Integrative analysis of transcriptome and metabolome reveals the possible mechanism of leaf yellowing in pak choi (*Brassica rapa* subsp. *chinensis*) with 1-methylcyclopropene treatment during storage at 20 °C

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Abstract

To understand the regulatory mechanism of leaf yellowing in pak choi with 1-methylcyclopropene (1-MCP) treatment at (20 ± 0.5) °C, integrative analysis of the metabolome and transcriptome profiles was performed. Results showed that treatment with 1-MCP significantly delayed degreening and inhibited the respiration rate and ethylene production of pak choi. Chlorophyllide (Chlide) a, pheophytin (Phy) a and pheophorbide (Pheide) a were the main chlorophyll (Chl) catabolites in pak choi which diminished concomitantly with leaf yellowing. 1-MCP effectively retarded the formation and decrease of Chl intermediate metabolites (Phy a and Pheide a) by suppressing the activities of Chl-degrading enzymes such as Mg-dechelatase (MD) and pheophytinase (PPH), and therefore, maintained high levels of Chl a, Chl b and Chl cycle metabolites. 1-MCP significantly down regulated ethylene related biosynthesis and signal transduction genes including *BcMSAMS2*, *BcACO* and *BcACO4*, together with *BcMPK19*, *BcEIN3* and *BcERF073*. While expressions of *BcACS4*, *BcCTR1* and *BcETR1* were slightly affected by 1-MCP treatment. The treatment also significantly inhibited the expressions of most of Chl degradation associated genes (*BcPPH1/2, BcSGR1/2, BcPAO, BcNYC1* and *BcNOL*) except for *BcRCCR*. However, chlorophyllase (CLH) activity with 1-MCP treatment were enhanced, as well as B*cCLH1/2* expression. Pak choi preserved high Mg-chelating substance (MCS) activity throughout storage, without being affected by 1-MCP. PPH rather than CLH played a central role in Chl catabolism. 1-MCP promoted the conversion of Chl a and Chlide a to Chl b by up-regulating *BcCAO*, retarding Chl degradation. In conclusion, 1-MCP fumigation significantly attenuated the expressions of genes related in ethylene biosynthesis, signal transduction and Chl degradation, and increased *BcCAO* expression, ultimately inhibiting Chl degradation and relieving the yellowing of pak choi. The results provide a possible target for delaying the yellowing of green vegetables.