

Complexities of 'Hass' avocado skin colour change during ripening

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ABSTRACT

South African 'Hass' avocado fruit continue to show poor skin colour development during ripening, and a conundrum compromised export quality. In response to such a challenge, the South Africa Avocado Growers' Association (SAAGA) commissioned the Agricultural Research Council – Tropical and Subtropical Crops (ARC-TSC) to investigate the causing factors and propose applied mitigation strategies. In the last two years, the findings demonstrated that poor 'Hass' skin colour change is predominantly an early to mid-season phenomenon. Furthermore, ripening temperature had no significant effect on 'Hass' skin colour development during ripening but only affect the colour change rate for late season fruit. Moreover, effect of orchard slope, fruit canopy position, production site, orchard blocks and 1-MCP also had no significant effect on 'Hass' skin colour change. Therefore, the aim of this work was to investigate the potential of tree stem girdling, fruit maturity and 1-MCP on 'Hass' avocado fruit skin colour change during ripening. In terms of tree girdling, 'Hass' avocado fruit showed no significant skin colour change during early and mid-season, only fruit internal quality improved. With respect to 1-MCP treated fruit, there were no significant differences on 'Hass' avocado skin colour change during early, mid- and late season when compared with untreated fruit, only the ripening time was extended. In conclusion, production conditions and postharvest treatments clearly has no effect on early and mid-season 'Hass' avocado fruit skin colour change during ripening.

INTRODUCTION

In 2014, the South African Avocado Growers' Association commissioned Agricultural Research Council – Tropical and Subtropical Crops to investigate pre- and postharvest factors causing poor skin colour development on 'Hass' avocado fruit during ripening. The findings from the 2014 study showed that poor 'Hass' avocado fruit skin development during ripening was mainly prevalent in early (April) to mid-season (June) fruit, irrespective of ripening temperature (Mathaba *et al.*, 2015). According to Cox *et al.* (2004), lower ripening temperature can reduce 'Hass' avocado fruit skin colour development only for late season fruit. In the 2015/16 season, we investigated the effect of production site (Tzaneen and Hazyview), orchard topography (lower and upper slopes), fruit canopy position (inside and outside canopy), skin minerals and 1-Methylcyclopropene (1-MCP), and concluded that these pre- and postharvest factors had a minimal effect on 'Hass' avocado fruit skin colour development during ripening (Mathaba *et al.*, 2016). Therefore, skin colour development of 'Hass' avocado fruit during ripening is a complex conundrum with multiple physiological and production environmental condition interactions. Physiologically, 'Hass' skin colour change is caused by an increase

in anthocyanin synthesis, concomitantly, decreasing chlorophyll a and b. In fruit, cyanidin-3-O-glucoside is a major anthocyanin responsible for colour change from green to purple. The synthesis of cyanidin-3-O-glucoside requires sugars (C6 – glucose) and accumulation of sugars in fruits can be stimulated with girdling. Therefore, the objectives of this work were: 1. To verify the effect of harvest time and 1-MCP on 'Hass' avocado fruit skin colour development during ripening; 2. To investigate the potential of tree girdling to mitigate poor 'Hass' avocado fruit skin development during early and mid-season.

MATERIALS AND METHODS

Harvest time x 1-MCP experiment

Avocado cv. 'Hass' fruit were harvested early season (April 2016), mid- (June 2016) and late (August 2016) from Kiepersol area. After harvest, fruit were transported to the ARC-TSC postharvest laboratory, whereby fruit were sorted and graded. Thereafter, sorted and graded 'Hass' avocado fruit were treated with 1-MCP (300 ppm) for 16 hours at 16°C. After 1-MCP treatment, fruit were stored at 5.5°C for 28 days. After withdrawal from cold storage, fruit were ripened at 21°C and evaluated for firmness and colour at 0, 2, 4, 6, 8 and 10-day intervals.



Harvest time x topography x tree girdling

Avocado cv. 'Hass' trees were girdled early in February 2016 and fruit were harvested early- (April 2016) and mid season (June 2016) from the Kiepersol area. After harvest, fruit were transported to the ARC-TSC postharvest laboratory for grading, sorting and storage. Sorted 'Hass' avocado fruit were stored at 5.5°C for 28 days, thereafter ripened at 21°C. During ripening, fruit were evaluated for firmness and skin colour change at 0-, 2-, 4-, 6- and 8-day intervals.

Data collection and statistical analysis

During ripening at 21°C, fruit were evaluated for the following quality parameters: firmness, subjective (eye colour) and objective colour (Hue angle (h°)) using a Chroma meter. Collected data was subjected to statistical analysis using Genstat version 18.

RESULTS

Harvest time x 1-MCP

In terms of harvest time and 1-MCP on firmness, early season fruit treated with 1-MCP showed lower firmness decline when compared with untreated fruit (Fig. 1 A). Subsequently, eye colour change and hue angle also change at reduced rate for early season fruit treated with 1-MCP when compared with untreated fruit (Fig. 1 B and C). Interacting findings were: early season fruit treated with 1-MCP seemed to have reached purple colour in terms of eye colour (>4.0) and hue angle (70°), however, its dark colour due to external chilling damage (Plate 1).

Avocado 'Hass' fruit harvested at mid- and late season seemed to have responded similarly with respect to firmness, eye colour and hue angle during ripening (Fig. 1 C – H). However, 1-MCP treated fruit showed lower firmness decline when compared with untreated fruit (Fig. 1 C and F). In general, late season 'Hass' avocado fruit showed improved skin colour (eye colour and hue angle) change when compared with mid-season fruit, irrespective of 1-MCP treatment. However, 1-MCP continued

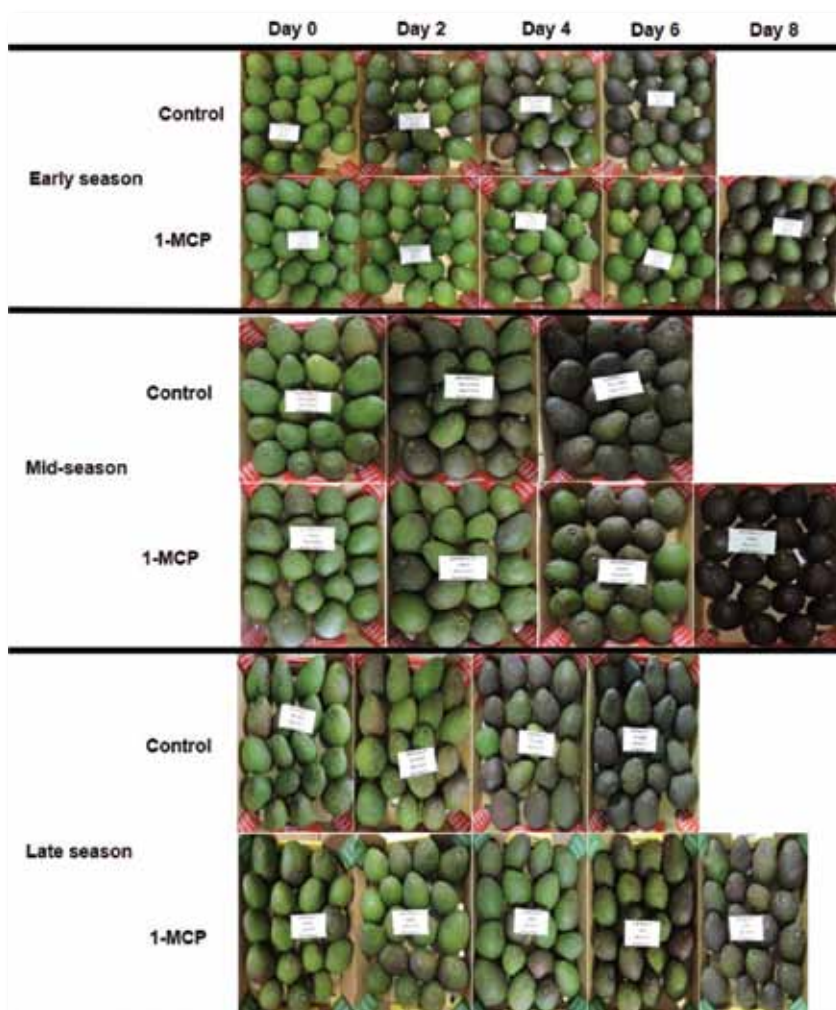


Plate 1. Skin and eye colour development of 1-MCP treated 'Hass' avocado fruit harvest early, mid- and late season.

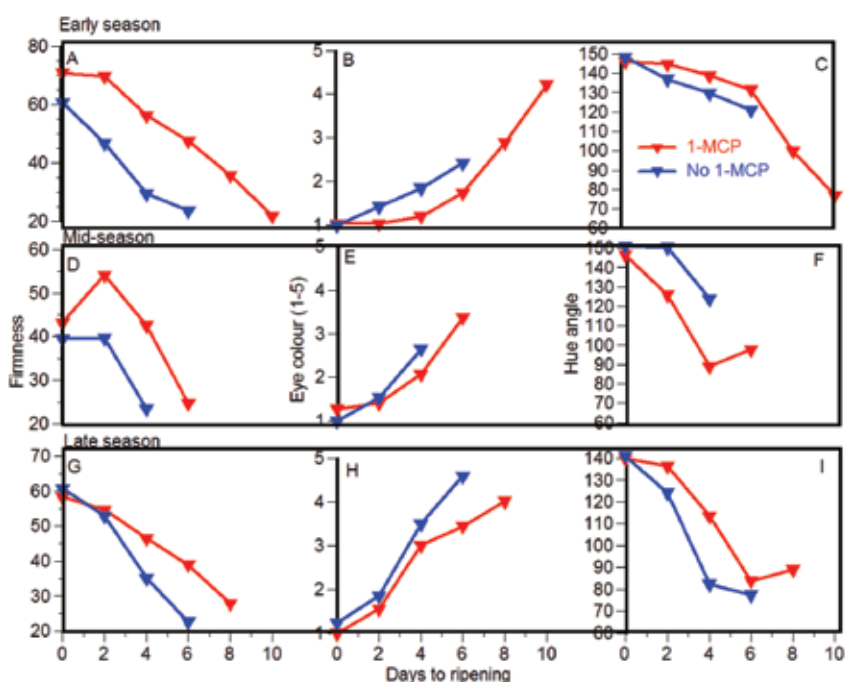


Figure 1. Effect of harvest time (early A-C, mid- D-F and late harvest G-I) and 1-MCP on firmness and skin colour development of 'Hass' avocado fruit during ripening.

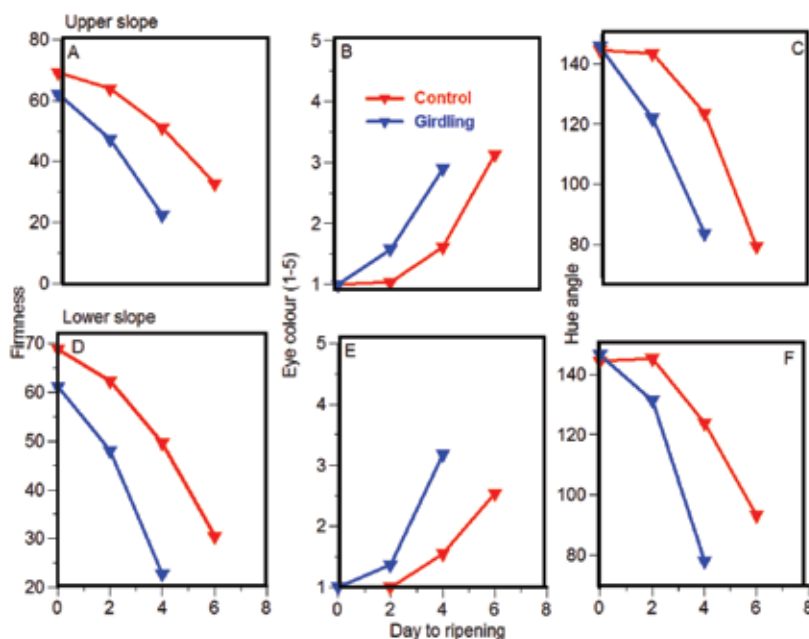


Figure 2. Effect of tree girdling and orchard topography (slope) on early season 'Hass' avocado fruit firmness (A and D), eye skin colour (B and E) and hue angle (C and F) during ripening.

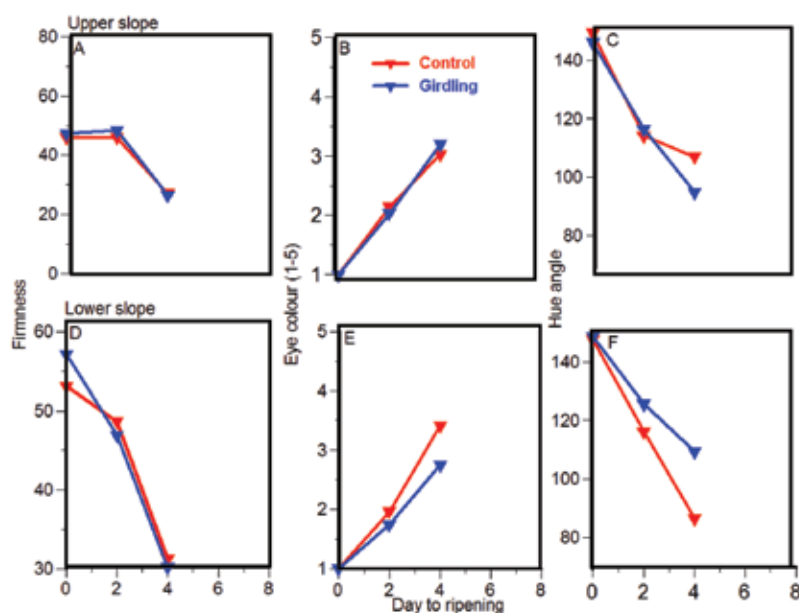


Figure 3. Effect of tree girdling and orchard topography (slope) on mid-season 'Hass' avocado fruit firmness (A and D), eye skin colour (B and E) and hue angle (C and F) during ripening.

to reduce 'Hass' skin colour change when compared with control, irrespective of harvest time.

Harvest time x topography x girdling

Avocado fruit harvested early season, from upper slopes and girdled trees, showed accelerated firmness decrease when compared with fruit harvested from un-girdled trees (Fig. 2 A). In terms of skin colour change, early season fruit harvested from upper slopes and girdled trees showed poor skin colour change (average eye colour <3.5 and hue angle = 80) with no significant difference with compared with fruit harvested from un-girdled trees (Fig. 2 B and C). In terms of early season fruit

harvested from lower slopes and girdled trees, firmness decline was similar (Fig. 2 D), and skin colour change was also poor as upper slope fruit (Fig. 2 E and F).

At mid-season, girdling and slope had no significant effect on fruit firmness decrease and skin eye colour change and hue angle during ripening (Fig. 3). In general, 'Hass' avocado fruit showed poor skin colour development, irrespective of slope and girdling.

DISCUSSION

In 2014-2015 season, we concluded that poor avocado skin colour development is mainly an early to mid-season conundrum and postharvest ripening temperature (16, 21 and 25°C) has no effect on fruit skin colour change during ripening (Mathaba *et al.*, 2015). Thereafter, we proved that pre-harvest factors such as production site (Tzaneen and Hazyview), orchard topography (upper and lower slopes), fruit canopy position (inside and outside canopy) and postharvest 1-MCP treatment also had no effect on 'Hass' avocado skin colour development during ripening (Mathaba *et al.*, 2016). According to Cox *et al.* (2004), avocado skin colour development is caused by an increase in the synthesis of anthocyanin, specifically, cyanidin-3-O-glucoside. In grapes, the synthesis of cyanidin-3-O-glucoside (a pigment responsible for purple colour) requires a carbon 6 (C6) sugar, glucose (He *et al.*, 2010). In avocado production, girdling has been used to increase carbohydrates accumulation above the girdled tree branch (Davie *et al.*, 1995).

In this study, girdling seem not to improve carbohydrate (glucose) accumulation in the skin of avocado fruit, therefore, reduced cyanidin-3-O-glucoside and purple colour for early to mid-season fruit. Based on this findings, there are complex assumptions we extrapolate on poor avocado fruit skin colour development during ripening for early to mid-season fruit.

- There is a competition for C6 carbohydrates between the seed and skin during early to



mid-season as sugar-sink-strength favours seed growth, development and maturation

- Therefore, early to mid-season fruit have low C6 (glucose) sugars required in the anthocyanin (cyanidin-3-*O*-glucoside) during ripening, leading to poor skin colour development
- According to Mita *et al.* (1997), the cascade physiological events signalling cyanidin-3-*O*-glucoside synthesis is regulated by sugars (glucose), and sugars signal the expression of anthocyanin synthesis enzymes, chalcone synthase (CHS) and anthocyanidin synthase (ANS).

In conclusion, early to mid-season poor 'Hass' avocado fruit skin colour development during ripening can be due to carbon 6 (glucose) competition between the avocado seed and skin, leading to reduced synthesis of cyanidin-3-*O*-glucoside. Late season improved 'Hass' avocado skin development is assumable due to mature seed which no longer compete with the skin for sugars, therefore, high cyanidin-3-*O*-glucoside synthesis. This means that, maturation and sugar accumulation in avocado fruit skin are the main factors contributing to skin colour development during ripening. Other pre-and postharvest factors, therefore, have minimal contribution into early to the mid-season skin colour development conundrum in cv. 'Hass' avocado fruit.

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