Title Structural and physiological changes associated with the skin spot disorder in apple

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Abstract

Skin spot is an important physiological disorder of 'Elstar' apples (*Malus* × *domestica* Borkh.) that occurs after fruit have been removed from controlled atmosphere storage. Skin spots are irregular patches of small, round, brown blemishes. Cross-sections reveal a browning of protoplasts (coagulated) and of cell walls that extends into the hypodermis. Skin spots are always associated with linear, gaping and non-gaping microcracks in the cuticle. Staining of apple skin with calcofluor white usually results in white fluorescence of cell walls but, within a skin spot, the white fluorescence is weak or absent. Cell walls within, and in the immediate vicinity of skin spots stain with phloroglucin/HCl indicating the presence of lignin. The area of skin affected by skin spots was positively and linearly correlated with the area of the non-blush fruit surface infiltrated by acridine orange. In general, skin spots were limited to the non-blush fruit surface and occurred more frequently near the stem-end than the calyx region of the fruit. Skin spot areas were correlated with a 2.5-fold increase in water vapour permeability compared with unaffected areas (23.8 ± 4.0 m s^{-1} with skin spots, $9.6 \pm 2.1 \times 10^{-5}$ m s^{-1} without skin spots). Strips of the fruit skin from regions with skin spots had an increased maximum force and modulus of elasticity. Dipping fruit in ascorbic acid (0.1 or 0.3 mM for 10 min) before storage decreased the area affected by skin spots. There was no effect of dipping in ethanol/water (70%, v/v, 15 min) or in solutions of captan (1.5 g L^{-1}, 10 min) or trifloxystrobin (0.1 g L^{-1}, 10 min). In contrast, prestorage treatment with 1-methylcyclopropene (630 nL L^{-1} for 24 h) or poststorage incubation in H_2O_2 (10% for 2, 6, 10 and 16 h) increased skin spots. Our data are consistent with a typical cell response to an oxidative burst that seems to be focussed on particular regions of the 'Elstar' fruit surface by concentrations of cuticular microcracks, and that is possibly caused by reoxygenation injury upon removal from CA storage.