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Use of 1-Methylcyclopropene (1-MCP) on Tomato and Avocado Fruits: Potential for Enhanced Shelf Life and Quality Retention [1]

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Handling and storage practices for fruits and vegetables are designed with the goal of maintaining quality and delaying over-ripening and senescence. Historically, temperature and humidity control and the selective use of controlled or modified atmospheres have helped postharvest handlers obtain these goals. These parameters are central to most postharvest storage regimes, with allowances made for specific commodity types. For example, many fruits and vegetables of subtropical or tropical origins are chilling sensitive (injured by exposure to low, but non-freezing temperatures) which limits the use of traditional low-temperature storage conditions.

The last several years have witnessed the emergence of powerful new tools for delaying postharvest senescence and deterioration of perishable fruits, vegetables, potted plants, and cut flowers. These include the molecular modification of ripening physiology and the use of compounds that specifically target and inhibit ethylene responsiveness. Ethylene is the natural plant product that coordinates ripening processes (e.g. softening, color change, conversion of starch to sugars, loss of acidity, etc.) in fruits and vegetables. One of these compounds, 1-methylcyclopropene (1-MCP), has been shown to specifically but reversibly suppress ethylene responses and extend the postharvest shelf life and quality of numerous fruits and vegetables. In particular, apple, tomato, and avocado fruits have shown remarkable results.

Several years of studies have culminated in the recent approval of 1-MCP, marketed as *SmartFresh*™ (Agro-Fresh, Inc., a division of Rohm and Haas), for use with apple fruit. Approval of 1-MCP for use with other fruits and vegetables in both the U.S. and a number of countries is imminent. Use of 1-MCP is considered a breakthrough in apple storage technology for maintaining quality to the consumer. In apples, 1-MCP maintains critical taste components including firmness (crunchiness), sugar content (sweetness), and titratable acidity (tartness). 1-MCP is applied as a gas for relatively short periods (2-24 hours), is effective at very low concentrations, is nontoxic, and leaves virtually no residue. Work at the University of Florida's Horticultural Sciences department has been addressing the effects of 1-MCP on Florida-grown avocado and tomato fruits.

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1-MCP Effects on Florida-Grown Tomato Fruit

1-MCP has been shown to greatly delay softening and red color development of tomato fruit compared to untreated fruit. Figure 1 and Figure 2 illustrate the changes in firmness and color of 'Florida 47' tomato fruit following exposure (24 hour) to 1 ppm 1-MCP. Fully ripe tomatoes soften to about 6-7 N with good red development represented with a hue of about 40 to 50 degrees. Untreated fruit reached the full-ripe condition after 5 to 7 days of storage at 20°C while 1-MCP-treated took 13 to 15 days at the same temperature to become fully ripe. Thus, 1-MCP treatment resulted in nearly a doubling in shelf life. Figure 3 illustrates the appearance of untreated and 1-MCP-treated tomato fruit after 8 days of storage at 20°C, and of 1-MCP-treated fruit after 16 days of storage. As mentioned, these fruit were harvested and treated at the turning stage of development, indicating that 1-MCP is effective in slowing postharvest ripening *even when applied after ripening has started*. In this regard, 1-MCP has potential to increase overall fruit quality by allowing fruit to ripen on the vine for an extended period. Consequently, the use of 1-MCP is compatible with vine-ripe harvesting practices resulting in fruit that can tolerate the rigors of shipping and handling better than non-treated fruit.

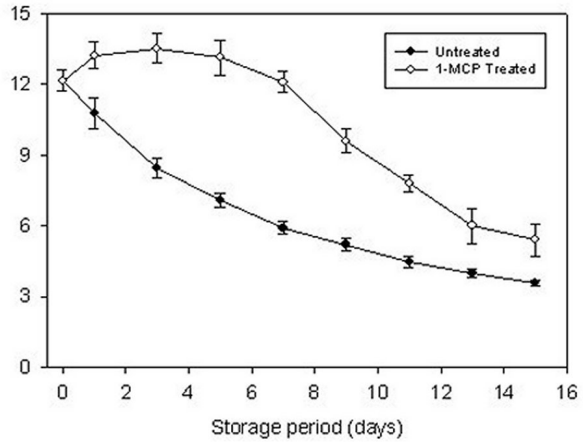

Figure 1. Firmness (N) of Florida 47 tomato fruit stored at 20° C following 1-MCP treatment (1 part per million, 20° C, 24 h)

1-MCP is **not** recommended for use with mature-green tomato fruit due to the presence of immature fruit that are virtually impossible to distinguish from mature-green fruit during normal harvesting operations. Consequently, loads of mature-green fruit typically include immature tomato which do not ripen to acceptable quality.

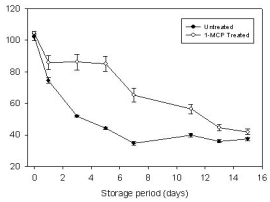

Figure 2. Color (as hue angle) of Florida 47 tomato fruit stored at 20° C following 1-MCP treatment (1 part per million, 20° C, 24 h). The table ripe stage is achieved when the hue angle attains values between 40 to 50.

Figure 3. Photograph shows 'Florida 47' tomato fruit 8 days (tray 1) and 16 days (tray 3) with the control group in tray 2 following treatment with 1-MCP.

1-MCP Effects on Florida-Grown Avocado Fruit

1-MCP has been shown to greatly delay avocado softening and loss of green color compared to untreated fruit. The effect of 1-MCP (400 parts per billion, 12 hours) on the softening and ripening of 'Simmonds' avocado fruit is shown in Figure 4. Similar to tomato, 1-MCP-treated avocado fruit required nearly twice the time to reach the full ripe edible stage (15 to 20 Newtons). As shown in Figure 5, the external color of avocado fruit (shown after 6 days at 20°C) was maintained longer after exposure to 1-MCP.

How 1-MCP Works

The use of 1-MCP for harvested fruits and vegetables represents a revolutionary advance in postharvest science and practices. The gas works by attaching to a site (receptor) in fruit tissues that normally binds to ethylene. Binding of ethylene to these sites is how plant tissues perceive that ethylene is present in the environment. If ethylene binding is prevented, ethylene no longer promotes ripening and

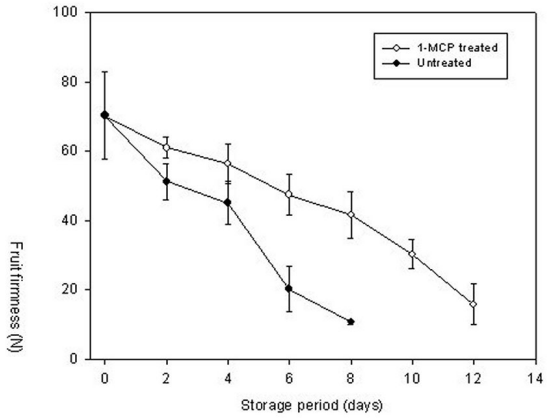

Figure 4. Fruit firmness (N) of Simmonds avocado fruit stored at 20° C following 1-MCP treatment (450 parts per billion, 20° C, 24 h).

Figure 5. Simmonds avocado fruit 6 days (20° C) after treatment with MCP.

senescence. This causes fruits to ripen and soften more slowly therefore maintaining their high-quality, edible condition for longer periods of time. Even some fruits and vegetables that do not go through a ripening phase (e.g. broccoli, lettuce, carrots etc.) may benefit from 1-MCP exposure.

The Future of 1-MCP

Though 1-MCP may not be beneficial for every horticultural commodity, the effects of this gas on many fruits and vegetables are currently under study at university and industry labs throughout the world and will undoubtedly lead to numerous and varied commercial applications. The gas may be especially beneficial in slowing ripening and deterioration of some tropical and subtropical fruits and vegetables to allow prolonged storage under the higher temperatures required to prevent chilling injury to these commodities. Even with temperate fruit, 1-MCP could improve tolerance of commodities to interruptions in the cold chain and possibly reduce dependency on costly controlled atmospheres. Finally, 1-MCP treatment may prove useful for protecting ethylene-sensitive members of mixed-load shipments.

It is important to note that 1-MCP has been approved for commercial use only with apples. As was the case for apples, additional research with tomato and avocado (and other fruits and vegetables) will be required to precisely determine the optimum 1-MCP treatment levels, length of exposure, and to establish whether different cultivars will require unique application conditions.