

Cabbage

Also applies to Napa and Bok Choy Chinese Cabbage

Revised 2018

Thermal Properties

	English	Metric
Moisture, %	92.18	--
Protein, %	1.28	--
Fat, %	0.10	--
Carbohydrate, %	5.80	--
Fiber, %	2.50	--
Ash, %	0.64	--
Specific Heat Above Freezing	0.96 Btu/lb*°F	4.02 kJ/(kg*K)
Specific Heat Below Freezing	0.44 Btu/lb*°F	1.85 kJ/(kg*K)
Latent Heat of Fusion	132 Btu/lb	308 kJ/kg

Storage Conditions

	Refrigeration		Controlled Atmosphere (CA)	Frozen
Temperature	32°F (0°C)		32°F (0°C)	-5°F (-20.6°C)
Relative Humidity	98 to 100%		95 to 98%	
Storage Period	early crop	3 to 6 weeks	7 to 9 months	1 to 4 years
	late crop	5 to 6 months		
	Chinese	2 to 3 months		
Highest Freezing Point	30.4°F (-0.9°C)			

Mature or late crop cabbage can be stored for many months at 32°F (0°C). Since it is not overly perishable and is usually harvested in cool weather, late crop cabbage does not require precooling before being placed into storage. Early crop cabbage and Chinese cabbage containing a high degree of field heat benefit from hydrocooling and forced-air cooling prior to storage, and top icing before

shipping. Placing a layer of crushed ice over car or truck loads of sacked or crated cabbage is sometimes done to maintain desired low temperatures.

Cabbage should be handled carefully from field to storage, and only solid heads with no yellowing, decay or mechanical injuries should be stored. Before storage, all loose leaves should be trimmed away, leaving heads with 3 to 6 tight wrapper leaves. Loose leaves interfere with ventilation between heads, which is essential for successful storage. On being removed from storage, the heads should be trimmed again to remove loose and damaged leaves. Cabbage in mesh bags is easily damaged unless carefully handled.

Crates or bins are the best storage containers. Many growers use pallet boxes as both field containers and for storage so that there is no handling of the cabbage from the time of harvest until preparation for shipment. Some of the larger storages stack these pallet boxes five high.

Care should be used in loading pallet boxes in the field to see that no single head is above the plane of the stacking points of the boxes. When cabbage heads are piled above the plane of the crate they will be damaged during stacking of crates. The placement of another pallet on top forces the exposed head downward into the load. Since cabbage heads are quite firm, the dispersal of the crushing forces bruises every head below and adjacent to the exposed head. These bruised places leak cell sap and are ideal focal points for the initiation of storage diseases, particularly *Botrytis* gray mold, whose spores seem to be ever present.

Cabbage wilts quickly if held under storage conditions that are too dry. The relative humidity (RH) should be nearly saturated at 98-100% RH to keep the leaves fresh and turgid, reduce decay development, and minimize trimming losses. Air circulation must be adequate to remove respiratory heat. Under some storage conditions, use of perforated polyethylene liners or pallet box covers to prevent desiccation may prove desirable. When rubbed against each other, the heads should squeak, indicating crispness.

Late crop cabbage under proper refrigeration at 32°F (0°C) should keep for 5 to 6 months in storage. Late crop cabbage is also successfully held in common storage (utilizing cool night temperatures and insulated structures) in the northern regions, where a fairly uniform inside temperature of 32 to 35°F (0 to 2.2°C) can be maintained. However, care must be taken so that stored cabbage is not exposed to air below its highest freezing point 30.4°F (-0.9°C).

Early crop cabbage, especially southern-grown, has a limited storage life of 3 to 6 weeks at 32°F (0°C) with 98 to 100% RH. Savoy cabbage and Chinese cabbage will not store as long as the regular smooth leaf types, generally not more than a maximum of 2 to 3 months.

Late crop cabbage can be stored for 7 to 9 months in controlled atmosphere (CA) at 32°F (0°C) with 2 to 3% O₂ plus 4 to 5% CO₂. CA inhibits decay, root growth, and sprouting, and generally retards senescence, resulting in less yellowing or bleaching of the leaves, more succulence, and greater retention of flavor.

Usually trimming is less with CA. Storage disorders such as gray speck disease and vein streaking are reduced or eliminated in some cultivars when stored in CA. Chinese cabbage stored in 1% O₂ at 32°F (0°C) has kept in good condition for 5 months.

Sanitizing of pallet boxes will reduce fungal infections when cabbage is stored in the same pallet boxes year after year. The boxes should be first cleaned, and then sanitized using labeled products such as a 10% solution of NaOCl (household bleach). Prepare fresh chlorine solutions frequently as organic debris and soil quickly tie up active chlorine, and water pH should not go above 7.5.

Cabbage is sensitive to ethylene exposure, more so in air storage than in CA. Ethylene concentrations as low as 1 ppm have been shown to cause some cabbage leaf abscission and color loss after several months of storage. Concentrations of 10 to 100 ppm of ethylene are known to cause leaf abscission (fall-off) and loss of green color in as little as 5 weeks. Adequate ventilation or the use of an ethylene scrubber system is recommended for long term cabbage storage in refrigeration. Cabbage should never be stored with apples or any other fruit or vegetable known to give off ethylene (C₂H₄) in cold storage. Disease organisms also cause so-called wound ethylene in cabbage, and an excessive amount of disease in a store can cause considerable ethylene damage.

Cabbage shredded into coleslaw is very perishable and should be distributed from the processor to food service or retail channels under good refrigeration at 40°F (4.4°C) or below. Coleslaw has only a few days shelf life. Sanitation in processing is extremely important.

Diseases and Injuries

Alternaria Leaf Spot	At first grayish to black spots most conspicuous on outer leaves. Spots enlarge to 1 inch or more in diameter - 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 head. 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

	<p>only slightly soft.</p> <p>Control: Low temperature storage.</p>
Black Leaf Speck, Pepper Spot	<p>Sharply sunken brown or black specks occurring chiefly on wrapper leaves but may occur on leaves throughout the head. Midveins and small leaf veins may be discolored a gray-blue and are soft to mushy. Disease in Florida reported to be associated with high copper content of soils or may be physiological in nature. Normally symptoms do not appear until after field chilling, or the cabbage is held in refrigerated storage or transit.</p> <p>Pepper Spot symptoms are similar to those for Black Leaf Speck. The disease may be caused by several viruses including cauliflower or turnip mosaic virus introduced by aphids in the field. Development of the physiological Pepper Spot symptoms on Chinese cabbage in storage is faster at 41°F (5°C) than at either 32°F (0°C) or 50°F (10°C).</p> <p>Control: Maintaining storage at 32°F (0°C) may slow symptom development.</p>
Blackleg	<p>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.</p> <p>Control: Seed treatment of cabbage seed includes hot water and chemical.</p>
Black Rot	<p>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.</p> <p>Control: Little storage operator can do after harvest other than careful grading to remove heads 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.</p>
Botrytis Fray (Leaf) Mold	<p>This fungus disease causes serious losses to cabbage in storage. Small, brown or gray fluffy fungus patches develop on old or damaged leaves. <i>Botrytis cinerea</i> prefers senescent tissues, so it becomes an increasingly important cause of rot as stored cabbage ages.</p> <p>Control: Use maximum care to reduce bruising of heads because <i>Botrytis</i> 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.</p>
Sclerotinia Rot or White Mold	<p>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 mid-season with tan,</p>

	<p>water-soaked, circular areas caused by white, cottony fungal growth appearing at the top or on the sides of cabbage heads. The fungus can colonize the entire head and produce large, black, seed like structures called sclerotia on the diseased tissue.</p> <p>Control: There are no fungicides registered for use on cabbage 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 cabbage heads as wounds are readily colonized by the white mold fungus. In storage, an infected, wounded head will provide inoculum for infection of healthy cabbage heads that are in contact with the diseased tissues.</p>
Downy Mildew	<p>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.</p> <p>Control: Use fungicides to control fungus <i>Peronospora parasitica</i> in the field. Carefully sort heads at the packing shed. Store cabbage at 32 to 33°F (0 to 0.6°C) but not over 35°F (2.2°C).</p>
Watery Soft Rot	<p>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 head of cabbage may be covered with the white cottony growth of the fungus, containing at first white, and later, black, mustard seed-like bodies. Such infected heads 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 heads and spreads rapidly during storage. Nesting is common.</p> <p>Control: Careful sorting of infected heads. Maintain temperature as near 32°F (0°C) as practical because rot progresses even at 32°F (0°C).</p>
Thrips	<p>Brown to black spots of leaves resembling black speck. 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.</p> <p>Control: No warehouse control measures.</p>
Freezing Injury	<p>May occur at 30.4°F (-0.9°C). Heads 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 cabbage 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 until the head is cut. The damaged tissues become rusty red in color when exposed to air and eventually collapse.</p>

Some cabbage growers who store also have termed this condition as "red heart".

Control: Avoid temperatures below 31°F (-0.6°C).

Freezing

Cooked cabbage in the form of stuffed cabbage and the like are frozen prepared items that freeze well. Uncooked cabbage loses its crispness on freezing.

Whole fresh cabbage in 1,000-lb (454-kg) bins can be frozen for later processing. Storage life is 1 to 4 years, although 5 years is not uncommon. After delivery to the processor, the thawing process is accomplished by soaking the product in hot water for 24 hours.

WFLO is indebted to Dr. Jeff Brecht, Horticultural Sciences Department, University of Florida, for the review and revision of this topic.