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Postharvest physiology, storage quality and physiological disorders of 'Gem' pear (*Pyrus communis* L.) treated with 1-methylcyclopropene

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ABSTRACT

'Gem' is a crisp, juicy European pear (*Pyrus communis* L.) that can be consumed immediately at harvest or directly from cold storage. Alternatively, 'Gem' pears can ripen (5 d of 20 °C) to a soft, buttery, juicy texture once fruit accumulate 30 to 60 d of low temperature chill. In either condition, 'Gem' has a relatively short postharvest storage life of 5 months in regular air (RA). The purpose of this work was to evaluate two concentrations of 1-methylcyclopropene (1-MCP), 0.15 and 0.3 μL L^{-1}, to maintain crisp, juicy textural properties and extend the postharvest storage life of 'Gem'. Fruit were treated with 1-MCP, held in −1.1 °C RA and evaluated monthly (+1 d at 20 °C) for 7 months. Only minor differences were observed between 0.15 and 0.3 μL L^{-1} 1-MCP for any of the response factors assessed. The respiration (Rs) and ethylene production rates of non-treated fruit increased ~2- and 30-fold, respectively, between 2 and 7 months. Fruit firmness (FF), peel chlorophyll content (I_{AD}), and titratable acidity (TA) all decreased linearly over the 7-month storage period. Treatment with 1-MCP completely inhibited internal ethylene production for the first four months. Ethylene production increased linearly between 5 and 7 months to a maximum value ~15% of non-treated fruit. 1-MCP similarly suppressed Rs. FF, I_{AD}, and TA were all significantly higher for 1-MCP-treated fruit than non-treated fruit. 1-MCP maintained the crisp and juicy textural properties of non-ripened fruit throughout the entire 7-month experiment by inhibiting ripening, despite a five-day 20 °C ripening treatment. In contrast, non-treated 'Gem' ripened after 2 months; however, the eating quality of non-treated fruit decreased after 5 months. Poor eating quality was associated with mealiness and insufficient softening after ripening. Internal browning and scald were first observed in non-treated fruit following five months of RA and reached levels of 26% and 85%, respectively, after seven months. The development of scald was closely associated with the accumulation of α-farnesene and conjugated trienols (CTols) in the fruit skin. 1-MCP significantly reduced the incidence of internal browning and completely inhibited the development of scald. Overall, 0.15 μL L^{-1} 1-MCP maintained texture and fruit quality for 7 months RA and reduced the incidence of physiological disorders.

1. Introduction

'Gem' pear is a new, fire-blight resistant European pear (*Pyrus communis* L.) with a smooth, russet-free finish and red blush (Bell et al., 2014). 'Gem' is crisp and juicy at harvest and can be consumed directly from the tree (i.e., without ripening). While crispness is a desirable sensory attribute of apple (Daillant-Spinnler et al., 1996) a small, but significant population of pear consumers prefer crisp pears (Jaeger et al., 2003). The textural sensory attributes crispness, hardness and fracturability were strongly correlated for several European pear cultivars, but juiciness and crispness were not (Chauvin et al., 2010), rendering 'Gem' unique among European pear cultivars. 'Gem' can also ripen to a soft, buttery and juicy dessert quality but requires a minimum of 30 d low temperature conditioning to attain ripening competency (Einhorn and Wang, 2016). To optimize fruit quality, the recommended harvest maturity of 'Gem', as indicated by flesh pressure, is 42 to 47 N. While other European pear cultivars are harvested at markedly higher FF, scuffing or peel damage of 'Gem' was not observed during commercial postharvest operations when harvested at these pressures (Einhorn and Wang, 2016). One drawback associated with a delayed harvest, however, is a short postharvest storage life. Postharvest RA storage of 'Gem' is four to five months with additional time in storage

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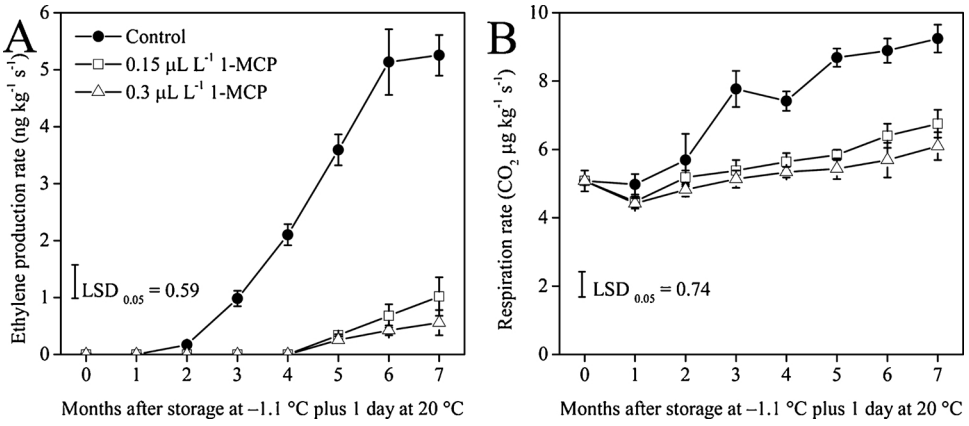

Fig. 1. Ethylene production (A) and respiration rates (B) of 'Gem' pears influenced by 0.15 and 0.3 μL L^{-1} 1-methylcyclopropene (1-MCP) following 7 months storage at –1.1 °C plus 1 day at 20 °C. Vertical bars represent standard error (SE). Means were separated among treatments by Fisher's protected least significant difference test (LSD) ($P < 0.05$).

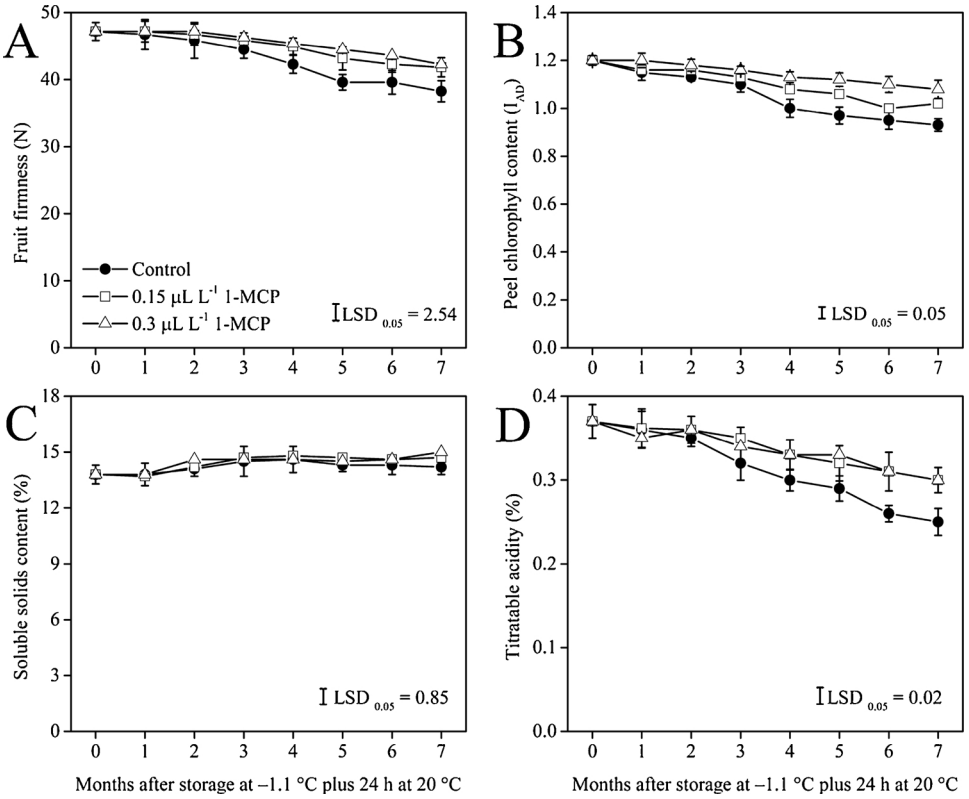

Fig. 2. Fruit firmness (A), peel chlorophyll content (B), soluble solids concentration. (SSC) (C), and titratable acidity (TA) (D) of 'Gem' pears as influenced by 0.15 and 0.3 μL L^{-1} 1-MCP following 7 months storage at –1.1 °C plus 24 h at 20 °C. Vertical bars represent SE. Means were separated among treatments by Fisher's protected LSD ($P < 0.05$).

resulting in a loss of ripening capacity (Einhorn and Wang, 2016) and the occurrence of storage disorders (Wang, unpublished data). Developing 'Gem'-specific postharvest protocols to increase consistency of non-ripened fruit quality and storage life is an area in need of research attention.

European pears are climacteric fruit and are susceptible to postharvest disorders during long-term RA storage due to high rates of internal ethylene production (Villalobos-Acuña and Mitcham, 2008). The use of 1-methylcyclopropene (1-MCP) to bind ethylene receptors has been successfully applied by commercial postharvest operations to inhibit ethylene action and maintain higher quality of climacteric fruits such as apple, pear and kiwifruit (Watkins, 2006). Several factors such as genotype, 1-MCP concentration, duration of exposure, and storage temperature can all modulate a fruit's response to 1-MCP (DeEll and Ehsani-Moghaddam, 2011; Wang and Sugar, 2015; Xie et al., 2014). For pear, cultivars can be grouped broadly into two categories, summer and winter pears, based on differences in their development, storability, ripening and response to ethylene. The response of summer pears, 'Bartlett' (Wang and Sugar, 2015) and 'Starkrimson' (Xie et al., 2015) and winter pears, 'd'Anjou' (Wang, 2016) and 'Comice' (Wang and Sugar, 2013) to 1-MCP has been previously examined. Generally, summer pears require two-fold 1-MCP concentration than winter pears (i.e, 0.3 μL L^{-1} versus 0.15 μL L^{-1} for summer and winter pears, respectively (Wang, 2016; Xie et al., 2015). 1-MCP increased storage life of pears, in part by reducing skin scald, internal browning and impact bruising but concomitantly inhibited fruit ripening capacity, which has limited its utilization (Bai et al., 2006; Chen and Spotts, 2005; Xie et al., 2014).

'Gem' pear, with its distinct crisp, juicy texture may prove an ideal candidate for 1-MCP given that the benefits of minimizing physiological disorders and extending the postharvest storage life would not come at the cost of softening inhibition. The objectives of this study, therefore, were to investigate the effect of 1-MCP on physiology, storage quality, eating quality and physiological disorder development of 'Gem' pears following 7 months of RA storage plus 5 days at 20 °C. Given that the physiology of 'Gem' cannot be easily characterized as either a summer or winter pear, two rates of 1-MCP (0.15 and 0.3 μL L^{-1}) were evaluated.