Scientia Horticulturae 209 (2016) 293–299

Contents lists available at ScienceDirect

Scientia Horticulturae

journal homepage: www.elsevier.com/locate/scihorti

On-tree maturity control of peach cultivars: Comparison between destructive and nondestructive harvest indices

Rita G. Gonçalves [a], João Couto [b], Domingos P.F. Almeida [a,*]

[a] Instituto Superior de Agronomia, Universidade de Lisboa, Tapada da Ajuda, 1349-017 Lisbon, Portugal
[b] Prosa, Produtos e Serviços Agrícolas, S.A., Marco de Canavezes, Portugal

ARTICLE INFO

Article history:
Received 3 April 2016
Received in revised form 27 June 2016
Accepted 30 June 2016
Available online 16 July 2016

Keywords:
DA-meter
I_{AD}
Fruit firmness
Harvest
Maturity index
Nectarine
Prunus persica
Ripening

ABSTRACT

Optimal harvest maturity is required for flavorful peach. The supply chain often errs on the side of immature fruit with subsequent consumer dissatisfaction. Maturity indices used to determine harvest date of peach include nondestructive assessments of size and background color, and destructive measurements of flesh color, firmness and soluble solids content (SSC) . More recently an index related to the absorbance of chlorophyll (I_{AD}) can be nondestructively assessed with a DA-meter. This application is particularly useful in red-skinned cultivars in which background color changes from green to yellow are not perceptible to the naked eye. The objective and nondestructive I_{AD} was compared with objective and destructive assessments of firmness and SSC, as indices to make harvest decisions on peach orchards. Seven peach and five nectarine cultivars [*Prunus persica* (L.) Batsch] were studied. Fruits were assessed with a DA-meter and the resulting I_{AD} values were related to firmness and SSC in several consecutive samplings during the maturity period for each cultivar. Pooling all sampling dates for each cultivar, significant positive linear regressions were observed between I_{AD} and firmness, with coefficients of determination $0.11 < R^2 < 0.65$. However, in each cultivar the linear regression parameters between I_{AD} and firmness are different and changed in sequential samplings required for maturity control and in successive harvests. No significant relationship was observed between I_{AD} and SSC in any cultivar. In conclusion, the DA-meter cannot replace firmness and SSC measurements during on-tree maturity control, which remain essential for sensory quality management in the supply chain. .

1. Introduction

Harvest maturity is a key determinant of fruit quality in the supply chain. However, balancing quality requirements of different supply chain operators can be challenging. Growers value the easiness of harvest operations, resistance to damage and disease; packing houses favor tolerance to handling, absence of physiological disorders, and reduced decay; consumers buy on appearance but their satisfaction depends largely on textural properties and flavor (Shewfelt and Brückner, 2000).

Given the central role of harvest maturity for subsequent storage and marketable life, and for sensory quality, harvest timing must be based on adequate maturity indices. Several indices are used in peach, including objective measurements and subjective assessments, as well as destructive and nondestructive indices. Maturity indices adopted by the peach industry are: nondestructive assessments of size, shape and background color, and destructive measurements of flesh color, flesh firmness, soluble solids content (SSC), and titratable acidity (Crisosto, 1994). The use of objective nondestructive indices to monitor the same fruit over time, increases precision and minimizes sampling costs (Crisosto, 1994).

Peach is a climacteric fruit (Tonutti et al., 1991) able to ripen autonomously if harvested mature (Borsani et al., 2009). Physiological maturity of yellow fleshed peaches is achieved when the skin and the flesh color change from a green to a yellow hue, concomitant with fruit softening (Crisosto, 1994). This change in background color is generally a good harvest index for melting yellow fleshed peach and is used to determine minimum maturity (Crisosto, 1994). However, in the red-skinned cultivars that currently dominate the European market, the change of the background color is not perceptible to the naked eye.

An index related to the absorbance of chlorophyll (I_{AD}) can be nondestructively assessed by a handheld spectrometer DA-meter. This device resorts to the interaction between radiation of wavelengths in the visible and near infrared range with fruit outer layers to infer about its properties. The DA-meter calculates I_{AD} based on

* Corresponding author.
E-mail address: dalmeida@isa.ulisboa.pt (D.P.F. Almeida).

http://dx.doi.org/10.1016/j.scienta.2016.06.040

the difference in absorbance of radiation with 670 nm and 720 nm, two wavelength near the chlorophyll absorbance peak (Ziosi et al., 2008). I_{AD} is correlated with the content of chlorophyll in the fruit mesocarp (Zude-Sasse et al., 2002) and with ripening-related ethylene production rate (Ziosi et al., 2008). Therefore, I_{AD} can be a good harvest index for red skin peaches, detecting maturity-related changes in chlorophyll content.

I_{AD} has been used to assess maturity of peach for a number of experimental purposes: to evaluate maturity homogeneity within the orchard canopy (Bonora et al., 2013a), to estimate shelf-life potential (Lurie et al., 2013), to study the effect of growth regulators on ripening (Soto et al., 2012, 2013), to predict harvest date and yield (Bonora et al., 2014) and to assess the ripening stage (Ziosi et al., 2008). DA-meter has also been used in other fruit, including apple (Nyasordzi et al., 2013; Toivonen and Hampson, 2014; Farneti et al., 2015), apricot (Costa et al., 2010), kiwifruit (Costa et al., 2011), and plums (Infante et al., 2011a, 2011b). The correct interpretation of I_{AD} values is cultivar-dependent (Ziosi et al., 2008) but apparently the relationship between I_{AD} and consumer preference is stable among seasons for each cultivar (Bonora et al., 2013b).

Despite the growing numbers of reports on the use of I_{AD} as a maturity index in several fruit types, a major issue remains unsolved. It is currently unclear whether I_{AD} be used as the sole harvest index for maturity control and determination of harvest date in peach and how stable is the relationship between I_{AD} and major determinants of consumer preference for peaches, such as firmness and SSC, during the harvest season.

Since peach orchards require multiple harvests for uniform and consistent maturity, the replacement of destructive measurement of firmness and SSC would be beneficial for harvest management. Therefore, the aim of this study was (i) to evaluate the feasibility of the application of the I_{AD} as the sole nondestructive maturity index to base harvest decisions in peach cultivars, and (ii) to understand the stability of the index in relation to firmness in sequential harvests in the same orchard as different fruit mature.

2. Materials and methods

2.1. Plant material

Trials were conducted in 2015 on seven peach and five nectarine [*Prunus persica* (L.) Batsch] cultivars. Peach cultivars used for this study were 'Ruby Rich', 'Early Rich', 'Royal Glory', 'Royal Summer', 'Summer Rich', 'Sweet Dream' and 'Royal Lee'. Nectarine cultivars were 'R8', 'Honey Bla', 'Big Top', 'Luciana' and 'Honey Royal'. These yellow-fleshed and red-skinned cultivars were grown in a 45 ha orchard located in Vale da Vilariça (41.33 N; −7.05 W), Northeastern Portugal with five-year old trees, planted with density ranging from 660 to 900 trees per hectare, grafted onto Monclair and trained in axis or vase.

2.2. Orchard sampling

Fruit from each cultivar were sampled at each harvest date and each cultivar was harvested at three to five dates as maturity progressed. In three cultivars – 'R8', 'Luciana', and 'Sweet Dream' – fruits were sampled before the expected harvest date to assess their maturity. Fruit were sampled during the months of June and July, depending on the maturity season for each cultivar.

Fruit samples were obtained from 20 trees per cultivar, previously tagged and chosen in a crisscross pattern. At each sampling date, 20 fruits with final size, adequate shape, and located in the positions most likely to be harvested in the tree were randomly removed from the branch. Immediately after recollection the fruits were analyzed for firmness, soluble solids content, and I_{AD}. Flesh temperature at harvest was measured with a digital thermistor thermometer (model Checktemp 1, Hanna Instruments, Woonsocket, RI, USA) and ranged from 15 °C to 23 °C.

2.3. Assessment of firmness and soluble solids content

Flesh firmness was measured after peel removal with a handheld penetrometer (FT 327, T.R. Turoni, Forli, Italy) equipped with an 8-mm diameter probe. Two measurements were manually made per fruit at the equatorial region of each cheek. Firmness of each fruit was the mean of the two measurements.

Soluble solids content (SSC) was measured in the same fruit using a digital refractometer (HI 96801, Hanna Instruments, Woonsocket, RI, USA), and expressed as percentage of sucrose equivalents in the fresh mass.

2.4. Measurement of I_{AD}

The I_{AD} was measured with a DA-meter (T.R. Turoni, Forli, Italy). Two measurements of opposite sides of each cheek were made. The fruit was protected from direct sunlight during the measurements. Measurements were made in the same fruit used to analyze firmness and SSC.

2.5. Data analysis

Measured values were summarized as mean and standard deviation for general characterization. Exploratory graphical analyses of data from each cultivar at each sampling date consisted on scatter plots between I_{AD} and firmness and I_{AD} and SSC. These relationships were subsequently analyzed by linear regression.

Table 1
Characteristics of peach cultivars used in the study. Values are mean ± SD, $n = 4$.

Cultivar	Type[a]	Harvest period	*N*	Flesh firmness (N)	SSC (%)	I_{AD}
'Big Top'	N	June 22–July 1	40	46.6 ± 9.5	13.7 ± 2.7	0.6 ± 0.2
'Early Rich'	P	June 15–16	40	49.9 ± 13.0	10.0 ± 1.3	1.3 ± 0.4
'Honey Blaze'	N	June 16–22	60	51.5 ± 7.5	12.4 ± 2.6	0.9 ± 0.4
'Honey Royal'	N	July 13–23	140	53.0 ± 6.9	15.0 ± 2.1	1.3 ± 0.3
'Luciana'	N	June 22–July 23	120	49.4 ± 6.3	13.4 ± 1.6	0.4 ± 0.2
'R8′	N	June 12–22	100	44.6 ± 7.0	9.8 ± 1.3	0.8 ± 0.3
'Royal Glory'	P	June 22–29	40	42.0 ± 6.4	11.3 ± 1.2	1.2 ± 0.4
'Royal Lee'	P	July 10–20	120	46.8 ± 8.5	12.6 ± 1.7	0.7 ± 0.3
'Royal Summer'	P	July 2–13	60	46.9 ± 7.3	12.9 ± 1.7	1.3 ± 0.4
'Ruby Rich'	P	June 12–22	40	19.9 ± 7.5	10.2 ± 1.6	1.3 ± 0.4
'Summer Rich'	P	July 9–23	140	49.6 ± 11.8	12.1 ± 1.6	0.9 ± 0.4
'Sweet Dream'	P	July 9–24	180	47.8 ± 5.5	13.1 ± 1.9	1.0 ± 0.3

[a] P: peach; N: nectarine.