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SHORT COMMUNICATION

Enhancement of apple coloration using jasmonate treatment without sacrificing storage potential

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ABSTRACT

Apple coloration is very important for most cultivars. The application of jasmonate can effectively enhance the coloration of apple fruit, but it might ruin the fruit's storage potential. Here, we report that applying methyl jasmonate on apple fruit 3 weeks before commercial harvest not only enhanced the fruit coloration but also did not affect its storage potential. Our findings provide important information for enhancing apple coloration using jasmonate.

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Red peel color is a very important agronomic trait for many apple (*Malus domestica*) cultivars.[1] Poor red color development of the apple fruit surface decreases its attractiveness to consumers. Anthocyanin is responsible for the red coloration of apple fruit.[2] Its biosynthesis is affected by external cues, including light, temperature and nutrients as well as growth regulator.[1,3-6] Ripening is another important trait for apple fruit, which determines the fruit's storage potential, especially in climacteric fruit.[7-9] Paclobutrazol, a gibberellin inhibitor, can markedly enhance red coloration while delaying fruit ripening. Both auxin and ethylene can also promote coloration, but they accelerate fruit ripening.[1,10] It would be tremendously interesting to find a way to enhance the fruit's red color without affecting its ripening.

Jasmonate is another phytohormone that is used to enhance the red coloration of apple fruit.[4,6,11,12] In some cases, the use of jasmonate can also enhance fruit ripening and can shorten the fruit's storage potential.[13] In the June issue of The Plant Cell, we reported that jasmonate promotes ethylene production by enhancing the transcription of *MdACS1*.[14] However, jasmonate-promoted ethylene biosynthesis is dependent on the expression of *MdACS1*, meaning that jasmonate is not able to promote ethylene production in apple fruit until *MdACS1* expression has been initiated.[14] In apple fruit, *MdACS1* is the key gene responsible for ethylene biosynthesis during fruit ripening.[15] *MdACS1* is not expressed during fruit development but is specifically expressed during fruit ripening.[13,16,17] These results suggest that the application of jasmonate on apple fruit during development would not influence the ethylene production or fruit ripening. Interestingly, applying jasmonate during fruit development is effective in enhancing fruit coloration.[18]

In this sense, it is possible to identify a certain period before fruit ripening when applying jasmonate not only enhances the fruit color but does not ruin its storage potential. To test this possibility, we treated apple fruit (*M. domestica* cv. Hanfu) with 10 mM of methyl jasmonate (MeJA) 3 weeks before commercial harvest, as described in Li et al.[14]

After harvest, the fruit were subjected to an evaluation of their anthocyanin content and their storage potential. The anthocyanin was extracted from the fruit skin and measured, as described in Wang et al.[19] The result showed that the MeJA treatment significantly enhanced the anthocyanin content at the time of commercial harvest (Fig. 1). Interestingly, when fruits were stored at room temperature for 15 days, the ethylene production showed no significant difference between the MeJA treated and control fruits (Fig. 2A) during the storage period; meanwhile, fruit firmness was investigated at 15 d after storage, and it also showed no significant difference (Fig. 2B). We also treated 'Hanfu' apple fruit with 10 mM of MeJA one week before commercial harvest; however, it did not obviously affect the anthocyanin content (data not shown). A previous study has obtained similar results, where anthocyanin content was significantly enhanced in the fruit by applying MeJA on 'Cripps Pink' apple fruit at 21 d before harvest; earlier applications worsen the effect.[18] Although Shafiq et al.[18] did not investigate the fruit's loss of firmness during the storage period, they have at least shown that the MeJA treatment does not affect the fruit's firmness at harvest compared with that of control fruits. Our findings in combination of the results from Shafiq et al.[18] strongly suggest that it is absolutely possible to enhance the anthocyanin content of apple fruit using MeJA 3 weeks before commercial harvest without influencing the fruit's storage potential.

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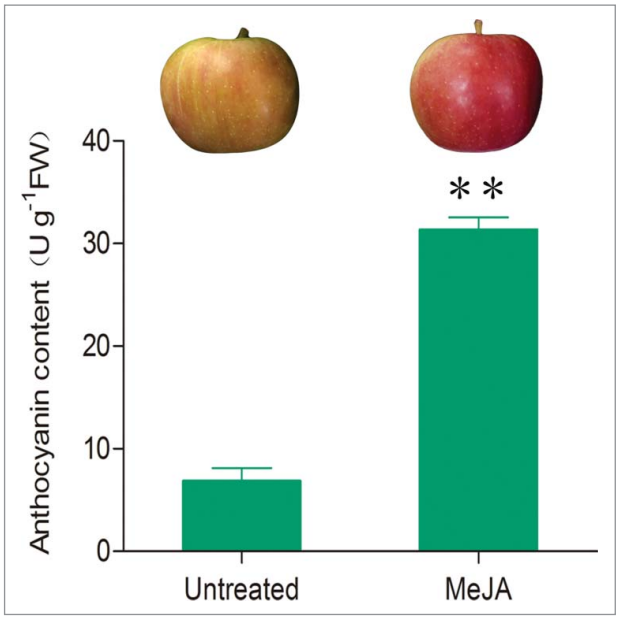

Figure 1. Anthocyanin content of 'Hanfu' apple fruit with or without the application of methyl jasmonate (MeJA). Ten mM of MeJA was applied to apple fruit 3 weeks before commercial harvest. The fruits were collected at commercial harvest and subjected to measurement of their anthocyanin content as described in.[19] Three biological replicates were performed. Values represent means ± SE. Statistical significance was determined using a Student's *t*-test (** $P < 0.01$). Untreated, fruits without MeJA application; MeJA, fruits with MeJA application.

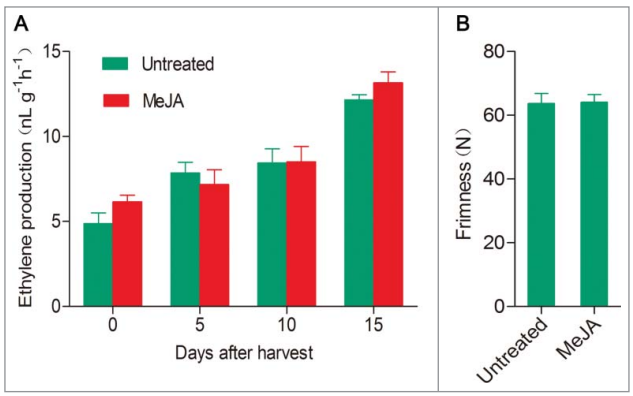

Figure 2. Ethylene production and firmness of 'Hanfu' apple fruit with or without the application of MeJA during storage. Fruits were collected at commercial harvest and stored at room temperature for 15 days. Fruits were sampled every 5 d, and ethylene production and fruit firmness were measured according to Tan et al.[20] A, ethylene production of apple fruit during storage. B, firmness of apple fruit at 15 d after storage. Three biological replicates were performed. Values represent means ± SE. Statistical significance was determined using a Student's *t*-test. Untreated, fruits without MeJA application; MeJA, fruits with MeJA application.

Moreover, we observed that the application of MeJA on the shaded side of the apple fruit did not obviously change the coloration (data not shown), suggesting that light is an important player in jasmonate-induced anthocyanin biosynthesis. It would be quite interesting to study the co-regulation of light and jasmonate on anthocyanin biosynthesis in apple fruit.

Disclosure of potential conflicts of interest

No potential conflicts of interest were disclosed.

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