



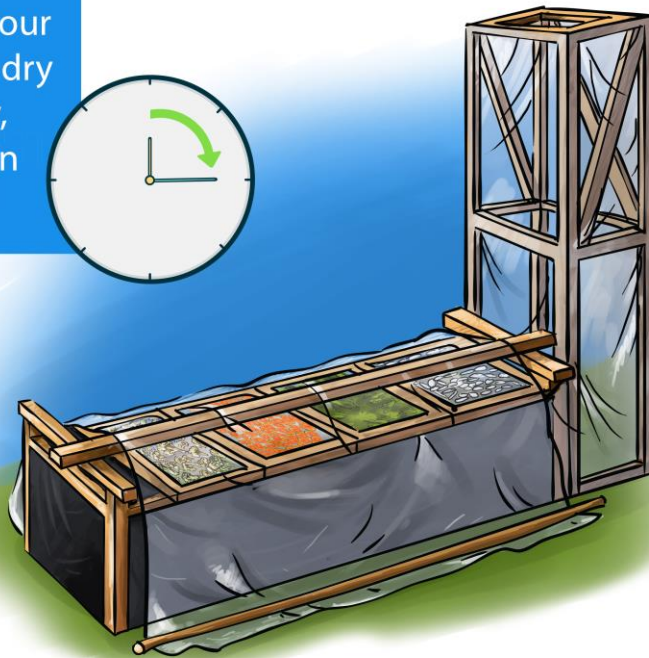
FEED ^{THE} FUTURE

The U.S. Government's Global Hunger & Food Security Initiative

Facilitator manual: How to use the chimney solar dryer

An improved solar dryer for fruits and vegetables

Protect your product, dry it quickly, and retain quality.



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HORTICULTURE
INNOVATION LAB

UC DAVIS
UNIVERSITY OF CALIFORNIA

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This manual was first designed to guide the facilitation of training workshops on how to use the chimney solar dryer in Dadeldhura, Nepal. The information has been generalized and can be modified to lead trainings with the chimney solar dryer anywhere in the world.

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OVERVIEW OF FACILITATOR MANUAL: TRAINING OBJECTIVES AND LEARNING ACTIVITIES

The overall purpose of these learning activities is to help give farmers and other community members the knowledge and confidence to use the chimney solar dryer to dry fruits and vegetables. This training will cover the benefits and nutrition of dried fruits and vegetables, how to select and prepare fruits and vegetables for drying, and how the chimney dryer works, including setting it up and loading it with produce. In addition to drying, the training activities will explore safe storage and consumption of dried foods.

In addressing each of these issues, farmers reach a more complete understanding of how to properly dry food using the chimney dryer and how to safely store fruits and vegetables, extending shelf life and making these nutritious foods available during the lean season. The topic also encourages them to diversify their diets and consider new uses for dried foods. To achieve this purpose, you—the facilitator—present this training.

By the end of this training, participants will have accomplished the following activities:

- Reviewed how the chimney dryer works, the set-up process, and its benefit
- Understood critical concepts key to drying: solar radiation, air speed, temperature, and water-loss
- Followed proper sanitation and personal hygiene when handling the fresh produce and using the chimney dryer
- Prepared a variety of fresh produce items to dry in the chimney dryer
- Loaded the dryer with produce items and rotated the trays for more uniform drying
- Understood the health hazards of insufficiently dried product and determined if product is dry enough to safely store
- Experimented with different airtight and sanitary storage containers and conditions
- Understood the nutritional benefits of dried produce and any changes in nutrition that are a result of drying
- Tasted dried product and discussed/brainstormed different culinary uses, recipes, and market opportunities for dried products
- Created a community plan for utilizing the chimney dryer moving forward

The following table gives the title and purpose of each learning session:

How to use the chimney solar dryer learning sessions	
Session Title	Session Purpose
1. Pre-training baseline survey or discussion	To understand the participants' current knowledge, attitudes, and practices around drying
2. Handwashing and utensil cleaning	To demonstrate and practice handwashing and review the importance of good hygiene and sanitation in food preparation activities, including drying
3. Selecting products for drying	To identify what makes a fruit or vegetable good for drying, like ripeness, size, or quality
4. Preparing products for drying	To practice preparing products for drying, including washing, peeling or slicing thinly
5. Filling the trays, loading the dryer, covering with plastic, checking the seal and ensuring airflow	To practice filling trays with the correct amount of produce and loading the trays into the trays with the proper orientation to optimize drying, and to handle the plastic to modify airflow within the dryer
6. Dryer location and orientation	To understand the importance of selecting a good location for the dryer and properly orienting it to maximize sun exposure
7. What are the benefits of drying fruits and vegetables?	To discuss and review why we dry fruits and vegetables
8. How the chimney dryer works	To identify the different components of the chimney dryer to understand how it works and what makes it better than traditional, open air sun drying
9. Weather, temperature and drying time	To discuss how different weather conditions can affect drying time and chimney dryer usage and to explore how different food products will take varying amounts of time to dry, including shuffling the trays for more uniform drying and practices to modify temperatures inside the dryer
10. Measuring dryness of product with the DryCard™	To review the importance of ensuring that product is dry enough to store safely and to measure product dryness using different methods, with an emphasis on the DryCard™
11. Storage containers and conditions	To explore different airtight storage containers and to identify the aspects of ideal storage conditions (e.g. dry, cool, and dark)

12. Nutrition of dried fruits and vegetables	To review the nutritional benefits and changes in dried fruits and vegetables and to think about ways to reduce nutrient loss
13. Tasting, culinary uses/recipes, and market sales	To taste, discuss and brainstorm different uses of dried fruits and vegetables in household diets and to explore opportunities to sell dried fruits and vegetables for income
14. Community planning for future chimney dryer usage and maintenance	To create a plan (e.g. forming groups or making a schedule) for the community to use, share and maintain the chimney dryer in the future
15. Post-training survey or discussion and closeout	To understand the participants' knowledge, attitudes, and practices around drying after the training

SCHEDULING THE TRAINING

This training agenda assumes that the chimney solar dryer has already been built. For this training, **please follow the activities in the order recommended**, especially preparing the dried product and placing it in the dryer early in the day so it has adequate time to dry. To prevent moisture development and reduce health hazards, we recommend that you bring the drying food product inside overnight.

The sessions total about 10 hours of active learning time, but can be broken up into multiple (ideally two) days. We recommend starting this training the day after building the dryer and conducting it over two consecutive days, in which case, day 1 should end after learning session #9 “Weather, temperature, and drying time” (which is around six hours of learning time, not including breaks or lunch) and day 2 (about four hours long) should begin with learning session #10 “Measuring dryness of product”.

If you do not have a full two days for this workshop, you can shorten the training several ways. First, interactive group discussions that help reinforce learning may be cut out if you don't have time, but topics that must be shared/known are bolded in the text or put inside boxes. You can also skip certain activities like produce sorting for selection (learning session #3), weighing/re-weighing product (learning session #4 and #9), and sorting images from Appendix 4 (learning session #8). Furthermore, preparing most of the food products ahead of time (washing, slicing, etc.) and only demonstrating how to prepare produce by using a small sample will save time, as well as pre-washing all utensils, drying trays, work surfaces, etc.

You can also skip learning session #6 (dryer location and orientation) if the chimney dryer is already placed in an optimal location with maximum sun exposure.

To build upon and reinforce the training content, we encourage you to bring successfully dried fruits and vegetables to the training for demonstration and tasting purposes. For instance, **the use of dried foods throughout the day during snack breaks or rehydrated in lunch dishes** can help emphasize the learning.

FULL LIST OF MATERIALS NEEDED FOR TRAINING

- Notebook and writing utensil for training facilitator
- A clean water source (boiled or treated with sodium hypochlorite to reduce bacteria if needed)
- Separate containers for holding fresh water and washed produce
- Soap for both handwashing and dishwashing
- Stiff non-metal brush for washing the drying trays
- Writing utensils and paper/notebook for each participant (if literate)
- Washing instructions handout (Appendix 1) – one for each participant
- Fresh produce for sorting, preparing, and drying (approximately 10-13 kg total):
 - ~6-9 kg of fresh, fully ripe, unbruised, high quality produce for drying (mix of product type and size: some small and some large)
 - ~1 kg of “poor quality” produce items for sorting (including some unripe, rotting, bruised, and recently-sprayed items) per small group of 3-4. For example, if there are four groups, then you should have 4 kg of produce.
 - *Ideally produce that participants select themselves from the market or bring from home*
- Cutting boards
- Knives
- “Sample cards” (small 10 cm x 10 cm cut outs of the food-grade tray mesh)
- Small scale for measuring the starting fresh weight and ending dry weight of product
- Flipchart easel, paper and markers
- Drying trays (previously built)
- A small piece of tissue/toilet paper for demonstrating airflow in the dryer
- Optional: A bee smoker and fuel or an incense stick and lighter/match for demonstrating airflow in the dryer
- Dryer usage checklist handout – one for each participant (Appendix 2)
- Chimney dryer airflow diagram – one for each participant (Appendix 3)
- Pictorial images for drying comparison (benefits of using the chimney dryer over traditional sun drying) – enough sets of cards for each small group (Appendix 4)
- Simple dial thermometer or instant read/digital thermometer
- Weather and drying conditions visual aid – one copy for demonstration (Appendix 5)
- DryCards – one for each participant
- DryCard visual instructions (Appendix 6) – one for each participant
- Dried product from earlier in the training to test dryness
- Sample dried product at different relative humidity levels (some above 65% relative humidity/not dry enough to store and some below 65% relative humidity/dry enough to store, including some product that is moldy or spoiled) in containers with DryCards for reference
- Airtight storage containers such as plastic bags, plastic containers, or glass jars that can be sealed (*ideally, ask training participants to bring a storage container with product they’ve previously dried inside*)
- Fully dried fruits and vegetables for tasting (including produce previously dried with the chimney dryer, either from this training or earlier drying activities, and if possible, produce dried traditionally in the sun), enough for all participants to eat a sample

ENGAGING LEARNERS AND PRINCIPLES OF ADULT LEARNING

We recommend using **Classroom Assessment Techniques (CATs)** during the learning sessions, which are activities that an instructor can use to quickly and easily evaluate student learning in the moment by getting feedback on whether learners understand course material. CATs can improve the teaching and learning process. Below are examples of useful CATs to assess participants' knowledge and skills on the new topics and the box to the right includes tips on using CATs in this training.

Examples of Classroom Assessment Techniques (CATs) and Active Learning Strategies:

- **“The minute paper”** – ask participants to either write (if they are literate and there are paper and writing utensils available), think about, or say aloud 1) the most important thing they learned in a given learning session or even during the whole day, and 2) what they understood least, or what remains the most unclear
- **“The Muddiest point”** – ask participants to either write (if they are literate and there are paper and writing utensils available), think about, or say aloud something they didn't understand and what they think might help them understand
- **Simply pausing while teaching** – stop every 12-18 minutes of lecture, and for two minutes, ask students to think and have a discussion with their neighbor about what they're thinking about what they're learning
- **Use memory recall or “retrieval” to see if participants are remembering what they're learning:** stop every 15 minutes, and for 2-3 minutes, ask people to write down or share aloud with a neighbor everything they remember from the previous 15 minutes

Tips on using Classroom Assessment Techniques (CATs) in the chimney dryer use training:

- Before using a CAT, explain to the participants the purpose: for the instructor to assess if the learners are understanding the content and how you plan to reflect on and use their feedback to either adjust your teaching-style or alter the material
- The above techniques can also be done in pairs (“think, pair, share”) or small groups instead of the whole group, which can encourage participation from everyone
- Use any of the above CATs throughout the training day: for example, at the end of the morning before a lunch break and again at the end of the training day
- Use CATs at least once at the end of a full day of learning sessions
- When participants share feedback and ideas in response to the above CATs, record what they say for evaluation and improvement purposes. Make a plan to follow up on the feedback or adjust the teaching style or learning session accordingly.

When teaching the content, you can use your own words to further explain each point, being careful to ensure that all of the information in the training is shared with the participants.

- Arrows and **bolded text** are used to emphasize that a question or presentation information is important and should be delivered *as it is written*. **Boxes are used throughout the learning sessions to present important technical information.**

The box to the right (“Important Principles of Adult Learning to Remember”) is a reminder of some important practices to keep in mind as you lead each learning session for adult learners. Remember that although you are facilitator, you do not have all of the answers. The participants come to the learning sessions with a great deal of experience and have many things to add, so the training has been designed to honor and build upon this existing knowledge. We have included activities that turn the power over to the learner, promoting learner participation, sharing of experiences, and discussion, as it is important that all participants (including you) teach and learn.

Important Principles of Adult Learning to Remember (Davis et al., 2003)

- Create a **safe learning environment** by assuring participants that their opinions are respected.
- Give **feedback** to the participants and **praise** them for their efforts.
- Think about ways to make the topic **useful** to all of the participants present.
- Let the participants know that you are a **learner** with them.
- Use **small groups** (as suggested in the learning sessions). Small groups help involve all participants, build a sense of teamwork and create safety, which can help more people feel engaged and comfortable sharing their opinions and experiences.
- Show **respect** by valuing the participants’ knowledge and experience with the subject.
- Be sure that throughout the learning session there is an opportunity for **thinking, acting** and **feeling**.
- Give learners the **opportunity to discuss and ask questions**, expressing what they understand and also what they don’t understand

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INTRODUCING THE CHIMNEY DRYER TRAINING – 5 MINUTES

Welcome the participants and introduce the new topic.

Say:

- *Today we are exploring a new technology called the chimney solar dryer, an improved dryer for drying fruits and vegetables. This technology aims to help reduce food loss, increase shelf life, and improve access to diverse and nutritious foods.*
- *This training will cover the benefits and nutrition of dried fruits and vegetables, describe how to select and prepare fruits and vegetables for drying, and explain how the chimney dryer works compared to traditional open air sun drying, including setting up and loading the chimney dryer with produce.*
- *In addition to drying, the training activities will explore safe storage and consumption of dried foods.*

Ask participants:

- **What questions, comments, or expectations do you have about this training?**

1. PRE-TRAINING BASELINE SURVEY OR DISCUSSION – 15 MINUTES

Say:

To understand more about what you already know about drying fruits and vegetables, including your current practices, we are going to conduct a brief pre-training survey/discussion.

Either administer the survey as a written survey (ideally with names to compare learners' pre/post data) or a hand-raising option where you ask the question and people raise their hands in response. If you want to reduce the chances for group think and/or peer pressure, consider asking people to cover their eyes during the survey so people don't copy their neighbors. Alternatively, you can collect this information as a brief group discussion.

Ideally, you should gather the pre-training survey information from participants days or weeks before the training, so you can tailor the workshop content according to the baseline situation. However, if you cannot obtain this information ahead of time, you can ask these questions at the start of the training.

Pre-Training Survey Questions:

1. Do you currently dry fruits or vegetables? (Y/N) If yes, which products?
2. Do you use traditional, open air sun drying? (Y/N)
3. If yes, are you satisfied with traditional sun drying / does it meet your needs? (Y/N)
4. Do you like to eat dried fruits and vegetables (F&V)? (Y/N), if yes, which products?
5. Which of the following should be washed with clean water before drying F&V – a) hands; b) produce; c) tools; d) trays; or e) all of the above
6. Do you think it is better to dry ripe or unripe F&V?
7. Will drying moldy or spoiled product make it edible and safe to eat? (Y/N)
8. How do you think the sanitation of traditional sun drying compares to the chimney solar dryer? (Sun drying is more / less sanitary than the chimney dryer)
9. Do you think airflow makes F&V dry faster or slower?
10. Do you feel confident that you know when a product is dried enough to store safely for a long time period? (Y/N)
11. What will happen if a product is not dried enough and then stored for a long time? (nothing will happen; mold will develop; or unsure)
12. Do you know how to select a proper storage container for your dried product? (Y/N)
13. Do you think dried F&V have the same amount of nutrients as fresh F&V? (Y/N)
14. Do you feel confident incorporating dried foods in your household diet? (Y/N)
15. Do you plan to use the chimney solar dryer to dry F&V in the future? (Y/N)
16. Do you plan to sell dried F&V in the future? (Y/N)

You should record the responses to each of the questions to compare to the post-training survey for evaluation purposes.

2. HANDWASHING AND UTENSIL CLEANING - 25 MINUTES

Objectives

By the end of this learning session, participants will have:

1. Observed a demonstration of proper handwashing
2. Learned why proper handwashing and cleaning of drying tools, utensils and equipment is important
3. Practiced washing their hands using the proper technique

PREPARATION/MATERIALS

- A clean water source (boiled or treated with hypochlorite to reduce bacteria if needed)
- Container for catching dirty water
- Soap for washing hands and dishes
- Stiff non-metal brush for washing the drying trays
- Writing utensils and paper
- Washing instructions handout (Appendix 1) – one for each participant

TIME

25 minutes

STEPS

1. Handwashing explanation and demonstration – 7 minutes
2. Participants practice washing their hands – 8 minutes
3. Explain the importance of washing drying utensils and equipment – 2 minutes
4. Summarize the importance of good hygiene and sanitation – 3 minutes
5. Question and answer session – 5 minutes

REFERENCES

- CDC. (2016). When & how to wash your hands. Retrieved August 6, 2019, from <https://www.cdc.gov/handwashing/when-how-handwashing.html>
- Text from Tatge, S. (2014). *Reservoir Limited solar drying instruction manual (Unpublished)*.
- WHO, UNICEF, & USAID. (2015). *Improving nutrition outcomes with better water, sanitation and hygiene: Practical solutions for policy and programmes*. Geneva, Switzerland. Retrieved August 6, 2019, from https://www.who.int/water_sanitation_health/publications/washandnutrition/en/

STEPS

1. Sanitizing water (if a clean water source is unavailable)

To use sodium hypochlorite to sanitize water, combine the following:

- 2 drops (0.1 mL) of household bleach (contains about 5.25% sodium hypochlorite)
- 1 liter of water

Cover and let stand for 30 minutes before using. You should notice a slight chlorine smell after the 30 minutes. If not, add another 2 drops. Let the water stand for another 15 minutes.

If you do not have access to hypochlorite, you can also boil water at full boil for 1-2 minutes to sanitize. Then place water in a clean container.

2. Handwashing explanation and demonstration – 7 minutes

Say:

- **Hands should be washed thoroughly before handling food or drying utensils.** It is very important to wash hands properly to prevent bacteria from contaminating food. Bacteria are invisible to the naked eye, but can be present on your hands for long periods of time if they are not washed well.
- **You should wash your hands at the following critical times:**
 - Before, during, and after preparing food;
 - Before eating food;
 - Before feeding someone else;
 - After defecating/using the toilet;
 - After cleaning a child's bottom;
 - Before and after caring for someone who is sick;
 - Before and after treating a cut or wound;
 - After handling livestock, animal feed, or animal waste;
 - After blowing your nose, coughing, or sneezing;
 - After touching garbage.
- **To ensure your hands are clean, wash your hands with the following steps:**

Demonstrate the following steps while you say them aloud (CDC, 2016):

1. **Wet** your hands with clean, running water (warm or cold), turn off the tap, and apply soap.
2. **Lather** your hands (and arms) by rubbing them together with the soap. Be sure to lather the backs of your hands, between your fingers, under your nails, (all the way up to your elbow).
3. **Scrub** your hands for at least 20 seconds.
4. **Rinse** your hands well under clean, running water.
5. **Dry** your hands using a clean towel or air dry them.

Say:

- **After washing your hands, avoid touching your face and head** (including your eyes, mouth, nose and hair) while you are handling food. This may reintroduce bacteria onto your hands after they have been cleaned.
- **Additionally, if you use the toilet during the drying process, wash your hands again** following the process described above.

3. Participants practice washing their hands – 8 minutes

All participants should wash their hands properly using the previously demonstrated technique.

[Assessment] Observe their handwashing and make sure everyone is following safe practices.

4. Explain the importance of washing drying utensils and equipment – 2 minutes

First, pass out the *Washing Instructions Handout (Appendix 1)* – one for each participant. Then say:

- *When using the chimney dryer, it is very important to maintain a clean environment, including when preparing and handling food. In addition to washing your hands, **ensure maximum cleanliness of the drying surfaces and utensils, including knives, cutting boards, containers and the drying trays.** All of these items should be well cleaned to improve hygiene and ensure a high-quality dried food product.*
- *If these items are not clean, it may result in contamination of the food and make the person who eats it very ill. Keeping all areas protected from insects, pests, and other animals is also important.*
- *Therefore, before beginning the drying process, wash all utensils with clean water and dish washing soap. The chimney dryer trays should also be cleaned thoroughly with hot soapy water and a stiff non-metal brush after every use, especially if you are drying one type of produce then another.*
- *If you are drying spicy chili peppers, you should use separate trays labeled just for chili peppers because the heat/spiciness may transfer to other products.*
- *To save time → For the purposes of this training, we have already washed the drying equipment.*

5. Summarize the importance of good hygiene and sanitation – 3 minutes

Ask participants:

- **Can someone summarize why it is important to use clean water and practice good sanitation and hygiene when drying fruits and vegetables?**
- **Can someone list the critical times when you should wash your hands?**

If the following point is not raised, explain again:

If your hands, drying utensils, and drying equipment are not properly washed and sanitized, this could result in contamination of the food and make people very sick.

6. Question and answer session – 5 minutes

Ask participants:

- **I want to know how much each of you is understanding these concepts. Close your eyes and show me how much you understand by holding up 1-5 fingers. One finger means you don't understand at all and five fingers mean you understand completely. You should record different responses for evaluation and improvement purposes.**
- **What questions do you have about handwashing or cleaning equipment?**

Thank people for sharing and acknowledge their responses.

3. SELECTING PRODUCTS FOR DRYING - 25 MINUTES

Objectives

By the end of this learning session, participants will have:

- Discussed how to select products for drying
- Sorted different produce items into two categories: more suitable for drying and less suitable for drying

PREPARATION/MATERIALS

- ~1 kg of fresh, fully ripe, unbruised, high quality produce (mix of size: some small and some large) per each small group
- ~1 kg of “poor quality” produce items (including some unripe, rotting, bruised, and recently-sprayed items) per each small group
- Clean containers
- Writing utensils and paper

TIME

25 minutes

STEPS

- Explanation of how to select product for drying – 7 minutes
- Sorting activity – 13 minutes
- Question and answer session – 5 minutes

REFERENCES

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- Text from Tatge, S. (2014). *Reservoir Limited solar drying instruction manual (Unpublished)*.

STEPS

1. Explanation of how to select product for drying – 7 minutes

Say:

- *It's best to experiment with small amounts of produce to become familiar with the chimney dryer and how it operates.*
- *If you are drying multiple foods at a time, be sure to **only combine foods with similar flavors**. For example, if you dry apple and onion together, the strong smell of the onion may alter the taste and smell of the apple.*
- *As previously stated, it is important to **use separately labeled trays just for spicy chili peppers to prevent contamination of other food products**.*
- *Through trial and error, you can become familiar with the drying process and find which foods, recipes and combinations you prefer.*
- *If you start by experimenting with only small amounts of product in the dryer and then move onto preparing enough product to fully load the dryer, the drying time might be slightly longer due to increased product amounts.*
- ***Choosing good quality raw product is extremely important for the drying process.** Dried food made with poor quality product may taste bad, spoil easily, and has the potential to make people ill. And remember, **drying cannot improve poor quality produce.***
- *Here are some aspects to consider when selecting product for drying:*

Selecting Product for Drying

1. **Select produce that is freshly harvested and ripe** (at peak quality and flavor). Overly ripe fruit may not sell in a market, however, their sweetness makes them taste better dried and their additional sugars are a natural protector against bacteria.
2. In addition to large or normal sized produce, **consider selecting produce that is small or “b-grade”**. Small product may not be saleable on the market; however, these products are very good to dry, and this is an excellent way to recover income that might be lost on the open market.
3. You can **select produce that is either entirely undamaged or only partially damaged**. For hard products, you can cut away the damaged or broken portion, and what remains can still produce good quality dried product. Again, drying can help recover income that might otherwise be lost. However, if a soft product is partially damaged or shows sign of mold, then the entire product should be disposed of because the mold may have spread.
4. **Avoid produce that is rotting or moldy** - a moldy fresh product will result in a moldy dried product. Mold can spread unseen throughout a fruit or vegetable. If one part is infected, the whole fruit or vegetable is most likely infected. In addition, molds may also spread to other products within the dryer or possibly the dryer itself.
5. **Avoid produce recently sprayed with pesticides**, as pesticides are poisonous if ingested recently after application. If sprayed produce is harvested too soon, the chemicals will remain inside them. Products should be harvested two weeks or more after the last application of insecticide, before they are usable for solar drying, to prevent consumption of chemicals.

2. Sorting activity* – 13 minutes

Explain to participants that we are going to do a sorting activity. Say:

- *Now, we are going to take the next 10 minutes to break up into small groups of 3-4 people to do a sorting activity to show how to select produce that is good for drying in the chimney dryer.*
- *I am going to pass around about 2 kg of different produce items to each group. You should observe, discuss, and work together to sort the products into two piles: more suitable for drying or less suitable for drying.*

Pass around the produce including a mix of size, ripeness, freshness, bruised, sprayed, etc. and walk around to different groups to observe them sorting. If participants are placing a produce item in the incorrect pile, ask them to explain their choice and discuss as a group before placing it in the correct pile.

Say:

Now, we are going to go around to each group and have one person demonstrate and explain your choices to the larger group.

**If you have time to make this selecting and sorting activity more relevant to training participants, make an announcement prior to the training that encourages them to either go to the market to purchase fruits and vegetables, or bring produce items from home, that they would like to dry during the training. By having participants select and bring products they are interested in drying, this engagement creates an opportunity for conversation and active learning (for example: ask why they selected certain produce items to dry, including aspects such as ripeness, color, size, aesthetics, freshness, etc.).*

3. Question and answer session – 5 minutes

Ask participants:

- **I want to know how much each of you is understanding these concepts. Close your eyes and show me how much you understand by holding up 1-5 fingers. One finger means you don't understand at all and five fingers mean you understand completely.** *You should record different responses for evaluation and improvement purposes.*
- **What questions do you have about the sorting activity or how to know if a product is suitable for drying?** *You should record people's questions for evaluation and improvement purposes.*

4. PREPARING PRODUCTS FOR DRYING - 45 MINUTES

Objectives

By the end of this learning session, participants will have:

- Washed produce
- Peeled produce (if relevant for items)
- Pitted produce (if relevant for items)
- Sliced or torn produce

PREPARATION/MATERIALS

- ~6-9 kg of fresh, fully ripe, unbruised, high quality produce (mix of product type and size: some small and some large) for washing, peeling/tearing/slicing/pitting, and drying (*ideally produce that participants select themselves from the market or bring from home*)
- A clean water source (treated with hypochlorite to reduce bacteria if needed)
- Containers for water and produce
- Dishwashing soap
- Cutting boards (pre-washed to save time)
- Knives (pre-washed to save time)
- 10 cm x 10 cm “sample cards” (small cut outs of the food-grade tray mesh)
- Small scale for measuring the starting fresh weight of product
- Flipchart paper and markers

TIME

45 minutes

STEPS

- Wash produce – 10 minutes
- Peel produce (if relevant) – 10 minutes
- Slice, tear, or pit produce – 10 minutes
- Weigh produce – 10 minutes
- Question and answer session – 5 minutes

REFERENCES

- Text from Horticulture Innovation Lab. (2018). *Chimney solar dryer manual*. Retrieved from <https://horticulture.ucdavis.edu/information/chimney-solar-dryer-manual>
- LaBorde, L. (2013). Drying fruits and vegetables (dehydration). Retrieved October 2, 2018, from <https://extension.psu.edu/lets-preserve-drying-fruits-and-vegetables>
- Mkeni, A., Soundy, P., & Brutsch, M. (2001). Solar drying of fruit and vegetables. Retrieved September 25, 2018, from <https://www.nda.agric.za/docs/solar/solardrying.htm>
- Text from Tatge, S. (2014). *Reservoir Limited solar drying instruction manual (Unpublished)*.

STEPS

In preparing products for drying, it works well for participants to divide into several small groups and each group can be responsible for one product.

1. Wash produce – 10 minutes

Say:

- ***It is best to begin the drying process in the morning to give the maximum drying time before sunset.***
- *We are now going to prepare the raw product for drying. The first step is washing produce.*

- **All products should be washed before being dried** to remove unwanted dirt and ensure that the dried product will be clean and safe to eat.
- When washing fresh produce, remember to **only use clean water** to avoid contamination from unwanted bacteria.
- Take care when washing, especially with more fragile produce, as to not damage or bruise them.
- After they have been washed, be sure to place them into a clean container.

Participants should break up into groups and take turns washing the produce in clean water and placing it into a clean container.

2. Peel produce (if relevant) – 10 minutes

Ask participants:

- **When you dry your own fruits and vegetables, do you peel, slice, or do some other pretreatment such as blanching or adding preservatives like salt, sugar, or citric acid?**
- **Do you think peeling, slicing, or breaking down the product into smaller pieces increases or decreases the drying time?**

Thank people for sharing and acknowledge their responses.

Say:

- *This training is not going to go into pretreatment with preservatives, but know that blanching, sulfiting, and/or adding salt, sugar, or citric acid can further extend the shelf life of products by killing harmful microorganisms, speed up the drying time, affect the nutrition, and potentially improve the flavor.*
- *Another pre-drying activity is **peeling produce, which may speed up the drying time**. However, **peeling produce may also remove valuable nutrients**. The peeling process may also expose dirt within the layers of produce such as onions, which will require additional washing.*
- *If produce does not require peeling, or if you don't want to peel it, proceed to the next step in the pre-drying process: tearing, slicing or pitting.*
- *Otherwise, to peel, remove the outer protective peel from the fruit or vegetable with a sharp knife. For produce that is difficult to cut, a cutting board is recommended.*

In their groups, participants should take turns peeling produce items and placing them in clean containers.

3. Tearing, slicing, and pitting produce – 10 minutes

Say:

- **Thin items like herbs and leafy greens may dry in a few hours, while large products like whole apricots or whole bananas will require several days to dry** (depending on local conditions).
- **Breaking down the produce into smaller pieces by tearing, slicing, or removing pits can help speed up the drying process and also prevent product from sticking to the trays.**
- **The width of the sliced product is very important to the drying process. Pieces that are too thick will not dry efficiently; pieces too thin may burn.**
- Leafy green vegetables can be hand torn into smaller pieces to dry more quickly, but observe closely during drying to prevent burning.
- Thick or bulky produce needs to be sliced into small, thinner pieces, approximately 3-6 mm.
- If you are drying produce with a large pit (e.g. stone fruit), then the pit should be removed after slicing.
- ****It is very important to tear or slice produce items to be roughly the same size for uniform drying.****
- While slicing, allow produce to fall into a clean container before placing them in the drier. This also allows for the easy addition of preservatives such as salt, sugar, or acid, if you choose to use them for additional flavoring and shelf life.

In their groups, participants should take turns tearing leafy green vegetables or slicing thick produce items and placing them in clean containers.

4. Weigh produce – 10 minutes

Say:

To understand what happens to fruits and vegetables when we dry them, we are going to take their weight before, during, and after putting them in the chimney dryer.

Demonstrate how to weigh a sample card of one of the products, and ask for a volunteer to help weigh the remaining sample cards of products. The volunteer should use the scale to separately weigh each sample card of product.

Record the weight of each sample card on the flipchart paper before filling the trays and loading the product into the dryer. Later, the product will be weighed again to see how much water weight was lost through dehydration.

5. Question and answer session – 5 minutes

Ask participants:

- **I want to know how much each of you is understanding these concepts. Close your eyes and show me how much you understand by holding up 1-5 fingers. One finger means you don't understand at all and five fingers mean you understand completely.** *You should record different responses for evaluation and improvement purposes.*
- **What questions do you have about preparing raw produce items for drying?** *You should record people's questions for evaluation and improvement purposes.*

5. FILLING TRAYS, LOADING THE DRYER, COVERING WITH PLASTIC, CHECKING THE SEAL AND ENSURING AIRFLOW - 75 MINUTES

Objectives

By the end of this learning session, participants will have:

- Filled the trays with prepared fruits and vegetables
- Loaded the dryer with the trays in the correct orientation
- Covered the drying table with clear plastic
- Checked the plastic seal and airflow inside the dryer tunnel

PREPARATION/MATERIALS

- Drying trays (pre-washed to save time)
- A small piece of tissue/toilet paper for demonstrating airflow in the dryer
- Optional: A bee smoker and fuel or incense stick with lighter/match for demonstrating airflow in the dryer
- Dryer usage checklist handout (Appendix 2) – one for each participant
- Paper and writing utensils

TIME

75 minutes

STEPS

- Fill the trays – 15 minutes
- Load the dryer – 15 minutes
- Cover the drying table with plastic – 15 minutes
- Check the plastic seal and ensure airflow – 25 minutes
- Question and answer session – 5 minutes

REFERENCES

- Text from Horticulture Innovation Lab. (2018). *Chimney solar dryer manual*. Retrieved from <https://horticulture.ucdavis.edu/information/chimney-solar-dryer-manual>
- Mkeni, A., Soundy, P., & Brutsch, M. (2001). Solar drying of fruit and vegetables. Retrieved September 25, 2018, from <https://www.nda.agric.za/docs/solar/solardrying.htm>

STEPS

1. Fill the trays – 15 minutes

Ask participants:

- **How do you think the trays should be filled?**
- **Should each tray contain the same or different types of produce?**
- **Should the produce items be stacked on top of each other within a tray?**

Say:

- *The amount of produce and how it is placed onto trays is important. You can load the trays with whole or sliced fruits and vegetables, but the **pieces should not overlap too much to ensure efficient drying** (see photo below). Some overlap, especially of thin leafy greens is okay.*

- If you are loading wedges of sliced product onto the trays, **orientation of the wedges is important**. The peel or rind should be parallel to the long edge of the table, not facing the entrance, which can block airflow and slow down drying (figure 1 below).
- Also, it is good practice to **load the same product onto one tray because of similar drying time** (figure 1 below).
- Make sure the tray is not too heavy to lift.
- Note that adding more product (by weight) to the trays increases the overall amount of product dried per drying cycle; however, it also increases the length of the drying cycle.
- Light tray loads such as with flowers or herbs will dry in less than one day.
- With thicker, heavier products on a tray, drying may require several days.
- You should experiment with the product load to determine what works best under your drying conditions.

Participants should take turns filling the trays, taking care to put the same product on the same tray.

[Assessment] You should observe and correct participants to make sure they are loading the trays properly based on the above steps, with the same type of product and enough quantity to fill the trays, but not placing pieces on top of each other.

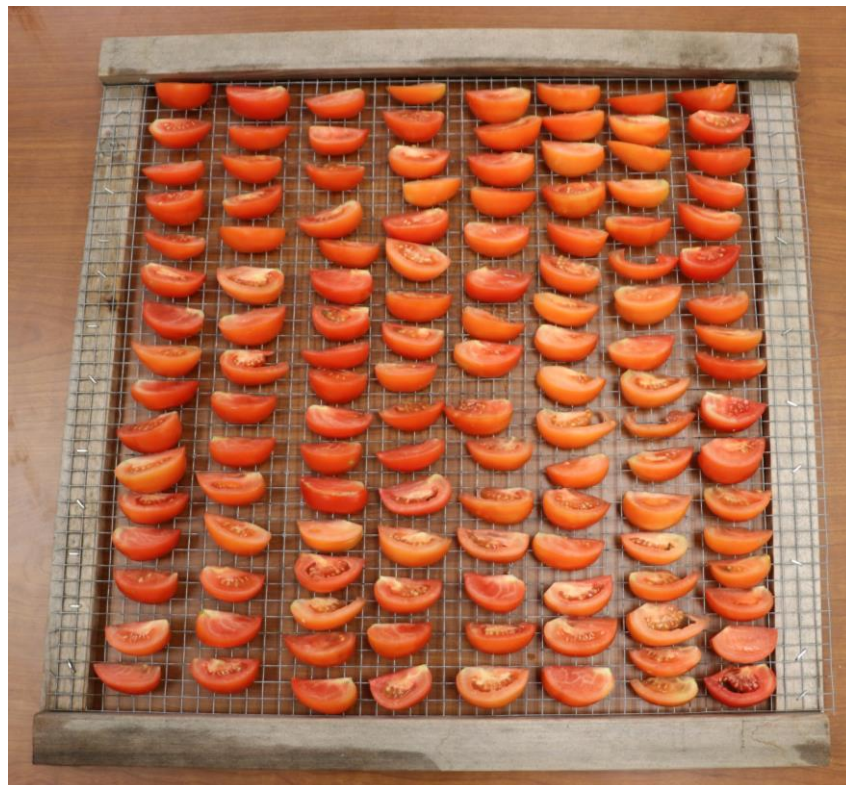


Figure 1. A tray filled with tomatoes that are uniformly sliced (same thickness), wedges with the peel/skin parallel to the wooden sides of the tray, and not over-filled (product is not touching or overlapping)

2. Load the dryer – 15 minutes

Once all the produce is placed on the trays, ask participants:

- Do you think it matters **how** the trays are oriented on the table (i.e. what direction they are facing)?
- Do you think it matters **where** the trays are placed on the table (i.e. front, back, middle)?

Say:

- **It is important to place the trays in the correct orientation on the dryer.**
- *When you place the trays on the drying table, you should turn them to ensure that the pieces of wood on the edges of trays do not block airflow (Figure 2 compared to Figure 3 below).*
- **You can also stack the trays up to two trays high** (Figure 2 below).
- *The first tray space (closest to the opening and farthest away from the chimney) should be left empty (Figure 4 below). Leaving the first tray space empty allows the air to heat up before it flows over the product.*



Figure 2. Correct tray orientation



Figure 3. Incorrect tray orientation



Figure 4. Empty space at the front of the dryer as a pre-heat area. Photo by Brenda Dawson

Demonstrate to participants by placing the first tray on the table in the correct orientation so the side wood panels are not blocking the airflow over the product. When you place the tray, be sure to leave empty space at the front of the dryer for the pre-heat area).

[Assessment] Observe the participants placing the rest of the trays in the correct orientation, stacking them up to two trays high along the table.

3. Cover the drying table with plastic – 15 minutes

Once all the trays are correctly placed on the drying table, ask participants:

- **Do you think the produce will dry faster if it is covered with plastic or left uncovered?**

Acknowledge responses and say:

- **Covering the table with clear plastic will enclose the produce and create airflow across the product, making it dry faster.**
- *It is important that product dry relatively quickly because if the drying process is too slow, the produce may start to ferment, mold, or otherwise spoil.*

Ask someone to volunteer to help you roll the clear plastic over the table, creating a tent over the product and trays. The plastic should be tight but not touching the fresh produce. Tuck the plastic around the sides and chimney-end of the dryer to seal the product. Having a tight seal at the chimney-end of the dryer is critical.

To seal the table to the chimney with the clear plastic covering, secure the long ends of the plastic to the ground with two lateral poles to take slack out of the plastic on the sides of the drying table. Tuck the clear plastic tightly over the support shelf and two vertical boards at the back of the dryer, securing the table to the chimney. To create an airtight seal between the table and chimney, use any combination of the following actions:

- *Wrap a bicycle tire inner tube around the shelf area (Figure 5 below)*
- *Use bricks or scrap wood to weigh down the plastic (Figure 6 below)*
- *Apply tape or Velcro to secure the plastic*



Figure 5 (left). A bicycle tire inner tube and bricks used to seal the table and chimney.

Figure 6 (right). Bricks and a wooden pole to seal the plastic to the side of the drying table.

Say:

Although we just demonstrated covering the chimney dryer with clear plastic using two people, **you do not need two people to use the dryer**. You should be able to operate the dryer, including cover and sealing it, alone as a single user.

4. Check the plastic seal and ensure airflow – 25 minutes

Say:

Now that the product is inside the dryer, we want to make sure the **plastic is fully sealed** and that air is flowing through the tunnel and out the chimney.

Ask participants:

- **Why do you think airflow in the dryer is important?**
- **Why might it be a problem if air is not flowing through the dryer?**

Acknowledge responses, and say:

- *The chimney design ensures continuous airflow around the product, which increases the speed of drying compared to other dryer designs.*
- *Faster airflow increases the rate of moisture loss from the product and speeds up drying.*
- **Make sure the air entrance at the front of the drying table is not blocked or covered in any way** (Figure 7 compared to Figure 8 below).
- *A few centimeters of headspace over the product is enough to provide for the free flow of air and allow for air to heat up (Figure 9 below). If the plastic covering is too high above the trays, air speed will be slowed and drying times will become longer.*
- *The plastic should be as taut as possible, creating a tent over the product and trays. **The clear plastic that covers the trays should not touch the fresh product**, which will dirty the plastic and may possibly cause either burning or incomplete drying.*
- *Make sure that there is plenty of airflow through the dryer, especially above and below the product.*
- *Remember, ambient air enters, quickly warms up and dries the product. Warm, humid air exits through the chimney.*

As you speak, demonstrate that the front of the dryer is not blocked by waving your hand in the tunnel entrance to show that it is open and not obstructed by plastic, wood, etc. Also demonstrate with your fingers only a few cm of space above the product, but not too much space, and show that the plastic is tight around the product and trays.



Figure 7. The front of the dryer is open for air to flow.



Figure 8. The front of the dryer is blocked by the clear plastic. Air cannot flow.



Figure 9. Only a few centimeters of headspace above the product, the plastic is not touching the product, and the front of the dryer is open. Note that trays can be stacked two high.

Photo by Brenda Dawson.

Ask participants:

- **If constant airflow is so important, how do you think you can tell if air is flowing through the dryer?**
- **Do you have any ideas for measuring the movement of air?**

Acknowledge responses and share/demonstrate the following methods. Ask for participants to observe and try out some of the methods too, asking them if they think the air is flowing:

Here are some ways to know if the air is flowing correctly in the dryer:

1. Hang a few small strips of tissue/toilet paper (~0.5 x 7.5 cm) from the center pole above the trays along the length of the table. When air is flowing, these strips will move with the flowing air.
2. Observe if the clear plastic covering the table is suctioning inward slightly.
3. Do the “nose check” – go to the opening at the end of the table and put your nose to it. If the air is flowing across the table and out of the chimney, you should not feel warm air hitting your nose or smell a strong aroma of the product. If the plastic is not sealed around the table correctly, then you might smell a strong aroma of whichever food product you are drying, or you may feel warm air on your nose.
4. Look at the shadow of the top of the chimney, cast by the sun on the ground. When air is flowing, you may see a shimmer just above the chimney shadow.
5. Use a bee smoker or incense stick to puff smoke into the opening of the dryer and see if the smoke goes across the product, and up and out of the chimney

Say:

Sometimes product is not drying fast enough or sufficiently.

Ask participants to turn to the person next to them and for the next 1-2 minutes, discuss the following questions:

- **If product is not drying fast enough or becoming dry enough, what do you think is causing the problem?**
- **How can we fix the issue?**
- **What are some of the negative results that could occur if the product does not dry fast enough or completely?**

After 1-2 minutes, ask for a few volunteers to share their ideas, and **take notes on their responses for evaluation purposes**. If the following point is not raised, explain:

- **The reason that product may not be drying fast or thoroughly enough is because the air may not be properly flowing over the product and out the chimney.**
- *The air may not be flowing properly is because the clear plastic may be too loose and not tight around the table and at the chimney-end. It is important that the plastic is tight around the trays, but not touching the product.*
- **The plastic should be sealed around the sides and chimney-end of the dryer to create a vacuum**, which prevents air from “short-circuiting” the product on the drying table. Short-circuiting means that air will immediately enter the chimney through any unwanted openings in the plastic (e.g. near the sides or back of the dryer), rather than first flowing into the tunnel entrance and over the product.
- *Now that you’ve started to think about some of the negative effects of not drying product enough later in the training, we will discuss these impacts later in the training.*

Demonstrate correct scenarios by tucking the plastic around the sides of the table and chimney-end of the dryer, and show that there is no blockage in the front of the dryer opening.

*Pass out the **Dryer usage checklist handout (Appendix 2)**, one for each participant, which they can take home as a visual reminder for using the chimney dryer.*

5. Question and answer session – 5 minutes

Ask participants:

- **I want to know how much each of you is understanding these concepts. Close your eyes and show me how much you understand by holding up 1-5 fingers. One finger means you don't understand at all and five fingers mean you understand completely. You should record different responses for evaluation and improvement purposes.**
- **What questions do you have about sealing the plastic around the drying table and ensuring airflow? You should record people's questions for evaluation and improvement purposes.**

6. DRYER LOCATION AND ORIENTATION - 25 MINUTES

Objectives

By the end of this learning session, participants will have:

- Discussed how to select a location for the chimney dryer
- Practiced rotating the dryer to maximize sun exposure

PREPARATION/MATERIALS

- Paper and writing utensils

TIME

25 minutes

STEPS

- Discuss selecting a location for the chimney dryer – 10 minutes
- Rotate the dryer to maximize sun exposure – 10 minutes
- Question and answer session – 5 minutes

REFERENCES

- Text from Helen Keller International. (2018). *Training manual on post-harvest management (processing and storage)* (Unpublished).
- Text from Horticulture Innovation Lab. (2018). *Chimney solar dryer manual*. Retrieved from <https://horticulture.ucdavis.edu/information/chimney-solar-dryer-manual>
- Text from Tatge, S. (2014). *Reservoir Limited solar drying instruction manual* (Unpublished).

STEPS

1. Discuss selecting a location for the chimney dryer – 10 minutes

Gather participants around the chimney dryer and ask:

- **What do you think is important about the location of the dryer?**
- **What do you observe about the location we have selected?**
 - **How sunny is the location?**
 - **Is the area clean?**
 - **Is it far from or close to the road?**

Acknowledge responses, and say:

- **Selecting a sunny and clean drying location is very important.**
- *Poor locations can lead to the introduction of bacteria, dirt, and mold into the dried product, and a location that doesn't get enough sun will not dry product efficiently.*

- *When selecting a location, remember these characteristics:*

Selecting a location for the chimney dryer

- 1) *The area should be flat with good sun exposure. Notice that we selected an area where trees or structures do not shade the dryer. Make sure the ground is cleared of tall grasses.*
- 2) *No garbage: garbage must be kept at least 30 yards from the drying location. Garbage is full of harmful bacteria and will attract unwanted pests and insects which may damage food. By keeping garbage away from the drying location, you can protect your product from contamination.*
- 3) *Keep far enough away from roads: even though food is protected inside the drying rack, your solar dryer is exposed to the elements when it is open. Dust constantly stirred up from roads can contaminate your dried food products. Keep your dryer away from such areas.*
- 4) *The drying area should be free of dust, smoke, stench and germs. The drying area must be clean and hazard-free. It must be far from sewers and toilets, and the area should be free of roaming animals.*

2. Rotate the dryer to maximize sun exposure – 10 minutes

Ask participants:

- **From which direction does the sun rise? From which direction does the sun set?**
- **Where is north? Where is south?**
- **Compared to the sun, which direction should the dryer face?**

Acknowledge responses, and [depending on your location], say:

- ***The opening of the dryer should always face the equator, to maximize sun exposure.***
- *[In the northern hemisphere, this means the opening of the dryer should face south, with the chimney in the north.]*
- *[In the southern hemisphere, this means the opening of the dryer should face north, with the chimney in the south.]*

Ask for a couple of volunteers to hold up either end of the chimney dryer to show that the open end of the table can be easily rotated around the chimney to better align with the sun.

3. Question and answer session – 5 minutes

Ask participants:

- **I want to know how much each of you is understanding these concepts. Close your eyes and show me how much you understand by holding up 1-5 fingers. One finger means you don't understand at all and five fingers mean you understand completely. You should record different responses for evaluation and improvement purposes.**
- **What questions do you have about the chimney dryer location or orientation to the sun? You should record people's questions for evaluation and improvement purposes.**

7. WHAT ARE THE BENEFITS OF DRYING FRUITS AND VEGETABLES? – 20 MINUTES

Objectives

By the end of this learning session, participants will have:

1. Considered the benefits of drying fruits and vegetables
2. Discussed personal motivations for drying

PREPARATION/MATERIALS

- Writing utensils and paper, for facilitator and all participants (if they are literate)

TIME

20 minutes

STEPS

1. Think – 2-3 minutes
2. Pair – 5-7 minutes
3. Share – 5 minutes
4. Question and answer session – 5 minutes

REFERENCES

- Barrett, D. (2002). Processing of horticultural crops. In A. A. Kader (Ed.), *Postharvest Technology of Horticultural Crops* (Third, pp. 465–479). Oakland, CA: University of California Agriculture and Natural Resources.
- FAO. (2019). Key facts on food loss and waste you should know! Retrieved August 8, 2019, from <http://www.fao.org/save-food/resources/keyfindings/en/>
- Text from Horticulture Innovation Lab. (2018). *Chimney solar dryer manual*. Retrieved from <https://horticulture.ucdavis.edu/information/chimney-solar-dryer-manual>

STEPS

1. Think – 2-3 minutes

Say:

We are going to think about the benefits of drying fruits and vegetables. Let us take some time to think about why we dry fruits and vegetables.

Ask participants to take a few minutes to think independently and quietly to themselves about why they dry fruits and vegetables. If participants are literate, ask them to write down their thoughts.

Say:

- **Take the next 2-3 minutes to think about the reasons why you dry fruits and vegetables.**

2. Pair – 5-7 minutes

After a few minutes of independent thinking, ask the participants:

- **Turn to the person next to you, and use the next 5-7 minutes to take turns describing and sharing your thoughts on why you dry fruits and vegetables.**

3. Share – 5 minutes

*After 5 minutes, ask for volunteers to share their discussions, and **take notes on their responses for evaluation purposes**. Thank people for sharing and acknowledge their responses. Raise any of the following points that are not mentioned:*

Why dry fruits and vegetables

1. Fruits and vegetables are nutritious and can be sold for high profit. Unfortunately, fresh produce is very perishable and postharvest losses can be quite high globally, with 40-50% of production lost between the growing site and the consumer (FAO, 2019). In lower income countries, much of this loss occurs soon after harvest or during processing, whereas losses in higher income countries occur more at the retail and consumer levels. Drying reduces this food loss and increases shelf life, especially during the harvest season when there is a large quantity of ripe produce all at once.
2. Dried fruits and vegetables are nutritious and can add variety and diversity to a household diet, especially during the lean season.
3. Dried fruits and vegetables have the potential to be sold for household income.
4. Drying reduces the volume and weight of products, resulting in lower transportation and storage costs if being sold (Barrett, 2002).

4. Question and answer session – 5 minutes

Ask participants:

- **I want to know how much each of you is understanding these concepts. Close your eyes and show me how much you understand by holding up 1-5 fingers. One finger means you don't understand at all and five fingers mean you understand completely.** *You should record different responses for evaluation and improvement purposes.*
- **What questions do you have about why we dry fruits and vegetables?** *You should record people's questions for evaluation and improvement purposes.*

8. HOW THE CHIMNEY DRYER WORKS - 35 MINUTES

Objectives

By the end of this learning session, participants will have:

1. Identified components of the chimney dryer and their functions
2. Compared and contrasted the chimney dryer to traditional, open air sun drying

PREPARATION/MATERIALS

- Chimney dryer airflow diagram (Appendix 3) – one for each participant
- Pictorial images for drying comparison (benefits of using the chimney dryer over traditional sun drying) (Appendix 4) – enough sets of cards for each small group
- Paper and writing utensils

TIME

35 minutes

STEPS

1. Identify components of the chimney dryer and their functions – 10 minutes
2. Compare the chimney dryer to traditional, open air drying – 20 minutes
3. Question and answer session – 5 minutes

REFERENCES

- Text from Helen Keller International. (2018). *Training manual on post-harvest management (processing and storage)* (Unpublished).
- Text from Horticulture Innovation Lab. (2018). *Chimney solar dryer manual*. Retrieved from <https://horticulture.ucdavis.edu/information/chimney-solar-dryer-manual>




STEPS

1. Identify components of the chimney dryer and their functions - 10 minutes

Gather participants around the chimney dryer and ask:

- **How do you think the chimney dryer works?**
- **Can you identify different components of the dryer? What do you think their function is?**

Acknowledge and correct any inaccurate responses, and add any of the following points that are not raised:

How the Chimney Dryer Works: Four Main Components <i>Photos by Brenda Dawson</i>	
Component	Function
<p>Drying table covered with black plastic or fabric</p> 	<ul style="list-style-type: none"> • The large area absorbs heat to dry the product, ensuring higher temperatures and rapid moisture removal • Raises the trays off the ground for convenience, physical comfort of the user, and hygiene
<p>A chimney covered with clear plastic with an opening at the drying table</p> 	<ul style="list-style-type: none"> • Draws hot air out of the dryer, removing moisture from the product • Remember, air enters the dryer, quickly warms up and dries the product. Warm, humid air exits through the chimney. • The chimney ensures continuous airflow around the product, thus increasing the speed of drying compared to sun drying and other dryer designs
<p>Mesh-covered drying trays</p> 	<ul style="list-style-type: none"> • Hold the produce • Mesh helps air circulate around the product, above and below • Can be stacked up to two trays high, but make sure that the product on the bottom tray does not touch the tray above • Can be shuffled (top to bottom, and front to back) in their location on the drying table to ensure more uniform drying

Clear plastic film that covers the trays and the drying table and is sealed to the chimney



- Covers the trays, but does not touch the product, which can cause burning, sticking, or incomplete drying
- The dryer should use clear polyethylene (PE) plastic (not polyvinyl chloride or PVC plastic)
- Protects the food product from contamination
- Is sealed to the chimney to trap and move hot air across the product and out of the dryer, removing moisture
- Does not cover the front opening of the dryer, which would block airflow – remember to remove any blockages from the front of the dryer opening

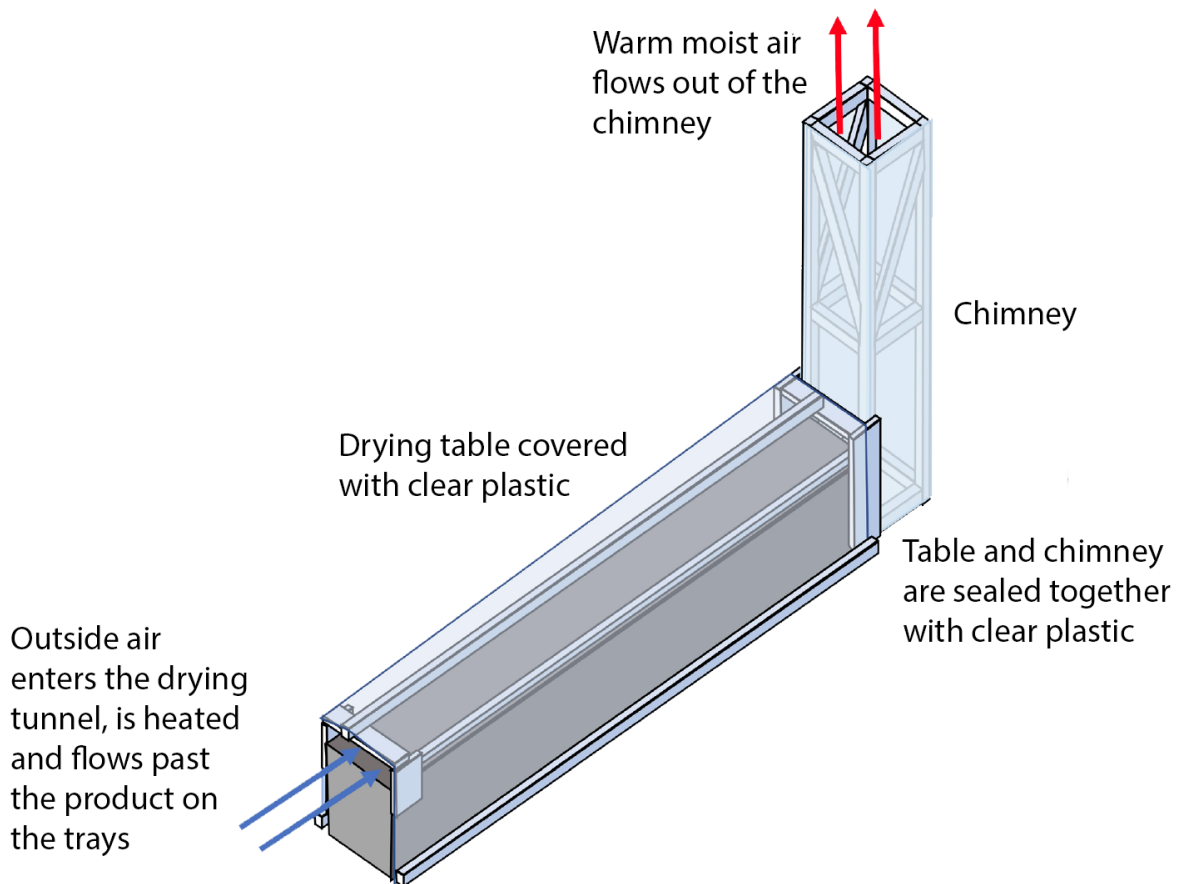


Figure 10. Chimney dryer airflow diagram for your reference (also in Appendix 3).

Illustration by James Thompson.

Pass out a copy of the **Chimney dryer airflow diagram (Appendix 3)** to each participant to take home for future reference.

2. Compare the chimney dryer to traditional, open air sun drying – 20 minutes

Ask participants:

- **What is different about the chimney dryer compared to traditional, open air sun drying?**

Probe by asking:

- **Which method of drying is more protected?**
- **Which method of drying do you think is usually faster?**
- **Which method of drying do you think is more sanitary/hygienic/clean?**
- **Which method of drying do you think retains the quality and nutrients of the food products?**

Acknowledge the responses. Say:

We are now going to compare and contrast the chimney dryer with traditional, open air sun drying by thinking about the different characteristics and sorting these cards into two piles.

*Ask the participants to divide into small groups. Pass out sets of **Pictorial images for drying comparison (benefits of using the chimney dryer over traditional sun drying)** (Appendix 4), one set for each small group. Ask participants take the next 10 minutes to sort the cards into two piles: chimney dryer and open-air sun drying. Walk around and observe them. If someone suggests placing a card in the incorrect pile, ask them to explain their choice and discuss as a group before placing it in the correct pile.*

For your reference:

Solar drying with the Chimney Dryer	Traditional, open air sun drying
Usually more reliable with generally faster drying time (less time to dry means decreased risk of spoilage)	Usually slower drying time (more time required to dry means higher chances of spoilage)
Protected environment, covered and safe from physical contaminants like dust, weather events like rain, and pests such as birds, livestock, rodents, and insects (covered = more hygienic/sanitary)	Open/exposed environment, not protected against contamination or damage from pests and weather (uncovered = less hygienic/sanitary)
Nutrients, color, texture, taste, and overall quality are generally more preserved	Nutrients, color, texture, taste and overall quality are generally more degraded

After the sorting activity, ask participants:

- **Can someone summarize the benefits of the chimney dryer compared to traditional, open air sun drying?**

3. Question and answer session – 5 minutes

Ask participants:

- **I want to know how much each of you is understanding these concepts. Close your eyes and show me how much you understand by holding up 1-5 fingers. One finger means you don't understand at all and five fingers mean you understand completely.** *You should record different responses for evaluation and improvement purposes.*
- **What questions do you have about the chimney dryer compared to traditional, open air sun drying?** *You should record people's questions for evaluation and improvement purposes.*
- **What hesitations do you have about using the chimney dryer instead of traditional sun drying?** *You should record people's responses for evaluation and improvement purposes.*

9. WEATHER, TEMPERATURE, AND DRYING TIME - 85 MINUTES

Objectives

By the end of this learning session, participants will have:

- Discussed how product type, thickness, water content, and preparation method affect drying time
- Predicted drying times for different products
- Checked the temperature inside the dryer
- Shuffled the trays for more uniform drying
- Observed current weather conditions
- Discussed using the chimney dryer in different weather conditions

PREPARATION/MATERIALS

- Simple dial thermometer or instant read/digital thermometer
- Markers and flipchart paper (including the paper with the previously recorded weights of fresh product and predicted drying times from earlier learning sessions)
- Scale
- Weather and drying conditions visual aid (Appendix 5) – one copy for demonstration purposes
- Paper and writing utensils

TIME

85 minutes

STEPS

- Sorting product by drying time – 10 minutes
- Exploring temperature inside the dryer and tray rotation – 45 minutes
- Weather observation and discussion – 10 minutes
- Re-weighing product – 15 minutes
- Question and answer session – 5 minutes

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- Text from Helen Keller International. (2018). *Training manual on post-harvest management (processing and storage)* (Unpublished).
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STEPS

1. Sorting product by drying time - 10 minutes

Ask participants:

- **In your experiences drying fruits and vegetables, do you think they all require the same amount of time to dry?**
- **Which products take more time to dry? Why?**
- **Which products take less time to dry? Why?**

Say:

- *Not all fruits and vegetables are the same. Some items are bulkier, have peels, contain more water content, or are more sensitive to heat and high temperatures.*
- *Let's consider the produce items that we're drying today. Think about how long it might take for these different food products to dry.*
- *Now please discuss and arrange the produce items in order, from shorter to longer drying time required.*

To remind people what's currently being dried, announce the produce items and have participants work together through group discussion to order the items by drying time. Record the participants' predictions on flipchart paper for reference later.

Say:

- *We will come back to your ideas later in the workshop.*
- *For now, you should **remember that in addition to water content, the thickness of the product or outer peels will also affect drying time, with thicker products requiring more time to dry.***

2. Exploring dryer temperature and tray shuffling – 45 minutes

Say:

- *While drying, it is important that product be dried as quickly as possible (to prevent spoilage), but not under temperatures so high that the product gets damaged.*
- ***Produce should be checked on periodically throughout the day to observe the level of dryness and to prevent possible damage.***
- *When using the chimney dryer, careful attention must be paid to the heat inside the dryer throughout the drying process, which affects drying time.*
- *To check the heat, temperature levels at different spots within the dryer should be monitored with a thermometer.*
- *While heat and high air temperatures speed drying, **air temperatures must not get too hot**, or it could damage the product by burning or blackening it, or the outside may become too hard.*
- *Alternatively, **when the dryer is too cool and drying slowly, the product can mold, ferment or otherwise spoil before it is dried.***
- *The dryer may become too hot or too cool at different times, depending on which product you are drying or the location of the dryer.*
- *Note that while opening the dryer to check on produce is recommended throughout the day, opening the dryer too frequently will release heat and cool down the dryer enough to affect drying times.*

Ask participants:

- **What do you think would cause temperatures to be too hot in the chimney dryer?**
- **What do you think would cause temperatures to be too cold in the chimney dryer?**

Acknowledge responses and say:

- *The movement of air over the food product inside the drying tunnel is a key part of the chimney dryer. Very high temperatures may result from too little airflow inside the dryer.*

Ask participants:

- **Now that we know airflow is needed to regular temperature inside the dryer, if it gets too hot and product is burning, can you think of some ways to lower the temperature?**

Acknowledge responses and say:

- *To maintain airflow and temperature inside the drying tunnel, make sure the clear plastic is fully sealed around the sides and chimney-end of the dryer.*
- *Also check that the openings at the front of the drying table and the back opening near the chimney are not blocked.*
- *Make sure the clear plastic cover is not touching the product.*
- *Other actions you can take to prevent products from burning:*
 - *First, operate the dryer when the outside air temperatures are lower (e.g. during cooler parts of the day).*
 - *Second, face the opening of the drying tunnel towards the wind, which can increase airflow over the product and cool down the inside of the dryer.*

Ask participants:

- **Do you have any questions about what to do when the dryer gets too hot?**

Answer any questions and say:

- *It is also possible that temperatures inside the dryer may be too low (i.e. too cool), and thus drying product too slowly.*
- *Cooler temperatures could occur if the dryer is in the shade and not receiving enough sunlight, or if the outside temperatures are very low.*
- *In this case, make sure the dryer is in full sun the entire day, or consider drying product when it's warmer outside.*

Ask participants:

- **Do you have any questions about what to do when the dryer is too cold?**

Answer any questions and say:

- *Knowing the recommended drying temperature for particular products will help prevent both under-drying or spoiling and over-drying or burning your product.*
- *Maximum air temperature during drying of most fruits and vegetables should be in the range of 60 – 65°C (140 – 150°F).*
- *Fruit slices should be dried in the 50-60°C (122-140°F) temperature range.*
- *Cabbage, onions, herbs and leafy greens are more temperature sensitive and should not be dried at temperatures above 57°C (135°F).*

- Grains and most nuts should not be dried above 54°C (130°F), with the exception of walnuts that should not be dried above 43°C (110°F).
- Air temperatures above these recommendations cause quality loss, such as darker color or decreased storage life.
- **Trial and error and testing different products in the dryer is the best way to be sure of the conditions required for best quality.**
- Regularly monitor air temperature inside the dryer. An inexpensive dial or instant read thermometer works well for this purpose.

Demonstrate how to measure temperature inside the dryer using a simple thermometer. Ask for a couple volunteers to come up and measure temperature in different parts of the dryer: opening-end, middle, and chimney-end, reading it out to the rest of the group. This can be done by poking a small hole in the clear plastic covering the drying table with the pointed end of the thermometer (if the hole in the plastic becomes too big, repair it with clear tape). Record the temperatures for different parts of the dryer on the flipchart paper.

Ask participants:

- **Which end of the dryer was the warmest?**
- **Which end of the dryer was the coolest?**

Acknowledge responses, and say:

The dryer is usually hotter on the chimney-end, though the exact temperatures at different locations inside the dryer may vary throughout the day, depending on the moisture content of the products being dried.

Ask participants:

- **What do you think is a potential benefit of having these mesh trays to hold the produce rather than a plastic trap, cloth sheet, bamboo mat, etc.?**

Acknowledge responses, and say:

- One benefit of the mesh trays is that you may not have to individually flip each piece of the food product because air is reaching both sides.
- Some products like tomatoes might stick, so you might want to move the pieces around on the trays to make sure they don't get stuck, but otherwise, the mesh trays should save you time.

Ask participants:

- **Do you think you should shuffle/change the location of the trays while drying? Why or why not?**

Acknowledge responses, and say:

- Because the dryer is usually hotter on the chimney-end, **the trays should be shuffled from front to back to ensure more uniform or even drying.**
- Because the dryer can also be used with two trays stacked on top of each other and sun exposure is greater at the top of the drying table, the top trays will generally dry faster than the lower trays. Thus, **trays should also be shuffled from top to bottom.**

- *Shuffling trays (in addition to covering product with a thin cloth) may also reduce burning or bleaching from direct sun exposure.*
- *Shuffle the trays according to the thickness and water content of the product. Generally, thicker and moister products require more time to dry and therefore more shuffling compared to leafy products, herbs, and other thin products.*
- ***It is advised that you rotate the trays 1-2 times a day or 2-3 times during the total drying process (depending on how many hours/days).***
- *To shuffle the trays, move the trays closest to the chimney to the opening of the dryer and the trays from the opening next to the chimney.*
- *Switch the bottom tray with top tray if trays are stacked.*
- *Remember that if the trays are stacked, make sure that the product on the bottom tray does not touch the tray above.*
- ***By shuffling trays and leaving an open preheat area at the front of the dryer, you will get more uniform drying across all products.***

[Assessment] Ask for two participants to volunteer to demonstrate removing the clear plastic and shuffling the trays as you have described. Observe and correct as necessary.

After shuffling the trays, re-cover the table with the clear plastic and tuck it in around the sides and chimney end so it is sealed again.

Ask participants:

- ***I want to know how much each of you is understanding these concepts. Close your eyes and show me how much you understand by holding up 1-5 fingers. One finger means you don't understand at all and five fingers mean you understand completely. You should record different responses for evaluation and improvement purposes.***
- ***What questions do you have about monitoring and modifying temperature inside the dryer? You should record people's questions for evaluation and improvement purposes.***

3. Weather observation and discussion – 10 minutes

Ask participants:

- ***What is the weather like right now? Cool/warm, sunny/cloudy, etc.***
- ***Do you think the chimney dryer can be used in all weather conditions?***
- ***What weather conditions do you think are best for drying?***
- ***When do you think the chimney dryer should not be used?***

Acknowledge responses, use the **Weather and drying conditions visual aid (Appendix 5)** as a visual training aid and say:

- *Dry air leads to a faster drying time. Humid environments are okay, but product may take longer to dry.*
- *The dryer works best in full sun, but can be used when the weather is cloudy too.*
- *Even occasional rain showers are not a problem. Light rain is okay, but make sure to lift the center pole over the table, so that the rain does not pool over the product.*
- *Drying should not be attempted during periods of continuous rain (i.e. monsoon season).*
- *To prevent dryer damage during heavy rainfall, high winds, or other stormy conditions, the chimney should be secured to the ground, turned over on its side, or ideally brought into safe, sheltered location.*

4. Re-weighing product – 15 minutes

Say:

- *Now that products have been dryer in the chimney dryer for a few hours, we are going to check on them.*
- *We know that different fruits and vegetables take different amounts of time to dry, so let's make some predictions about our drying demonstration.*

Ask participants:

- **Which product do you think dried the fastest?**
- **Which product do you think lost the most weight?**
- **Where do you think the weight went?**

Ask for volunteers to help separately weigh each product using the scale. Write down the dry weight of each product on the same flipchart paper where you wrote the original fresh weight and also recorded predicted drying times, and then remind participants what the fresh weight was for each product and their drying time predictions. Show participants the fresh vs. dried weights, drying predictions, and allow them to compare.

Ask participants:

- **Were your predictions correct about which products would lose the most weight?**
- **Are you surprised by the weight change results?**
- **Were your predictions correct about which products would dry the fastest?**
- **What do you think the results mean about each product?**

Acknowledge responses, and if the following points are not raised, explain:

- *One reason why XX product lost the most weight is because it had the most water content to begin with.*
- *One reason that XX product dried very fast is because we sliced it thinner.*

5. Question and answer session – 5 minutes

Ask participants:

- **I want to know how much each of you is understanding these concepts. Close your eyes and show me how much you understand by holding up 1-5 fingers. One finger means you don't understand at all and five fingers mean you understand completely.** *You should record different responses for evaluation and improvement purposes.*
- **What questions do you have about weather, temperature or drying time?** *You should record people's questions for evaluation and improvement purposes.*

RECAP TRAINING DAY 1 (10 MINUTES)

“The minute paper” – ask participants to either write (if they are literate and there are paper and writing utensils available), think about, or share with another training participant:

1. *The most important thing they learned today*
2. *What they understood least, or what remains the most unclear or confusing*

Ask for a few people to share their thoughts with the whole group and answer any points that are still unclear.

Thank them for their time and attention and remind them to bring storage containers with previously dried product to the next training if they are able.

10. MEASURING DRYNESS OF PRODUCT WITH THE DRYCARD™ - 30 MINUTES

Objectives

By the end of this learning session, participants will have:

1. Discussed the importance of making sure product is dry enough to store
2. Assessed common methods to tell if product is dry enough to store
3. Observed and learned how to use DryCard™ to check product dryness

PREPARATION/MATERIALS

- DryCards – one for each participant
- DryCard visual instructions (Appendix 6) – one for each participant
- Dried product from earlier in the training to test dryness
- Sample dried product at different moisture levels in separate containers with DryCards for reference (e.g. one at 35%, one at 55% and one at 75% relative humidity)
- Samples of moldy or spoiled product in a container with a DryCard
- Paper and writing utensils

TIME

30 minutes

STEPS

1. Discuss the importance of sufficient dryness to stop mold growth and assess common methods to tell if product is dry enough to store – 15 minutes
2. DryCard demonstration and Q+A – 15 minutes

REFERENCES

- Text from Horticulture Innovation Lab. (2018). *Chimney solar dryer manual*. Retrieved from <https://horticulture.ucdavis.edu/information/chimney-solar-dryer-manual>
- Text from Horticulture Innovation Lab. (2018). DryCard. Retrieved September 25, 2018, from <https://horticulture.ucdavis.edu/drycard>

STEPS

1. **Discuss the importance of sufficient dryness to stop mold growth and ways to tell if product is dry enough to store – 15 minutes**

At the beginning of this session, select a small sample of each product that is currently being dried inside the dryer and place each product in a clean, separate airtight container (ideally a clear container for demonstration purposes later). Place a DryCard in each container with the dried product and seal the container. Make sure to show the participants the color of the DryCard at the beginning of this session (consider having someone say the starting card color out loud for all to hear).

Say:

- *We will come back to this product later in the training.*
- *Now, we are going to think about and discuss the importance of making sure product is dry enough to store.*
- *Turn to the person next to you, and use the next 5 minutes to take turns describing and sharing your thoughts on the following questions:*

- **In your experiences drying fruits and vegetables, how do you know if a product is dry enough to store? What method do you use to assess dryness?**
- **Have you had any problems or challenges with determining if a product is dry enough to store?**
- **If a product becomes moldy in storage, what do you think is causing the mold growth?**
- **Why is mold growth a problem?**
- **How can we solve the problem of mold on dried product?**

*After 5 minutes, ask for volunteers to share their discussions, and **take notes on their responses for evaluation purposes**. Add any of the following points that are not raised:*

- *The moisture content of fresh produce at harvest ranges from 20-95%.*
- ***Crops must be sufficiently dried to be safely stored, otherwise harmful fungus/mold will develop.***
- *Moldy food can have a bad taste and may be contaminated with harmful toxins, which make it a health hazard to consume.*

Depending on which products you've dried in the training or which products participants plan to dry in the future, you should make the following specific recommendations and demonstrate by bending, biting, crushing or listening to the product rattle in a container. After demonstrating these common methods, pass around a small samples of each food item, including products with different levels of relative humidity, to the participants so they can test for dryness using one of the common methods.

For your reference:

Recommendations: How dry is dry enough?

- High sugar content fruit should be dried to approximately 20% moisture content; this means that the fruit will still be pliable/bendable/flexible, but not sticky or tacky.
- Dried berries should rattle when shaken in a container.
- Vegetables are sufficiently dried when they are hard and brittle or tough and leathery, depending on the vegetable.
- Sufficiently dried beans, corn and peas are hard and can shatter.
- Dried leafy, thin vegetables should be brittle and will easily shatter or be crushed into powder, and larger chunks or slices of vegetables should be leathery. At this stage, the produce should contain about 10% moisture.

[Assessment] Participants should bite, bend, rip or crush the sample product to test if it's dry enough to store. Ask participants: Do you think it's dry enough to store? Is it hard to determine? Do you think your guess is correct?

2. DryCard demonstration and Q+A – 15 minutes

After demonstrating and passing around each product, say:

- You can also tell that a product is not dry enough to store if you place it in a sealed container and see condensation/moisture start to develop.
- However, **the best and most accurate method of determining safe product for storage is to measure the relative humidity of the air in the dried product storage container. Mold will not grow when relative humidity is lower than 65%.**
- One inexpensive method for measuring relative humidity is to use a DryCard™ indicator (more information at <http://drycard.ucdavis.edu/>).
- The DryCard™ is an inexpensive device developed by researchers at the University of California, Davis to determine if dried food is dry enough to prevent mold growth during storage.
- **The DryCard is a reusable device that works by incorporating a cobalt chloride humidity indicator paper strip that changes color with changing relative humidity.**
- When a dry product is stored in a sealed container, mold will not grow on it if the relative humidity within the container is lower than 65%.



Photo by Brenda Dawson

Hold up the DryCard to show participants, then pass it around so participants can look at it. Say and demonstrate the following (based on Appendix 6), on a new sample of dried product:

- **To use the DryCard to check dryness, place the DryCard and a sample of the dried product in an airtight container, such as a sealed plastic bag or a jar.**
- The card will display an estimate of the relative humidity within the sealed container in approximately 30–60 minutes. Waiting for 2 hours will provide a more accurate measure.
- **If the paper indicator strip on the card turns the color blue or mauve, then the product adequately dried.**
- **If the DryCard turns pink, this indicates the product is too wet to be stored safely. In this case, the product should be consumed immediately or dried further before storage.**

Hold up a few clear containers with DryCards and samples of dried product from the beginning of the session to show any color change, as well as the additional dried product (including the moldy or spoiled samples). Pass around these containers for participants to observe the color on the DryCard.

Ask participants:

- **What is the color of the DryCard in these containers?**
- **Has the DryCard color changed from the beginning of the session?**
- **What do you think the color change indicates?**
- **Do you think the product is dry enough to store based on the color of the DryCard now?**

Acknowledge responses, and explain if the products are dry enough to store based on the DryCard reading. Be sure to point out how the color of the paper strip can be read based on the color scale with different relative humidity values; highlight the cutoff line at 65% RH.

*When you show containers with DryCards and samples of product (e.g. tomatoes) divided into different containers based on levels of relative humidity (some products should be above 65% and others below, including the moldy or spoiled product), remove each product from its container, pass it around and state the level of relative humidity according to the color on the DryCard. Have participants observe and feel each product to understand different levels of dryness for future reference. **The goal is to show people that there is a spectrum of dryness, and even partially dried product without mold or visible signs of spoilage may not be safe to store for later consumption.***

Ask participants:

- **I want to know how much each of you is understanding these concepts. Close your eyes and show me how much you understand by holding up 1-5 fingers. One finger means you don't understand at all and five fingers mean you understand completely. You should record different responses for evaluation and improvement purposes.**
- **What questions do you have about the DryCard or how to know if product is dry enough to store? You should record people's questions for evaluation and improvement purposes.**

Say:

- **A DryCard can be reused many times if well cared for. Store the card in a plastic bag to keep dry. Accidental contact with water or high humidity conditions will stop the card from working properly.**
- **The indicator strip contains cobalt chloride. Do not remove the strip from the card or leach the cobalt chloride by placing the card in water, which will ruin it.**

*Pass out a DryCard to each participant to take home, plus one copy of the **DryCard visual instructions** (Appendix 6). Share contact information of the local DryCard manufacturer if available.¹*

¹ Note that at the time of this manual publication, DryCards are currently available in Africa, Asia, Central America, and the U.S. and are being sold for \$1 to \$1.50 per card. More information on DryCards can be found on the website: <http://drycard.ucdavis.edu/>

11. STORAGE CONTAINERS AND CONDITIONS - 30 MINUTES

Objectives

By the end of this learning session, participants will have:

- Discussed the importance of proper storage containers
- Reviewed proper storage conditions

PREPARATION/MATERIALS

- Airtight storage containers that can be sealed, such as zippered plastic bags or plastic containers or glass jars with lids (ideally a few clear containers for demonstration purposes) – *if possible, ask training participants to bring a storage container with product they have previously dried*
- Paper and writing utensils

TIME

25 minutes

STEPS

- Discuss storage containers – 15 minutes
- Discuss storage conditions – 10 minutes
- Question and answer session – 5 minutes

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STEPS

1. Discuss storage containers – 15 minutes

Say:

- *Now that the product is dried, we are going to think about and discuss the importance of proper storage containers and conditions for storing dried food products.*
- *Turn to the person next to you, and use the next 5 minutes to take turns describing and sharing your thoughts on the following questions:*
 - **What containers are you currently using to store your dried food products? If you've brought containers with you from home with dried product inside, show each other what you've brought.**

- **How long do you tend to store dried food products before consumption?**
- **Are you having any issues with storing dried product?**

*After 5 minutes, ask for a few volunteers to share their discussions, and **take notes on their responses for evaluation purposes**. Thank the participants for their answers, acknowledge responses and say:*

- **Properly dried, packaged, and stored food products can last up to one year or more at room temperature.**
- *Following initial sufficient drying, product should be stored in proper containers to help maintain good flavor and aroma.*
- *To extend the shelf life and quality of dried product and to prevent mold growth/spoilage and pest or insect damage, **containers that are food grade, clean, and airtight** (e.g. plastic bags, containers, or glass jars) are **critical**.*
- *Consider using brown paper bags folded tightly, which can keep out light, and then place the folded brown paper bags inside sealed plastic bags or containers.*
- *Dried food products should be stored in small quantities to reduce widespread contamination and increase shelf life.*
- *Do not be afraid to pack the dried product tightly together, though do so carefully so as to not damage the product.*
- *It is also good practice to **label the containers with key information such as the name of the product, the date of packing, and the method of pretreatment if you used one** (e.g. blanching, any preservatives).*
- *Be sure to **discard any foods that develop unpleasant smells or off flavors or show signs of mold**.*

Demonstrate by placing dried product in different airtight storage containers based on what is locally available (e.g. plastic bags, plastic containers, glass jars, etc.). Seal the containers to show the importance of creating an airtight environment.

Ask participants:

- **Do you think these containers [would] work well in your community? Why or why not?** *You should record the responses for evaluation and improvement purposes.*

2. Discuss storage conditions – 10 minutes

Say:

Once we put the sufficiently dried product into storage containers, we have to place the containers somewhere.

Ask participants:

- **What kind of environment do you think dried food products should be stored in? (e.g. inside or outside, hot or cold, dry or wet, etc.)**

Acknowledge responses and say:

- **Proper storage conditions are cool (ideally 0-10°C or 32-50°F), dry, and dark.**
- *Moisture is required for microorganisms like mold to grow, so moisture must be controlled for safely storing dried food.*
- *In addition to moisture, exposure to too much light and heat can also degrade the color and general quality of dried food products.*
- **Therefore, storing dried product inside a cool, dry cupboard away from light and protected from rodents and pests is advised.**
- *After storing dried fruits in an airtight container, it is good practice to shake up the contents and watch for 10-14 days to see if condensation/moisture starts to develop. If moisture develops, you will need to check for any mold growth, discard any contaminated product and continue to dry the rest of the product.*

3. Question and answer session – 5 minutes

Ask participants:

- **I want to know how much each of you is understanding these concepts. Close your eyes and show me how much you understand by holding up 1-5 fingers. One finger means you don't understand at all and five fingers mean you understand completely.** *You should record different responses for evaluation and improvement purposes.*
- **What questions do you have about proper storage containers and conditions?** *You should record people's questions for evaluation and improvement purposes*

Optional activity: *As an additional activity that might be interesting to the training participants, you could run DryCard tests on the previously dried food products they brought from home in their containers to see if the items were sufficiently dried for safe storage. This also gives you as the trainer the added benefit of seeing what farmers are already drying at home, how dry their product is, and the type of storage container they typically use.*

12. NUTRITION OF DRIED FRUITS AND VEGETABLES - 25 MINUTES

Objectives

By the end of this learning session, participants will have:

- Reviewed the effect drying has on the nutrition of fruits and vegetables
- Discussed ways to reduce nutrient losses

PREPARATION/MATERIALS

- Paper and writing utensils

TIME

25 minutes

STEPS

- Review the effect of drying on nutrition – 10 minutes
- Discuss ways to reduce nutrient losses – 10 minutes
- Question and answer session – 5 minutes

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STEPS

1. Review the effect of drying on nutrition – 10 minutes

Say:

As you may know, consuming a diverse diet with many different types of food groups, including fruits and vegetables, is important for human health and nutrition.

Ask participants:

- **Do you think the nutrition of dried fruits and vegetables is the same as fresh?**

Acknowledge responses and say:

- *Drying is a form of food processing and preservation that may affect the nutrition of the fruits and vegetables.*
- **Drying and applying heat can degrade some nutrients, especially vitamins C, A, E and B (e.g. thiamin, niacin, and riboflavin), due to oxidation and other chemical reactions.**
- *Vitamin C is especially unstable and mostly destroyed during drying. Beta-carotene, a precursor to vitamin A, has also been especially shown to*

decrease upon drying vegetables including carrots, broccoli, and spinach. Under controlled heat, however, vitamin A can be retained.

- In contrast, iron, calories, and fiber remain constant, although more concentrated due to a reduction in the size of the product after drying.
- Changes in macronutrient contents, including proteins, fats, and carbohydrates, may result in color and texture differences, off or rancid flavors, and an overall decrease in product quality.

2. Discuss ways to reduce nutrient losses – 10 minutes

Ask participants:

- **Can you think of any ways to reduce nutrient losses while drying?**

Acknowledge responses and say:

There are some practices that can be used with drying to help preserve nutrients.

For example:

- *Minimizing the peeling of fruits and vegetables can help retain vitamins and minerals, especially vitamins C and B.*
- *Rubbing leafy greens with salt before drying can help retain ascorbic acid (vitamin C) and beta-carotene (vitamin A precursor).*
- *Utilizing improved solar dryers instead of traditional sun drying can prevent direct exposure to ultraviolet light.*
- *Proper storage in a cool, dark and dry place and consumption within a year can help retain nutrients.*

****Summarize the following with strong emphasis**:** *Drying retains the food value but reduces vitamin content, so it's important to supplement dried foods with fresh fruits and vegetables. Moreover, although drying fruits and vegetables can lead to some nutrient loss, it is still beneficial to consume dried fruits and vegetables, especially if drying makes them available year-round.*

3. Question and answer session – 5 minutes

Ask participants:

- **I want to know how much each of you is understanding these concepts. Close your eyes and show me how much you understand by holding up 1-5 fingers. One finger means you don't understand at all and five fingers mean you understand completely. You should record different responses for evaluation and improvement purposes.**
- **What questions do you have about the effect of drying on the nutrition of fruits and vegetables? You should record people's questions for evaluation and improvement purposes.**

13. TASTING, CULINARY USES/RECIPES, AND MARKET SALES – 60 MINUTES

Objectives

By the end of this learning session, participants will have:

1. Tasted and discussed food product that was dried using the chimney dryer
2. Reflected on and discussed household use of dried fruits and vegetables
3. Brainstormed other ideas for how to use dried fruits and vegetables in the household diet
4. Discussed potential market opportunities for selling dried fruits and vegetables

PREPARATION/MATERIALS

- Fully dried fruits and vegetables (including produce previously dried with the chimney dryer, either from this training or earlier drying activities, and if possible, produce dried traditionally in the sun), enough for all participants to eat a sample
- Flipchart paper and markers
- Paper and writing utensils, for training facilitator and participants (if they are literate)

TIME

60 minutes

STEPS

1. Tasting and discussing dried product - 15 minutes
2. Think about incorporation of dried foods into the household diet – 5 minutes
3. Pair – discuss with another person about the incorporation of dried foods into the household diet – 8 minutes
4. Share with the group – 7 minutes
5. Think about market opportunities – 5 minutes
6. Pair – discuss market opportunities – 8 minutes
7. Share with the group – 7 minutes
8. Question and answer session – 5 minutes

STEPS

1. Tasting and discussing dried product – 15 minutes

Say:

Now that we know the importance of consuming dried fruits and vegetables as part of a diverse, nutritious diet, we are going to get a chance to taste some fruits and vegetables, samples that were successfully dried using the chimney dryer and dried traditionally in the sun.

Pass around a few samples of dried fruits and vegetables for each participant to taste.

Ask participants to turn to the person next to them and take the next five minutes to discuss the following questions:

- **Did you like the dried food product?**
- **What did you think about the taste or smell?**
- **What did you think about the texture or mouth feel?**
- **How did the chimney-dried food product compare to traditional sun-dried product? Did you notice a difference?**
- **Is there anything else you noticed or that you want to share?**

*After 5 minutes, ask for a few volunteers to share their discussions. Thank the participants for sharing and **take notes on their responses for evaluation purposes.***

2. Think about incorporation of dried foods into the household diet – 5 minutes

Say:

Now that we've gotten the chance to sample some dried food products, we want to consider how to further incorporate them into your household diet.

Ask participants to take the next 5 minutes to think independently and quietly to themselves about the following questions. If participants are literate, you can write the questions on the flipchart paper for them to see and ask them to write down their thoughts. Otherwise, you can ask the questions one by one to participants to reflect on for about a minute each.

- **Does your household currently consume dried fruits and vegetables? Which ones?**
- **How often does your household eat dried fruits and vegetables?**
- **Who in your household eats them?**
- **How are they prepared/eaten? For example, plain as a snack food or rehydrated in hot dishes.**
- **Are there specific food dishes or recipes that you have used dried foods in?**
- **Do you have any other ideas for how you might be able to use dried foods in your household diet?**

3. Pair – discuss with another person about the incorporation of dried foods into the household diet – 8 minutes

After a few minutes of independent thinking, ask the participants:

- **Turn to the person next to you, and use the next 8 minutes to take turns describing and sharing your thoughts on the previous questions.**

4. Share with the group – 7 minutes.

After about 8 minutes, ask for volunteers to share their discussions. Thank them and write down responses on the flipchart paper (also for evaluation purposes). Feel free to include any of your own ideas or personal experiences with eating dried foods.

5. Think about market opportunities – 5 minutes

Say:

In addition to eating dried fruits and vegetables at home, we want to discuss any potential opportunities to sell dried fruits and vegetables in your community.

Ask participants to take the next 5 minutes to think independently and quietly to themselves about the following questions. If participants are literate, you can write the questions on the flipchart paper for them to see and ask them to write down their thoughts. Otherwise, you can ask the questions one by one to participants to reflect on for about a minute each.

- **Do you think people would be interested in buying dried fruits and vegetables? What is the value proposition?**
- **Who are the customers that would be interested? Where would the best market be?**
- **Would you personally be interested in selling dried fruits and vegetables?**
- **What would you say to a potential customer to convince them to buy your dried fruits and vegetables? What would your “elevator pitch” be?**
- **What are the potential uncertainties, barriers, or challenges to selling dried fruits and vegetables?**

6. Pair – discuss market opportunities – 8 minutes

After a few minutes of independent thinking, you can either do a group brainstorming session where participants share their ideas to the group, or you can ask the participants to break up into pairs to discuss:

- **Turn to the person next to you, and use the next 8 minutes to take turns describing and sharing your thoughts on the previous questions.**

7. Share with the group – 7 minutes.

After 8 minutes, ask for volunteers to share their discussions. Thank them and write down responses on the flipchart paper (also for evaluation purposes). Feel free to include any of your own ideas or personal experiences with selling dried produce.

8. Question and answer session – 5 minutes

Ask participants:

- **I want to know how much each of you is understanding these concepts. Close your eyes and show me how much you understand by holding up 1-5 fingers. One finger means you don't understand at all and five fingers mean you understand completely. You should record different responses for evaluation and improvement purposes.**
- **What questions do you have about incorporating dried foods in your household diet and market opportunities? You should record people's questions for evaluation and improvement purposes.**

14. COMMUNITY PLANNING FOR FUTURE CHIMNEY DRYER USAGE AND MAINTENANCE - 30-60 MINUTES

Objectives

By the end of this learning session, participants will have:

1. Created a community plan (e.g. formed groups and a schedule) for using and maintaining the chimney dryer in the future

PREPARATION/MATERIALS

- Flipchart paper and markers

TIME

30-60 minutes

STEPS

1. Discuss as a group and create a written action plan

STEPS

1. **Discuss as a group and create a written action plan – 30-60 minutes**

Say:

- *Now that we have discussed the importance of eating dried fruits and vegetables and have learned how to use the chimney solar dryer as an improved method for drying, we want to make sure that the community will actually use and maintain the chimney dryer.*
- *We would like to help create a plan among the group for using, sharing, and maintaining the chimney dryer in the future.*

Community-level discussion and action plan should address these points:

- How will we decide who uses the dryer when? Do we need to create a schedule or form groups?
- If the plastic rips or the dryer somehow breaks and needs repairs, who will fix it?
- How will we pay to fix the dryer - will community members combine our money?

If participants don't live close by to the chimney dryer, ask:

- Do you plan to build your own dryer (either as an individual household or part of another group)? If yes, what is your plan?
- What crops do you intend to dry?
- What quantities do you hope to dry?
- Do these products take a long or short time to dry? (This will likely impact the dryer usage schedule/rotation, as participants may want to plan to minimize the time periods when the dryer is unused.)

15. POST-TRAINING SURVEY/DISCUSSION AND CLOSEOUT – 30 MINUTES

Say:

Now that we have finished this training, we are interested in checking back in on what you know about drying fruits and vegetables. We will now conduct a brief post-training survey/discussion.

STEPS

1. “The minute paper” and sharing – 10 minutes

Ask participants to either write (if they are literate and there are paper and writing utensils available), think about, or share with another training participant:

- *The most important thing they learned today*
- *What they understood least, or what remains the most unclear or confusion*

Ask for a few people to share their thoughts with the whole group and answer any points that are still unclear.

2. Endline survey – 15 minutes

*Either administer the survey as a written survey (ideally with names to compare learners’ pre/post data) or a hand-raising option where you ask the question and people raise their hands in response. If you want to reduce the chances for group think and/or peer pressure, consider asking people to cover their eyes during the survey so people don’t copy their neighbors. Alternatively, you can collect this information as a brief group discussion. **Record the responses to each of the questions to compare to the pre-training baseline survey for evaluation purposes.***

Post-survey questions

1. Do you currently dry fruits or vegetables? (Y/N) If yes, which products?
2. Do you practice traditional, open air sun drying? (Y/N)
3. If yes, are you satisfied with traditional sun drying / does it meet your needs? (Y/N)
4. Do you like to eat dried fruits and vegetables (F&V)? (Y/N), if yes, which products?
5. Which of the following should be washed with clean water before drying F&V – a) hands; b) produce; c) tools; d) trays; or e) all of the above
6. Do you think it is better to dry ripe or unripe F&V?
7. Will drying moldy or spoiled product make it edible and safe to eat? (Y/N)
8. How do you think the sanitation of traditional sun drying compares to the chimney solar dryer? (Sun drying is more / less sanitary than the chimney dryer)
9. Do you think airflow makes F&V dry faster or slower?
10. Do you feel confident that you know when a product is dried enough to store safely for a long time period? (Y/N)
11. What will happen if a product is not dried enough and then stored for a long time? (nothing will happen; mold will develop; or unsure)
12. Do you know how to select a proper storage container for your dried product? (Y/N)
13. Do you think dried F&V have the same amount of nutrients as fresh F&V? (Y/N)
14. Do you feel confident incorporating dried foods in your household diet? (Y/N)
15. Do you plan to use the chimney solar dryer to dry F&V in the future? (Y/N)
16. Do you plan to sell dried F&V in the future? (Y/N)

3. Logistics Debrief – 5 minutes

If there is time, you should also ask and record responses to the following additional questions about the training logistics (either through hand raising or discussion):

1. Were you satisfied with the training content? (Y/N)
2. Were you satisfied with the facilitators/instructors? (Y/N)
3. Did you like the activities/teaching style? (Y/N)
4. Were you satisfied with the amount of information (e.g. too much, too little)? (Y/N)
5. Did you find the topics personally relevant and useful? (Y/N)
6. Were you satisfied with the timing/schedule of the training? (Y/N)
7. Were you satisfied with the lunch and breaks? (Y/N)
8. Were you satisfied with the training facility/venue? (Y/N)

Thank everyone for participating. Tell them you look forward to hearing their progress and achievements in using the chimney dryer in the future and supporting them as challenges arise.

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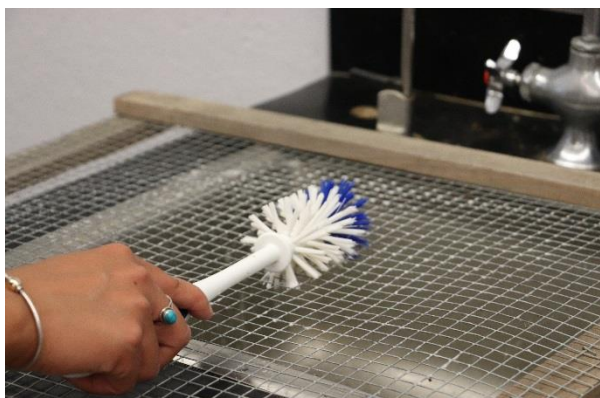
APPENDIX 1: WASHING INSTRUCTIONS HANDOUT



Rinse produce with clean water; gently rub produce, while holding under plain running water. There's no need to use soap.



Use a clean vegetable brush to scrub firm produce, such as melons and cucumbers. Dry produce with a clean cloth or paper towel to further reduce bacteria that may be present.



Wash metal mesh on drying trays using soap, clean water, and a stiff, non-metal brush.



Wash tools like cutting boards and knives with clean water and soap.

APPENDIX 2: DRYER USAGE CHECKLIST HANDOUT (2 pages)



Dryer Usage Checklist



Fill the trays with a proper amount of product



Don't overfill the trays with too much product



Align the wooden strips on the sides of the drying trays parallel with the sides of the drying table



Make sure the wooden strips on the sides of the drying trays are not blocking the air from flowing over the product



Make sure the front opening of the dryer is not blocked





Seal the clear plastic over the drying table at the back of the dryer (photo below), near the chimney (photo top left), and along the sides of the drying table (top right)



Photo by Brenda Dawson

APPENDIX 3: CHIMNEY DRYER AIRFLOW DIAGRAM

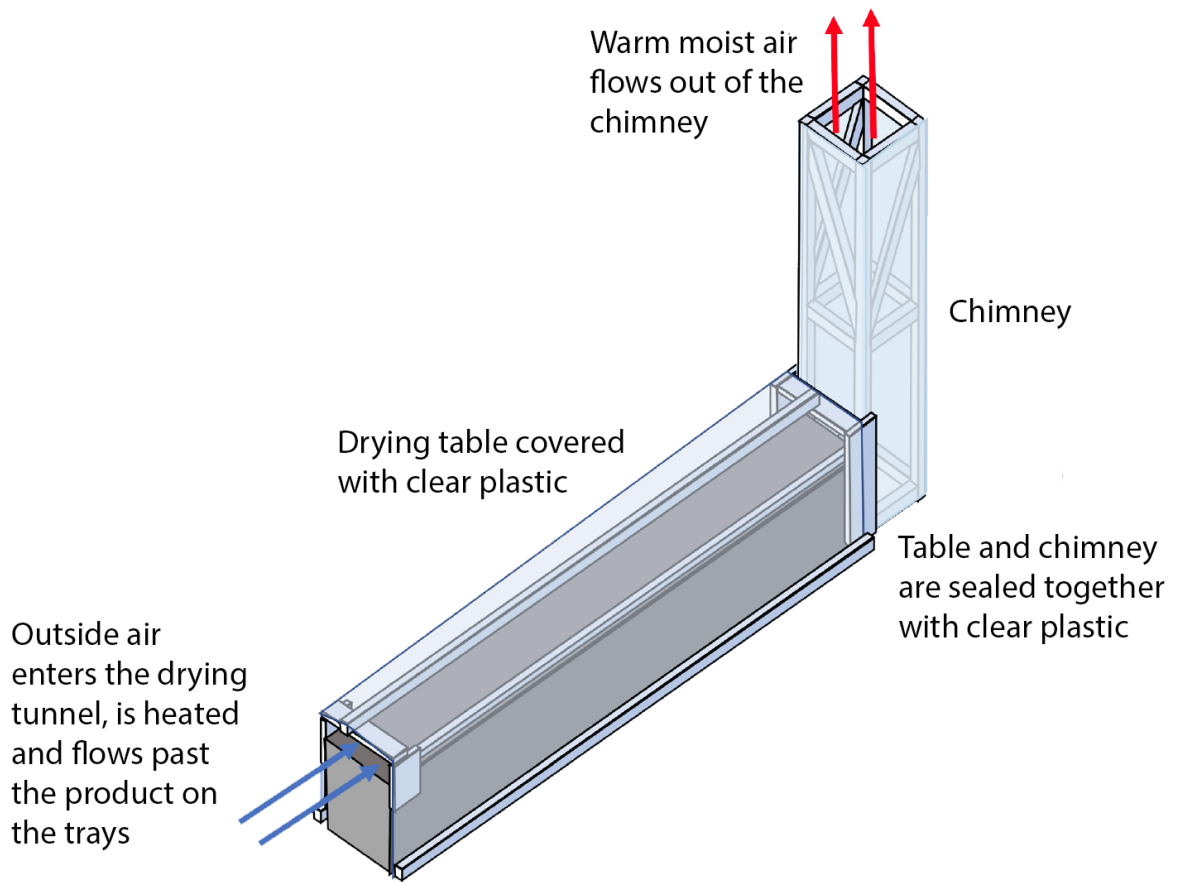
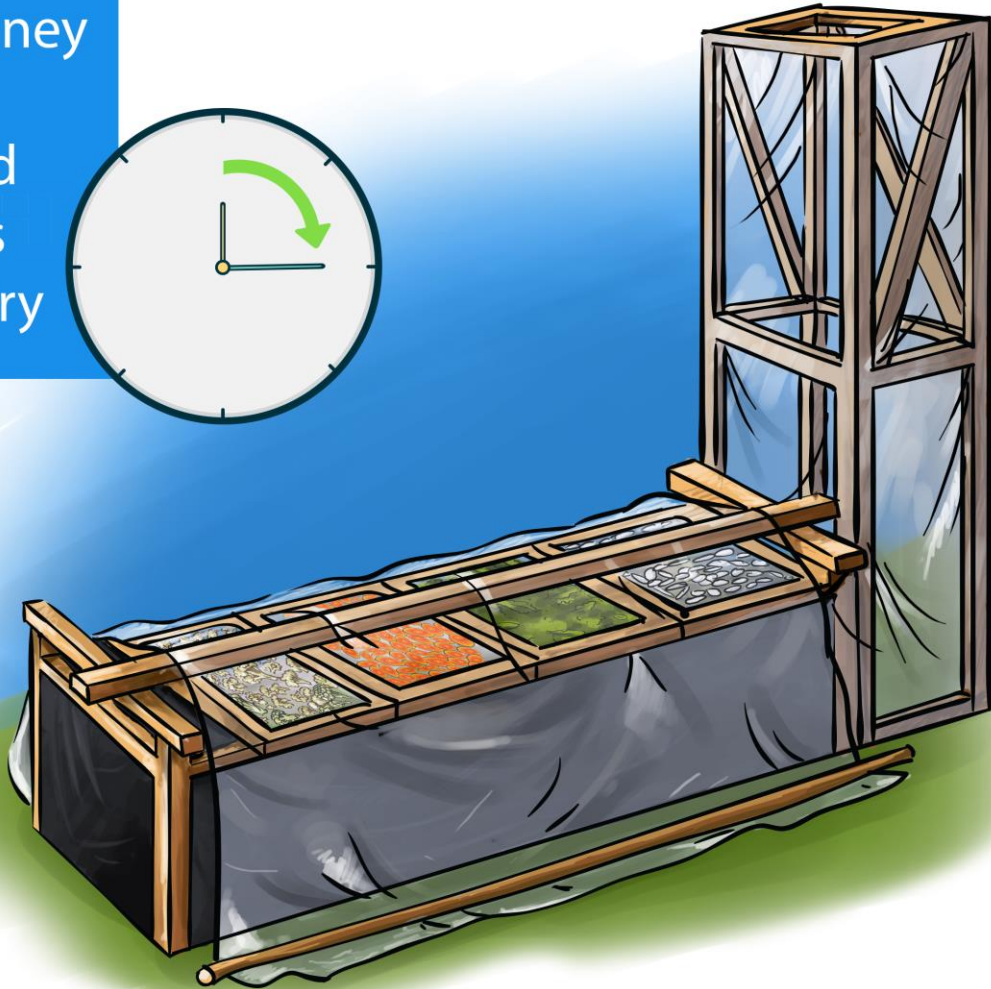


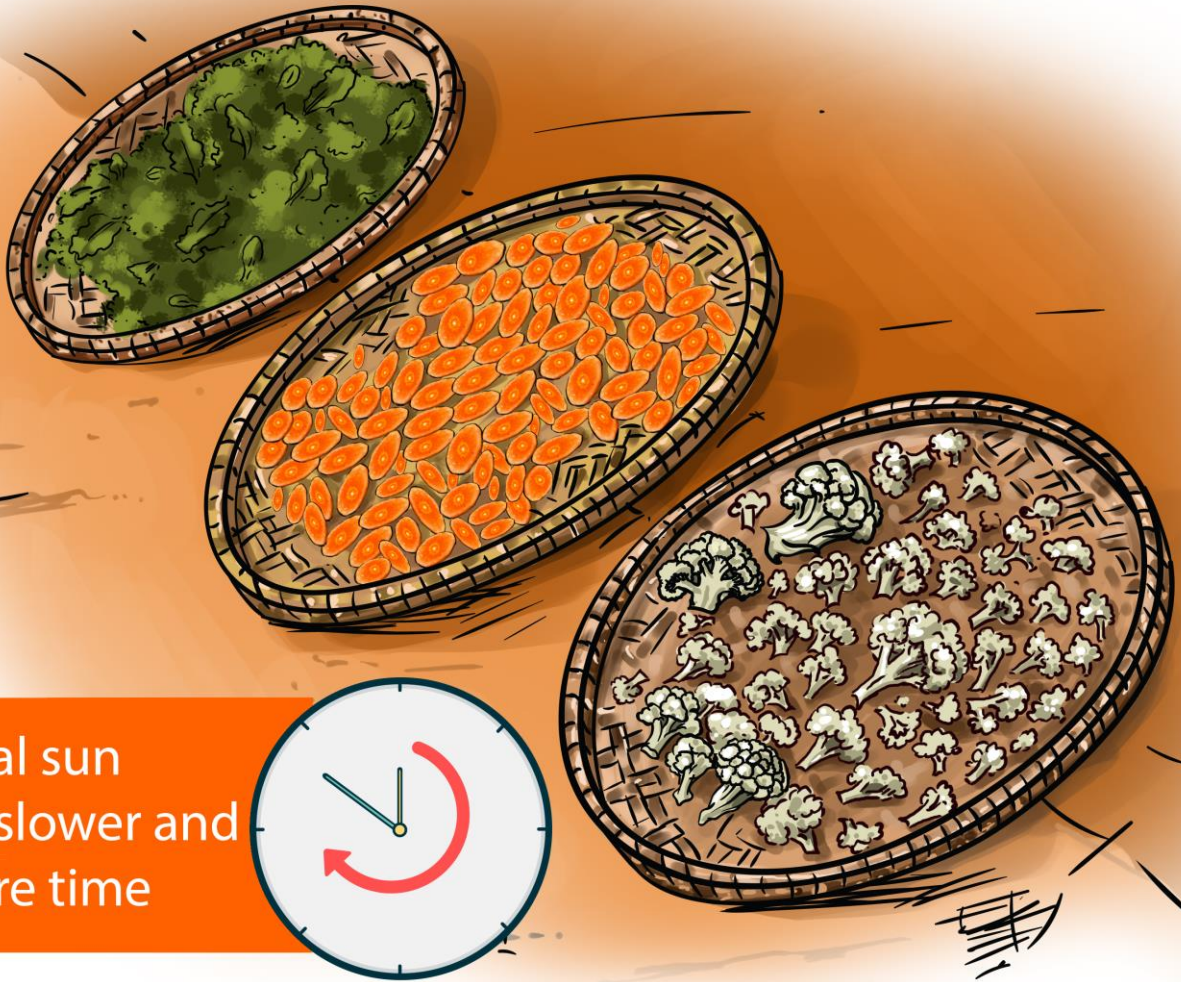
Illustration by James Thompson

APPENDIX 4: PICTORIAL IMAGES FOR DRYING COMPARISON (Benefits of using the chimney solar dryer, 6 pages)

Illustrations by Quriem Pvt. Ltd.

The chimney
dryer is
faster and
takes less
time to dry





Traditional sun
drying is slower and
takes more time



The chimney dryer protects product from contamination



 Traditional sun drying leaves product open and exposed to contamination





The chimney dryer
preserves product
color and quality





Traditional sun
drying degrades
product color
and quality



APPENDIX 5: WEATHER AND DRYING CONDITIONS VISUAL AID

Created by Michelle Boutell



Windy



Sunny



Shady/Dark



Cloudy



Light Rain

APPENDIX 6: DRYCARD VISUAL INSTRUCTIONS

Created by Anthony Phan

