NAC transcription factors *SNAC4* and *SNAC9* synergistically regulate tomato fruit ripening by affecting expression of genes involved in ethylene and abscisic acid metabolism and signal transduction

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Abstract

NAC (NAM, ATF1/2 and CUC2) is a transcription factor that can regulate many physiological and biochemical reactions in plants. Two *NAC* genes, *SNAC4* (NM_001279348.2) and *SNAC9* (NM_001365397.1), with similar secondary structures have been isolated from tomato (*Solanum lycopersicum* L.). The pattern of *SNAC4/9* co-regulation of tomato ripening with abscisic acid (ABA) and ethylene through yeast two-hybrid and bimolecular fluorescence complementation assays has revealed that *SNAC4/9* can interact with genes related to ABA and ethylene (*SAPK3, SlPYL9, SlAREB1, SlACS2* and *SlACO1*) at the protein level. Electrophoretic mobility shift assay and yeast one-hybrid showed that *SNAC4*, but not *SNAC9*, acts directly on the promoter regions of *SAPK3, SlCYP707A1, SlACS8* and *SlACO6* and can activates them. In addition, quantitative real-time PCR analyses of *SNAC4/9*-silenced fruit obtained by virus-induced gene silencing, and phytohormone-treated fruit, confirmed that the interaction genes are regulated by *SNAC4/9* and thereby affect fruit ripening. In summary, we found that *SNAC4/9* can regulate fruit ripening by positively acting on key genes in the synthesis and signal transduction of ABA and ethylene. *SNAC4/9* cooperates with these phytohormones as part of the tomato fruit ripening regulatory network.