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WTFRC Project # **Organizational Project # 58-1275-9-076**

Project Title: Vapor and nonchemical treatments for decay control and flavor retention in apples.

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Objectives:

1) Evaluate the efficacy of prestorage air heat, and chemical vapor treatments, alone and in various combinations, to control postharvest decay while maintaining fruit quality especially flavor-associated volatile levels.

The principle anticipated benefit of this research is to better understand the relative effectiveness of a prestorage heat treatment and prestorage vapor treatments of methyl jasmonate (MJ), 1-methylcyclopropene (1-MCP), and poststorage vapor treatment of allylisothiocyanate (AITC) to control decay development caused by major postharvest pathogens of apple, i.e., *P. expansum*, *B. cinerea*, and/or *C. acutatum* and to reduce the dependence of the apple industry upon postharvest use of synthetic fungicides. High oxygen treatment during cold storage was evaluated as a possible means of increasing volatile levels.

Significant findings:

- Prestorage 1-MCP treatment reduced decay development caused by *P. expansum*, *B. cinerea*, and *C. acutatum* between 18 % and 38 % but had no effect on the incidence of pathogen-induced decay. 1-MCP treatment never increased decay development in apple.

- A high (100 Pa for 3 hours) vapor dose of AITC was phytosanitary eliminating lesion incidence caused by *P. expansum* but was also phytotoxic to the fruit unless they were wax coated prior to the chemical treatment.

- While prestorage heat treatment were phytosanitary at the time of treatment, they provided little residual protection against the incidence of lesions and decay development caused by *P. expansum*, *B. cinerea*, and *C. acutatum*.

- Prestorage MJ vapor treatment reduced the natural incidence of decay during storage by about 50 % but had little to no effect on decay development caused by wound inoculating fruit with *P. expansum*, *B. cinerea*, or *C. acutatum*.

- Prestorage treatment with 1-MCP followed by a heat treatment led to superficial fruit injury in one year of testing.

Methods:

This study was conducted over a three year period, during one year of which the WTFRC

funded my proposal to purchase a gas generator. The gas generator was used to generate precise concentrations of MJ and AITC for testing their antimicrobial properties in apples. Sets of preclimacteric 'Golden Delicious' apples were treated with 0.1 Pa 1-MCP for 18 hours at 20 °C, 38 °C for 4 days, 0.2 or 2 Pa MJ for 24 hours at 20 °C, or left untreated before placing in air storage at 0 °C. Some sets of fruit also were treated with 1-MCP followed by the heat treatment. In addition, some sets of untreated fruit were stored at 0 °C in a controlled atmosphere of 1.5 kPa O_2 and 2.5 kPa CO_2. Other sets of untreated fruit were stored in 100 % O_2 for 12 days at 0 °C at the beginning of the cold storage period, then transferred to air storage at 0 °C. After various cold storage periods, fruit were warmed to 20 °C, and subsets were either quality evaluated or wound inoculated with 10^5 spores/mL aliquots of *P. expansum*, *B. cinerea*, or *C. acutatum*. Following one week at 20 °C, lesion incidence and decay development were measured along with quality-related characteristics of respiration and ethylene production rates, volatile levels, and Magness-Taylor firmness. Other untreated sets of fruit were warmed to 20 °C, wound inoculated with *P. expansum* and treated 2 hours later with 0, 10, 30, and 100 Pa AITC for 0.25, 1, 2, or 3 hours. Lesion incidence and decay development were measured 7 to 9 days after treatment with the chemical.

Results and Discussion:

Regarding the antimicrobial treatments, both the heat treatment and the AITC treatment (100 Pa for 3 hours) were phytosanitary, eliminating lesion development caused by wound-inoculated *P. expansum*, *B. cinerea*, or *C. acutatum*. The heat treatment, however, provided little (~10 %) residual protection against these pathogens and would require a large input of energy to heat and cool large quantities of fruit. The heat treatment delayed ripening as indicated by decreased respiration and ethylene production rates and good maintenance of firmness. While quality-associated volatile production was initially inhibited, volatile levels recovered to near control levels following storage for 5 months at 0 °C and 1 week at 20 °C. One other benefit of the heat treatment was a noticeably increased peel yellowing even when the fruit had received a 1-MCP treatment prior to the heat treatment. Regarding AITC, it is inexpensive, a natural product, and can be easily reapplied as needed to control decay pathogens, but the chemical also was phytotoxic to the fruit at doses that are phytosanitary. To avoid fruit injury, the fruit had to be wax coated before poststorage treatment to protect against AITC adsorption by the cortical tissue. When AITC was limited to the pathogen-inoculated wound sites, AITC had no effect on fruit quality as indicated by respiration and ethylene production rates, volatile levels, and flesh firmness being similar to that of untreated fruit.

The prestorage MJ and 1-MCP treatments had no effect on the incidence of lesions caused by wound inoculating with *P. expansum*, *B. cinerea*, or *C. acutatum*. The 1-MCP treatment provided residual protection against decay development by these pathogens, i.e., lesion size was decreased between 18 % and 38 % following storage for 2.5 or 5 months at 0 °C and 1 week at 20 °C. At the dose used, 1-MCP prevented the climacteric increase in respiration and ethylene production rates, and maintained flesh firmness at near harvest levels following storage for 5 months at 0 C and 1 week at 20 °C. However, quality-associated volatile levels were inhibited by more than 90 % compared to that in untreated fruit and peel degreening was noticeably inhibited following storage. What impact these inhibitory effects of 1-MCP would have on consumer acceptance of 'Golden Delicious' apples is unknown. 1-MCP inhibited ripening more effectively than CA storage. Caution is advised when combining stress treatments to control ripening and decay development. In one of three years of testing, treatment with 1-MCP followed immediately by heat treatment led to peel browning during storage in many of the duel-treated fruit while none of the fruit that were treated with 1-MCP or heat alone were injured. In the year that injury from the 1-MCP and heat treatments was observed, no time had been left between the 1-MCP treatment and the heat treatment for 1-MCP outgassing to occur from the fruit. In the two years that injury was not observed, an 8-hour period had been left between the two treatments for 1-MCP to outgas. Whether including the outgassing period between treatments protected the fruit from injury or was the result of physiological variations of the fruit from

different growing seasons is not known. Applying the heat treatment before the 1-MCP treatment has not been done to our knowledge, but should be evaluated as an alternative strategy to potentially obtain the beneficial effects of both treatments on quality maintenance and decay control while lessening the risk of fruit injury. However, until the cause of the fruit injury associated with the duel treatment is understood, combining these two stressful treatments commercially should be avoided in 'Golden Delicious' apples.

Methyl jasmonate treatments of preclimacteric apples at 0.2 or 2 Pa for 24 hours at 20 °C was not phytosanitary and provided little to no residual protection against wound-inoculated decay development caused by *P. expansum*, *B. cinerea*, or *C. acutatum*. However, in one year of testing when natural decay development was higher than normal, MJ vapor treatments reduced the incidence of lesions by about 50 % during 5 months of storage at 0 °C. These results would suggest that MJ vapor is not an effective antimicrobial treatment in apples. Methyl jasmonate vapors increased peel yellowing without affecting flesh firmness, but not as effectively as the heat treatment which additionally maintained flesh firmness.

The 12-day high oxygen treatment at the beginning of storage at 0 °C did not increase quality-associated volatile levels in fruit following storage at 0 and 20 °C. The potential phytosanitary benefits of treating apples with high oxygen during cold storage were not investigated in this study.