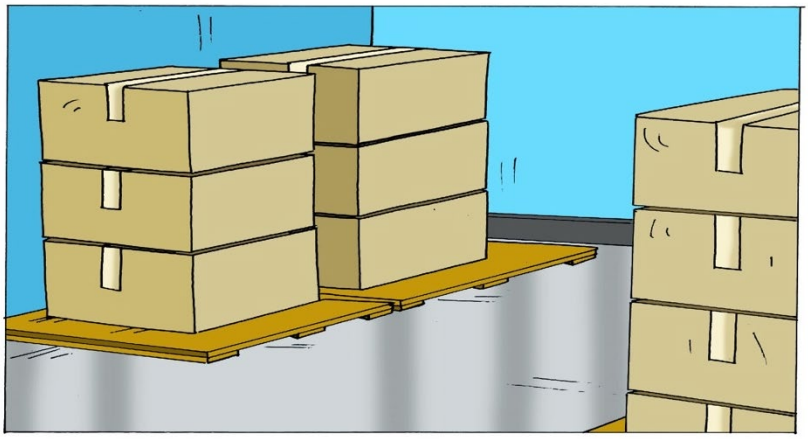
My experience Knowledge, skills, and attitudes	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Plan for and perform drying of cereals on various drying systems					
Test maize to ensure sufficiently dryness					
Clean cereals by dehusking maize or threshing grain					
Describe sorting techniques					
Identify grading methods					
Define grading standards/ attributes according to market standards					
Sort produce with sieve and hand pick grains					

2. Complete the table below by identifying areas from the unit where you have improved and where you need improvement with the actions/strategies you will use to help you improve when receiving and interpreting information at the workplace

Areas of strength	Areas for improvement	Actions to be taken to improve
1. **2.**	**1.** **2.**	**1.** **2.**

Unit 2: Perform packaging





Topics

2.1 Selection and acquisition of packaging materials

2.2 Package produce following requirements

2.3 Identify cooling methods following instructions and crop requirements

Unit Summary:

This unit describes the knowledge, skills, and attitudes required to perform packaging. At the end of this unit, trainees will be able to select and acquire proper packaging materials; package produce; identify appropriate cooling methods according to different crops.

Self-Assessment: Unit 2

1. Observe the unit illustration above. What is happening? What do you think this unit will be about?

2. Fill in the self-assessment below.

There are no right or wrong ways to answer this survey. It is for your own use during this course. Think about yourself: do you think you can do this? How well? Read the statements across the top. Put a check in column that best represents your situation. At the end of this unit, we'll take this survey again.

My experience Knowledge, skills, and attitudes	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Explain the requirements of packaging and its functions					
Describe different types of packaging materials for agriculture produce					
List criteria for selecting a packaging					
Select appropriate package materials according to market requirements					
Use appropriate packaging materials to maintain the quality of produce					
Apply criteria when selecting packaging					
Recognizes conditions of individual packages such as filling capacity					

My experience Knowledge, skills, and attitudes	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Identify hygienic conditions of packages					
Identify key aspects of labelling					
Measure and fill accurately the quantity required for the package					
Practice hygienic conditions measures while packaging					
Produce appropriate package labels					
Outline cooling methods at small scale farm level					
Describe a Zero-Energy Cooling Chamber (ZECC)					
Explain a room cooling system					
Apply cooling methods to ensure good quality of produce					
Use a Zero-Energy Cooling Chamber (ZECC) to preserve produce quality					
Use a room cooling system to maintain the freshness of produce					

Topic 2.1: Selection and acquisition of packaging materials

Key Competencies:

Knowledge	Skills	Attitudes
1. Explain the requirements of packaging and its functions	**1.** Select appropriate packaging materials according to market requirements	**1.** Self -confidence
2. Describe different types of packaging materials for agriculture produce	**2.** Use appropriate packaging materials to maintain the quality of produce	**2.** Attentive
3. List criteria for selecting a packaging	**3.** Apply criteria when selecting packaging	**3.** Accurate

Getting Started: What do we know and where are we going?

Topic 2.1 Task 1:

1. Reflect upon the following:

a. What kinds of horticulture crops and produce i.e. fruits or leafy vegetables are grown in your area?

b. How are they transported? By car, by bike, by foot?

c. Why is some produce transported differently than others?

2. Share your responses with the rest of the class.

3. Review the Key Competencies table together.

Problem Solving Activity

Topic 2.1 Task 2:

1. Imagine the following situation:

a. You have just finished harvesting some delicious bananas and they are so good that you want to share them with a friend or family member who is living far away in

another province or even another country. What would you do? How could you make sure that the bananas arrive to this person unspoiled?

b. Consider other produce that is commonly grown in your area, e.g. mangos, passion fruit, avocados, etc. How might sending these fruits be different? Make a list of things that should be considered when sending different fruits.

c. Brainstorm with a partner and make a list of your ideas.

2. Prepare to share your thoughts with your trainer and your fellow trainees.

3. Refer to **2.1 Key Facts** and read them together as a class.

2.1 Key Facts

- **Different types of produce require different packaging.**

- **Important criteria for selecting packaging:**
  - Requirements of the produce, i.e. temperature, relative humidity, durability of the fruit.
  - Availability
  - Cost
  - Dimensions are suited for transport
  - Ease of filling, assembling, and collapsibility
  - Ventilation for produce
  - Ease of handling and transport
  - Capacity of container
  - Protection provided against vibration and impact
  - Visibility of produce for ease of identification/marketing
  - Suited for market demands

- **Materials commonly used in packaging:**
  - Woods and textiles
  - Paper and cardboard
  - Coated films

- **Types of packaging used for produce:**
  - **Wooden crates:** large capacity; reusable; good ventilation and visibility;
  - **Carton or fibreboard boxes**: Large capacity; good for round shaped produce; limited reusability; collapsible.

- **Plastic crates:** Well suited for domestic markets (inside Rwanda; provide excellent protection for produce; adequate ventilation; cooling; transport and storage
- **Woven Baskets** (bamboo or plastic): Good availability; low cost; reusable.

All reusable packaging should be cleaned on a regular basis with chlorinated water and detergent to reduce the chances of spreading decay from one load to the next.[10]

Guided Practice Activity

Topic 2.1 Task 3:

1. Your trainer will now divide your class into groups of three. Discuss among your groupmates the following imaginary scenario:

After packaging and sending some of your extra produce to friends a local fruit buyer notices your work and contacts you about growing your business. She can help sell your fruit to other provinces in Rwanda. You have prepared your farm for the next season to increase production but first you must also show that you can package your produce according to market standards.

a. In your group think of three horticulture crops i.e. fruits or leafy vegetables grown in your area and decide which ones you could consider growing in the future.

b. What packaging materials would be best for transporting them and why? (Consider that the packaging may be different depending on the produce.)

c. Discuss the pros and cons of your packaging selection.

d. Now consider how your packaging selection may change based on sending the various produce to different locations.

e. Would you choose a different package for sending produce to another country compared to sending it to another province?

f. It may help to think about how you prepare differently for different types of longer journeys to different locations. What challenges do you face and how do you prepare to overcome them?

[10] Food and Agriculture Organization of the United Nations. (n.d.). *Small-scale postharvest handling practices*. https://www.fao.org/3/ae075e/ae075e08.htm

2. Share your group's findings with the class.

3. Review **2.2 Key Facts** together as a class.

2.2 Key Facts

- **Other packaging requirements are determined by the distance of the journey and market: Domestic vs International**
  - Large amounts of produce are often sent in containers.
  - There are two types of containers:
    - Shipping containers: Used for very long journeys and should be covered in polyurethane films.
    - Field containers: Used for initial collection during harvest and provide convenience for shorter transportation but are not suitable for longer time intervals in between harvest and market delivery.
  - All containers should be cleaned on a regular basis with chlorinated water and detergent to reduce the chances of spreading decay from one load to the next.[11]

Application Activity

Topic 2.1 Task 4:

1. Your trainer will divide your class into several groups. You will act out the following role play scenario with the help of your trainer and fellow group members:

a. There are three roles: the fruit buyer, the farmer, and an observer.

b. Pick one person to play the farmer who will packages the fruit, another person to play the role of the fruit buyer, who will buy the fruit (only on the condition that it is in the correct packaging). Finally, the third group member observes the process and gives feedback at the end of the role play session.

c. Your trainer will provide your group with various fruits or vegetables and different types of packages.

d. Role play is as follows: The farmer should select the appropriate packaging for a particular piece of produce and then properly package it. The fruit buyer should

[11] Food and Agriculture Organization of the United Nations. (n.d.). *Small-scale postharvest handling practices*. https://www.fao.org/3/ae075e/ae075e08.htm

inspect the produce to ensure that the correct packaging is selected and will hold up during the journey according market standard. If the packaging is up to market standard the buyer makes an offer to the farmer based on quality standards covered in this topic. If not, the farmer must repackage the produce correctly. The observer should watch the two others in order to make sure both are role playing according to the standards addressed in the unit.

e. Once each group member has played a role the activity is finished.

2. Share a few observations and experiences from the role playing activity for the entire class in a group discussion.

Points to Remember

- Different produce requires different kind of protection and space when traveling.
- Price, durability, reusability and protection are key factor to consider while choosing the correct packages for different produce.
- For domestic markets, plastic crates provide excellent protection for produce and adequate ventilation during handling, cooling, transport, and storage.

Formative Assessment

Answer the following questions:

1. From the display of produce that your trainer has set up, select the incorrectly packaged produce and explain why it is not suitable for transportation.

2. List three of the most important criteria when selecting appropriate packaging for produce:

a. _____

b. _____

c. _____

3. Answer the following True/False questions. If true, write “true”. If false, write in the correct answer:

a. Plastic crates are a poor packaging option for the domestic market?

b. Containers are used to transport large quantities of produce?

c. When transporting containers to distant or international markets, a shipping container is usually used?

Topic 2.2: Packaging produce following requirements

Key Competencies:

Knowledge	Skills	Attitudes
1. Recognize conditions of individual packages such as filling capacity	**1.** Measure and fill accurately the quantity required for package	**1.** Diligent
2. Identify hygienic conditions of packages	**2.** Practice hygienic conditions measures while packaging	**2.** Accurate
3. Identify key aspects of labelling	**3.** Produce appropriate package labels	**3.** Creative

Getting Started: What do we know and where are we going?

Topic 2.2 Task 1:

1. Look at the illustration above and answer to the following questions:

a. What do you think is happening in the picture above?

b. What are the people wearing?

c. Why do you think they are wearing such uniforms?

d. Have you ever seen a scenario similar to this?

e. Describe where it was.

2. Share your answers with the rest of the class. Be sure to ask questions and add any information to other groups' ideas.

3. Refer to the Key Competencies table and review them together.

Problem Solving Activity

Topic 2.2 Task 2:

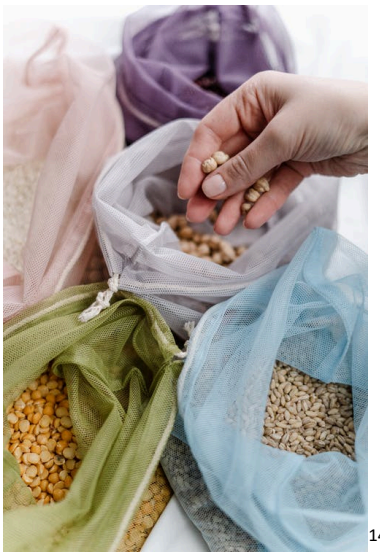
1. Read the following scenario carefully:

The Twongere Umusaruro cooperative in Kayonza district wants help training their employees. There are many new employees in coffee packaging who have never been trained in hygiene procedures. They want you to help make a training manual. Identify the images you think best show proper hygiene practices for coffee packaging. Pick five images and prioritize them from most to least important.

A	B
 [12]	 [13]

[12] Ring, D. (n.d.). *Hairnet* [Ink on paper]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Hairnet.jpg

[13] *Medical gloves* [Photograph]. (n.d.). PngImg. https://pngimg.com/download/81665

C  14	D  15
E  16	F  17

[14] Cottonbro. (2020, January 31). *Person holding corn on white plastic bag* [Photograph]. Pexels. https://www.pexels.com/photo/food-love-people-woman-3737693/

[15] *Sink* [Photograph]. (n.d.). Png Img. https://pngimg.com/download/37502

[16] *Rice, the bag, plastic, packaging, agriculture* [Photograph]. (n.d.). Pikist. https://www.pikist.com/free-photo-vctgr

[17] *Farmers of Twongere Umusaruro Cooperative weighing their produce* [Photograph]. (2019). The New Times Rwanda. https://www.newtimes.co.rw/news/coffee-farmers-falling-prices

G	H
 [18]	 [19]

List five images you think are most important to include in a training manual on hygiene and explain why:

1. _____

2. _____

3. _____

4. _____

5. _____

Now list three more ideas of you own for images that would best express proper hygiene on a packaging line:

1. _____

2. _____

3. _____

2. Turn to a partner and share your ideas.

3. Share your findings with the rest of the class.

4. Refer to **2.3 Key Facts** and read them together.

[18] Barthdqp. (2011, November 28). *Squat toilet* [Photograph]. Wikipedia. https://en.wikipedia.org/wiki/File:Squattoilet.jpg

[19] Brandenburg, F. (2014, March 12). *Dirty shoes* [Photograph]. Pixabay. https://pixabay.com/photos/shoes-mud-dirty-beach-ebb-tides-285986/

2.3 Key Facts

- **Package hygiene:**[20]
  - All packaging materials should be made of food contact grade materials.
  - Empty packages, such as boxes and plastic bags should be stored in an enclosed storage area
  - Potential sources of contamination: insects, rodents, dust, dirt and water

- **Employee hygiene:**
  - Gloves
  - Hairnets
  - Clean smocks
  - Adequate bathroom facilities
  - Hand wash stations
  - Shoe or boot cleaning stations
  - Employees should have training regarding sanitary food handling practices

- **Modified atmosphere packaging (MAP):**[21]
  - Used for packaging small quantities of roasted consumer coffee.
  - Keeps oxygen levels low which help maintain the quality of fresh produce and extend shelf-life.
  - Check valve after packing but before sealing by squeezing bag and top together forcing oxygen rich air to escape.

- **Filling:**[22]
  - Packaging should be filled accurately according to quantity or weight
  - Look to the label for the product's quantity.
  - Smaller consumer packaging requires accurate weighing scales.
  - Larger packaging for wholesale usually have maximum requirements.
  - Maximum requirements must be followed in order to avoid package failure or damage to the produce.

- **Labelling purpose:**
  - helps handlers to keep track of the produce as it moves through the postharvest system

[20] Food and Agriculture Organization of the United Nations. (n.d.). *Chapter 4: Packing and packaging materials*. https://www.fao.org/3/ae075e/ae075e23.htm
[21] Food and Agriculture Organization of the United Nations. (n.d.). *Chapter 4: Packing and packaging materials*. https://www.fao.org/3/ae075e/ae075e23.htm
[22] Food and Agriculture Organization of the United Nations. (n.d.). *Small-scale postharvest handling practices*. https://www.fao.org/3/ae075e/ae075e08.htm

- assists wholesalers and retailers in using proper practices.

- **Types of labels:**
  - pre-printed on fibreboard boxes
  - glued
  - stamped
  - stencilled on to containers

- **Brand labelling packages:**
  - Aids in advertising for the product's producer
  - Communicate details about storage methods or recipes for consumers.

- **Common information found on shipping labels:**
  - Common name of the product.
  - Net weight, count and/or volume.
  - Brand name.
  - Name and address of packer or shipper.
  - Country or region of origin.
  - Size and grade.
  - Best before date.
  - Recommended storage temperature.
  - Special handling instructions.
  - Names of approved waxes and/or pesticides used on the product.

- **Labelling of consumer packages:**
  - Is mandatory under many national and international regulations.
  - Must contain the name of the product
  - Must contain net weight
  - Must contain name and address of the producer, packer, or distributor[23]

[23] Center for Food Safety and Applied Nutrition: Food and Drug Administration. (2013, January). *A food labeling guide*. U.S. Food and Drug Administration. https://www.fda.gov/media/81606/download

Guided Practice Activity

Topic 2.2 Task 3:

1. Your task is to create a label according to the following scenario:

Twongere Umusaruro cooperatives in Kayonza district pays an exporter fee when selling their coffee abroad. They have decided that they want to gain more money by exporting their washed unroasted coffee bean product themselves. They plan to use 50kg bags but their buyers are complaining that they have no way of identifying the cooperative's product or to distinguish between different types of coffee beans. For example, beans from the Nyampinga plantation are selling for a price of 600rwf per kg while the Kayonza plantation product only fetches 400Rwf per kilo. All coffee produce is high grade Arabica bean. The cooperative needs your help in designing an appropriate label for their coffee.

2. Design and draw your label in the space provided below. You may want to consider the following:

- The contents of the package
- where the coffee is being sold
- Price
- Brand.
- If the label is appealing and helps sell the coffee

3. After you are finished, you will have the chance to present your work to the rest of the class.

Twongere Umusaruro Cooperative

4. For the next lesson you should look for examples of packaging and labels which you think are good. Collect these examples or take a photo of them using a mobile phone. Bring them to your next class.

Application Activity

Topic 2.2 Task 4:

Your trainer will organise a field visit to a coffee packaging house, cooperative, or station in the district where you live.

1. Observe while a worker in the group demonstrates the following aspects of coffee packaging related operations.
   a. Hygiene practices: both employee hygiene and package hygiene inspection.

   b. Correctly filling and weighing packaged products.

   c. Seal and label packages correctly (if applicable).

2. After observing the demonstration of how coffee is correctly packaged, perform the packaging yourself.
   a. Practice hygienic procedures before, during, and after working on the jobsite.

   b. Inspect packaging before filling to prevent contamination.

   c. Pay special attention to fill capacities and amounts.

   d. Practice measuring the correct amount of product and filling the package accordingly to ensure that the correct amount is included.

   e. Seal and label the package correctly (if applicable).

3. At the end of the activity, you should have the chance to interview a worker from the packaging house or station. Be sure to ask as many details concerning packaging as you need to.

4. Finally, after your field visit your trainer will follow up with the label and packaging collection from the previous activity.

5. Share your labels and packaging with your trainer and fellow trainees and describing why you believe it is a good example.

Points to Remember

- Practice good hygiene techniques before, during, and after working on a jobsite: washing hands, wearing a hairnet and gloves, and cleaning boots can all prevent package contamination.
- Labels have a variety of functions such as indicating important information e.g. price, quantity, and brand.
- Labels may require extra information depending on if the produce is being sold to an international market.

Formative Assessment

1. Answer the following True/False questions. If true, write “true”. If false, write in the correct answer:

a. Modified atmosphere packaging (MAP) is used for packaging large quantities of wholesale coffee.

b. Labels usually indicate the quantity of product included in the package.

c. Labels can help increase the chance that a product is sold.

d. You should always pack as much produce into a package as the label shows, to ensure that consumers feel they are getting a good product.

Topic 2.3: Identification of cooling methods

Key Competencies:

Knowledge	Skills	Attitudes
1. Outline cooling methods at the small scale farm level	**1.** Apply cooling methods to ensure the good quality of produce	**1.** Methodical
2. Describe a Zero-Energy Cooling Chamber (ZECC)	**2.** Use a Zero-Energy Cooling Chamber (ZECC) to preserve produce quality	**2.** Attentive
3. Explain a room cooling system	**3.** Use a room cooling system to maintain the freshness of produce	**3.** Detail-oriented

Getting Started: What do we know and where are we going?

Topic 2.3 Task 1:

1. Look at the illustration above and respond to the following questions:

a. What do you think is happening in the illustration?

b. Have you ever seen a similar situation in real life?

c. Make a prediction about what this topic will be about.

2. Share your thoughts with the rest of the class.

3. Refer to the Key Competencies table and review it together.

Problem Solving Activity

Topic 2.3 Task 2:

1. Read the following scenario and respond to the questions:

Kamana is a farmer in your neighbourhood who has ventured into farming of tomatoes and his crops have yield a good harvest. However, after negotiating at the market and local restaurants he has only managed to sell off half of his harvest. Now he is afraid that his remaining harvest may be lost if nothing is done.

2. Brainstorm with your assigned group: What should Kamana do in order to prevent the loss of his unsold tomato harvest?

3. Read **2.4 Key Facts** and recommend a cooling system for Kamana.

4. Follow the trainer's instructions for a group activity in which you will share your ideas with the other trainees.

2.4 Key Facts

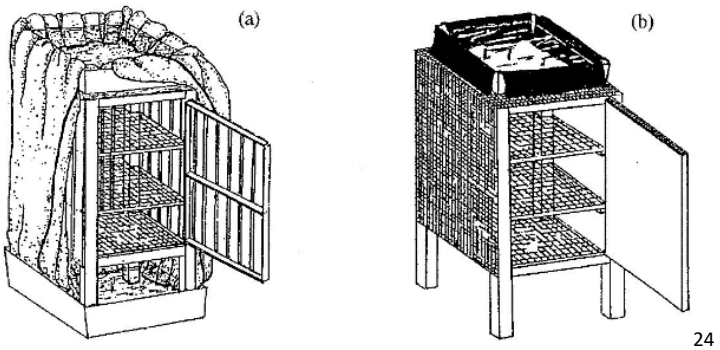
- **Cooling methods at the small scale farm level**

- **Room cooling**: Produce is simply loaded into a cold room, and cold air can circulate among the stored produce.
  - Low cost
  - Store in vented boxes when possible
  - Best suited for cured produce: potatoes, onions, apples, sweet potatoes, citrus fruits
  - Cools too slowly for highly perishable crops

- **Forced-air cooling**: Mechanical system forces cold air over produce.

- Fast cooling rate
- Most reliable cooling method
- Requires constant supply of electricity

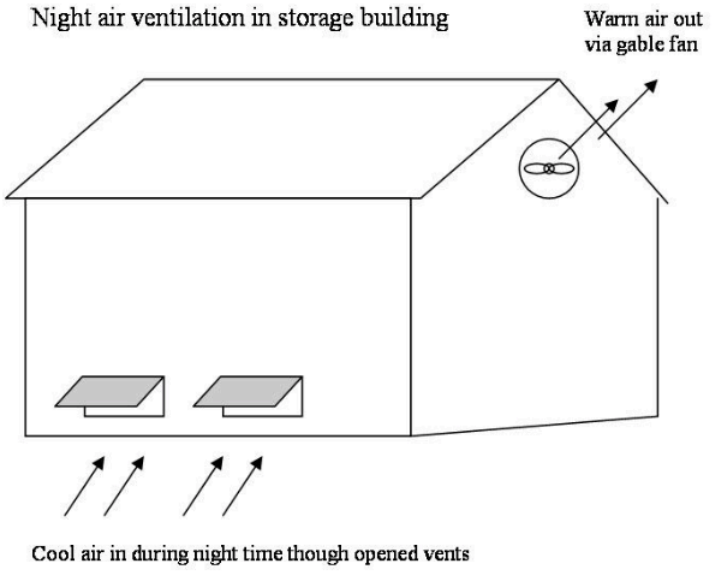
- **Hydro-cooling:** Uses cold water to cool produce.
  - Provides fast, uniform cooling for some commodities.
  - The commodity and packaging materials must be able to stand wet conditions.
  - Simplest versions include a tank of cold water in which produce is immersed.
  - Elaborate systems utilize water pumps, jets and conveyor belts.



[24]

- **Evaporative cooling**: When water is naturally dried from materials by the sun.
  - Wetting the walls and roof of a storage facility in the morning creates conditions for evaporative cooling.
  - Evaporative coolers can be constructed to cool the air in an entire storage structure or just a few containers of produce. e.g. diagram a) a rack standing in a galvanized iron pan of water with another pan of water on top and sides and top covered with jute sacks kept wet by dipping their top and bottom edges into the pans of water.
  - Best suited to lower humidity regions.
  - Degree of cooling is limited to 1 to 2 C (2 to 4 F) below ambient temperature.
  - A cooling pad of wood fibber or straw can be moistened and air pulled through the pad using a small fan.
  - Evaporative cooler and forced air coolers can be combined.

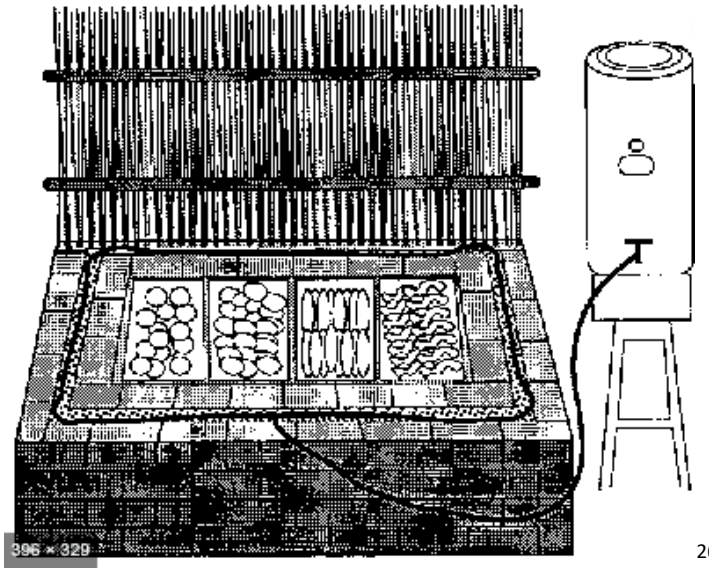
[24] Acedo, A. L. (1997). *Storage life of vegetables in simple evaporative coolers* [Sketch]. Food and Agriculture Organization of the United Nations. http://www.fao.org/3/ae075e/ae075e140.jpg



25

- **Night air ventilation**: Storage structures can be cooled using night air if the difference in day and night temperature is relatively high.
  - The storage facility should be well insulated, and vents should be located at ground level.
  - Vents can be opened at night, and fans can be used to pull cool air through the storeroom.
  - Air is cooled during the night-time though opened vents.
  - The structure will best maintain cool temperatures during the heat of the day if it is well insulated and vents are closed early in the morning.

[25] Food and Agriculture Organization of the United Nations. (n.d.). *Night air ventilation* [Sketch]. http://www.fao.org/3/ae075e/ae075e143.jpg



[26]

- **Zero- Energy Cool Chamber/Charcoal cooler (ZECC):** is a small chamber made out of bricks and sand where farmers can store freshly harvested produce before it is transported to market.
  - The low cost cooling chamber.
  - Appropriate when handling high value products and highly perishable produce.
  - Very practical for places which do not have stable electrification.
  - A cavity between the walls is filled with sand and the bricks and the sand is kept saturated with water.
  - Fruits and vegetables are loaded inside, and the entire chamber is covered with a rush mat, which is also kept moist.
  - Relatively large amounts of materials are required to construct this cold storage chamber.[27]

[26] Roy, S. K. (1989). *Postharvest technology of vegetable crops in India* [Sketch]. http://www.fao.org/3/ae075e/ae075e142.gif

[27] Food and Agriculture Organization of the United Nations. (n.d.). *Chapter 6: Temperature and relative humidity control*. https://www.fao.org/3/ae075e/ae075e13.htm#room_cooling

Guided Practice Activity:

Topic 2.3 Task 3:

1. Read the following scenario and determine which cooling system is appropriate for the cured produce and which one is appropriate for the highly perishable produce using the questions bellow:

Kamana has decided to keep the other half of his tomato harvest by cooling it using a Zero Energy Cooling Chamber (ZECC). However, when transporting them, the driver has mixed all his tomatoes with other crops and now cannot remember which produce should be placed in the ZECC and which ones can be cooled using a simple room storage method.

Kamana's tomatoes	sweet potatoes
onions	lettuce
bell peppers	potatoes

2. Your task is to guide the driver by showing him which produce should go in which cooling system.

a. Write the produce which should be cooled in the ZECC.

Example: tomatoes

_____

b. Write the produce to be cooled in the cool room storage.

_____

Application Activity:

Topic 2.3 Task 4:

1. With the help of your trainer arrange a field visit to a farm which harvests both highly perishable and cured produce.

2. You should gain practical experience on how to operate a ZECC as well as how to cool the appropriate produce in a cool room storage facility.

3. With your partner, make a list of similarities and differences between the two cooling methods: a ZECC and cooling room.

4. Share your list with your fellow trainees and the trainer.

5. After your field visit is complete, take time to reflect on how your new knowledge could help you become employed in the future. For example:
   a. Are there any farmers in your area who grow highly perishable crops?

   b. Are they using proper cooling methods to ensure that they are selling the majority of their harvest?

   c. How might your new knowledge about cooling methods help fill a need in the production of crops in your area and create greater value?

Points to Remember

- Zero Energy Cooling Chamber (ZECC) is cooling chamber constructed from bricks and is suitable for highly perishable produce.
- Cool room storage is the simplest cooling method but does not provide adequate cooling for highly perishable produce.

Formative Assessment

1. Answer the following True/False questions. If true, write "true". If false, write in the correct answer:

   a. Potato crops will deteriorate quickly if not adequately cooled directly after harvest.

   b. Highly perishable produce such as tomatoes can be cured in a dry, cool room.

   c. Simplest versions of hydro coolers include a tank of cold water in which produce is immersed.

   d. Forced air cooling is the least reliable cooling method

   e. Night air ventilation storage structures can be cooled using night air if the difference in day and night temperature is relatively low.

2. Fill in the blank:

a. A ZECC is very practical for places which do not have stable _____.

b. _____is a method best suited for produce such as such as potatoes, onions, apples, sweet potatoes, and citrus fruits.

Self-Reflection

1. You have come to the end of the unit. You are going to do the survey you did at the beginning of the unit again to help you do self-assessment of your knowledge, skills and attitudes.

Again, there are no right or wrong answers to this survey. It is for your own use to gauge your knowledge, skills and attitudes after the unit. Read the Knowledge, Skill or Attitude in the left column. Think about yourself: do you think you can do this? How well? Read the statements across the top. Put a check in column that best represents your situation.

My experience **Knowledge, skills, and attitudes**	**I don't have any experience doing this.**	**I know a little about this.**	**I have some experience doing this.**	**I have a lot of experience with this.**	**I am confident in my ability to do this.**
Explain the requirements of packaging and its functions					
Describe different types of packaging materials for agriculture produce					
List criteria for selecting a packaging					
Select appropriate package materials according to market requirements					
Use appropriate packaging materials to maintain the quality of produce					
Apply criteria when selecting packaging					
Recognizes conditions of individual packages such as filling capacity					

My experience Knowledge, skills, and attitudes	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Identify hygienic conditions of packages					
Identify key aspects of labelling					
Measure and fill accurately the quantity required for the package					
Practice hygienic conditions measures while packaging					
Produce appropriate package labels					
Outline cooling methods at small scale farm level					
Describe a Zero-Energy Cooling Chamber (ZECC)					
Explain a room cooling system					
Apply cooling methods to ensure good quality of produce					
Use a Zero-Energy Cooling Chamber (ZECC) to preserve produce quality					
Use a room cooling system to maintain the freshness of produce					

2. Complete the table below by identifying areas from the unit where you have improved and where you need improvement with the actions/strategies you will use to help you improve when receiving and interpreting information at the workplace.

Areas of strength	Areas for improvement	Actions to be taken to improve
1.	**1.**	**1.**
2.	**2.**	**2.**

Unit 3: Storage

Topics

3.1 Cleaning of storage rooms

3.2 Identification of storage methods

3.3 Selection of storage materials

3.4 Storage of produce

Unit Summary:

This unit describes the knowledge, skills, and attitudes required to perform storage. At the end of this unit, trainees will be able to clean storage rooms following guidelines and instructions, identify storage methods following requirements, select and acquire storage materials according to the size of store, crop product and recommended storage conditions and store produce following guidelines and requirements.

Self-Assessment: Unit 3

1. Look at the unit illustration above. What is happening? What do you think this unit will be about?

2. Fill in the self-assessment below.

There are no right or wrong ways to answer this assessment. It is for your own use during this course. Think about yourself: do you think you can do this? How well? Read the statements across the top. Put a check in column that best represents your situation. At the end of this unit, we'll take this assessment again.

My experience Knowledge, skills, and attitudes	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
State the tools and materials used for cleaning and maintaining storage rooms					
Describe how to clean and maintain the storage rooms					
Describe how to maintain the storage structure					
Use different tools and materials to clean and to maintain storage rooms					
Remove trash and infected produce from storage room					
Produce rat guards, check screens, and floors					
State criteria for selecting storage methods					
Describe different storage methods for different crops					
Explain bulk and field storage					
Select storage methods based on criteria					
Select storage methods for different crops.					

My experience Knowledge, skills, and attitudes	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Distinguish between when to use bulk storage and field storage					
List main materials available in storage					
Describe materials used in storage					
Explain the use of storage material					
Select storage materials					
Use storage materials					
Handle storage materials					
Describe general requirements for good storage					
Recognize need for quality control					
Explain procedures for receiving, storing and withdrawing produce from storage					
Apply requirements for good storage					
Perform quality control for different crops					
Apply guidelines for storing produce					

Topic 3.1: Cleaning of storage rooms

Key Competencies:

Knowledge	Skills	Attitudes
1. State tools and materials used for cleaning and maintaining storage rooms	**1.** Use different tools and materials to clean and to maintain storage rooms	**1.** Methodical
2. Describe how to clean and maintain the storage rooms	**2.** Remove trash and infected produce from storage room	**2.** Precise
3. Describe how to maintain the storage structure	**3.** Produce rat guards, check screens, and floors	**3.** Detail-oriented

Getting Started: What do we know and where are we going?

Topic 3.1 Task 1:

1. Reflect upon the following:

a. Think of a storage facility in your neighbourhood or area.

b. Have you ever been inside of it? What did it look like?

c. What was it used for and what products did it store?

d. List some reasons why produce might be kept in storage facilities?

2. Refer to the Key Competencies table and review it together.

Problem Solving Activity

Topic 3.1 Task 2:

1. Think of a time when you had to clean up your house or another place and briefly discuss with a partner:

a. What steps did you have to take to make sure the house was clean?

b. What tools or cleaning supplies did you use?

c. What kinds of things did you have to remove from the house to make sure it stayed clean?

2. Based on your previous experience, brainstorm a list of potential problems that could occur when storing large amounts of grain in one room. Try to think of at least five.

3. Discuss as a class: How could these problems be overcome?

4. Refer to **3.1 Key Facts**. Read the information together.

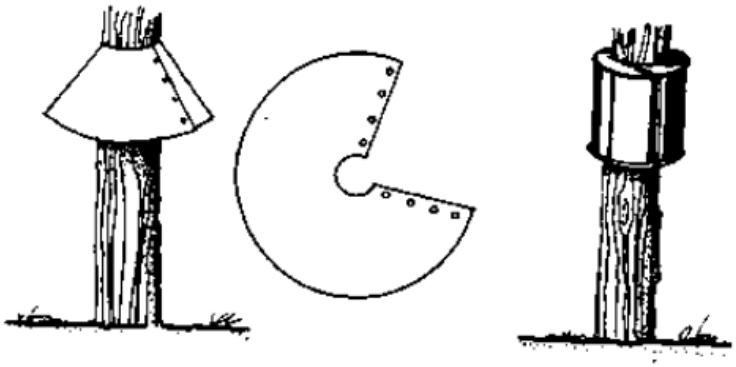
3.1 Key Facts

- **Sanitation:** It is crucially important to reduce the initial pest population and prevent development of any insect pests in the crop products. Before bringing a new crop into store, the following steps are necessary:
  - Separate and remove any infested material during harvest.
  - Do not mix new grain with old
  - Old material that must be kept should be thoroughly fumigated.
  - Brush away all traces of spilled grain, dust, etc.
  - Remove dust from handling equipment and machinery.
  - Disinfect sacks and baskets by sunning or chemical treatment.[28]

[28] Food and Agriculture Organization of the United Nations. (n.d.). *Prevention of post-harvest food losses*. https://www.fao.org/3/x0039e/X0039E05.htm

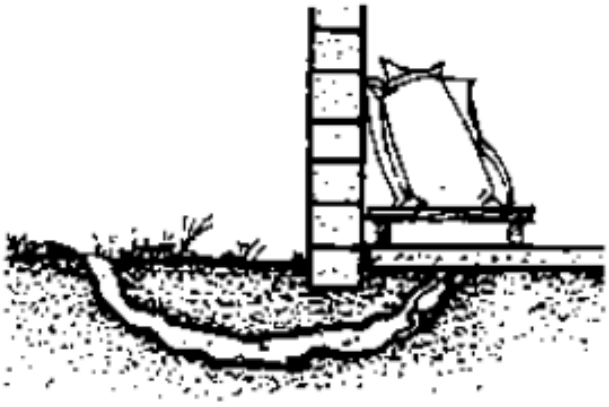
- **Structure size:** The size of the storeroom will determine cleaning maintenance procedures.
  - Large structures usually require chemical treatment
  - Small rural structures can be cleaned by using smoke and making use of the sun.
  - Take control measures early to prevent infestation of crops maturing in the field.[29]

- **Rat guards**: Can be made from simple materials such as old tin cans or pieces of sheet metal fashioned to fit the extended legs of storage structures.[30]



[31]

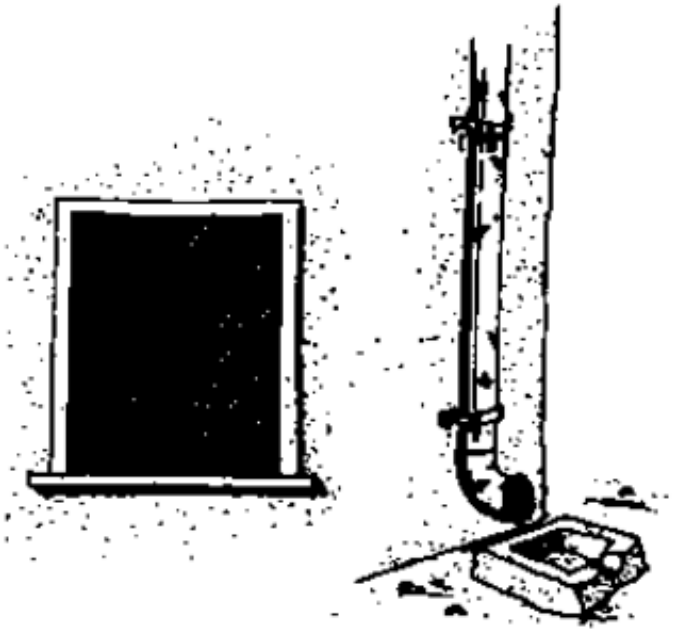
- **Concrete floors:** will help prevent rodent entry. However, floors must be checked to ensure there are no cracks.



[32]

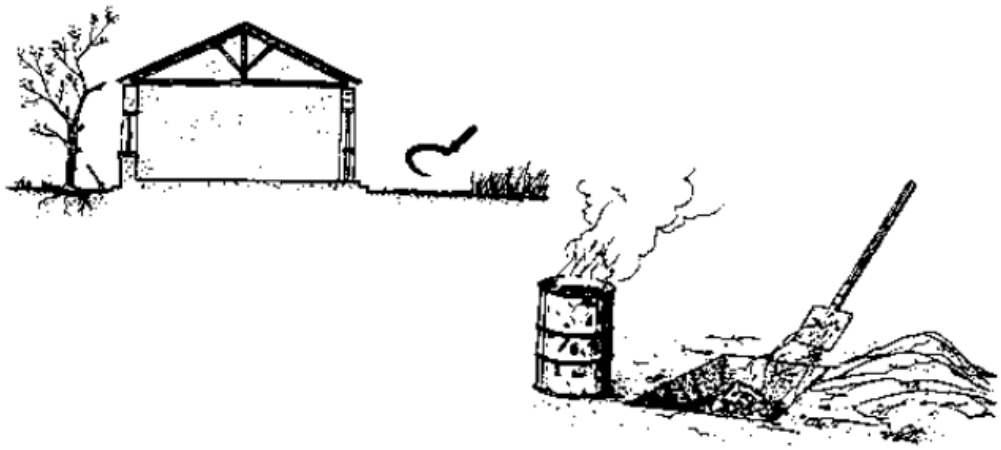
[29] Food and Agriculture Organization of the United Nations. (n.d.). *Prevention of post-harvest food losses*. https://www.fao.org/3/x0039e/X0039E05.htm
[30] Food and Agriculture Organization of the United Nations. (1985). *Chapter 7: Storage of horticultural crops*. https://www.fao.org/3/ae075e/ae075e16.htm
[31] FAO. (1985). *Rat guards* [Sketch]. http://www.fao.org/3/ae075e/ae075e157.gif
[32] FAO. (1985). *Cement floors* [Sketch]. http://www.fao.org/3/ae075e/ae075e159.gif

- **Window, screens and drains:** also represent easy entry points for insects and rodents and should be checked regularly to ensure that no holes or gaps are left open.



[33]

- **Storage practices:** Inspecting stored produce and cleaning storage structure and surrounding area on a regular basis will help:
  - Reduce losses.
  - Discourages spread of diseases.
  - Removing waste can reduce the chance that pests are attracted to the storage facility.



[34]

[33] FAO. (1985). *Screens* [Sketch]. http://www.fao.org/3/ae075e/ae075e158.gif
[34] FAO. (1985). *Remove trash and weeds* [Sketch]. http://www.fao.org/3/ae075e/ae075e156.gif

Guided Practice Activity

Topic 3.1 Task 3:

1. You will perform a practical exercise related to storage room maintenance according to the following scenario:

   A grain storage room in your neighbourhood has an infestation of rodents and they need your help! You and your fellow trainees should take measures to rat proof the structure.

2. Your task is to:
   a. Make several rat guards and place them on the table legs of your training centre to ensure that no rats can access the grain stored on the tables.

   b. Check all other entry points in your classroom to ensure that no rats can enter from any other points.

   c. When you have completed your list of potential entry points, make recommendations on how rat infestation could be reduced.

3. Refer to **3.1 Key Facts** for guidance and observe the trainer's demonstration. Prepare to share your points with the rest of the trainees and trainer.

4. Volunteer to share your findings.

Application Activity

Topic 3.1 Task 4:

1. Visit a storage facility in your neighbourhood or surrounding area to verify the knowledge you have gained from the previous practical experience. Your task it to carefully observe how the storage room is maintained by staff. You may need to ask questions to staff when they are available.

2. Take special note of any details that may arise around the following questions:
   a. What is the size of the storeroom?
   b. How is waste removed?
   c. Locate any points of entry such as windows, drains, and screens. Are they protected?

d. Are rat guards in use?

e. Do the staff disinfect the storage room? How?

f. How do the staff start their work each day and how do they end it?

g. How are staff certain that their work or task is finished, for example cleaning floors or fumigating grain?

h. How often do staff clean the surrounding area of the storage facility?

3. Organise these key observations present your findings to the rest of your fellow trainees and trainer.

4. Reflect on how these observations could help you if you were to start working at a storage facility in the future, or how they could lead to any other possible opportunities. For example, if the storage facility did not use rat guards, could the rat guards be sold and installed for a profit?

Points to Remember

- When inspecting stored produce, any spoiled or infected produce should be removed and destroyed.
- Do not mix new grain with old; old material that must be kept should be thoroughly fumigated.
- Take control measures early to prevent infestation by covering drains windows and all entry points of the facility.

Formative Assessment

1. True or false: Answer the following questions. If true, write "true." If false, write in the correct answer:

a. Do not mix new grain with old; old material that must be kept should be thoroughly fumigated.

b. Inspecting stored produce, cleaning the storage structure, and the surrounding area on a regular basis will help spread disease.

2. Fill in the blank:

a. Large structures usually require _____.

b. Small rural structures can be cleaned by using _____ and making use of the sun.

Topic 3.2: Identification of storage methods

Key Competencies:

Knowledge	Skills	Attitudes
1. State criteria for selecting storage methods	**1.** Select storage methods based on criteria	**1.** Precise
2. Describe different storage methods for different crops	**2.** Select storage methods for different crops	**2.** Self-confident
3. Explain bulk and field storage	**3.** Distinguish between when to use bulk storage and field storage	**3.** Precise

Getting Started: What do we know and where are we going?

Topic 3.2 Task 1:

1. With a partner reflect upon the following:
   a. Have you ever had to keep something safe and secure, for example money, a possession, or maybe a bit of food? If so, how did you do it?

   b. Now imagine if you were paid to keep a large amount of such items safe. How would you go about doing this?

   c. How would different items determine what you would do to keep them safe?

2. Refer to the Key Competencies table and review it together.

Problem Solving Activity

Topic 3.2 Task 2:

1. Find a partner and perform a role play using the following roles:
   a. One of you is a small scale farmer producing bulb crops, who is not totally familiar with various storage systems or the cost of storing produce.

b. The other is a bulk storage facility manager at Matima Store Warehouse.

2. Next read the objectives for each role:

a. As a small scale farmer, you want to store your crops but are not sure if the storage facility will meet your needs. Ask the manager as many relevant questions as you possible can to see if their storage facility can adequately store your harvested crops.

b. As a storage manager you want to store the famers crops and be paid. However, you must present your facility as having the capacity to meet the needs of the farmers' harvest. Think of how you would present your storage facility so that the farmer agrees to pay for storage.

3. Role play the scenario until an agreement is met or it is determined that the storage facility does not meet the needs. It may help to organise the role play around the following aspects:

- The hygiene and maintenance procedures of the facility.
- The cost of storage
- The size of containers and ability to move them.
- Ventilation
- Specific requirements of the crops
- The quantity of crops

4. After you have finished your role play, your trainer will pair you and your partner with another pair, making a group of four, and assign your group a section of **3.2 Key Facts**.

5. After your group has finished reading the Key Facts, discuss how you would make your role play decisions differently.

6. Finally, your trainer will facilitate a discussion where each group presents their section of **3.2 Key Facts** and their brief reflection on how it affected their role playing decisions.

3.2 Key Facts

- **Storage Criteria:** Storage methods should be determined by
  - Cost of storage
  - Quantity of crop needing to be stored
  - Requirement of each crop

- **Requirements for crops:** Each crop requires different storage conditions.

- **Perishable crops:**
  - Need substantially lower temperatures to retain moisture
  - Have large unit size, typically 5 g to 5 kg
  - Have high to very high respiration rate
  - Have natural shelf life of a few days to several months
  - Losses usually caused by rotting (bacteria, fungi), senescence, sprouting. and bruising

	Temp (°C)	RH (%)	Potential storage life
Apples	-1° - 4 °	90-95	1-12 months
Avocado	7 °	85-95	2 weeks
Bananas (green)	13 ° - 14 °	90-95	14 weeks
Carrots	0 °	95-100	2 weeks-9months
Mushrooms	0 °	85-95	34 days
Pineapple	7° - 13 °	85-90	24 weeks
Tomatoes	13° - 15°	90-95	4-7 days

- **Storage of dried and bulb crops:**
  - Store in low humidity
  - Pungent types of onions have high soluble solids and will store longer than mild or "sweet" onions, which are rarely stored for more than one month.
  - For long term storage, onions are generally sprayed with maleic hydrazide (MH) a few weeks before harvest to inhibit sprouting during storage.[35]

[35] Food and Agriculture Organization of the United Nations. (n.d.). *Chapter 7: Storage of horticultural crops*. https://www.fao.org/3/ae075e/ae075e18.htm

	Temp (°C)	RH (%)	Potential storage life
Onions	0-5 °	65-70	6-8 months
	28°-30 °	65-70	1 month
Garlic	0	65-70	6-7 months
	28-30°	82-86	1month

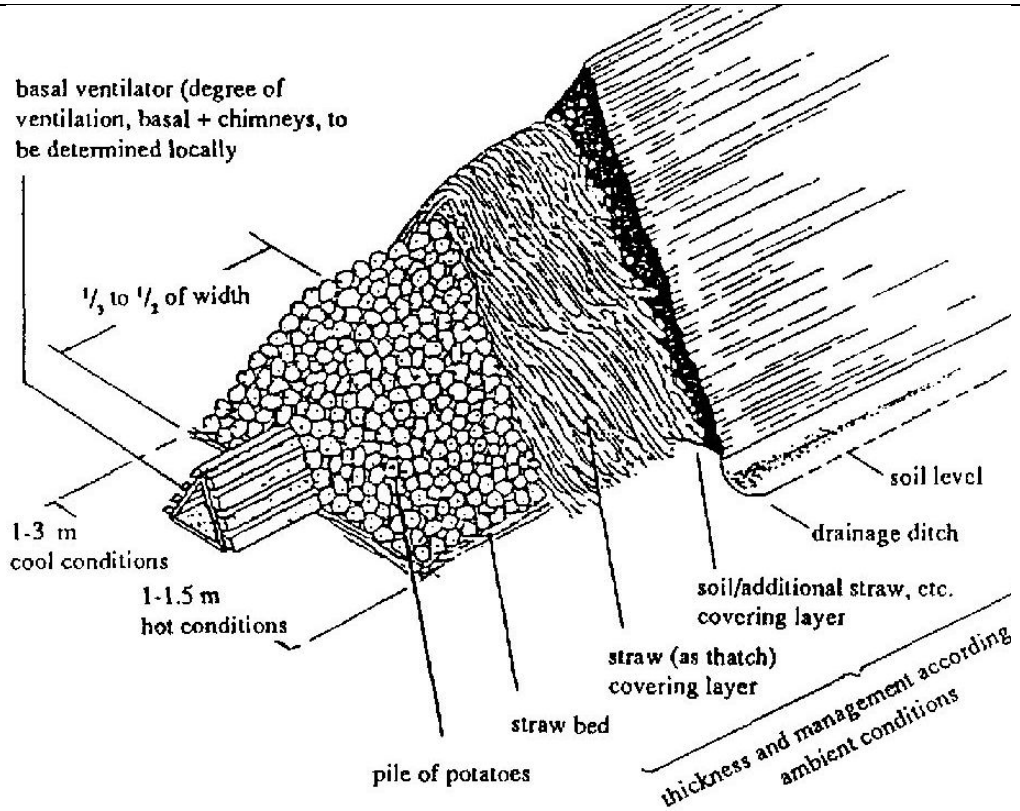
- **Storage of potatoes:**[36]
  - Potatoes for processing are best kept at intermediate temperatures to limit the production of sugars which darken when heated during processing.
  - Potatoes meant for consumption must also be stored in the dark, since the tubers will produce chlorophyll (turning green) and develop the toxic alkaloid solanine if kept in the light.
  - Potatoes stored for use as "seed" are best stored in diffuse light
  - The chlorophyll and solanine that accumulate will aid to protect the seed potatoes from insect pests and decay organisms.

	Temp (°C)	RH (%)	Potential storage life
Potatoes:			
Fresh Market	4-7 °	95-98	10 months
Processing	8°-12 °	95-98	10 months
Seed potatoes	0-2°	95-98	10 months
Cassava	5-8°	80-90	2-4 weeks
Cassava	0-5°	85-95	1-2 months
Sweet potatoes	12-14°	85-90	6 months

- **Field storage:** Underground field storage is an inexpensive and effective way to store crops if transportation is not immediately available or practical after harvest.

- **Potato clamp:** a field storage clamp is a low cost technology that can be designed using locally available materials for ventilation and insulation

[36] Food and Agriculture Organization of the United Nations. (n.d.). *Chapter 7: Storage of horticultural crops*. https://www.fao.org/3/ae075e/ae075e18.htm



- Employs a wooden ventilator box and straw for insulation at the bottom of the clamp.
- The entire pile of potatoes and straw is covered with a layer of soil, which should not be highly compacted.
- To reduce heat gain, locate the field clamp in the shade (under a tree, on the cool side of a building, or under a tarp shade.)

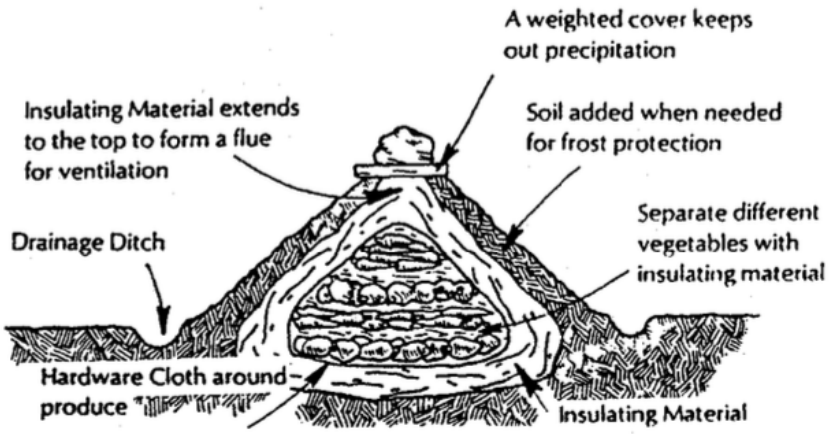
- **Simple storage houses**: this simple storage house for potatoes can be constructed for small quantities of produce.

  The examples provided here can store 1 to 2 metric tons, practical for farms in mountain villages.

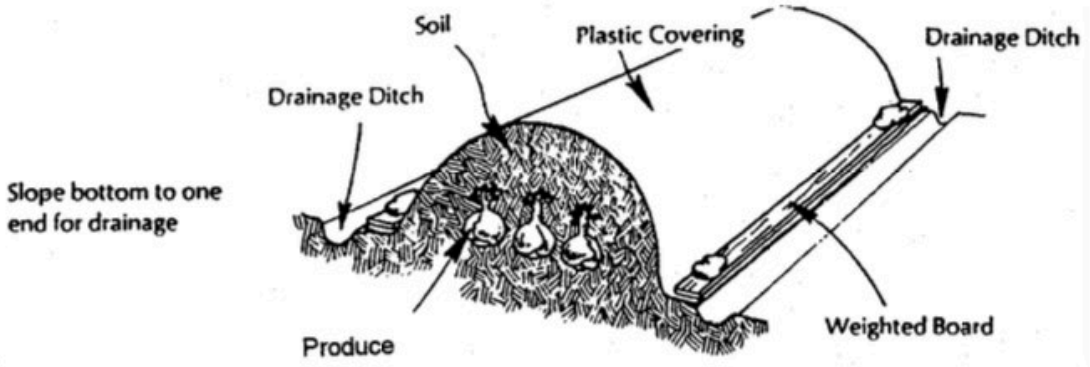
  - made from unfinished wooden planks painted white to reduce heat accumulation from the sun and
  - covered with a large thatched roof for protection from sun and rain.

  - It has a large door on one side for loading and unloading.

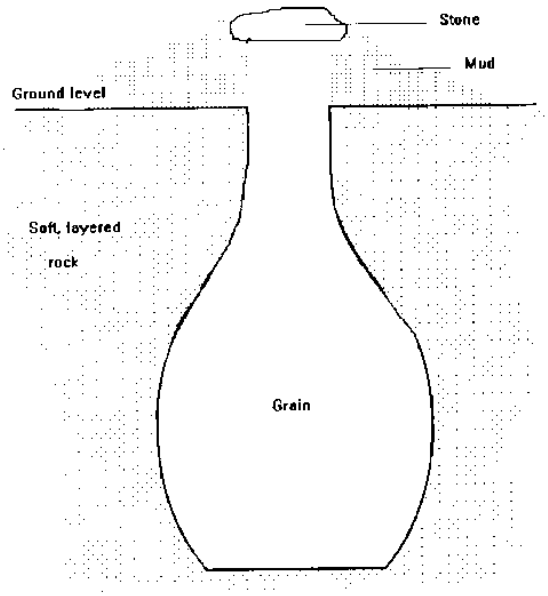
- **Pit Storage:** Can store different kinds of produce as long as they are separated by insulating materials.



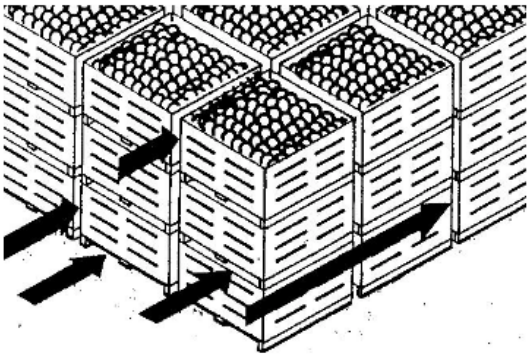
- **Trench storage:** can be useful if transportation for the crops from the field is not immediately available



- **Modified atmosphere and Hermetic storage:**
  - Sealed storage systems for grains are placed inside an airtight container
  - The seal stops oxygen and water movement between the outside atmosphere and the stored grain.
  - Natural biological processes use up oxygen killing unwanted pests



- **Bulk storage:**
  - For bulk storage of onions or garlic, ventilation systems should be designed to provide air into the store from the bottom of the room.
  - If produce is in cartons or bins, stacks must allow free movement of air.
  - Rows of containers should be staked parallel to the direction of the flow of air and be spaced 15 cm to 17 cm apart.
  - An adequate air supply must be provided at the bottom of each row and containers must be properly vented.[37]



[38]

[37] Food and Agriculture Organization of the United Nations. (1985). *Chapter 7: Storage of horticultural crops*. https://www.fao.org/3/ae075e/ae075e16.htm

[38] All images from Food and Agriculture Organization of the United Nations. (n.d.). *Chapter 7: Storage of horticultural crops*. https://www.fao.org/3/ae075e/ae075e18.htm

Guided Practice Activity

Topic 3.2 Task 3:

1. With the help of your trainer, your group will perform a community mapping activity to help identify different storage methods used in your area.

2. In your group, choose an area that you are all familiar with and brainstorm a list of as many farms and storage facilities as you can, keeping in mind where they are located.

3. Note what produce is grown at each farm, as well as what methods are used to store the produce.

4. Beginning with one of the locations you have listed, draw the important features of the surrounding community such as:
   a. Infrastructure: roads and building
   b. Geological features: rivers, hills, valleys
   c. Agricultural sites: fields, plantations
   d. The school (if in the area)
   e. Your home (if in the area)

5. Add the farms and storage locations from your brainstormed list, indicating where the produce is grown and what methods are used to store them.

6. Once your group has finished, the entire class will share their maps.

7. A discussion will be conducted around the following points:
   a. How many farms and storage facilities are present on your map?

   b. What relationships did you notice between where the farms and the storage facilities are located?

   c. How many of each method of storage facilities were identified on your map?

   d. What relationships did you notice between what the farms grew and what storage method was used in the area?

8. Once the discussion is concluded, reflect on how the community mapping activity could help you identify potential existing workplaces or an opportunity to create a new storage site where there currently is none.

Note: It may help to use an existing physical map of your neighbourhood or other digital map resources.

Application Activity

Topic 3.2 Task 4:

1. Your class will visit a storage facility (or multiple facilities or field storage sites) in your neighbourhood or surrounding area to verify the knowledge you have gained from the previous practical experience. Your task is to carefully identify which methods are being used. You may need to ask questions to staff when they are available. Take special note of any details that may arise around the following questions:
   a. What are the methods of storage?

   b. What produce is being stored?

   c. What is the temperature of the facility (or each room if multiple rooms)?

   d. How is the air circulated?

   e. What is the total capacity of the storage facility?

   f. What is the storage capacity for each particular crop?

   g. How much does it cost to store produce at the facility?

   h. Raise any other relevant questions

2. Prepare your observations for a discussion after the field visit.

Points to Remember

- Storage methods should be determined by cost of storage, the quantity of crop needing to be stored, and the requirements of each crop.
- Underground field storage is an inexpensive and effective way to store crops if transportation is not immediately available or practical after harvest.
- For bulk storage of produce in cartons or bins, stacks must allow free movement of air.

Formative Assessment

1. List three criteria for selecting a storage method:

a. _____

b. _____

c. _____

2. True or false: Answer the following questions. If true, write "true". If false, write in the correct answer:

a. Bulk stored crates of produce should be packed close together to save space and avoid contamination.

b. Potato clamps are a low cost technology that can be designed using locally available materials for ventilation and insulation Inspecting stored produce.

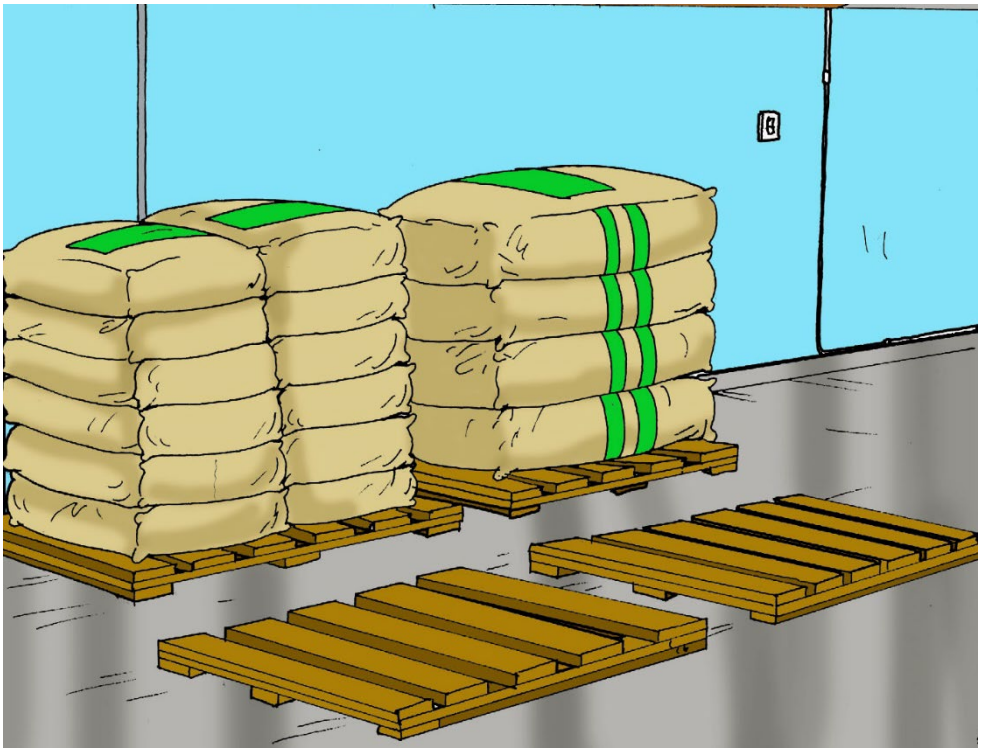
c. Hermitage storage is suitable for storing bulk grain.

Topic 3.3: Selection and acquisition of storage materials

Key Competencies:

Knowledge	Skills	Attitudes
1. List main materials available in storage	**1.** Select storage materials	**1.** Self -confident
2. Describe materials used in storage	**2.** Use storage materials	**2.** Attentive
3. Explain the use of storage material	**3.** Handle storage materials	**3.** Respectful

Getting Started: What do we know and where are we going?



Topic 3.3 Task 1:

1. Look at the illustration above and reflect on the following:

a. What kinds of agricultural products might be stored in the illustration?

b. Can you think of alternatives ways of storing agricultural products that are not show in the illustration (think back to previous unit)?

c. Brainstorm possible items and materials that may be found in this setting and others.

d. How are agricultural products affected by the materials used for storage and how those materials are used?

2. Volunteer to share your responses with the rest of the class.

3. Refer to the Key Competencies table and review it together.

Problem Solving Activity

Topic 3.3 Task 2:

1. Read the following scenario:

The new Matima Store Warehouse has a new manager who is not sure what materials she will need in order to properly store the produce which will soon arrive to the storage facility. She does know however that she plans to receive the following:

- 100 sacks of cassava flower weighing 50k each.
- 2 truckloads of unpackaged load potatoes.
- 300kg of avocados
- 5 sacks of coffee weighing 25kg each
- 20 boxes of tomatoes
- 1000kg of unpackaged grain
- 500kg of unpackaged onions

She is not sure when these deliveries will arrive so it will be important to keep in mind that each commodity can be moved as easily as possible within the warehouse while at the same time adequately protecting the produce and providing any other needs such as humidity and temperature.

2. With a partner, help the manager of Matima Store Warehouse select the correct storage materials so that her business can thrive.

3. Refer to **3.3 Key Facts** to enhance your answers and ideas.

4. Share your responses with the rest of the class.

5. Review **3.3 Key Facts** as a class and confirm your answers with the trainer.

3.3 Key Facts

- **Bulk storage materials:**
  - Sacks: flexible, made of plastic or jute
  - Wooden crates
  - Carton or fibreboard boxes
  - Plastic crates
  - Baskets: made of woven strips of leaves, bamboo, plastic, etc.
  - Pallets on which bag stacks are to be stacked

- **Quality control:**
  - A set of weighing scales to weigh grain in and out (these scales must be regularly calibrated)
  - A sampling spear to check grain quality

- **Hygiene and maintenance:**
  - Brooms used to keep the store clean
  - Tarpaulins that can be used to cover bag stacks to prevent insect infestation moving from
    - one stack to another and as a base on which to do grain conditioning operations
  - Spare sacks to replace damaged sacks and to contain spilt grain
  - Ledgers to record the movement of produce in and out of the store
  - Moisture meter to check moisture content (if available)

- **Sacks and nets:** Sacks and nets may be woven of natural fibre (jute, sisal, cotton), or synthetic fibres (polypropylene, polyethylene), knitted natural fabric (cotton), knitted synthetic (polyethylene) or non-woven synthetic (propylene).[39]

Advantages	Disadvantages
● Sacks and nets are cheap ● Low weight/volume ratio ● Synthetic material, will not rot.	● Low protection against puncturing, compression, vibration and impact injuries ● Difficult stacking/must be hung ● Low rate of vapour transmission and the need of special stitching equipment. ● In general, nets are only suitable for hard produce such as coconuts and root crops (potatoes, onions)

- **Wooden crates**:[40]

Advantages	Disadvantages
● The crates can be manufactured and repaired locally. ● Wood is relatively resistant to different weather conditions and (sea) water. ● Wooden crates are often used on more than one journey and have a higher capacity for larger fruits, e.g. watermelons. ● Most crates have good ventilation and fast pre-cooling is possible.	● Untreated wood can easily become contaminated with fungi and bacteria. ● Treatment of wooden crates with paint or other chemicals may cause produce deterioration. ● The material may be too hard or rough for produce like soft fruits, and therefore liners of a soft material may be needed. ● Manufacturing of wooden crates puts an extra claim on the natural forest resources.

[39] Food and Agriculture Organization of the United Nations. (n.d.). *Packaging for fruits, vegetables and root crops: Classification and designs for packaging*. https://www.fao.org/3/x5016e/X5016E04.htm
[40] Mujtaba, S. A. (2015, December 12). *Wooden boxes and crates as a packaging material*. LinkedIn SlideShare. https://www.slideshare.net/SyedAasifMujtaba/packaging-ppt-56076652

- **Plastic crates and trays:**[41]

Advantages	Disadvantages
● Longer life span ● Polyethylene has higher impact strength and a low degradation by ultra-violet radiation while polypropylene has a better scratch resistance.	● More expensive than wooden crates or carton boxes ● Because of their value, stealing of the crates should be taken into account when considering purchase of this type of packaging ● The hard surfaces have no cushioning effect, but a hard, smooth surface is easy to clean and gives good protection to the produce.

- **Pallets:**[42]

[43]

  - When the product is stored in bags these should preferably be stored on pallets. Pallets can be made of wooden laths or poles
  - The bags should always be neatly stacked, in such a way that air can pass through the sacks to dry and cool the grain
  - Maximum weight should be written on the pallet and never exceeded. If it is not written, inquire with other colleagues about how much load the pallet(s) can handle.

[41] Mujtaba, S. A. (2015, December 12). *Wooden boxes and crates as a packaging material*. LinkedIn SlideShare. https://www.slideshare.net/SyedAasifMujtaba/packaging-ppt-56076652
[42] de Groot, I. (2004). *Protection of stored grains and pulses*. Agromisa Foundation. https://mail.journeytoforever.org/farm_library/AD18.pdf
[43] Open Logistics. (2007, June 20). *Pallet FSC*. Flickr. https://www.flickr.com/photos/ecososlog/767750167

Guided Practice Activity

Topic 3.3 Task 3:

1. Read the following scenario:

   Matima Store Warehouse has been so successful that they plan to expand by building a new warehouse and they want to hire you to design the floor plan and acquire the correct materials.
2. Using the space below, draw a floor plan of a storage facility that you could see yourself managing one day in your own neighbourhood.

3. Clearly depict what kinds of produce you plan to store and what storage materials you would select to store them.

4. Also, consider the size available for your storage area based on how much and what kind of produce you intend to store.

5. Draw a plan that would allow you to move the produce around as easily as possible.

6. Do not forget to include tools for maintaining hygiene standards, checking quality and recording deposits and withdrawals.

7. Once everyone has completed his/her work, go around and share your work with others.

8. Save the floor plans because they will be used in the next topic.

Application Activity

Topic 3.3 Task 4:

1. Plan to visit a produce storage facility in your neighbourhood and note the following aspects:
   a. Identify which crops and produce are being stored.

   b. Make note of what storage materials are used and how they are placed within the warehouse.

   c. Record any differences that you notice between what you have learned in your class and what you observe in the workplace.

   d. Reflect on how you might use your new knowledge in the future to work in a storage facility.

2. Participate in a class discussion and share your observations.

Points to Remember

- There are various materials that can be used to store different types of produce based on space available.
- Materials for quality control hygiene and maintenance must be included in a warehouse plan.
- When the product is stored in sacks these should preferably be stored on pallets.
- When the sacks are stacked on the pallets, they should always be neatly stacked, in such a way that air can pass through the sacks to dry and cool the grain.

Formative Assessment:

1. Complete the missing table to indicate the advantages and disadvantages of each storage material:

Materials*:*	**Advantages**	**Disadvantages**
Wooden crates		Material may be too hard or rough for produce
	Have a higher capacity for larger fruits	
Plastic crates		Can be stolen
	Longer life span	

True or false: Answer the following questions. If true, write "true". If false, write in the correct answer:

2. A set of weighing scales to weigh grain on should never be recalibrated.

3. Sacks are inexpensive but offer low protection against puncturing, compression, vibration and impact injuries, and often times they must be hung when stored.

Topic 3.4: Storage of produce

Key Competencies:

Knowledge	Skills	Attitudes
1. Describe general requirements for good storage	**1.** Apply requirements for good storage	**1.** Precise
2. Recognize need for quality control	**2.** Perform quality control for different crops	**2.** Attentive
3. Explain procedures for receiving, storing and withdrawing produce from storage	**3.** Apply guidelines for storing produce	**3.** Teamwork spirit

Getting Started: What do we know and where are we going?

Topic 3.4 Task 1:

1. Look at the illustrations with a partner and discuss the following:
   a. Have you ever stored something and it ended up going bad?

   b. What do you think caused the item to go bad?

   c. How do you think this could be related to storing produce?

2. Volunteer to share your responses.

3. Refer to the Key Competencies table and review it together.

Problem Solving Activity

Topic 3.4 Task 2:

1. With your group, read the following scenario:

   With the help of your floor plan drawing, Matima Store Warehouse has expanded its operations and can now store many varieties of grains, cured produce, and even fresh produce. Word has spread around and last week the manager took in the following produce:

   - 100 bushels of bananas
   - 50kg avocados
   - 100kg of lemons
   - 20kg of limes
   - 100kg sweet potatoes

   The manager decides to store the produce together, since they all require the same temperature of 13-18°C and similar relative humidity, in a smaller room which has been sealed off to prevent infestation. However, after several days the farmer returns to collect her harvest, they find the produce has over ripened and will be difficult if not impossible to sell at market.

2. Complete the following with your group:
   a. Brainstorm what may have caused the produce to overripen.

   b. Make a list of other problems that could occur at storage facilities like Matima Store Warehouse which need to carefully receive new produce, store it, and manage how it is withdrawn.

3. Refer to **3.4 Key Facts** to strengthen your responses.

4. Find a new partner and explain your answer and the three Key Facts that you think are most relevant.

5. Participate in a full class discussion based on the activity.

3.4 Key Facts

- **Aim of good storage practice:** All produce should be stored and handled with the ultimate goal of reducing damage and waste.

- **Factors that limit post-harvest produce lifespan are the following**:
  - **Temperature**- An increase in temperature causes an increase in the rate of natural breakdown of all produce as food reserves and water content become depleted. The cooling of produce will extend its life by slowing the rate of breakdown.
  - **Water loss**- High temperature and injuries to produce can greatly increase the loss of water from stored produce. Maximum storage life can be achieved by storing only undamaged produce at the lowest temperature tolerable by the crop.
  - **Mechanical damage**- Damage caused during harvesting and subsequent handling increases the rate of deterioration of produce and weakens its defences. Mechanical damage to root crops will cause heavy losses, owing to bacterial decay and must be remedied by curing the roots or tubers before storage.
  - **Decay in storage**- Decay of fresh produce during storage is mostly caused by the infection of mechanical injuries. Furthermore, many fruits and vegetables are attacked by decay organisms which penetrate through natural openings or even through the intact skin. These infections may be established during the growth of the plant in the field but lie dormant until after harvest, often becoming visible.[44]

- Guidelines for receiving grain and maize -

- **Handling grains/maize:**
  - Weigh and record each sack arriving with a scale and ledger.
  - All sacks entering the store should be placed on pallets.
  - Make sure the pallets are clean, level and have no protruding nails.

[44] Food and Agriculture Organization of the United Nations. (n.d.). *Prevention of post-harvest food losses fruits, vegetables and root crops: Reduction of losses during transport*. https://www.fao.org/3/t0073e/t0073e05.htm

- **Quality control for grains/maize:**
  - Grain and maize must be checked for moisture content before being accepted. (See **1.4 Key Facts** for effective testing methods.)
  - Grain should be sampled with a sampling spear – take 25g from 50kg bags or 50g from 100kg bags (this would require two insertions of the sampling spear). Samples should be taken at random from anywhere in the sack.

- **Pest control for grains and maize and grain:**
  - Place fumigation tablets in trays on the top of the stacks

- Guidelines for receiving fruits, leafy vegetables, bulbs, roots, and tubers -

- **Receiving and handling of produce:** The quantity and quality of produce should be checked on arrival before being transferred to the storage area.
  - Avoid rough handling,
  - plan storing to minimize the number of handling steps
  - Maintain the lowest feasible temperature.
  - Trim excess part from produce stems when necessary, e.g. undesirable leaves, stems.
  - Surface contaminants removed by washing or brushing, and chemicals applied to extend storage or market life;
  - Never mix produce that have different temperature requirements or store ethylene sensitive produce near ethylene generating produce.

- **Ethylene generating produce:**
  - Apples, apricots, avocados, bananas (ripe), figs, green onions, guavas, grapes, mangoes, papayas, passion fruit, peaches, potatoes, tomatoes

- **Ethylene sensitive produce:**
  - Asparagus, bananas (unripe), broccoli, cabbage, carrots, cauliflower, chard, cucumbers, eggplant, garlic, green beans, kale, leafy greens, leeks, lettuce, okra, onions, parsley, peas, peppers, spinach, squash, strawberries, sweet potatoes, watercress, watermelon.[45]

[45] Food and Agriculture Organization of the United Nations. (n.d.). *Handling of fresh fruits, vegetables and root crops*. https://www.fao.org/3/a-au186e.pdf

- Quality control for handling produce and leafy vegetables -

- **Sorting**: Remove undesirable pieces and foreign matters, such as plant debris, soil and stones, before the produce passes on to further operations.

- **Grading:** Grouping similar items of one kind of produce together factors such as maturity, colour, and size, e.g. group large yellow bananas separately from smaller green bananas.

- **Pest control for fruits:**
  - **Dipping fruits:** Treatment is normally carried out by hand operation using a suspension of fungicide agitated using stick
    - Wire-mesh baskets are used to dip the fruits. After dipping produce should be drained and dried.
  - **Spraying fruits:** Often done to prevent pest damage while on racks after washing and drying, e.g. bananas following the de-handing of bunches.
    - Hand-operated sprayer are suitable for small scale storage.

- **Dumping:** Any time produce is dumped from one container into another, care should be taken to reduce mechanical damage to the commodity. When dumping produce from field bins or from transport vehicles into the packinghouse, dry or wet dumping can be practiced. Wet dumping is the practice of adding water to the produce to avoid mechanical damage. [46]

- **Cleaning and washing:** Some type of produce can be washed, brushed or cleaned with a soft cloth.
  - Use only clean water
  - Remove latex stains from produce which were poorly harvested or handled

- **Waxing/Coating:** Waxing of immature fruit or vegetables, such as cucumbers and summer squash; mature fruit vegetables, such as eggplants, peppers and tomatoes; and fruits such as apples and peaches is common. Food grade waxes are used to replace some of the natural waxes removed in washing and cleaning operations and can help reduce water loss during handling and marketing. If produce is waxed, the wax coating must be allowed to dry thoroughly before further handling.[47]

[46] Food and Agriculture Organization of the United Nations. (n.d.). *Small-scale postharvest handling practices: Packinghouse operations*. https://www.fao.org/3/ae075e/ae075e06.htm

[47] Food and Agriculture Organization of the United Nations. (n.d.). *Small-scale postharvest handling practices: Packinghouse operations*. https://www.fao.org/3/ae075e/ae075e06.htm

- **Artificial ripening:** Ripening rooms are often used for tomatoes, citrus fruits and bananas. The use of diluted ethylene gas mixtures is safer than using pure ethylene which is flammable at concentrations of 3% or higher.[48]

- **Degreening:** Degreening is the process of removing the green colour (chlorophyll) from the skin of fruit after harvest using ethylene gas treatment. Only mature fruit are suitable for degreening. It is absolutely critical that immature fruit are not harvested and degreened.[49]

- **Effective store management policies:**
  - Removal all of the old produce and grain from the store regularly
  - Maintain good hygiene standards
  - Keep accurate records of all incoming and outgoing commodities
  - Spray and fumigate for pests when necessary[50]

Guided Practice Activity

Topic 3.4 Task 3:

1. With a group of three, perform the following role play. There are three roles: the store manager, store labourer and sector food inspector.

a. The storage manager is in charge of:
- deciding where to store the produce
- what to store
- keeping records of what is coming in and out of the store
- ensuring the labourer is working to minimize handling steps

b. The labourer is in charge of:
- checking quality and moisture of the produce
- handling the management

[48] Food and Agriculture Organization of the United Nations. (n.d.). *Small-scale Postharvest handling practices: Handling at destination*. https://www.fao.org/3/ae075e/ae075e21.htm

[49] Golding, J. (2019, November 12). *The essentials of degreening*. Citrus Australia. https://citrusaustralia.com.au/news/latest-news/the-essentials-of-degreening

[50] GTZ. (n.d.). *Manual on the prevention of post-harvest grain losses: Store management*. New Zealand Digital Library. https://www.nzdl.org/gsdlmod?e=d-00000-00---off-0cdl--00-0----0-10-0---0---0direct-10---4-------0-1l--11-en-50---20-about---00-0-1-00-0--4----0-0-11-10-0utfZz-8-00&cl=CL2.13&d=HASH015ffd7c5bc720db8714248d.9.3&x=1

- ensuring that the managers decisions result in the best storage practices and preventing loss
- controlling pests

c. The inspector is in charge of:
- ensuring the produce and grains being stored are up to standard and free of contamination.

2. Next, read the rules of the role play:

a. Each turn begins by getting a new set of three variable cards from the trainer which indicate the kind of produce, the quantity, and how long it is being asked to be stored for.

b. The manager then has to decide where this commodity will be stored in their warehouse, using the floor plan they drew up in **Topic 3.3 Task 3** which now serve as the imaginary warehouse.

c. The store manager should look at the cards first and assess the needs of the produce and status of the warehouse. Then decide how and where to put the produce and properly record it.

d. Next, the labourer explains what should be done in terms of quality control, pest control, and receiving procedures.

e. The inspector takes notes on any complications they see.

f. After three rounds of "simulated storage" each member should have a chance to debrief by explaining what they observed, highlighting both what was properly and poorly executed.

g. After the debriefing has occurred, switch roles.

h. Once everyone has played the different roles, the role play is over.

3. You will receive variable cards from your trainer, which describe the kinds and quantity of produce, and how long it needs to be stored.

4. You can use your floor plan design from **Topic 3.3 Task 3** as the imaginary warehouse when making decisions where to store your produce.

5. Prepare for a class discussion on how the role play went and new insights you may have gained from it.

Application Activity

Topic 3.4 Task 4:

1. With the same group you preformed the previous role play activity, arrange a field visit to one of the larger warehouses in your surrounding area. Think back to the Community Mapping activity in **Topic 3.2 Task 3** for ideas. If possible, visit a facility that stores a wide variety of produce.

2. Interview the store manager using the following questions to guide your observations and record them for later discussion:
   a. What kinds of problems do you encounter regularly?

   b. How are decisions made and problems solved in the warehouse/storage facility?

   c. What do you consider to be best practices for storing each crop type (when applicable): grains, leafy vegetables, fruit, bulb crops, roots, and tuber?

   d. What other procedures do you recommend for maintaining the warehouse?

3. Interview another employee(s) (if applicable):
   a. How do the employees of the warehouse work together?

   b. What tasks and responsibilities are shared? Which ones are not?

4. Discuss your experiences and observations with the rest of the class.

Points to Remember

- All produce should be stored and handled with the ultimate goal of reducing damage and waste. Samples should be taken at random from anywhere in the sack.
- Remove all the old produce and grain from the store regularly.
- Keep accurate records of all incoming and outgoing produce.

Formative Assessment

1. List the four factors that limit post-harvest produce lifespan:

a. _____

b. _____

c. _____

d. _____

2. True or false: Answer the following questions. If true, write "true. If false, write in the correct answer:

a. Grains should be checked for moisture content after they have been received and stored.

b. Bananas should be stored close to sweet potatoes to prevent early ripening.

3. In your opinion, what is the most important guideline to remember when practicing storage of various crops and produce? Why?

Self-Reflection

1. You have come to the end of the unit. You are going to do the survey you did at the beginning of the unit again to help you do self-assessment of your knowledge, skills and attitudes.

Again, there are no right or wrong answers to this survey. It is for your own use to gauge your knowledge, skills and attitudes after the unit. Read the Knowledge, Skill or Attitude in the left column. Think about yourself: do you think you can do this? How well? Read the statements

My experience **Knowledge, skills, and attitudes**	**I don't have any experience doing this.**	**I know a little about this.**	**I have some experience doing this.**	**I have a lot of experience with this.**	**I am confident in my ability to do this.**
State the tools and materials used for cleaning and maintaining storage rooms					
Describe how to clean and maintain the storage rooms					
Describe how to maintain the storage structure					
Use different tools and materials to clean and to maintain storage rooms					
Remove trash and infected produce from storage room					
Produce rat guards, check screens, and floors					
State criteria for selecting storage methods					
Describe different storage methods for different crops					
Explain bulk and field storage					
Select storage methods based on criteria					
Select storage methods for different crops.					

My experience Knowledge, skills, and attitudes	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Distinguish between when to use bulk storage and field storage					
List main materials available in storage					
Describe materials used in storage					
Explain the use of storage material					
Select storage materials					
Use storage materials					
Handle storage materials					
Describe general requirements for good storage					
Recognize need for quality control					
Explain procedures for receiving, storing and withdrawing produce from storage					
Apply requirements for good storage					
Perform quality control for different crops					
Apply guidelines for storing produce					

2. Complete the table below by identifying areas from the unit where you have improved and where you need improvement with the actions/strategies you will use to help you improve when receiving and interpreting information at the workplace.

Areas of strength	Areas for improvement	Actions to be taken to improve
1.	**1.**	**1.**
2.	**2.**	**2.**

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