Book of Abstract

Metabolic and molecular responses of 'Red Delicious' apple to static and dynamic extreme low oxygen concentrations during storage

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Red Delicious (RD) apples benefit from storage under low oxygen, which delays ripening and maintains fruit quality. However, sensitivity to such conditions often causes excessive accumulation of ethanol/off-flavors, and the onset of storage disorders, leading to unmarketability and losses. To mitigate these effects, Initial Low Oxygen Stress (ILOS) storage has been applied. ILOS involves exposing fruit to very low oxygen levels (<1kPa) at the beginning of cold storage, switching it to higher levels after few weeks and triggering stress responses that impact both fundamental and specialized metabolisms. To investigate these responses, RD apples were stored at 1 °C under different conditions: normoxia, extremely low oxygen (ELO; 0.3 kPa O_2,1.1 kPa CO 2) for 180 DIA, and ILOS (0.3 kPa O_2 for 30 DIA followed by 0.8 kPa for 150 DIA, 1.1 kPa CO 2). Peel and flesh tissues were collected separately at 30, 90, and 180 DIA and evaluated through transcriptomic and metabolomic analyses. Results confirmed strong induction of ethanol and high accumulation of ethyl esters and alanine under ELO. Common and tissue-specific responses between peel and flesh were identified. Both tissues accumulated non-ethyl esters under normoxia, anaerobic-related VOCs under ELO, and amino acids like valine and lysine under ILOS. Tissue-specific responses included higher polyphenol accumulation in the flesh under hypoxic storage and in the peel under normoxia. Transcriptomics analysis confirmed and complemented these findings, highlighting the possible role of ERF transcription factors in low oxygen responses. Notably, ERF-VII members MdRAP2.2, MdRAP2.3, MdRAP2.12, and the hypoxia-responsive MdHRE1, MdHRE2, and MdHRE-like, showed differential regulation under ELO and ILOS, with more moderate responses after ILOS. Genes commonly affected by hypoxia were mainly involved in polyphenol and amino acid metabolism, consistent with observed metabolomic patterns in the flesh. The study provides insights into metabolic and molecular adaptations underlying common and tissue-specific responses to low oxygen storage in RD apples.

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