



Food Dehydration Options

Value-Added Technical Note

***Abstract:** Dehydrating foods reduces the moisture in them to levels that inhibit the microbial growth that causes them to rot. Pre-treating some foods before drying preserves their flavor, color, and nutrients; prevents microbial contamination; and prolongs their shelf life. Dehydration reduces weight – an important consideration when shipping – and eliminates the need for refrigeration, making it easier to pre-mix retail products. This publication focuses on commercial-scale food dehydration and equipment. It also outlines solar dehydration, a low-cost method for some small-scale operations.*

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 August 2004
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Introduction

Dehydration is an intermediate step in turning raw agricultural products into retail products. Dehydration makes the conventional food and pharmaceutical industries possible – and profitable. Since large food processors either have their own drying facilities or (more likely) hire specialty dehydration firms, there is little opportunity to market bulk dehydrated farm products (except for grains) through conventional channels. Floral products, including herbal wreaths, are air dried or dried in silica gel.(1) (Some are freeze dried.) Meat products – hard sausages, jerky, and pemmican – may be dried, but they are strictly regulated.

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Types of dehydration

Industrial dehydration uses particalized or liquid “feed” to produce a powder that can become one ingredient in an end product.

Batch dryers are an older technology used in small production runs or for their flexibility. A commercial-scale batch dryer may take from 55 sq. ft. of floor space (forced convection, through-flow) to 245 sq. ft. (forced convection, cross-air-flow). These have been replaced by fluidized-bed batch dryers, especially for pharmaceutical products. A fluidized-bed dryer keeps the material

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from sticking throughout the cooling and bagging operation. Aggregation of the particles is often used to produce “instant” powders.

Continuous dryers are good for drying liquids or liquid suspensions. A common type is the drum or “double drum” dryer, heated by steam. Although continuous drying of temperature-sensitive material in a partial vacuum is an option, spray drying offers the same advantages at less cost.

Spray drying

Spray drying, especially “rapid flash evaporation,” is the current state of the art in the food industry, because it offers an excellent solution to many drying problems. According to Frederick J. Francis, of Amherst University (2):

Fundamentally, the spray-drying process is a simple one. However, the design of an efficient spray-drying plant requires considerable expertise along with access to large-scale test facilities, particularly where particle size and bulk density requirements in the dried product are critical. (p. 545)

There are three basic feed devices:

1. single-fluid nozzles (pressure type)
2. two-fluid nozzles (pneumatic type)
3. centrifugal feeds (spinning disks)

The flat-bottomed spray dryer with a tempered “air broom” is currently the dryer of choice for fruit and vegetable pulps and juices, as well as meat extracts. Its advantage is reduced sticking. It is also used for drying egg products, ice cream powder, and toppings. The correct balance of dryer inlet and outlet temperatures can reduce energy use. This three-stage dryer is ideal for “non-dusty, hygroscopic, and high-fat-content products.” (2) It costs about \$306,000, with operating costs of \$36/hr. (labor figured at \$15/hr.). At this rate, the cost per pound of powder is about \$.042.

The even newer “spin-flash” dryer is about one-third cheaper to build and operate, using much less energy. However, it is not suitable “when a free-flowing spherical particle of a particular

size range is required, or when agglomeration is needed.” (2) Cost per lb. of powder is about \$.03.

Freeze-drying

Freeze-drying (also known as “lyophilization”) is

...the drying of material in the frozen state. It is usually carried out under vacuum, at absolute pressures that readily permit ice to ... change directly from solid to vapor. (2)

Products most often freeze-dried include:

- Instant coffee
- Vegetables for dried soup mixes
- Mushrooms
- Herbs
- Spices
- Cheese starter cultures
- Shrimp
- Fruits for ready-to-eat breakfast cereals

End products include military and space rations and camping foods, especially those containing vegetables, meats, fish, and fruit. Freeze-drying has technical advantages and disadvantages.

Advantages

- Little thermal damage
- Good retention of volatile flavors
- Good vitamin retention
- Rapid product rehydration
- Little product shrinkage
- Long product storage life – if suitably packed
- Good retention of biological activity (with use of cryoprotectants)

Disadvantages

- High drying cost
- Damage to certain products by initial freezing
- Rapid deterioration unless products are packed and maintained at low humidity
- Product friability (crumbles easily)
- Pre-treatment sometimes necessary (e.g., with carrots) to avoid color loss

Note: Current freeze-drying technologies are uniformly protected by patent.

Dairy products

Fluid milk has been dried since the 1960s, principally through roller (drum) drying. Recently, spray drying has replaced this form of processing. First, an evaporator or vacuum pan condenses the milk to 40% solids. An “agglomerating process” makes instant dry milk from non-instant. It is used in prepared dry mixes, the confectionery and bakery industries, and animal feed (e.g., calf starter). Industrial uses, including dried butter-milk, accounted for 89% of domestic sales in 1998. U.S. production of dried milk for all uses has been falling or stationary since 1960. Dried cheese powders are manufactured by other methods.

Solar drying

Solar drying is an industrial process in many countries where outdoor temperatures reach 115°F or higher. In East Asia, spice crops and other exported plant materials are routinely solar dried. Solar drying is different from “sun drying.” Solar drying uses equipment to collect the sun’s rays in a unit designed to ventilate moisture. The temperature in the unit is usually 20 to 30 degrees higher than in open sunlight.

In much of the continental U.S., weather conditions do not allow sun drying or solar drying. There are too few consecutive days of high temperatures (above 85°) and low humidity (below 60%) to assure that the food will not spoil before dehydration is complete. Low temperature or high humidity encourages microbial growth. If the temperature is too high at first, a hard shell may develop on the food, trapping moisture inside. This is called “case hardening.” If temperatures are too high at the end of the drying period, food may scorch. Temperatures of 120°F to 140°F are best for drying fruits and vegetables. Temperatures may go up to 150°F at the beginning, but must be lowered as food begins to dry. For at least the last hour of the drying period, temperatures should not exceed 130°F.(3)

Reports from Bill Blake, University of California—Davis, about the situation in California, where solar drying of fruits and vegetables is

commercially feasible, suggest possible legal issues for small-scale start-up operations.

I looked into the legalities of sun-drying a couple of months ago [1996], and discovered that small-scale farmers would have a difficult time complying with the laws. First, after talking with people at several county and state agencies as well as producers and an industry group, I couldn’t get a straight-forward answer about what a producer would need to do to be in full legal compliance. Second, the answers I got from health commissioners and the like indicated that producers would need a concrete-floored drying yard (no dust) with a fence (no animals), methods for insect exclusion (no bugs, eggs, etc.), and a certified kitchen for cutting fruits and vegetables for drying.(4)

Blake could not determine how California producers can legally sun-dry in the open or why no one in the health department has “picked up on it yet.” A possible explanation is that existing businesses are sometimes “grandfathered in” when new, tighter restrictions are published. Or perhaps health officials realize that the conditions in the San Joaquin Valley for drying grapes into raisins (ideal temperatures, low humidity, a constant breeze, and no need to cut the fruits) are uniquely hard to replicate with other crops in other climates.

A University of Georgia publication warns against drying vegetables (with the exception of vine-dried bean seeds) and meats outdoors. “The high sugar and acid content of fruits make them safe to dry out-of-doors when conditions are favorable.” However, if rain falls while the crop is drying, a whole year’s work can be lost. Cut fruits require access to a commercial kitchen. Since cool night air condenses and can add moisture back to the food, fruits dried out-of-doors must be covered or brought under shelter at night.(5)

Drying as an on-farm added-value strategy

While dehydrated products don’t play to the main strengths of small-farm marketing (luscious, succulent, farm-fresh, local), there are certainly market niches for such products. For example, while it may be difficult to sell many pounds of dried fruits such as apples to retail customers,

dried fruits can provide a handsome return as ingredients in, say, “Good Morning Farm’s gourmet pancake mix.” Grains (especially organic or specialty grains) can be profitable when sold in one- or two-pound bags, milled into flour, turned into pasta, or marketed as part of a pilaf mix. Dehydrated vegetables and herbs can be added to gourmet soup mixes, as well as dry mixes for toppings, sauces, rubs, and seasonings—even pet treats. Niches already exist for dried chile peppers of many types, exotic fruits and nuts, seasoning mixes, baking mixes, mushrooms, teas, and similar items.

Related ATTRA publications

*Adding Value to Farm Products: An Overview
Keys to Success in Value-Added
Agriculture*
*Grain Processing: Adding Value to Farm
Products*
Alternative Meat Marketing
Alternative Beef Marketing
“Green” Markets for Farm Products

Most information on simple, small-scale drying methods and building batch dryers is about their use as an energy-efficient way to preserve a harvest for a single household. Books such as Rodale’s *Stocking Up* (6) and Extension publications on food preservation are intended for families who grow their own food. Some of these resources are listed below. However, commercial

standards for taste and appearance can be different and hard to meet in a sustainable way. Some commercial dehydration methods may not meet the new USDA organic standards.

Product development and marketing

For the producer interested in selling value-added farm products, the 2002 catalog of the National Association for the Specialty Food Trade, Inc., www.specialty-food.com, lists an interesting array of new products. Trade publications such as *Natural Foods Merchandiser* regularly publish “new product” editions. Anyone seriously interested in adding value on the farm should study this information, as it is predictive of trends in consumer preferences for taste and convenience. The gourmet gift item is always popular. The typical retail item using a dehydrated ingredient also uses other ingredients (which may have to be purchased off-farm), distinctive packaging/containers, printing, and intangibles such as a popular theme (Cajun, holiday, Southwest, international, health food, etc.). The item may claim a secret recipe or processing steps. Certain ingredients are popular in special seasonings or sauce mixes; not all can be grown in North America. Dried tomatoes, carrots, garlic, onions, hot peppers, celery leaf/seed, mustard seed, horseradish, and herbs are common ingredients in such mixes. Other seed spices that can be grown in North America include caraway, coriander, cumin, and ajwain.

Rosalind Creasy (7) offers the following comments on drying apricots, apples, nectarines, peaches, and pears.

... [fruits] turn brown when exposed to the air. If the discoloration doesn’t bother you, it is a simple matter to dry the fruits after sectioning, pitting, or coring. However, if you prefer orange apricots, nectarines, and peaches and white apples and pears, methods exist for maintaining fresh-fruit color:

- Blanching fruits for 3 minutes in boiling water;
- Soaking fruit in a sodium metabisulfite solution for 1 minute;
- Sulfuring the fruit with sulfur smoke.

The last two methods preserve more of the color and more of the vitamins than the first. They also kill any insects that might still be on the fruit. . . . I find that fruits treated with sulfur taste and look better than blanched or untreated. (bullets added)

Some new specialty food products

Soups – are described as “carefully crafted mixes... with no salt, MSG, preservatives, or dehydrated bouillons...naturally low in sodium, fat, sugar and high in protein.” [contain beans, grains, and seasonings].

22 different ones. 12-oz. packages sell for \$6.00 - \$7.00 each.

Cottage Cheese Pancake Mix

Contains dried cottage cheese, dried apples, whole oats, and cinnamon.

Gourmet Gifts

- Baking mixes
- Drink mixes
- Seasonings
- Herb blends

International Specialty Item

Bread dipping set – four [Ital.] regional seasonings

Set includes 6 oz. mixed dried herbs, 4 dipping saucers, porcelain cruet, colorful box.

(Purchaser or gift recipient supplies own olive oil, loaf of crusty bread, and a glass of wine.)

Spiced Nuts

Described as “forbiddingly complicated,” this snack product has been “painstakingly hand-crafted every step of the way.”

[Peppered walnuts include 3 types of ground pepper.]

Health Snack Food

- “Just Veggies” – freeze-dried corn, peas, carrots, tomatoes, bell peppers – “eat like popcorn.”
- “Fruit Munchies” – freeze-dried apples, bananas, blackberries, blueberries, cherries, cranberries, mango.
- Single veg/fruit packs in colorful plastic containers, including dried tomatoes, garlic.
- “Just Cranberries” – Freeze-dried cranberries that hold their shape.

Creative Condiments

Spice, rice, and bean mixes in a box. Based on Tucson restaurant recipes.

Additive-free Seasoning Blends

- (kosher approval)
- Pure ground dried chiles (8 kinds)
- Pepper Sauce
- 15 other seasoning blends

Pet Treats

Organic vegetarian dog treats – including “Vegetable Crisp” and “Apple Crisp”

Fortunately for many alternative farmers, the gourmet foods and organic foods categories are converging. Many of the products described above can be considered “natural gourmet.”

“Specialty organics” are “products that have a unique quality, possibly trend driven, which makes them more valuable and allows an added price point.”(8) During the past 40 years, gour-

met food manufacturers have been paying more attention to healthful ingredients, and organic foods have become more tasty. Busy adults readily accept dried mixes for their convenience. Paul's Grains (9), of Laurel, Iowa, sells organic flours, corn meals, and rice from grain grown and milled on the farm – at a farm store and also at trade shows, fairs, and festivals. The products come in handy one- to five-pound amounts. Additional examples of on-farm businesses marketing dried products are in the ATTRA publication *Keys to Success in Value-Added Agriculture*.

Many universities provide assistance in new product development through “business incubators.” Universities also have information about market assessment resources and marketing techniques – as well as advice on regulations that pertain to processing, packaging, labeling, and selling food. A marketing plan is necessary before investing in specialized equipment. More information on sources of assistance is in the ATTRA publication *Adding Value to Farm Products: An Overview*. Examples of new product planning, such as the Mississippi State University Extension document (see **Resources** below), are available on the Internet.

The information on equipment suppliers listed below is from a massive new food industry directory compiled by Grey House Publishers (10) from two industry databases. The new *Thomas Food & Beverage Market Place* contains more than 6000 pages of services available to the food industry. Volume 2, *Equipment, Supplies and Services*, lists product categories, company profiles, transportation firms, warehouse companies, and wholesalers/distributors.

The 2000 edition (2nd ed.) of the *Wiley Encyclopedia of Food Science* (2), compiled and edited by Frederick J. Francis of Amherst University, has more particulars on the types of industrial food dehydration I have summarized above. A farmer with a product concept and raw materials should carefully consider contracting out specialized dehydration, rather than buying expensive equipment and building an on-farm factory that meets all government regulations for this type of processing.

More than 73 corporations perform custom drying services nationwide, according to the *Thomas*

Food & Beverage Marketplace – six of them specializing in custom freeze drying and eleven in spray drying.

Regulations

To produce processed food products on the farm, the processor has to meet local, state, and federal requirements. In the experience of those now selling such products, the regulations may be expensive and time-consuming, but they are not unreasonable. Access to a commercial kitchen may be required. A Southern region survey found regulators quite willing to work with producers to help them meet the requirements.(11) The federal Food and Drug Administration administers the Food, Drug, and Cosmetic Act. The Dietary Supplement Health and Education Act of 1993 governs vitamins, herbal supplements, and nutraceuticals. Handling and labeling requirements for products are quite specific.

The USDA National Organic Program (NOP) recognizes food dehydration as a handling or processing operation, making it subject to the national organic standards. Handlers who annually sell, label, or represent more than \$5,000 worth of a processed agricultural product or products as “organic” or “organically produced” must have their operations certified by an accredited certifying agent. Handlers selling less than \$5,000 worth of such commodities annually must follow the regulations, but are not required to be certified. In general, mechanical and biological processes that do not involve material inputs are deemed natural and allowable under the NOP standards. The standards prohibit the use of certain materials, specifically sulfites, for food preservation. For more complete information, visit the homepage of the NOP at www.ams.usda.gov/nop/indexNet.htm, or contact an accredited certifying agent through www.ams.usda.gov/nop/CertifyingAgents/Accredited.html.

References

- 1) Ralph L. Cramer. 1992. Herbs and everlasting: Harvesting, drying and shipping. *The Herbal Connection*. Vol. 4, No. 2. p. 6. *Cramer operates Cramers' Psieatch, Lancaster County, PA, wholesaling 39 acres of herbs and everlastings annually.*

- 2) Francis, Frederick J. (editor/compiler). 2000. Wiley Encyclopedia of Food Science and Technology. 2nd edition. 4 vols. John Wiley & Sons, NY. Vol. 1: p. 480-498; 540-578.
- 3) Hughes, Karla Vollmar, and Barbara J. Wilenberg. 1994. Quality for Keeps – Drying Foods. University of Missouri Extension, Columbia. Pub. GH1562. 6 p. <http://muextension.missouri.edu/explore/hesguide/foodnut/gh1562.html>.
- 4) Blake, Bill. 1996. Sun Drying in CA. June 3. www.sare.org/htdocs/hypermail/html-home/13-html/0498.html. 1 p.
- 5) Reynolds, Susan. 1993. Drying Foods Out-of-Doors. University of Georgia Cooperative Extension Service. Ext. Bull. 989. p. 1-3.
- 6) Stoner, Carol (ed.). 1977. Stocking Up: How to preserve the foods you grow, naturally. Rodale Press, Emmaus, PA. 532 p.
- 7) Creasy, Rosalind. 1993. Drying apricots, apples, nectarines, peaches, and pears. The Southwest Organic News [originally published in *Organic Gardener's Edible Plants*]. July. p. 7.
- 8) May, Thomas Garvey. 2001. Gourmet, organics merging into one. The Natural Foods Merchandiser. July. p. 16.
- 9) Paul's Grains
2475-B 340th Street
Laurel, IA 0141
541-476-3373
- 10) Staff (ed./compilers). 2001. Thomas Food and Beverage Market Place. 3 vols. Grey House Publishing, Millerton, NY. 6000+ p.
- 11) Born, Holly. 2001. Keys to Success in Value-Added Agriculture. NCAT/ATTRA, Fayetteville, AR, and Southern Sustainable Agriculture Working Group. p. 1-2.

Resources

On-line Extension bulletins:

Drying vegetables and fruits at home

www.ext.colostate.edu/pubs/foodnut/pubfood.html#pres

How to dry foods at home

<http://muextension.missouri.edu/explore/hesguide/foodnut/gh1563>

Drying fruits

<http://msucares.com/pubs>

Drying foods:

Out of doors (FCS 8493)

Indoors (FCS 8494)

<http://hammock.ifas.ufl.edu/dosearch.htm>

Note: FCS 8493 is the 1993 University of Georgia CES 989 publication (see footnote 5).

Drying food

www.ag.uiuc.edu/~vista/html_pubs/drying/dryfood.html

(Circular 1227)

Drying foods at home

www.agcom.purdue.edu/AgCom/Pubs/CFS/CFS-146.html

(CFS-146)

Drying foods

http://www.cahe.nmsu.edu/pubs/_e/e-322.html

(Guide E-322)

Post-harvest handling of dehydrated chiles

www.g6csy.net/chile/index.html

Other

Dehydration: A Dry Run for Lean Times

By Joseph Grant

www.logicsouth.com/~lcoble/jg/dehydra/

Commercial processing/product development

University of Arkansas
Institute of Food Science/Engineering. 2001. Starting a Food Processing Business. UA Cooperative Extension, Little Rock, AR. 162 p.

Covers product development, principles of preservation and processing, labeling, operation management, HACCP, regulations [pertaining to Arkansas], marketing strategies, and basic business considerations. Related publications are available; ask for brochure. \$40.00. Send check or money order to Cooperative Extension Service, Business Office, Publication Sales, P.O. Box 391, Little Rock, AR 72203.

University of Massachusetts
www.umass.edu

Fifty-nine publications on aspects of commercial processing. Read on-line or download.

Mississippi State University Extension Staff. 2000. Exploring the potential for new food products. <http://msucares.com/pubs/p2170.html>. 40 p.

This publication is intended to help individuals and companies develop a more sharply focused product concept.

Deis, Ronald C. (ed.). 1997. Food Product Design [library]: Spray-drying, Innovative use of an old process. www.foodproductdesign.com/archive/1997/0597DE.html. Weeks Publishing Co., Northbrook, IL. 7 p.

Nichols, P.F. et al. 1925. Commercial Dehydration of Fruits and Vegetables. USDA Bulletin No. 1335. 40 p.

Note: Many older U.S. government documents contain information especially useful for sustainable practices. The best place to start if you need to search for a specific document or topic relating to agriculture is your state's land-grant university library. A complete collection of government documents may be found in each state's depository, usually at the university nearest to the state capital. Try requesting copies through InterLibrary loan.

Russell, G.A. 1921. Drying crude drugs [herbal medicines]. U.S.D.A. Farmers' Bulletin 1231. 16 p.

Resources for building a dryer

Dong, Allen. 1998. I-Tech Farm-Scale Food Dehydrator. Veneta, OR.

See figure, p. [7] above; see plans for dehydrator on UC-Davis Web site.

Lavallee, Thomas. 1993. The fruit/herb dryer. The Growing Edge. Spring. p. 46-47, 49-51, 53.

Vivian, John. 1993. How to build a food dryer. Mother Earth News. February-March. p. 54-60.

Consultant:
David Stone
Commercial Dehydrator Systems, Inc.
256 Bethel Drive
Eugene, OR 97402
800-369-4283 (toll-free)
541-688-5281
541-688-5989 FAX

Charges by the day for consulting; can build any kind of dehydrator. Will provide a realistic price quotation upon request.

Sources of dehydration equipment (all types)

Brothers Metal Products, Anaheim, CA. 714-630-1051.

Vegetable dryers.

Brown Int'l Corporation, Covina, CA. 626-966-8361.

Fruit and vegetable de-waterers.

P&F Metals, Turlock, CA. 209-667-2515.

Custom-engineered food processing equipment.

Excalibur Food Dehydrators, Sacramento, CA. 916-381-4274.

USDA-approved stainless steel home and commercial food dehydrators, grain mills, jerky-making supplies.

Joneca Corp., Anaheim, CA. 714-993-5997.
joneca@aol.com.

Dehydrators.

Wittmann Co., Palm Coast, FL. 904-445-4205.
www.wittmann.com.

Freeze-drying equipment.

Low Humidity Systems, Covington, GA. 770-385-8690. www.dehumidifiers.com.

Desiccant dehumidifiers.

Fluid Air, Aurora, IL. 630-851-1200. www.fluidairinc.com.

Manufactures dryers/equipment for "drying, agglomerating, coating foods and flavors."

BNW Industries, Mentone, IN. 219-353-7855.
<http://www.belt-o-matic.com/>.

North Liberty, IN. 219-656-3956.

Drum dryers and flakers.

Littleford Day, Florence, KY. 859-525-7600.

Vacuum dryers.

C.E. Rogers Co., Mora, MN. 320-679-2172. www.cerogers.com.

Spray dryers and equipment.

CTB Grain Systems, Kansas City, MO. 816-968-6101.

Grain drying equipment.

Goodnature Products, Buffalo, NY. 716-855-3325.
www.goodnature.com.

Dewatering equipment.

Aeroglide Corp., Cary, NC. 919-851-2000. www.aeroglide.com.

Customized dryers and coolers; belt and rotary dryers.

Lanly Co., Cleveland, OH. 216-731-6115. www.lanly.com.

Ovens and dryers for snack foods.

United McGill Corp., Westerville, OH. 614-882-5455.

Vacuum drying equipment.

Commercial Dehydrator Systems, Eugene, OR. 800-369-4283. www.dryer.com.

Continuous belt, bin, and tray dryers.

Andritz, Muncy, PA. 570-546-8211.

Wide variety of dehydration equipment.

Fluid Energy Aljet, Telford, PA. 215-766-0300.
www.fluidenergype.com.

Flash drying equipment. Toll processing services.

SG Technologies/Hull Corp., Hatboro, PA. 215-672-7800.

Freeze dryers.

National Drying Machinery Co., Philadelphia, PA. 215-464-6070. www.nationaldrying.com.

Thermal processing equipment, including dehydrators and dryers.

Davron Technologies, Chattanooga, TN. 877-683-5498. www.davrontech.com.

Custom processing equipment, including spray drying equipment.

Automation Products, Houston, TX. 713-869-0361.

Dehydrators.

Evaporator Dryer Technologies, Hammond, WI. 715-796-2313. www.evapdryertech.com.

Spray dryers, nozzles.

Sources for freeze-drying equipment

SG Technologies/Hull Corporation, Hatboro, PA. 215-672-7800.

Apollo Sheet Metal, Kennewick, WA. 509-586-1104. www.apollo-sm.com.

United McGill Corp., Westerville, OH. 614-882-5455.

Vacuum drying equipment.

Wittmann Co., Palm Coast, FL. 904-445-4205.
www.wittmann.com.

Freeze-drying equipment.

Littleford Day, Florence, KY. 859-525-7600.

Vacuum dryers.

Sources for spray-drying equipment

Evaporator Dryer Technologies, Hammond, WI. 715-796-2313. www.evapdryertech.com.

Spray dryers, nozzles.

Davron Technologies, Chattanooga, TN. 877-683-5498. www.davrontech.com.

Custom processing equipment, including spray drying equipment.

C.E. Rogers Co., Mora, MN. 320-679-2172. www.cerogers.com.

Spray dryers and equipment.

Spraying Systems Company, Wheaton, IL. 630-665-5000. www.spray.com.

Nozzles, spray guns, portable spray systems, spray nozzle accessories.

Spray Drying Systems, Randallstown, MD. 410-922-5900. www.spraydrysys.com.

Niro, Hudson, WI. 715-796-2313. 715-386-9371. www.niroinc.com.

Food and dairy dryers.

Paget Equipment Co., Marshfield, WI. 800-234-3158.

Sources of used and rebuilt dehydration equipment

Aeroglide Corporation, Cary, NC. 919-851-2000.

Market Place lists 28 other companies that sell used/rebuilt food processing equipment.

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August 2004**

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**Edited by Paul Williams
Formatted by Cynthia Arnold**

**IP147
Slot#137
082404**

The electronic version of **Food Dehydration Options** is located at:

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PDF

<http://www.attra.ncat.org/attra-pub/PDF/dehydrate.pdf>