Solar Drying

For further information

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Solar Energy

Among all renewable energy sources, solar radiation is in abundance, freely available, widely distributed and can easily be converted into other forms of energy. This makes solar energy the most promising future source of energy. On reaching the earth its peak value at the sea level is 900 to 1000 W/m² global irradiation falling on the horizontal surface is about 1.5 - 2.0 MWh/m² per year. This value is more than 10,000 times the current value of all type of energies that the world is using. The mean global irradiance falling on horizontal surface in Pakistan varies from 4.7 -- 6.2 kWh/m² the number of clear sunny days in the country varies from 250 in the Northern region to above 300 days in most part of the rest of the country.
PCRET ACHIEVEMENT IN SOLAR DRYING

- Several models of different capacities from 5 – 1000 kg Solar Dryers have been developed by this council and are being disseminated.
- PCRET designed developed and installed 10 unglazed collector type hybrid (Solar + Biomass) dryer having 500 kg capacities for drying of dates in Punjab, Khyber Pakhtoonkhwa, on Public Sector Development Program, Govt. of Pakistan.
- Designed Solar Dryer for Pakistan Tobacco Board for curing of tobacco.
- Designed 500 kg capacity solar tunnel dryer for drying of fruits and vegetables for Govt. of Sindh in this project Sindh Govt. disseminate 80 solar dryers of 500 kg each in Sindh.

SOLAR DRYER

Agriculture forms the base of the Pakistan economy, which produces large quantities of grains, fruits and vegetables. But due to the inadequate post harvest care, it is estimated that about 20-30 percent of the produce is wasted. If solar dryers are used to remove excess moisture from the product before storage, their quality will not deteriorate during storage and insect infestation will be reduced. Similarly, large quantities of excess vegetable and fruits, now being wasted, could be solar dried in a controlled manner for use during off-season.

Basic Principle

A solar food dryer consists of a flat box (frame) placed at an angle, with an open bottom and top, so that the air can circulate. Corrugated metal sheet, painted black, is placed on the bottom of the box. The black color absorbs the sunrays and heats the air above. The frame is covered with glass, transparent plastic foil or a plain garden plastic. The warm air reaches 40-50°C, rises and leaves the heating box through the top opening and flows through the drying chamber with the drying screens. Cool environment air is sucked off through the bottom opening.

The dryer’s angle must be adapted to the respective geographical latitude: In Pakistan steeper (35-45°). With a flat angle, air circulation can be improved by adding a chimney. The solar dryer only works with direct solar radiation and works best during dry periods when there is little humidity in the air.

What can be dried?
The solar dryer is suitable for all fruits and vegetables.

How to dry?

Food to be dried is cut in halves or slices or shredded and placed on the screens. Fruit should not be too ripe and juicy to avoid dripping (Detail will be in the next section).

Drying time

The length of time with any drying procedure depends on the water content of the food, the temperature and the humidity in the air. Tomatoes and fruit may take several days to dry. The interruption of the drying process at night is an advantage because fast drying produces crusts that obstruct a further withdrawal of water. Any crusts are therefore soaked during the night and the next day the drying process can go on unhindered (Detail will be in section) Cover

Food should not be exposed directly to the sun because it changes its colours. Therefore, the top drying screen should be covered with an empty screen or a lid with holes, keeping off flies at the same time.

Position of the dryer

It is not necessary to direct the solar dryer in the course of the day to the changing position of the sun. It is good enough to place it according to the highest position of the sun at midday.

<table>
<thead>
<tr>
<th>Description</th>
<th>Application</th>
<th>Temp °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Room Temperature</td>
<td>Solar Room Heating</td>
<td>22-24</td>
</tr>
<tr>
<td>Most Germs can’t grow</td>
<td>Solar Drying</td>
<td>50-70</td>
</tr>
<tr>
<td>Water Pasteurization</td>
<td>Solar Desalination</td>
<td>65-75</td>
</tr>
<tr>
<td>Food Pasteurization</td>
<td>Food Pasteurization</td>
<td>70-80</td>
</tr>
<tr>
<td>Food Cooks</td>
<td>Solar Baking</td>
<td>82-150</td>
</tr>
<tr>
<td>Water Boils</td>
<td>Solar Water Heating</td>
<td>100-120</td>
</tr>
<tr>
<td>Steam Generation</td>
<td>Solar Cooking</td>
<td>150-250</td>
</tr>
<tr>
<td>Heating different material for solar trough,</td>
<td>Solar Power Generation</td>
<td>300-650</td>
</tr>
</tbody>
</table>
### TYPE OF COLLECTOR USED IN SOLAR ENERGY APPLICATION

<table>
<thead>
<tr>
<th>Type of collector</th>
<th>Temp. Range (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air collector</td>
<td>20 - 50</td>
</tr>
<tr>
<td>Flat plate collector (Unglazed collector or uncovered absorber)</td>
<td>Up to 40-50</td>
</tr>
<tr>
<td>Flat-plate collector (Glazed covered with glass)</td>
<td>20 - 80</td>
</tr>
<tr>
<td>Evacuated tube collector</td>
<td>50 - 150</td>
</tr>
<tr>
<td>Heat Pipe tube collector</td>
<td>50 - 150</td>
</tr>
<tr>
<td>Super tube collector</td>
<td>50 – 150</td>
</tr>
</tbody>
</table>

### TYPES OF DRYING PROCESSES

Several types of dryers and drying methods, each suited for a particular product and situation, are commercially used to remove moisture from a variety of food products including fruits and vegetables.

There are three basic types of drying process:

- atmospheric drying including batch (kiln, tower, and cabinet dryers) and continuous (tunnel, belt, belt-trough, fluidized bed, explosion puff, foam-mat,
- spray, drum and microwave) drying
- sub-atmospheric dehydration (vacuum shelf/belt/drum and freeze dryers)

While sun drying is practiced for certain fruits such as prunes, apricots, grapes and dates, atmospheric dehydration processes are used for apples, prunes and several vegetables. Continuous processes such as tunnel, trough, fluidized bed and foam mat drying are mainly used for vegetable drying.

Factors for selection of a particular dryer/drying method include:

- forms of raw materials and their properties
- desired physical forms and characteristics of the dried product
- operating costs

### ADVANTAGES OF DRYING

The major advantages of drying fruits and vegetables are given below:

Drying hardly affects the main calorie-providing constituents.
Dried fruits and vegetables have a longer shelf-life under proper storage conditions. Transportation, handling and storage costs are substantially lowered. They provide a consistent product, an important modern marketing requirement. They utilize the most economical and disposable form of packaging.

**NATURAL SUN DRYING**

Traditionally, sun-drying is carried out by spreading the product out on the ground and exposing it to the sun during the day and covering it at night to protect it from rain, dust and other damaging elements. Though open-air (natural) sun drying has been practiced for a very long time, there are many disadvantages associated with it: since the drying temperatures cannot be controlled, quality products cannot be obtained. The products cannot be safe from scavenging animals and birds. contamination by dust and other foreign particles, alternate drying and wetting of the product (during day and night) can cause cracking of the kernel, which in turn reduces the quality of the crop.

**SOLAR DRYING**

To have a valuable quality product and to minimize the wastage, artificial drying of the product should be employed. The earlier dryers used conventional fuels like electricity, coal and fossil fuel to heat ambient air for drying purpose. Drying of agricultural product is an energy intensive operation. High cost of fossil fuel and gradual depletion of its reserve has incited the use of solar energy as an alternative energy source for dryers. Solar dryers can find wide-spread applications in tropical and sub-tropical countries because of the following reasons: the amount of solar energy available in most cases is high enough to cover the heat requirement of small dryer units as well as the temperature level required for optimal drying of the crops. the technology is much easier to adapt than fully mechanized technologies. solar dryers can be easily constructed using local and cheap raw materials.

**FACTORS GOVERNING SOLAR DRYING**

Solar drying is a continuous process where moisture content, air and product temperature, and the humidity of air all change simultaneously along with the two basic inputs to the system: the solar insolation and the ambient temperature. The drying rate is affected by ambient climatic conditions. These include:

- temperature
- relative humidity
- available solar insolation
- wind velocity
- frequency and duration of rain-showers during the drying period

**CLASSIFICATION OF SOLAR DRYERS**

Various types of solar dryers have been developed in many countries over a long period. The solar dryers can be classified according to their heating modes, or the manner in which the heat derived from the solar radiation is utilized:
NATURAL OPEN-AIR DRYERS

These types of dryers are the simplest in construction. The agricultural product to be dried is placed on a tray or a mat and left to dry by ambient sunshine and wind. They have no protection against rain, dust and scavenging animals.

DIRECT SOLAR DRYERS

In this type of dryers, the product to be dried is placed on a tray or a mat and covered by a transparent plastic sheet or glass. The transparent material reduces the loss of heat. A thin layer of the material to be dried is placed inside the enclosure and exposed to direct solar radiation. Heat is generated by the absorption of solar radiation by the product itself as well as the heat build-up caused by the enclosure. The moist air is removed by natural convection. Covering the product to be dried reduces drying time and gives protection from dust and rain. Insect infestation and losses caused by birds and rodents cannot be prevented in this type of dryer.

INDIRECT SOLAR DRYERS

The collector heats up the drying air which flows through the dryer. The main advantage of using indirect solar dryers is that the crop is not directly exposed to direct solar radiation. This prevents the undesired discoloring while drying products such as apricots, apples and grapes. The crop is also protected from rain, dust, animals and insects. Therefore, indirect solar drying accounts for the production of high quality products.

DIRECT AND INDIRECT SOLAR DRYERS (MIXED MODE)

The combined action of the solar radiation incident directly on the material to be dried and of air pre-heated in a solar collector can also be used for drying agricultural products. This mixed mode dryer consists of a solar air heating collector and a drying chamber holding the trays for the crops.

HYBRID SYSTEMS

These are solar dryers which use another energy source such as a fossil or biomass fuel or electricity, to supplement solar energy in the drying process; e.g. for additional air heating during cloudy period. Hybrid dryers find useful applications in developing countries where the conventional energy sources are either scarce or expensive and where heat generating capacity of the solar system alone is insufficient.

SOLAR TUNNEL DRYER

The solar tunnel dryer was invented for use in sunny areas of tropical and subtropical countries and over the years, with some modification, it has become fully adopted to the
prevailing conditions in these areas. Its design focused mainly on overcoming the existing bottlenecks in this conservation technique, which include the availability of a reliable energy supply, paying attention to the hygienic conditions of processing and consideration of the labour requirements. The design of the solar tunnel enabled even small farmers or women groups to produce high quality dried products without permanent supervision of the drying process.

The solar tunnel is one of the few solar dryers that were successfully introduced for the processing of dried products. Nowadays it is used by different target groups and for drying of most types of agricultural produce including fruits, vegetables, spices, medicinal plants and marine products. The dryer is used by research institutions, farmers and small co-operatives, womens’ groups and small and medium sized businesses to produce anything from several hundred kg of dried products per season.

The solar tunnel dryer consists of a solar collector, drying tunnel, and a small radial flow fan. The crop to be dried is placed in a thin layer inside the drying tunnel. Heat is generated by absorption of solar energy on the absorber of the collector as well as on the crop itself. Air entering the solar collector is heated and this air is forced on the crop placed in the drying tunnel. This type of forced air circulation is made possible by using fans at the air inlet of the solar collector.

**Maximum Permissible temperature for drying agricultural produce and their initial and final moisture contents**

<table>
<thead>
<tr>
<th>Produce</th>
<th>Moisture Content (%)</th>
<th>Max. Permissible Temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dates</td>
<td>Initial: 80</td>
<td>Final: 25</td>
</tr>
<tr>
<td>Chillies</td>
<td>Initial: 80</td>
<td>Final: 5</td>
</tr>
<tr>
<td>Onions</td>
<td>Initial: 80</td>
<td>Final: 4</td>
</tr>
<tr>
<td>Potatoes</td>
<td>Initial: 75</td>
<td>Final: 13</td>
</tr>
<tr>
<td>Apple</td>
<td>Initial: 80</td>
<td>Final: 24</td>
</tr>
<tr>
<td>Apricots</td>
<td>Initial: 85</td>
<td>Final: 18</td>
</tr>
<tr>
<td>Green Peas</td>
<td>Initial: 80</td>
<td>Final: 5</td>
</tr>
<tr>
<td>Green beans</td>
<td>Initial: 70</td>
<td>Final: 5</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>Initial: 80</td>
<td>Final: 6</td>
</tr>
<tr>
<td>Cabbage</td>
<td>Initial: 80</td>
<td>Final: 4</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>Initial: 96</td>
<td>Final: 10</td>
</tr>
<tr>
<td>Brinjal</td>
<td>Initial: 95</td>
<td>Final: 6</td>
</tr>
<tr>
<td>Peaches</td>
<td>Initial: 85</td>
<td>Final: 18</td>
</tr>
<tr>
<td>Grapes</td>
<td>Initial: 80</td>
<td>Final: 15-20</td>
</tr>
</tbody>
</table>
Pictures of Different Types of Dryer

Solar Natural Dryer
(Glazed Collector)
10-kilogram loading capacity

Cabinet Type Solar Dryer
15-kilogram loading capacity
Solar Tunnel Dryer
80 kilogram loading capacity
Green House Solar Dryer

Green House Solar Dryer
Solar Dryer for Green House Type for larger application

Apricot Drying in Hilly Areas
Unglazed type transpired collector type hybrid (Solar-biomass) dryer 150 kilogram loading capacity
Unglazed collector type hybrid (solar-biomass)
Dryer 500 kilogram loading capacity

Solar Drying of Fruits & Vegetables
Solar dryer at PCRET with special sheet of 200-300 kg capacity
Solar Dryer one ton capacity in Sindh for ripening of dates
Dried fruits are unique, tasty and nutritious. Begin by washing the fruit and coring it, if needed. For drying, fruits can be cut in half or sliced. Some can be left whole. See Chart 2 below for specific directions for preparing each fruit. Thin, uniform, peeled slices dry the fastest. The peel can be left on fruit, but the fruit will take longer to dry. Apples can be cored and sliced in rings, wedges or chips. Bananas can be sliced in coins, chips or sticks. Fruits dried whole take the longest to dry. Before drying, skins need to be "checked" or cracked to speed drying. To "check" the fruit, place it in boiling water and then in cold water. Because fruits contain sugar and are sticky, coat the drying trays with a very thin layer of oil before placing the fruit on the trays. [Oiling the metal is especially important with acidic fruits]. After the fruit dries for one to two hours, lift each piece gently and turn it.

**PRETREATMENT OF FRUIT**

Pretreatments prevent fruits from darkening. Many light-colored fruits, such as apples, darken rapidly when cut and exposed to air. If not pretreated, these fruits will continue to darken after they are dried. For long-term storage of dried fruit, sulfuring or using a sulfite dip are the best pretreatments. However, sulfites remaining in the food after either of these treatments have been found to cause asthmatic reactions in a small portion of the asthmatic population. Thus, some people may want to use the alternative shorter-term pretreatments. If home-dried foods are eaten within a short time, there may be little difference in the long- and short-term pretreatments.

**Sulfuring**--Sulfuring is an old method of pretreating fruits. Sublimed sulfur is ignited and burned in an enclosed box with the fruit. The sulfur fumes penetrate the fruit and act as a pretreatment by retarding spoilage and darkening of the fruit. Fruits must be sulfured out-of-doors where there is adequate air circulation.

**Sulfite Dip**--Sulfite dips can achieve the same longterm anti-darkening effect as sulfuring, but more quickly and easily. Either sodium bisulfite, sodium sulfite or sodium meta-bisulfite that are USP (food grade) or Reagent grade (pure) can be used. To locate these, check with your local pharmacy.

Directions for Use--Dissolve ¾ to 1½ teaspoons sodium bisulfite per quart of water, (If using sodium sulfite, use 1½ to 3 teaspoons. If using sodium meta-bisulfite, use 1 to 2 tablespoons.) Place the prepared fruit in the mixture and soak 5 minutes for slices, 15 minutes for halves. Remove fruit, rinse lightly under cold water and place on drying trays. Sulfited foods can be dried indoors or outdoors. (This solution can be used only once. Make a new one for the next batch.)

**Ascorbic Acid**--Ascorbic acid (vitamin C) mixed with water is a safe way to prevent fruit browning. However, its protection does not last as long as sulfuring or sulfiting. Ascorbic acid is available in the powdered or tablet form, from drugstores or grocery stores. One teaspoon of powdered ascorbic acid is equal to 3000 mg of ascorbic acid in tablet form. (If you buy 500 mg tablets, this would be six tablets). [C.F.: citric acid (sold as “lemon powder” works well, too).

Directions for Use: Mix 1 teaspoon of powdered ascorbic acid (or 3000 mg of ascorbic acid tablets, crushed) in 2 cups water. Place the fruit in the solution for 3 to 5 minutes. Remove fruit, drain well and place on dryer trays. After this solution is used twice, add more acid.
**Fruit Juice Dip**--A fruit juice that is high in vitamin C can also be used as a pretreatment, though it is not as effective as pure ascorbic acid. Juices high in vitamin C include orange, lemon, pineapple, grape and cranberry. Each juice adds its own color and flavor to the fruit.

Directions for Use--Place enough juice to cover fruit in a bowl. Add cut fruit. Soak 3 to 5 minutes, remove fruit, drain well and place on dryer trays. This solution may be used twice, before being replaced. (The used juice can be consumed.)

**Honey Dip**--Many store-bought dried fruits have been dipped in a honey solution. A similar dip can be made at home. Honey dipped fruit is much higher in calories. This is the method Charlie uses at ECHO.

Directions for Use--Mix ½ cup sugar with 1½ cups boiling water. Cool to lukewarm and add ½ cup honey. Place fruit in dip and soak 3 to 5 minutes. Remove fruit, drain well and place on dryer trays.

**Syrup Blanching**--Blanching fruit in syrup helps it retain color fairly well during drying and storage. The resulting product is similar to candied fruit. Fruits that can be syrup blanched include apples, apricots, figs, nectarines, peaches, pears, plums and prunes.

Directions for Use--Combine 1 cup sugar, 1 cup light corn syrup and 2 cups water in a saucepot. Bring to a boil. Add 1 pound (1/2 kg) of prepared fruit and simmer 10 minutes. Remove from heat and let fruit stand in hot syrup for 30 minutes. Lift fruit out of syrup, rinse lightly in cold water, drain on paper toweling and place on dryer trays.

**Steam Blanching**--Steam blanching also helps retain color and slow oxidation. However, the flavor and texture of the fruit is changed.

Directions--Place several inches of water in a large saucepot with a tight-fitting lid. Heat to boiling. Place fruit not more than 2 inches deep, in a steamer pan or wire basket over boiling water. Cover tightly with lid and begin timing immediately. See Chart 2 for blanching times. Check for even blanching, half way through the blanching time. Some fruit may need to be stirred. When done, remove excess moisture using paper towels and place on dryer trays.

**DRYING VEGETABLES**

Vegetables can also be preserved by drying. Because they contain less acid than fruits, vegetables are dried until they are brittle. At this stage, only 10% moisture remains and no microorganism can grow.

**PRETREATMENT OF VEGETABLES**

To prepare vegetables for drying, wash in cool water to remove soil and chemical residues. Trim, peel, cut, slice or shred vegetables according to the directions for each vegetable on Chart 3. Remove any fibrous or woody portions and core when necessary, removing all decayed and bruised areas. Keep pieces uniform in size so they will dry at the same rate. Prepare only as many as can be dried at one time.

**PRETREATMENT OF VEGETABLES**

Blanching is a necessary step in preparing vegetables for drying. By definition, blanching is the process of heating vegetables to a temperature high enough to destroy enzymes present in the tissue. Blanching stops the enzyme action which could cause loss of color and flavor during
drying and storage. It also shortens the drying and rehydration time by relaxing the tissue walls so moisture can escape and later re-enter more rapidly. Vegetables can be water blanched or steamed blanched. Water blanching usually results in a greater loss of nutrients, but it takes less time than steam blanching.

**Water Blanching**—Fill a large pot 2 full of water, cover and bring to a rolling boil. Place the vegetables in a wire basket or a colander and submerge them in the water. Cover and blanch according to directions for each vegetable in chart 3. If it takes longer than one minute for the water to come back to boiling, too many vegetables were added. Reduce the amount in the next batch.

**Steam Blanching**—Use a deep pot with a tight fitting lid and a wire basket, colander or sieve placed so the steam will circulate freely around the vegetables. Add water to the pot and bring to a rolling boil. Place the vegetables loosely in the basket no more than 2 inches deep. Place the basket of vegetables in the pot, making sure the water does not come in contact with the vegetables. Cover and steam according to the directions for each vegetable in chart 3.

**COOLING AND DRYING THE PREPARED VEGETABLES**

After blanching, dip the vegetables briefly in cold water. When they feel only slightly hot to the touch, drain the vegetables by pouring them directly onto the drying tray held over the sink. Wipe the excess water from underneath the tray and arrange the vegetables in a single layer. Then place the tray immediately in the dehydrator. The heat left in the vegetables from blanching will cause the drying process to begin more quickly. Watch the vegetables closely at the end of the drying period. They dry much more quickly at the end and could scorch.

**DETERMINING DRYNESS OF VEGETABLES**

Vegetables should be dried until they are brittle or "crisp." Some vegetables would actually shatter if hit with a hammer. At this stage, they should contain about 10 percent moisture. Because they are so dry, they do not need conditioning like fruits.

**PACKAGING AND STORING DRIED FOODS**

After foods are dried, cool them completely. Then package them in clean moisture-vapor-resistant containers. Glass jars, metal cans or freezer containers are good storage containers, if they have tight-fitting lids. Plastic freezer bags are acceptable, but they are not insect and rodent proof. Fruit that has been sulfured or sulfited should not touch metal. Place the fruit in a plastic bag before storing it in a metal can. Dried food should be stored in a cool, dry, dark place. Most dried fruits can be stored for 1 year at 60°F, 6 months at 80°F. Dried vegetables have about half the shelf-life of fruits.

**USING DRIED FOODS**

Dried fruits can be eaten as is or reconstituted. Dried vegetables must be reconstituted. Once reconstituted, dried fruits or vegetables are treated as fresh. To reconstitute dried fruits or vegetables, add water to the fruit or vegetable and soak until the desired volume is restored. (See Chart 1, Rehydrating Dried Food, for the amount of water to add and minimum soaking time.) Do not over-soak the food. Over-soaking produces loss of flavor and a mushy, water-logged texture.
For soups and stews, add the dehydrated vegetables, without rehydrating them. They will rehydrate as the soup or stew cooks. Also, leafy vegetables and tomatoes do not need soaking. Add enough water to cover and simmer until tender.

CAUTION! If soaking takes more than 2 hours, refrigerate the product for the remainder of the time.

**How to Dry or Dehydrate Fruit**

Dehydrating (or drying) fruit, whether from your garden or from the produce market, for use in the off-season, is actually one of the healthiest ways of preserving your crop. The nutritional content retained in the dehydrating process far surpasses that of its canned equivalent. Additionally, the drying process is often more cost-effective than freezing, as you don't use electricity in the long-term storage of your items. The process of dehydrating (drying) your fresh garden fruit can be broken into a couple of simple steps:

- **Preparation, including pre-treating the fruit (when necessary)**
- **Dehydrating / drying**
- **Storing the finished product**

**How to Dehydrate or Dry Apple**

Golden apples are cleaned, cored and sliced to 3-5 mm thick. To prevent browning, the apples can be immersed for 1s in 2% citric acid or 2% Na2S2O5 solutions immediately after slicing. The apples dried under light conditions becomes a little brown but the ones that are dried without exposure to light are kept their natural, light colour. The choice of drying conditions depends on the consumer's demand. Dried apples have a water activity of 0.38 and a yield of 15%.

To rehydrate apples: soak in hot water for about 15 minutes. Use rehydrated apples for pies, bakery, pancakes, in your oatmeal, as an ingredient in your stuffing, etc. Dried apples make a wonderful winter snack, as is. I can never keep enough of these on hand!

If you like fruit leather, apple makes a fine fruit leather. Season like you would for an apple pie (cinnamon, ginger, cloves, allspice, nutmeg, etc.) or mix with other fruit purees. Making apple (fruit) leather's pretty simple. Just puree the apples (and other fruit, if mixing), sweeten with honey or fruit juice concentrate to taste. Add spices, if desired. Spread purees 1/4” thick on a solid plastic drying tray (or cover a ventilated drying tray with plastic wrap). Leave about an inch around the edges. Dry at 100 for 18 hours, or until leathery and pliable. You'll want to remove the leather from the tray while it's still warm. Roll it up and wrap in plastic. Store in an airtight container, or it will dry out and become brittle.
How to Dehydrate or Dry Apricots

Wash apricots. Cut in half and remove pits. Place apricots on drying trays, skin side on top. Dry for approximately 48 hours at 38°C or until pliable (the same consistency as store bought). Note: dehydrated apricots will be darker in color than store bought, but have wonderful flavor!

To rehydrate: soak in hot water for 15 minutes. Dried apricots make nutritious snack treats. They're also great for baking, trail mixes, or even chop the apricots and add to dress up your cereal or oatmeal! Apricots also make a nice fruit leather.

How to Dehydrate or Dry Bananas

Dried banana chips are family favorites. If you watch the produce section, you can often find "older" bananas for cheap (but not squishy overripe ones), that will be fine for dehydrating. Peel bananas and cut into 1/4 slices (chips). Pretreat by soaking in ascorbic acid solution for 2 minutes and drain. (I prefer to use pineapple juice). Drying bananas takes about 55 hours 38°C. dehydrate banana chips until crisp.

To rehydrate, soak in hot water for 10 minutes. Dried banana chips are wonderful nutritious snacks, and great additions to trail mixes. Rehydrated dried bananas are useful in bakery like muffins, breads, and even pancakes. Banana is also a good ingredient in fruit leather, generally coupled with another ingredient, and bananas are too sweet by themselves (dehydrating concentrates the flavor!).
**How to Dehydrate or Dry Blackberries**

Wash and dry (shake off moisture or gently pat dry). Remove stems from blackberries. Dehydrating blackberries at 38°C takes approximately 10 hours. Dehydrate until brittle.

To rehydrate, soak in hot water for 15 minutes. Note: blackberries are loaded with seeds. You may wish to make a puree from the rehydrated berries and strain out the seeds. Blackberries make very good fruit leather also.

**How to Dehydrate or Dry Blueberries**

Drying blueberries, because of their skins, requires a little extra effort, but is well worth it. Wash and drain blueberries. Remove stems. Drop blueberries in boiling water until skins crack (1-2 minutes). Drain and immediately immerse in ice water to stop cooking process. Drain and place on cookie sheets in freezer. Once frozen, remove and place on dehydrator trays. Dehydrating blueberries at 38°C takes about 10 hours.

To rehydrate, soak in hot water for 15 minutes. Dried blueberries are perfect additions to your morning oatmeal (just toss in with the dried oats as they're cooking). Also, they're great additions to your bakery. No need to rehydrate before using in your bakery. They also make a nice addition to homemade herbal teas.

**How to Dehydrate or Dry Cantaloupe**

Remove cantaloupe rind and seeds (consider saving seeds for next year's crop!). Cut into bite-sized pieces about 1/4" thick. Dehydrate cantaloupe at 38°C for approx 30 hours (or until pliable). Cantaloupe is a good choice for fruit leather. Also, dried cantaloupe makes a nice snack or addition to trail mix.

**How to Dehydrate or Dry Cherries**

Wash cherries, remove stems and pits. Because the skins are so thick, you'll need to "check" the cherries before dehydrating (just like you would with blueberries). Drop the cherries into a pot of boiling water for no more than 2 minutes (or until the skins crack). Drain.

Dehydrate cherries at 38°C for about 48 hours. (When done, they should have the consistency of raisins).

To rehydrate, soak in hot water for 15 minutes. Drain. Cherries work well for fruit leather. Dried cherries can be eaten as a snack, like you would raisins. They're also good in bakery.

**How to Dehydrate or Dry Cranberries**

Wash and drain the cranberries. Because they have such tough skin, you'll need to "check" them as you would with blueberries or cherries.

To check the berries, drop them in boiling water until the skins crack (shouldn't take any longer than 2 minutes). Drain.
Dehydrate cranberries at 38°C for approximately 12 hours. (Should have the same consistency as raisins.)

To rehydrate, soak in hot water for 15 minutes.

You can use cranberries for leathers, but it's best to use them combined with other fruits. Use dried cranberries in your bakery.

**How to Dehydrate or Dry Dates**

Wash dates, remove the pits, and cut in half lengthwise. Place cut-side down on dehydrator tray.

Dehydrate dates at 38°C until leathery (+/- 20 hours).

Dried dates are great for snacking by themselves, for bakery, for trail mixes, even cereal/oatmeal additions.

**How to Dehydrate or Dry Figs**

Wash figs, remove the pits, and cut in half lengthwise. Place cut-side down on dehydrator tray.

Dehydrate figs at 38 Centigrade until leathery (+/- 20 hours).

Dried figs are great for snacking by themselves, for bakery, for trail mixes, even cereal/oatmeal additions.
How to Dehydrate or Dry Grapefruit

Wash fruit, leaving peels attached. Slice into thin, even slices.

Dry grapefruit at 38 °C for about 45 hours. Finished consistency should be brittle.

Note: you can also just dry the peels. If doing this, try to remove the white part of the peel, as it's bitter. If drying just the peels, dehydrating should take only about 10 hours.

*make sure it's completely dry and brittle, as this fruit is prone to mold if there's any moisture left.

Uses for dried grapefruit: grind into a powder, and use as a spice/flavoring. Use dried grapefruit to flavor beverages. Dried grapefruit also makes a very aromatic and pretty addition to homemade potpourris.

How to Dehydrate or Dry Grapes / Raisins

It's best to use seedless grapes. Remove the grapes from the stems and wash.

Check the grapes by dropping them into boiling water until the skins crack (should take no longer than 2 minutes). Remove from water and drain.

Dehydrate grapes at 100% for about 80 hours, until leathery and they look similar in consistency to store-bought raisins. (no moisture pockets).

Rehydrate: I like to plump raisins for my bakery by soaking them in hot water for about 20-30 minutes before adding to my recipe. (Save the water and use it in your recipe, if it calls for water. It'll add extra flavor!)

Use your raisins just as you would store bought.
How to Dehydrate or Dry Lemons

Wash fruit, leaving peels attached. Slice into thin, even slices.

Dry lemons at 38 °C for about 45 hours. Finished consistency should be brittle.

Note: you can also just dry the peels. If doing this, try to remove the white part of the peel, as it's bitter. If drying just the peels, dehydrating should take only about 10 hours.

*make sure it's completely dry and brittle, as this fruit is prone to mold if there's any moisture left.

Uses for dried lemons: grind into a powder, and use as a spice/flavoring. Use dried lemons to flavor beverages. Dried lemons also make a very aromatic and pretty addition to homemade potpourris.

How to Dehydrate or Dry Limes or Mitay

Wash fruit, leaving peels attached. Slice into thin, even slices.

Dry limes at 38 °C for about 45 hours. Finished consistency should be brittle.

Note: you can also just dry the peels. If doing this, try to remove the white part of the peel, as it's bitter. If drying just the peels, dehydrating should take only about 10 hours.

*make sure it's completely dry and brittle, as this fruit is prone to mold if there's any moisture left.

Uses for dried limes: grind into a powder, and use as a spice/flavoring. Use dried limes to flavor beverages. Dried limes also make a very aromatic and pretty addition to homemade potpourris.

How to Dehydrate or Dry Mangoes

Wash peel, remove seed. Cut into 1/4" slices

Dehydrate mangoes at 38 °C for approximately 20 hours. (Finished consistency should be pliable)

Mangoes are good for fruit leather. Dried mangoes make a wonderful snack. Rehydrated mango is best used in bakery, or try it with your favorite chutney.
How to Dehydrate or Dry Oranges

Wash fruit, leaving peels attached. Slice into thin, even slices.

Dry oranges at 38 °C for about 45 hours. Finished consistency should be brittle.

Note: you can also just dry the peels. If doing this, try to remove the white part of the peel, as it's bitter. If drying just the peels, dehydrating should take only about 10 hours.

*make sure it's completely dry and brittle, as this fruit is prone to mold if there's any moisture left.

Uses for dried oranges: grind into a powder, and use as a spice/flavoring. Use dried oranges to flavor beverages. Dried oranges also make a very aromatic and pretty addition to homemade potpourris.

How to Dehydrate or Dry Papaya

Wash, peel, halve and remove seed from papaya. Cut into 1/4” slices.

Dry papaya at 38 °C for about 20 hours. Finished consistency should be pliable.

Papaya makes great fruit leather, and combines well with other fruits for leather. Dried papaya is a tasty snack.

Papaya doesn't rehydrate very well - it's best to use it in it's dried form.
**How to Dehydrate or Dry Pears**

Wash, peel and core pears. Cut into 1/4" slices.

Pears will discolor some as they dehydrate. You may elect to pretreat in ascorbic acid/lemon juice solution (soak for 2 minutes).

Dry pears at 38 °C for about 10 hours. Finished consistency should be pliable.

Use dried pears in bakery, as a snack by itself, in trail mixes, etc. Pears also are good for making fruit leather.

**How to Dehydrate or Dry Pineapple**

Peel pineapple, core and cut into 1/2" slices (or cut into bite-sized pieces, if you prefer).

Dehydrate pineapple at 38 °C for about 70 +/- hours. Finished consistency should be leathery.

Use dried pineapple as a stand-alone snack, in baked goods, trail mixes. Pineapple also makes a nice fruit leather.

**How to Dehydrate or Dry Plums / Prunes**

It is known that certain treatments used to modify the waxy cuticle of the surface of various fruits (prunes, grapes, cherries, etc.) accelerate the drying as a result of an increase in the skin permeability. Dipping in olive oil emulsions is a traditional practice in direct solar drying of pieces and it is recorded that this increases the drying rate of grapes approximately 30%. Different olive oil concentrations combined with sodium or potassium carbonate or ethyl esters of fatty acids are used for this purpose. Researchers have found that the most effective compounds are the ethyl esters of fatty acids in the C10-C18 range with ethyl oleate being the easiest to handle. Prunes can be dried at 55-60°C in solar tunnel driers. At this temperature, prunes pretreated with 2% ethyloleate or 2% olive oil+4% potassium carbonate dried in 3-4 days. Dried plums make a tasty snack, but eat in moderation (for their laxative effect). Use in bakery, sweet and sour dishes, etc.
How to Dehydrate or Dry Peach

Peaches are washed, destoned and sliced 1-2 cm thick. The thickness of the slices is very important since very thin slices causes hardening and brownish colour in the final product. Different concentrations of Na$_2$S$_2$O$_5$ and citric acid can be used as pretreatment agent: 2% citric acid for 30s, 1 Na$_2$S$_2$O$_5$ for 1 s, and 1 % citric acid + 0.5% Na$_2$S$_2$O$_5$ for 1 s. Peaches which are consumed directly or used in recipes can be dried at 45-50°C in 2 days. The yield of the final product is 11 % and final moisture content is about 8.5%.

![Dried Peaches](image)

How to Dehydrate or Dry Strawberries

Wash strawberries and remove caps. Cut into 1/4" slices.

Dehydrate strawberries at 38 °C for about 30 hours. Finished consistency should be leathery.

Strawberries make nice fruit leather. Dried strawberries are great as additions to oatmeal, cereal, bakery, yogurt.

How to Dehydrate or Dry Watermelon

Remove rind and seeds. (Consider saving seeds for next year, if an heirloom variety.) Cut into 1/4" thick bite-sized pieces.

Dehydrate watermelon at 38 °C for about 30 (+/-) hours. Finished consistency should be pliable. Use dried watermelon as a snack.

How to Dehydrate or Dry Artichoke

Wash and remove the outer leaves. Cut the artichoke hearts into quarters. Steam blanches for 4 minutes, and drain well. Dehydrate (dry) at 38 °C for 18 hours, or until brittle. Store in a clean, dry airtight container, in a cool dark location. (Light can cause discoloration) Use your dried artichoke hearts marinated (for salads, antipasto platters, topping on pizzas, casseroled) or in dips. To rehydrate: soak in boiling water for about 15 minutes, adding a little lemon juice to help keep the color.
**How to Dehydrate or Dry Asparagus**

Wash and remove tough ends. Steam blanches for 3 minutes. Drain. Dehydrate at 38 °C for 35 hours or until dry and brittle (to avoid them molding in storage). To rehydrate, soak in hot water for 30 minutes and drain. Stalks will likely remain a little tough. Dried asparagus is best used in soups, casseroles, or dishes that require mashed asparagus.

**How to Dehydrate or Dry Green Beans**

Wash, snip ends and cut into 1” pieces. Steam blanches for 4 minutes, then soak in iced water for 4 minutes. Drain. Place on cookie sheet in single layer and freeze for 45 minutes. Dehydrate at 38 °C for 30 hours, until crisp. To rehydrate, soak in cold water for 2 hours, or in hot water for 1 hour. Drain. Dried green beans are best served in hot main dishes like stews, soups, and casseroles. You can add dried green beans directly to soups and stews… just add a little extra liquid to the recipe.

**How to Dehydrate or Dry Broccoli**

Wash and peel the tough skin from the stalks. Separate the florets from the stalks. Cut stalks into ½” diagonal slices. Cut florets into uniform pieces. Dry at 100 degrees for 18 hours or until brittle. To rehydrate, soak in hot water for 30 minutes or steam for 15 minutes (until tender). For fresher looking broccoli, soak in cold water for 5 minutes before cooking. Rehydrated broccoli is best used in soups and casseroles.

**How to Dehydrate or Dry Cabbage (Red or Green)**

Wash, trim outer leaves. Remove core and shred. Steam blanches for 2 minutes. Dry at 38 °C for 18 hours or until crisp. To rehydrate, soak in cold water with a little lemon juice for 30 minutes and drain. You can add dried cabbage directly to soups or stews without rehydrating. Note: Red cabbage loses some of its color when rehydrated.

**How to Dehydrate or Dry Carrots**

Before loading into the dryer, carrots are peeled, washed, cut into small cubes and treated with 2% sodium metabisulfite solution for 1s and 10s or dried as natural. Carrots can be dried at 50-55°C for 1-1.5 days to a final moisture content of 7.5 %. Naturally dried carrots lose their bright orange colour. The sodium metabisulfite treated ones preserve their colour to the largest extent.
How to Dehydrate or Dry Eggplant

Wash and cut into ½” slices. Dry at 38 °C for about 20 hours or until leathery. To rehydrate, soak in hot water for about 30 minutes and drain. Dried eggplant works well in casseroles.

How to Dehydrate or Dry Garlic Cloves

Use firm cloves without bruises. Peel cloves and cut in half. Remove the sprout in the middle. Dry at 38 °C for about 6 hours or until crisp. To rehydrate, soak in cold water for about 3 hours in the fridge and drain. To make garlic powder, grind the dried garlic in a blender or seed grinder. For garlic salt, mix ground-dried garlic with 4 parts salt.

How to Dehydrate or Dry Mushrooms

Rinse quickly, trim and cut into ¼” slices. Dry at 38 Centigrade for 18 hours or until crisp. To rehydrate, soak in cold water for 30 minutes and drain. No need to rehydrate if using in soups or stews.

How to Dehydrate or Dry Okra or lady finger

Okra is one of the most popular vegetables consumed in tropical and subtropical countries, because of its adaptability and resistance to hot and humid weather. Before loading into solar dryer, okra is washed and its head is removed. One of the following treatments can be applied to okra prior to solar drying: dipping in 0.2% Na₂S₂O₅ for 20 min; 0.1% Na₂SO₃ for 30min; 0.3% Na₂S₂O₅ 10 min; 2% Na₂S₂O₅ for 1s, and 3 minutes of blanching followed by dipping in 0.2% Na₂SO₃ for 15 min, and finally blanching and dipping in 0.2% Na₂SO₃ for 15 min. On the basis of colour, flavour and microbiology of the final product, it was observed that high quality dried okra was obtained using 2% Na₂S₂O₅ dipping as a pretreatment and drying of okra at 50-55°C in the solar dryer under dark conditions. Drying time was about 1day. Blanching of okra before drying needs ice-bath dipping. Therefore it is not considered as a practical method.
**How to Dehydrate or Dry Onions**

A large part of the dehydrated onion production is used as seasoning in production of catsup, chilli sauce and meat casseroles, as well as cold cuts, sausages, potato chips, crackers and other snack items. Food service outlets also use dehydrated onions because of its convenience in storage, preparation and use. Before drying, onions are peeled and sliced into desired shapes. Onions can be dried at 45-50°C for 2-3 days to a final moisture content of 15% in tunnel solar dryers. Sodium metabisulfite dipping can be used to preserve colour. Drying temperatures of onions should not exceed 50°C in order to prevent browning of the product. The yield in onion drying is 8%.

To rehydrate, soak in hot water for 15 minutes and drain. No need to rehydrate if using in soups or stews. Make onion flakes and onion powder by grinding in a food mill or blender. For onion salt, mix onion powder equally with salt.

NOTE: A dehydrating onion makes the house smell very strongly of onions. You may consider dehydrating them outside or in a less used space.

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**How to Dehydrate or Dry Peas**

Remove peas from the pods. Steam blanch for 3 minutes and drain. Dry at 38°C for 12 hours or until brittle. To rehydrate dried peas, soak in hot water for 30 minutes and drain. No need to rehydrate if using in soups.

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**How to Dehydrate or Dry Bell Peppers**

Wash and core pepper. Dice or cut into 1/4” slices. Dry at 38°C for 24 hours or until brittle. To rehydrate dried peppers, soak in hot water for 20 minutes and drain. No need to rehydrate if using in soups. For a little crunch in your salad, try adding dried bell pepper pieces.
**How to Dehydrate or Dry Potatoes**

Drying potatoes is a smart way to store this vegetable for later use. There are a few different methods of doing this, including a dehydrator, solar oven or conventional oven. Follow the listed steps to figure out how to dry your potatoes. Wash the potatoes you wish to dry and remove any areas that have spoiled. Skins can either be peeled, or left on if you wish for vitamins. Bring a large kettle of water to a boil and add salt to your taste. Slice the potatoes into rounds that are 1/8-inch thick and place these slices in a vegetable basket and dip that into the boiling salt water. Wait for the water to return to a boil, and continue boiling them for about seven minutes. Take the potatoes out of the kettle and place the basket in ice water for approximately 15 minutes. Spread the potatoes in a single layer between paper towels and blot them to dry, put the potato slices on racks that are coated lightly with vegetable-oil spray. Put the slices in a single layer, and make sure they are not touching one another.

**How to Dehydrate or Dry Spinach**

Wash well and remove stems. Dry at 38 °C for 10 hours or until brittle. To rehydrate, soak in hot water with a little lemon juice for 15 minutes, drain well.

**How to Dehydrate or Dry Tomatoes**

Due to the increasing demand to dried tomatoes from the industry, especially from the soup manufacturers, interest in producing high quality dried tomatoes has been increasing. Therefore, it is important to establish a drying method, which yields products with higher sensory and sanitary quality in a shorter drying time compared to the conventional sun-drying method. Both 2% Na₂S₂O₅ and 2% citric acid pretreatments can be used to protect the bright, red colour of tomatoes. However, citric acid did not prevent the growth of moulds and yeasts effectively. Therefore, dipping into sodium metabisulfite solution for 3 minute is the best type of pretreatment. Tomatoes can be dried at 55°C in solar tunnel dryer without a darkening in colour. At this temperature the drying takes 4-5 days to final moisture content of 11 %. To rehydrate, soak for 15 to 30 minutes in cold water. Use in stews, sauces or marinades.
How to Dehydrate or Dry Red Pepper

Red peppers are deseeded, cut into small pieces, and washed before loading into the tunnel solar dryer. Pretreatment with 2% Na$_2$S$_2$O$_5$ for 1 second gives the best colour. Moreover, the drying temperature and piece size of red peppers affects the final product quality. Temperatures higher than 60°C results in dark brown colour formation in red peppers, Red peppers that are cut into bigger pieces needs a longer time period to dry and therefore the colour of the final product are darker. Drying at low temperatures (45-50°C) for about 1 day gives good results. To increase the capacity of the solar dryer, a double layer system can be constructed, but with this system, drying needs a more careful control. Final moisture content of dried red peppers, which are pretreated with 2 Na$_2$S$_2$O$_5$ for 1 second, is 3.5%. The yield is 9% for both pretreated and naturally dried peppers.

How to Dehydrate or Dry Green Pepper

Green peppers are used especially in the soup manufacturing. Therefore, establishing an efficient and economic method for peppers is important for the food industry. Green peppers are washed, deseeded and cut into small pieces before loading into the dryer. Green peppers are very sensitive to high temperatures and light. Therefore, green peppers should be dried under dark and at 45-50°C to preserve the natural green colour. 2% Na$_2$S$_2$O$_5$ dipping for 1 sec can be applied to obtain a microbiologically safe product. Drying at 45-50°C under dark conditions takes about 1 day. Green peppers dried under these conditions have final moisture content of 6%, and a yield of 10%.
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