



PREPARATION

Drying Vegetables

no. 9.308

by P. Kendall, P. DiPersio and J. Sofos^{1 (3/08)}

Quick Facts...

Successful drying depends on heat, air dryness and air circulation.

Select vegetables to be dried at peak flavor and quality.

Blanch vegetables before drying to stop enzyme action and enhance destruction of microorganisms.

Package dried foods in tightly sealed containers and store in a cool, dry place.

Drying is one of the oldest methods of food preservation. Drying preserves foods by removing enough moisture from food to prevent decay and spoilage. Water content of properly dried food varies from 5 to 25 percent depending on the food. Successful drying depends on:

- enough heat to draw out moisture, without cooking the food;
- dry air to absorb the released moisture; and
- adequate air circulation to carry off the moisture.

When drying foods, the key is to remove moisture as quickly as possible at a temperature that does not seriously affect the flavor, texture and color of the food. If the temperature is too low in the beginning, microorganisms may survive and even grow before the food is adequately dried. If the temperature is too high and the humidity too low, the food may harden on the surface. This makes it more difficult for moisture to escape and the food does not dry properly.

Although drying is a relatively simple method of food preservation, the procedure is not exact. A “trial and error” approach often is needed to decide which techniques work best.

Nutritional Value of Dried Foods

Drying, like all methods of preservation, can result in loss of some nutrients. Nutritional changes that occur during drying include:

- Calorie content: does not change, but is concentrated into a smaller mass as moisture is removed.
- Fiber: no change.
- Vitamin A: fairly well retained under controlled heat methods.
- Vitamin C: mostly destroyed during blanching and drying of vegetables.
- Thiamin, riboflavin, niacin: some loss during blanching but fairly good retention if the water used to rehydrate also is consumed.
- Minerals: some may be lost during rehydration if soaking water is not used. Iron is not destroyed by drying.

For best retention of nutrients in dried foods, store in a cool, dark, dry place and use within a year.

Drying Trays

Drying trays can be simple or complex, purchased or built. Good air circulation without reaction between food and trays is most important. For small amounts of food and trial runs, cheesecloth or synthetic curtain netting stretched over oven racks, cake racks, broiler racks or cookie sheets work well. Attach with clothes pins. For large quantities of food, use shallow wooden or plastic trays with slatted, perforated or woven bottoms.

**Colorado
State**
University

Extension

Packaging and Storing

Pack cooled, dried foods in small amounts in dry, scalded glass jars (preferable dark) or in moisture- and vapor-proof freezer containers, boxes or bags. Metal cans may be used if food is first placed in a freezer bag.

To protect from insects and reabsorption of moisture, seal lids onto containers. Wrap the edge where the lid meets the container with a plasticized, pressure-sensitive tape or clean, 1-inch cloth strip dipped in melted paraffin. Bags may be heat-sealed or closed with twist ties, string or rubber bands.

Label containers with the name of the product, date, and method of pretreatment and drying. Store in a cool, dry, dark place. Properly stored, dried vegetables keep well for six to 12 months. Discard all foods that develop off smells or flavors or show signs of mold.

Using Dried Vegetables

One cup of dried vegetables reconstitutes to about 2 cups. To rehydrate and cook leafy or tender vegetables (spinach, kale, cabbage, chard, tomatoes), cover with hot water and simmer to desired tenderness. Soak root, stem and seed vegetables (carrots, green beans, peas, corn) before cooking. Cover with cold water and soak 30 to 90 minutes, or cover with boiling water and soak 20 to 60 minutes. After soaking, simmer until tender.

Dehydrated vegetables have a unique texture and flavor. They are best used as ingredients for soups, casseroles, sauces, stuffings and stews.

If preparing your own trays, do not use galvanized screening for tray bottoms. It has been treated with zinc and cadmium, which can cause a harmful reaction when in contact with acid foods. Other metals such as aluminum also are not advisable because they may discolor and corrode with use. If used, line with cheesecloth or synthetic curtain netting to keep food from touching the metal. A liner also helps keep foods from sticking to trays and prevents pieces of food from falling through.

Wash trays in hot, sudsy water with a stiff brush. Rinse in clear water and air dry thoroughly before and after each use. A light coat of fresh vegetable oil or nonstick substance helps protect wood slats and makes cleaning easier.

If trays are used in an oven, they should be 1 1/2 inches smaller in length and width than the oven dimensions to allow for good air circulation. When stacking trays, place blocks of wood 2 inches or higher between trays.

Selecting Vegetables

Select vegetables at peak flavor and eating quality. This usually is just as they reach maturity. Sweet corn and green peas, however, should be slightly immature so they retain their sweet flavor before their sugars change to starch. Refer to Table 1 for fresh-to-dried ratios for a variety of produce.

Table 1: Yield of dried vegetables.

Produce	Amount purchased	Amount dried product	
	or picked Pounds	Pounds	Pints
Beans, lima	7	1 1/4	2
Beans, snap	6	1/2	2 1/2
Beets	15	1 1/2	3 to 5
Broccoli	12	1 3/8	3 to 5
Carrots	15	1 1/4	2 to 4
Celery	12	3/4	3 1/2 to 4
Corn	18	2 1/2	4 to 4 1/2
Greens	3	1/4	5 1/2
Onions	12	1 1/2	4 1/2
Peas	8	3/4	1
Pumpkin	11	3/4	3 1/2
Squash	10	3/4	5
Tomatoes	14	1/2	2 1/2 to 3

Source: *Drying Foods at Home*, Marjorie M. Philips, Cooperative Extension Service, University of Arkansas, Little Rock, Arkansas 72203

Picking activates enzymes that cause color, flavor, texture, sugar content and nutrient changes in vegetables. To control such changes, prepare the produce immediately after gathering and begin processing at once. Thoroughly wash or clean produce to remove any dirt or spray. Drain thoroughly. Shake leafy vegetables well. Sort and discard any food with decay, bruises or mold. Such defects may affect all pieces being dried. Follow preparation steps outlined in Table 2.

Pretreating Vegetables to Enhance Quality and Safety

Pretreating vegetables by blanching in boiling water or citric acid solution is recommended to enhance the quality and safety of the dried vegetables (see Table 2). Blanching helps slow or stop the enzyme activity that can cause undesirable changes in flavor and texture during storage. Blanching also relaxes tissues so pieces dry faster, helps protect the products vitamins and color and reduces the time needed to refresh vegetables before cooking. In addition, research studies have shown that pretreating vegetables by blanching in water or citric acid solution enhances the destruction of potentially harmful bacteria during drying, including *Escherichia coli* O157:H7, *Salmonella* species and *Listeria monocytogenes*.

References

DiPersio, P.A., P.A. Kendall, M. Calicioglu and J.N. Sofos. (2003). Inactivation of *Salmonella* during drying and storage of apple slices treated with acidic or sodium metabisulfite solutions. *J. Food Prot.* 66:2245-2251.

DiPersio, P.A., P. A. Kendall, Y. Yoon and J.N. Sofos. (2004). Inactivation of *Salmonella* during drying and storage of Nantes carrot slices treated with steam blanching, water blanching or immersion in a 3.23% salt solution before drying, or oven heating after drying. IFT Annual Meeting Poster. Abstract available at: http://ift.confex.com/ift/2004/techprogram/paper_7122.htm

DiPersio, P.A., P. A. Kendall, Y. Yoon and J.N. Sofos. (2004). Inactivation of *Salmonella* during drying and storage of Nantes carrot slices treated with steam, water or acid blanching before dehydration. Poster session: Intl. Assoc. Food Prot. Annual Meeting. Abstract available at www.foodprotection.org.

See fact sheet 9.309, *Drying Fruits*, for details on how to condition dried foods.

Testing for Dryness

Foods should be dry enough to prevent microbial growth and subsequent spoilage. Dried vegetables should be hard and brittle.

Remove a small handful of food and cool for a few minutes before testing for dryness. When warm or hot, foods seem more soft, moist and pliable than they actually are. See Table 2 for dryness tests for individual foods.

Blanching

Water blanching is recommended over steam blanching or blanching in a microwave because water blanching achieves a more even heat penetration than the other two methods. Plain water or water with added citric acid may be used. Citric acid acts as an anti-darkening and anti-microbial agent. Prepare the citric acid water by stirring 1/4 teaspoon (1 gram) of citric acid into one quart (approximately one liter) of water.

Work with small amounts so plain or citric acid water doesn't stop boiling. Watch closely and precook as follows:

- Fill large kettle half full with plain or citric acid water and bring to a boil.
- Put no more than one quart of the vegetable pieces in a cheesecloth or other mesh bag. A 36-inch cloth square gathered at the corners works well. Secure ends.
- Drop vegetable bag in boiling water, making sure water covers the vegetables. Shake bag so hot water reaches all pieces.
- Start timing as soon as vegetables are in boiling water. Adjust heat to ensure continuous boiling.
- Heat for length of time shown in Table 2.
- Drop bag in very cold water to cool (same time as blanched).
- Drain on paper towel or cloth.

Drying Methods

Arrange pretreated vegetables on drying trays in single or thin layers, 1/2 inch deep or less. Dry in dehydrator or oven as described below.

Dehydrator Drying. Thermostatically controlled electric dehydrators are recommended for home food drying. They are relatively inexpensive, convenient for drying large or small batches of food, and easy to use. The best dehydrators have thermostatically controlled heat settings and fans that blow warm air over the foods. Some models have a heat source at the bottom and removable, perforated trays (for air circulation) stacked above the heat source. Dehydrators should be used indoors in a dry, well-ventilated room. Food on lower trays near the heat source will often dry more rapidly than food on higher trays and, therefore, trays should be rotated throughout drying.

Oven Drying. If you do not have access to a food dehydrator, either a gas or electric oven may be used to dry vegetables. Both require careful watching to prevent scorching. Proper temperature and ventilation are most important in oven drying. To oven dry, preheat oven at lowest setting (140 to 150 degrees F), then adjust the thermostat and prop the oven door open to achieve a consistent oven temperature of 140 degrees F, and to allow moist air to escape.

Conventional ovens may not maintain consistent temperatures at low settings. To ensure maintenance of 140 to 150 degrees F, monitor oven temperature using a calibrated oven thermometer. Place the oven thermometer directly on the oven rack or tray and check it every two hours throughout drying.

Place trays of prepared food in oven. Stack trays so there is at least 3 inches of clearance at the top and bottom of the oven and 2 1/2 inches between trays. Shift trays, top to bottom and front to back, every half hour. Stir food often if it is 1/2-inch deep or more. Single layers need no stirring. Food scorches easily toward the end of drying time; therefore, turn the heat off when drying is almost complete and open the door wide for an additional hour or so.

Post-Drying Treatment. When drying is complete, some pieces will be moister than others due to size and location during drying. Conditioning distributes residual moisture evenly in dried food. In doing so, it reduces the chance of spoilage. Because vegetables dry to a nearly waterless state, conditioning them is not always necessary.

Table 2: Steps for drying vegetables. (See text for details.)

Vegetable	Preparation	Blanching Time* (mins.)	Drying Time (hrs.)	Dryness test
Asparagus	Wash thoroughly. Halve large tips.	4-5	6-10	Leathery to brittle
Beans, green	Wash. Cut in pieces or strips.	4	8-14	Very dry, brittle
Beets	Cook as usual. Cool, peel. Cut into shoestring strips 1/8" thick.	None	10-12	Brittle, dark red
Broccoli	Wash. Trim, cut as for serving. Quarter stalks lengthwise.	4	12-15	Crisp, brittle
Brussels sprouts	Wash. Cut in half lengthwise through stem.	5-6	12-18	Tough to brittle
Cabbage	Wash. Remove outer leaves, quarter and core. Cut into strips 1/8" thick.	4	10-12	Crisp, brittle
Carrots, parsnips	Use only crisp, tender vegetables. Wash. Cut off roots and tops; peel. Cut in slices or strips 1/8" thick.	4	6-10	Tough to brittle
Cauliflower	Wash. Trim, cut into small pieces.	4-5	12-15	Tough to brittle
Celery	Trim stalks. Wash stalks and leaves thoroughly. Slice stalks.	4	10-16	Very brittle
Chili peppers, green	Wash. To loosen skins, cut slit in skin, then rotate over flame 6-8 minutes or scald in boiling water. Peel and split pods. Remove seeds and stem. (Wear gloves if necessary.)	None	12-24	Crisp, brittle, medium green
Chili peppers, red	Wash thoroughly. Slice or leave whole if small.	4	12-24	Shrunken, dark red pods, flexible
Corn, cut	Husk, trim. Wash well. Blanch until milk in corn is set. Cut kernels from the cob.	4-6	6-10	Crisp, brittle
Eggplant	Wash, trim, cut into 1/4" slices.	4	12-14	Leathery to brittle
Horseradish	Wash, remove small rootlets and stubs. Peel or scrape roots. Grate.	None	6-10	Brittle, powdery
Mushrooms**	Scrub. Discard tough, woody stalks. Slice tender stalks 1/4" thick. Peel large mushrooms, slice. Leave small mushrooms whole. Dip in solution of 1 tsp. citric acid/quart water 10 minutes. Drain.	None	8-12	Dry and leathery
Okra	Wash thoroughly. Cut into 1/2" pieces or split lengthwise.	4	8-10	Tough, brittle
Onions	Wash, remove outer paper skin. Remove tops and root ends, slice 1/8 to 1/4" thick.	4	6-10	Very brittle
Parsley; other herbs	Wash thoroughly. Separate clusters. Discard long or tough stems.	4	4-6	Flaky
Peas	Shell and wash.	4	8-10	Hard, wrinkled, green
Peppers; pimentos	Wash, stem. Remove core and seeds. Cut into 1/4 to 1/2" strips or rings.	4	8-12	Tough to brittle
Potatoes	Wash, peel. Cut into 1/4" shoestring strips or 1/8" thick slices.	7	6-10	Brittle
Spinach; greens like Kale, Chard, mustard	Trim and wash very thoroughly. Shake or pat dry to remove excess moisture.	4	6-10	Crisp
Squash, summer or banana	Wash, trim, cut into 1/4" slices.	4	10-16	Leathery to brittle
Squash, winter	Wash rind. Cut into pieces. Remove seeds and cavity pulp. Cut into 1" wide strips. Peel rind. Cut strips crosswise into pieces about 1/8" thick.	4	10-16	Tough to brittle
Tomatoes	Steam or dip in boiling water to loosen skins. Chill in cold water. Peel. Slice 1/2" thick or cut in 3/4" sections. Dip in solution of 1 tsp. citric acid/quart water for 10 minutes.	None	6-24	Crisp

*Blanching times are for 3,000 to 5,000 feet. Times will be slightly shorter for lower altitudes and slightly longer for higher altitudes or for large quantities of vegetables.

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

¹P. Kendall, Colorado State University Extension foods and nutrition specialist and professor, food science and human nutrition; P. DiPersio, Colorado State University Ph.D. candidate, food science and human nutrition; and J. Sofos, Colorado State University professor, department of animal sciences.

Colorado State University, U.S. Department of Agriculture, and Colorado counties cooperating. CSU Extension programs are available to all without discrimination. No endorsement of products mentioned is intended nor is criticism implied of products not mentioned.