Fig. 1. Symptoms of russet spotting on lettuce.

Avoiding ethylene concentrations in harvested lettuce

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At almost any stage of the handling process, lettuce may be exposed to ethylene gas, trace amounts of which can cause russet spotting.

Lettuce is a major vegetable crop in California, with a farm value of slightly over $300 million in 1977. The value can increase about tenfold between the field and the consumer. Therefore losses at destination, estimated to range between 10 and 20 percent, are important. About one-third of these losses are related to physiological disorders. Russet spotting can be serious and is characterized by small elongated and pitted brown, tan, or olive-colored lesions (fig. 1).

The concentration of ethylene gas in the atmosphere is the primary factor in the incidence and severity of russet spotting. Exposure to ethylene may be encountered in the field, during handling,

in transit, under wholesale and retail conditions, and in the home. Tests carried out in our laboratory have shown that 0.1 ppm ethylene is sufficient to cause commercially important damage during a normal transit period of 5 to 8 days. Ethylene can also reduce overall quality by causing accelerated senescence. Other factors that promote russet spotting include overmaturity at harvest, temperatures of 41°F or higher, susceptible cultivars, and duration between harvest and consumption.

Sources of ethylene

Sound lettuce heads produce very little ethylene (less than 0.01 µl/kg-hr). However, the rate of ethylene production is greatly increased by physical damage, the presence of pathogens, and by ethlyene in the atmosphere from an external source. Because ethylene is an emission product of internal combustion engines, and is produced by plant tissues (especially ripening fruits), the possibility of lettuce exposure to it exists throughout the marketing channel.

To determine where potentially harmful concentrations of ethylene might occur, air samples were collected from various locations throughout the handling system from 1975 to 1977. Evacuated air sampling containers were used and were returned to the laboratory for analysis. Ethylene concentrations were determined by flame ionization gas chromatography. Results of this survey (see table) show that the two most likely commercial problem areas are: (1) cold storage rooms at vacuum coolers where ethylene is produced in forklift emissions, especially from propane fuel, and (2) retail-store holding rooms where the ethylene source most likely is ripening fruits. Ethylene levels in cold rooms clearly fluctuate with the amount of forklift activity, as demonstrated by data in fig. 2. Efforts should be directed at minimizing or removing ethylene from these two steps in the lettuce handling system.

Data in the table also show that lettuce can be exposed to significant concentrations of ethylene in home refrigerators. Consumers should avoid mixing ripening fruits with lettuce in the same crisper or section of the home refrigerator, although first placing it in a polyethylene bag or a plastic container may help protect it from ethylene exposure.

Exclusion of ethylene from storage and handling channels is important for many commodities. It is known to produce a bitter taste in carrots, induce sprouting of potatoes, and cause loss of green coloring in leafy vegetables, cucumbers, and squash. Ethylene also can cause abscission of leaves from plants, as well as promote the ripening and eventual senescence of many fruits and vegetables.

Exclusion and removal methods

Vacuum cooling is effective in removing ethylene from within the lettuce carton, but the benefit is lost or reversed if the vacuum is broken with ethylene-contaminated air. To avoid or exclude ethylene in holding rooms at shipping point, one should consider (1) conversion to systems not requiring fossil fuel consumption inside the cold rooms (for example, electric forklift or non-forklift handling systems), (2) use of absorbers, external exhaust gas venting, or exhaust gas capture to prevent its release inside the cold room, (3) use of polyethylene pallet covers inside the cold room, or (4) periodic flushing of cold room air with uncontaminated air. To avoid or exclude ethylene in holding rooms of retail stores, lettuce should not be held with ripening fruit.

Ethylene can be absorbed from holding rooms by use of potassium permanganate adsorbed on vermiculite or alumina pellets. But, the effectiveness and longevity of this material can be reduced by other unsaturated hydrocarbons in the atmosphere. Other systems, using ozone produced by ultraviolet light or electric discharge to oxidize ethylene, have been developed on a laboratory scale. However, all these systems need wider study before their cost and effectiveness can be evaluated for recommendation.

The desirability of avoiding exposure to ethylene, by its exclusion or removal, should be considered by handlers and consumers of lettuce.

Levels of Ethylene Found in the External Atmosphere and in Packed Cartons at Various Locations between Field and Consumption

Sample locations		Ethylene concentration (ppm) Range	Mean	No. of samples analyzed	Potential sources
Field	A*	trace†—0.12	—	21	Air pollution.
Field to cooler	B*	0.03—0.11	0.07	3	Mechanically injured lettuce. Exhaust from truck, other pollution
Holding areas prior to vacuum cooling	A	0.01—0.61	0.05	47	Exhaust from trucks and forklifts
	B	0.01—0.80	0.16	12	
Immediately following cooling	B	0.01—0.29	0.12	11	(Vacuum cooling removes much of the C_2H_4 inside cartons)
Cold storage rooms at vacuum coolers	A	0.01—2.78	0.33	144	Exhaust from forklifts, other commodities
	B	0.01—1.56	0.22	73	
Inside rail cars at destination	A	0.01—0.19	0.06	14	Decay, other pollution sources
	B	0.01—0.02	0.01	3	
Inside truck units at destination	A	0.04—0.22	0.08	9	Decay, other pollution sources
	B	0.08—0.11	0.09	4	
Distribution centers and warehouses	A	0.03—2.49	0.25	22	Exhaust, other commodities
	B	0.01—0.78	0.08	43	
Retail storage areas	A	0.02—2.95	0.36	19	Other commodities
	B	0.06—2.88	0.41	18	
Home refrigerator	A	0.02—1.58	0.25	33	Other commodities

*A = atmosphere external to carton; B = inside carton
†Trace = less than 0.10 ppm

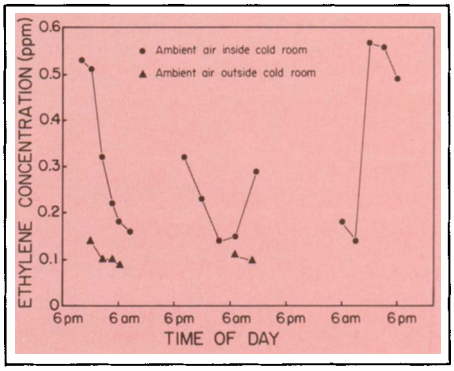

Fig. 2. Fluctuations of ethylene concentration in a cold room used for holding lettuce after cooling, where propane-fueled forklifts were operated during a 3-day period.

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