Lettuce

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Scientific Name and Introduction

Four distinct types of lettuce are produced in the United States: crisphead or iceberg *(Lactuca sativa* L. var. *capitata);* butterhead, bib, or Boston *(L. sativa*, var. *capitata);* cos or romaine *(L. sativa*, var. *longifolia);* and leaf *(L. sativa*, var. *crispa).* Two others types, stem or celtuce *(L. sativa* var. *asparagina)* and Latin are rarely found outside local or ethnic communities.

Crisphead lettuce produces large, heavy, compact folded heads with crisp, brittle, prominently veined leaves. Butterhead lettuce forms open heads with softer leaves having a smooth texture. Cos lettuce does not form a true head, but is composed of upright, large, elongated, and often coarser leaves. Leaf lettuce also does not produce a head, and the leaves are more spreading, delicate, smaller, and less elongate than cos.

Crisphead lettuce is the main type grown in the United States and is best adapted for long distance shipment. A greater percentage of all types of lettuce are being processed into fresh-cut salad mixes for commercial and home use. With proper vacuum-cooling and packaging, refrigerated transportation under controlled atmosphere can supply whole and packaged lettuce to national and international markets.

Quality Characteristics and Criteria

Head lettuce should be solid with no seed-stem, defects, or decay. In general, high-quality lettuce should be clean, free of browning, crisp and turgid, and bright light green.

Horticultural Maturity Indices

Head lettuce is harvested when the heads are well formed and solid (Ryall and Lipton 1979). Maturity is based on head compactness, and the firmness of the head is related to its susceptibility to certain postharvest disorders. Soft heads are easily damaged, while fairly firm heads have higher respiration rates. Firm heads have maximal storage life, while hard and extra-hard heads are more prone to develop russet spotting, pink rib, and other physiological disorders.

Grades, Sizes, and Packaging

Head lettuce is graded by size and firmness, while leafy types are graded by size (Hardenburg et al. 1986). Lettuces, as with other leafy vegetables, must be kept clean and free of soil and mud. This is easier when grown on mineral soils than on muck (organic) soils. A strong bitter taste and toughness develops if harvest is delayed or if lettuce is overmature, and then the product becomes unmarketable.

Because lettuce is very fragile, it should be handled as little as possible. Field packing and palletizing eliminate a major source of mechanical damage, but they require specialized handling

equipment and vacuum-cooling facilities to be practical. The stem is cut at ground level and the head trimmed of unusable leaves. Harvesting and field packing by hand is assisted by various equipment including conveyors and mobile packing stations. Heads can be wrapped or bagged in plastic film by the cutter or the packer. Wrapped or loose heads are then placed in cardboard containers that are stapled closed and palletized. Leaf, butterhead, and cos types are cut, trimmed, and tied into compact bundles before being placed in cartons.

Crisphead or iceberg lettuce is usually packaged in 20- to 22-kg (43- to 48-lb), 24-count cartons. Cos or romaine lettuce is commonly packaged in 24-count cartons. Leaf lettuce is usually packaged in 9- to 11-kg (20- to 25-lb) or 24-count cartons. Butterhead or Boston lettuce is usually packaged in 9-kg (20-lb) cartons. Bibb and greenhouse-grown lettuce are commonly packaged in 4.5-kg (10-lb) cartons.

Lettuce harvested for processing is placed in large bulk bins for transportation to the precooling or processing facility. Lettuce may be cored in the field or at a local or regional processing facility. At the processing facility, heads are cut, washed in cold water, and centrifuged to remove excess water. Cut lettuce is often mixed with other types of lettuce or greens, shredded carrot, and red cabbage to produce a salad bag mix. The mix may be treated with a processing aid composed of a chlorine-containing compound and/or an antioxidant or preservative during washing or before packaging. The package is made from special films that are selected to maintain a desired lower O_2 and higher CO_2 concentration than in air. The bags are then placed in cartons for temporary cold storage or for immediate shipment to market. Since gas composition in bags results from a dynamic interplay between tissue respiration and film permeability, it is important to maintain proper temperature and to know the respiratory characteristics of the enclosed tissue.

Precooling Conditions

Vacuum-cooling is the preferred method for precooling all lettuces (Ryall and Lipton 1979, Hardenburg et al. 1986). For effective vacuum-cooling, containers and film wraps are perforated or readily permeable to water vapor. If heads of lettuce are dry and warmer than 25 °C (77 °F), clean water is sprinkled on them the before closing the cartons to aid cooling. A modification called hydrovacuum reduces water loss during cooling. Thorough precooling is essential because mechanically refrigerated trucks do not have enough cooling capacity to cool warm lettuce during transit. Field heat retained in the densely packed cartons can be removed by forced air where vacuum-cooling facilities are not available, but it is much less effective. Hydrocooling is effective for nonheading lettuce types but should not be used with head lettuce since the water retained in the head fosters decay.

Optimum Storage Conditions

Lettuce should be quickly cooled and maintained as close to 0 °C (32 °F) as possible with 98 to 100% RH. Head types are better adapted to prolong storage than are the other types, but none keep longer than 4 weeks, and about half that time at 5 °C (41 °F). Film liners or individual polyethylene head wraps are desirable for attaining high RH; however they should be perforated or be permeable to maintain a noninjurious atmosphere and to avoid 100% RH on removal from

storage. Lettuce is easily damaged by freezing, so all parts of the storage room must be kept above the highest freezing point of lettuce, -0.2 °C (31.6 °F).

Though most lettuce is hand-harvested, some mechanical harvesters are available for product destined for processing into bag mixes. The attendant greater damage to the tissue and the induced higher rates of respiration and water loss requires greater attention to maintaining the optimal storage conditions of temperature and RH.

Controlled Atmosphere (CA) Considerations

Lettuce, especially crisphead and fresh-cut, respond favorably to CA (Saltveit 1997a). Levels of 1 to 3% O_2 at temperatures of 0 to 5 °C (32 to 41 °F) reduce russet spotting in susceptible lots. Intact heads do not benefit from elevated CO_2, and injury—brown stain—may develop when lettuce is transferred from storage in >2% CO_2 to air at 10 °C (50 °F) (Ke and Saltveit 1989). A 2 to 5% O_2 atmosphere maintains appearance of lettuce and inhibits pink rib and butt discoloration compared to air. Brown stain is intensified when O_2 is reduced to 2 to 3%, but the effect differs by cultivar. If lettuce needs to be in transit overseas for a month, an atmosphere of 2% CO_2 and 3% O_2 is recommended because the reduction in decay achieved by 2% CO_2 outweighs the danger of injury. Romaine and leaf lettuce appear to tolerate a slightly higher CO_2 level when packaged than head lettuce. Browning is a major problem with fresh-cut lettuce, and is controlled by packaging in <1% O_2 and 10% CO_2 (Lopez-Galvez et al. 1996, Smyth et al. 1998). The elevated level of CO_2 is more effective at reducing browning of the cut surfaces than it is at inducing brown stain.

Retail Outlet Display Considerations

Lettuce should be maintained under cold conditions to maximize storage and shelf-life. Periodic sprays of cold water minimize dehydration. Avoid storage with commodities that produce ethylene such as apples and tomatoes. All lettuces are very susceptible to water loss and to ethylene-induced disorders, and they rapidly deteriorate at elevated temperatures.

Chilling Sensitivity

Not chilling sensitive, but freezing at -0.2 °C (31.6 °F) must be avoided.

Ethylene Production and Sensitivity

Ethylene production is very low, but exposure to ethylene can result in damage such as russet spotting and leaf yellowing.

Respiration Rates

Temperature	Head lettuce	Leaf lettuce
	-------mg CO_2 kg^{-1} h^{-1}-------	
0 °C	6 to 17	19 to 27
5 °C	13 to 20	24 to 35

10 °C	21 to 40	32 to 46
15 °C	32 to 45	51 to 74
20 °C	51 to 60	82 to 120
25 °C	73 to 91	120 to 173

To get mL CO_2 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 ton^{-1} day^{-1} or by 61 to get kcal $tonne^{-1}$ day^{-1}.

Physiological Disorders

Some of the more common disorders of head lettuce include tipburn, russet spotting, brown stain, and pink rib (Ryall and Lipton 1979, Saltveit 1997b). Hard heads are more susceptible to these disorders than firm lettuce. Tipburn is of field origin, but occasionally increases in severity after harvest. Leaves with tipburn have brown, often necrotic leaf margins. Russet spotting, which is caused by exposure to ethylene and its induction of the synthesis, accumulation, and oxidation of phenolic compounds at temperatures around 5 °C (41 °F), occasionally causes serious losses. Russet spots appear as dark brown, oval lesions on the midribs, and on the green leaf tissue in severe cases. It is easily controlled by making sure the storage atmosphere is free of ethylene and that the temperature is below 2 °C (36 °F).

Lettuce should not be stored with ethylene-producing commodities such as apples, cantaloupes, pears, and peaches. Storage in a low-O_2 atmosphere (1 to 8%) is very effective in controlling russet spotting. Brown stain is causedby exposure to >2.5% CO_2 and appears as large, irregularly shaped brown spots or streaks mostly on the midrib. Pink rib occurs in overmature heads stored at elevated temperatures and appears as a diffuse pink discoloration of the midrib; the cause of this disorder is unknown.

Postharvest Pathology

Bacterial soft rot, the most serious disease of lettuce, often starts on bruised leaves and results in a slimy breakdown of the tissue (Saltveit 1997b). A similar breakdown of tissue follows fungal infection by *Sclerotinia* and gray mold rot caused by *Botrytis cinerea*. Trimming and storage at 0 °C (32 °F) greatly reduce the severity of these disorders.

Quarantine Issues

None are known.

Suitability as Fresh-Cut Product

Suitability is very high, especially in salad mixes with other leafy greens.

Special Considerations

Lettuce is fragile and must be handled with care to avoid mechanical damage and to minimize

discoloration and pathological problems. Temperatures must be kept low and RH high to prevent loss of turgor and wilting. Ethylene must be avoided.

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