Brussels Sprouts

Revised 2018

Thermal Properties

	English	Metric
Moisture, %	86.00	--
Protein, %	3.38	--
Fat, %	0.30	--
Carbohydrate, %	8.95	--
Fiber, %	3.80	--
Ash, %	1.37	--
Specific Heat Above Freezing	0.93 Btu/lb*°F	3.90 kJ/(kg*K)
Specific Heat Below Freezing	0.46 Btu/lb*°F	1.91 kJ/(kg*K)
Latent Heat of Fusion	123 Btu/lb	287 kJ/kg

Storage Conditions

	Fresh	Frozen	
Temperature	32°F (0°C)	0°F (-17.8°C)	-10°F (-23.3°C)
Relative Humidity	95 to 100%	Vapor proof packaging	Vapor proof packaging
Storage Period	3 to 5 weeks	10 months	1 year +
Highest Freezing Point	30.5°F (-0.8°C)		

Brussels sprouts may be cold-stored for processing or favorable markets. Sometimes Brussels sprouts are stored in large containers, although this is not advisable since they pack rather closely and have a tendency to heat, discolor, and develop mold, especially in the center of the mass. Prompt refrigeration, good aeration, and high relative humidity (RH) are essential for successful storage.

The maximum storage life for Brussels sprouts is 3 to 5 weeks at 32°F (0°C) with 95 to 100% RH and depends on sound, clean, mold-free sprouts being stored. Storage life is 10 to 18 days at 41°F (5°C), only half as long as at 32°F (0°C), and 7 days or less at 50°F (10°C). Deterioration in the form of yellowing and discoloration of the stem end is rapid at temperatures of 50°F (10°C) and above. Sufficient air circulation

and spacing between packages is desirable to allow good heat removal and to prevent yellowing and decay.

Brussels sprouts may be cooled rapidly by vacuum cooling or hydrocooling. Vacuum cooling is most effective if the sprouts are wetted prior to cooling in order to minimize wilting. Bulk shipments usually are package-iced and top-iced to ensure maintenance of desirable low temperature and high humidity. After precooling, shelf life can be extended by the use of perforated polyethylene liners, which prevent moisture loss. Non-perforated poly liners can lead to accumulation of injurious CO_2 levels or depletion of O_2, leading to off-odors.

Controlled atmosphere (CA) storage benefits Brussels sprouts, retarding yellowing and decay, if storage conditions are higher than 32°F (0°C). Brussels sprouts are tolerant of up to 10% CO_2 and down to 1% O_2 levels. At 41 to 45°F (5 to 7.2°C) the best CA for quality preservation is 1 to 2% O_2 plus 5 to 10% CO_2. CA storage can extend storage at 41°F (5°C) 10 to 18 days to about 4 weeks, but does not extend storage life at 32°F (0°C).

Brussels sprouts are extremely sensitive to exposure to ethylene, which causes rapid leaf yellowing and leaf abscission. Brussels sprouts must never be stored with fruits that produce substantial quantities of ethylene, especially apples, pears and peaches.

The most important diseases that affect Brussels sprouts storage life are Bacterial Soft Rot and Alternaria Rot.

Diseases and Injuries

Alternaria Leaf Spot	At first grayish to black spots most conspicuous on outer leaves. Spots are usually brown-black and may have concentric rings of infected tissue, producing "target board" effect. When infection is severe, leaves become yellow or drop from the bud. **Control:** Avoid bruises. Trim infected leaves before shipment. Maintain transit temperatures near 40°F (4.4°C) and store at 32 to 33°F (0 to 0.6°C) but not above 35°F (2.2°C).
Bacterial Soft Rot	First seen as water-soaked or greasy spots on leaves. Often follows bruises, cracks or other injuries. In later stages, infected areas turn brown to black, often with a foul odor. Disease spreads rapidly in warm, humid weather. **Control**: Care in handling to avoid cuts, bruises and other injuries. Store at 32 to 33°F (0 to 0.6°C), not above 35°F (2.2°C), and avoid freezing temperatures. Aeration to increase drying of infected areas may partially prevent spread of decay.
Bacterial Zonate Spot	Potentially important market disease sometimes confused with Alternaria. First symptom to appear is irregular lesions, 1/16 to 1/2 inch (1.6 to 12.7 mm) in diameter, light brown at first, later turning darker brown. Infected areas are firm and pliable but only slightly soft.

	Control: Low temperature storage.
Blackleg	This disease has always been a threat because of the seed borne nature of the pathogen. The fungus attacks the plant stem causing it to decay from the surface of the ground downward. The decay is a dry rot or girdle that leaves a dead brown stub below ground. Tiny black dots, the fungus fruiting bodies, develop within the lesions and these contain numerous spores. Heads from late infected plants may appear healthy at harvest but may later in storage develop sunken black spots around their base. **Control:** Seed treatment includes hot water and chemical.
Black Rot	Field disease characterized by darkening of vascular elements forming black network of leaves. Yellowing and brown-black spots may occur at margins of leaves during early stages. Infected head may remain firm, but vascular elements of stem discolored. Bacterial soft rot may rapidly invade infected tissue. **Control**: Little storage operator can do after harvest other than careful grading to remove buds showing infected outer leaves. Unlike bacterial soft rot, black rot does not spread or develop appreciably in storage under refrigeration. Control of black rot relies on a comprehensive program to prevent or eliminate the spread of bacteria from season to season, and the use of disease-free seed.
Botrytis Fray (Leaf) Mold	This fungus disease causes serious losses to Brussels sprouts in storage. Small, brown or gray fluffy fungus patches develop on old or damaged leaves. *Botrytis cinerea* prefers senescent tissues, so it becomes an increasingly important cause of rot as stored sprouts age. **Control**: Use maximum care to reduce bruising of sprouts because *Botrytis* is typically a wound parasite. The best control appears to be high relative humidity and low temperature, which keeps leaf tissues green and viable, hence less susceptible to attack. Maintain good circulation of the storage air.
Sclerotinia Rot or White Mold	This fungus disease can cause losses in the field, in storage, and under transit and market conditions. Most plants are infected in the field after midseason with tan, water-soaked, circular areas caused by white, cottony fungal growth appearing at the top or on the sides of sprouts. The fungus can colonize the entire bud and produce large, black, seed like structures called sclerotia on the diseased tissue. **Control**: There are no fungicides registered for use on Brussels sprouts to control white mold. Thus, growers must rely upon sound cultural practices for control. Avoid planting in fields that will restrict air circulation. Continuous cropping of susceptible crops will result in a buildup of the fungus in the soil. Non-susceptible crops include corn, rye, wheat, etc., which should be used in rotation. Because the fungus will also infect weeds (ragweed, dandelion, and wild clover), good weed control is important. Avoid mechanical injuries to sprouts as wounds are readily colonized by the white mold fungus. In storage, an infected, wounded bud will provide inoculum for infection of

	healthy buds that are in contact with the diseased tissues.
Downy Mildew	First pale greenish-yellow angular spots later covered with white downy growth on underside of leaves. Older spots enlarge and become yellowish brown. Older infected leaves may be shed. Grayish-black discoloration may occur in the stalk and extend to innermost bud leaves. **Control**: Use fungicides to control fungus *Peronospora parasitica* in the field. Carefully sort sprouts at the packing shed. Store Brussels sprouts at 32 to 33°F (0 to 0.6°C) but not over 35°F (2.2°C).
Watery Soft Rot	During transit and storage, infected produce may leak, but have no disagreeable odor. In moist air, the lesions may be water soaked or have a pinkish border and yellow to light brown center. Eventually, the entire bud may be covered with the white cottony growth of the fungus, containing at first white, and later, black, mustard seed-like bodies. Such infected buds in moist air may be completely liquefied. In dry air they may become brown mummies. The disease appears most often at the base of the buds and spreads rapidly during storage. Nesting is common. **Control**: Careful sorting of infected buds. Maintain temperature as near 32°F (0°C) as practical because rot progresses even at 32°F (0°C).
Thrips	Brown to black spots or specks of leaves. Larvae and adult thrips may be found in interior leaves. Insects puncture leaves and may cause edema or raised pustules. Leaves may have silvery sheen between areas of discolored tissue. **Control:** No warehouse control measures.
Freezing Injury	May occur at 30.4°F (-0.9°C). Buds may freeze without apparent injury, but injury noticed when leaves thaw. After thawing, tissue appears water soaked, or slightly shriveled or wilted. Frozen tissues may become pithy or spongy and tough with loss of flavor. Frozen tissues are very susceptible to invasion by bacterial soft rot organisms. When Brussels sprouts is held below 31°F (-0.6°C) for any extended period in refrigerated storage, there can be an internal breakdown of the non-green tissues, especially over the top of the core. This condition is not readily apparent unless the bud is cut open. **Control:** Avoid temperatures below 31°F (-0.6°C).
Atmosphere injury	Exposure to below 1% O_2 can cause extreme bitterness and may also cause internal discoloration. Exposure to greater than 10% CO_2 can result in off-flavors and off-odors. **Control:** Avoid exposure of Brussels sprouts to <1% O_2 or >10% CO_2.

Freezing

Brussels sprouts may be blast frozen after packing on trays or individually quick frozen (IQF). If packed in bulk in 20- to 60-lb (9.1- to 27.2-kg) cartons or tote bins, it is advisable to IQF the product, preferably by fluidized bed technique before packing. Sometimes Brussels sprouts are 'shocked' with dry ice (solid CO_2) to enable them to be frozen by IQF.

Frozen Brussels sprouts lose their brilliant green color and become soggy when stored at temperatures above 0°F (-17.8°C). The chlorophyll changes to a brown color. Exposure to elevated temperatures for short periods of time is not critical, but repeated exposures do damage quality. If stored at 0°F (-17.8°C), good quality is maintained for 10 months and, if stored at -10°F (-23.3°C), for 1 year or longer.

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