High CO_2 alleviates cell ultrastructure damage in Autumn Royal table grapes by modulating fatty acid composition and membrane and cell oxidative status during long-term cold storage

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Abstract

Cell membranes provide a link between postharvest disorders and their integrity is essential for reducing table grape deterioration due to dehydration and susceptibility to fungal infection. We examined the relationship between ultrastructural membrane integrity at the subcellular level (transmission electron microscopy), cell (H_2O_2 generation) and membrane (malondialdehyde accumulation) oxidative status, membrane fatty acid composition (polar lipid fraction) and berry quality in order to determine the critical membrane events associated with long-term storage disorders at 0 °C in table grapes (*Vitis vinifera* L.) cv. Autumn Royal, and evaluate their response to the application of a single or dual short-term 20 kPa CO_2 treatment. The results revealed a progressive disorganization of the cytoplasm and the breakdown of the cell organelle ultrastructure, associated with elevated hydrogen peroxide generation and lipid peroxidation rates and an imbalance in the saturated/unsaturated ratio of polar lipids, mainly due to the decrease in the degree of unsaturation of 18-carbon fatty acids. Conversely, high CO_2 levels maintained the integrity of the microstructure of cell and energy-related organelles that are essential for metabolic damage repair and cell membrane restoration, reduced oxidative damage in cells and membranes, and increased the unsaturation of 18-carbon fatty acids, lipid unsaturation ratio and index of unsaturated fatty acids (IUFA) in the membrane polar lipids. The results also revealed that the more short-term high CO_2 treatment is applied to Autumn Royal grapes, the more cytological evidence there is of enhanced tolerance to long-term cold and prevention of storage disorders in terms of cluster weight loss, rachis browning, berry water loss and decay incidence.