



**MANUAL ON SAFETY
AND USAGE OF A DIRECT
SOLAR DRYER
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UGANDA**

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UNIT1: SOLAR DRYING TECHNOLOGY

Solar drying is one of the most efficient, and cost-effective, renewable, and sustainable technologies to conserve agricultural products in sub-Saharan African countries including Uganda.

WHAT IS A SOLAR DRYER?

This is a structure used for drying agricultural produce eg cassava, coffee and other crops used as raw material majorly by food processing industries

An active-type, environmentally friendly, low-cost solar dryer can be designed to dry various agricultural products. One of the energy consuming activities in the rural households is the drying of food products such as cassava, fruits and vegetables. In Uganda drying has evolved as a common practice, as it enhances women to preserve perishable agricultural products for consumption in off-season, increase market access and increase the shelf life of those products.

- ▶ Solar drying can enable many products to fetch better price in the market, when dehydrated and sold. The most commonly used method for drying of agricultural products, cassava, potatoes and vegetables is under the open sun. However, open sun drying is slow and affects the quality of the products, no quality control and food is easily contaminated by rodents, dust, dirt and insects.
- ▶ Solar drying technology is emerging as an alternative method of dehydrating food among rural women who need to consume healthy dried agriculture products and venture into commercialization of those dried commodities through selling value-added products
- ▶ Solar dryers with its advantages can not only save drying time but also maintain the quality of food products. There is an urgent need to enhance access among rural farmers who produce most of the food in Uganda and lose the most.
- ▶ Its against this backdrop that EBAFOSA Uganda is developing a solar dryer fabrication manual to enable artisans within the communities and other interested stakeholders to develop & decentralize affordable solar dryer technology to rural areas to increase value addition activities of agricultural produce
- ▶ A solar dryer uses the sun to dry agriculture product like cassava, potatoes, fruits and vegetables. Chilli dried in a solar dryer stays bright red. The chilli dries quicker so moulds do not develop. Screens keep out the dirt. When the chillies are of good quality you can sell them for a better price. A solar dryer can dry all sorts of food, such as spices, vegetables and fruits
- ▶ A low moisture content is the most important factor in maintaining the quality of the cassava during storage and a low moisture content should be acquired to prevent development of microorganisms and insects in the dried product. This solar dryer can record moisture content below 10% but 12% is the recommended moisture content in line with Uganda National Bureau of Standards (UNBS) specifications for dried cassava.

- ▶ The dryer is built with a cabinet consisting mainly of metallic frame covered by durable greenhouse uv-polythene, developed to withstand varying weather extremities.
- ▶ The blower is designed to work through scavenging and natural convection. Placement of the vents cold denser air can enter at lower level, gets heated by accumulated heat in the dryer and begins to rise as it carries with it moisture from the drying food and exits through vents at the top. To take full advantage of natural convection, the inlet vent is placed in the direction of the wind to create high pressure at inlet, and lower pressure at outlet. This blower should be made with materials and shape that allows hot dry air circulates around the proper circulation of air hence reducing accumulation of high moisture content in the structure. The high temperatures and adequate air circulation ensure the cassava dry evenly at a much faster and convenient rate
- ▶ The vent behind at the roof of the dryers allows hotter, moisture laden air as it rises, can escape out of the dryers and also to prevent the solar dried products sweeting which can lead to fermentation. The structure has a vent approximately 40cm at the roof that allows escape of hot air generated within the structure.
- ▶ Trays (Shelves) are made of metal, wire mesh and nets are constructed inside the dryer structure for spreading out the chipped cassava, vegetables or any other product. Depending on the size of the structure, you can have 2 to 3 rows of the dried product beds at a spacing of 50cm between them with each having 2 layers of shelves.

TYPES OF SOLAR DRYERS

There are many different types of solar dryers but they can all be conveniently classified into three different categories depending on the mode of heat transfer from the sun to the product. ·

Direct mode solar dryers

In a direct mode solar dryer, the crop is directly exposed to solar radiation. For this to occur, the structure containing the crop to be dried must be covered with a transparent material. The solar radiation passes through the glazing and is absorbed by the crop and its immediate surroundings

Indirect mode solar dryers

In an indirect mode solar dryer, the crop is not directly exposed to solar radiation. The incident solar radiation is absorbed by some other surface – usually a solar collector- where it is converted into heat. The air for drying flows over this absorber and is heated. The warmed air is then used to transfer the heat to the crop located within an opaque structure. High and controllable temperature can be achieved in this type of dryer if a fan is used to move the air through the solar collector.

Mixed mode solar dryers

The mixed mode solar dryer combines the principles of the above two, where the product is exposed to the sun and a stream of pre-heated air simultaneously.

Direct solar dryer

This direct solar dryer was designed with sustainability in mind. All the materials for this dryer can be found locally on the market. The design is affordable, so if parts do fall apart replacement parts may be found easily. The design of the dryer can be altered to include more durable materials such as fixing a heating chamber to replace a blower. The size of the dryer may also be decreased which will reduce the costs of the materials or it can be increased on the size according to the needs of the farmer use.



Figure 1 External view of a solar dryer:



Figure 2 External view of a solar dryer. Place in an open environment



Figure 3 Interior view of a solar dryer: Showing trays having agriculture products



Figure 4 Interior view of a solar dryer

UNIT 2: SOLAR DRYER FABRICATION

Solar dryer construction Materials needed:

- ▶ Round tubes-Metallic
- ▶ Insect net.
- ▶ Ultra violet cover (Polythene)
- ▶ Nuts and bolts.
- ▶ Self-drilling screws.
- ▶ Profiles and locking wires
- ▶ Tape rule
- ▶ Pencil
- ▶ Electric circular saw,
- ▶ Hand saw may be used as well Electric drill with bits,
- ▶ Hand drill may be used as well Hammer Safety glasses
- ▶ Heavy duty scissors Screwdrivers Wire cutters

Duration: 1 hr – 2hrs minutes

Preparations: Videos and pictures of on-going solar dryer construction.

Set up

Attention: Ask the learners to detail how they constructed their houses from start to occupying.

Introduction: Inform learners that the session follows a similar pattern as in making a functional solar dryer.

Objectives: To learn how to fabricate and manage a solar dryer construction project from onset to end.

Benefits: Learners will be retooled with knowledge and practical skills of making and running a functional solar dryer centre for various uses with special emphasis on cassava and vegetable drying.

Direction: Have a hybrid lesson that combines lectures and practical lessons on project management, procurement of materials, project supervision and deliverables management. **Delivery:** Class room lectures coupled with practical lessons where learners can participate in managing a solar dryer centre.

UNIT 3: REQUIREMENTS

The first steps are making a sketch diagram of the solar dryer and develop the structure design or plan of the Solar dryer.

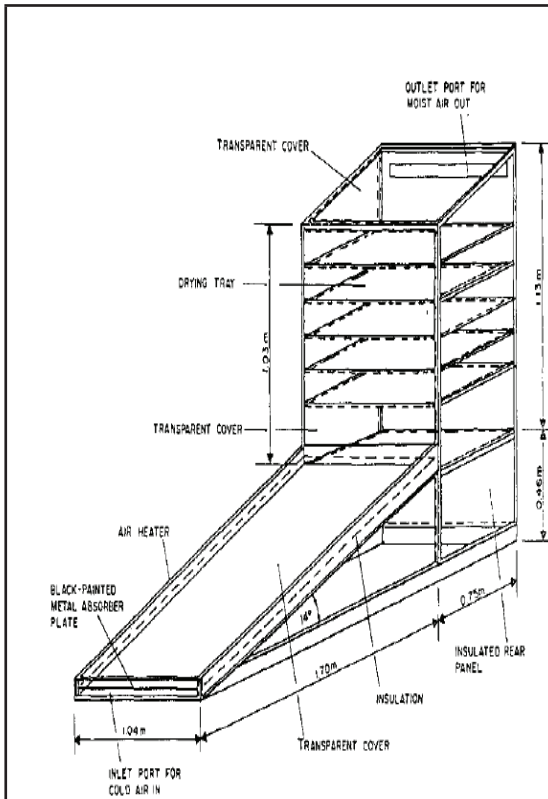


Figure 5 solar dryer sketch

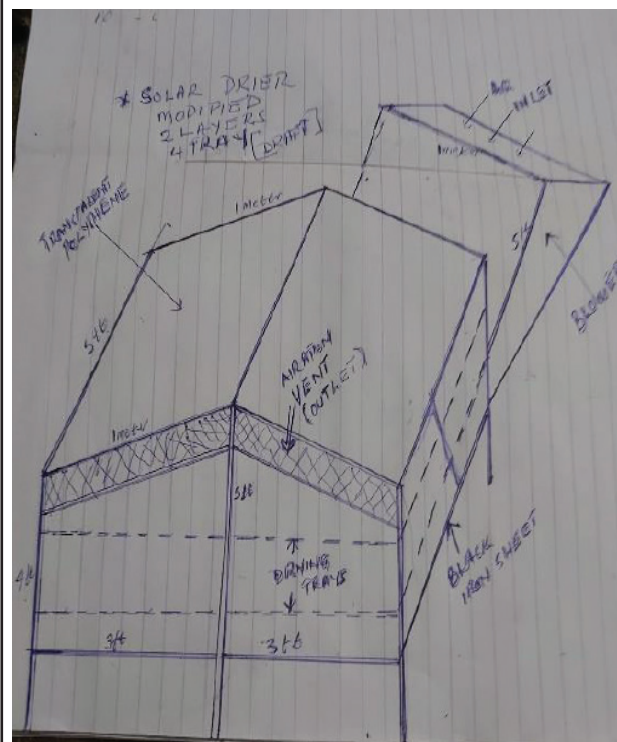


Figure 6 development of structure design

FOUR MAIN COMPONENTS OF THE SOLAR DRYER

The dryer design has four elements:

- i. A black iron sheet at the bottom of the dryer.
- ii. A solar dryer blower covered with UV polythene with an opening at the solar dryer
- iii. Mesh-covered drying trays to hold the produce and wood at the edges.
- iv. UV Clear polyethylene that covers the metallic frame, doors and sides of the solar dryers.

Bill of Quantities for one drier

The second step is to make a budget or a bill of quantities of all materials needed to construct the drier. According to this plan you will need UGX 1.5million as detailed below. This is the market price in Uganda as of October 2020.

DESCRIPTION	QUANTITY	UNIT COST	COST (UGX)
UV Polythene	30 meters	4800	144,000
Metallic pipes hole section	20 pieces 25 by 25 ft	30 000	600,000
Metallic poles	4 pieces 16 by 16 ft	15000	60,000
Net mesh	1 roll	150,000	150,000
Nails	3 kgs		30,000
Black Iron sheet	8 by 7 ft 1 roll		110,000
Pins	2 boxes	6000	12,000
Hammer	1	15000	15,000
Timber for making trays	6 by 2	150,000	150,000
Pata	12	6000	72000
Locks	6	2,000	12,000
Logistics			200,000
Total			1,555,000

Site Preparation

For the dryer construction, the following things have to be considered:

- i. Choose a south or north (depending on location) facing area. The main element required for a solar dryer is good consistent sunlight where sunrays can fallow on the dryer both in the morning and evening.
- ii. Give preference to locations that have morning sun over afternoon sun: Although all day sun is the best option, opening up the area to morning light will increase the temperatures to fasten drying
- iii. Choose a well-drained area: This is to avoid dampness that will encourage growth of molds.

- iv. Site slope: the site for the construction has to be gently sloping to a flat surface, where the slope is very steep. Soil leveling has to be done before the actual installation is undertaken.
- v. Wind direction: the direction of the wind year-round determines how the dryer should be oriented. The dryer should be constructed along the wind direction and not against it.
- vi. NOTE Ask members of the area on the direction of the wind, you can also use the existing feature to see the direction of the wind.

Installation

Frame construction Once the site for the construction is identified and meets the basic requirements, the dryer is constructed as follows:

- a) On a level ground, map out an area using a tape measure 8m by 8m for the length and Wide side 4m by 4m.
- b) Measure 8 m for the top part to enable the dryer to have two surfaces for the sun rays. And 2m is required to make a vent
- c) On the stands of the solar dryer 4m by 4m is required to make the 4 legs of the solar dryer.
- d) Another two metallic pipe of 4m measures is required support the trays and another 4m is required to short supports for trays inside the solar dryer (Where trays are placed)
- e) Solar dryer door requires 12ft to enable and the blower require 5ft is required for making a blower.



Figure 7 Youth Joining Frames of solar dryer



Figure 8 Inserting of a black iron sheet and painting of solar dryer



Figure 9 Adding timber on the solar dryer frame using nails and hammer



Figure 10 Joining small sized timber on the metallic frame of solar dryer

Drying Trays

Solar dryer trays are made each measure 3ft wide by 4ft long. Each tray has two parts of net and timber on the edges. On the net is where the agriculture product is placed to dry and it ensures food doesn't drop on the black iron sheet. Between the trays, a height of 1feet is provided for easy movement of trays in the solar dryer.



Figure 11 Making of trays for a solar dryer



Figure 12 A women holding a solar dryer tray. Where Food is placed



Figure 13 Spreading cassava chips on the solar dryer tray



Figure 14 Internal view of a solar dryer complete with upper and lower shelves

UNIT 4. SOLAR DRYER TRANSPORTATION

The solar dryer is transported on a truck in its bear minimum state. It is not covered with the UV polythene which is sensitive and easily destroyed with rough handling. This is the only part that needs to be carried separately.



Figure 15 Loading of solar dryer and trays.



Figure 16 Off Loading of the solar dryer from the truck

UNIT 5: MAINTENANCE OF SOLAR DRYER

- ▶ UV sheet should be clean with cloth twice a week and clean water.
- ▶ Wash the trays every after drying food and make sure the trays are not washed with chemicals. NOTE; Use clean water
- ▶ The drying area should equally be cleaned to keep it free from dust and dirt
- ▶ Clean the drying surface the more effective the drying of products.
- ▶ Inside dryer should be clean in every 3 weeks.
- ▶ Mesh (trays) should be cleaned after every use and if some products stick on mesh, Place wet cloth over it for 1-2 hr and then rub with scrubber.
- ▶ Wash cloth piece after every use.
- ▶ Make sure the solar dryer not near toilet areas.

Personal & Hygienic practices to be followed while drying:

- ▶ Persons involved in food processing must be healthy & free from diseases
- ▶ Short cut nails
- ▶ Washing hands thoroughly & wearing gloves
- ▶ Wearing head gear / shower cap to prevent falling of hair
- ▶ Wearing a clean apron / a coat to protect clothing
- ▶ Avoid licking & tasting while handling & processing

Reasons why Solar Dryers are better than Open Sun Drying

1. Heat intensity is double than open sun heat – A solar dryer can get inside temperature like 58°C while the outdoor temperature is still °32C. This makes the dryers take away moisture from food products and dry it rapidly which is 5 times faster than sunlight heating. This will increase operational productivity with a reduced drying period¹.
2. Can be used even on rainy days – A Rainy climate is not suitable for the drying process. But using solar dryers can retain heat up to a maximum of 46°C compared to a mere outside temperature of 26°C. Reducing the reliance on labor to keep and store products in case of rain and strong winds can be avoided.
3. Normal drying methods not only attract flies, dust, and other microbes, it also hassles during the rainy season. As Solar dryers have enclosed space this is no longer a problem. Farmers will get a higher and better-quality yield. This will ultimately increase farmer's income.

1 <https://aspirationenergy.com/7-reasons-why-solar-dryers-are-better-than-open-sun-drying/>

4. Reducing the operational cost. As Solar dryers are a one-time investment you won't get any other operational cost unlike other dryers using electrical energy. Maintenance costs also very much negligible.
5. It occupies less area. Unlike conventional solar heating where you need a lot of space to spread the food products for drying, in solar dryers, you can stack products in trays and place one above another occupying very little space. You can stack how much you need and it is easily movable.
6. Solar dryers last longer and it is estimated that the average like is around 5-10 years.
7. No Color degradation due to UV rays. Since a layer is present between the food product and the sunlight source, the color and value of the food products are preserved.

UNIT 6: FREQUENTLY ASKED QUESTIONS

What is the working principle of solar dryer?

The principle of the solar drying technique is to collect solar energy by heating-up the air volume in solar collectors and conduct the hot air from the collector to an attached enclosure, the meat drying chamber.

1. How much is going to be transportation cost?

Answer. It depends upon the distance from our manufacturing plant, which is based in Indore. As the design of solar dryer is foldable and light weight, don't worry the cost is going to be minimum.

2. Can we keep tray over black collector area?

Answer. No, it will affect the quality of dehydrated product.

3. How many days do it fabricate a solar dryer?

Answer. The fabrication time can take 3 days, but it depends on the size of solar dryer and area where its going to be fabricated.



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