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 C2H4/hr | 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

<table>
<thead>
<tr>
<th>Sample Location</th>
<th>Range (ppm)</th>
<th>Mean (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field</td>
<td>Trace-0.12</td>
<td></td>
</tr>
<tr>
<td>Field to cooler</td>
<td>0.03-0.14</td>
<td>0.07</td>
</tr>
<tr>
<td>Holding before cooling</td>
<td>0.01-0.19</td>
<td>0.16</td>
</tr>
<tr>
<td>After cooling</td>
<td>0.01-0.24</td>
<td>0.12</td>
</tr>
<tr>
<td>Cold storage</td>
<td>0.01-0.78</td>
<td>0.33</td>
</tr>
<tr>
<td>Inside rail cars</td>
<td>0.01-0.20</td>
<td>0.06</td>
</tr>
<tr>
<td>Inside trucks</td>
<td>0.04-0.22</td>
<td>0.08</td>
</tr>
<tr>
<td>Distribution warehouses</td>
<td>0.02-2.49</td>
<td>0.25</td>
</tr>
<tr>
<td>Retail storage</td>
<td>0.06-2.88</td>
<td>0.41</td>
</tr>
<tr>
<td>Home refrigerator</td>
<td>0.02-1.58</td>
<td>0.25</td>
</tr>
</tbody>
</table>

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

• 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 O₂ (<8%) reduces ethylene action and production rates.
  – Elevated O₂ (>21%) stimulates ethylene production and action.

Factors Affecting Ethylene Production & Action

• CO₂ level.
  – CO₂ competitively inhibits ethylene action.
    • Inhibition of ripening at >1.0%.
    • Inhibition of degreening at >0.1%.
  – CO₂ 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 (C₂H₄ in N or CO₂) with flowmeters.
  - Ethylene generators (liquid ethanol plus catalyst → C₂H₄).
  - 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
- Avocados
- Kiwifruits
- Melons
- Mangos
- Pears
- Papayas
- Persimmons
### Commercial Use of Ethylene

<table>
<thead>
<tr>
<th></th>
<th>Tomato</th>
<th>Banana</th>
<th>Avocado</th>
<th>Kiwifruit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp.</td>
<td>68-70F</td>
<td>58-65F</td>
<td>60-65F</td>
<td>32-68F</td>
</tr>
<tr>
<td>RH</td>
<td>90-95%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethylene (ppm)</td>
<td>100-150</td>
<td>10-100</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Ventilation</td>
<td>Keep CO₂ &lt; 1% (approx 1 room exchange/h)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Circulation</td>
<td>0.1 to 0.2 ft³ per min. per lb. product.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration</td>
<td>72-84 h</td>
<td>24-48 h</td>
<td>8-48 h</td>
<td>12 h</td>
</tr>
</tbody>
</table>

### 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 ft³ per min. per box.
  - Ventilation = 1 air change per hour.
  - Rate of degreening is slowed if CO₂ 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 ft³ 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

- Methionine (MET) → S-Adenosylmethionine (SAM) → ACC Synthase
- ACC Oxidase
- 1-aminocyclopropane-1-carboxylic acid (ACC) – Can be transported in plant
- Ethylene (C₂H₄)