Potatoes, Irish

Revised 2018

Storage Conditions

	Temperature		Storage Period*	Relative Humidity or Packaging
	°F	°C		
Raw Product				
Early Crop	40 to 50	4.4 to 10	0 to 3 months	95%
Late Crop				
Seed Potatoes	38	3.3	5 to 10 months	90 to 95%
Table	40	4.4	5 to 10 months**	90 to 95%
For French Frying	45	7.2	1 to 10 months**	90 to 95%
For Dehydrating	45	7.2	1 to 10 months**	90 to 95%
For Chipping	45 to 50	7.2 to 10	1 to 8 months**	90 to 95%
Reconditioning Only	50 to 60	10 to 15.6	1 to 3 weeks	85 to 90%
Frozen Product				
	-10 to 0	-23.3 to -17.8	12 months	Vapor-tight packaging
Dehydrated Product				
	45	7.2	3 to 6 months	Vacuum pack
	32	0	6 to 12 months	Vacuum pack
* Raw products must be cured (i.e., wounds healed) before storage				
** Sprout suppressors must be used for long storage periods				

General Information

A high quality fresh-market potato tuber will be turgid, well-shaped, uniform, brightly colored, and free from adhering soil, mechanical damage, greening, sprouts, diseases, and physiological defects. United States Department of Agriculture (USDA) market grades, based primarily on external conditions and appearance are Extra No. 1, No. 1, Commercial, and No. 2. The minimum diameter for U.S. No. 1 or No. 2 is 1 7/8 to 2 inches (4.8 to 5.1 cm) for round potatoes, and 4 oz (118 g) for long potatoes. Sometimes an additional requirement is imposed in that ≥ 60% of the tubers must be a minimum of 5 oz (142 g). A 'B-size' grade (tubers < 1 7/8 to 2 inches, 4.8 to 5.1 cm) is becoming more common, primarily for round red and white potatoes.

Oblong and long russets are commonly wholesale marketed in 'Count' boxes of 60, 70, 80, 90 or 100 tubers in a 50-lb (22.7-kg) carton, thus averaging approximately 13, 11, 10, 9 or 8 oz (369, 312, 283, 255, or 227 g) each, respectively. These are retailed bulk for consumers to select individual tubers. Common retail packages of 5 and 10 lbs (2.27 and 4.54 kg) plastic and paper bags generally contain tubers from 5 to 8 oz (142 to 227 g). B-size tubers are sold in pint, 'strawberry' baskets or in bulk. Pre-peeled tubers are generally packaged in plastic trays covered with plastic wrap.

Recommended raw potato storage conditions depend greatly on type of end use (seed, table, or processing), disease incidence, risk of sprouting, and, to a certain degree, on variety. The cooler the storage temperature can be, the lower both the tuber respiration rate and the disease risk and the longer the dormancy period. In general, tubers may start to sprout 4 to 6 weeks after harvest if maintained at room temperature. At lower temperatures, this dormant period can be greatly extended. However, storage temperatures should not be allowed to fall below 45°F (7.2°C) to avoid sweetening of table stock and browning during frying and chipping, or 38°F (3.3°C) to avoid mahogany browning (chilling injury) of seed stock.

The highest freezing point of most potato varieties is 31°F (-1.1°C). Potatoes are readily injured by freezing and should be protected accordingly.

Tubers should be stored in the dark. Light causes greening of the tuber surface due to chlorophyll development. Light also promotes synthesis of bitter tasting glycoalkaloids, primarily solanine, which may be toxic if consumed in very large quantities.

Potatoes should be stored separately from other fruits and vegetables to avoid transfer of odors or flavors. Potatoes may impart an 'earthy' odor to apples and pears and may acquire an off-flavor from odor volatiles released by other produce items.

Careful culling of injured or diseased potatoes should precede storage. Potatoes intended for storage should be handled carefully to avoid bruises and cuts. Tubers that are badly cut or bruised become discolored, wither and decay much more rapidly than uninjured potatoes. This is especially true of early potatoes harvested during hot weather. Avoid storing potatoes from fields where late blight or other decay type disease was prevalent or from wet areas in fields.

Both mature and immature Irish potatoes have the ability after harvest, with moderate temperature and high relative humidity (RH) conditions, to quickly develop corky tissue in the skin where wounds have occurred. This 'wound healing' or 'curing' reduces tuber water loss and also protects against invasion by decay causing organisms. Under optimum conditions, this corky protective tissue begins to develop within 24 to 48 hours after the injury occurs.

Newly harvested potatoes are held at moderate temperatures (50 to 60°F/10 to 15.6°C) and rather high RH of 95% with good aeration for 10 to 14 days after harvest to complete the wound healing/curing process. They then may be stored at lower temperatures. At temperatures below 45°F (7.2°C) and above 95°F (35°C), this wound healing/curing does not take place rapidly enough to offer protection against fungal or bacterial invasion. At temperatures above 60°F (15.6°C) high tuber respiration rates become a concern if the tubers are to be held for long-term storage.

In order to control shrinkage in potatoes, the desired RH is 95% or higher. However, due to lack of sufficient storage insulation (dew point/condensation), non-uniformity of some air distribution systems and certain disease situations, lower RH may be required in actual storage situations. Use only air, at this RH, which is colder than the tubers to avoid condensation. During the first 2 to 4 weeks of storage, when wound healing/curing occurs and temperatures are declining, high RH is much more critical than later. High RH reduces weight loss and tuber flattening due to pressure. Humidifiers may be used to add water to the air.

Management decisions for storing potatoes are affected by the duration of the storage period, generally early versus late crop harvest. Recommended holding temperature depends on the anticipated length of storage, raw product end use, and condition of the potatoes.

For short term storage of less than 3 months, most Irish potatoes, except seed and table stock, are not cooled below 50°F. Although the storage life is shortened at the higher temperatures, if early potatoes are to be used for chipping purposes, a storage temperature of 55 to 60°F (12.8 to 15.6°C) is recommended. Even if held for only a few days at colder temperatures, such as 45°F (7.2°C), reducing sugars may accumulate and result in undesirable dark-colored chips. Maintaining dormancy is not a major concern for this short period and the expense of cooling to lower temperatures may not be worthwhile. Allowing cycling of storage temperatures is not conducive to end use quality.

When late crop potatoes are to be kept longer than 3 months, the temperature is lowered after the wound healing/curing period is completed. The general practices are as follows:

Seed Potatoes	The temperature may be lowered to approximately 38°F (3.3°C), at which dormancy will persist indefinitely. It is not necessary to use a temperature as low as 32°F (0°C). Storage at 32°F (0°C) may cause mahogany browning (chilling injury). About 36 to 38°F (2.2-3.3°C) is usually cold enough to maintain dormancy, thus suppressing sprouting.
Table Potatoes	Table potatoes are usually stored at 40 to 45°F (4.4 to 7.2°C). At lower temperatures a noticeable sweet flavor develops due to conversion of starch to sugars. This can usually be reversed by raising the storage temperature to 50 to 55°F (10 to 12.8°C) for a week. Potatoes stored for more than 2 to 3 months are usually treated with a sprout inhibitor. Storage of table stock Russet Burbank potatoes is best at 45°F (7.2°C) with 95% RH. Under these conditions tubers of Russet Burbank treated with a sprout inhibitor will remain sprout free and maintain quality for 10 months or more.
Processing Potatoes	Below 45 to 50°F (7.2 to 10°C), current Irish potato varieties undergo a transformation of starch to sugar, becoming sweet, thus reducing processing quality. Depending on the variety, age of the potato and the extent of the sugar accumulation, this can usually be reversed by holding the potatoes at 55 to 60°F (12.8 to 15.6°C) for 1 to 3 weeks (reconditioning). Cooking tests will show if the sugars have been reduced below the point of causing browning in the processed product. Most varieties can be stored at 50°F (10°C) for approximately 3 months before sprouting begins, and after this, sprout growth will be rapid. Potatoes stored for more than 2 to 3 months are usually treated with a sprout inhibitor. General guidelines for specific end uses are: **French fries:** Potatoes for French fries are usually stored at about 45 to 50°F (7.2 to 10°C) and fried without reconditioning, or they are stored at 40 to 42°F (4.4 to 5.6°C) and reconditioned before frying. Reconditioning is sometimes less than satisfactory. **Chipping:** Potatoes for chips are very often stored at 48 to 55°F (8.9 to 12.8°C). With 'cold chipping' varieties that are being developed, these temperature recommendations may become lower. Temperatures of 60 to 65°F (15.6 to 18.3°C) favor internal and external sprouting. **Dehydrated:** Same as French fries.

Controlled atmosphere storage has not been shown to lengthen storage life more than 2 to 3 weeks. Low oxygen [less than 45°F (7.2°C)] inhibits wound healing/curing.

Major Diseases and Disorders

Note: control temperatures of 38 to 40°F (3.3 to 4.4°C) do not apply to processing potatoes. The lowest control temperature recommended for processing potatoes is 45 to 55°F (7.2-12.8°C) depending on the variety.

Alternaria Tuber Rot	Occurs most frequently in Northern-grown potatoes harvested and stored during cool, humid weather. Opens way for secondary invasion by disease organisms. Various shaped, quarter-inch to 2-inch (0.6-cm to 5.1-cm) diameter, lesions on tubers are dark brown to black. Lesions are slightly sunken with raised margins. Adjacent skin is slightly puckered. Underlying tissue is black and often surrounded by a yellowish zone. Affected areas appear similar to those infected with late blight, but the decay does not spread irregularly into healthy tissue as late blight does. **Control:** Field application of fungicides, vine killing prior to harvest and careful harvesting and handling will reduce disease spread. Storage below 50°F (10°C) and above 38 to 40°F (3.3 to 4.4°C) is preferred, in a well-ventilated storage, and elimination of free moisture will stop fungal spore germination. Reduce storage temperature rapidly after curing period.
Bacterial Ring Rot	External rot symptoms occur usually as a result of secondary invasion. Vascular ring turns light yellow to yellow brown. Decayed tissue is soft cheesy consistency and may be forced from ring by pressure on tuber. **Control:** Use certified disease-free seed. Disinfect equipment after handling infected lots. Severely affected lots should be culled and marketed immediately. Store promptly at 38 to 40°F (3.3 to 4.4°C) in a well-ventilated storage, raising temperature later, if necessary, to avoid sweetening.
Bacterial Soft Rot	Following heat injury, bruising or certain fungal disease, decay is cream-colored first, and then becomes brown to black. Soft but not watery with well-defined edges. Outer parts of tuber may remain intact while inner parts decay. As decay advances, decomposed tissue becomes mushy and wet. This tissue will turn chalk-white when dried. Secondary invasion by other rots may cause slimy and ill-smelling decay. Appears also as lenticel (breathing pore) infection in wet-stored potatoes. **Control:** Field sanitization. Protect potatoes against bruising and heat injury or freezing temperatures. Severely affected lots should be culled and marketed immediately. Potatoes that are washed should be dried before storage or packing in plastic containers. Cull out all potatoes showing decay, before storage. Cure at 50 to 55°F (10-12.8°C) and 85% RH in a well-ventilated storage. Reduce temperatures quickly after curing.
Black Heart	Usually occurs in storages with inadequate ventilation and high temperatures. No external symptoms. Discoloration in center of tuber starts as pink color, eventually turning to black, leathery tissue. Caused by lack of oxygen. **Control:** Harvest when tuber pulp temperature is below 70°F (21.1°C). Reduce temperature well below 70°F (21.1°C) promptly and ventilate well to provide oxygen.

Black Leg	A specific type of soft rot that enters tuber through the stem end. See Bacterial Soft Rot for control.
Browning	Discoloration of skinned areas on early crop potatoes. Most serious if followed by hot dry winds in the field, during transit or during packing. If browned potatoes are stored wet, moist sticky surface decay may follow. **Control:** Warehouseman should ventilate well with cool air having 95% RH or higher. Air must be cooler than the potatoes to avoid condensation and keep the tuber surface dry.
Brown Rot	Little external symptoms. Internally, moist yellow to brown discoloration and softening of water-conducting tissues, with a grayish, watery ooze from cut vascular surface, without application of pressure. The oozing without pressure clearly differentiates the disease from bacterial ring rot, with which it is often confused. Later, tuber centers become soft and brown and only a thin crust holds potato together. If other potatoes come into contact with these, they will be smeared by the rotted ones and secondary decay invasion may finally cause foul odor. **Control:** Field sanitization. Potatoes that are known or even suspected to be diseased should never be stored in cold storage.
Dry Rot	See Fusarium Rot (below).
Early Blight	Same as Alternaria Tuber Rot.
Freezing Injury	If frozen solid, potatoes become soft, rubbery and exude moisture. Slightly frozen tubers show darkening of the water-conducting tissues and dull red or bluish-gray to black areas in the flesh, or just under the surface of the peel. Decay rarely follows internal necrosis, but bacteria do invade severely frozen tubers causing a foul odor. **Control:** Obviously frozen tubers should be removed before storage. Usually, tubers will show symptoms if left in the field for at least 3 days before harvest. Severely affected lots should be culled and marketed immediately. Do not allow the storage temperature in the bin or in 'frozen pockets' (through poor aeration) to drop below 30°F (-1.1°C) or rise above about 50°F (10°C) (from the respiratory heat of decay organisms). If field frozen potatoes are found in the storage, the bins should be well ventilated until the damaged tubers are dried out.
Fusarium Rot	Brown to black, moist or dry rot with white, yellow, or pink mold, often in cavities throughout potatoes. May enter from stem end, but more commonly through injuries anywhere on the surface. **Control:** Careful handling of tubers to avoid cutting and bruising and curing at moderate temperatures and high RH [55°F (12.8°C) and 95% RH] before cooling to holding temperature, to encourage wound healing. Store in well-ventilated storage below 50°F (10°C). Fungicides provide some control.
Greening	Caused by exposure to sunlight or indoor lighting in field or storage or retail channels for some period of time. Have bitter taste that is unpalatable and may even be mildly hazardous to health because of the presence of solanine, which is poisonous if ingested in sufficient doses.

	Control: Always store Irish potatoes in darkness and avoid extended exposure to light.
Hollow Heart	Too rapid or irregular growth. Interior cavities lined with light brown or brown dead tissue. Not evident until tubers are cut. **Control:** No warehouse control. It is neither caused by nor develops during storage.
Internal Black Spot	Often associated with pressure bruising during harvest or in storage. Blackening of internal tissues usually in area between skin and water-conducting tissues. Not always evident until tubers are cut, but flat or sunken area may indicate location of black spot. Often becomes evident after handling potatoes that have been stored for several months. **Control:** Add moisture or ventilate with 95% RH air in the storage to prevent desiccation and pressure bruising. Before grading and shipping after prolonged period of storage, warm potatoes to at least 55 to 60°F (12.8 to 15.6°C).
Internal Brown Spot	Irregular, indefinitely outlined light-brown, scattered promiscuously through the tuber. Frequently found at bud end. Diseased tissue is firm or somewhat corky. **Control:** A field disease not caused by cold storage. Seems to occur mostly in hot, dry seasons.
Jelly-End Rot	Soft, jelly-like decay, especially in elongated type potatoes. **Control:** Provide uniform moisture during growing period. Not caused by cold storage but may show up there. Adequate ventilation in storage aids in preventing wet breakdown.
Late Blight	Reddish-brown, brown or purplish-brown areas on the skin that is papery when dry. Fairly firm granular, yellowish or brownish areas in the outer flesh of tuber. Rarely more than ½-inch (13-mm) deep in flesh, appears anywhere on tuber. Commonly followed by bacterial soft rot and Fusarium rot, which may invade the entire tuber. **Control:** Field sanitization. Keep potatoes dry. Store at 50°F (10°C) in a well-ventilated storage and market promptly.
Leak (also Pink Rot)	Extensive metallic-gray color on red-skinned tubers; brownish or water-soaked appearance on other type tubers. Injuries may start in moist areas in the field or at the ends of tubers. Internal tissues granular, cream-colored at first, changing to reddish brown or inky-black; most evident symptom is extremely watery nature of diseased tissues, resulting in large quantities of yellowish or brownish liquid exuding under slight pressure. **Control:** Protection from mechanical injury. Keep tubers as cool [less than 55°F (12.8°C)], and as dry as possible during storage and transit. Keep storage well-ventilated. Reduce irrigation towards end of growing season.
Mahogany Browning	Reddish-brown patches or blotches in flesh, due to prolonged holding at or near 32°F (0°C). It is chilling injury, not freezing injury.

	Control: Store at 38°F (3.3°C) or above. Large varietal differences in susceptibility.
Net Necrosis	Internal discoloration due to Potato Leafroll Virus (PLRV), dark brown to black at stem end and in vascular strands throughout tuber gives dark-brown netted appearance to flesh when tuber is pared lengthwise. Earlier stages resemble some other diseases or even freezing injury. Increases during storage. **Control:** Control aphids. Use PLRV-free seed. Use resistant varieties. Russet Burbank is especially susceptible. Prompt storage at 40°F (4.4°C).
Pressure Flattening / Bruising	Potatoes show a surface depression that is caused by external pressures during storage followed by dehydration of the tuber. This will progressively develop during storage. The tissue beneath the depression may turn dark and is often referred to as a pressure bruise. Some varieties are more susceptible than others. **Control:** Maintain the RH as close to 95% as possible. Keeping the pile depth less than 16 ft (4.9 m) reduces the incidence.
Scald (Sunburn)	On early potatoes, appears as sunken, injured areas, later turning black and sticky, followed by bacterial rots. **Control:** Minimize exposure to sun and wind. Place at temperatures and RH suitable for wound healing/curing.
Shatter Bruise	A crack or split in the surface of the tuber that penetrates through the skin; due to harvesting and handling impact injury. It will have a shattered or net-like appearance. The edge of the bruise has the same discoloration as black spot bruises but differs in that with the shatter bruise the skin is damaged and the flesh is penetrated. Turgid, cold tubers are very vulnerable. Very high specific gravity tubers are also vulnerable. **Control:** Do not harvest vulnerable tubers with pulp temperatures below 45°F (7.2°C). Handle tubers very gently.
Silver Scurf	More or less circular, small, superficial, brownish spots in skin. Eventually expanding and developing a silvery, bronze or golden color. Causes undesirable surface blemishes. Permits excessive water loss and shriveling in storage. **Control:** Decrease the storage temperature as rapidly as possible after curing.
Stem End Browning	Dark-brown or black discoloration of stem end usually in vascular strands may be aggravated by some diseases, or rapid vine kill. **Control:** Store resistant varieties. Retarded by prompt storage below 50°F (10°C); 38 to 40°F (3. 3 to 4.4°C) is preferred. Avoid rapid vine killing.
Transit Bruising	Caused by pressure and rubbing in transit. Similar to but differs from freezing injury in that bruising symptoms are confined to vicinity of flattened areas. **Control:** Nothing a warehouseman can do. Load to minimize movement. Protect by use of pads or tight loading.

Quarantine issues are important for export and import of potato tubers. Among the most common quarantined diseases and nematodes are cyst nematode (*Globodera spp.*), viruses and viroids, brown rot (*Pseudomonas solanacearum*), ring rot *(Corynebacterium sepedonicum)* and powdery scab (*Spongospora subterranean).* Currently, potato tubers may not be imported into the U.S. from any country except Canada.

Frozen Products

More pre-cooked potatoes are frozen than any other vegetable. Most of these are in the French fry form. However, some are in mashed, whipped, diced, scalloped, baked, hashbrown, puffs, and cake forms. 'Oil blanched' and incompletely cooked French fries are a big item for the institutional trade where the finishing is done in deep fryers just before serving.

The variety, season, growing location, harvest condition, storage management, and other factors affect the quality of potatoes for freezing purposes. In general, the potatoes are prepared for freezing in the same manner as if they were to be served freshly prepared. Avoid the use of low temperature potatoes, below 45 to 50°F (7.2 to 10°C) or re-condition them before processing. This avoids the risk of undesirable flavor and reduces the amount of surface sugars that need to be removed by washing before freezing in order to prevent browning of the processed fries.

Freezing of the product may be done before or after packaging. Loose pieces are frozen on a continuous belt in an ammonia, blast-freezing tunnel. This method requires only about 10 minutes at -40°F (-40°C). The product leaves the freezing operation at a core temperature of -10°F to 10°F (-23.3 to -12.2°C). Colder core temperatures increase breakage in the handled product, so 5 to 10°F (-15 to -12.2°C) is often used for French fries. Occasionally over-wrapped, retail-size cartons are frozen in a blast freezer. It may take up to 2.5 hours for the product to reach 0°F (-17.8°C) by this method.

For retail trade, frozen French fries are usually packed in poly bags of 1 to 2 lbs (0.45 to 0.9 kg).

For the institutional trade, the 36- to 39-lbs case (16.3- to 17.7-kg), with six bags per case, is common. Cased products are held in storage at 0°F (-17.8°C) or lower for 9 to 12 months.

A storage unit that will maintain a constant temperature below 0°F (-17.8°C) is recommended for long term storage. Frozen products kept under these conditions will deteriorate less and maintain quality. Frozen French fries held at a constant -6°F (-21.1°C) can be held for at least 1 year with very little loss due to storage. Relative humidity is not a factor, since we assume uniform temperature and vapor proof packaging.

Dehydrated Products

Fresh potatoes contain about 80% water. During dehydration, the total solids ratio can be expected to increase by 4 to 5-fold. Some of the nutrient ratios, however, do not increase to this extent because of losses sustained during high temperature dehydration. These losses could be minimized if potatoes were freeze dried, but the cost of this technique is prohibitive. Frequently, antioxidants and sulfites are added,

which not only prevent discoloration, but also improve nutrient retention. Vacuum packing also aids in the extension of shelf life.

Two ounces (57 g) of dehydrated potatoes will reconstitute into a half pound (227 g) of mashed potatoes. A half-pound (227 g) of reconstituted product will provide about 200 calories, vitamins C, B1, B2, niacin, iron, protein and calcium.

To minimize discoloration and maintain these valuable nutrients at levels approaching the freshly dehydrated potatoes for as long as 3 months, dehydrated product should be stored at 45°F (7.2°C), even if vacuum packed. If stored for longer periods, dehydrated products should be held at lower temperatures, and if storage for 1 year or longer is anticipated, dehydrated potatoes should be stored in freezers.

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