Onion

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Scientific Name and Introduction: Onions, *Allium cepa* L., Cepa group, is a biennial of the *Alliaceae* family. The edible portions of the bulb are the enlarged leaf bases and compact stem. Green onions, also called scallions, are eaten for their immature bulb and green foliage. The predominant flavor component results from activity of the enzyme alliinase in broken or crushed tissue, yielding the volatiles propyl disulfide and methyl propyl disulfide. Major onion producers are China, India, U.S., Turkey, Japan, Spain, Holland, Poland and Ukraine.

Quality Characteristics and Criteria: High quality onions should have mature bulbs with good firmness and compactness of fleshy scales. The size, shape and color of the dry skin should be typical for the variety. They should be free of mechanical or insect damage, decay, sunscald injury, greening of fleshy scales, sprouting, bruising, doubles, bottlenecks (onions which have abnormally thick necks with only fairly well developed bulbs) and any other defects.

Horticultural Maturity Indices: Harvest maturity depends on the purpose for which they are grown. Onions intended for storage should be harvested when 50 to 80% of the tops have fallen over and bulbs are mature with a thin neck. Yields are higher when harvested after the tops are completely dry, but bulbs tend to have a shorter storage-life. To hasten maturity, tops can be rolled with a light roller when 10% of tops have fallen. About 7 days prior to lifting, bulbs can be undercut by a blade. Such onions should not be used for long-term storage. Onions for bunching can be harvested from pencil size until they have proper bulb size.

Grades, Sizes and Packaging: Grades for green onions include U.S. No. 1 and U.S. No. 2 based on external appearance and size. For U.S. No. 1, the overall length (excluding roots) must be 20 to 61 cm (8 to 24 in), and the diameter of the bulb 6.4 to 25.4 mm (0.25 to 1 in). Sizes are based on bulb diameter: Small, < 12.7 mm (0.5 in); Medium, 12.7 to 25.4 mm (0.5 to 1 in); and Large, > 25.4 mm (1 in). Trimmed green onions are bunched and marketed as bulb-type in 9.1 and 12.7 kg (20 and 28 lb) cartons, and as 24, 36 and 48 count, bunched in 9.1, 5.0 and 5.9 kg (20, 11 and 13 lb) containers, respectively.

Grades of Bermuda-Granex-Grano type onions include U.S. No. 1, U.S. No. 2 and U.S. Combination and are based on external appearance and size. U.S. Combination consists of a mixture of U.S. No. 1 and U.S. No. 2 onions in which at least 50% (by weight) of the onions in each lot meet the requirements of U.S. No. 1 grade. Bulb diameters are defined as: Small, 2.5 to 5.7 cm (1 to 2.25 in); Pre-packer, 4.5 to 7.6 cm (1.75 to 3 in); Medium, 5.1 to 8.3 cm (2 to 3.25 in.); Large or Jumbo, 7.6 to 9.5 cm (3 to 3.75 in); and Colossal, > 9.5 cm (3.75 in). Containers vary from 2.3 to 22.7 kg (5 to 50 lb) with 9.1 kg (20 lb) being the most common size.

For onions other than Bermuda-Granex-Grano and Greole types, there are five Grades: U.S. No. 1, U.S. Export No. 1, U.S. Commercial, U.S. No. 1 Boilers, U.S. No. 1 Picklers and U.S. No. 2. The sizing of onions in this group is the same as above. Containers are usually 9.1 kg (20 lb), except for export onions which are packed in 25 kg (56 lb) containers.

Pre-cooling Conditions: In order to maintain high quality, bunched green onions should be pre-cooled to < 4 °C (29 °F) within 4 to 6 h of harvest. Hydro-cooling, forced-air cooling and vacuum-cooling are used with crushed ice over the product to maintain temperature and moisture.

Dry onion bulbs for long-term storage should be pre-cooled to 0 °C (32 °F) immediately after drying,

or within 1 mo using cool outside air. The pre-cooling method affects storability. Rapid pre-cooling inhibits rooting and sprouting during storage. Natural cooling (slow) has a positive effect on storability when onions have a long rest period and weather conditions are good for curing. Gradual cooling at 1 °C (1.8 °F) per day in storage is less effective at inhibiting sprouting and rooting than rapid cooling (Grzegorzewska, 1999).

Optimum Storage Conditions: Bunched green onions can be stored 3 to 4 weeks at 0 °C (32 °F) with 95 to 98% RH. Under these conditions, bunched onions stored in polyethylene-lined containers and top-iced maintain excellent quality for 1 mo. Storage-life decreases to 1 week if the temperature is 5 °C (41 °F), and rapid yellowing and decay of leaves occurs at higher temperatures.

Pungent, dry onions can be stored for 6 to 9 mo at 0 °C (32 °F) with 65 to 75% RH. High RH induces root growth, while high temperature induces sprouting. A combination of high temperature and high RH increases rotting and decreases quality. Storage below the freezing point of -1 to -2 °C (30 to 28 °F) is recommended in Europe. Mild type or sweet onions can be kept for 1 to 3 mo; they are stored in common storage with cool, circulating ambient air or in refrigerated cold rooms. Onions grown from seed store better than those grown from sets or transplants.

After harvest, onion bulbs enter a state of rest for a period of 4 to 6 weeks, depending on cultivar and weather conditions during growth. Maleic hydrazide, a sprouting inhibitor, is often used to prevent root growth and sprouting during long-term storage. It is applied 2 weeks before harvest, when bulbs are mature and 50% of tops are down. But, onion plants must still have five to eight green leaves in order to absorb and translocate the sprout inhibitor to bulbs.

Onions intended for storage should be dried well and cured in the field, under sheds, or in storage. After 2 weeks of field drying, onions can be transferred to storage rooms for final drying and curing. Forced-air ventilation at 25 to 27 °C (77 to 81 °F) using outside or heated air is commonly used to dry onions. Onions can be stored and dried on the floor in bulk 3 to 4 m deep or in 500 to 1000 kg (1,100 to 2,200 lb) boxes. Drying is complete when the onion neck is tight, outer scales are dry and make a rustling noise when touched, and the skin color is uniform. Weight loss of 3 to 5% can occur during drying. Losses from neck rot are reduced by rapid drying immediately after harvest. After drying and curing, the temperature should be lowered gradually to the normal seasonal temperature, or bulbs can be pre-cooled in cold storage at 0 °C (32 °F). In either case, condensation should be avoided as it encourages rot and changes the color of the dry skin.

In most European countries and in the northern U.S., onions are stored in common storage, using cool, ambient air to maintain optimum temperature and RH. In this condition, onions are usually stored only until the end of March or beginning of April, since further storage can cause losses due to sprouting and rotting.

Refrigerated storage is used for onions that are to be marketed in late April to early July. For cold storage, onions are usually packed in crates or containers. Air circulation must be sufficient to maintain a constant temperature and remove moisture from inside storage containers. Onions packed in sacks can only be stored for a limited period of time, about 1 mo, since air movement through sacks is insufficient to maintain proper storage conditions. When stored below - 1 to -2 °C (30 to 28 °F), onions should be thawed at 5 °C (41 °F) for 1 to 2 weeks before they are removed from storage. Rapid thawing damages onion bulbs.

Mild and sweet onions can be stored for only 1 to 4 mo, even in optimal cold storage. CA may extend the storage period.

Onions tolerate storage at 30 to 35 °C (86 to 95 °F) for short periods before marketing or processing, but their quality and external color is less attractive than cold-stored onions.

Controlled Atmosphere (CA) Considerations: Bunched green onions can be stored for 6 to 8 weeks in 2% O_2 + 5% CO_2 at 0 °C (32 °F). They can tolerate 1% O_2 and up to 5% CO_2, but off- flavor may develop if stored at > 5 °C (41 °F) (Suslow and Cantwell, 1998).

Low O_2 atmospheres reduce respiration and extend storage-life, while elevated CO_2 reduces sprouting and root growth. CA has been used for storage of pungent onions in England, Switzerland and Poland

(Adamicki, 1998). A 3% O_2 + 5% CO_2 atmosphere inhibits rooting, sprouting and disease development (Adamicki and Kepka, 1974; Smittle, 1988). But, onions stored in 3% O_2 + 10% CO_2 showed physiological disorders; high CO_2 caused injury, but neck rot (*Botrytis* spp.) was reduced (Sitton et al., 1997).

CA can have also residual effects. After storage for up to 226 days in 3% O_2 + 5% CO_2, sprouting of 'Wolska' onions at 20 °C (68 °F) was delayed for 10 days, compared to air-stored controls (Adamicki and Kepka, 1974). It is possible to store onions in low O_2 (1 to 2%) with 2% CO_2 (Adamicki, 1995, 1998; Tanaka et al., 1996). There is some commercial use of 3% O_2 and 5 to 7% CO_2 for sweet onion cultivars (Smittle, 1989; Mikitzel et al., 1993; Sitton et al., 1997).

Retail Outlet Display Consideration: Onion bulbs can be displayed in small packages or in bulk at < 5 °C (41 °F). This temperature effectively retards sprouting for up to 7 mo. Onions should not be stored with fruits and vegetables that tend to absorb odors.

Chilling Sensitivity: Onions are not sensitive to chilling and can be stored at -2 to -3 °C (28.4 to 26.6 °F), since the highest freezing point is - 0.8 °C (30.6 °F). Storage at < -4 °C (24.8 °F) may cause freezing injury.

Ethylene Production and Sensitivity: Ethylene production is very low, at < 0.1 µL kg^{-1} h^{-1} at 20 °C (68 °F) (Suslow and Cantwell, 1998). Sensitivity to ethylene is also low, but concentrations > 1500 to 2000 µL L^{-1} encourage sprouting of onion bulbs.

Respiration Rates:

Temperature	mg CO_2 kg^{-1} h^{-1}
0 °C	3
5 °C	5
10 °C	7
15 °C	7
20 °C	8

To get mL kg^{-1} h^{-1}, divide the mg kg^{-1} h^{-1} 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^{-1} h^{-1} by 220 to get BTU per ton per day or by 61 to get kcal per metric ton per day. Data are from Robinson et al. (1975).

Physiological Disorders: Onion bulbs are affected by the following physiological disorders:

Freezing injury. Soft, water-soaked fleshy scales and rapid decay after transfer from cold storage to higher temperature, which results in microbial growth.

Translucent scales. Resembles freezing injury and is prevented by prompt cold storage following curing. Translucent scales occur with loss of or changes in carbohydrate content. Storage of onions at > 7 to 8% CO_2 can also lead to development of translucent scales. Late harvesting and a long drying period at high temperatures produce the highest incidence of translucent scales.

Watery scales. Typically, symptoms include thick leathery skin, which when peeled away, reveals watery, glassy, fleshy scales below. The watery scales may later be affected by fungal or bacterial growth. Late harvesting and prolonged field drying produce the highest occurrence of leathery skin.

Scale Greening. Exposure to light after curing causes green coloration of outer scales.

Ammonia injury. Brown-black blotches resulting from leakage of ammonia during storage (Adamicki, 1974; Smittle, 1988; Hoftun, 1993; Suslow and Cantwell, 1998; Solberg, 1999).

Postharvest Pathology: A number of microorganisms attack onions postharvest:

Botrytis neck rot. Watery decay, which begins at the neck and then attacks the entire bulb. A gray fungal mold then covers the neck of the bulb and later the whole bulb surface. Neck rot can be slowed after harvest, but not stopped, even during storage under optimum conditions. Proper drying in the field and

during storage can decrease this postharvest fungal decay disease.

Black mold rot. Black discoloration and shriveling at the neck and on outer scales caused by *Aspergillus niger* van Tiegh. Infection usually occurs in the field, but the disease spreads from bulb to bulb postharvest. The surface of bulbs must be dry during and after harvest to avoid infection. Storage at 0 °C (32 °F) with moderate RH prevents the spread of this disease.

Blue mold rot. Watery soft rot of neck and outer scales, followed by formation of blue to blue-green mold of the fungus *Penicillium* spp. Harvest of mature bulbs, proper curing, and storage at 0 °C (32 °F) with 60 to 70% RH minimizes blue mold problems.

Bacterial soft rot. Water soaked individual scales or the entire onion, with foul smelling, viscous, liquid-covered, rotted areas is caused by *Erwinia carotovora* Jones. The disease progress rapidly under warm, humid conditions. Harvesting at full maturity, proper drying, minimizing bruising and maintaining optimum storage conditions prevent bacterial soft rot (Ryall and Lipton, 1983; Suslow and Cantwell, 1998).

Quarantine Issues: Onions intended for export should be free from *Ditylenchus dipsaci* Kühn.

Suitability as Fresh-cut Product: Demand for fresh-cut onions (ready-to-eat) is increasing.

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