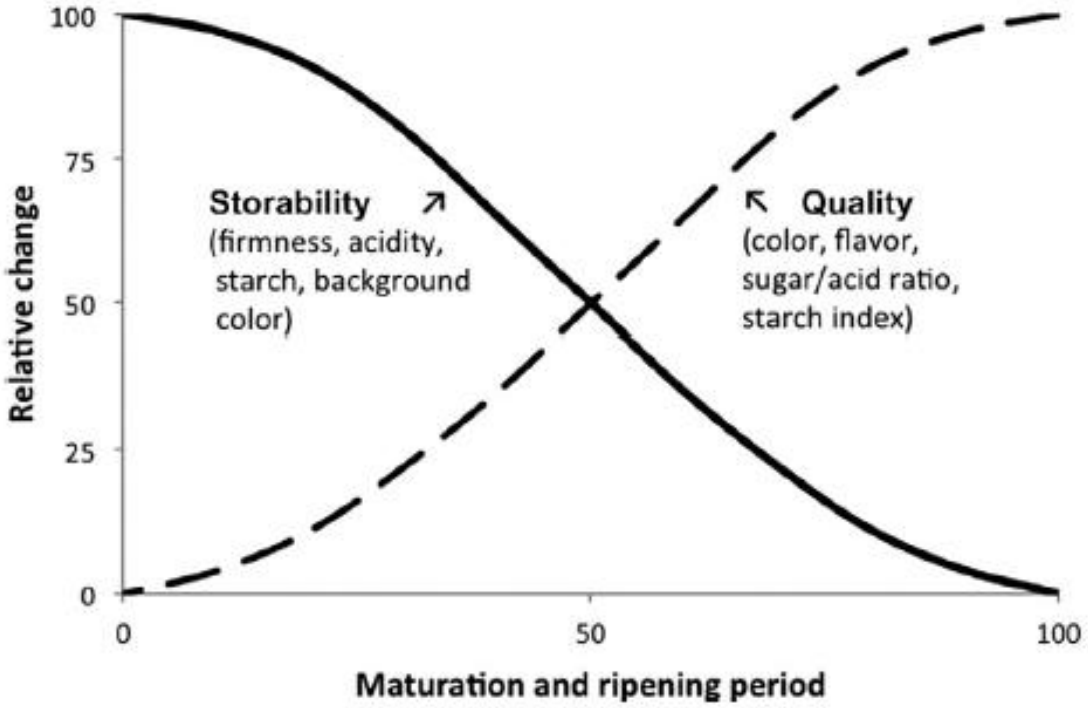
Effect of ethylene on quality of fresh fruits and vegetables

FIG. 5.2 The relationship between the storability and quality in fruit and vegetables (Watkins and Nock, 2012).



Classification of Fruits and Vegetables according to Ethylene Production Rates at 20ºC

Class	Rate (µL/kg h)	Examples
I. Very low	<0.1	Artichoke, asparagus, cauliflower, cherry, strawberry, pomegranate, leafy vegetable, potatoes
II. Low	0.1–1.0	Blueberry, cranberry, cucumber, eggplant, okra, olive, pepper, persimmon, pineapple, pumpkin, raspberry, tamarillo, watermelon
III. Moderate	1.0–10.0	Banana, fig, guava, melon, honeydew, mango, plantain, tomatoes
IV. High	10.0–100.0	Apple, apricot, avocado, cantaloupe, feijoa, kiwi, nectarine, papaya, peach, pear, plum
V. Very high	>100.0	Cherimoya, passionfruit, sapota

Biological attributes of ethylene

Colorless gas at biological temperatures.
Naturally occurring organic compound.
Readily diffuses within and from tissue.
Produced from methionine via ACC by a highly regulated metabolic pathway.
Key enzymes are ACC synthase and ACC oxidase.
Ethylene synthesis is inhibited (negative feed-back inhibition) by C_2H_4 in vegetative and immature climacteric and non-climacteric reproductive tissue.
Ethylene synthesis is promoted (positive feed-back promotion, or autocatalytic) by C_2H_4 in reproductive climacteric tissue.
Effective at part-per-million (ppm, $\mu l\ l^{-1}$) and part-per-billion (ppb, $nl\ l^{-1}$) concentrations (1 ppm equals 6.5×10^{-9} M at 25°C).
Requires O_2 to be synthesized, and both O_2 and low levels of CO_2 to be active.

Plant responses to ethylene

Ethylene stimulates
Synthesis of C_2H_4 in ripening climacteric fruit.
Ripening of fruit.
Pigment (e.g. anthocyanin) synthesis.
Chlorophyll destruction and yellowing.
Seed germination.
Adventitious root formation.
Respiration.
Phenylpropanoid metabolism.
Flowering of bromeliads.
Abscission.
Senescence.
Ethylene inhibits
Ethylene synthesis in vegetative tissue and non-climacteric fruit.
Flower development in most plants.
Auxin transport.
Shoot and root elongation (growth).
Normal orientation of cell wall microfibrils.

Examples of how the same ethylene response can be beneficial in one system and detrimental in another

Example of benefit	Ethylene response	Example of detriment
Degreening of citrus	Accelerates chlorophyll loss	Yellowing of green vegetables
Ripening of climacteric fruit	Promotes ripening	Overly soft and mealy fruit
Defense against pathogens	Stimulates phenylpropanoid metabolism	Browning and bitter taste

Beneficial effects of ethylene on the quality of fresh fruits and vegetables

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Promotes color development in fruit.
Stimulates ripening of climacteric fruit.
Promotes de-greening of citrus.
Stimulates dehiscence in nuts.
Alters sex expression in the cucurbitaceae.
Promotes flowering in bromeliaceae (e.g. pineapple).
Reduces lodging of cereals by inhibiting stem elongation.

Detrimental effects of ethylene on the quality of fresh fruits and vegetables

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Accelerates senescence.
Stimulates chlorophyll loss (e.g. yellowing).
Enhances excessive softening of fruits.
Stimulates sprouting of potato.
Promotes abscission of leaves and flowers.
Stimulates phenylpropanoid metabolism.
Promotes discoloration (e.g. browning).
Hastens toughening of vegetables.

Adverse Effects of Ethylene in Fruits and Vegetables

Produce	Symptoms
Asparagus	Woodiness
Carrots	Bitterness due to isocoumarine formation
Potatoes	Sprouting
Lettuce	Russet spotting
Broccoli	Yellowing, abscission, off flavors
Eggplant	Browning of flesh and seeds, decay induction
Cucumber	Yellowing, softening
Sweet potatoes	Browning of pulp, off flavor, failure to soften upon cooking

Activity of ethylene analogs in plants

Gases	Half-maximal activity $\mu l\ l^{-1}$
Ethylene	0.1
Propylene	10
Carbon monoxide	270
Acetylene	270
1-Butene	27 000

Optimal ripening conditions for fruit ripening

Temperature	18 to 25°C
Relative humidity	90 to 95%
Ethylene concentration	10 to 100 ppm
Duration of treatment	24 to 74 hours depending on fruit type and stage of maturity
Air circulation	Sufficient to ensure distribution of ethylene within ripening room
Ventilation	Require adequate air exchange in order to prevent accumulation of O_2, which reduces effectiveness of C_2H_4.

Commodity	Ethylene conc.(ppm)	Ethylene exposure time (hr.)	Ripening temp. °C	Storate Temp.°C
Avocado	10-100	12-48	15-18	4.4-13
Banana	100-150	24	15-18	13-14
Honey dew melon	100-150	18-24	20-25	7-10
Kiwifruit	10-100	12-24	0-20	0.5-0
Mango	100-150	12-24	20-22	13-14
Orange degreening	1-10	24-72	20-22	5-9
Stone fruit	10-100	12-72	13-25	-0.5-0

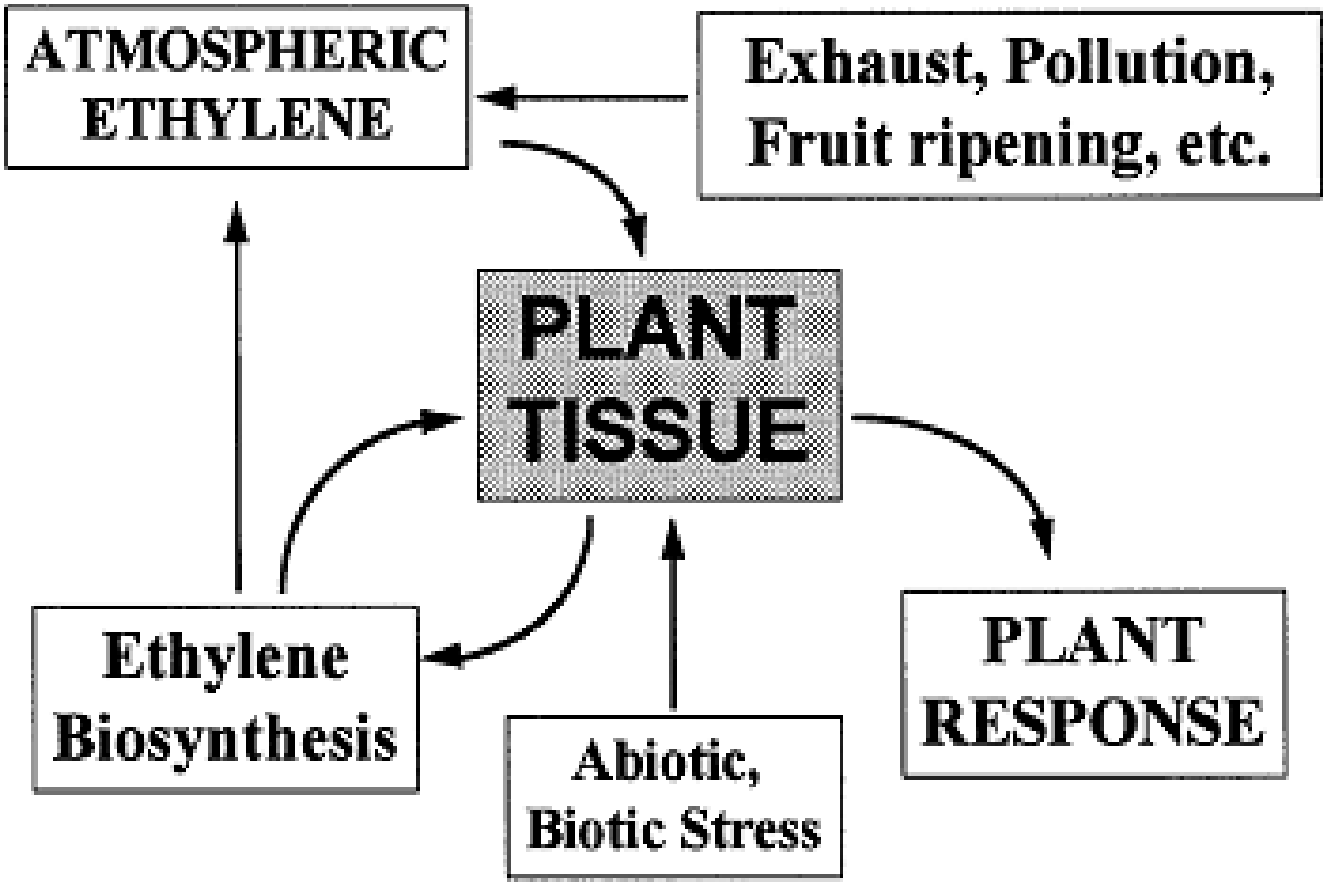

Fig. 2. Ethylene interactions with the plant and its environment.