

# Solar Drying Equipment: Notes on Three Driers

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*Food losses in the developing world are estimated to be 50% of the fruits and vegetables grown and 25% of harvested food grain (Burden, 1989). Food preservation by drying can reduce wastage of a harvest surplus, allow storage for food shortages, and in some cases facilitate export to high-value markets. This paper presents the characteristics of three solar driers. A 15 US\$ tent drier, a 400 US\$ box drier, and a 5,000 US\$ tunnel drier are discussed. References are given to solar drier vendors and sources leading to numerous other solar drier designs. For an overview of solar drying theory and equipment classification, refer to "Solar Drying Technology for Food Preservation" (Green & Schwarz, 2001).*

## **PGCP Solar Coconut Drier**

A small, portable, and inexpensive coconut drier was developed and tested as part of the GTZ Philippine German Coconut Project (PGCP). The drier improves upon traditional open-air sun drying by reducing drying time and increasing the quality of the dried coconut, as demonstrated in tests from 1994-95. The PGCP drier required 4-5 days of drying time, whereas open-air drying required 5-7 days. With the PGCP solar

drier, approximately 50% of the coconuts maintained their white color, but with open air drying less than 20% stayed white.

As shown in Figure 1, the drier consists of a frame of bamboo (or rattan) supporting a clear plastic sheet in a dome shape. The coconut halves are spread on the ground and then the drier is placed over them. The first day of drying should be sunny to produce a quality dried product. This drier is most suitable for farms of one hectare or less, and requires an elevated site where rain water will run off. It is possible the drier may be adapted to products other than coconuts, providing the required temperature is less than 60°C.



**Figure 1: PGCP Coconut Drier (Villaruel, 1996)**

The cost of one drier is estimated as 15 US\$, and replacement plastic will cost approximately 3 US\$ every two to three years. The frame can be constructed with local skills and materials. A drier 4.5m long and 1.6m wide (7m<sup>2</sup>) will dry 200-300 nuts at a time. A center height of roughly 0.3m was found satisfactory for climatic conditions in the Philippines. A UV-stabilized polyethylene (PE) plastic sheet 0.125mm thick will work as the cover. One way to attach the plastic sheet is with nails. Small canvas pieces may be used as washers to prevent the plastic from tearing off. The possibility of stray animals damaging the plastic should be considered. The PGCP Coconut drier is not sold, and so must be manufactured. A dimensioned schematic is given in the document "Solar Drier Plans: PGCP Coconut Drier and Kenya Black Box Drier" (Green & Schwarz, 2001).

### PGCP Coconut Drier: Key Features

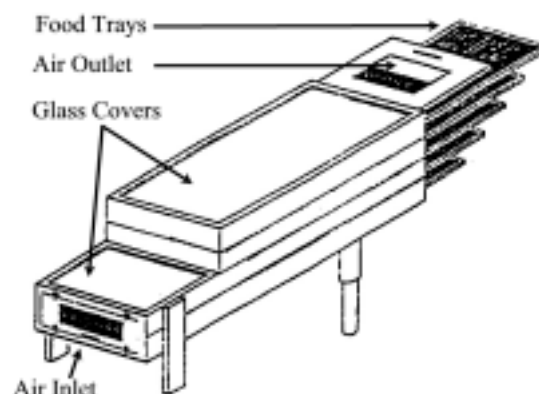
- 4-5 days to dry coconuts (Philippine climate)
- US\$ 15 (local manufacture) and US\$ 3 every 2 to 3 years
- 200-300 coconuts at one time
- 7m<sup>2</sup> drying area
- Size: 4.5m x 1.6m x 0.3m

*Note: The PGCP solar drier was not actually adopted by farmers. They favored the indirect type coconut husk-fired natural draught PGCP copra dryer (Cocopugon) with a processing capacity of 2000 nuts per two days of operation.*

### Kenya Black Box Solar Drier

More than 90 "black box" solar driers were tested in Kenya from 1996-97 as part of a GTZ project. Although various factors hindered the success of the project, the driers were pronounced technically reliable and economically viable. Without any special promotion, individuals in other areas who knew of the black box drier

project began their own drying activities. In addition to over 1 tone of mangoes; smaller amounts of guavas, papaws, bananas, vegetables, greens, and tomatoes were also successfully dried.



**Figure 2: Kenya black box solar drier (Eckert, 1998)**

The black box solar drier consists of a heating chamber and a drying chamber, each with a glass cover to allow sunlight to enter. The glass traps the solar heat inside so that the drier reaches up to 40°C above ambient. The two glass tops together measure approximately 2m x 0.8m, for an effective collector area of 1.7m<sup>2</sup>. Fresh air enters the heating chamber through a vent near the bottom of the drier. The heated air rises into the drier chamber and flows around the trays, absorbing moisture from the produce. Air exits near the top of the drier through a wire-gauze covered vent. The drying chamber holds five food trays with wire gauze bottoms, each 1m<sup>2</sup>. This is enough area to dry 15-20kg of fresh mangos per day in the Kenyan climate, resulting in approximately 0.5kg/day of dried product. Kenyan carpenters manufactured these driers in 1996 for 340 US\$ each.

### Kenya Black Box Solar Drier: Key Features

- 5 x 1m<sup>2</sup> drying area
- US\$ 340 (local manufacture)
- 1 day to dry 1mm thick mango slices (in Kenyan climate)
- Length, Width: 2m x 0.8m

In the 1996-97 project, mangos were sliced 1mm thick so that drying could be completed in one day. Drying was started early in the morning and trays were rotated every two hours for even drying. The slices were dry in late afternoon, and immediately stored in airtight containers. Successful drying requires the drier to be exposed to bright sunlight and re-oriented throughout the day to keep the glass facing the sun. The black box solar drier can be appropriate for small-scale drying in areas with a climate conducive to solar drying with convection. For dimensioned drawings of the drier, refer to "Solar Drier Plans: PGCP Coconut Drier and Kenya Black Box Drier" (Green & Schwarz, 2001).

### Hohenheim Solar Tunnel Drier

More than ten years of research and field-testing has resulted in the development of a solar tunnel drier well suited to medium-sized farms or small cooperatives. The non-patented design was developed at the University of Hohenheim, Germany, and has been duplicated successfully throughout the world. A key to this success has been the adaptation of the drier design to the local climate and manufacturing possibilities in multiple countries. By 1997 over 200 Hohenheim-type solar driers were in use in 35 countries. Over half of these driers were manufactured in the country of use; the rest were supplied by Innotech, a German corporation manufacturing prototypes of the driers. Innotech supplies the driers in kit form for roughly 5,500 US\$, for use in locations where manufacturing has not yet

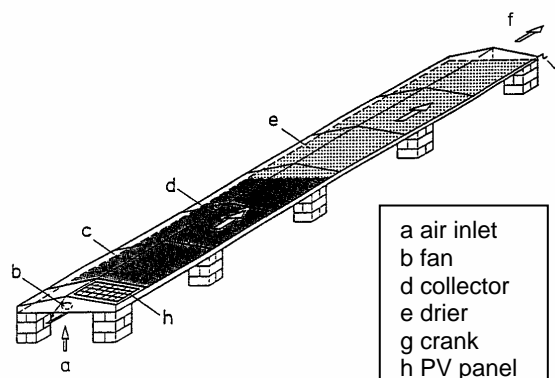
been established. Innotech also offers a consultancy for quality assurance and marketing of dried products for export to industrial countries. The Hohenheim-type drier results in faster drying and higher quality than traditional open-air methods. In Turkey, for example, apricots can be dried in 2 days – half the time required by traditional methods. An important feature contributing to consistent quality is the use of photovoltaic powered fans for forced convection. The clean, controlled drying process results in high-quality produce that can be taken directly from the drier and packaged for sale or export. The acceptable load for the drier ranges from 1.5kg/m<sup>2</sup> for medicinal herbs to 25 kg/m<sup>2</sup> for rice or coffee. For a standard drier with a 20m<sup>2</sup> drying area, this corresponds to 30 to 500kg per batch.

Thailand and Turkey are two examples of the success of solar tunnel driers. By 1997 ten driers were built in Thailand with another five planned, primarily for banana drying. Turkey had 60 machines drying figs and apricots, with 150 tones a year of dry fruit exported to Switzerland. Thai machines are equipped with a gas-powered air-heating unit to allow drying during the six-month rainy season. In contrast, Turkish weather is dry enough to allow the all-solar driers to operate well with twice the standard drying area. Local manufacture of the Turkish models allowed a total installation cost of less than 1000 US\$ in 1997, resulting in a payback period of only one year. The models used in Thailand were more expensive due to the gas-powered heating unit.

## Hohenheim Solar Tunnel Drier: Key Features

- 20m<sup>2</sup> drying area
- 3 fans, PV or mains powered
- Operation in arid and humid regions
- Self regulated airflow and temperature (solar panel type)
- One day set up time
- Price: US\$ 5,250 (+ US\$ 250 for PV)
- Indirect operation ideal for sensitive products
- Air temperature: 30-80°C
- Size: 18m x 2m x ≈1m high
- Adaptable to local climate and materials

The three major drier components, as shown in Figure 3, are the solar collector (part d), food drier compartment (e), and the airflow system (a, b, and h). Air is circulated by fans, which use from 20-40W of power from a photovoltaic panel, a generator, or a central utility. Air is forced into the solar collector by the fans where it is heated by the sun, and then flows on to the food drier section. An advantage of the PV powered system is that, depending on the solar radiation, the air throughput is automatically adjusted by the speed of the fans. The plastic cover may be constructed from a sheet of greenhouse-type UV-stabilized polyethylene (PE). Access to the drying chamber is gained by removing the plastic covering using the hand crank. The food is placed on a polyester mesh suspended by a grid of galvanized wire. This arrangement allows air to flow on all sides of the food, preventing the need to turn it during the drying process. Depending on local circumstances a drier may be built in a permanent installation (with concrete, for example), or in a portable construction. When introduced in a new region, the Hohenheim-type drier often requires customization to suit the local climate and manufacturing possibilities. Often a prototype is adapted and tested before proceeding with local manufacture.



**Figure 3: Components of a Hohenheim solar tunnel drier (GATE 3/97)**

Hohenheim engineers have produced a set of design specifications to help insure quality performance. As long as these design specifications are followed, considerable opportunities exist for successful variation of the drier. Table 1 shows some of the options viable for making each part of the drier.

**Table 1: Options for adapting a solar tunnel drier (GATE 2/96).**

Part	Options
Support	Stone, slate, wood, metal, loam, barrels
Frame	Steel sheeting, wood, plywood, slate, concrete, stone, loam
Heat insulation	Polyurethane, Styrofoam, building insulation, cork, flax, straw, coconut fibers, wood shavings, leaves
Sheeting (cover)	LD-PE, LLD-PE, PTFE, PVC, PE-EVA
Winding shaft	Steel pipe, plastic, wood, bamboo, wicker
Power source	Photovoltaic cells, utility power, diesel or petrol generator

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Vargas, Tania V. Camacho, Sylvia A. 1996: Solar Drying of Fruits and Vegetables: Experiences in Bolivia. FAKT, Energetica. 65 pgs.

### Solar Drier Designs:

Devices for Food Drying: State of Technology Report on Intermediate Solutions for Rural Applications. 1979. GTZ-GATE. 80 pgs. (Drier theory and design; overview of 12 drier designs).

Green, Matthew G. Schwarz, Dishna. 2001: Solar Drier Plans: PGCP Coconut Drier and Kenya Black Box Drier. GATE Technical Information E16e. GTZ-GATE. 8 pgs. <http://www.gtz.de/gate/>

Survey Of Solar Agricultural Dryers – Technical Report T99. 1975: Brace Research Institute. 150 pgs. brace@macdonald.mcgill.ca (Reviews 24 drier designs).

### Solar Drier Equipment Suppliers:

Equipment Database. As of 2001, lists 4 solar drier vendors. <http://www.fao.org/inpho/>

Grupp, M. et. al. 1995: Comparative Test of Solar Dryers. Technology Demonstration Center Serial Report 2/95. Plataforma Solar de Almeria (PSA), Synopsis. 22 pgs. (Quantitative comparison of 7 drying methods).

Judge, Emma, et. al. 2000: Small Scale Food Processing – Revised Second Edition. Chapter 23: Dryers. ITDG Publishing. Available from <http://www.developmentbookshop.com> Old edition online at <http://www.fao.org/inpho> (Mentions less than 10 solar driers).