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Drying Foods at Home

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Drying is believed to be one of man's oldest methods of food preservation. While there is little recorded history of dehydration of foods, sun-drying and the smoking of foods over a hot fire are mentioned in the Bible. Samples of foods which were discovered within the last few years were believed to have been dried in Jericho 4,000 years ago. An important part of the diet of American Indians was smoked fish and meat. Dried corn was an important part in the diet of colonial America.

In 1917 the United States Department of Agriculture published the first instruction booklet on drying foods at home. Many of the methods described would not be considered safe today. During World Wars I and II many foods were dehydrated in an effort to develop light weight, nutritious, stable foods for the military.

Today there has been a renewed interest in drying as a method of home food preservation. Both counter top dehydrators and portable convection ovens are being promoted for use in home drying.

Many claims are currently being made by promoters of these appliances about the nutrient content, keeping quality, and energy use involved in preparing home dried foods. Only a small number of research articles have been published in this area. Those published indicate that the nutritional content of home dried foods is not superior to that of foods canned or frozen at home. Home drying is used most successfully by persons preparing small quantities of food for camping or backpacking trips.

BASIC PRINCIPLES OF DRYING

Drying preserves food by lowering the amount of water or moisture in the food material. This is necessary to prevent microbial growth and chemical reactions which can only occur when enough water is present in the food. Equilibrium Relative Humidity (ERH) is a term used to describe the availability of the water to the chemical environment and microorganisms present in foods. The equilibrium relative humidity or percent ERH scale varies from zero to 100. Figure 1 illustrates the meaning of percent ERH.

If a food of a certain moisture content is put in a closed chamber which is set to some relative humidity, the food will change its moisture content in an attempt to equal the ERH of the chamber. If a dry food such as a cracker which has an ERH equal to 11 percent is placed in a chamber with a high ERH, for example 60 percent, the cracker will gain water from the air until it reaches the ERH of the air, in this case the cracker will lose its crispness. If a fresh tissue food such as lettuce which has an ERH equal to 98 percent is placed in a chamber set at 60 percent ERH, the lettuce will lose moisture to the air and become wilted. These two foods will have different moistures at 60 percent ERH, but they will both have the same availability of water to chemical reactions and microorganisms present in the food.

Fresh tissue foods, such as meat, vegetables, and fruit products, have an ERH close to 100 percent. An ERH level this high means that the water present in these foods is available for rapid growth of microorganisms leading to deterioration and spoilage of the food. By drying foods it is possible to lower the percent ERH. As the percent ERH is lowered, the growth of microorganisms slows or ceases since the water is no longer as available for their growth. This occurs at an ERH of 60 percent. Therefore, all foods must be dried to below 60 percent ERH and kept in a dry environment to be shelf stable from microbial growth because microorganisms cannot survive below this ERH level.

CHEMICAL CHANGES DURING DRYING

Although drying foods to about 60 percent ERH prevents microbial growth, certain chemical reactions caused by enzymes can still occur which result in spoilage and deterioration of the product. Fresh produce contains many different enzymes which cause loss of color, loss of nutrients, and flavor changes in dried vegetables and fruits. These enzymes must be inactivated to prevent such reactions from taking place.

Enzymes in vegetables are inactivated by the blanching process. Blanching is the exposure of the vegetables to boiling water or steam for a brief period of time. Blanched vegetables when dried, will have better color and flavor than unblanched. For blanching times consult the tables on page xx.

The major problem associated with enzymes in fruits is the development of brown colors and loss of vitamins A and C. Fruits are not blanched like vegetables because the blanching process gives fruits a cooked flavor. Instead, the enzymes in fruits are inactivated by using chemical compounds which interfere with deteriorative chemical reactions. The most common control chemicals used are sodium bisulfite and ascorbic acid (Vitamin C). Ascorbic acid may be used in its pure form or in chemical mixtures of ascorbic acid and other compounds such as "Fruit Fresh." Food grade sodium bisulfite, sodium sulfite or sodium metabisulfite may also be used for pretreatment of fruit. Follow the pretreatment directions for fruit in the table on page xx.

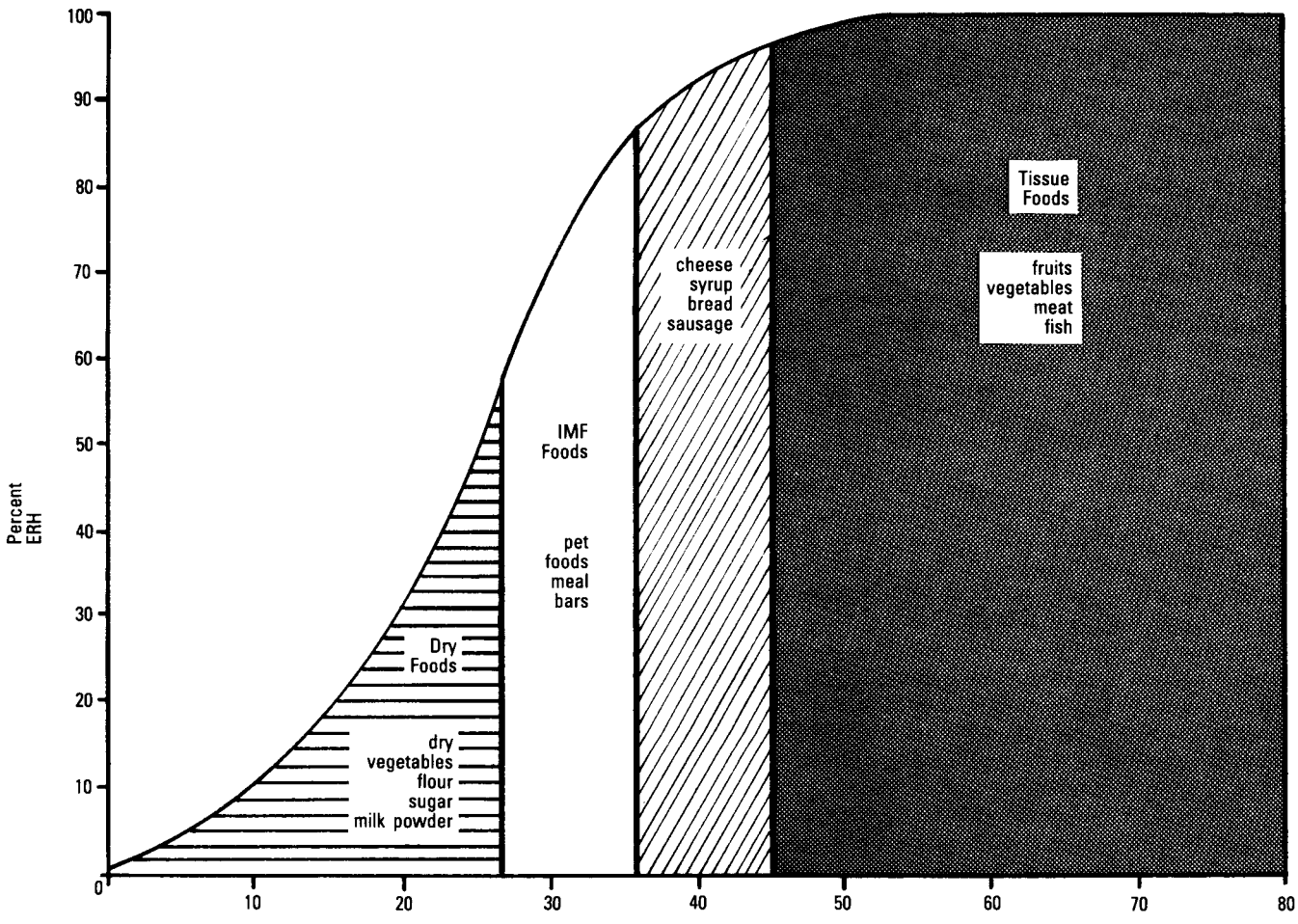


Figure 1

DEHYDRATION PROCESSES

Sun-Drying

Many booklets are available which describe sun-drying of foods. Sun-drying requires constant exposure to direct sunlight during the day and a relative humidity of less than 20 percent. These conditions are usually found in only a few regions of the United States, such as in the Sacramento Valley of California or in Arizona. Foods dried in the sun can take from 3-4 days to dry and if the humidity is high, as is generally the case in Minnesota, the food will mold before it dries. The sun-drying process is inefficient because it requires much more space and drying time than drying in conventional home driers. In addition, food dried in the sun is exposed to dirt, insects, rodents, and bird wastes. The practice of sun-drying is not recommended for home food preservation because complete drying cannot be assured and the quality of the food is questionable.

Dehydrators

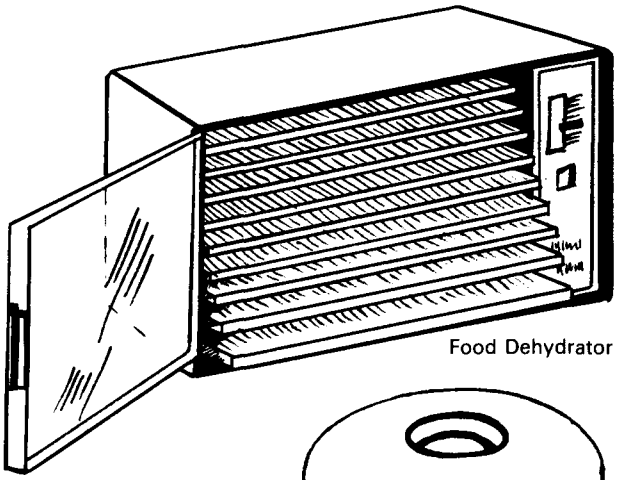
Purchased home food dehydrators and portable convection ovens fitted with drying trays, provide better control over climatic conditions and food quality than sun-drying. Drying foods in a conventional oven gives much less satisfactory results. Home dehydrators and convection ovens are equipped with a heating element and fan which blows hot, dry air at moderate speeds around the food. The air serves two purposes. It supplies the heat needed to evaporate the water. As the air heats up its relative humidity decreases allowing the food to dry at a faster rate and reach a low equilibrium relative humidity. The dry air blown across the food also serves to carry away the water vapor. The air must by kept in motion by the fan because stagnant air takes on as much moisture as it can hold, and if it is not removed, drying no longer takes place.

Both counter top dehydrators and portable convection ovens can be used on a 110/120 volt general purpose circuit (15 AMP). The food dehydrators draw 525-800 watts; the convection ovens draw about 1500 watts and should not be used on the same general household circuit with other heating appliances such as a coffee maker or toaster. This may be an important consideration in view of the fact that convection ovens used for drying may be running for many hours.

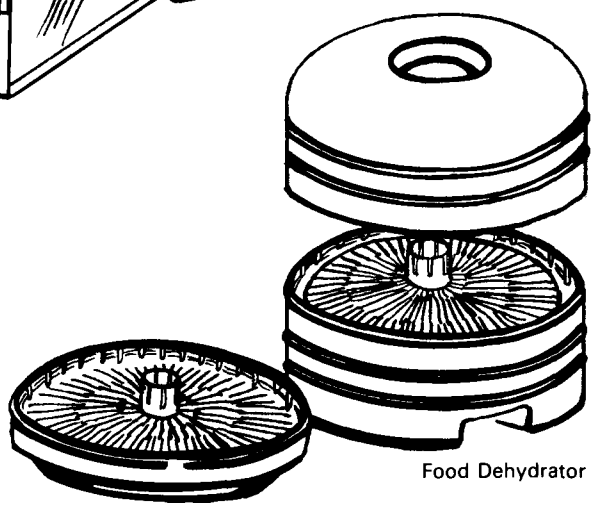
Food dehydrators and convection ovens differ in their range of temperature settings and available square feet of drying space. The range of temperature settings for

dehydrators has a low of 85° to 110° F up to a high of 140° to 145° F. The range for convection ovens has a low of 140° to 175° F up to a high of 500° F. Food dehydrators are usually made to handle more racks and, therefore, have more square feet of drying space than portable convection ovens. The appliances require 18-24 inches of counter space and vary in height from 10-16 inches. The height is a consideration if it is to fit on a counter with cabinets above.

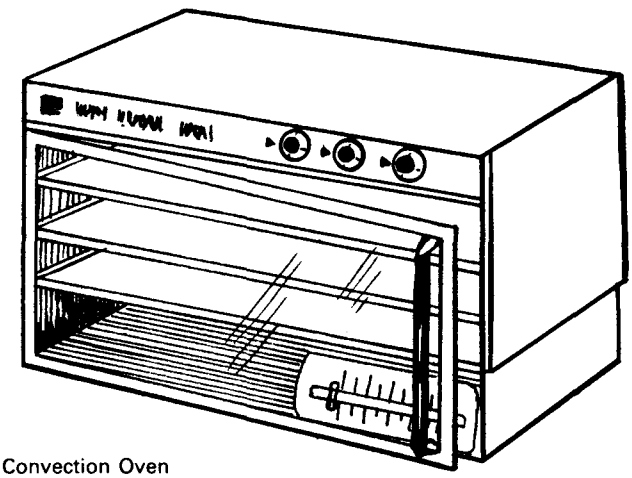
Food dehydrators range in cost from $100 to $250; convection ovens that recommend drying range from $150 to $200; drying racks for convection ovens would be $25 to $50 extra.



Food Dehydrator



Food Dehydrator



Convection Oven

FACTORS AFFECTING DRYING TIME

Temperature for Drying Foods

In general, safe drying temperatures for most vegetables and fruits are between 140° to 145° F. Even on rainy days when the relative humidity is 85 to 95 percent, it is better to dry in this temperature range than to raise the temperature. It is important that very high temperatures are not used to speed the drying process. Higher temperatures only serve to dry the outermost portion of the food while the interior remains moist resulting in what is called case hardening. Such foods will spoil due to microbial growth when the moisture from the interior migrates to the exterior of the product. In addition, higher temperatures speed up chemical reactions which deteriorate foods.

Do not attempt to dry food on rainy days when the relative humidity is high. The drying process will take much longer than on low humidity days. Humid air blown across the food contains more water vapor than dry air, so the humid air cannot hold as much of the water being removed from the food.

Size of Food Particles

The size of the pieces of food is another important factor influencing the rate of drying. Food should be cut into halves, strips, or slices and should not be more than ⅛- to ¼-inch thick. Larger pieces take longer to dry because it is more difficult for the water to travel through the pores in the food. In general a piece which is twice as thick as another one will take four times longer to dry. Thus, all pieces of food should be of uniform size and thickness. The pieces of food should be spread evenly on the dehydrator trays in thin layers and stirred occasionally. The trays should be rotated if top trays dry at different rates than the bottom trays.

Capacity of the Drier

The amount of food that should be dried at one time depends on the dehydrator. The manufacturer's direction book usually contains specifications about the amount of food that can be dried at one time. Some large dehydrators can hold up to 8 pounds of prepared produce. Portable convection ovens may hold only 2 to 3 pounds of prepared produce.

Do not keep adding fresh produce to the dehydrator as the food is drying. This common practice increases the time required to reach an acceptable degree of dryness and will produce a poor quality product.

Determining Dryness

A major problem in drying foods at home is determining if and when the food item is dry. In general, vegetables must be dried to about 5 percent water content and fruits to 15 to 20 percent water content. Dried fruits are stable at a higher moisture content than dried vegetables because the concentrated natural sugars and acids in the dried fruit function as preservatives.

To determine if **vegetables** are dry, remove some pieces near the end of the drying process. This time will usually be after a minimum of 6 to 8 hours. Cool the pieces to room temperature. The vegetable is dry if it is

brittle or crisp when bitten, and if it will shatter when hit with a hammer.

Remove a piece of fruit during the end of the drying period. Cool to room temperature. It should feel pliable, leathery, and have no pockets of moisture.

Time and Energy Considerations

Preliminary studies conducted at the University of Minnesota give some indication of the time and energy requirements for food dehydration. Drying time per load of fully loaded dryer ranged from 5 to 23 hours.

An average of 1 kWh of electricity was needed for drying each pound of fresh prepared produce. This energy cost is similar to the cost to freeze and store food in a freezer for 6 months. Freezer costs were based on 0.1 kWh per pound to freeze and 0.7 to 1.5 kWh[1] to store food for 6 months and assumes a full freezer.

The kWhs required to blanch and dry tomatoes were 1.324 kWh per pound. Zimmerman[2] reported the energy used in home canning tomatoes in a water bath canner to be 3.093 kWh for seven quarts which is 0.173 kWh per pound. A comparison of these figures indicates that home drying tomatoes used considerably more energy than processing them in a water bath canner.

Storing Dried Foods

Dried foods must be stored properly to maintain the low moisture content and to prevent microbial deterioration. Before packing foods, the dried pieces should be allowed to cool for a short amount of time. Immediately after the product has cooled the food should be stored.

To store dried foods, place the dried food in plastic bags, press out air, seal or close, and then place in glass jars which are tightly sealed. Plastic containers or metal cans with plastic lids are not recommended because moisture can enter through the container. To be sure that the food remains dry, add dessicant or silica gel which you can purchase in the notions or housewares section of a department store or at hobby shops. Place the substance in the glass jar to cover the bottom of the container to a depth of ¼-inch thick.

The dessicant absorbs any moisture from the surroundings and prevents the food from absorbing moisture. Place the dried food wrapped in a sealed plastic bag over the dessicant and tightly seal the jar. Packaged dried food should be stored in a dry, cool, 60° F place. Dried food should also be kept out of the sun to prevent discoloration and nutrient loss.

Dried foods in sealed plastic bags may also be stored in the refrigerator or freezer.

Shelf Life

In general, the shelf life of home dried vegetables and fruits stored at 60° F is 4 to 6 months. If the product is stored at 70° F, shelf life will be shortened. See tables on p. 7 and 8 for storage times.

[1]Based on range of operating cost of 15 cubic foot freezers as reported in the March 25, 1980, Federal Register

[2]Zimmerman et al. "Home Canned Tomatoes: A Comparison of the Effects of Varying Time and Temperature Combinations During Processing," *Home Economics Research Journal* 7 (1978): 108-115.

The shelf life of food dried in the home is not as long as the shelf life of commerically freeze-dried products. This is because freeze-dried foods are first frozen at –40° F and then placed in a chamber connected to a vacuum pump. Heat is applied to the frozen food after the air is evacuated from the chamber and the ice sublimes or evaporates directly into vapor. Because the food is frozen and is at a low temperature during drying, there is little nutrient loss and textural damage. Freeze-drying is not practical for home use because elaborate and expensive equipment is necessary.

Drying Instructions

All foods should be prepared by properly sorting, washing, and peeling. If possible, gather vegetables or fruits early in the morning and start the drying process as soon as possible to prevent browning or wilting.

Vegetables

Vegetables must be blanched to inactivate enzymes. The blanching time is counted as soon as the vegetable is immersed in vigorously boiling water. Do not add so much food that the water stops boiling.

The quality of water used to blanch the vegetables can have an effect on the texture of certain vegetables. Very hard water can cause the toughening of vegetables, such as green beans. If you have problems with excessively tough green beans, check into the level of hardness in your water supply.

To Blanch in Boiling Water

- Use 1 gallon water for each pound of vegetable.
- Bring water to rolling boil.
- Immerse wire basket or mesh bag containing vegetable.
- Cover kettle and boil at top heat the required length of time (see table).
- Begin counting time as you place the vegetable in water. You may use the same blanching water 2 or 3 times. Keep it at required level. Change the water if it becomes cloudy.
- Drain the vegetables thoroughly.

To Blanch in Steam

- Put 1 inch of water in kettle, bring to a rolling boil.
- Suspend a thin layer of vegetables in steaming basket or loose cheese cloth bag over rapidly boiling water.
- Cover and steam blanch vegetables required amount of time as listed on table.
- Remove from steamer.

Fruits

Pretreating fruit with sodium bisulfite will reduce vitamin loss, flavor loss, browning, and deterioration during storage. Sodium sulfite and sodium metabisulfite, available at wine making shops, may also be used.

Some books on home drying suggest the use of ascorbic acid solutions to prevent browning reactions, but the bisulfite treatment is more effective.

Prepare a solution of 1 tablespoon sodium bisulfite, or 2 tablespoons sodium sulfite, or 4 tablespoons of sodium metabisulfite to a gallon of water. Soak slices of fruit for 5 minutes and halves of fruit for 15 minutes.

When soaking is complete, remove fruit and rinse lightly under cold tap water. Then place the fruit on the drying trays.

Fruit leathers are chewy candy-like products which are made by pureeing fresh fruits in a blender or food processor. The thick pureed fruit is poured onto a dehydrator tray lined with 4 mil food grade plastic and dried. The puree layer should not be more than ¼-inch thick. Leave a 1 inch border around the puree to allow for spreading during drying. It usually takes 6 to 8 hours to dry fruit leathers.

USING HOME DRIED PRODUCE

Dried vegetables need about 2 hours soaking time before cooking. When you soak or rehydrate the vegetables they should plump to nearly the same size they were when fresh. Start with 1½ to 2 cups of water for each cup of dried vegetables. If necessary, add more water during the soaking process.

Cook the vegetables in the same water in which they have soaked to save nutrients. Boil or simmer dried vegetables in soups, stews, or other dishes cooked in liquid.

Most dried fruit can be eaten or used in recipes as it is. If you wish to plump or soften the fruit slightly to make it more chewable, you can use one of these methods:

- Cover the dried fruit with boiling water. Let it stand for 5 minutes then drain.
- Place the dried fruit in the top of a steamer over boiling water and steam 3 to 5 minutes until the fruit is plump.

FOODS YOU SHOULD NOT DRY AT HOME

Eggs, fish, poultry, and meat (except beef jerky) are not recommended for home drying. *Salmonella* and *Staphylococcus* bacteria, which thrive on these foods, can survive and grow at low temperatures used to dry meat and dairy products. These bacteria grow very rapidly in meat and poultry products because all the nutrient needs of these pathogenic or disease producing bacteria are supplied by meats, eggs, and dairy products.

The growth of the pathogenic bacteria will stop when 60 percent ERH is reached, but when water is added to the product, the bacteria will grow again. The poisonous toxin produced by *Staphylococcus* is not destroyed by cooking the food.

Salmonella and *Staphylococcus* have caused food poisoning outbreaks in home dried foods.

Chart I
How to Prepare Vegetables for Drying

Vegetables	Preparation	Recommended Storage Time in Months	
		70° F	60° F
Beans, Snap	Wash, snap off ends and cut diagonally to expose most surface area into 1 or ½-inch lengths. Water blanch 3-4 minutes. Steam blanch 4-6 minutes. Dry.	3-4 months	4-6 months
Beets	Remove tops leaving 2 inches of top and wash. Steam until almost tender. Peel. Cut into strips ⅛-inch thick. Dry.	3-4 months	4-6 months
Carrots	Top, wash, and scrape. Dice or slice ¼-inch thick. Water blanch 3 minutes, steam blanch 4 minutes. Dry.	4-6 months	6-8 months
Celery	Wash, cut stalks crosswise into ¼-inch slices. Water blanch 1 minute. Dry.	1-2 months	2-4 months
Corn	Husk, remove silks and trim ends. Steam blanch whole ears of corn 3 minutes. Cut kernels from cob after blanching. Dry.	3-4 months	4-6 months
Mushrooms*	No blanching required. Cut into ¼-inch thick slices. Dry.	1-2 months	2-4 months
Onions	Wash, remove outer paper skins. Remove top and root ends. Slice into quarter sections ¼- to ⅛-inch thick. No blanching required.	2-4 months	4-6 months
Peas	Wash, shell. Water blanch 2 minutes. Steam blanch 3 minutes. Dry.	3-4 months	4-6 months
Peppers and Pimentoes	Wash, cut out stem, remove seeds and partitions. Dice or slice. No blanching required. Dry.	6-8 months	8-12 months
Potatoes	Wash, peel, remove deep eyes, bruises, and green surface coloring. Cut in ¼- to ½-inch cubes. Blanch 5 minutes over water containing 1 teaspoon sodium bisulfite per cup of water until translucent but firm. Rinse to remove gelled starch. Dry.	2-4 months	4-6 months
Summer Squash	Wash, peel, slice ¼- to ⅛-inch thick. You can grate zucchini for use in soups. Dry.	< 1 month	1-2 months
Tomatoes	Dip in boiling water to loosen skins. Slice crosswise ¼-inch thick slices. Dry.	2-3 months	3-4 months

*Warning. The toxins of poisonous varieties are not destroyed by drying or cooking. Only an expert can differentiate between poisonous and edible varieties.

Chart II
How to Prepare Fruits for Drying

Fruits	Preparation	Storage Time in Months at 70° F
Apples*	Wash, peel, core and cut into pie slices or rings. Dip in sodium bisulfite solution for 5 minutes. Rinse. Dry.	4-6 months
Apricots*	Wash, halve, remove pits. Dip in sodium bisulfite solution for 10 minutes. Rinse. Dry.	6-8
Bananas	Peel, slice, dip in sodium bisulfite solution for 5 minutes. Rinse. Dry.	2-4
Blueberries	Wash, and remove stems. Dry.	4-6
Cherries	Wash, remove stems, slice in half, remove pits. Dip in sodium bisulfite solution for 5 minutes. Rinse. Dry.	8-12
Grapes yellow seedless	Wash, steam for 30-60 seconds to crack skins. Dry.	4-6
Peaches*	Wash, scald to remove skins. Slice into ¼-inch slices. Soak in sodium bisulfite solution for 5 minutes. Rinse. Dry.	4-6
Pears*	Wash and peel thinly. Remove core. Slice. Soak in sodium bisulfite solution for 5 minutes. Rinse. Dry.	4-6
Rhubarb	Slice diagonally into 1 inch slices. Steam 1 to 2 minutes. Dry.	2-4
Strawberries	Wash, slice, dip into solution of ½-teaspoon ascorbic acid per cup of water to protect vitamin C content. Dry.	4-6

*Hold cut fruit in a solution of 1 teaspoon of ascorbic acid per quart of water while preparing rest of fruit for bisulfite dip. This helps prevent darkening.

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