Ripening and Conditioning Fruits for Fresh-cut

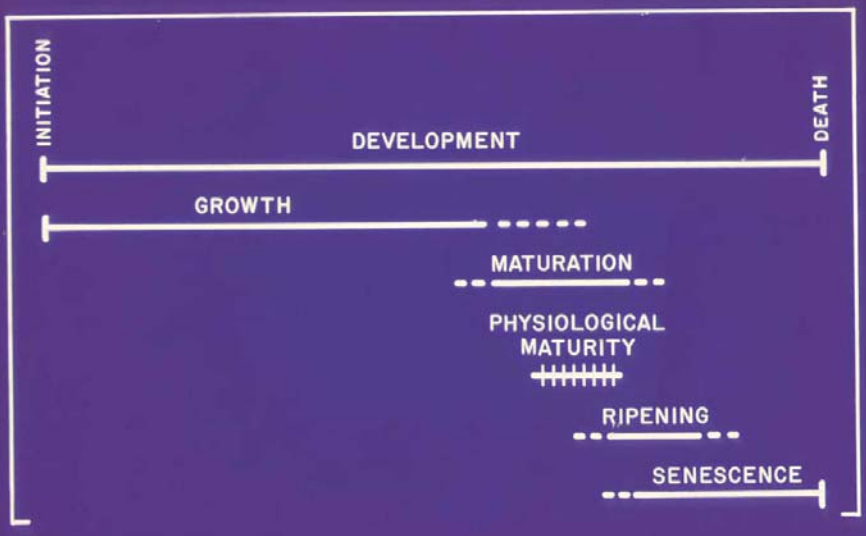
Adel Kader

UCDavis

Management of Ripening of Intact and Fresh-cut Fruits

1. Stages of fruit development
2. Fruits that must ripen on the plant
3. Fruits that can ripen on or off the plant
4. Role of ethylene in fruit ripening
5. Efficacy of 1-methylcyclopropene in extending shelf-life of fresh-cut fruits

Stages of Fruit Development



Development

- *–The series of processes from the initiation of growth to death of a plant or plant part*

Growth

- *–The irreversible increase in physical attributes (characteristics) of a developing plant or plant part*

Maturation:

- *The stage of development leading to the attainment of physiological or horticultural maturity*

Physiological maturity:

- *The stage of development when a plant or plant part will continue ontogeny even if detached*

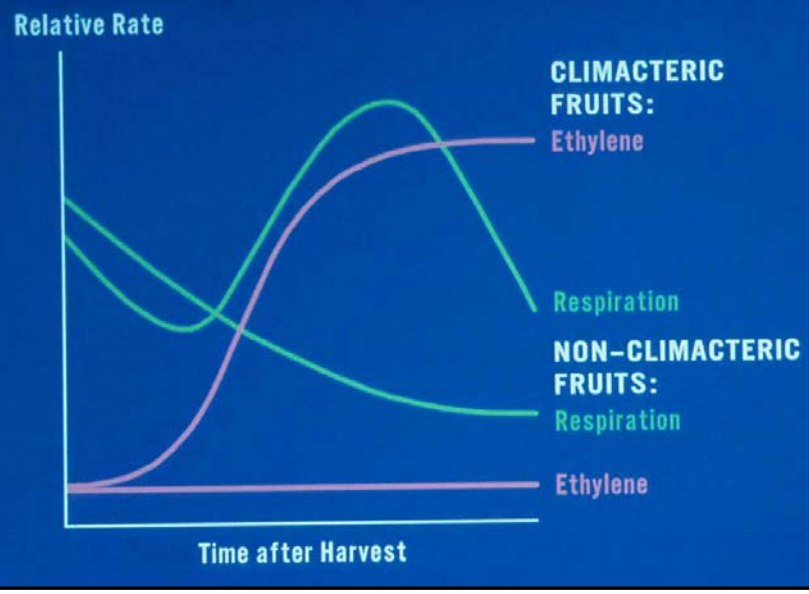
Horticultural maturity:

- *The stage of development when a plant or plant part possesses the prerequisites for utilization by consumers for a particular purpose*

Ripening:

The composite of the processes that occur from the latter stages of growth and development through the early stages of senescence and that results in characteristic aesthetic and/or food quality, as evidenced by changes in composition, color, texture, or other sensory attributes

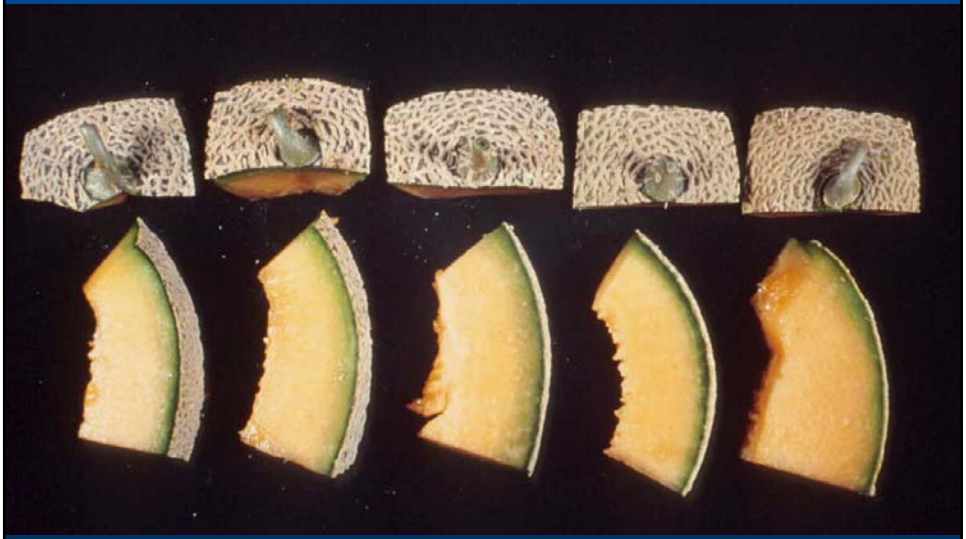
Respiration and Ethylene Production Rates of Climacteric vs Nonclimacteric Fruits



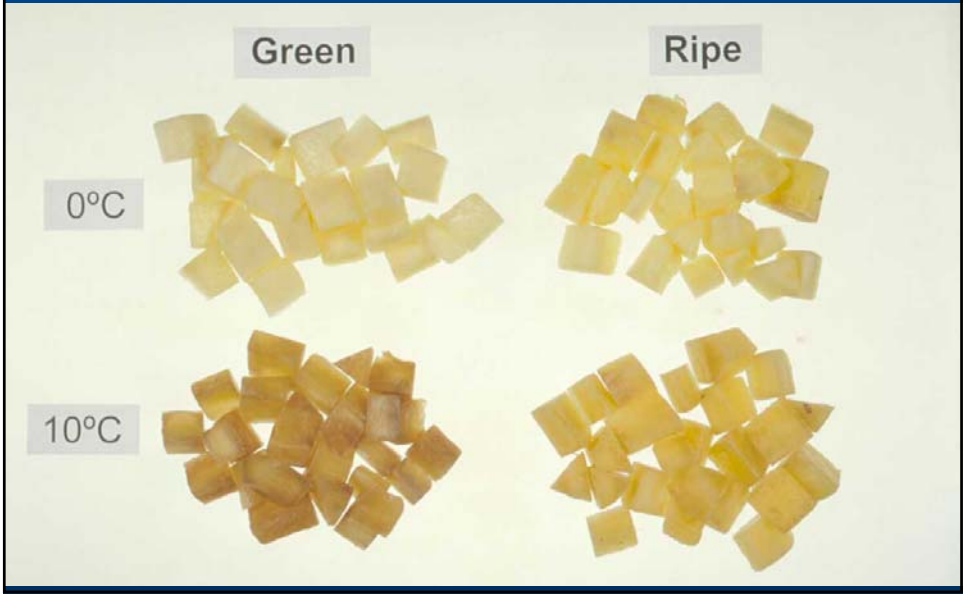
Group 1:
Fruits that are not capable of continuing their ripening process once removed from the plant

Blackberry	*Loquat*	*Pomegranate*
Cherry	*Lychee*	*Prickly pear*
Grape	*Mandarin*	*Rambutan*
Grapefruit	*Muskmelons*	*Raspberry*
Lemon	*Orange*	*Strawberry*
Lime	*Pepper (bell)*	*Tamarillo*
Longan	*Pineapple*	*Watermelon*

Maturity and Ripeness Stages of Cantaloupes



Cut ripe pineapple cubes have a longer post-cutting life than those cut green



Group 2:
Fruits that can be harvested and ripened off the plant

Apple	*Mango*	*Persimmon*
Apricot	*Nectarine*	*Plum*
Avocado	*Papaya*	*Quince*
Banana	*Passion fruit*	*Sapodilla*
Cherimoya	*Peach*	*Sapote*
Guava	*Pear*	*Tomato*
Kiwifruit	*Pepper (chili)*	

Maturity and Quality

- **Most non-fruit and immature-fruit-vegetables attain their optimal eating quality before reaching full maturity**
- **Most mature fruit-vegetables and fruits reach peak flavor when fully ripened on the plant**
- **Often, compromises between optimal maturity and optimal quality are made to facilitate long-distance transport**

Maturity vs Quality

Immature	Poor quality when ripe More susceptible to shriveling and physical damage
Mature	Good quality when ripe Longest postharvest-life potential
Overmature	Too soft, more off-flavors More susceptible to physiological disorders

Maturity Indices for Fruits

- Size and shape
- Skin color
- Flesh color
- Flesh firmness
- Soluble solids content
- Titratable acidity
- Starch content
- Internal ethylene concentration

California Minimum Maturity Indices for Selected Fruits

Fruit	Minimum maturity indices
Apple	Starch pattern, above 10.5 to 12.5% SS and below 18 to 23 lb-force firmness (depending on cultivar)
Apricot	Color of the external surface area: >3/4 yellowish green or >1/2 yellow
Cherry	Entire surface solid light-red and 14 to 16% SS (depending on cultivar)
Nectarine & peach	Surface ground color change from green to yellow, shape (fullness of shoulders and suture)
Pear (Bartlett)	Yellowish-green color, and/or below 23 lb-force firmness, and/or above 13% SS
Persimmon	Yellowish-green to orange color (depending on cultivar)
Plum	Surface color and flesh firmness (depending on cultivar)
Pomegranate	Red juice color and below 1.85% A in juice

SS = Soluble solids, A = Acidity

California Minimum Maturity Indices for Selected Fruits

Fruit	Minimum maturity indices
Avocado	18.5 to 25.9% dry weight (depending on cultivar, e.g. 19.9% for 'Fuerte' and 21.6% for 'Hass')
Grape	14 to 17.5% SS (depending on cultivar and production area) or a SS/A ratio of 20 or higher
Grapefruit	SS/A ratio of 5.5 or 6.0 (desert areas), 2/3 of fruit surface showing yellow color
Kiwifruit	6.5% SS
Lemon	30% juice by volume
Orange	SS/A ratio of 8.0 (and orange color on 25% of the fruit surface) or 10.0 (and less intense orange color)
Strawberry	<2/3 fruit surface showing a pink or red color
Tangerine	SS/A ratio 6.5 and yellow, orange, or red color on 75% or more of the fruit surface

SS = Soluble solids, A = Acidity

Proposed minimum soluble solids content (SSC) and maximum titratable (TA) acidity for acceptable flavor quality of fruits

Fruit	Minimum SSC %	Maximum TA %
Apple	10.5 to 12.5 (depending on cultivar)	
Apricot	10	0.8
Blueberry	10	
Cherry	14-16 (depending on cultivar)	
Grape	14-17.5 (depending on cultivar) or SSC/TA ratio of 20+	
Grapefruit	SSC/TA ratio of 6+	
Kiwifruit	14	

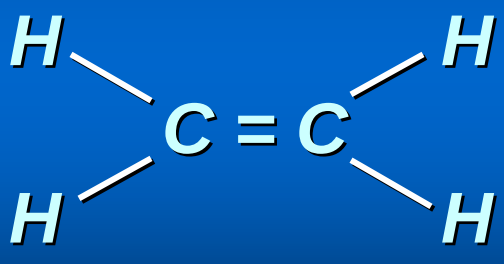
Proposed minimum soluble solids content (SSC) and maximum titratable acidity (TA) for acceptable flavor quality of fruits

Fruit	Minimum SSC %	Maximum TA %
Mandarin	SSC/TA ratio of 8+	
Mango	12-14 (depending on cultivar)	
Muskmelons	10	
Nectarine	10	0.6
Orange	SSC/TA ratio of 8+	
Papaya	11.5	
Peach	10	0.6

Proposed minimum soluble solids content (SSC) and maximum titratable acidity (TA) for acceptable flavor quality of fruits

Fruit	Minimum SSC %	Maximum TA %
Pear	13	
Persimmon	18	
Pineapple	12	1.0
Plum	12	0.8
Pomegranate	17	1.4
Raspberry	8	0.8
Strawberry	7	0.8
Watermellon	10	

Ethylene
Ripening Hormone



Threshold = 0.1 to 10 ppm

Ripening Fruits at Destination Markets

- Ripening rooms
  - Temperature (15-25ºC / 59-77ºF)
  - Relative humidity (85-95%)
  - Air circulation (more uniform temperature and ethylene concentration)
  - Ventilation (introduction of fresh air to keep carbon dioxide below 1%)
- Treatment with ethylene

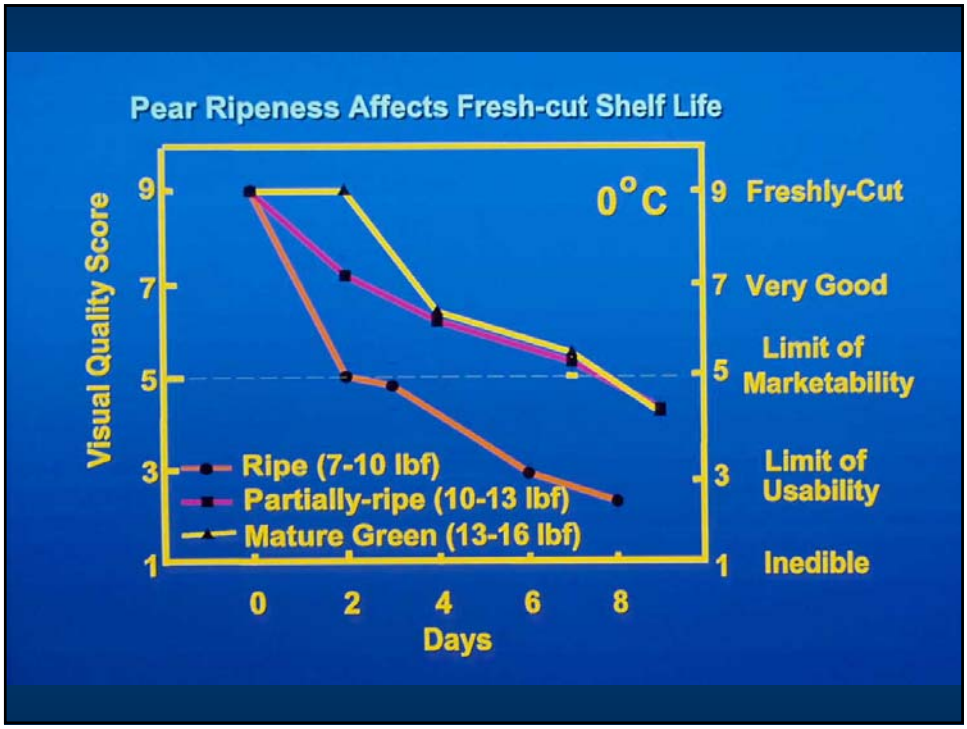
Ripening Rooms

Ripening Conditions For Some Commonly-ripened Fruit

Fruit	Exposure time (hours)[1] To 100ppm ethylene	Range of ripening temperatures[2]
Avocado	8-48	15-20ºC / 59-68ºF
Banana	24-48	14-18ºC / 58-65ºF
Kiwifruit	12-24	12-25ºC / 54-77ºF
Mango	24-48	20-25ºC / 68-77ºF
Pear	24-48	20-25ºC / 68-77ºF
Tomato	24-72	18-20ºC / 65-68ºF

[1] Shorter duration for more mature fruit
[2] Faster ripening rate at higher temperatures

Ethylene induces faster and more uniform ripening of pears



Average Rate of Kiwifruit Softening Following Ethylene Treatment at 20°C (68°F)

Temperature		*Firmness loss per day*		*Number of days to soften from 12 to 3 lbf*
°C	*°F*	*Newtons*	*lb-force*	
0	*32*	*6.7*	*1.5*	*7.0*
7	*45*	*8.9*	*2.0*	*6.0*
20	*68*	*13.3*	*3.0*	*3.0*

Effect of Ethylene on Watermelon Quality After 7 Days at 18°C

C_2H_4 (ppm)	Firmness (N)	Rind Thickness (mm)	SSC (%)		Acceptability (%)
			Heart Area	Seed Area	
0	12.7 a	16 a	10.3	9.7	87
5	9.6 b	13 b	10.3	9.9	20
30	9.8 b	13 b	10.6	10.0	13

Risse & Hatton (1982)

Ethylene Effects on Quality of Fresh-cut Fruits

Ethylene production is enhanced by wounding during processing and the accumulation of this gas within the packages of fresh-cut fruits can be detrimental to their quality and shelf-life. These effects can be reduced by:

1. **Exclusion and/or removal of ethylene from packages.**
2. **Treatment with 1-methylcycloprene (1-MCP) to block ethylene action**

USEPA Approval of Smartfresh™ Technology

On July 17, 2002, USEPA approved registration of Smartfresh™ technology and established an exemption from tolerance for its active ingredient: 1-methylcyclopropene (1-MCP) for the following fruits:

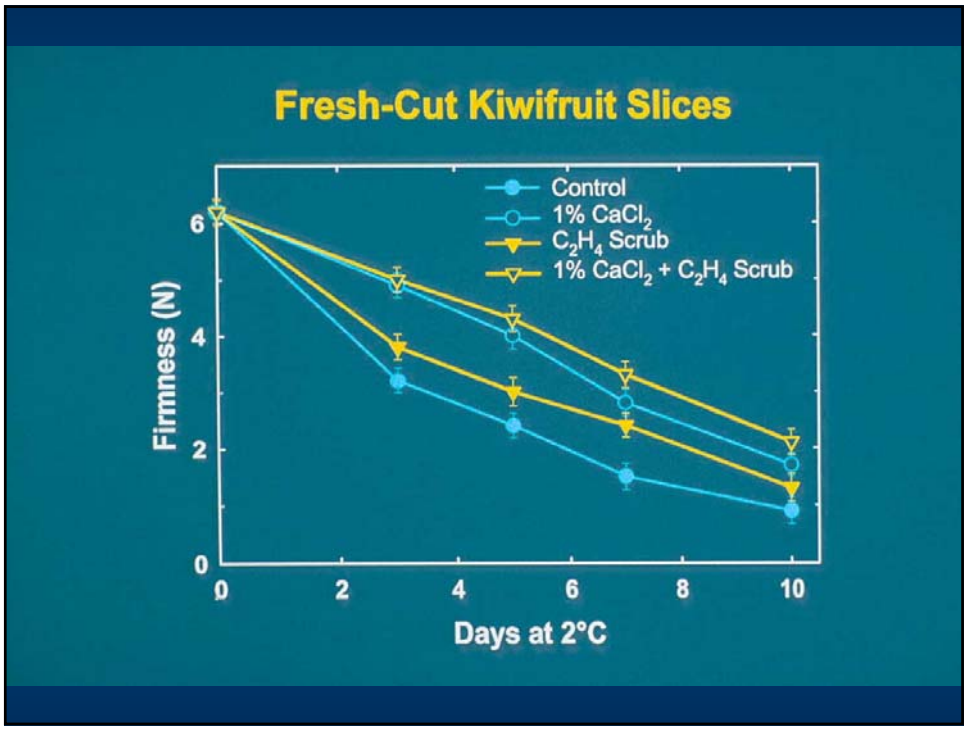
Apple, apricot, avocado, kiwifruit, mango, melons, nectarines, papaya, peach, pear, persimmon, plum, tomato

Options for 1-MCP Treatments
(1 ppm for 6 hours at 10ºC)

1. Treatment of partially-ripe intact fruits before cutting
2. Treatment of fresh-cut fruit products

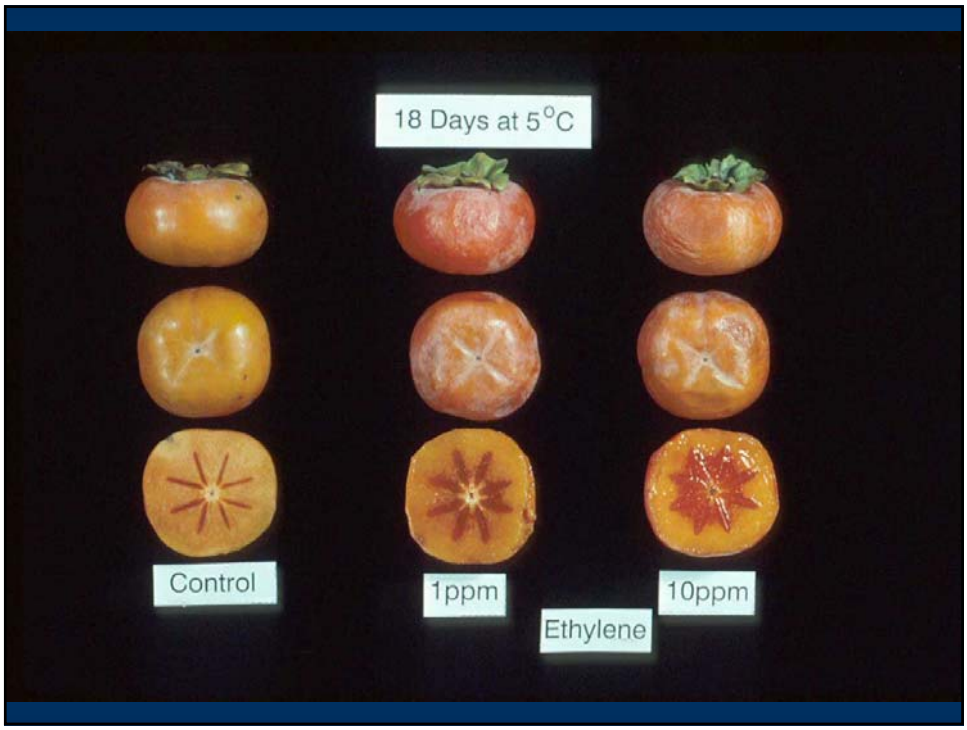
Effects of 1-MCP on Fresh-cut Kiwifruit Slices

Softening of fresh-cut kiwifruit slices was delayed and their ethylene production decreased by 1-MCP (whether it was applied before or after processing) during storage at 5º for 7 days



Effects of 1-MCP on Fresh-cut Mango Cubes

Application of 1-MCP directly on mango cubes delayed their softening and darkening during storage at 5ºC (41ºF) for 9 days



Effects of 1-MCP on Fresh-cut Persimmon Slices

Treatment of intact persimmons with 1-MCP before processing retarded softening and darkening of fresh-cut slices kept at 5ºC (41ºF) for 7 days

Combined Effects of 1-MCP, Calcium Dips, and/or Modified Atmospheres on Fresh-cut Fruits

We found synergistic beneficial effects (delaying softening and browning) of combining the 1-MCP treatment with calcium dips (1% calcium chloride or calcium lactate or calcium ascorbate) and/or modified atmosphere packaging to reach 2-4% oxygen and 8-12% carbon dioxide.