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An effective combination storage technology to prolong storability, preserve high nutrients and antioxidant ability of astringent persimmon

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ABSTRACT

'Fangshan' persimmon is one of the most important astringent persimmon cultivars. The combined use of postharvest treatments, 5% CO_2 and 1-methylcyclopropene (1-MCP), at two storage temperatures (1 °C and 20 °C) was evaluated to determine the change rules of persimmon nutritional quality during storage and a best storage method on astringent persimmon. Results show that Total phenols, soluble tannins and total flavonoids were significantly positively correlated to the DPPH ($0.502 \le r \le 0.617$, $P < 0.01$) and ABTS ($0.604 \le r \le 0.646$, $P < 0.01$) radical scavenging ability. Sucrose was significantly negatively correlated with fructose and glucose with r of -0.466 ($P < 0.01$), -0.290 ($P < 0.05$), respectively. Glucose was significantly positively correlated with fructose with r of 0.708 ($P < 0.01$). At the end of storage, the treatment with combined use of 1-MCP, 1 °C and 5% CO_2 resulted in higher nutrient content (except for sugars) compared to other treatments. And in this treatment, persimmon can be stored up to 4 months. Therefore, using the combination storage technology of 1-MCP, 1 °C and 5% CO_2 is the most effective way to prolong astringent persimmon storability and preserve high nutrients and high antioxidant ability.

1. Introduction

Persimmon (*Diospyros kaki* L.) is cherished for its unique flavor and high nutrient content. It is a fruit that mainly originates in China, Japan and Korea (Lucas-González et al., 2017). In 2012, the area under persimmon cultivation in China was 734,800 ha. The global persimmon production was over 4.4 million tons, out of which 75.77% was from China, 8.97% from Republic of Korea and 5.68% from Japan (FAOSTAT, 2012). Astringent persimmons are climacteric fruit and ethylene plays a major role in the regulation of ripening (Oz, 2013). 'Fangshan' is one of the astringent persimmon cultivars which matures between late October and early November. Currently, accelerated softening reduces the harvest window and causes excessive fruit drop. Considering climacteric ripening of fruit, inhibiting ethylene biosynthesis or action may therefore slow the ripening process and enhance the storage life (Luo, 2007).

Refrigeration is usually considered to be a useful way of extending the postharvest storage life of fruit including Tarocco blood orange (Pannitter et al., 2017), loquat (Liguori et al., 2017) and tomato (Majidi et al., 2014). But low-temperature storage can lead to flesh softening when fruit are transferred to shelf temperature (Besada et al., 2014). Furthermore, storage temperature has also been demonstrated to affect fruit color index, appearance and astringency of 'Rojo Brillante' persimmon stored at 1 °C for 34 days (Arnal and Del Río, 2004).

Controlled atmosphere (CA) storage was recently demonstrated to be beneficial for maintaining fruit quality of harvested apples (Thewes et al., 2017), mangoes (Sivakumar et al., 2012) and pears (Suchanek et al., 2017). In persimmons, the effect of CA on extending shelf life has been widely studied for the non-astringent cultivar, 'Fuyu'. Currently, the incidence of skin and flesh disorders is the main limitation for using CA to store 'Fuyu' fruit (Besada et al., 2014). Therefore, Park and Lee (2008) studied effect of different CO_2 and O_2levels on skin and flesh

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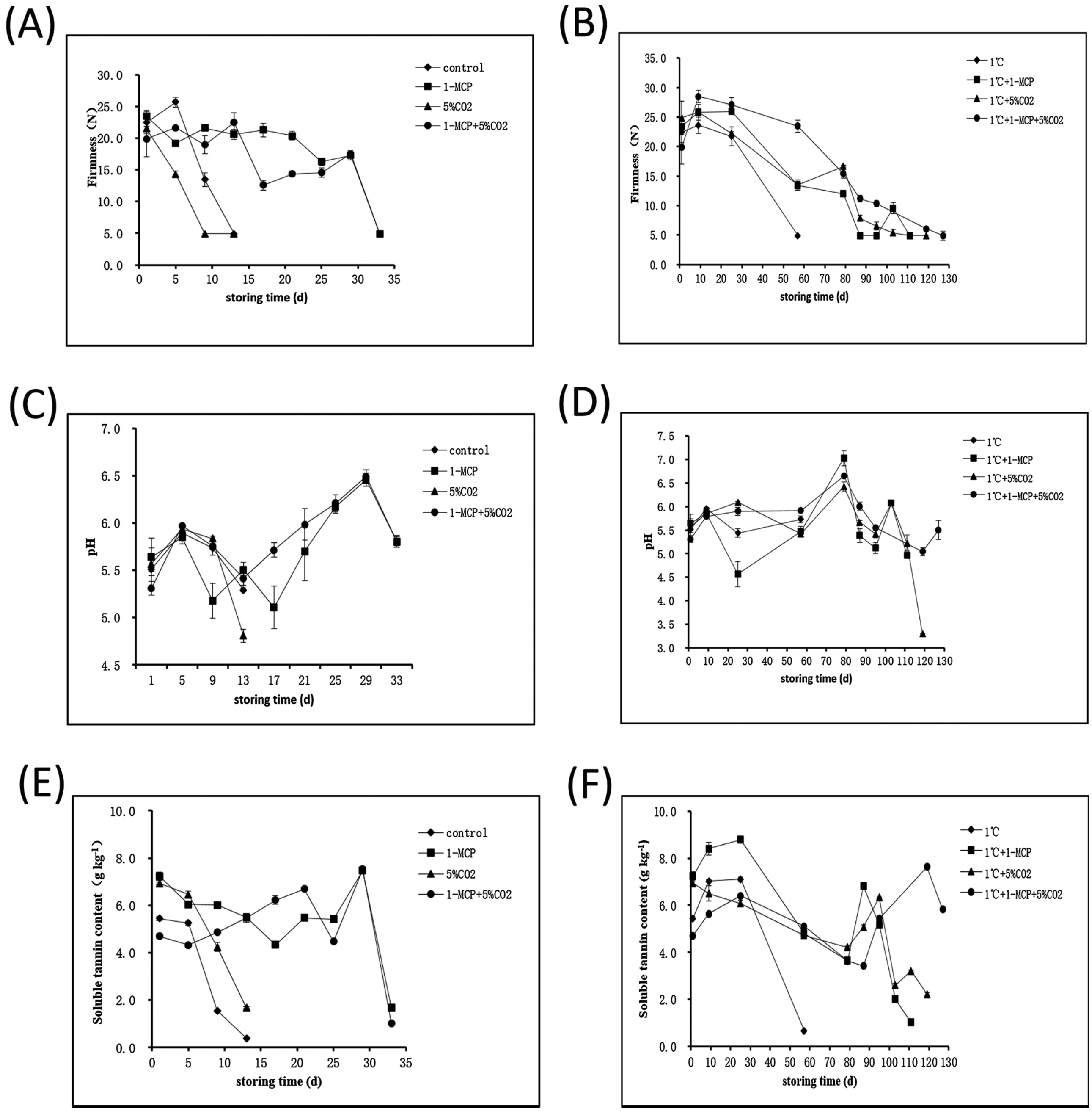

Fig. 1. Effect of postharvest treatment with 1-MCP, used alone or combined with 5% CO_2, on flesh firmness (N), pH and soluble tannins (g/kg FW, FW = fresh weight) of persimmon cv. Fangshan fruit during storage at 20 °C (A, C, E) and 1 °C (B, D, F). Error bars indicate the standard error.

browning of cold-stored ‘Fuyu’ persimmon. Recently, Besada et al. (2014) reported that combination of 1-MCP pre-treatment and CA storage based on 4–5 % O_2 + N_2 is useful for prolonging the storage time of ‘Triumph’ as it preserved internal and external fruit quality.

1-Methylcyclopropene (1-MCP) is a new potent inhibitor of ethylene action. It has been recommended for commercial use to extend fruit shelf life (Li et al., 2017). The application of 1-MCP can greatly extend the postharvest life of ‘Qiandaowuhe’ persimmon at 20 °C (Luo, 2007). 1-MCP maintained ‘Rojo Brillante’ persimmon fruit firmness and inhibited calyx abscission at 1 °C, and there were no significant differences between 1-MCP concentration of 0.3 and 1 μL L^{-1} (Salvador et al., 2004). Choi et al. (2012) reported that repeated application of 1-MCP, *i.e.* pre- and post-load, did not increase fruit firmness compared to single application of pre-load 1-MCP. However, applying 1-MCP and using modified atmosphere packaging (MAP) after three-month-cold storage delayed ripening process of ‘Fuyu’ sweet persimmon for 30 d at room temperature compared to using 1-MCP or MAP separately. On the other hand, 1-MCP and gibberellic acid treatments delayed the softening and ethylene peak of persimmon fruit, as well as extended the storability at 1 °C for up to nearly 3 months (Besada et al., 2008). Recently, 1-MCP has been used in other fruit to extend storage time and maintain quality. Examples are apples (Hoang et al., 2011), banana (Ketsa et al., 2013), durian (Amornputti et al., 2014) and muskmelon (Supapvanich and Tucker, 2013).

Earlier studies indicated that 1-MCP delayed softening and color change of persimmon fruit, but had no effect on weight loss (Salvador et al., 2004). However, the combined effect of 1-MCP, low temperature and CO_2 on persimmon fruit storage and fruit nutritional quality during softening period have not yet been elucidated. Therefore, we examined the fruit nutritional quality including firmness, pH, soluble sugar,