Kiwifruit

Revised 2018

Storage Conditions

Temperature	32-33°F (0 to 0.6°C)
Relative Humidity	90-95%
Atmosphere	<10 parts per billion (ppb) ethylene

Storage Life

	$2\%\ O_2$ and $5\%\ CO_2$	Air Storage
Normal maturity	6-8 months	3-4 months
High maturity	8 months or more	6 months

Storage Information

Kiwifruit are capable of long-term storage only if carefully protected against deterioration prior to and during storage. They are harvested when mature but unripe and must ripen before eating. Kiwifruit are extremely sensitive to ethylene gas, which causes rapid flesh softening during storage, starch depletions to reduced sugars, increased susceptibility to rotting organisms, and physiological breakdown, even when held in controlled atmospheres. At harvest, kiwifruit contain high amounts of starch which will convert to reduced sugars during storage and ripening.

Fresh kiwifruit should be harvested with a minimum Soluble Solids Content (SSC) of 6.2%, and a minimum flesh firmness of 13-16 pounds-force, as determined with a penetrometer with a 5/16-inch tip diameter. Good quality kiwifruit will reach 14% SSC or higher after ripening. Best long-term air storage, in excess of 4 months, results from high maturity harvest, typically late September-November in California, when flesh firmness is higher than 14 pounds-force and SSC is >7.0%. Kiwifruit should be rapidly cooled after harvest either before or after packing. Cooling delays of only 6 to 18 hours in the presence of as little as 10 ppb ethylene will accelerate flesh softening during subsequent storage. Care should be taken to avoid handling injuries which can result in physical bruising and increased ethylene production, especially as the fruit soften.

A common "curing" treatment involving a 48-hour delayed cooling at 59°F (15°C) under medium air velocity and a high relative humidity reduces gray mold (*Botrytis*) incidence during storage. Free ethylene condition during this "curing" period is essential to avoid an earlier fruit softening during storage.

Kiwifruit for storage should be protected from any exposure to external sources of ethylene. These can include any internal combustion engines, petroleum fuel, open flame heaters, tobacco or other smoke, decaying or deteriorating produce or plant residues, tar base ballasts for lighting fixtures, or other ethylene producing commodities. Storage rooms should be cleansed and ventilated with ethylene-free air in advance of storage to purge residual ethylene that might remain from other operations.

Only electric forklifts should be used in transporting kiwifruit in the warehouse, since internal-combustion engines produce large amounts of ethylene. Petroleum fueled forklifts must not be used in handling kiwifruit. Kiwifruit should not be stored with or near any ethylene-producing commodity (e.g., apples, pears). Even ethylene diffusion through walls from an adjacent storage room can cause problems.

A continuous purge of six or more air changes per day will prevent ethylene buildup where very low outside ethylene concentrations exist. Variable air flow capability is useful in adjusting to changing needs for air purging. Outside ethylene concentrations in rural areas during fall and winter are usually below 5-7 ppb. For storage in or near industrial areas, ethylene content of outside air should be monitored to assure that it is sufficiently low to use. Where continuous venting is not used, cross ventilation air flow should be available in air storage rooms for easy purging if ethylene concentrations rise. Purging should be done in early morning hours when outside ethylene concentrations are lowest and air temperatures are minimum. Where outside air cannot be used or in addition to it, ethylene "scrubbing" devices are available for use inside storage rooms, but efficiency may be poor at these very low ethylene levels. The most commonly available scrubbers use a bed of potassium permanganate impregnated aluminum oxide pellets to oxidize ethylene contacting it.

Controlled-atmospheres (CA) storage reduce excessive flesh softening during long-term storage. An atmosphere containing 2% O_2 and 5% CO_2 and low or free from ethylene has performed best. Ethylene must be excluded from CA storage as carefully as from air storage because it induces an internal breakdown or white inclusions problem in the presence of as little as 3% CO_2 (use ethylene scrubbing devices – see above). Because of rapid softening of kiwifruit following harvest, the CA conditions must be established within 1 week of harvest.

Kiwifruit are commonly packed in plastic trays in 1-layer flats or in volume-fill or 3-layer tray packed lugs. The flats and lugs are lined with a polyethylene plastic sheet or liner that is folded over the packed fruit to protect against water loss. This wrap seriously inhibits the air flow that is needed for rapid cooling of the packed fruit.

Forced-air cooling of poly-wrapped kiwifruit in flats can be accomplished using the following schedule:

	Air flow (cfm/lb. fruit)		**Static pressure through pallet (inches w.g.)**	
7/8 cooling time	12 hours	18 hours	12 hours	18 hours
PACKAGE (POLY-WRAPPED FLATS):				
Wood, ¼" cleats, no pad	0.7	0.3	0.9	0.4
Wood, no cleats, no pad	0.6	0.4	0.9	0.4
Corrugated, 5% vent, no pad	0.5	0.26	0.8	0.4
Wood, ¼" cleats, top pad	1.0	0.5	1.3	0.5
Wood, no cleats, top pad	1.0	0.6	1.4	0.7

Corrugated, 5% vent, top pad	0.9	0.4	2.1	1.0

The freezing point of kiwifruit can be as high as 33°F (0.6°C) for early harvested fruit and 32°F (0°C) for late harvested fruit. Thus, storage facilities must have minimal temperature fluctuation to avoid the danger of freezing while maintaining kiwifruit at 32-33°F (0 to 0.6°C). During storage the SSC should increase to more than 12% as a result of starch conversion and other changes that are associated with ripening. A high relative humidity of around 95% is important because of water loss and subsequent fruit shrivel associated with long-term storage.

Diseases

Storage rots cause serious losses to kiwifruit, especially during extended storage periods. These losses are aggravated by rapid spread of the rot organisms, from infected to healthy fruits ("nesting"). Packed flats are commonly opened and inspected prior to shipment and any diseased fruit are removed. This is expensive because of the direct fruit losses and the high repacking cost.

Mold growth is sometimes seen over the surface of kiwifruit when the fruit is removed from storage. This normally does not penetrate the skin and rot the fruit's flesh. It causes concern during marketing because buyers and receivers may associate such conditions with fruit rotting. The problem starts with infection of dead organic matter on the fruit surface. Old floral parts may remain attached, or detached floral parts and other debris will lodge in the surface hairs, called trichomes, and serve as a fungal infection source. During storage in a high relative humidity (RH) environment, the fungi will spread mycelia over the fruit surface. Upon removal to dry conditions, such as for repacking, the visible mold will often disappear, but will quickly reappear when returned to high RH, such as during transport to market.

Most kiwifruit are now brushed to remove as much surface debris as possible prior to packing. Brushing can be effective if it completely removes both entrapped and attached materials; however, thorough brushing is difficult to achieve. Brushing should be carefully monitored to minimize injury to the fruit, including but not limited to short dwell time, soft brushes, and moderate brushing speed. Injuries caused by brushing can result in accelerated ethylene production by the fruit, thus aggravating the flesh softening problem during subsequent storage.

Gray Mold (*Botrytis cinerea Pers. ex. Fr*.):

The most extensive pathogenic losses to California kiwifruit result from gray mold infections. Harvest wounds, even when too small to be visible to the unaided eye, are a major path for infection. Such wounds provide an ideal environment for spore germination and penetration into the fruit. Contaminated tissue at the stem and blossom ends of the fruit, including adhering dead floral parts such as styles, stamens, and petals, become colonized by the organism and provide inoculum for future infections. The gray mold organism is also capable of direct penetration, given favorable temperature, moisture, and fruit conditions.

Gray mold is capable of continued growth even at low storage temperatures. The organism can spread from fruit to fruit, so a "nesting" pattern is often seen in flats after prolonged storage. Rapid spread during storage normally follows excessive flesh softening associated with ethylene exposure or too high a storage temperature.

Other Storage Rots:

Alternaria rot, caused by the same species that causes surface mold, is occasionally found in sunburned tissue. This causes a hard dry rot of the tissue.

Juice Blotch. On occasion, fruit lots handled in packing houses may contain some fruit so soft that they are crushed. The resulting juice may contaminate surfaces over which sound fruit are placed. In highly humid storage rooms, these may support the growth of *A. alternata* or other fungi that have adapted to the low temperatures of storage rooms. The dark blotches, which defy cleaning, adversely affect the fruit's appearance but have not resulted in fruit rot. In one instance the blotches were white because of the presence of an unidentified chalk-colored fungus. A somewhat different discoloration occurs when fruit contact juice that is on unprotected metal.

Blue mold (*Pencillium sp.*) is occasionally found after prolonged storage, but is seldom serious, and likely results from contamination of fruit wounds.

Phomopsis stem end rot (*Diaporthe actinidiae Som. and Ber.*) has been observed in both New Zealand and California fruit. It is a soft rot, usually starting at the stem end, and may cause wetness on infected and surrounding fruit from exuding juice.

Disease Control:

Anything that can slow the rate of physiological activity of the fruit can also slow the growth and spread of disease organisms. Avoiding physical injury to the fruit will minimize disease development. Keeping the fruit in a firm unripe condition will avoid major fruit rotting problems. Short delay cooling, low storage temperature, avoidance of ethylene exposure before and during storage, and CA storage will all help to delay ripening, and thus the growth and spread of disease organisms. Thorough brushing to remove dead tissue can greatly reduce the surface mold problem, but care must be taken to avoid injuring the fruit.

Because of changes in registration of chemicals for postharvest application, operators should seek current registration information on fungicides available for kiwifruit in their region. All fungicides must be used in accordance with registration provisions, and may not be allowed on fruits destined for certain markets.

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