NC STATE UNIVERSITY

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Things to Remember:

- Most herbs and roots are sold dried.
- Good quality dryers preserve herb quality.
- Clean thoroughly between crops to avoid adulteration.

NORTH CAROLINA STATE UNIVERSITY

Dryers for Commercial Herb Growers:
A Construction Guide

An Introduction to Herb Dryers

Colorful Celosia flowers, for demonstration, are supported by screens shelves in this herb dryer.

Most medicinal and culinary herbs are sold dried. When drying large quantities of herbs for commercial sale, growers should use a forced-air dryer to preserve their color, flavor, oil content, and medicinal properties. To achieve this, good air circulation within the dryer is important, as it reduces drying time and allows the use of lower temperatures, both of which can prevent the degradation of chemical constituents during the drying process. Therefore, dependable temperature control and the ability to provide high air flow throughout the plant material is important. Drying temperatures and times differ by plants, plant parts, and ambient conditions. In general, most herbs should be dried at low temperatures, ideally around 90-100° F. When outside conditions are hot and humid, however, it may be necessary to raise temperatures to as high as 130°F.

The size of the dryer should be based on the herb production area and how much will be harvested at one time. For example, we found that slightly less than one-fourth acre of skullcap herb (foliage) required 700 ft^2 of flat drying space. The dryer should have well-spaced racks to ensure that all sides of the plant receive sufficient air flow and the plant material dries evenly. The shelves should be constructed of food grade screens or covered with an acceptable food grade material. The dryer should be free of dust, dirt, insects, and rodents. Evidence of any of these in the final product can lower its value or render it unmarketable.

The dryer should be able to hold an entire harvest and dry it fast enough that the crop does not spoil. Efficiency and economic concerns must be taken into consideration to ensure the cost-effectiveness of its operation.

Many different kinds of commercial herb dryers are available for purchase and can be fairly expensive, ranging from $15,000 used to $30,000 new. In eastern North Carolina, existing forced air tobacco dryers (kilns) can be used to dry herbs. Most mountain farmers, however, do not have access to forced air tobacco dryers based on the agricultural history of the area. In this case, a dryer can be constructed from a new or existing shed outfitted with a heater, fan, and dehumidifier. Additionally, a grower may choose to construct one from scratch.

What's Inside?

Small Indoor Dryer Guidelines

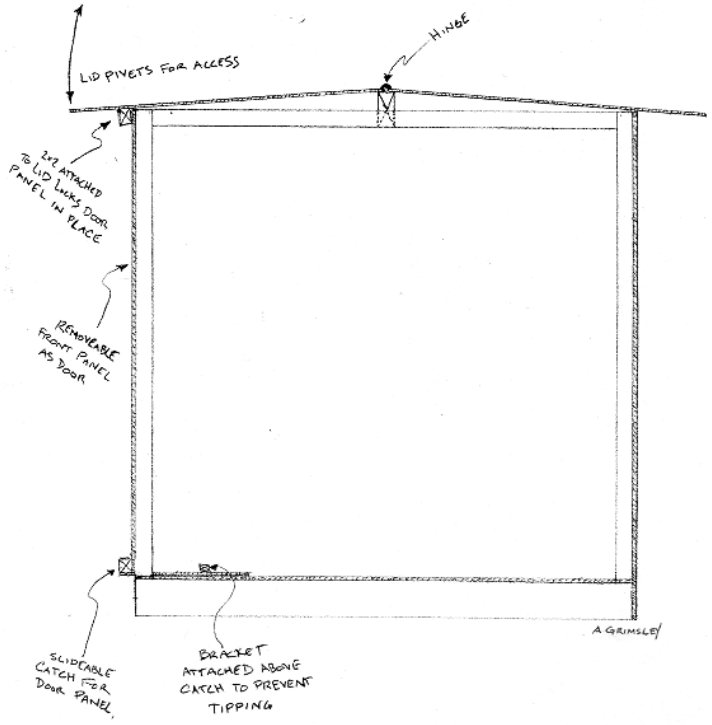
Materials:

- 4' by 8' Plywood sheets (5/8" thick)
- 1"x1" lumber for framing the structure and framing the shelves
- Screws
- Hinges (3 ½" by 1 ½" weather resistant hinges, 3 on each roof)
- Aluminum window screen
- 4" personal fan
- Large plastic staples (1/2", 12.7 mm) for attaching fan inside unit
- Electric baseboard heater ($60 Honeywell Low Profile Silent Comfort Heater, portable electric baseboard heater with cord, model number HZ-515)
- Gutter guards for vents (5 Gutter World snap-in gutter filters costing approximately $9.00 total - Lowe's item number 179783)
- Staples for attaching the gutter guard & screens
- Thermometer ($10)
- Outdoor outlet with timer ($21 Heavy duty outdoor timer with 6 receptacles. Intermatic. 15 amps. From Lowe's.)
- Primer and paint (Kilz premium primer-sealer-stainblocker – interior/exterior water-base, and white exterior semigloss latex paint)
- Fine screen (to protect baseboard heater)

The design of this dryer is based on a prototype originally created by Anita Hayden of Native American Botanics for use in her research on medicinal herbs. This dryer was designed to serve relatively small-scale growers. In 2006, this dryer cost roughly $300 in materials, labor not included.

The dryer is constructed of plywood framed by 1"x1" lumber. It is 8' long, 4 ½' wide, and 4 ½' tall. It has a floor lifted a few inches off the ground with framing lumber, three stationary sides, and one removable side serving as an access door (see **Figure 1**.). The roof is gabled and hinged on one side for easy access when loading and unloading. Prime the exterior with a high quality primer/sealer, and paint it with an exterior semi-gloss latex paint. Cut a 34" by 5" rectangular hole 5" from the bottom of the removable side to serve as an air intake vent. Position another small hole (5" diameter) several inches from the top of the dryer on the left side. Attach a small electric fan to the inside of the unit, facing outward. This serves as an exhaust vent for moist air during the drying process. Mount the fan with ½" plastic staples or something similar. Both vent holes, as well as the roof gable, should be covered with plastic gutter filters cut to size. Place a portable electric baseboard heater in the bottom of the unit as a heat source (**Figure 2**). The heater should be protected from above with a fine screen to prevent introduction of dried material into the vents. Position wooden

Figure 2: Baseboard heater with chord



SIDE SECTION VIEW

1" SCALE

Figure 1: Schematic depicting the front view of the small dryer (*Illustrated by Agatha Grimsley*)

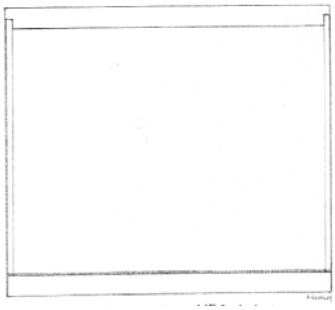
Small Indoor Dryer Guidelines (cont.)

"stops" on the floor of the unit to keep the heater safely away from the walls of the dryer. A thermometer with a temperature range up to 120° F should be mounted inside the unit (**Figure 3**). An outdoor outlet box fitted with a timer can be used to plug in both the fan and the heater . The outlet box is then plugged into a regular 110 outlet. Alternatively, the fan and heater can each be plugged into a regular 110 outlet.

The small herb dryer is not weather-proof. Remember to store it indoors or under cover.

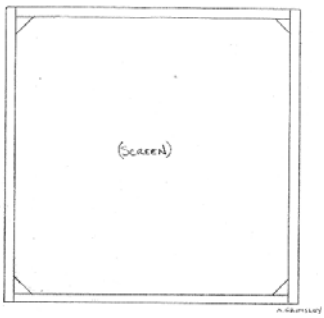
Three or more levels of removable shelves can be constructed inside the unit (See **Figure 4 & Figure 6**) to provide a flat surface for drying the plant material. Two shelves sit side by side on each level to allow for easy loading and removal. Aluminum window screening can be used to line each shelf to allow air flow around the plant material as it dries. To the best of our knowledge, aluminum shelving has not been noted as a contaminant problem in this industry. Visit www.atsdr.cdc.gov/tfacts22.html for more information about the safety of aluminum shelves. You may also line the aluminum screens with another material, such as cheesecloth to keep the herbs from being in contact with the screening, or you can research alternative screening to use in your dryer. Finally, growers should maintain good contact with buyers to be kept informed about as new regulations and standards emerge

Figure 3: 120°F Thermometer mounted inside the drying unit..



FRONT SECTION VIEW SHOWING FLOOR AND RIDGE SUPPORT, FRAME, AND SHEATHING

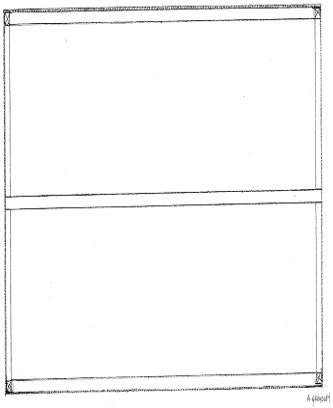
1' SCALE



Plan View of One Removable Rack

1' Scale

Figure 4: Schematic of small dryer front and schematic of a small dryer removable rack.



PLAN VIEW SHOWING FRAME AND BRIDGE SUPPORT, WITH 1/4" PLYWOOD SHEATHING.

1' SCALE

Figure 5: Schematic depicting the top view of the shelf for the small dryer

Figure 6: Completed small dryer with herb material *(Photo courtesy of Anita Hayden)*

Large Exterior Dryer Guidelines (10' x 16' walk-in building)

Materials:

- **Building:** 10' x 16' utility building - about $2,500.
- **Duct work:** Custom fabricated duct work -about $780.
- **Fan**: Dayton Tubeaxial Fan, Model 7F951, about $690.00, Blade Diameter 18", Fan Speed 1719 RPM, Motor Power Rating ¾ HP. Includes other components such as a ¾ HP motor, V Belt, and Sheave.
- **Heating element**: Two for each unit. Vulcan model FTH30B-B 3000 Watt Finned Tubular Heater Element, 240 Volts, length 17 7/16 inches. About $106 each.
- **Window**: small window with roll out panels - $40.
- **Thermostat**: Honeywell model T675A1425 Remote Bulb Sensor Range 55-175 °F, about $114.
- **Thermometer**: Ashcroft Bimetal Thermometer item# 50 Ei60R-180-0/200. Rear connection, 18" stem length, degrees Farenheit range 0-200. Approx. $63.
- **Air switch**: Columbus Electric Air sensing switch model GRH3AD, about $32.
- **Snap Disc Control**: approximately $20.

Continued next page

This dryer will accommodate a higher volume of plant material (approximately 800 fresh pounds of aerial parts) than the small dryer. Accordingly, the construction of this dryer is much more involved and expensive than the small dryer. In 2006, this dryer cost approximately $5,000, including labor. However, commercially available herb dryers can cost over $25,000. Thus, building your own dryer may still afford a significant cost savings.

The Building Before starting any construction process, check with your local zoning office to see if permits and/or inspections are required. You will need a free-standing, wooden, weather-proofed utility building to serve as the dryer unit to be modified according to these instructions. Utility buildings, such as the 10'x16' building pictured above, are widely available (Figure 7). You can use an existing structure if it meets the requirements, or build one to suit your needs. (**Figure 7**). The building should be roofed and painted with severe weather paint.

Framing the shelves Construct four levels of frames for the shelves on each side of the dryer, allowing an aisle to span the length of the building (**Figure 8**). The frames should have one center support and 2 front and end supports (2"x4"s). The supports are framed with 2"x4"s approximately 4' long. Shelf frames are about 12" apart. Adjust the distance between shelves to fit your crop: for example, you can increase the number of shelves if you anticipate drying more root crops than aerial crops. Finish the frame by horizontally attaching 2"x4"s to the 4' support boards to allow plywood sheets to slide into the aisle area once the crop is in place on the drying shelves (**Figure 10**). This forces the air through the crop on the shelves.

Figure 7: Converted 10' x 16' utility building..

Figure 8: Unfinished frames with shelves installed.

Figure 9: Duct work and access doors housing heating elements and fan

Shelving Construct four levels of shelving. Each level should consist of two shelves which together run the length of the dryer, yielding a total of 16 shelf pieces. Rip 2"x4"s in half length-wise to make 2"x2"s for the shelf frame. Brace the middle of the frame. Shelves should be 3' wide. Cover the frame with galvanized steel hardware cloth attached with staples. The hardware cloth allows for air to flow through the shelves, maximizing flow around the plant material as it dries. Galvanized steel is not recommended for use with high-acid material, so growers who want to dry such products should consider covering the shelves with an alternative material.

To maximize space, consider installing an additional set of removable shelves (8) down the central aisle of the building. If space is not needed, simple pieces of plywood should be placed across the aisle to force the air through the plant material. (**Figure 10**). Only position the mate-

Materials (cont.):

- **Shelving Materials**:
- **Lumber**: (Measurements may vary depending on the size of the dryer building). Enough 2X4's to frame and construct shelves.
- **Hardware cloth:** Galvanized Hardware Cloth. 6 rolls of 25 foot length, 36 inch height, ½ inch mesh, 20 gauge. Each roll costs approximately $25.

Large ExteriorDryer Guidelines (10' x 16' walk-in building) cont.

rial to be dried onto the shelves with the hardware cloth.

Duct Work and Electrical Components Sheet metal ducts are necessary for housing and protecting the main electrical components (fan/motor and heating coils) on the back side of the building and for directing air flow from the top of the building, over the heating coils, and into the bottom of the building (**Figure 9**). A local sheet metal company should be able to custom-fabricate the duct work. The duct work attaches to two points on the outside of the back of the building. At the points where the ducts are attached to the building, vents should be cut to the appropriate size and the seams sealed (**Figure 11**). It is important to keep the fan/motor and heating coils protected from moisture.

Install the fan and motor several feet above the heating elements inside the duct work. The fan will then draw air through the return (upper) vent in the building, forcing it down over the heating elements, and back into the building through the lower vent. The heated air will be forced up through the plant material and then recirculated back to the fan or exhausted out the front vent. Install the heating elements underneath the fan in a way that maximizes air flow over them. The air velocity will be greatest near the blade tip. For instance, it is not a good idea to install them directly in the middle of the duct, as this puts them in the "calm eye" of the air flow. Install a thermostat on the inside of the building to control the temperature of your dryer. You may also install the thermostat on the outside of the building, but keep in mind that it needs to be protected from the weather in some way. Placing a thermometer (18" stem) with the face visible outside of the building allows for monitoring internal temperature with-

Figure 11: Upper and lower vents. These are the two points where the ductwork connects to the rear of the building. Air circulates into the shed via the lower vent, and back through the heating ducts via the upper vent.

Figure 10: The interior of a modified utility building. Note the four levels of shelves on either side of the center aisle. Plywood spacers span the aisle to direct airflow up through the material on either sides of the aisle.

Large Exterior Dryer Guidelines (10' x 16' walk-in building) cont.

out opening doors, saving energy.

Accessories Several modifications to the building are necessary to make it functional. A small window with a screen (or other suitable product) should be installed on the front of the building (**Figure 12**). The window is very important, as it serves as a vent for the dryer, and can be adjusted by a hand crank to regulate how much ventilation is provided at a particular time. As the material dries and there is less moisture being released, the vent may be closed gradually. The duct work housing the fan and heating elements will have to be sealed thoroughly to protect from rain. Depending on your area, you may be required to anchor the building with tie-downs or some other materials. Lastly, the fan belt may need to be adjusted to achieve higher temperatures. We experienced a few cases of the temperature only reaching around 80° F in the dryer. Decreasing fan speed by lengthening the belt on the motor allowed us to increase the temperature inside the building.

Figure 12: Window with screen and crank. Adjusting the opening of this window regulates the ventilation in the dryer.

Figure 13: Fuse box with different switches for fan, heat, light, and main.

Electrical Wiring

Hire a licensed electrician to install the wiring for your dryer. Be sure your electrician understands that the air flow needs to be downward, so air is taken into the fan from the top of the dryer and heated air is forced back into the dryer at the bottom of the building. When the power is turned on to the unit, the fan must be able to remain in the "on" position regardless of whether the heating coils are energized. In other words, the heating coils are the only components that should be tied to the thermostat control. When the temperature inside the building reaches the setting on the thermostat, then the heating coils should turn off. The fan should continue running to keep air moving over the drying product. This unit requires a 220 volt electrical capacity (**Figure 13**). Additionally, wiring diagrams for the fan motor, the heaters, and the thermostat were commissioned by an electrical contractor. James Myles, Jr. prepared the schematics, available in **Figure 14.**

Energy Conservation Energy conservation is a leading national concern. As many growers are tackling energy issues on their own farms, herb dryers may also be examined from a conservation perspective. Adding insulation to the structure is recommended to reduce energy use and cost. Additionally, consider purchasing a fan with a higher

Large Exterior Dryer Guidelines (10' x 16' walk-in building) cont.

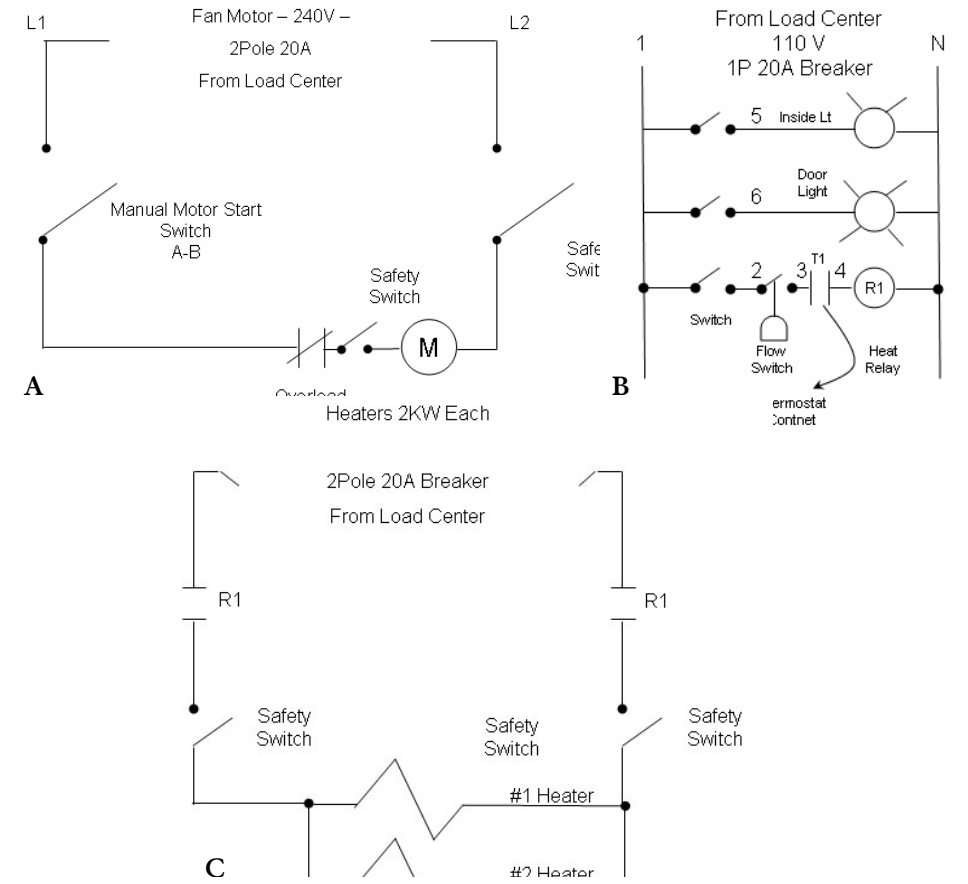


Figure 14: Wiring diagrams for the fan motor, the heaters, and the thermostat were commissioned by an electrical contractor.

CFM (Cubic Feet per Minute) output, or consider installing high R-value windows on the southern side to increase the incoming solar heat. The windows would need to be painted to protect the herbs from UV radiation. Finally, look into solar energy options. Using passive solar design and energy would allow for placement of herb dryers directly beside the field from which the herb material will be gathered. This would reduce the amount of time between harvest and drying which is an important factor in post-harvest processing. There are some models of solar greenhouse dryers available online. Another benefit of using solar energy is that the unit does not have to be located adjacent to a power source, nor would the additional costs of connecting to a more distant power source be incurred. Converting a greenhouse to a dryer would be

Drying Methods

Drying Methods Once you have established your herb dryer, some general instructions for drying are in order. The best method to dry your herb will depend largely on the physical characteristics of the material, the volume of herb in the dryer, the relative humidity of the outside air, and the physical properties that are important to your commercial buyer(s). Methods vary only slightly when using the small versus the large herb dryer.

Keeping the Green. Most commercial buyers want green color to be maintained in the dried product that they buy. This is especially important for above ground plant parts which contain chlorophyll. This will be less important for roots or other low-chlorophyll parts. Start with higher temperatures and decrease them over time. It is a good idea to maintain high temperatures for at least the first 24 hours.

When are my plants dry? Aerial parts will be dry when you can break a piece of it and it "snaps." When drying roots, keep in mind that you want the roots to dry from the inside out. If temperatures are too high, the roots will dry on the outside first and seal in moisture on the inside. This would result in a moldy, inferior product that would be rejected by a buyer. Instead, keep temperatures low enough to dry the root from the inside out more slowly. Depending on the plant, some roots may need to be cut in half or quartered in order to thoroughly.

What temperature should I use? Different herbs will require different temperatures. In the mountains, expect herbs to dry at somewhere around 90-105° F. In the Piedmont and Coastal areas of North Carolina, temperatures may need to be around 110-130° F. Typically, the higher the ambient humidity, the higher the temperature that is required to dry the material thoroughly. One report recommends the following temperatures based on the major medicinal chemical composi-

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No matter what your scale of medicinal herb production, quality of your final product will depend, in part, on your ability to efficiently and adequately dry your harvested material. We hope that these two dryer designs will serve as a starting point for you as you develop a dryer to suit the particular needs of your farm. Please contact us if you come up with innovative modifications to these designs to improve quality in your final product or overall efficiency of the dryer itself. Additionally, please contact us with questions or seeking advice as you build your own dryer.

Other Resources:

www.ncspecialtycrops.org/medherbs - *for general herbal information*

www.agf.gov.bc.ca - *for general drying information*

www.library.wur.nl/frontis/medicinal_aromatic_plants/17_muller.pdf

For a detailed report on drying specific medicinal herbs

We're on the Web
http://ncspecialtycrops.org

Drying Methods (cont.)

tion of the plant: for glycoside content dry at a maximum of 212°F; for mucilage content dry at a maximum of 149°F; and for essential oil content dry at a maximum of 95°. It is believed that each herb requires a specific procedure, including temperature regime and duration of drying, yet these procedures have only recently begun to be developed. In our experience, following the general guidelines set forth in this document resulted in a high quality product.

Check the material often to monitor its progress and adjust the temperature as necessary. Unless your dryer is equipped with a thermostat, you will need to adjust this manually as needed. For the first 24 hours or so, keep the fan on and vents open. For the large dryer, you will need to open the intake vent on the duct (see **Figure 9**) to introduce drier air and force the more humid air out through the front vents. This will help remove moisture and lower the humidity in the dryer. As the material dries, the vents may be progressively reduced. This is extremely important. Introducing drier air will reduce the amount of time the material is in the dryer, thus reducing the cost of drying the material. Be sure to turn the material gently at least once during the initial phase of drying.

Depending on the plant material and your buyer's specifications, the final product should be between 8 -12% moisture. This means that approximately 2/3 of the fresh weight will be lost in the drying process.

It is important to get harvested plant material from the field to the dryer as quickly as possi-

Drying Rules of Thumb

1. Aerial material should be dried at higher temperatures at first, followed by decreased temperatures.
2. Root material can be maintained at a constant temperature throughout the drying process.
3. Keep in mind that these are "general rules." Please verify the drying needs of your product prior to starting the process.