Expression of antioxidant-related genes in flavedo of cold-stored grapefruit (*Citrus paradisi* Macfad cv. Rio Red) treated with pectic oligosaccharides

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Abstract

Cold storage is one of the main postharvest technologies for fruit preservation, however, cold-sensitive citrus fruits develop peel physiological alterations affecting external quality known as chilling injury (CI). An efficient antioxidant system has been associated to an enhanced cold stress tolerance in citrus fruits. The application of pectic oligosaccharides (POs) stimulates the enzymatic antioxidant system in plants and reduces CI development in grapefruit fruit (*Citrus paradisi*) during cold storage. The aim of this study was to contribute to the basic understanding of peel physiological disorders in cold-stressed 'Rio Red' grapefruit fruit at ultrastructural level and to determine whether the POs are involved in the CI reduction by modulating the antioxidant enzymatic system at the transcriptional level. Peel morphology in grapefruit fruit stored at chilling (2 °C) and non-chilling (13 °C) temperatures was analyzed by electronic microscopy and the effect of POs treatment on *manganese superoxide dismutase* (*MnSOD*), *ascorbate peroxidase* (*APX1*), *catalase* (*CAT1*) and *glutathione reductase* (*GR2*) gene expression was investigated by RT-qPCR. Results indicate that a prolonged cold storage promoted the incidence of CI symptoms in 'Rio Red' grapefruit and altered the ultrastructural morphology of flavedo epidermal tissue. POs significantly modulated the *MnSOD, APX1* and *CAT1* expression levels mainly in a storage time- and temperature-dependent manner with regards to controls. By contrast, POs only significantly affected the *GR2* gene expression when grapefruit were stored at non-chilling temperatures. Our results revealed a possible involvement of the *MnSOD, APX1* and *CAT1* genes in the CI susceptibility reduction induced by POs in 'Rio Red' grapefruit stored at chilling temperatures.