DETERMINING MINIMUM MATURITY LEVELS FOR 'MALUMA HASS' – FIRST SEASON RESULTS

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ABSTRACT

'Hass' dominates the avocado plantings in South Africa in terms of hectares per specific cultivar. 'Hass' production challenges created a requirement for Hass-like cultivars like 'Maluma Hass', as well as a need for extending the export season of these varieties. Exporters face major challenges due to uneven ripening and variable quality. Physiological maturity is a major determinant of postharvest quality, and unfortunately there is no "one-size-fits-all" approach when it comes to maturity indices for different avocado cultivars. In turn, maturity is influenced by genotype and climatic conditions, and therefore the purpose of this study is to determine the minimum harvest maturity level of 'Maluma Hass' for multiple growing regions, across two consecutive growing seasons. Harvesting palatable fruit at minimum maturity will allow exporters to provide quality fruit with minimum disorders early in the season. Currently, the minimum dry matter content (DM) is 22% for 'Maluma Hass' (Ernst *et al.,* 2015) and the aim is to decrease the required %DM for this cultivar. The relationship between %DM, days to ripen, together with fruit shrinking/shrivelling, and incidence of postharvest defects, was used to determine the minimum harvest maturity levels for 'Maluma Hass' in the different growing regions. First season results indicated that fruit harvested during the earlier weeks in Levubu (at a lower %DM) appear to have reached their minimum level of harvest maturity at an earlier stage than fruit from Letaba and Kiepersol.

INTRODUCTION

Mature avocado fruit do not ripen on the tree, but will soften several days after being picked, which makes identification of horticultural maturity difficult, as maturation is not accompanied by changes in external appearance (Lee *et al.*, 1983). During the maturation phase of development, some of the most noticeable changes in the flesh are increased total oil content and decreased soluble sugar content, while other changes include decreased calcium and magnesium together with increased total phenolic content (Johnston, 2007). These changes are linked to the storage potential of the fruit, as calcium is important in preventing premature softening and other disorders and phenolics are precursors for browning reactions.

Avocado harvesting together with postharvest processes account for up to 60% of total costs, while up to 50% of all fruits are not consumed (Hofman *et al.*, 2013). A shift towards storage of fruits and increasing distances between sites of production and consumption to overcome localised over-supply, has increased the focus on postharvest technologies and practices. Furthermore, there is increased understanding of the interactions between all phases of production and postharvest processes in relation to fruit quality. It is generally accepted that pre-harvest determines maximum product quality, while postharvest systems are optimised to minimise quality loss during handling and distribution (Hofman *et al.*, 2013).

It is commercially important to identify the maturity standard that ensures fruit are palatable with minimal fruit disorders, while allowing for early harvesting to take advantage of higher early season prices (Hofman *et al*., 2013), and at the same time reducing the risk of fruit loss from theft or weather damage, or from fungal diseases (Olarewaju, 2014). Harvesting fruit too early can result in poor fruit quality due to shrivelling, rubbery texture, as well as stringy vascular tissue, lack of flavour, and increased incidence of rot when ripe.

The level of maturity is largely determined by increasing oil content as the fruit mature and is still the most reliable indicator of maturity (Hofman *et al.*, 2013). The current maturity parameters for avocado are oil content, mesocarp moisture content (MC - used as the maturity parameter in the South African avocado industry) and the complementary value to MC, which is dry matter (DM - used in avocado fruit producing countries other than South Africa) (Olarewaju, 2014). An MC of 69-75% is considered to indicate acceptable eating quality, but is cultivar dependent (Mans *et al.*, 1995). Fruit firmness has also been found to have limitations as a horticultural maturity index (Hofman *et al*., 2013). Oil content, rather than carbohydrate status, has so far received the most attention, as oil is the dominant component in mature fruit. Type of cultivar, horticultural practices and season together with macro and micro climatic environments, can all influence the relationship between fruit oil content, %DM and fruit quality, which makes the use of one maturity standard problematic (Hofman *et al.*, 2013). Using two maturity indices e.g. DM (or MC in SA) together with fruit capable of ripening without shrivelling, will reduce the risk of marketing immature fruit (Hofman *et al.*, 2013).

The 2020 official industry estimate for total avocado plantings in South Africa is 14 700 ha, of which 'Maluma Hass' makes up 6.4%. 'Maluma Hass' is the second most planted Hass-type variety after 'Hass' (Subtrop, 2020). The 'Maluma Hass' plantings occur predominantly in Limpopo (830 ha = 5.8% of industry total), with 72 ha in Mpumalanga (0.5% of industry total) and the remaining 0.1% of industry total (15 ha) planted in the Western Cape (Subtrop, 2020). 'Hass' is the most planted and marketed cultivar worldwide, but this cultivar is not without its challenges and therefore there is a focus on finding high yielding, good quality Hass-like cultivars (Bruwer and Van Rooyen, 2007). 'Hass' is prone to alternate bearing and is a prolific producer of undersized fruit, which is aggravated by environmental stress and *Phytophthora cinnamomi* infection. The fruit of 'Maluma Hass' are larger than 'Hass' with a thick shiny purple-black skin when ripe and the flesh has a rich nutty taste. In the earlier ripening production areas with higher daily mean temperatures, 'Maluma Hass' can be harvested for export up to 4 weeks before 'Hass' and is available from March through to July. The majority of 'Maluma Hass' fruit reach maturity at the same time, with the additional bonus that the spraying of a growth retardant is not necessary to ensure high production. 'Maluma Hass' is specifically prone to two postharvest problems that have been identified, namely pink vascular stain and soft arrivals in Europe. Both these disorders are a function of the higher respiration rate of 'Maluma Hass' after harvest and can efficiently be controlled by storing fruit at < 6 °C and in a controlled atmosphere (CA) environment. Furthermore, the risk of pink vascular stain can be reduced by picking fruit at a higher %DM and reducing exposure to endogenous ethylene (Mhlophe and Kruger, 2013). Mhlophe and Kruger (2012) recommended that 'Maluma Hass' be harvested between 23% and 26% DM, as they found that the intensity of vascular staining decreases as %DM increases, but the current recommended minimum DM content for 'Maluma Hass' is 22% (Ernst *et al.*, 2015).

MATERIALS AND METHODS

Sites

Suitable orchards (8-year old or older) were identified in the following regions: 3 orchard blocks each in both the Letaba and Levubu areas of Limpopo, and 3 orchard blocks in the Kiepersol area of Mpumalanga.

Sampling

Sixty fruit were sampled from each block on a weekly basis and sampling took place over a period of 5 weeks, with sampling times correlating to dry matter content of > 18% and < 24%. Of the 60 fruit harvested weekly from each of the 9 orchards, 30 fruit were used for maturity determinations and 30 fruit for storage trials (28 days export simulation @ export temperature) and post-storage evaluation for internal and external defects. Fruit collection and measurement of fruit mass and mesocarp dry matter content were done by the Levubu Centre for Excellence. Dry matter content was then calculated using the following equation:

$$\%\ \text{Dry matter content} = \frac{(\text{weight of dried sample})}{(\text{weight of wet sample})} \times 100$$

Storage and post-storage assessments

The fruit were weighed before being stored at 5.5 °C under CA (6% CO_2; 4% O_2) for a period of 4 weeks to simulate export conditions. After 4 weeks in storage, fruit were removed weekly and allowed to ripen at ± 22 °C (room temperature). Postharvest internal and external quality of fruit harvested at different %DM were assessed for defects such as shrivelling, stem-end rot, grey pulp, anthracnose and vascular staining disorder. The relationship between %DM and days to ripen, together with fruit shrinking/shrivelling and incidence of postharvest defects, was used to determine minimum maturity levels for the different growing regions.

RESULTS AND DISCUSSION

As expected, the %DM for all areas increased over time and there was a significant increase in %DM by the third week of harvest for all areas (Figs. 1-3). The large variation seen in average %DM in Levubu (Fig. 1) for the earlier harvest weeks could be ascribed in part to rainfall. In the preceding 3 days before sampling in week 1 and 2, 61.1 mm and 43.1 mm of rain were recorded respectively. On average, the DM for the first week of harvest in the Letaba region was already at 21% and it was decided to sample this area earlier in the following season (Fig. 2). Kiepersol only had 4 weeks of sampling compared to the other two areas, as all the fruit were harvested before sampling for week 5 could take place (Fig. 3). No correlation was found between fruit weight and %DM for any of the areas (data not shown).

The incidence of shrivelling showed a marked decrease during the second week of harvesting in the Levubu area and did not occur from the third week of harvest onwards (Fig. 4). This decrease in shrivelling corresponded to a DM value of just over 18%, and the absence of shrivelling corresponded to DM of ≥ 20% (Fig. 1). Although fruit harvested during the first week from the Letaba area had a higher average DM of 21%, compared to fruit from the Levubu and Kiepersol areas, this %DM corresponded with a higher incidence of shrivelling (Fig. 5), which did not occur during subsequent weeks of harvest when the average DM of the fruit was ≥ 21.5% (Fig. 2). Fruit harvested from the Kiepersol area had low incidence of shrivelling during the earlier harvest periods, which corresponded to 18% DM, and also showed an absence of shrivelling once %DM reached 20% (Fig. 6).

The mean number of days required to ripen (DTR) the 'Maluma Hass' fruit were lower for all weeks from all three areas when compared to the results of Kruger and Lemmer (2012), where fruit were harvested at 30% DM, whereas in the current trial, the %DM at the respective dates of harvest was much lower (Figs. 4-6). The average DTR for fruit from the Levubu area was 4.5 days (Fig. 4) compared to 6.5 days for fruit from Letaba (Fig. 5) and 6.7 days for fruit from the Kiepersol area (Fig. 6).

The high incidence of stem-end rot and vascular staining seen in fruit from all areas was possibly due to a delay in cooling of the fruit after harvesting in the current study (Figs. 4-6). Mhlophe and Kruger (2012) reported that the occurrence and severity of vascular staining decreases as %DM increases, but that was not the case in this study, where levels of vascular staining were persistently high despite maturity of fruit increasing. Current protocols for 'Maluma Hass' dictate that fruit should be cooled within 4 hours after harvest when picked from younger trees with a high nitrogen status, and within 8 hours from harvest for fruit from normally fertilised older trees (Kruger *et al.,* 2017). There was high incidence of anthracnose on fruit from all areas (Tables 1-3) and it was possibly due to fruit not being treated with a postharvest

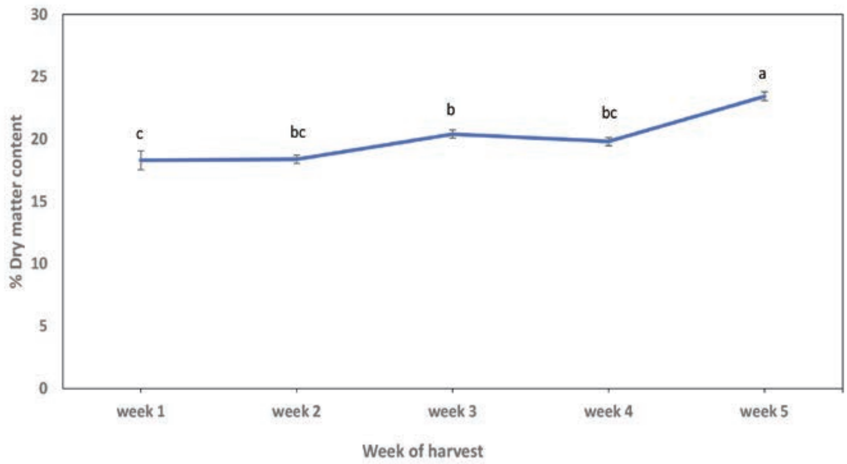

Figure 1: Change in % dry matter content over the harvest period for the Levubu region, Limpopo. Error bars denote standard error. Data were subjected to analyses of variance with Tukey post-hoc test. (p value = 0,0001).

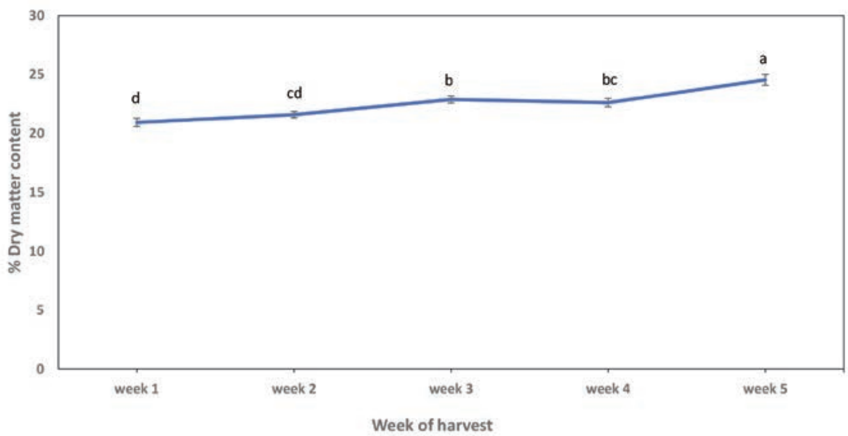

Figure 2: Change in % dry matter content over the harvest period for the Letaba region, Limpopo. Error bars denote standard error. Data were subjected to analyses of variance with Tukey post-hoc test. (p value = 0,0001).

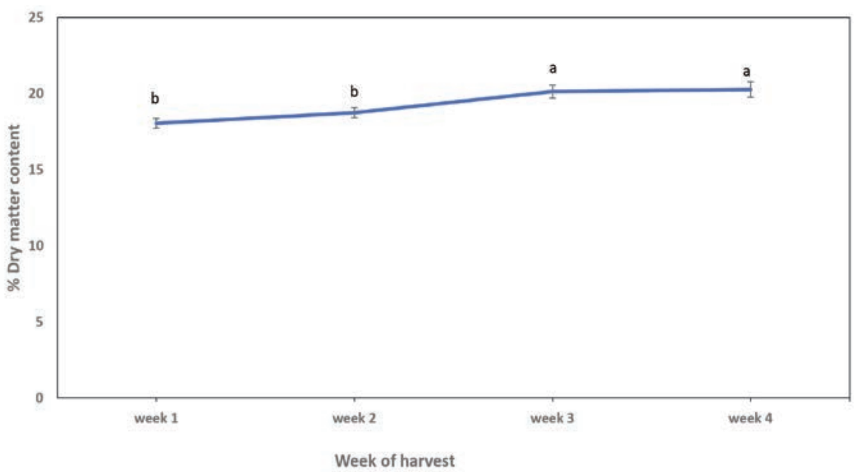

Figure 3: Change in % dry matter content over the harvest period for the Kiepersol region, Mpumalanga. Error bars denote standard error. Data were subjected to analyses of variance with Tukey post-hoc test. (p value = 0,0001).

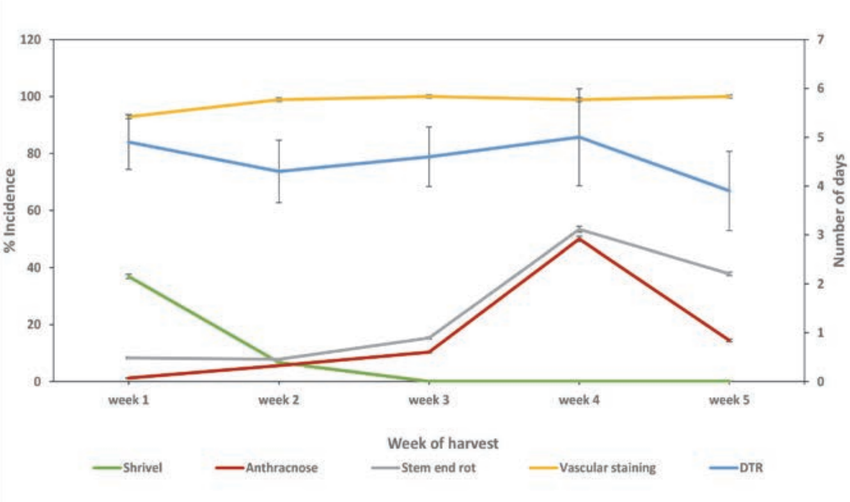

Figure 4: Summary of 'Maluma Hass' fruit quality post-storage assessments over the harvest period for the Levubu region, Limpopo. DTR = days to ripen is plotted on the secondary axis. Error bars denote standard error.

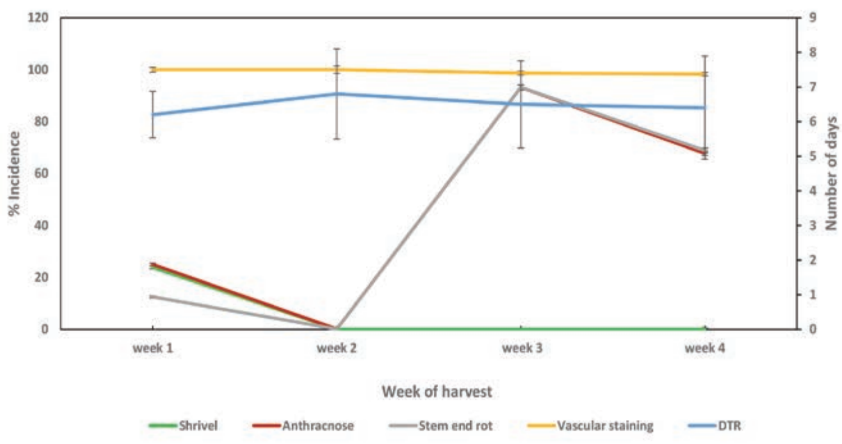

Figure 5: Summary of 'Maluma Hass' fruit quality post-storage assessments over the harvest period for the Letaba region, Limpopo. DTR = days to ripen is plotted on the secondary axis. Error bars denote standard error.

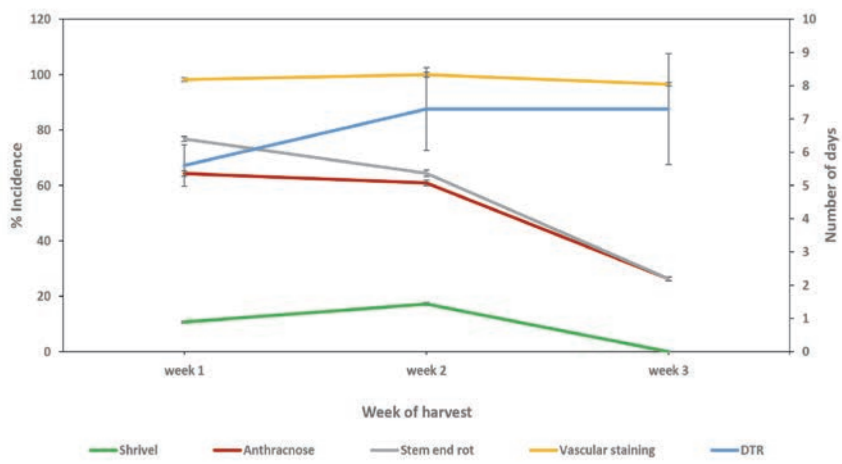

Figure 6: Summary of 'Maluma Hass' fruit quality post-storage assessments over the harvest period for the Kiepersol region. DTR = days to ripen is plotted on the secondary axis. Error bars denote standard error.

fungicide before placing into CA storage in the current study. In future seasons, a postharvest fungicidal dip of fruit will be done to minimise anthracnose infection.

CONCLUSIONS

Based on results from the first season, the fruit harvested during the earlier weeks in Levubu (at a lower %DM) appear to have reached their minimum level of harvest maturity at an earlier stage than fruit from Letaba and Kiepersol. Not all datasets were complete for all weeks in all areas, which complicated statistical analyses and requires the determination of minimum harvest maturity levels over the course of a subsequent season.

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