Characterization of Novel Fruit Ripening Pathways

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Abstract

Climacteric fruits are characterized by a dramatic increase in autocatalytic ethylene production, which is accompanied by a spike in respiration, at the onset of ripening. The change in the mode of ethylene production from autoinhibitory to auto-stimulatory is known as the system 1 (S1) to system 2 (S2) transition. European pear (*Pyrus communis L.*) cultivars require a genetically pre-determined duration of cold-temperature exposure to induce autocatalytic system 2 ethylene biosynthesis and subsequent fruit ripening. What happens during the cold treatment is becoming clearer at the molecular level. Differential expression, functional annotation, and gene ontology enrichment analyses have provided interesting evidence for the involvement of cold-induced, vernalization-related genes and repressors of endodormancy release, and an unexpected involvement of AOX transcription at pre-climacteric stage. These genes have not previously been described to play a role in fruit during the ripening transition. Besides the need for cold, application of 1-methylcyclopropene in European pear irreversibly obstructs the onset of system 2 ethylene production resulting in perpetually unripe fruit. 1-MCP in an ethylene receptor antagonist which blocks ethylene perception and downstream ripening responses. In pear, application of exogenous ethylene, carbon dioxide and treatment to high temperatures is not able to reverse the blockage in ripening. Activation of AOX via exposure of 1-MCP treated 'D'Anjou' pear fruit to glyoxylic acid has been shown to trigger an accelerated ripening response. Ripening is consistently evident in decrease of fruit firmness and onset of S1-S2 ethylene transition. Transcriptomic and functional enrichment analyses have helped in identifying genes and ontologies implicated in glyoxylic acid mediated ripening, including alternative oxidase, TCA cycle, fatty acid metabolism, amino acid metabolism, organic acid metabolism, and ethylene responsive pathways. These data point to the glyoxylate cycle as a metabolic hub linking multiple pathways to stimulate ripening through an alternate mechanism. The results have provided information regarding how blockage caused by 1-MCP may be circumvented at the metabolic level, thus opening avenues for consistent ripening in pear and possibly other fruit. Understanding metabolic intervention points at which ripening responses can be manipulated provide key, species- and cultivar-specific gene targets which can be altered via gene editing or transgenic approaches for proactive modulation of ripening to enable development of strategies or new cultivars for reducing overall postharvest wastage.