Fruit ripening
Biology and Technology

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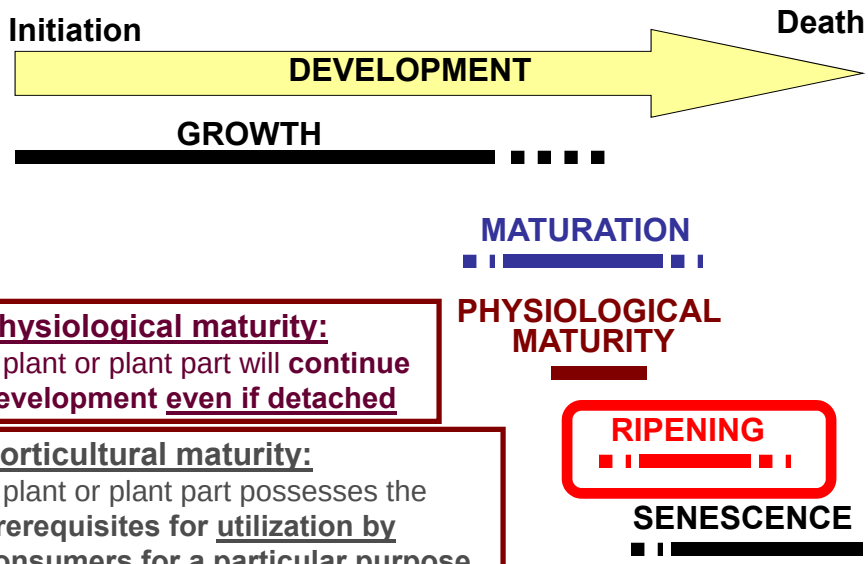
Fruit ripening
Biology and Technology

1. Fruit development
- Definition of Ripening

2. Importance of color

3. Technology – control of ripening
- Some examples

Stages of fruit development



Physiological maturity:
A plant or plant part will **continue development even if detached**

Horticultural maturity:
A plant or plant part possesses the **prerequisites for utilization by consumers for a particular purpose**

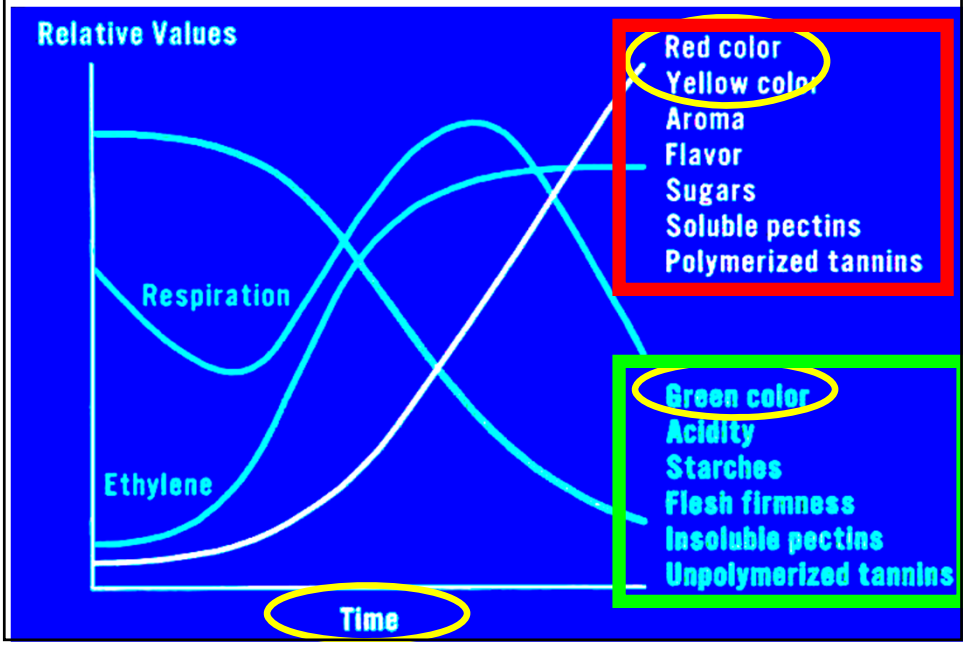
Ripening

- Made of multiple processes
- Occurring from the **latter stages of growth and development** through the **early stages of senescence**
- Resulting in **characteristic cosmetic and/or food quality,** as evidenced by **changes in composition, color, texture,** or **other sensory attributes**

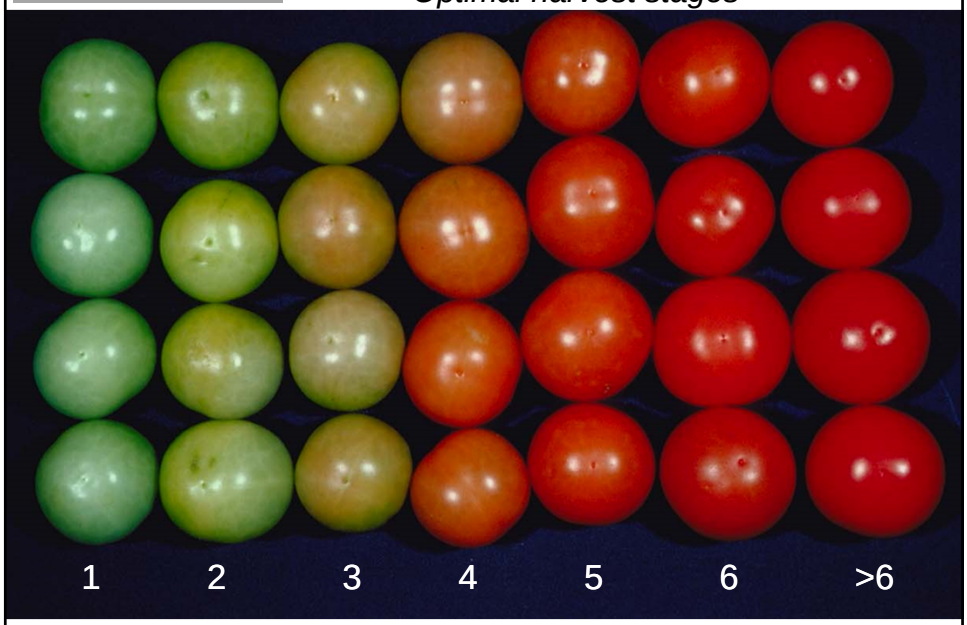
= accumulation or disappearance of metabolites
(nutrients, pigments, sugar, acid, aroma compounds, etc.)

KEY DETERMINANTS FOR QUALITY

Compositional changes accompanying fruit ripening



Optimal harvest stages



Maturity and ripeness stages of cherry tomatoes

Importance of "Color"

- Indicator of ripening

For us (people)..

- Cosmetic value
- Nutritional value .. provitamin A
  .. antioixdant

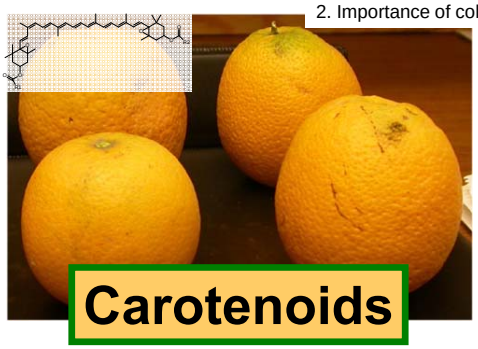
For plants..

- Green - capture light (photosynthesis)
- Red, *orange, etc.*
  Attract animals and insects that scatter seeds (fruits) or help pollinate (flowers)
  Photosynthesis (in green tissue)
  Protect themselves from oxidative stress

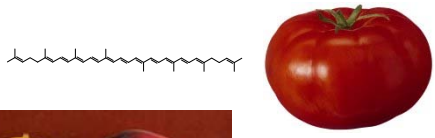
2. Importance of color

Anthocyanins

antioxidants

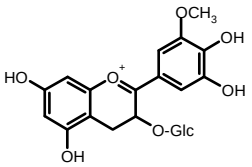


Carotenoids



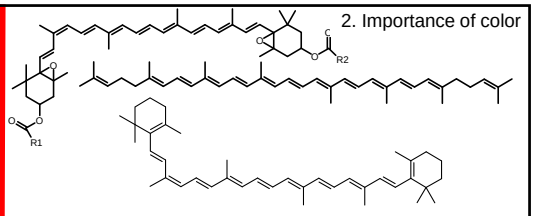
antioxidants

provitamin A



"Phenylpropanoids"

Anthocyanins



"Isoprenoids (terpenoids)"

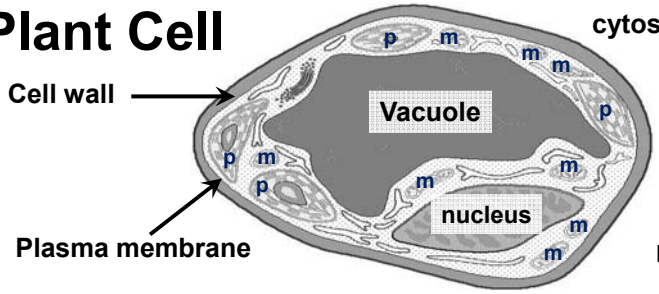
Carotenoids

Which one is water soluble?

A. Carotenoids
B. Anthocyanins
C. Both

2. Importance of color

Plant Cell

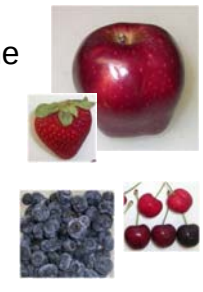


plastids (p)
Chloroplasts
Chromoplasts

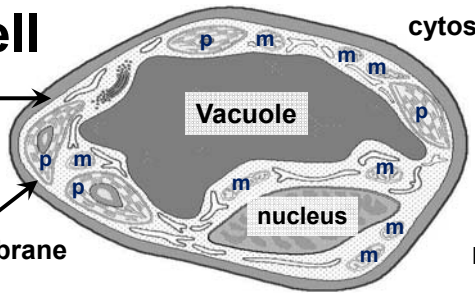
mitochondria (m)

Where do **anthocyanins** accumulate?

A. cell wall
B. plasma membrane
C. cytosol
D. nucleus
E. mitochondria
F. plastids
G. vacuole



Plant Cell



plastids (p)
Chloroplasts
Chromoplasts

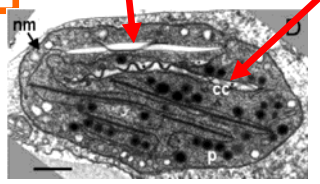
mitochondria (m)

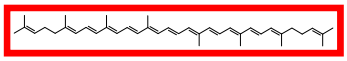
Where do **carotenoids** accumulate?

A. cell wall
B. plasma membrane
C. cytosol
D. nucleus
E. mitochondria
F. plastids
G. vacuole

chromoplast

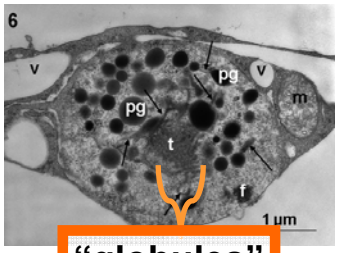
"crystaline structure"

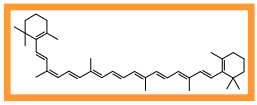




lycopene

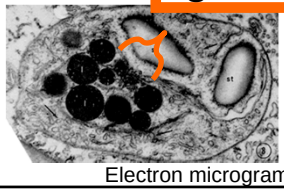
http://www.hormel.com/images/glossary/m/mango_champagne.jpg

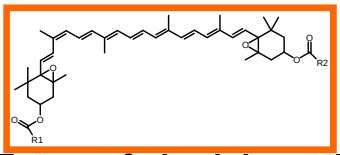




***cis*-β-carotene**

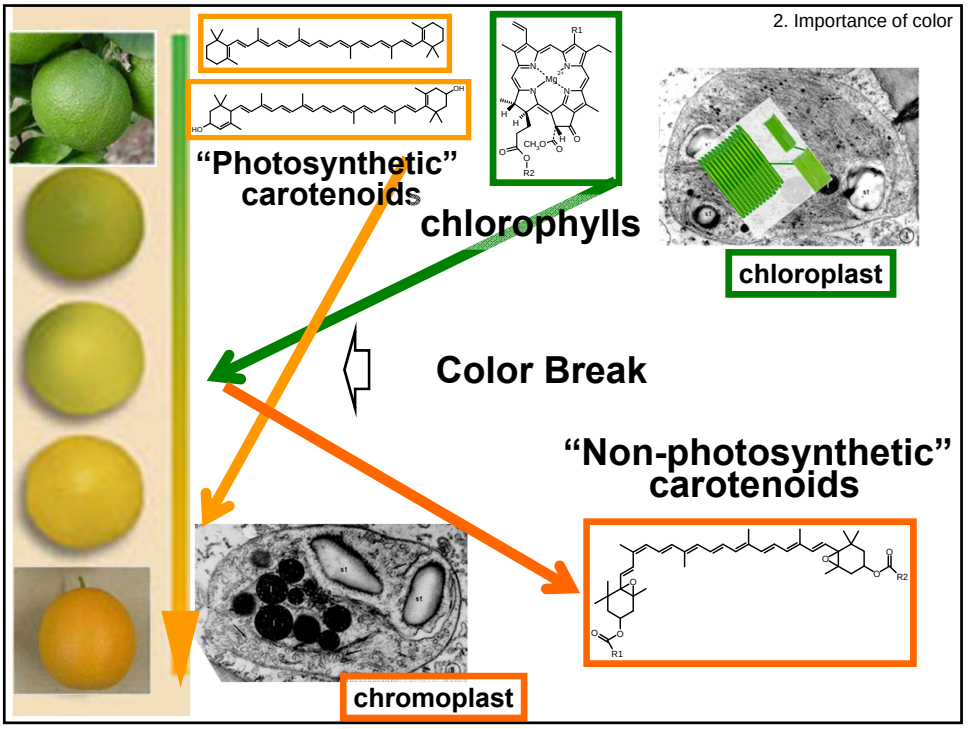
"globules"





Esters of *cis*-violaxanthin

Electron microgram image



Dr. Cantwell's lecture

Group 1: Nonclimacteric fruits: 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	***Muskmelon****	***Raspberry***
Lemon	***Orange***	***Strawberry***
Lime	***Pepper (bell)***	***Tamarillo***
Longan	***Pineapple***	***Watermelon***

**Some muskmelon varieties are climacteric, but are best when harvested partially- or fully-ripe.*

Group 2: Climacteric Fruits:
Fruits that can be harvested at physiological maturity 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)*	

Except avocado, banana and pear, these fruits attain best flavor IF ripened on the plant

Optimal conditions for ripening of climacteric fruits

Ripening rooms

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

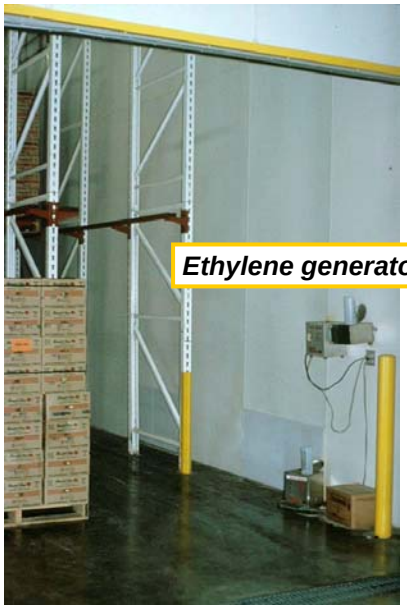
*Treatment with ethylene

- 100 ppm ethylene in air for 1-3 days, depending on maturity stage at harvest

Ripening rooms

***Temperature* and *relative humidity* management is the most important factor affecting ripening rate & uniformity**

Ripening rooms



Forced-air (pressure) ripening room

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*

Current recommendations for avocado ripening

Temperature:	***15.5-20°C (60-68°F)***
Relative humidity:	***90-95%***
Ethylene concentration:	***10-100ppm***
Duration:	***8-48 hr, depending on maturity stage***
Carbon dioxide level:	***Adequate air flow to keep CO_2 below 1%***

Effect of harvest date (maturity) on the time to ripen for 'Hass' avocado

Harvest date and Ethylene treatment	***Days to ripen at 20°C (68°F)***	
Harvest date	***Control***	***Treated****
Dec. 8	***13.9***	***10.8***
Feb. 6	***12.8***	***8.8***
April 10	***10.1***	***7.1***
June 5	***8.2***	***5.1***

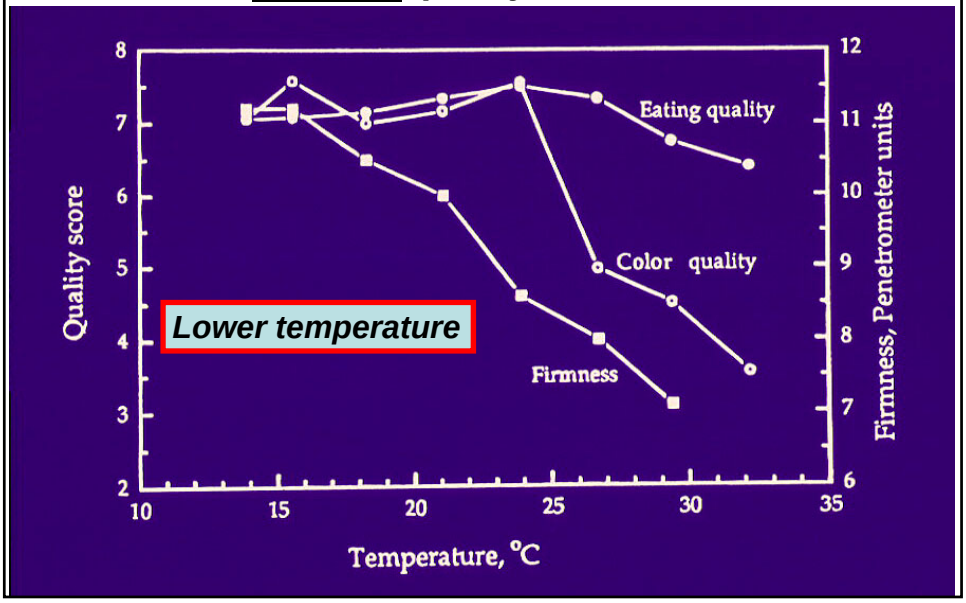
** Fruit treated with 1000 ppm propylene, an ethylene analogue*

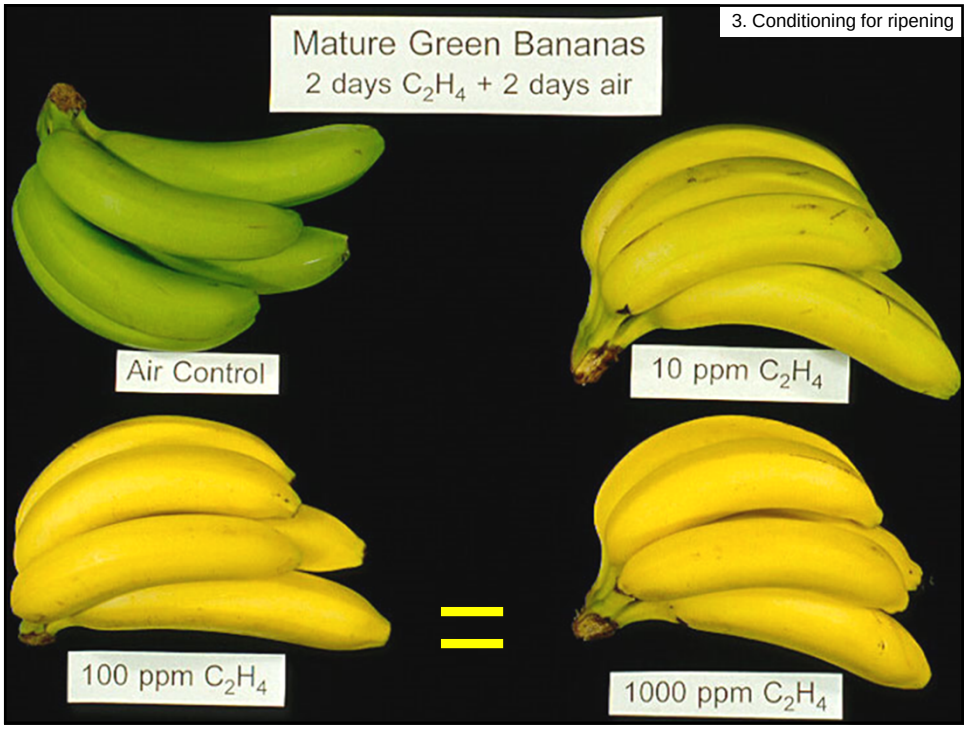
Ethylene (C_2H_4) is required to induce banana ripening

Ripening conditions for banana

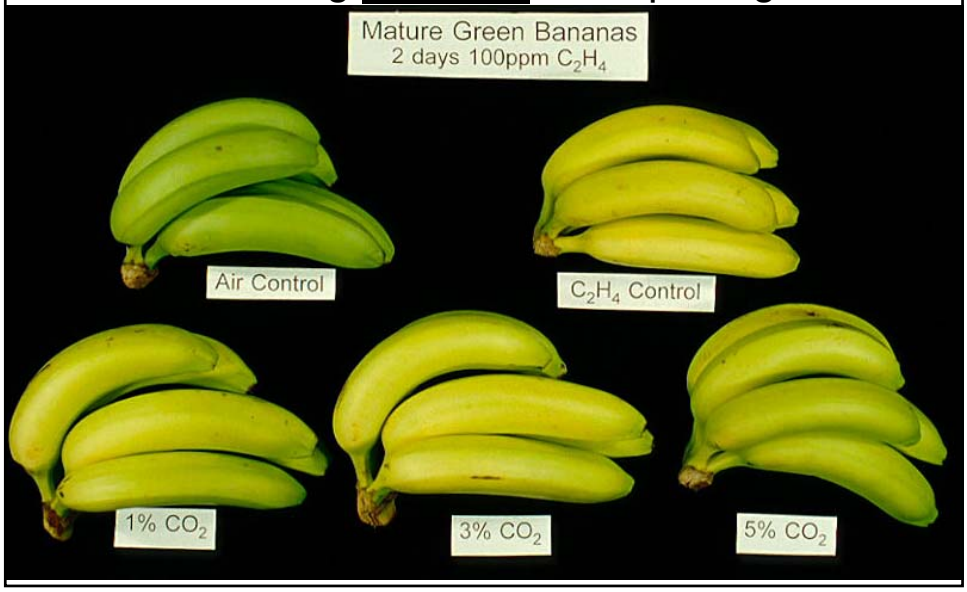
Fruit temperature:	**14-18°C (58-65°F)**
Relative humidity:	**90-95%**
Ethylene concentration:	**100 ppm**
Duration of exposure to ethylene:	**24-48 hours, depending on maturity stage**
Carbon dioxide:	**Adequate air exchange to prevent accumulation of CO_2 above 1%**

Effect of temperature during ripening on banana quality attributes

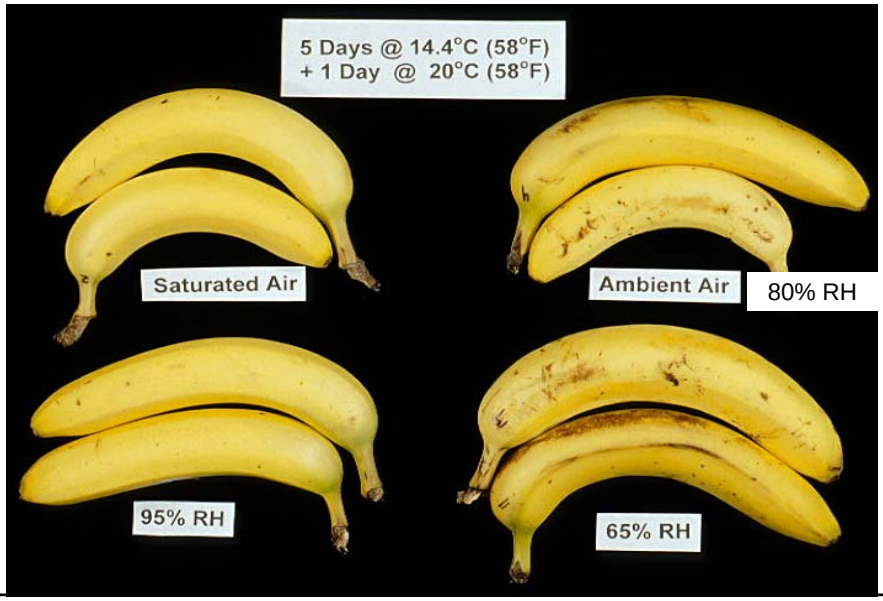




Carbon dioxide reduces efficacy of ethylene in inducing **banana** fruit ripening

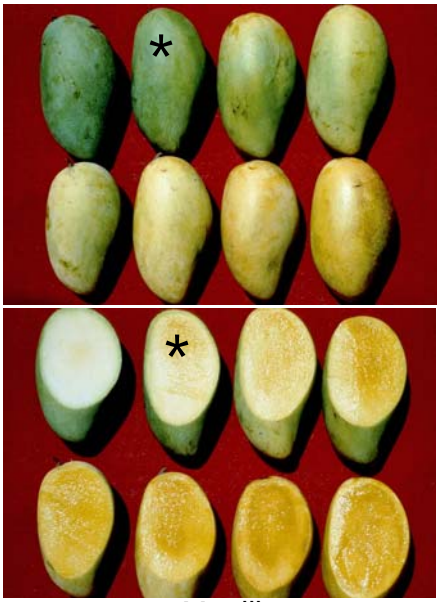


Low relative humidity (RH) accelerates water loss and appearance of physical damage symptoms on **banana**



Dr. Cantwell's lecture

***Mango* maturity and ripeness stages**



Manilla

Kent

* *Minimum stage for harvest*

Ripening conditions for mango

Fruit temperature:	**20 to 22°C (68-72°F)**
Relative humidity:	**90-95%**
Ethylene concentration:	**100 ppm**
Duration of exposure to ethylene:	**24-48 hours, depending on maturity stage (flesh firmness)**
Carbon dioxide:	**<1%**

Mango ripeness vs. flesh firmness

Ripeness stage	Flesh firmness (lb-force with 8mm-tip penetrometer)	Notes
Mature-green	>14	Treat with ethylene for 48 hours
Partially-ripe	10-14	Treat with ethylene for 24 hours
Firm-ripe	6-10	Best stage to send to retail stores
Soft-ripe	2-6	Best stage for eating
Over-ripe	<2	Good for juice

Let's see what we have learned

Importance of color

 ***vs.*** 

Timing of harvest

Postharvest treatment

Importance of color

Q1. We can estimate the degree of ripeness based on the color of fruits.

A. True
B. False

Importance of color

Q2. **Green** fruits usually do not accumulate any orange pigments as long as they are green.

A. True
B. False

Red fruits

Q3. The main pigment of **red** tomato is:

A. a carotenoid and is water soluble.
B. an anthocyanin and is water soluble.
C. a carotenoid and accumulates in chromoplasts.

Red fruits

Q4. The main **red** pigment of red delicious apple is:

A. a carotenoid and is water soluble.
B. an anthocyanin and is water soluble.
C. a carotenoid and accumulates in chromoplasts.

Timing of harvest

cherries

unripe ripe

mangos

unripe ripe

strawberries

unripe ripe

Q5. Choose the most appropriate description.

A. We can harvest unripe cherries and store them in a ripening room to ripen them.
B. We should always harvest ripe mangos if we want to sell ripe mangos.
C. We usually harvest unripe strawberries and use ethylene to ripen them.
D. All A-C are correct.
E. All A-C are incorrect.

Timing of harvest

Q6. In a ripening room, usually:

A. CO_2 level should be kept between 2.5-5%.
B. humidity should be kept around 40-60%.
C. temperature should be kept around 15-25°C (59 to 77ºF).

Q7. Which one of the postharvest treatments would most likely cause bruising of bananas?

A. High humidity (100%).
B. CO_2.
C. Low temperature (15 °C).
D. Low humidity (65%).

good bruised

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