# THE DA METER AS A NEW OPTION FOR DETERMINING OPTIMAL HARVEST MATURITY AND RIPENING STAGES OF FRUIT

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The DA-Meter, an innovative, non-destructive instrument for determining fruit maturity by measuring chlorophyll content in the skin, was recently showcased at Fruit Logistica, where it received 3rd place in the prestigious new innovation award (FLIA). Developed and patented by Prof. Costa's team from the University of Bologna, Italy, the DA-Meter is a portable spectrometer which they claim can monitor on-tree fruit ripening to accurately establish optimal harvest maturity, and which can also be used during the cold chain to establish maturity changes over time (Costa *et al*., 2009, Noferini *et al*., 2009). **ExperiCo** (Fruit Technology Solutions) has extensively tested the instrument for two seasons across several pome, stone and grape cultivars and so is a position to report back on the usefulness of this tool as a means of determining fruit maturity and storage potential.

## What do the manufacturers say about the DA-Meter?

This non-destructive fruit ripeness tester is marketed as a tool to be used during the production and consumption cycle of fruit, and, according to the manufacturers, can be utilised:

1. by the producer, to optimise fruit thinning, to obtain a homogenous product, and as a result reduce the number of picking stages
2. by the producer, during harvest time, to identify the optimal picking window
3. in the cold rooms, to determine the maturity of the stored fruit, and at any specific time the shelf-life potential of the fruit,
4. on the pack line, to sort fruit according to chlorophyll content, thus guaranteeing optimal distribution of produce for storage and for delivery, and,
5. at the retailer, to buy products at the intended maturity, and to select the most ripened fruit for selling

## How does the DA-Meter provide a ripening index?

The ripening stage of fruit is normally determined on the basis of destructive parameters such as flesh firmness, starch breakdown, levels of acidity and soluble solid content, on a small sample of fruit that may not fully represent of the variability within fruit batches. Non-destructive instruments, on the other hand, are able to carry out measurements on much larger sample sizes, with the added advantage of repeat analysis in time over the same samples to follow their physiological evolution (Ziosi *et al*., 2008). Visible (vis) and Near Infrared (NIR) Spectroscopy, are two such non-destructive technologies, which are currently utilised on pack lines, but which are expensive, relatively slow, and which require complex statistical elaboration of data to be useful. In contrast, the DA-Meter (Figure 1), which has been developed from vis/NIR spectroscopy, is reported to be a simple, cost effective and reliable technology that can rapidly assess fruit ripeness. Vis/NIR spectroscopy has been used to develop a new maturity index calculated as the difference in absorbance (DA) between two wavelengths (670 and 720 nm) close to the absorbance peak of chlorophyll-a (Ziosi *et al*. 2008, Noferini *et al*, 2008a). Simply stated, the DA-Meter, by means of its absorbency properties, measures the chlorophyll content in a fruit and, as a consequence, its state of ripeness. The index of absorbance difference ($I_{AD}$) decreases in value during ripening of the fruit, until it reaches very low values (0.00), when fruit are yellow and ripening is complete. Each fruit kind, and cultivar, has specific DA values according to the different phases of maturation, and so for this instrument to be practical, a full set of reference indices would be required for each cultivar.


Figure 1: The DA Meter being used to take the reading of a Bon Chretien pear

Research by Prof Costa's team indicated that the $I_{AD}$ exhibits great potential in the peach production chain. In the field, it was used to establish optimal harvest time, and in the pack house the $I_{AD}$ was correlated to ethylene emission levels and so enabled sorting of fruit according to fruit maturity (Noferini *et al*., 2008b). In another study, the index of absorbance difference was assessed as a tool for segregating peaches and nectarines into homogenous classes with different shelf-lives, and eating preferences (Gottardi *et al*., 2009). The $I_{AD}$ separated fully red peach fruit varieties into homogenous classes differing in ethylene emission levels, postharvest ripening behaviour and consumer acceptance. In apples, the $I_{AD}$ was found to be a reliable parameter for monitoring on-tree apple ripening. Decreasing index ranges corresponded to increasingly advanced stages of ripening, as indicated by differences in ethylene emissions and quality traits of fruit with different $I_{AD}$ values. Thus the $I_{AD}$ seemed a reliable parameter to establish optimal harvest time and to grade fruit according to their storage potential (Noferini *et al*., 2008c).

**Research by ExperiCo (Fruit Technology Solutions)**

In a trial conducted by **ExperiCo** on Golden Delicious apples, DA readings were correlated to skin colour measured with the industry colour chart for green apples and pears, flesh firmness measured with an FTA (Güss Instruments), and percentage starch breakdown measured according to the industry chart for starch breakdown (Figures 2 to 4). Fruit were harvested twice a week for six weeks, from a pre-optimum maturity stage (starch breakdown levels of 5.9%) until fruit were of a post optimum harvest maturity (starch breakdown levels of 86.8%). At each sampling period, DA and colour chart readings were measured on both cheeks of 20 fruit, replicated 5 times (total of 100 fruit). A Pearson Product-Moment Correlation (StatSoft Inc., 1999) was performed on the means of each replicate to determine if there was a relationship between DA readings and other fruit maturity indicators. In the case of the colour chart, only 52.7% of the chart readings could be explained by DA measurements (Figure 2), compared to 75.1% of the starch breakdown values (Figure 3) and 82.1% of the flesh firmness measurements (Figure 4). In other words, during harvest, the DA Meter could most accurately predict flesh firmness, followed by starch breakdown, and lastly skin colour. The low correlation noted with fruit colour, compared to flesh firmness and starch breakdown, was because the range of colour change over the 6 week harvesting period was not as great as the firmness loss or the degree of starch conversion.

On the other hand, when skin ground colour and flesh firmness data from many different trials were pooled and compared to DA Meter readings; it became evident, that for certain cultivars, very good correlations were found, especially for those cultivars experiencing wide skin colour changes during ripening (Table 1). This was particularly noticeable in the skin ground colour of Bon Chretien, Forelle, and Packham's Triumph pears ($r^2$ = 0.97, 0.80, and 0.78, respectively), and Golden Delicious apples ($r^2$ = 0.83). Assessment of skin ground colour correlations of bicolour cultivars such as Pink Lady® and Royal Gala apples showed a drop in correlation results, with $r^2$ values ranging between 0.63 and 0.68. Flesh firmness did not show the same high correlations as noted with skin colour, with Bon Chretien pears exhibiting the best correlation with an $r^2$ value of 0.67. Correlation analysis comparing

the DA Meter with other maturity parameters, such as soluble solid content and fruit acidity, resulted in very low $r^2$ values indicating little or no correlation. This was also the case between flesh firmness and hue angle in red coloured Larry Ann plums.

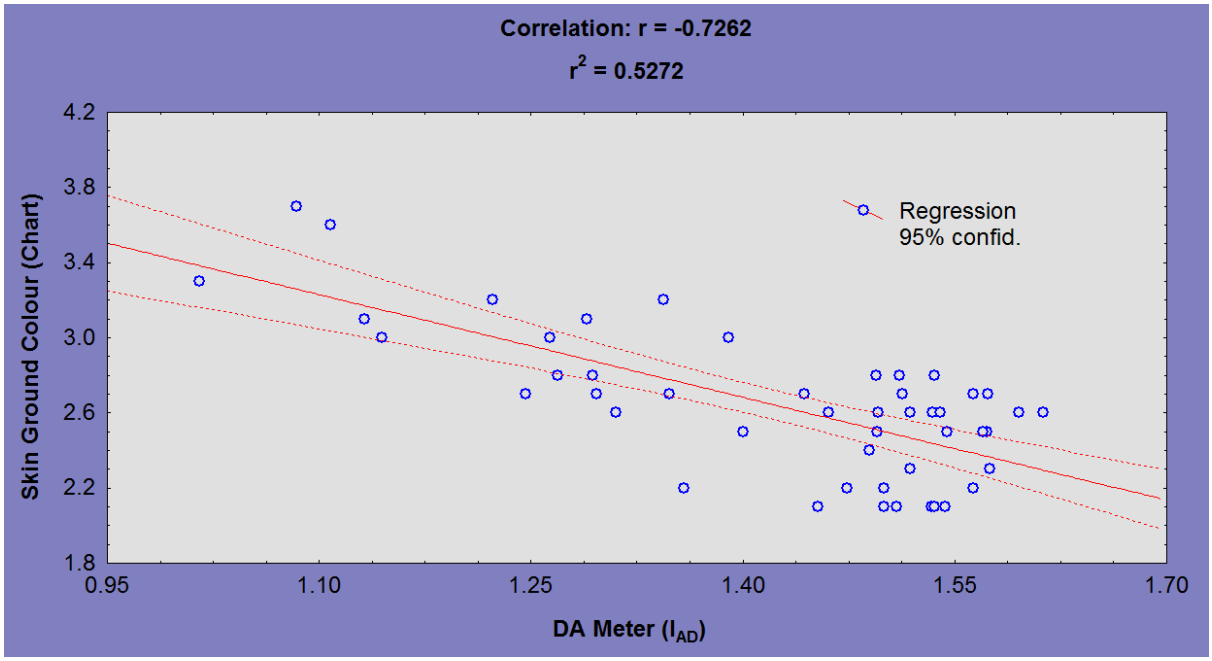


Figure 2: Pearson Product-Moment Correlation performed on DA Meter readings and corresponding skin ground colour measurements for Golden Delicious apples harvested twice weekly over a six week period

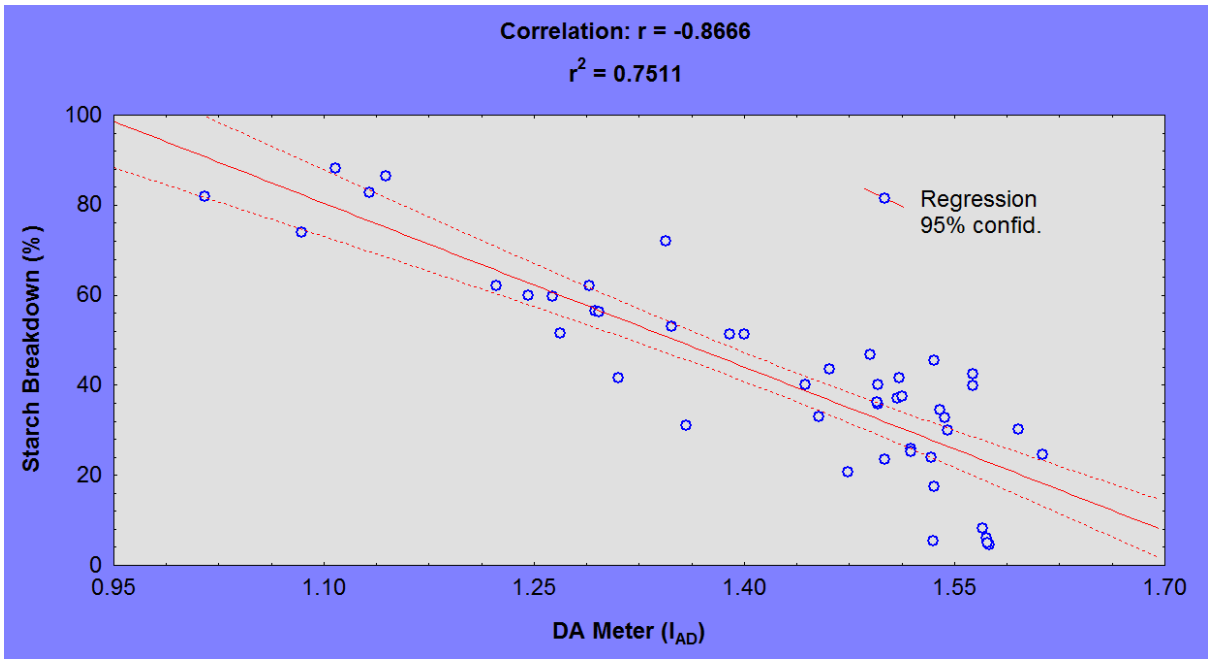


Figure 3: Pearson Product-Moment Correlation performed on DA Meter readings and corresponding starch break down measurements for Golden Delicious apples harvested twice weekly over a six week period

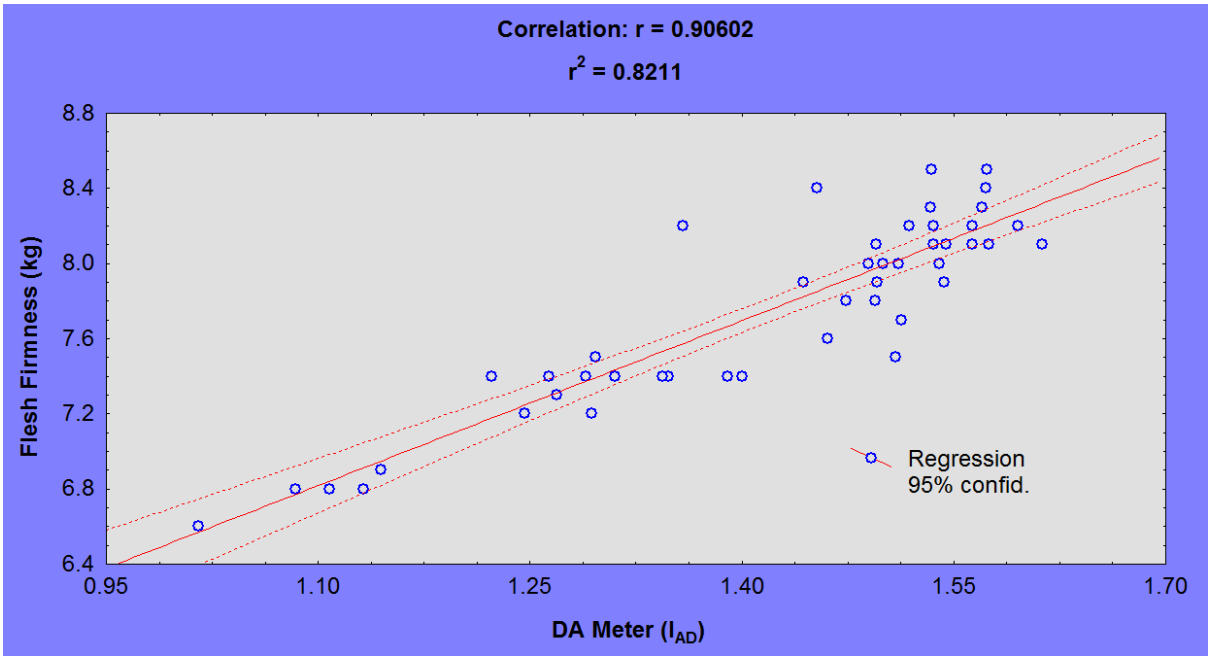


Figure 4: Pearson Product-Moment Correlation performed on DA Meter readings and corresponding flesh firmness measurements for Golden Delicious apples harvested twice weekly over a six week period

Table 1: Correlation of the DA Meter with skin ground colour and flesh firmness, measured with the Industry chart for green apples and pears, and the Fruit Texture Analyser, respectively

| Cultivar | n[1] | $R^2$ Value | |
|---|---|---|---|
| | | Skin Colour[2] | Flesh Firmness[3] |
| Bon Chretien pears | 320 | 0.9647 | 0.6665 |
| Packham's Triumph pears | 786 | 0.7800 | 0.4227 |
| Forelle pears | 719 | 0.7971 | 0.5947 |
| Golden Delicious apples | 1118 | 0.8263 | 0.4274 |
| Granny Smith apples | 61 | 0.3154 | 0.0739 |
| Royal Gala apples | 240 | 0.6767 | 0.5223 |
| Pink Lady® apples | 774 | 0.6262 | 0.3364 |
| Larry Ann plums[3] | 42 | 0.0190 | 0.0024 |

1. A Pearson Product-Moment Correlation (StatSoft Inc., 1999) was performed on the means of replicates of 20 fruit. Skin colour and flesh firmness measurements were taken on both cheeks of each fruit. The n value represents the replicate means
2. Skin colour was measured with the Industry colour hart for green apples and pears, where 0.5 = green and 5.0 = fully yellow fruit
3. Flesh firmness was measured with an FTA (Fruit Texture Analyser, Güss Instruments), fitted with an 11mm probe
4. In the case of Larry Anne plums, skin colour was measured with a Minolta Colour Meter as opposed to the colour chart

## Synopsis of findings by ExperiCo (Fruit Technology Solutions)

Initial results indicate that the DA Meter may be a useful tool in assessing fruit harvest maturity as strong correlations were found for both flesh firmness and starch breakdown in Golden Delicious apples. Skin ground colour, surprisingly showed relatively low correlations in this study, possibly

because skin colour remained relatively constant during the harvesting period, especially when compared to flesh firmness and starch conversion. However, when a large data set of skin ground colour measurements was examined, which included a full range of fruit maturities (both pre-harvest and post storage), exceptionally high correlations were found, particularly for Bon Chretien pears. On the assumption that skin colour is a reliable indicator of fruit quality, these results suggest that the DA Meter may well prove useful towards the end of cold storage in separating fruit populations into homogenous classes which can then be marketed according to storage and/or shelf life potential. As each cultivar, has specific DA values according to the different phases of maturation, and application, further research is required to assimilate a full set of reference indices which would be required before this instrument can provide commercial benefit. Results also indicated that skin ground colour and flesh firmness in bicolour apples such as Royal Gala and Pink Lady® did not show the same level of correlation as green fruit. It is possible that one reason for this is that, contrary to what is reported in the literature (Noferini, 2008c), the red anthocyanins masking the chlorophyll may affect the reading of the instrument. This may be the case, since a similar low correlation was noted in the red-skinned Larry Ann plums. This possible shortcoming would need to be assessed should this instrument be placed on a pack-line to sort fruit.

This study was made possible utilizing DA Meters supplied by AgroFresh Inc.

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