Imbalanced expression of *stay-green 1* alleles in banana AAB/ABB cultivars prevents high-temperature-induced green ripening as in AAA Cavendish fruit

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Abstract

Cavendish banana (*Musa* AAA) shows green-ripening at high temperatures above 24 °C, while Bluggoe fruit (*Musa* ABB) turns completely yellow. To understand the genomic constitution of the fruit de-greening trait, we compared fruit ripening and chlorophyll (Chl) degradation in 4 banana cultivars, belonging to the Cavendish (AAA), Mysore (AAB), Pisang Awak (ABB) and Bluggoe (ABB) subgroups, at 30 °C and 20 °C. Compared with fruit at 20 °C, ripening progress of the 4 cultivars at 30 °C, as represented by the change in fruit firmness and expression of fruit ripening-related genes, *ACS ACO* and *PG*, was accelerated, while the de-greening of fruits was repressed in the AAA cultivar but enhanced in the 3 hybrids (AAB/ABB). The expression of *Stay-Green 1* (*SGR1*), a key Chl degradation gene, was reduced in the AAA cultivar but induced in the hybrids, correlating to the fruit de-greening patterns. The *A-* and *B-SGR1* alleles, from the A- and B-genome, respectively, and a recombinant of the two alleles (*H-SGR1*) were identified in the AAB/ABB cultivars. A highly conserved polymorphism code was found to differentiate the *A/B/H-SGR1* alleles. Allele-specific expression analysis showed that the Bluggoe fruit transcribed only *B-SGR1*, while Pisang Awak and Mysore expressed *B/H-* and *A/B-SGR1*, respectively, and higher *B-SGR1* transcription levels were detected at 30 °C than at 20 °C. Transient expression of *A/B/H-SGR1* in tobacco leaves demonstrated that SGR1s were all targeted to chloroplasts, and A-SGR1 showed a weaker Chl degradation capacity than B/H-SGR1. The allelic imbalanced expression (AIE) of *SGR1* was demonstrated to confer the different fruit de-greening traits to the AAA and AAB/ABB cultivars at high temperatures.