UNIVERSITY OF FLORIDA
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VC29

Ripening Tomatoes With Ethylene [1]

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Ethylene - a Natural Plant Hormone

Ethylene is a naturally occurring plant hormone. It is one of the simplest compounds affecting physiological processes in plants. Effects can be initiated at internal concentrations of 0.1 to 1.0 ppm (parts per million).

Ethylene promotes ripening of apples, avocados, bananas, citrus (degreening), dates, mangos, some melons, papayas, pears, persimmons, pineapples, and tomatoes. The physiological activity of ethylene is widespread among many plants.

Characteristics

Ethylene is a colorless gas with a sweet odor. It is flammable at concentrations between 3.1 to 32% in air. The minimum flammable concentration of ethylene (3.1% or 31,000 ppm) is about 200 times the concentration suggested for tomato ripening.

Ethylene is naturally produced by a number of vegetable crops. Potatoes, leafy- and root-vegetables produce varying amounts; cucumbers, okra, and peppers produce intermediate amounts. Honeydew melons and tomatoes are relatively high producers of ethylene.

Tomato Fruit Growth & Development

Cell division and enlargement occur during early development of the tomato fruit. During the final stages of growth and development, the tomato fruit reaches full size and becomes mature. The total period for maturation generally requires 40 to 50 days. Ripening is the final stage of the maturation process, when the fruit changes color, softens and develops the flavor, texture and aroma that constitute optimum eating quality. Ethylene is the biological agent that initiates this ripening process. Ripening is irreversibly initiated when the internal ripening concentration of naturally-produced ethylene reaches 0.1 to 1.0 ppm; prior to this time the natural ripening process can be initiated by exposing fruits to external ethylene sources.

In mature-green fruit, there are no important biochemical, chemical or physiological differences between fruit ripened by naturally-produced ethylene or by externally applied ethylene. Tomatoes exposed to externally applied ethylene ripen more uniformly and in a shorter period of time. Therefore, there is less spoilage and they have a slightly higher vitamin C content. Although immature tomatoes can be ripened by exposure to externally applied ethylene, they will never develop comparable eating quality.

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Ripening Conditions

Optimum conditions for initiating ripening are:

1. A fairly air-tight enclosure for maintaining the desired atmosphere. Enclosures range from inflated plastic to permanent ripening rooms fabricated from aluminum-clad urethane panels.

2. Room temperature maintained at 20 to 25°C (68 to 77°F) and 85 - 90% relative humidity.

3. Exposure to ethylene for 24 to 48 hours. Tomatoes 5 x 6 or larger require less time and frequently don't benefit from an exposure period as ripening has already been initiated. Smaller fruit (7 x 7) and the less mature ones, may require an exposure period greater than 48 hours.

4. Carbon dioxide concentrations of less than 4%. Air-tight rooms should be opened and completely aired at 12-hour intervals to prevent accumulation of carbon dioxide.

5. Ethylene at 100 to 150 ppm if carbon dioxide levels are controlled; there is no sound basis for higher concentrations. While rooms are closed, internal fans should be used to insure uniform distribution of ethylene.

Methods for Initiating Ripening

Pressurized cylinders of technical grade ethylene, or generators are suitable for ripening initiation. Methods of application are shot, generator, and flow-thru or trickle.

1. **Shot method** : Placement of ethylene in the ripening room or transport vehicle, which is then closed for a period of time.

a. Tank weight - this is the most widely used shot method in Florida. A cylinder of ethylene is secured on a balance and weighed as the gas is released into the ripening room. Injection ports are provided for metering ethylene into the ripening rooms, but these ports are often not used because they restrict the rapid flow of ethylene. Tank-weighing and rapid application, which bypasses tie injection port, can be dangerous.

b. Lecture bottle or refillable small tank - these containers of ethylene are placed in the ripening room and their entire contents allowed to escape in the room over a period of a few minutes. This method is more costly and filling the tanks with the proper amount of ethylene is very difficult.

c. Slow release - ethylene is released at a very slow rate by means of a pressure regulator and flow meter. For example, if 4 cubic feet of ethylene are needed, the gas will be allowed to flow for 8 minutes at a rate of 1/2 cu. ft. (cubic foot) per minute. This method is more accurate than other shot methods.

2. **Generator:** Catalytic generators that produce ethylene are widely used for tomato ripening in Florida. Generators convert ethyl alcohol to ethylene and water in the presence of heat and a catalyst. However, only a manufacturer formulated concentrate can be used in currently available generators. Ethylene from generators is slowly released and does not reach dangerous concentrations when used as suggested by the manufacturer. One quart of concentrate should yield from 10-12 ounces of ethylene gas. The manufacturer suggests using 2 quarts of concentrate in an 8,000 to 10,000 cu. ft. room. The cost of operating generators is relatively high due to the cost of concentrate, frequency of room ventilation to remove carbon dioxide, and the compulsion of operators to use excess amounts of the concentrate.

Some operators claim "pan gassing" (pouring some of the concentrate in a pan or on the floor and allowing it to evaporate) is effective in ripening initiation. Pan gassing produces only alcohol vapor which has no effect upon ripening initiation.

3. **Flow - thru or trickle:** Ethylene is blended with outside air to a concentration of 150 ppm, and this mixture is passed through the ripening room at a minimum rate of one room change each 6 hours. This concentration of ethylene is sufficient to initiate ripening, and changing the air within the room each 6 hours keeps the carbon dioxide below 2%. A higher air rate would further reduce the carbon dioxide level, but would require additional ethylene.

Rate of air and ethylene needed for any given room size can be calculated by use of the following formula:

$$\text{Air(CFM)} = \frac{\text{Room size (cu. ft.)}}{\text{Frequency of air change (min.)}}$$

Ethylene (cc/min) = Air(CFM) x Vc x C

Where:

Vc = 28,320 (conversion of cu. ft. to cc)

C = desired concentration (150 ppm = 0.00015)

Example – If the ripening room contained 10,000 cu. ft. the rate to change the air once in 6 hours would be:

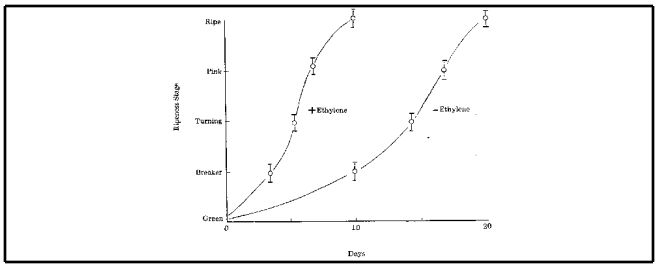
$$\frac{10{,}000}{6 \text{ hrs} \times 60 \text{ min}} = 27.8 \text{ CFM}$$

Ethylene required for 150 ppm would be:

27.8 x 28,320 x 0.00015 = 118 cc/min.

following formula: .

The larger ripening rooms in Florida are 15,000 cu. ft. The air/ethylene rate for this size room would be 41.7 CFM and 177 cc/min., respectively. An accurate flow meter is required for metering the rate of ethylene. This amount of air (41.7 CFM) can easily be provided by a small blower type fan mounted over a two inch diameter opening through the wall into the ripening room. The flow of ethylene is blended with air at this location. Another two inch hole should be cut in the wall opposite the blower to allow air passage out of the room (see Figure 1).



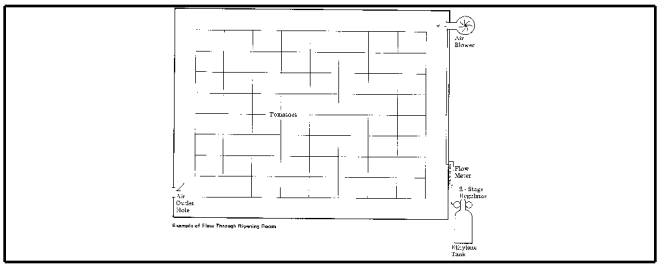
see Figure 1 .

With this method of application, only a very small amount of ethylene is used and the respired carbon dioxide is maintained at about 1.57%. The room need not be opened for aeration, but can be entered at any time for inspection of the fruit.

This is the most economical system currently available. Economic benefits arise both from the very small amount of ethylene required and the faster ripening initiation rate caused by the lack of carbon dioxide inhibition. With a faster initiation rate, a greater volume of tomatoes can be ripened with the existing room capacity. Decreasing the time for ripening initiation by only one day would represent substantial reduction of energy requirement, as ripening room construction and operation are high energy consumers.

Summary

Ethylene is a naturally occurring plant hormone that is produced by many fruits and vegetables. It initiates the ripening process when internal concentrations increase to 0.1 to 1.0 ppm. Externally applied ethylene can also initiate the ripening process. Ethylene is flammable at a concentration of 3.1 to 32% in air. The minimum flammable concentration of 3.1% or 31,000 ppm is about 200 times the concentration suggested for tomato ripening. The flow-thru system is the most efficient and economical method for initiating ripening of mature green tomatoes. In the flow-thru system, ethylene is blended with air to a concentration of 150 ppm and passed through the ripening room at a minimum rate of one room exchange each 6 hours. This concentration of ethylene is sufficient to initiate ripening and rate of air exchange keeps carbon dioxide level below 2% (see Figure 2).



see Figure 2 .