

Table 2 Tariff Range for Refrigerated Storage of 2000 Pounds of Candies in 41 Warehouses

Temperature F	Handling In and Out	Storage per Month	Total for Period Indicated			
			3 mo	6 mo	9 mo	12 mo
32	\$2.40-8.00	\$3.20-6.00	\$12.00-26.00	\$21.60-44.00	\$31.20-62.00	\$40.80-80.00
0	\$8.00-14.40	\$3.40-6.00	\$18.20-32.40	\$28.40-50.40	\$38.60-68.40	\$48.80-86.40

much as 10 times, and may be extended to 2-5 years; (b) the natural texture, color and flavor are retained almost perfectly from one season to the next; (c) staleness, rancidity and molding are retarded for more than two years, depending upon the temperature; and (d) insect activity is arrested at temperatures below 48 F. With optimum temperature, humidity, atmospheric conditions, and packaging, good quality nuts may be successfully stored for 5 years.

Temperature. There are no critical temperatures for storing nuts. Other conditions being equal, the lower the temperature the longer the storage life. Life may be extended from two to three times with each 20 deg. drop in temperature. The freezing point of nuts, depending upon the moisture content, is about 23 F for chestnuts, 14 F for walnuts, pecans, and filberts, and 13 F for peanuts. A normal moisture content (in percent) for stored nuts is: chestnuts, 20; peanuts, 6; walnuts, 4½; pecans, 4; and filberts, 3½.

Shelled nuts to be held from one harvest season to the next, without appreciable loss in quality, must be held at 36 F or lower; those to be held for 6 to 9 months must be kept at 48 F or lower; and all nuts stored for 4 to 6 months should be held below 68 F. The period of storage, at a given temperature, is doubled if the nuts are unshelled.

Relative Humidity. While the storage temperature of nuts may range from 68 F to -20 F or lower, the relative humidity must range between 65 percent and 75 percent. This is to maintain the optimum moisture content for desired texture, color, flavor, and stability. Should the moisture content rise as much as 2 percent above normal, the nuts (except chestnuts) will darken, become stale and maybe mold; while if the moisture drops more than 2 percent below normal the nuts become objectionably hard and brittle.

When the relative humidity is suitable, nuts that are too high or too low in moisture may be safely stored for a period, with the assurance that rapid circulation of air will bring the moisture content to a safe level. In this sense storage acts as a conditioning room.

Atmosphere. All nuts, except chestnuts, contain 45 percent or more of oil, and readily absorb odors and flavors from the atmosphere and surrounding products. Furthermore, certain gases, particularly ammonia, react with the tannin in the seed coats of nuts causing them to turn black. For these reasons the atmosphere in the nut storage room must be free of all odors. This includes the containers, walls of the room, pallets, and other stored products.

Products which may be safely stored with nuts are dried fruits, candies, rice or goods packaged in cans, bottles, or barrels. Commodities which must not be stored with nuts are onions, meats, cheese, chocolate, fresh fruits, or other products having an odor or a high moisture content.

Packaging. The storage life of nuts may be greatly influenced by the kind of package. When nuts are shelled they become bruised and oil oozes over the surface and onto the package in a very thin film. Unless this is retarded by a package that acts as a barrier, contains an antioxidant, or removes air by vacuum, the nuts become stale and rancid. Furthermore, some packaging materials such as polyfilm and

polyethylene should be avoided because they impart an undesirable odor to the nuts.

DRIED FRUITS AND VEGETABLES

The dried fruit and vegetable industry has received added emphasis during the last decade due to (a) perfection of methods of spray, vacuum, freeze, and foam drying and combinations; (b) improvements in methods of preparation such as: precooking and pulverizing, use of emulsifiers, impregnation with gases, finely dispersing the product and reforming into granules or pellets; and (c) wider use of stabilizers, antioxidants, buffers, humectants, and other additives.

With techniques perfected since 1950 the quantity and number of dried fruit and vegetable products has increased. These include white potato granules; precooked sweet potato powder; tomato puree powder; peas, beans, soup mixtures, rice, prunes, grapes, peaches, apples, citrus juice crystals, and others that may be reconstituted instantly.

Dried fruits and vegetables differ from each other in that (a) fruits contain sugars which render them more hygroscopic, harder to dry and greater absorbers of moisture during storage; (b) the moisture in dried fruits may range from 25 percent, to as low as 2 percent, while that in vegetables ranges from 7 percent to a low of 0.3 percent; (c) dried fruits are acid, more highly colored and more stable during storage than vegetables which are non-acid; (d) fruits are generally dried raw with active enzyme and respiration systems, while vegetables are blanched or precooked with no active enzymes (for this reason dried fruits are more responsive to storage temperature and humidity conditions than vegetables); (e) the juices of fruits are frequently expressed and crystallized by drying while vegetables are often precooked, disintegrated, granulated and dried; (f) the high sugar and acid content of dried fruits provide an adverse physical environment for bacteria, and thus makes their growth impossible even though the moisture level is higher than in dried vegetables.

In recent years research has established with reasonable clarity, the relationships of high quality in dried fruits to low temperatures in storage. Research on dried vegetables, on the other hand, has followed chiefly the military objective which is to develop products, packages, package atmospheres and special treatments that will yield products adapted to the severities of military use.

Some of the new directions of research involving dehydration and refrigeration are of interest. Dehydrofreezing (drying to a reduction of about 50 percent in weight and volume, followed by freezing) has yielded excellent experimental products, both fruit and vegetable. Concentration of juices by low-temperature evaporation and preservation of the concentrate by freezing (Chapter 39) is essentially a dehydrofreezing process, which has succeeded on a large scale in recent years. Methods of drying (in heated flowing air, under vacuum and freeze-drying) are also under consideration. Packaging under nitrogen or carbon dioxide and in the presence of a desiccant to achieve further reduction in moisture content has been evaluated at least partially for dehydrated vegetables. Treat-

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ment with sulfite to retain color and extend storage life has been used widely for dried vegetables, and recently application of a light coating of laundry starch to diced carrots prior to dehydration has achieved excellent results in retention of color and other quality factors during storage in cellophane at 84 F without sulfite.

A few juices, such as lemon and lime, have been dried to the powder stage, but refrigeration has not been found necessary.

Refrigerated storage at 40 to 50 F or lower retards and controls insect infestation. Substantial killing occurs with exposure at 32 F for 6 months or longer, and a temperature of 0 F kills insects within a few hours. An alternative method is fumigation which is used considerably in commercial practice.

Nonenzymatic browning in dehydrated vegetables (browning in products that have been scaled or blanched adequately to inactivate enzymes) is reduced in rate at low temperature. Cold storage offers protection for several years.

Staling (chard or off flavor) and other deteriorative changes in dehydrated vegetables are inhibited by packing in nitrogen. In air-packed samples, the rate of staling is reduced at low temperature.

It has been shown for dried apricots that increasing the temperature accelerates oxygen consumption, carbon dioxide production, disappearance of sulfur dioxide and darkening.

Molds and yeasts grow slowly and cause deterioration of dried fruits at 40 F unless relative humidity is very low (below approximately 50 percent). At 32 F, relative humidity is less important than at higher temperature.

Dried Fruit Storage

Refrigeration is beneficial in augmenting drying as a means of preserving fruits. The optimum conditions for holding most dried fruits is at about 55 percent rh and just above their freezing temperature. Since the sugar content of these products is rather high the freezing point varies from about 22 to 26 F. Refrigerated storage is beneficial in retaining natural flavor, ascorbic acid, carotene and sulfur dioxide; and in controlling browning, insects, rancidity and molding. Besides insect control, low humidity is more important than low temperatures for storage of dried fruit.

While most dried fruits are adversely affected by softening and injured by freezing, dates are held best by freezing. Before storage dried fruits should be brought to the desired moisture content and packed in moisture-proof containers. The latter not only insures a constant moisture content while in storage, but prevents injury from moisture condensation upon removal from storage.

Dried fruit storage recommendations are:

Raisins. At 32 to 40 F, and at 50 to 60 percent rh sugaring is prevented for one year, provided the moisture content of the dried fruit is not unusually high. Raisins contain 15 to 20 percent moisture, and for extremely long storage the lowest possible moisture content should be maintained.

Figs. These may be held for a year at 32 to 40 F at 50 to 60 percent rh. A temperature of 55 F or lower prevents darkening for more than 5 months; and low humidity controls sugaring.

Prunes. These may be held for a year at 32 to 40 F with a relative humidity from 50 to 60 percent. For storage of 4 to 5 months a relative humidity of 75 to 80 percent is not detrimental.

Apples. At 32 to 40 F with a relative humidity of 55 to 65 percent apples retained excellent color and texture for more than one year. A relative humidity of 70 to 80 percent is not objectionable at 32 F, but at 40 F enough moisture may be gained to cause the fruit to mold within 8 months. Browning develops gradually at temperatures of 40 F and above.

Pears. The same as for apples.

Peaches. Sun-dried freestone peaches are harder to store than most dried fruits. Therefore, the temperature would be held close to 32 F with a rh of 55 to 65 percent. At 40 F and a moderate humidity the moisture pick-up is sufficient to cause molding and browning to develop rapidly.

Clingstone peaches (dehydrated after steam scalding) should be stored at 32 to 40 F and at 55 to 75 percent rh. Sun-dried peaches will tolerate a slightly higher humidity than dehydrated peaches.

Apricots. Dried apricots are easy to keep in refrigerated storage at 32 to 40 F with a 55 to 65 percent rh. They remain in excellent condition for more than a year. At 40 F with moderate humidity there is enough gain in moisture content to cause molding.

Dates (sucrose or hard type). For storage of 6 months or less dates may be held at 32 F with 70 to 75 percent rh. But for longer storage they should be stored at 24 to 26 F. Usually it is more convenient to store them at 0 F, at which temperature they can be stored for over a year.

Soft or invert-sugar type dates may be held for 6 months at 28 to 32 F, but if stored for 9 to 12 months they should be stored from 0 to 10 F. Uncured dates should be stored at 0 to 10 F.

Dried Vegetable Storage

Few specific recommendations of storage temperatures for dehydrated vegetables are available. Decrease in storage temperature retards deterioration, but cold storage is considered necessary only for long storage. Among the advantages are: (a) control of insects at 45 F or lower, (b) prevention of loss of natural colors, and (c) retention of initial flavors and vitamins.

Since most dried vegetables have very low moisture content, are well packaged and usually surrounded by an atmosphere of nitrogen or rarefied air, refrigeration is less essential than for undried vegetables.

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