The Molecular Control of Tomato Fruit Quality Traits: the Trade Off Between Visual Attributes, Shelf Life and Nutritional Value

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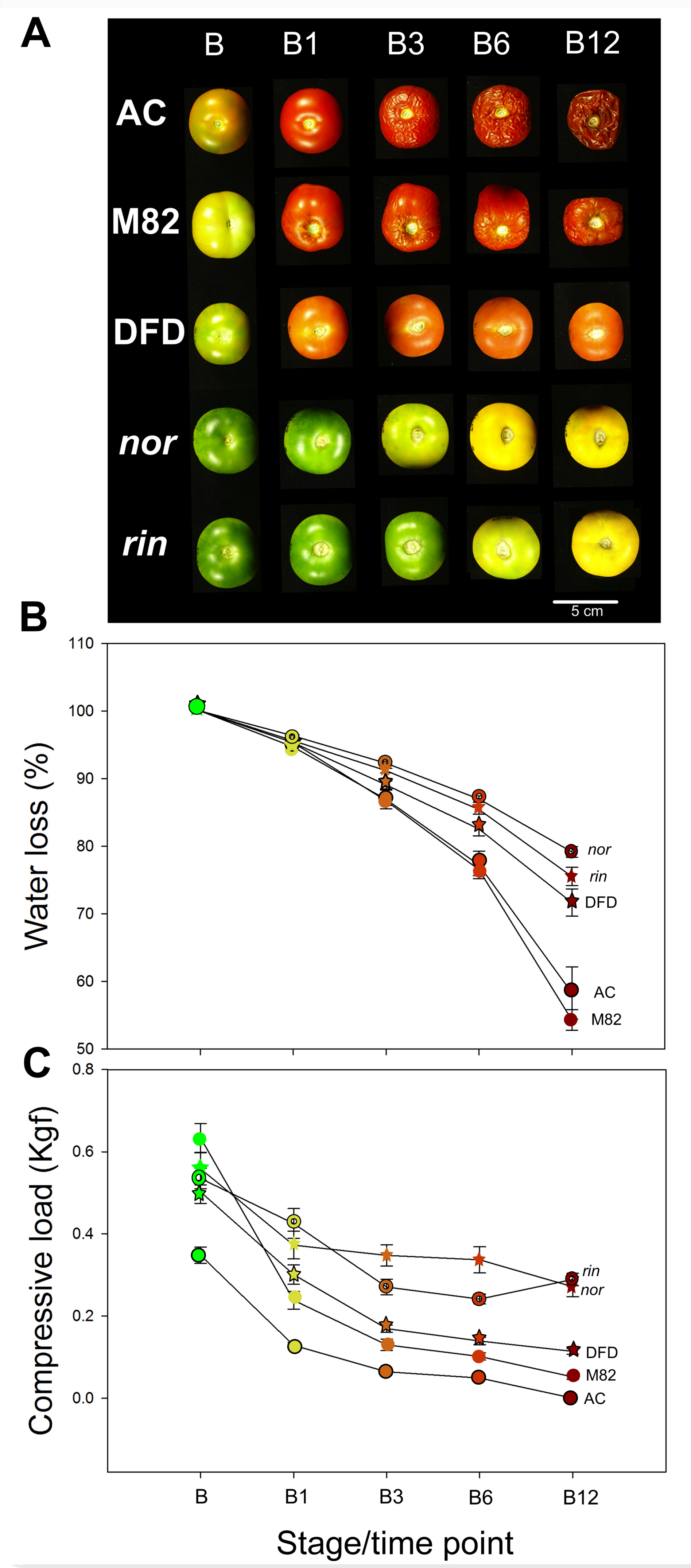
Tomato (*Solanum lycopersicum*) is an established model to study fleshy fruit development and ripening and is an important crop in terms of its economic and nutritional value. Tomato fruit quality is a function of metabolite content which is prone to physiological changes related to fruit development and ripening. It has been described some ripening tomato mutants, delayed fruit deterioration (DFD), non-ripening (NOR) and ripening-inhibitor (RIN) which substantially extend "shelf life" in tomato for up to several months when defined in terms of softening, water loss and resistance to postharvest biotic infection. However, it is not known whether this extension in "shelf life" is in fact a desirable objective from the perspective of nutritional quality of the fruits. The aim of this work was to use a metabolomics approach join to genomic tools to characterize compositional changes (sugars, amino acids, organic acids and carotenoids) of non-softening tomato mutants reported (DFD, NOR and RIN) in comparison with the normally softening fruits (Ailsa Craig and M82) during ripening and postharvest shelf-life.

POSTHARVEST CHARACTERISTIC OF THE MUTANTS



Water loss

Fruits from AC and M82 varieties lose more water and without significant changes between them (Figure 1B), which is reflected in clear signs of desiccation more rapidly that those of the *DFD, nor*, and *rin* mutants (Figure 1A).

Firmeness

Compression analysis of intact AC and M82 fruits showed a typical loss of fruit firmness from B to B12. In contrast, all stages from B to B12 from *nor*, *rin* and *DFD*, were statistically firmer than those of AC and M82 at the same stage, exhibited minimal softening during ripening (Figure 1C).

Figure 1. Comparison of AC (Ailsa Craig), M82, DFD (Delayed fruit Deterioration), *nor* and *rin*. (A) Ripening series of AC, M82, DFD, *nor* and *rin* at different time points (B; breaker, B1; breaker+1, B3; breaker +3, B6; breaker+6, and B12; breaker+12 DAP). (B) Percentage of weight loss from detached fruits. (C) Compression test of intact tomato fruit . Mean ± SE, n =20.

THE INFLUENCE OF RIPE ON/OFF VINE ON THE TOMATO METABOLOME

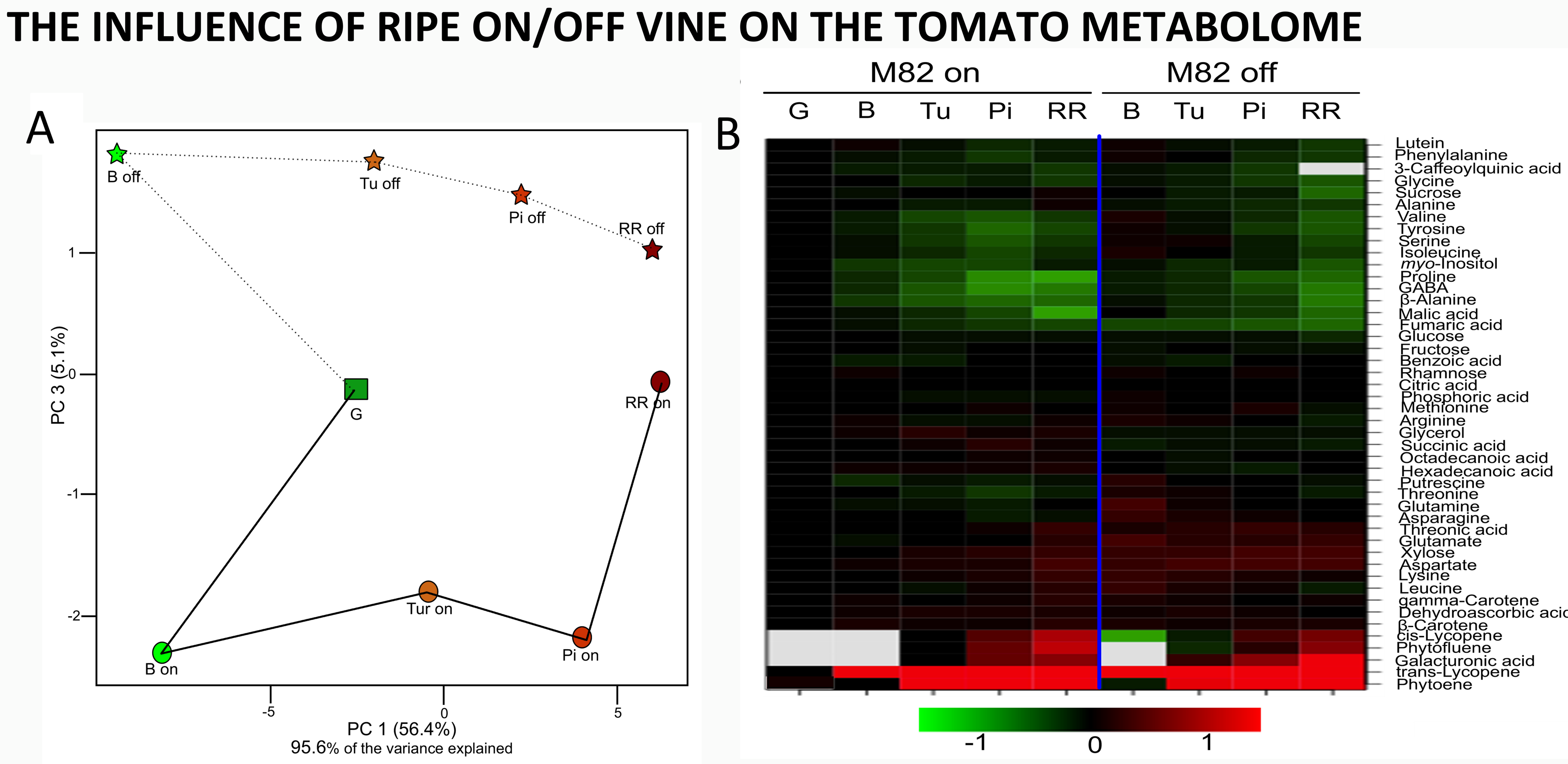


Figure 4. Global overview of the dynamic changes in primary and carotenoid metabolism in M82 ripened on plant (on) and tomato picked at green stage (G) and ripened under commercial conditions (off). The ripening stages were green (G), breaker (B), turning (Tu), pink (Pi) and red (RR). (A) Principal components analysis (PCA) and (B) Heatmap representation. Data are normalized to the mean response calculated for the green stage. The scale is logarithmic. Values presented are means of six replicates and are showed in false-color code.

POSTHARVEST-RELATED CHANGES IN METABOLITE LEVELS IN THE MUTANTS

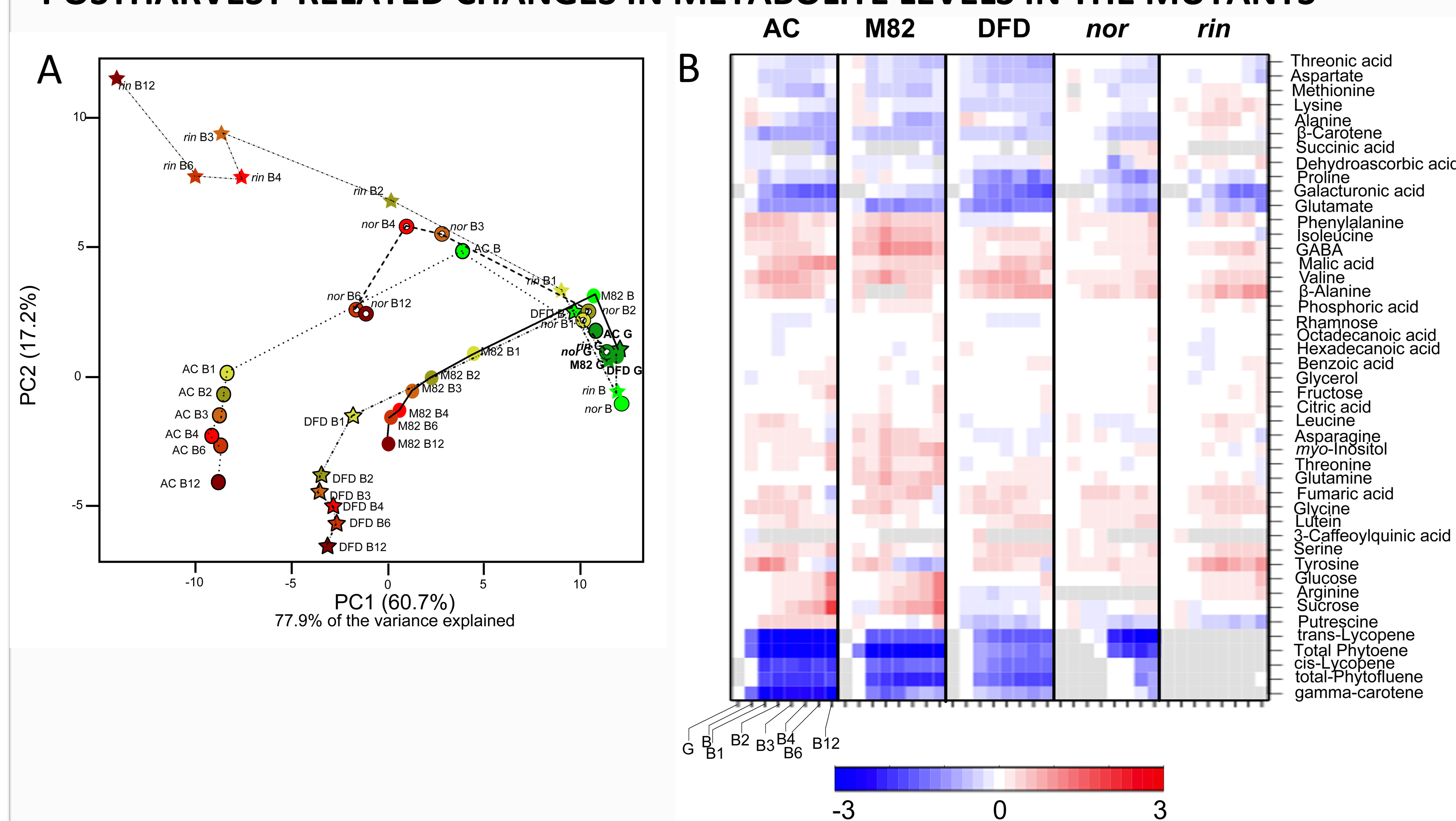


Figure 2. Principal components analysis (PCA) (A) and global overview of the dynamic changes (B) of primary and carotenoid metabolism during tomato ripening in AC (Ailsa Craig), M82, DFG (Delayed Fruit Deterioration), *nor* and *rin*. Time points presents are (G), green,(B), breaker, (B1), breaker+1, (B2), breaker+2, (B3) breaker+3, (B4), breaker+4, (B6) breaker+6 and (B12), breaker+12 DAP. Data are normalized to the mean response calculated for the green stage for each mutant. The scale is logarithmic. Values presented are means of six replicates and are showed in false-color code.

POSTHARVEST-RELATED CHANGES IN TRANSCRIP LEVELS IN THE MUTANTS

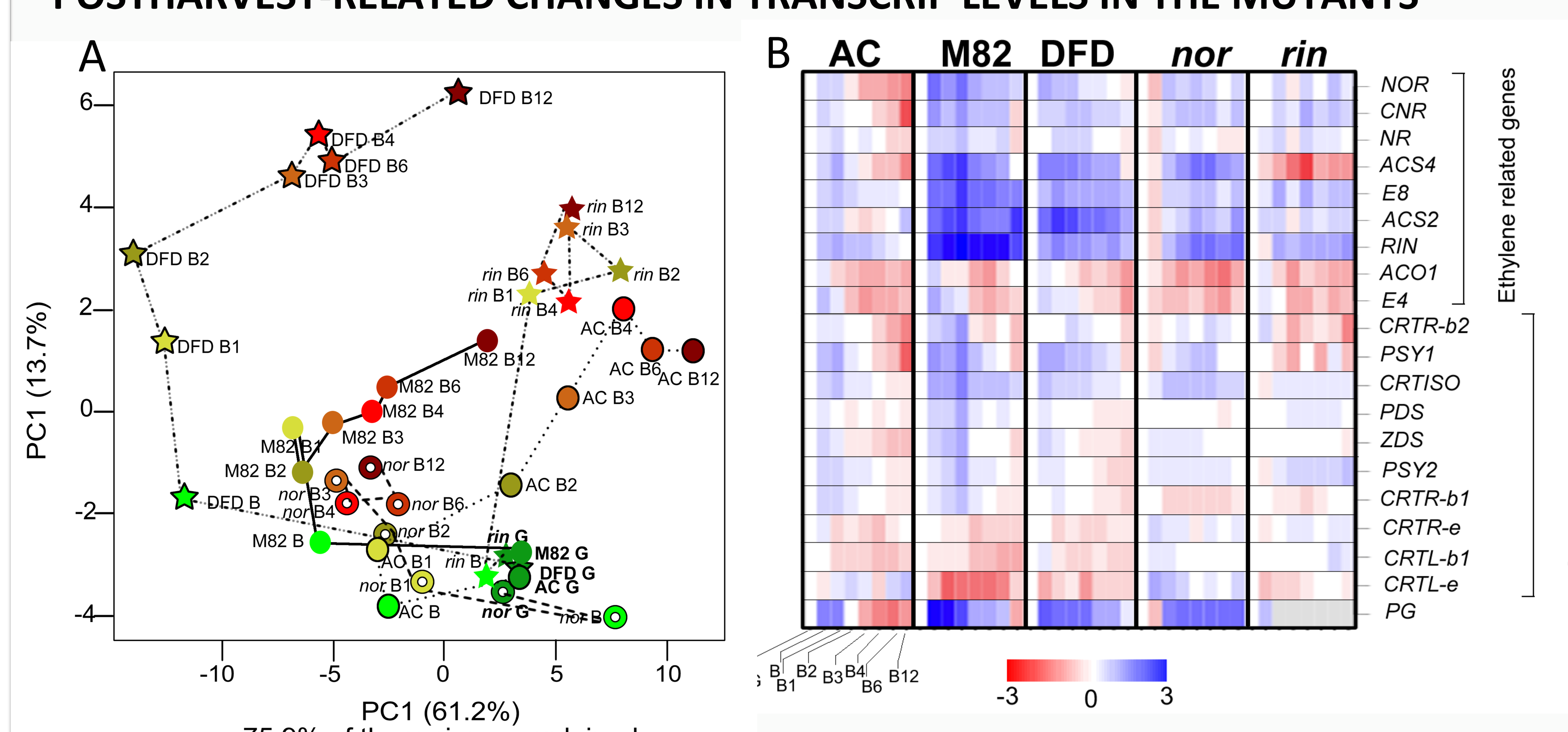


Figure 3. Principal components analysis (PCA) (A) and Global overview of the dynamic changes in expression (B) in expression of ethylene and carotenoid related genes of AC (Ailsa Craig, M82, DFD (Delayed Fruit Deterioration), *nor* and *rin* tomato fruit across ripening stages [(G) green, (B) breaker, (B1) breaker+1, (B2) breaker+2, (B3) breaker+3, (B4) breaker+4, (B6) breaker+6, (B12) breaker+12 DAP]. Different line styles join different stages from the same genotype.

CONCLUSIONS

- The *nor* and *rin* mutants show the most substantial differences, while the *DFD* mutant shows an intermediate phenotype.

Harvest fruit at pre-ripe stage and then triggering off-vine climacteric ripening by exposure to ethylene gas:

- Have a clear advantage of maintain firmness
- Detaching fruits means that the delivery of nutritionally valuable compounds from the parent plant ceases.