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COMPARISON OF CORE AND PEEL SAMPLING METHODS FOR DRY MATTER MEASUREMENT IN HASS AVOCADO FRUIT

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ABSTRACT

A pre-harvest dry matter (DM) test is used by the New Zealand avocado industry as a measure of fruit maturity. The current peel method requires fruit to be cut into quarters before slices are peeled from the length of one quarter. The current testing method is time consuming and potentially more hazardous than an alternative method developed by the Californian avocado industry. This new core method takes a plug of tissue from the centre of the fruit using a coring machine. Individual fruit were subjected to both the core and peel methods to evaluate the suitability of the core method for determining DM content in New Zealand Hass avocados. The core method was found to underestimate DM content relative to the peel method by 0.4% on average. Adjusting the mean DM content obtained using the core method by adding a correction value of 0.4% would bring the adjusted value to within ± 0.6% DM content compared with the peel method (for 95 out of 100 samples). The difference between the two methods can in part be related to the extent to which they capture the internal variation in DM content within an individual fruit. There was a consistent pattern of DM distribution within fruit, with a core taken from the middle of the fruit having the lowest DM content. It is suggested that the core method may be suitable for use as an alternative to the current peel method.

Keywords: *maturity, sampling error*

INTRODUCTION

A minimum maturity level for avocados is used to ensure that fruit store well, ripen without disorders and have desirable taste characteristics. Avocados destined for export from New Zealand are required to meet a minimum average dry matter (DM) content of 24% based on a 20-fruit sample with a restriction on variability in the sample, such that 18 out of 20 fruit must exceed 20.8% DM. Dry matter content is currently measured using the peel method test as outlined in the Avocado Industry Council Quality Manual

(AIC, 2001). This method of sample preparation is time consuming and requires the use of sharp knives in a potentially more hazardous way than an alternative method using fruit core samples that was developed in California (Arpaia et al., 2001). A tool has been developed to take flesh core samples from the central part of each fruit, reducing the use of knives and shortening sample preparation times (Arpaia *et al.*, 2001).

This study compared the DM content of individual fruit using two methods of sample preparation, namely flesh peeling and coring. The results were analyzed to determine the relationship between the peel and core method results and to establish a suitable correction value to apply to convert measurements from one method to the other. In addition, factors affecting accurate measurement of DM content using the core method were investigated.

MATERIALS AND METHODS

Twenty 'Hass' avocado fruit were harvested at fortnightly intervals from the 5th of June to the 6th of October 2003 from 13 orchards, four in the Far North region, five in the Whangarei region and four in the Bay of Plenty region. Orchards in the Far North and Whangarei regions were harvested 10 times (last harvest 18th September 2003) and orchards in the Bay of Plenty region were harvested 12 times (last harvest 6th October 2003). Dry matter content was determined for 135 twenty-fruit samples (a total of 2700 fruit), using both the peel and core methods on the same individual fruit.

A 20-fruit sample was placed immediately into plastic bags containing a small, moist paper towel. Fruit from the Far North and Whangarei regions were transported to the Avocado Industry Council offices, Tauranga, Bay of Plenty within 24 hours of harvest and processed to the drying stage within 4 hours of arrival. Fruit from the Bay of Plenty were processed to the drying stage within 5 hours of harvest. The coring machine (Figure 1) took a single, 16mm diameter core through the middle of the fruit, including the seed. The skin, seed and seed coat were trimmed off the core, resulting in two core pieces. Each core was halved longitudinally to aid drying (Figure 2). For the peel method, the same fruit was cut longitudinally through the hole left after removing the core, with a large knife. The seed was removed before one half was halved longitudinally again. A potato peeler was used to remove the skin and the seed coat, before thin strips of flesh were peeled from one quarter to obtain a 20g sample. Care was taken not to use the parts of the fruit where the core was removed.

Within fruit variability in DM content was investigated using the same core method described above for fruit from the Bay of Plenty where cores were sampled from the top (above the seed), middle (through the seed) and bottom (below the seed) of 960 fruit. The fruit were then sampled as described above for the peel method.

A further harvest, using the method described above was completed on the 26th of July 2004 from 13 orchards, four in the Far North region, five in the Whangarei region and four in the Bay of Plenty region. The fruit were sampled with the coring machine and with the peeling method as described above, before a second peel sample was taken from a different fruit quarter than was used to collect the first peel sample.

The results were analyzed as a repeated measurement trial using regression analysis

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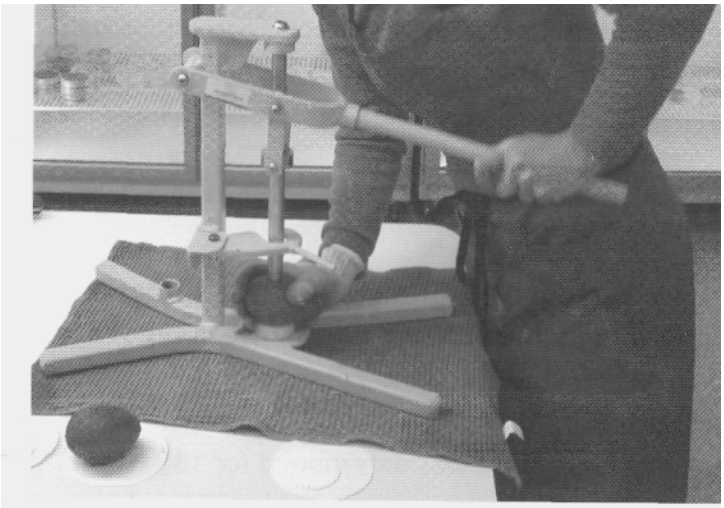

Figure 1. The Hofshi coring machine.

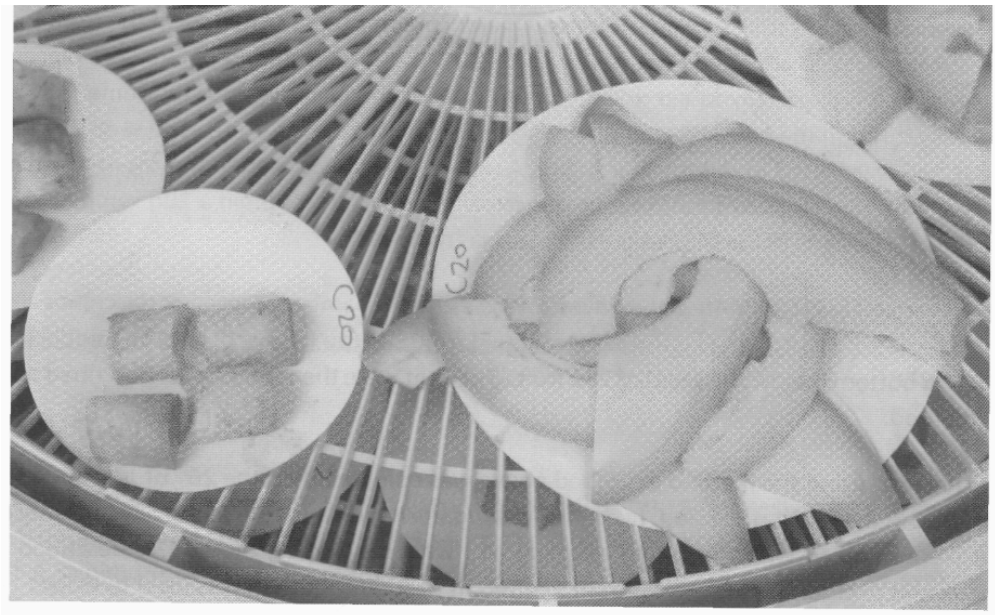

Figure 2. Avocado flesh sampled according to the core (left) and peel methods, ready for drying to determine dry matter content.

RESULTS AND DISCUSSION

Regression analysis

DM content obtained by the two methods was subjected to regression analysis for both individual fruit and the 20-fruit sample means. Regression analysis was completed with

either the core method or the peel method results as the independent variable (Table 1). Regression analysis of results has been used previously to compare the core method to other DM testing methods. The two methods correlate (Figure 3) well when examined across the seasonal range of DM contents studied. Arpaia *et al.* (2001) and Woolf *et al.* (2003) also obtained high r^2 values when comparing dry matter tests using regression analysis.

Table1. Regression analysis comparing peel and core methods of sample preparation at the individual and 20-fruit average level, using either the core or peel method as the independent variable.

Level	x variable	Regression equation	Value of y when x = 24	Correction value	r^2	n
Individual fruit	Core	y = 0.94 x + 1.56	24.15	0.15	0.931	2700
Individual fruit	Peel	y = 0.99 x - 0.16	23.59	-0.41	0.931	2700
20-fruit mean	Core	y = 0.96 x + 1.09	24.24	0.24	0.990	135
20-fruit mean	Peel	y = 1.03 x - 0.92	23.72	-0.28	0.990	135

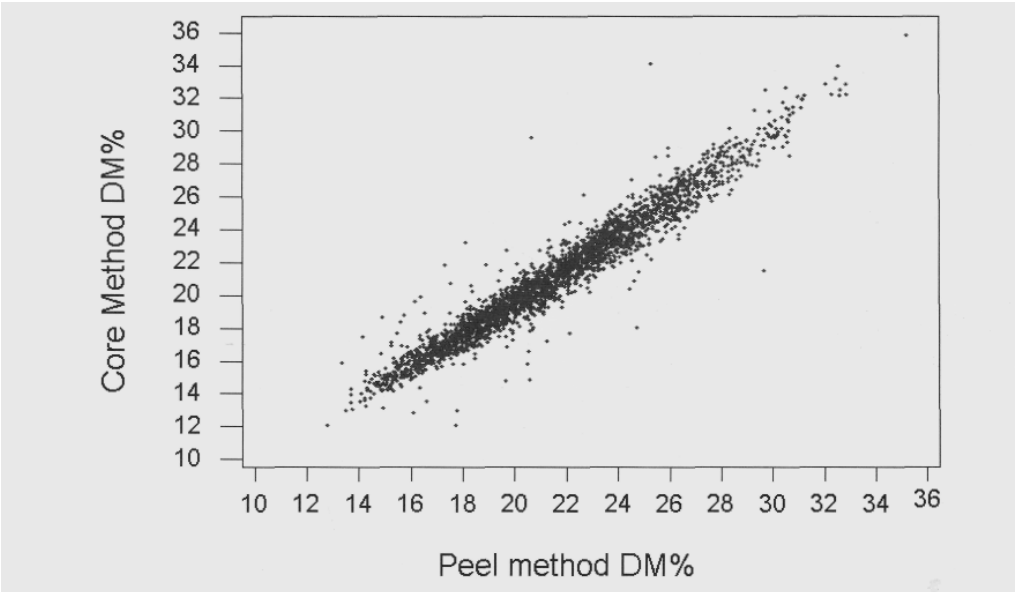

Figure 3. Correlation of peel and core method DM measurements (n = 2700)

Distribution of differences

Regression analysis focuses attention on the correlation between two variables and the variability about the regression line tends to be overlooked. This variability was examined by analyzing the distribution of the differences in DM content, calculated by subtracting the peel method result from the core method result both for each individual

fruit (Figure 4) and for each of the 20-fruit tests (Figure 5).

The distribution of differences between the two methods was used to determine an appropriate value to correct for the difference between the two methods. The differences between the two methods based on individual fruit analysis (Figure 4) are not normally distributed (Anderson Darling normality test, $A^2 = 26.757$, $p < 0.001$). The distribution of differences using 20-fruit means (Figure 5) eliminates the extremes in variation found in the individual differences, providing a normal distribution ($A^2 = 0.197$, $p = 0.886$). The 20-fruit mean distribution has the advantage of being applicable to the sample size required for the commercial maturity test. The differences of the 20-fruit means are distributed about a mean of -0.4% with a standard deviation of 0.3%. This gives a 95% confidence interval for the difference between the core and the peel method of-1 .0 to +0.2%.

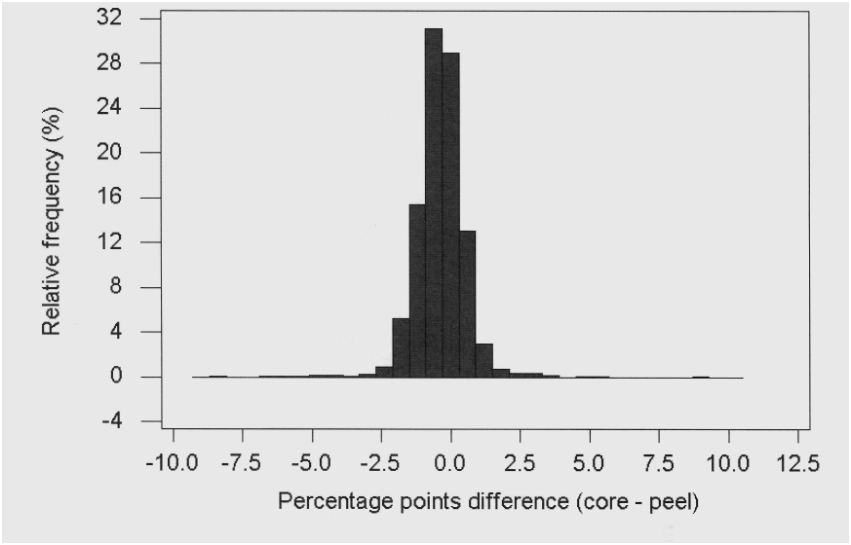

Figure 4. Relative frequency of the difference in DM measured by the peel method and core methods using INDIVIDUAL FRUIT. (n= 2700)

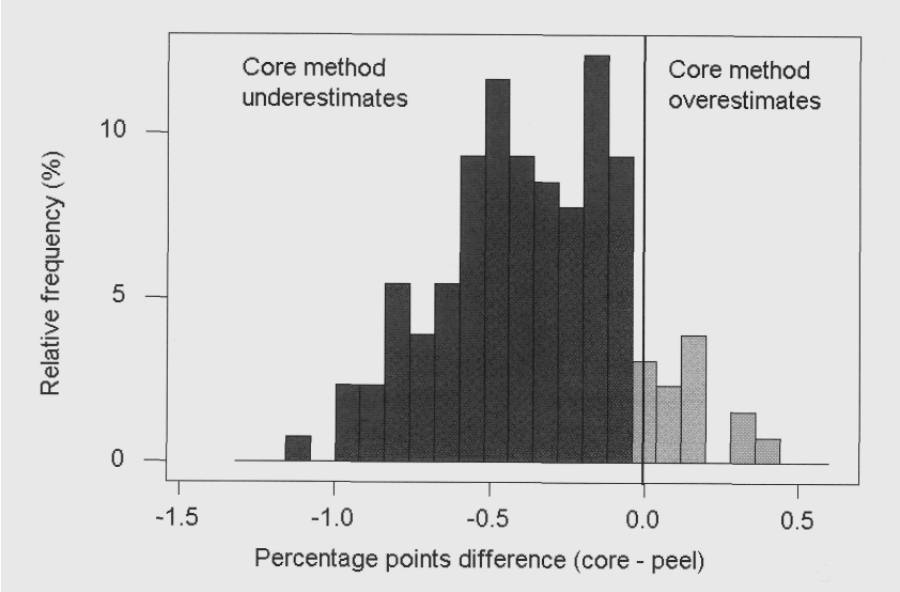

Figure 5. Relative frequency of the difference in DM measured by the peel method and core methods using 20-FRUIT SAMPLES. (n = 135)

Correction value

Estimates of the correction value determined using regression analysis ranged from -0.4 to -0.2 and varied according to the sample (individual fruit or 20-fruit mean) and the choice of dependent variable. Analysis of the distribution of differences between the two methods is a more appropriate basis for determining the appropriate correction factor. The correction factor obtained from this distribution of differences suggests that a correction value of 0.4 (± 0.6% DM) should be applied.

If a 20-fruit test mean, obtained using the core method result is adjusted by adding the correction value of 0.4%, there would be a 95% confidence the adjusted result would be within ± 0.6% DM content compared to the result obtained with the peel method (Table 2).

Table 2. Estimated DM and DM range using peel method, calculated for selected DM contents measured with the core method and adjusted using a correction value.

DM Core (%)	Estimated DM peel (%)	Range of DM peel (%)[1]
18	18.4	17.8 19.0
20	20.4	19.8 21.0
22	22.4	21.8 23.0
24	24.4	23.8 25.0
26	26.4	25.8 27.0
28	28.4	27.8 29.0

[1] 95% confidence limits

It is important to keep the difference in DM content obtained using the two methods in perspective. The average standard deviation of a 20-fruit sample over the harvest period, using either method is 1.9%. Over the course of a season, the average difference between the two methods represents between one half and one ninth of the average standard deviation in DM in a 20-fruit sample. Thus, the average difference in DM observed is less than the inherent sampling error associated with estimating the average DM content with a 20-fruit sample. In practical terms, it would only take approximately 4 to 6 days to accumulate 0.4% DM (Pak, 2002).

The inherent variability of the peel method

The variability between the two methods was examined in context of the inherent variability of the peel method test to determine the significance of the variability found. The distribution of differences in DM content measured using the peel method twice on the same fruit are compared with the differences in DM between samples prepared using the core and peel methods, is examined in figure 6 below. The repeatability of the peel method, when sampled twice on the same fruit is similar to the variability between the two methods, suggesting that neither method is inherently more accurate for calculation of DM content in a 20 fruit sample.

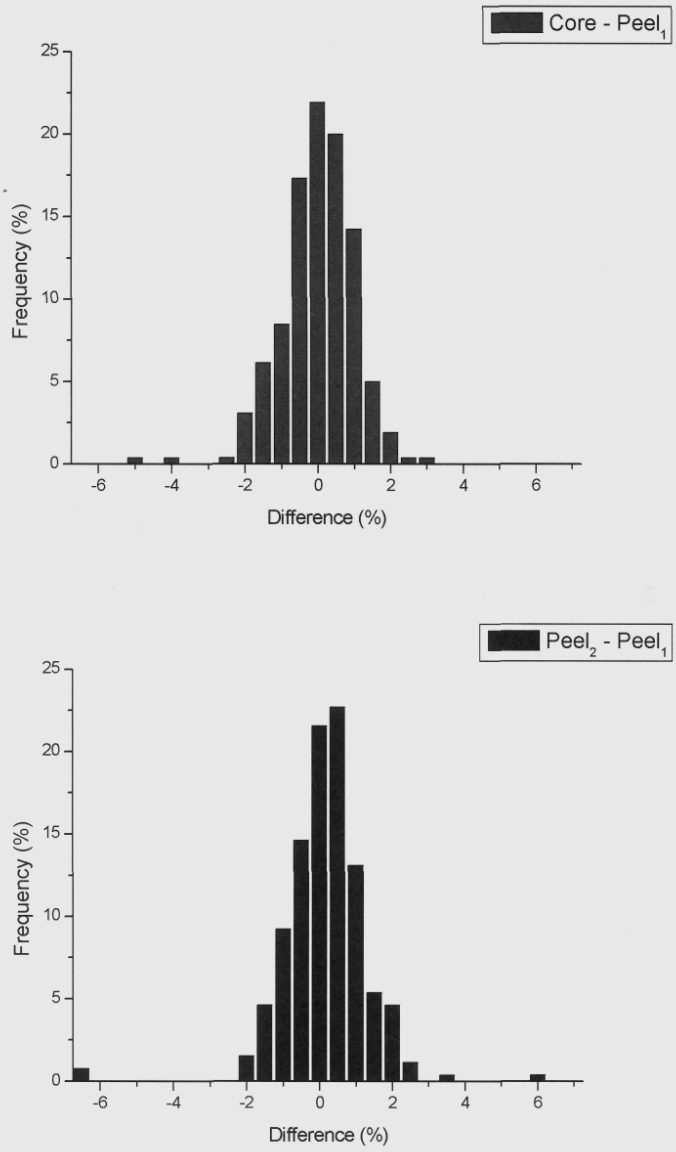

Figure 6. Relative frequency of the difference in DM measured by the peel method and core methods (n = 260) compared to repeated peel method tests (n = 260) on the same fruit.

Variation within fruit

The bottom of the fruit had the highest DM content followed by the top of the fruit. The middle of the fruit had the lowest DM content (Table 3). Dry matter measured from the middle of the fruit will therefore be a more conservative measure of DM content of an individual fruit, compared to the DM results using the peel method.

It is likely that the current peel method is more accurate at determining DM content in an individual fruit as it better averages within fruit variability in two ways. Firstly, peeling includes flesh from all sections of the fruit, in comparison to the core method which samples only from the middle of the fruit. Secondly, the peel method samples a larger

proportion of the fruit than the core method, with about 10% of the flesh of each fruit tested with the peel method compared to about 3% with the core method. That this variation is not reflected in the results based on a 20-fruit sample may be a reflection on the appropriateness of sampling for maturity testing using a small sample size.

Table 3. Mean and standard deviation in core method result from three locations in the fruit (n=100). Values in columns with no letter in common differ significantly ($p<0.001$) according to Fishers pair wise comparisons.

	Mean DM (%)	Standard Deviation
Top	21.4 a	3.35
Middle	20.0 b	3.36
Bottom	23.0 c	4.00

CONCLUSIONS

The core method underestimates DM content relative to the peel method by 0.4% on average. An appropriate correction value of 0.4% (± 0.6%) was determined. The mean difference between the two methods represents between one half and one ninth of the average standard deviation in DM result in a 20-fruit sample. The repeatability of the peel method, when sampled twice on the same fruit is similar to the variability between the two methods, suggesting that neither method is inherently more accurate for calculation of DM content. It is suggested that the core method may be suitable for use in place of the current peel method.

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