

## INFLUENCE OF EARLY SEASON MATURITY ON FRUIT QUALITY IN NEW ZEALAND 'HASS' AVOCADOS

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### ABSTRACT

Studies on early season maturity over the past three years (2000-2002) have focussed on 1) determining regional rates of dry matter (DM) accumulation early season 2) influence of fruit size on DM content and 3) investigating the relationship between DM content and fruit quality. Regional patterns of DM accumulation have been followed on monitor orchards in three of New Zealand's (NZ) production areas Far North, Northland and Bay of Plenty for the past 3 seasons. Samples of 20 fruit were drawn at 2 weekly intervals from several monitor orchards in each region for a period of 2-5 months at the start of each export season. Fruit weight and DM were determined for each individual fruit in a 20-fruit maturity sample. DM increased in a linear fashion within each region for a given season and the rate of increase ranged from 0.06 to 0.11% DM per day. Regional differences in rates of DM accumulation were not consistent on a seasonal basis. No significant relationship was observed between DM content and fruit size (weight) in any region for the 2000 and 2001 seasons, with weak relationships observed in the 2002 season. Significant relationships were observed between DM content and several aspects of fruit quality in each season, notably checker boarding, vascular stringiness and rot incidence, all of which decreased as fruit maturity increased. Minimum DM content within the maturity sample was a better indicator of fruit quality than the sample average.

**Key Words:** dry matter, maturity standard, body rots, stem end rots

### INTRODUCTION

Immature avocado fruit are prone to a range of quality disorders, which may be exacerbated by periods of extended cool-storage. The NZ industry is faced with the issue of managing the export maturity standard to minimise maturity related quality problems in early season (August) exports to the USA while obtaining as early a market presence as possible. The current industry maturity stan-

standard for 'Hass' avocados is an average DM of 24% with a constraint on variability within a 20 fruit sample (18 fruit must exceed 20.8% DM). In order to critically evaluate this standard, studies on early season maturity over the past three years (2000-2002) have focussed on 1) determining regional rates of DM accumulation early season, 2) influence of fruit size on DM content and 3) investigating the relationship between DM content and fruit quality.

## MATERIALS AND METHODS

In 2000 170 fruit were sampled at random from three orchards in the Far North (35°S, 173°E) on the 8/8/2000 and two orchards in Northland (35°41'S, 174°18'E) on the 3/8/2000. In 2001 samples of 120 fruit were harvested from two orchards each in the Far North on the 9/7, 29/7, 12/8, 27/8 and 14/8/2001 and in Northland on the 12/7, 23/7, 8/8, 3/9, and 1/10/2001. In 2002 20-fruit samples were harvested from five orchards in Northland and four orchards each in the Far North and the Bay of Plenty on the 3/5, 15/5, 4/6, 17/6, 1/7, 15/7, 6/8 and 2/9/2002.

In 2000 fruit were placed into cool-storage at 5-7°C for either 3 (50 fruit per orchard) or 6 weeks (100 fruit per orchard). Fruit were ripened at ambient temperatures after removal from cool-storage. In 2001 100 fruit per orchard were stored at 5-7°C for 4 weeks. In 2002 300 fruit per orchard from 4 orchards in the Bay of Plenty (37°S, 176°E) were held at 4-5°C for either 2, 4 or 6 weeks. In 2001 and 2002 fruit were ripened at 20°C after removal from storage.

Each year, DM content for each orchard and harvest was determined on a 20-fruit sample by drying 20g of flesh peelings from the inside face of one quarter of the fruit, after the skin and stone had been removed, to a constant weight (60°C for 24 hours). After removal from storage, fruit were assessed for checker boarding and when eating ripe for internal disorders according to the Avocado Industry Council Fruit Assessment Manual Version 1 (2000) and Version 2 (2001). Eating ripe, a softness reading of 85+, was determined by firmometer using a 300g weight or by hand-feel after calibration to a firmometer. Trays of green fruit were rated for checker boarding on a scale of 1-10 using the ratio of green to coloured fruit. For example, a rating of 1 was 100% of fruit green, a rating of 5 was 75% green: 25% coloured, a rating of 10 was 50% green: 50% coloured. Disorders were rated by assessing the percentage (scale 0 to 100) of the cut surface of the fruit or skin surface area that was affected by disorders. The cut surface of ripe fruit was rated for stem end rot (discoloured flesh from the stem button down), the underside of the peeled skin was rated for brown patches (body rot as circular brown coloured patches) and the flesh for vascular strands (incomplete breakdown of vascular tissue). Results were analysed using weighted regression analysis and analysis of variance in MINITAB release 13.31.

## RESULTS AND DISCUSSION

### Influence of DM on fruit quality

As fruit DM increased in both 2000 and 2001, fruit ripening was more even within trays as indicated by the checkerboard rating of fruit 48 hours after removal of fruit from coolstorage (Fig. 1A). In 2002 incidence of vascular strands was related to the minimum DM content for the 20-fruit sample (Fig 1B). In 2001 a declining exponential relationship ( $r^2 = 0.65$ ,  $p < 0.001$ ) was observed between incidence of body rots and minimum DM content recorded of the 20-fruit sample (Fig. 1C). In 2002 the incidence of stem-end rots decreased as the minimum DM content of a 20-fruit sample increased (Fig 1D).

In these studies minimum DM was a better predictor of fruit quality than either average DM or sampling date. A minimum DM content greater than 21% in a 20-fruit sample was consistently asso-

ciated with a low incidence of maturity related disorders in fruit evaluated over three years. Incorporating a constraint on DM variability in the NZ maturity standard that requires 18 fruit out of 20 fruit to exceed 20.8% DM ensures that fruit samples that meet the maturity standard will also have a low incidence of disorders.

### **Pattern of DM accumulation**

Dry matter accumulated at a constant rate, as shown by the significant fits obtained using linear regressions (Table 1, Figure 1). Many orchards had a 2-4 week period where DM changed little that coincided with inflorescence development. This slowdown in DM accumulation may reflect the differences in competitive sink strength for carbohydrate of inflorescences and developing fruitlets compared to fruit approaching harvest maturity.

Historically, the Far North region has been considered to have the earliest maturity in NZ. However, monitoring of DM (Figure 2) shows there is no consistency as to the time within a season when a region reaches an average 24% DM. For a given season one region could be early relative to previous seasons while another may be late maturing. This contrasts with the situation in California whereby the date at which maturity was reached as determined by taste was not significantly different from year to year within a location although there was variation between production areas (Lee et al, 1983). Ranney (1991) found that there were no significant differences between years in rates of DM accumulation for each variety, including Hass. Regression was used to determine rates of DM accumulation, with the rates for Hass in California (0.057 to 0.080 %DM per day) being very comparable to this study (Table 1). Ranney (1991) also observed that seasons could be early or late regardless of the actual rate of dry matter accumulation.

### **Dry matter and fruit size**

In 2002 there was a weak correlation between fruit size, as determined by fresh weight, and DM content. Fruit tested from the Far North had the highest correlation coefficient ( $r^2=0.23$ ,  $p<0.001$ ) and the fruit from the Bay of Plenty the lowest ( $r^2=0.10$ ,  $p<0.001$ ), with fruit from Northland intermediate ( $r^2=0.17$ ,  $p<0.001$ ). This contrasts with fruit tested in 2000 and 2001 where no significant relationship between fruit size and DM content was observed in any of the regions (Pak and Dawes, 2001). A lack of relationship between fruit size and DM is in contrast to the results of studies conducted in Australia (Hofman and Jobin-Decor, 1991). The reason why avocados in NZ do not accumulate DM in relation to fruit size is not known.

## **CONCLUSION**

Dry matter accumulation in NZ avocados from July to September increases in a linear pattern that is consistent over several seasons. However, there are considerable season to season differences in initial DM levels and subsequent rates of DM accumulation. Variations in the linear pattern occur in some regions in some seasons. Fruit with DM content greater than 24% ripened more evenly, had fewer vascular strands and a lower incidence of rots. The New Zealand maturity standard of average 24% DM appears to ensure early season fruit are of consistent quality in each season.

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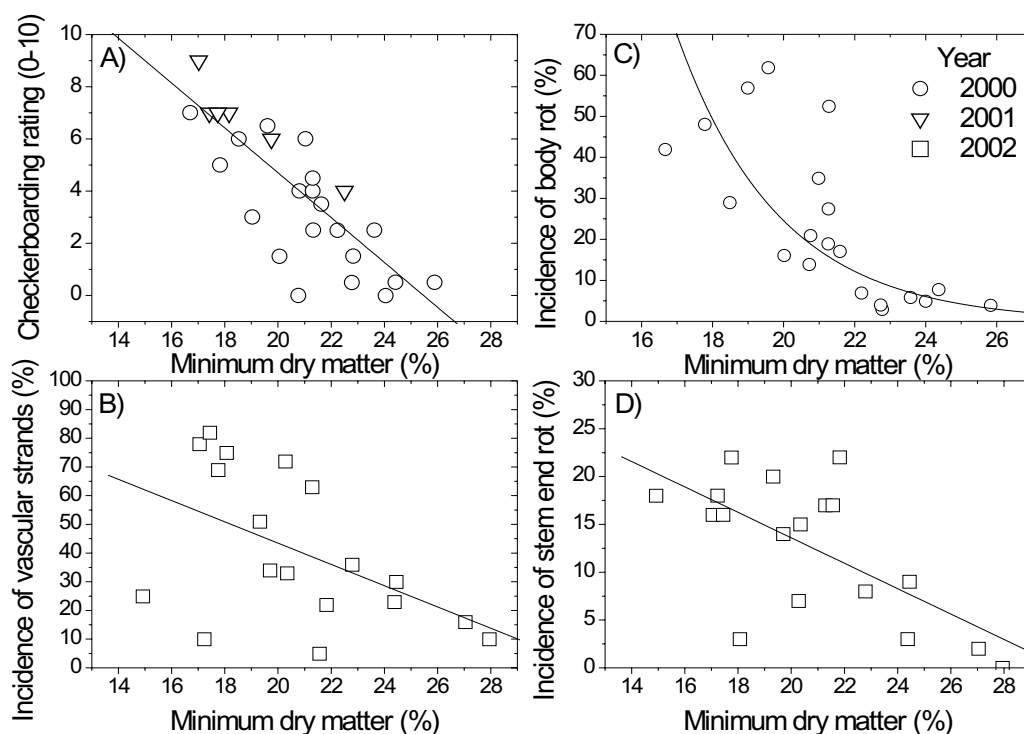
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**Table 1.** Regional rates of DM accumulation by season with results of regression analysis including goodness of fit ( $R^2$  and probability values).

Season	Region	Equation	$r^2$	p value
2000	Far North	$y = 22.21 + 0.080x$	0.98	< 0.01
	Bay of Plenty	$y = 19.08 + 0.105x$	0.99	0.07
2001	Far North	$y = 20.87 + 0.063x$	0.97	<0.001
	Northland	$y = 21.94 + 0.061x$	0.95	<0.001
	Bay of Plenty	$y = 21.05 + 0.070x$	0.96	<0.001
2002	Far North	$y = 19.13 + 0.061x$	0.97	<0.001
	Northland	$y = 16.95 + 0.078x$	0.99	<0.001
	Bay of Plenty	$y = 17.91 + 0.073x$	0.99	<0.001



**Figure 1.**

A) Evenness of ripening as measured by checker board rating in relation to minimum dry matter content recorded in a 20-fruit maturity sample. Combined data from the 2000-2001 and 2001-2002 seasons ( $y = 21.9 - 0.86 * x$ ,  $r^2 = 0.66$ ,  $p < 0.001$ ).

B) Relationship between vascular strand incidence (%) and minimum dry matter content recorded on a 20-fruit maturity sample ( $y = 117.7 - 3.71 * x$ ,  $r^2 = 0.225$ ,  $p < 0.05$ ).

C) Relationship between body rot incidence (%) and minimum dry matter content recorded in a 20-fruit maturity sample ( $y = 25658 * \exp(-0.3469 * x)$ ,  $r^2 = 0.65$ ,  $p < 0.001$ ).

D) Relationship between stem end rot incidence (%) and minimum dry matter content recorded in a 20-fruit maturity sample ( $y = 40.17 - 1.33 * x$ ,  $r^2 = 0.43$ ,  $p < 0.001$ ).

**Figure 2.** Patterns of dry matter accumulation in each of three regions of the North Island of New Zealand. Each point represents the mean of 5, 20-fruit samples. Lines are fitted lines from the linear regressions (Table 1). Dashed lines indicate the time that average dry matter reached 24%. Vertical bars represent the standard error of the mean of 5 20-fruit samples.

