Application of 1-MCP to Vegetable Crops

Jenny Bower and Beth Mitcham, Dept. of Pomology, UC Davis

Over the last few years a considerable amount of information has been collected on the effects of 1-MCP on many different fruits and cut flowers. It would appear that 1-MCP could also be a useful tool for extending the life of many vegetable crops. Unlike ripening fruit, products such as leafy green vegetables do not need to regain ethylene sensitivity in order to reach optimal quality. In this case, the main effect of ethylene is to increase the rate of senescence. Some initial work has been conducted on vegetable crops, primarily broccoli and tomatoes. However, surprisingly little research on the effects of 1-MCP has involved vegetables.

Although most vegetables produce only small amounts of ethylene, many are ethylene sensitive. For example, broccoli storage life may be halved if heads are exposed to moderate ethylene concentrations at 50°F (10°C), while as little as 0.1 ppm of ethylene at 41°F (5°C) can have a similar effect on beans. Recent publications have suggested that even ethylene concentrations of <0.1 ppm reduce the storage life of many green vegetables. The table below summarizes some of the specific effects of ethylene on various ethylene sensitive vegetables.

One of the main effects of ethylene on many horticultural commodities is to increase their respiration rate. Respiration indicates metabolic activity and, in general, treatments that increase the rate of respiration also decrease storage life. A direct relationship between respiration and storage life has been demonstrated for brussels sprouts and asparagus. This suggests that, even in the absence of specific symptoms of damage, ethylene can increase the rate of deterioration of fresh vegetable crops.

There are a number of possible reasons why using 1-MCP on vegetables has received relatively little attention. Ethylene is often not regarded as a significant factor affecting vegetable quality. Many

Table 1. Effects of ethylene exposure on some vegetables

Product	Effect of ethylene exposure
Asparagus	Toughening of stems, yellowing of tips
Beans	Yellowing
Broccoli	Yellowing of florets, increased decay
Brussels sprouts	Yellowing of outer leaves
Cabbage	Leaf abscission
Carrots	Formation of bitter compounds resulting in off flavors
Cauliflowers	Discoloration of the curd, abscission of outer leaf bases
Cucumbers	Accelerated yellowing and decay
Herbs	Leaf yellowing, stem distortion, leaf abscission (some herbs only)
Lettuce	Russet spotting along mid ribs
Onion	Increased sprouting during storage
Peas	Yellowing of calyx tissue
Radicchio	Pink discoloration of mid ribs
Spinach	Leaf yellowing
Sweet potato	Off-flavor development
Tomatillo	Color change from green to yellow, softening
Tomato	Ripening from green to red, softening

vegetables are consumed soon after harvest rather than stored for extended periods. This means that the effects of ethylene do not have time to develop. Also, products such as leafy greens are not chilling sensitive, and can be stored at close to 32°F (0°C). At this temperature, even relatively high ethylene concentrations have little effect on vegetable quality. Finally, many vegetables are comparatively low in value, and receive only minimal postharvest treatments.

Despite these considerations, 1-MCP could prove a useful tool for postharvest treatment of vegetables. In many cases, vegetable products are not stored separately, but combined in mixed loads with other products. If high ethylene producers, such as ripening tomatoes or fruit, are present, then the ethylene concentration in the storage environment can increase to levels >1 ppm. The effect of these ethylene levels may be increased if tropical fruit, or other chilling sensitive products such as beans, okra, bell peppers, basil and cucumbers are present. In this case, the storage temperature must be set at 41°F (5°C) or higher. Breaks in the cool chain during shipping and transport can also result in produce being exposed to warmer temperatures. Under either or both of these circumstances, irreversibly blocking the effects of ethylene by pretreatment with 1-MCP could prove beneficial. For example, there is little advantage in treating broccoli with 1-MCP when it is stored under ideal conditions at 32°F (0°C). However, if broccoli is stored at over 41°F (5°C), 1-MCP can significantly extend storage life. At 50°F (10°C), broccoli storage life was more than doubled by treatment with 1 ppm 1-MCP, while later experiments found that 0.01 ppm 1-MCP was equally effective.

Tomatoes are usually classified as a vegetable even though, biologically, they are a fruit. It can be useful to delay tomato ripening by storing at low temperatures. However, tomato fruit are chilling sensitive and will fail to ripen normally if kept too cold for too long a time. As has been tried with pears and avocados, it could be possible to apply low concentrations of 1-MCP to extend storage life while still allowing normal ripening after a time. For example, it has been shown that tomatoes respond to as little as 0.005 ppm of 1-MCP, while less than 0.01 ppm of 1-MCP delays tomato ripening by 8 days at 77°F (25°C). Further work could examine the effect of different 1-MCP concentrations on tomato ripening under normal storage conditions. Potentially, 1-MCP treatment could allow extended storage of mature green fruit while reducing the risk of chilling injury.

In conclusion, although there is little data available relating to the effects of 1-MCP on vegetable crops, the future potential of work in this area appears promising. This may be particularly true for ethylene sensitive, high value crops such as asparagus, basil, broccoli and Belgian endive. Chilling sensitive products such as tomatoes, beans and okra could also prove worthy of future research.

Further Reading

Fan, X., and Mattheis, J.P., 2000, Yellowing of broccoli in storage is reduced by 1-methylcyclopropene, HortScience, 35: 885-887.

Ku, V.V.V., and Wills, R.B.H., 1999, Effect of 1-methylcyclopropene on the storage life of broccoli, Postharvest Biology and Technology, 17: 127-132.

Serek, M., Sisler, E.C., and Reid, M.S., 1995, 1-Methylcyclopropene, a novel gaseous inhibitor of ethylene action, improves the life of fruits, cut flowers and potted plants, Acta Horticulturae, 394: 337-345.

Sisler, E.C., Serek, M., and Dupille, E., 1996, Comparison of cyclopropene, 1-methylcyclopropene, and 3,3-dimethylcyclopropene as ethylene antagonists in plants, Plant Growth Regulation, 18: 169-174.

Wills, R.B.H., and Kim, G.H., 1996, Effect of ethylene on postharvest quality of green beans, Australian Experimental Agriculture, 36: 335-337.

Wills, R.B.H., Ku, V.V.V., Shohet, D., and Kim, G.H., 1999, Importance of low ethylene levels to delay senescence of non-climacteric fruit and vegetables, Australian Experimental Agriculture, 39: 221-224.