

MdCAX affects the development of the ‘Honeycrisp’ bitter pit by influencing abnormal Ca distribution

Jia Liu, Zitao Jiang, Yingwei Qi, Yanfei Liu, Yuduan Ding, Xiaoning Tian and Xiaolin Ren

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Abstract

Bitter pit (BP) is a physiological disorder of calcium deficiency in apple fruit and has not been fully characterized. The $\text{Ca}^{2+}/\text{H}^{+}$ exchanger (CAX) is a kind of Ca^{2+} transport protein. In this study, we analysed mineral contents in different parts of fruit, the expression levels of genes related to Ca transport and the functional roles of *MdCAXs*. The results showed lower water-soluble Ca content and significantly higher ratios of water-soluble P/Ca and (K + Mg)/Ca in the calyx-end flesh of BP and normal fruit than the peduncle-end flesh of them. The expression level of *MdCAX11* increased as the severity of BP increased, and the expression profile was negatively correlated with the water-soluble Ca content. Yeast growth assays showed that both *MdCAX11* and *MdCAX5* have the function of transporting Ca to vacuoles. Subcellular localization analysis showed that *MdCAX11*-GFP and *MdCAX5*-GFP were colocalized on the vacuole membrane with a tonoplast marker. Taken together, the results of this study indicate that high expression levels of *MdCAX11* and *MdCAX5* may cause an influx of Ca from the cytosol into vacuoles, which may be related to the occurrence of BP.