Ethylene Treatments for Ripening & Degreening

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Ethylene

- The most important plant hormone in postharvest horticulture.
- Has a slight sweetish smell.
- Not toxic - but can cause asphyxiation if the gas displaces oxygen in the atmosphere.

Ethylene

- Has anesthetic properties.
- It is active at $\leq$ 0.1 ppm (some say as low as 0.005 ppm).
- Explosive at concentrations between 3.1% and 32% (31,000 to 320,000 ppm) by volume in air.

Ethylene

- Key hormone coordinating physical and biochemical changes associated with ripening of climacteric fruits.
  - E.g. “gassing” to ripen bananas, tomatoes, etc.
- Also stimulates respiration and hastens senescence in non-climacteric crops.
  - E.g. degreening in citrus.

Ethylene Production and Sensitivity

- Produced by all harvested commodities.
- Quantities vary depending on organ type.
- Effects desirable or deleterious.
- Commodities producing little or no ethylene may respond adversely to exposure.

Class	(µl C_2H_4/kg-hr at 20°C (68°F)	Commodities
Very Low	< 0.1	Artichoke, asparagus, cauliflower, cherry, citrus fruits, grape, jujube, strawberry, pomegranate, leafy vegetables, root vegetables, potato, most cut flowers
Low	0.1 - 1.0	Blackberry, blueberry, casaba melon, cranberry, cucumber, eggplant, okra, olive, pepper (sweet and chili), persimmon, pineapple, pumpkin, raspberry, tamarillo, watermelon
Moderate	1.0 - 10.0	Banana, fig, guava, honeydew melon, lychee, mango, plantain, tomato
High	10.0 - 100.0	Apple, apricot, avocado, cantaloupe, feijoa, kiwifruit, nectarine, papaya, peach, pear, plum
Very High	> 100.0	Cherimoya, mammee apple, passion fruit, sapote

Ethylene Pollution Sources

- Plants (e.g., ripening fruits).
- Decomposition of organic materials (incl. oil, coal, gas).
  - Internal combustion engines.
  - Decomposing/rotting produce.
  - Heating systems.
  - Cigarette or other smoke.
- Tar-based light ballasts.
- Some rubber materials when exposed to UV light.

Ethylene Concentrations

Sample Location	Range (ppm)	Mean (ppm)
Field	Trace-0.12	
Field to cooler	0.13-0.11	0.07
Holding before cooling	0.01-0.80	0.16
After cooling	0.01-0.29	0.12
Cold storage	0.01-2.78	0.33
Inside rail cars	0.01-0.19	0.06
Inside trucks	0.04-0.22	0.08
Distribution warehouses	0.03-2.49	0.25
Retail storage	0.06-2.88	0.41
Home refrigerator	0.02-1.58	0.25

Ethylene Effects

- Ripening and color changes in many fruits.
  - Promotes faster, more uniform fruit ripening.
- Loss of green color in citrus (degreening).
- Loosens fruits & nuts for mechanical harvest
  - Abscission

Ethylene – Negative Effects

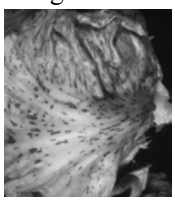
- Accelerated ripening & softening of fruits (e.g. kiwifruit) during storage.
- Hastens senescence.
  - E.g., yellowing of broccoli or cucumbers.
- Induction of stress metabolites.
  - Formation of a bitter-tasting chemical (isocoumarin) in carrots.
  - Promotes phenolic metabolism related to lignification and oxidative browning.

Ethylene – Negative Effects

- Toughening (lignification) of asparagus.
- Stimulated sprouting of potatoes (or inhibition if exposure prolonged and at high concentrations).
- Abscission of leaves and flowers (cabbage, cauliflower, ornamentals).
- Reduced storage life and quality of cut flowers (“sleepiness” in carnations).

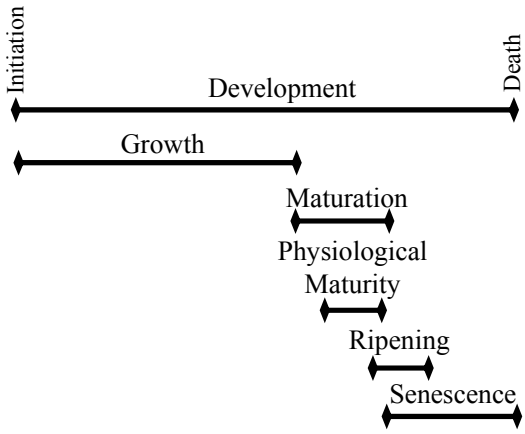
Ethylene – Negative Effects

- Causes or promotes some physiological disorder.
  - E.g., Russet spotting on lettuce.
  - 'Sleepiness' of carnations (the bloom does not open).
  - Bulb crops: inhibition of shoot and root elongation; gummosis; bud necrosis and flower bud blasting.



Factors Affecting Ethylene Production & Action

- Genotype (species and cultivar).
  - Apple vs. tomato vs. citrus vs. strawberry etc.
  - Different cultivars (e.g., of avocado) may have different ethylene production & ripening rates.
- Physiological age.
  - Ethylene production and response of climacteric fruits depends on their physiological age.



Factors Affecting Ethylene Production & Action

- Temperature.
  - Peak ethylene production at ~25°C.
  - Ethylene production inhibited above 30°C.
- Oxygen level.
  - Reduced O_2 (<8%) reduces ethylene action and production rates.
  - Elevated O_2 (>21%) stimulates ethylene production and action.

Factors Affecting Ethylene Production & Action

- CO_2 level.
  - CO_2 competitively inhibits ethylene action.
    - Inhibition of ripening at >1.0%.
    - Inhibition of degreening at >0.1%.
  - CO_2 injury can induce elevated ethylene production.
- Exogenous ethylene.
  - Ethylene exposure induces climacteric fruits to initiate autocatalytic ethylene production.

Factors Affecting Ethylene Production & Action

- Other hydrocarbons.
  - Propylene, carbon monoxide, acetylene, etc. can enhance ethylene production by fruits and mimic ethylene action.
- Stresses.
  - Physical damage, diseases, fumigation, irradiation, etc. are all stresses that stimulate ethylene production.

Ripening – Fruit Changes

- Softening of the fruit flesh.
  - Change in texture from firm to soft.
  - A function of cell wall and middle lamella dissolution.
- Changes in the synthesis and excretion of surface waxes.
  - E.g. development of the "bloom" on grapes, plums, etc.

Ripening – Fruit Changes

- Change in color.
  - Loss of chlorophyll.
  - Synthesis of yellow and red pigments.
    - Carotenoids - tomato, peach. Chloroplast conversion to chromoplasts.
    - Anthocyanins (pink, red, purple) – cherries, apples, blueberries.

Ripening – Fruit Changes

- Changes in aroma and flavor (compositional changes).
  - Conversion of starch to sugar (e.g. sucrose, fructose, glucose).
  - Decreases in acidity.
  - Production of aroma & flavor volatiles (alcohol esters).
  - Polymerization of tannins (reduced astringency, e.g. persimmons).

Commercial Use of Ethylene

- Methods of application
  - Cylinders of ethylene or banana gas (C_2H_4 in N or CO_2) with flowmeters.
  - Ethylene generators (liquid ethanol plus catalyst $\rightarrow C_2H_4$).
  - Ethylene-releasing chemicals.
    - E.g., Ethephon (2-chloroethane-phosphonic acid). Breaks down at pH>3.5 to release ethylene.

Commercial Use of Ethylene

- Ethylene concentration and duration of treatment
  - Physiological responses saturated at 100 ppm.
  - Mature climacteric fruit should initiate endogenous ethylene production within no more than 72 hours.
  - Degreening should continue for no more than 72 hours or risk increased peel senescence and decay.

Ethylene for Ripening

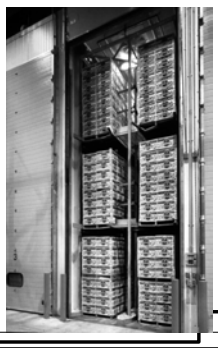
Ethylene can be used to ripen a variety of commodities

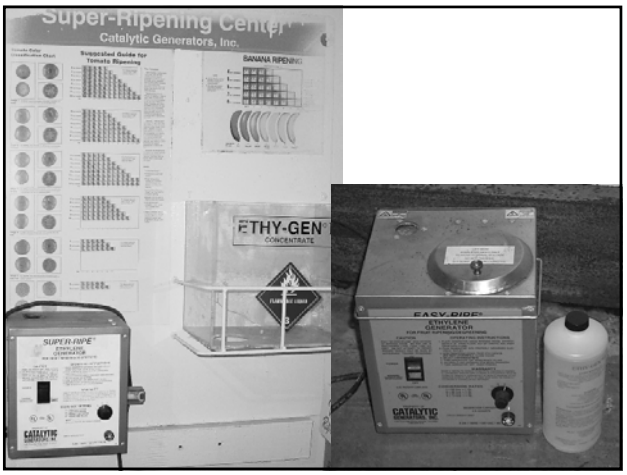
- Bananas
- Tomatoes
- Avocadoes
- Kiwifruits
- Melons
- Mangos
- Pears
- Papayas
- Persimmons

Commercial Use of Ethylene

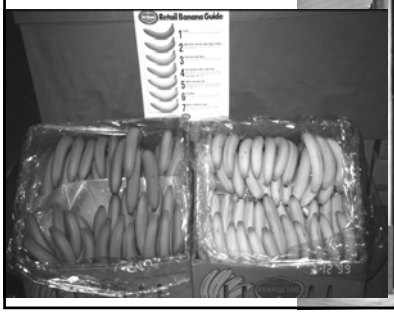
	Tomato	Banana	Avocado	Kiwifruit
Temp.	68-70F	58-65F	60-65F	32-68F
RH	90-95%			
Ethylene (ppm)	100-150		10-100	100
Ventilation	Keep CO_2 < 1% (approx 1 room exchange/h)			
Circulation	0.1 to 0.2 ft^3 per min. per. lb. product.			
Duration	72-84 h	24-48 h	8-48 h	12 h

Ethylene Ripening



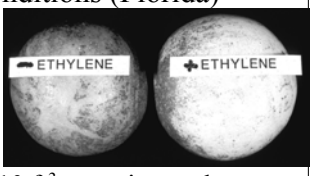


Banana pressure ripening room



Degreening of Citrus

- Recommended conditions (Florida)
  - 82 to 85°F (28 to 29°C).
  - 90 to 96% RH.
  - 5 ppm ethylene.
  - Air circulation = 10 ft^3 per min. per box.
  - Ventilation = 1 air change per hour.
    - Rate of degreening is slowed if CO_2 reaches 0.1%, and will nearly stop if it reaches ≥ 1%.



Degreening of Citrus

- Recommended conditions (California)
  - 68 to 70°F (20 to 21°C).
  - 90 RH.
  - 5 ppm ethylene.
  - Air circulation = 0.1 ft^3 per min. per. lb. product.
  - Ventilation = 1 to 2 air changes per hour.

Thank You

UF Postharvest Website

http://postharvest.ifas.ufl.edu

Ethylene Biosynthesis