

# Potato

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**Scientific Name and Introduction:** The white or Irish potato, *Solanum tuberosum* L., is an annual of the Solanaceae family. The edible portion is the tuber, an underground stem that forms at the end of stolons. Potato is a cool season plant, native to the Americas, with many close relatives in the Andean region of South America. New varieties commonly have one or more wild *Solanum* species included in their pedigree. Potato is grown throughout the world in temperate zones, with planting in the Spring and harvest in the Fall. There are many skin colors (brown russet, white, red, pink, yellow) and flesh colors (white, cream, yellow, blue/purple/red, and striated). Tuber shapes vary from round, oblate, oblong to long. Stored potatoes are available year-round; fresh potatoes are harvested year-round, albeit in small quantities, during the Winter, Spring and Summer. Processed potatoes, ie., frozen French fries, potato chips, flakes, etc., are manufactured year-round from fresh and stored tubers.

**Quality Characteristics and Criteria:** A high quality fresh-market potato tuber will be turgid, well shaped, uniform, brightly colored (especially reds, whites and yellows), as well as free from adhering soil, mechanical damage, greening, sprouts, diseases, and physiological defects.

**Horticultural Maturity Indices:** The ability of potato tuber skin to resist abrasion (skinning) during harvest is a common index for maturity. Sugar content is a maturity index for processing potatoes, with both immaturity and over-maturity resulting in higher sugar levels. Vine senescence is used as a pre-harvest maturity index, but the correlation between vine senescence and tuber skin-set varies among cultivars.

**Grades, Sizes and Packaging:** USDA market grades are Extra No. 1, No. 1, Commercial and No. 2 (established by the USDA in 1991), distinguished primarily on external condition and appearance. Grades vary among tuber shapes. The minimum diameter for U.S. No. 1 or No. 2 is 4.8 to 5.1 cm (1 7/8 to 2 in) for round potatoes, and 118 g (4 oz) for long potatoes. At times, an additional requirement that  $\geq 60\%$  of the tubers must be a minimum of 148 g (5 oz) is imposed. A 'B-size' grade is becoming more common, primarily for round red and white potatoes. B-size grade are tubers  $< 4.8$  to 5.1 cm (1 7/8 to 2").

Oblong and long russets are commonly wholesale marketed in 'Count' boxes of 60, 70, 80, 90 or 100 tubers in a 22.7 kg (50 lb) carton, thus averaging approx. 380, 325, 296, 266, or 237 g each (13, 11, 10, 9 or 8 oz), respectively. These are retailed bulk for consumers to select individual tubers. Common retail packages of 2.27 and 4.55 kg (5 and 10 lbs) plastic and paper bags generally contain tubers from 150 to 240 g (5 to 8 oz). 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.

Potatoes for processing, eg., French fries or chips, are graded using the U.S. grade and size standards in combination with individual quality and size requirements of each processing company. The latter component varies with type of product to be manufactured and the purchaser. Tubers are delivered to processing plants in bulk trucks or bins holding about 2000 lb (910 kg).

**Optimum Storage Conditions:** Long-term storage of potato tubers of up to 12 mo requires that they be cured. Curing stimulates suberization, wound healing and reduces respiration. Optimal curing conditions are around 20 °C (68 °F) with RH of 80 to 100%. Curing is markedly slower at temperatures  $< 10$  to 12 °C (50 to 55 °F) and  $> 25$  to 30 °C (75 to 85 °F). Similarly, RH  $< 80\%$  delays curing. Curing at 15 °C (59 °F) is commonly recommended to minimize decay. Frequently, potatoes harvested in the Fall in temperate climates are colder than the optimal curing temperatures. However, respiration in storage will heat the tubers and raise RH. Temperature and RH control during this 'sweating' or curing time is managed using

fans to bring outside air into the storage room, depending on the need during the night or day. Once cured, a process requiring 1 to 2 weeks, the tuber temperature is lowered by 1 to 2 °C per day until the desired maintenance temperature and RH are reached. In some cases, two additional steps must be employed: drying of wet potatoes upon entry into storage, and heating of tubers before removal from storage. Forced movement of air is used to insure uniform temperature throughout the storage pile. Maintaining 95 to 99% RH is required at all times to minimize shrink and pressure bruising in storage.

Desired maintenance temperature depends on the desired end use of the tubers. Respiration rate of potato tubers is lowest at 2 to 3 °C (36 to 37 °F). Storage at 0 to 2 °C (32 to 35 °F) increases the risk of freezing or chilling injury. Sprouting accelerates at temperatures > 4 to 5 °C (40 °F), so seed tubers are commonly stored at 4 to 5 °C (40 °F). Tubers for fresh consumption are stored at 7 to 10 °C (45 to 50 °F), to minimize conversion of non-reducing sugars such as starch to reducing sugars such as glucose, which darken during cooking. Tubers for frying are stored at 10 to 15 °C (50 to 59 °F), depending on cultivar and its respective sugar conversion characteristics. Many chipping cultivars accumulate excessive sugar if stored < 15 °C (59 °F). Thus, chipping cultivars are stored at 15 to 20 °C (59 to 68 °F); new cultivars are being developed that will not accumulate sugar at temperatures as low as 5 to 10 °C (41 to 50 °F).

Quality tubers can be stored for 2 to 12 mo, depending on quality at harvest, quality of storage facilities, variety, and whether or not sprout inhibitors are used. Sprout inhibitor may be applied in the field before senescence begins, on the tubers as they are graded and packaged, or in the storage after curing is completed.

**Controlled Atmosphere (CA) Conditions:** The usefulness of CA storage is minimal, and economic justification doubtful. Periderm development and wound healing is delayed at atmospheres < 5% O<sub>2</sub>. Injury from < 1.5% O<sub>2</sub> or > 10% CO<sub>2</sub> includes induced off-odors, off-flavors, internal discoloration and increased decay. While higher CO<sub>2</sub> tends to inhibit formation of reducing sugars, it also increases sucrose content.

**Retail Outlet Display Considerations:** Cured and new potatoes, whether displayed in bulk, or in cellophane or paper bags, are displayed dry. New potatoes that are displayed in bulk are commonly included with other cool season vegetables that receive periodic water misting or sprinkling.

*Chilling Sensitivity:* Potatoes freeze at approximately -1 °C (30 °F). Internal mahogany browning can occur at 1 to 2 °C (34 to 35 °F), while 3 to 4 °C (27 to 39 °F) typically results in increased reducing sugar levels that are not reversible with re-conditioning.

**Ethylene Production and Sensitivity:** Potatoes produce very low levels of ethylene at < 0.1 μL kg<sup>-1</sup> h<sup>-1</sup> at 20 °C (68 °F). Cut, bruised and/or wounded tubers have greatly increased ethylene production rates. Potato tubers are not very sensitive to external ethylene. Low levels of ethylene elevate respiration, especially in immature potatoes, and result in weight loss and mild shriveling. After 2 to 3 mo at > 5 °C (41 °F) without sprout inhibitor, low levels of ethylene may retard sprouting, while high amounts may induce sprouting.

**Respiration Rates:**

Temperature	Immature (mg CO <sub>2</sub> kg <sup>-1</sup> h <sup>-1</sup> )	Mature (cured)
5 °C	24	6 to 18
10 °C	30 to 40	13 to 19
15 °C	25 to 57	11 to 22
20 °C	32 to 81	14 to 29

To get mL kg<sup>-1</sup> h<sup>-1</sup>, divide the mg kg<sup>-1</sup> h<sup>-1</sup> rate by 2.0 at 0 °C (32 °F), 1.9 at 10 °C (50 °F), and 1.8 at 20 °C (68 °F). To calculate heat production, multiply mg kg<sup>-1</sup> h<sup>-1</sup> by 220 to get BTU per ton per day or by 61 to

get kcal per metric ton per day.

Immature potato tubers usually have higher respiration rates than mature or cured tubers. Cooler temperatures and/or increased air movement are effective to control effects of a high rate of respiration. Increased air movement in the absence of high RH, however, will cause desiccation.

**Physiological Disorders:** The most common and serious physiological disorders affecting potatoes include black spot, blackheart, freezing injury, greening, hollow heart, sugar end browning, and internal necrosis.

Black spot results from a physical impact to the tuber; the stem end of the tuber is most sensitive. Following severe bruising or cutting, the affected tissue turns reddish, then blue becoming black in 24 to 72 h. Severity increases with time. Cultivars differ significantly in their susceptibility and symptom expression. Soil conditions can predispose tubers to blackspot; poor aeration is the most common cause. Proper fertilization (particularly potassium), water management, careful handling and high RH to maintain turgor are important in minimizing black spot. Use of compost and/or manure helps prevent blackspot.

Blackheart is a storage or transportation induced disorder caused by low O<sub>2</sub>. Typically, blackheart is induced at > 30 °C (86 °F), which increases respiration. If air exchange around tubers is sufficient, low O<sub>2</sub> conditions develop in the interior of the tuber and the cells suffocate and turn black. Blackheart is rare in early-crop potatoes due to typical marketing practices.

Freezing at -1 °C (30 °F), whether induced in the field or in storage, typically results in a distinct demarcation between affected and unaffected tissue. Symptoms include a water-soaked appearance, glassiness, and tissue breakdown on thawing. Chilling injury can occur after a few weeks at 0 °C (32 °F) and result in a mahogany discoloration of internal tissue in some varieties. Much longer periods of storage are generally required for chilling injury to occur.

Greening may occur in part of a tuber exposed to light. Affected tubers are easily culled at grading and rarely proceed to marketing channels. Darkness is essential for long-term storage because greening can occur during storage or marketing. Exposure to bright light during postharvest handling, or longer periods (1 to 2 weeks) of low light, can result in development of chlorophyll (greening) and bitter, toxic glycoalkaloids, such as solanine. Solanine also forms in response to bruising, wounding (including fresh processing followed by storage), and during sprouting. Glycoalkaloids are heat stable and minimally degraded by cooking. Tubers in market displays should be replaced daily or more frequently to minimize greening.

Enlarged lenticels are a common disorder in early potatoes where excessive irrigation is often applied to maintain cooler soil temperatures in warm/hot climates. These lenticels are subject to pathological infection in the soil or during packing. Infections may remain innocuous, or if transportation conditions are not properly maintained, they can increase rapidly in severity. Tubers that appear sound at the packing shed can become unmarketable during transit.

Skinning is a common disorder in early-crop or “new” potatoes (harvested immature). Soil drying and vine death enhance skin set, and thus decrease skinning. Cultivars vary in ability to set-skin, in skin thickness, and thus in skinning susceptibility. “New” potatoes must be kept at a very high RH, near 100%, and must be handled with special care.

Hollow heart, sugar end accumulation and internal necrosis are all production problems, related to irregular growth, inadequate water availability and/or widely fluctuating temperatures; these conditions do not change during harvest and postharvest handling.

**Postharvest Pathology:** Diseases are an important source of postharvest loss, particularly in combination with rough handling and poor temperature control. Three major bacterial diseases and a greater number of fungal pathogens are responsible for, occasionally, serious postharvest losses. The major bacterial and fungal pathogens that cause postharvest losses in transit, storage, and to the consumer are bacterial soft rot (*Erwinia carotovora subsp. carotovora* and *subsp. atroseptica*), *Ralstonia* (ex *Pseudomonas*, ex

*Burkholderi solanacearum*, late blight (*Phytophthora infestans*), Fusarium dry rot (*Fusarium* spp.), pink rot (*Phytophthora* spp.), water rot (*Pythium* spp.) and silver scurf (*Helminthosporium solani*). Occasionally serious diseases of immature tubers include pink eye (*Pseudomonas fluorescens*) and grey mold (*Botrytis cinerea*).

In addition to careful sorting before placing tubers into storage, management of air, RH and temperature during storage and transit of potatoes with potential problems can be accomplished. Lower RH, shortened curing time, and lower temperatures can minimize spread of rot diseases.

**Quarantine Issues:** Export and import of potato tubers can involve numerous quarantine issues related to grade, diseases, and nematodes. Each country has its own phytosanitary requirements. Inspections and appropriate authorizations are required. Among the most common diseases and nematodes included in quarantine, or zero tolerance requirements are cyst nematode (*Globodera* spp.), viruses and viroids, brown rot (*Pseudomonas solanacearum*), ring rot (*Corynebacterium sepedonicum*) and powdery scab (*Spongospora subterranean*). Similarly, these diseases and nematodes are restricted on potato tubers to be imported. Currently, potato tubers may not be imported into the U.S. from any country except Canada.

**Suitability as Fresh-cut Product:** Potatoes are relatively new as a lightly-processed product. Fresh-cut potatoes are not marketed, but par-boiled whole tubers can be prepared and marketed in plastic trays with sealed plastic wrap with low O<sub>2</sub> transmission characteristics. Storage requirements for tubers to be processed in this manner have not been well defined.

**Special Considerations:** Potatoes may impart an "earthy" odor to apples and pears if held in storage with low air exchange. Potatoes may acquire an off-flavor from odor volatiles released by other produce items.

Postharvest handling and storage of late-crop potatoes is very complex and dependent on growing conditions, environment at harvest, variety, intended use and many other factors.

Additional information is available at:

<http://postharvest.ucdavis.edu/Produce/Produce Facts/Veg/Potato-early>

<http://www.css.orst.edu/potatoes/>

<http://www.gov.mb.ca/agriculture/crops/potatoes/bda01s00>

<http://www.npcspud.com/>

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