Optimum Procedures for Ripening Kiwifruit

by Carlos H. Crisosto

Most consumers prefer to purchase kiwifruit that are near ripe ("ready to eat"). To ensure good tasting, "ready to eat" fruit, kiwifruit should be ripened at any step during postharvest handling before consumer consumption. This is essential for early season, freshly harvested kiwifruit. To assure good flavor of kiwifruit when ripe, we recommend picking them when they reach at least a minimum of 6.5% SSC measured in the field or 13% SSC after the accelerated ripening test.

Flesh firmness is the best indicator of kiwifruit ripening and predictor of shelf life. Fruit that measures 2-3 pounds-force flesh firmness is ripe and "ready-to-eat."

Ripening at the Shipping Point Ethylene Pre-conditioning Treatment

Ethylene applied at 100 ppm by using the "shot system" for 12 hours within a 0 to 20°C (32 to 68°F) temperature range will induce ripening as indicated by uniform kiwifruit softening and starch conversion into sugars. Ethylene exposure can be shortened to 6 hours by using a catalytic generator (C_2H_4) or flow-through application system. Ethylene pre-conditioning treatment (100 ppm for 12 hours) is only effective on freshly harvested kiwifruit or those that have been in cold storage for less than 5 weeks. Fruits kept in cold storage for longer than 5 weeks will ripen upon transfer to ripening temperatures of 59-70°C (15-21°F) by their own ethylene.

The temperature setting during treatment and shipment should be adjusted according to the anticipated consumption schedule. To prevent softening due to delayed shipments, apply ethylene to cold kiwifruit. Cold kiwifruit treated at near 0°C (32°F) and maintained at that temperature may be held up to 5 weeks. These kiwifruit will reach a firmness of about 3 pounds in 2 to 3 days after being transferred to 20°C (68°F).

Application of Ethylene Pre-conditioning Treatment

Place kiwifruit in a ripening room with good temperature and relative humidity control. The type of kiwifruit container such as tray pack, volume fill packages, or tri-wall containers with polyliners do not interfere with the preconditioning treatment. The ripening room should be located far away from any packing facilities to avoid ethylene contamination of long-term storage kiwifruit. High relative humidity (90-95%) is especially recommended when ripening is carried out at temperatures higher than 7.5°C (45°F). The temperature setting during treatment and shipment should be adjusted according to the anticipated consumption schedule (Table 1).

Table 1. Rate of kiwifruit softening after ethylene treatment at 20ºC (68ºF).

Temperature		Days to reach a firmness
°C	°F	of 3 lbs-force
0	32	6.5 to 7.0
7.5	45	6.0 to 7.0
20	68	3.0 to 4.5

If shipping is delayed after treatment, fruit will reach a firmness of about 3 pounds-force within six days when held at 0°C (32°F). In this case, the temperature setting during storage and transportation should be close to 0°C (32°F). Cold kiwifruit treated at near 0°C (32°F) and maintained at that temperature may be held up to 5 weeks. These kiwifruit will reach a firmness of about 3 pounds-force in 2 to 3 days after being transferred to 20°C (68°F). The temperature should be set near 0°C (32°F) during transportation.

Ripening at the Retail End

As a general rule, non-conditioned ripened kiwifruit received in your warehouse that have been in storage less than 4 weeks or have a flesh firmness level of 8-10 pounds or greater should be ripened by using ethylene at warm temperature.

Pre-conditioned kiwifruit firmness must be tested upon arrival to the warehouse or retail store and handled according to its rate of softening and your rotation time. Fruit that has been in storage equal to or longer than 4 weeks or have a flesh firmness of less than 8 pounds can be ripened close to "ready to eat" by temperature management only.

In all the cases, temperature conditions for kiwifruit during storage treatment should be adjusted according
to your anticipated marketing/selling schedule. The flesh softening rate of kiwifruit is about 2.0 pounds per day when exposed to 20°C (68°F). Softening can be slowed down when fruit is stored at lower temperatures.

In general, kiwifruit should always be kept at low temperatures below 7.5°C (45°F) and enclosed with liners, except if they are going to be consumed within 3 days.

References

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Produce Facts

Kiwifruit

Recommendations for Maintaining Postharvest Quality

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Maturity Indices

Minimum of 6.5% soluble solids content (SSC) at harvest.

Minimum flesh firmness of 14 lbf (penetration force with an 8-mm = 5/16 inch tip).

Late-harvested kiwifruits retain their firmness better than early-harvested fruit and have higher SSC at harvest and when ripe.

Quality Indices

Freedom from growth cracks, insect injury, bruises, scars, sunscald, internal breakdown, and decay.

Minimum of 14% SSC when ripe (ready to eat); a kiwifruit at 2-3 lbf flesh firmness is considered ripe.

Kiwifruits are a good source of vitamin C.

Optimum Temperature

0°C (32°F); highest freezing point is -1.5°C (29.3°F).

Optimum Relative Humidity

90-95%

Rates of Respiration

Temperature	0°C (32°F)	5°C (41°F)	10°C (50°F)	15°C (59°F)	20°C (68°F)
ml CO_2/kg•hr	1.5-2.0	3-4	5-7	9-12	15-20

To calculate heat production multiply ml CO_2/kg•hr by 440 to get Btu/ton/day or by 122 to get kcal/metric ton/day.

Rates of Ethylene Production

Less than 0.1 µl/kg•hr at 0°C (32ºF), 0.1-0.5 µl/kg•hr at 20°C (68ºF) for unripe kiwifruit.

	Ripe kiwifruit (less than 4 lbf firmness) produce 50-100 µl/kg•hr at 20°C (68º)
Responses to Ethylene	Kiwifruits are extremely sensitive to ethylene. As little as 5-10 ppb ethylene will induce fruit softening. Avoid exposure of unripe kiwifruits to ethylene during harvest, transport, and storage.
Responses to Controlled Atmospheres (CA)	**Optimum CA:** 1-2% O_2 + 3-5% CO_2. CA delays ripening and retains flesh firmness. CO_2 levels above 7% can cause internal breakdown of the flesh. CA must be established within 2 days after harvest to maximize benefits; ethylene concentration should be kept below 20 ppb to avoid accelerated flesh softening and incidence of white core inclusions.
Physiological and **Disorders** Susceptible fruit be "graininess" observed on early- when subjected usually affected fruit at the stem	**Freezing Damage.** Flesh translucency starting at the stem end of the progressing toward the blossom end as the severity increases. come somewhat yellow-fleshed with prolonged storage. No in the fruit that showed these symptoms. Freezing damage can occur picked kiwifruit when stored at temperatures below 0°C (32°F) or to an early frost in the vineyard. Fruit frosted late in the season are on the shoulder where the cells collapse to cause a pinching of the end. **Hard-core.** This disorder is induced by exposure of kiwifruit to ethylene plus carbon dioxide levels above 8 percent. The fruit core fails to ripen when the remainder of the fruit is soft and ripe. **Internal Breakdown.** These symptoms start as a slight discoloration (water soaking) at the blossom end of the fruit. With time this progresses around the blossom end and ultimately encompasses a large part of the fruit. As symptoms progress a "graininess" develops below the fruit surface beginning in the area around the blossom end of the fruit. **Pericarp Granulation.** The occurrence of granulation is predominantly at the stylar end of the fruit, but as in the case of translucency may extend up the sides of fruit. This disorder also is more severe with prolonged storage and after ripening at 20°C (68°F). There is no obvious correlation between pericarp translucency and granulation since symptoms can occur independently. **Pericarp Translucency.** This disorder has been noted in both air- and CA-stored kiwifruit at 0°C (32°F). It appears as translucent patches in the outer pericarp tissue at the stylar end which may

extend up the sides of the fruit. Pericarp translucency is more severe after prolonged storage, but it can be observed after 12 weeks of storage at 0°C (32°F). The presence of ethylene in the storage atmosphere exacerbates symptom development.

White-core Inclusions. The occurrence of white-core inclusions is directly related to the presence of ethylene in CA storage. This disorder results in distinct white patches of core tissue that are obvious in ripe fruit. Symptoms have been observed as early as 3 weeks after storage at 0°C (32°F).

Pathological Breakdown

Several pathogens can cause postharvest deterioration of kiwifruit. *Botrytis* gray mold rot caused by *Botrytis cinerea* is the most important and can directly invade the fruit or enter through wounds. Kiwifruit becomes much more susceptible to *Botrytis* (and other fungi) as they soften. Thus, maintaining fruit firmness (by rapid cooling, cold storage, and use of controlled atmospheres) can significantly reduce pathological breakdown. Sunburned fruit and physically damaged fruit are also more susceptible to postharvest diseases.