Ready to Eat Nectarines - Assuring Quality in the Chain

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Abstract

Time-resolved reflectance spectroscopy, coupled to the modelling of firmness decrease, was used to predict at harvest softening behaviour of nectarines. Selected fruit were used in an export trial from Italy to The Netherlands. Quality assessed after shelf life was in agreement with the predicted firmness for fruit of different stages of maturity, showing that it is possible to select fruit at harvest for different market destinations and prevent transportation of fruit unsuitable for consumption.

INTRODUCTION

Traditional harvest criteria for nectarines and peaches are mainly based on colour development in the orchard. Contemporary cultivars however, have a very strong blush, fully developed before the fruit start to ripen. As a consequence, optimal harvest date for these cultivars is very difficult to assess. The tendency to harvest earlier and earlier to avoid product losses along the supply chain leads to more and more immature fruit. Fruit may be so immature that some of them never reach an edible state at the consumer. A new technology and especially, a new supply chain paradigm, is needed to reverse this development in the stone fruit supply chain.

Time-resolved Reflectance Spectroscopy (TRS) is a physical technique capable of non-invasive probing of fruit flesh by laser light. TRS measures the absorption coefficient (μ_a) separately from the scattering coefficient. Technical details of the TRS system, modelling of μ_a at 670 nm, modelling of firmness behaviour and the relation between softening, ripening and light absorption at harvest are reported in Cubeddu et al. (2001), Eccher Zerbini et al. (2006) and Tijskens et al. (2006, 2007). Using the developed models, the absorption coefficient of each fruit measured at harvest can be converted to a maturity stage, expressed as the biological shift factor, which makes prediction of softening during shelf life possible. In this way, nectarines can be selected at harvest time according to their maturity and expected shelf life, so facilitating fruit management.

To check applicability of this system for quality assurance at the consumer stage, an export trial was carried out with nectarines, harvested in Italy, screened by TRS and sent to The Netherlands for shelf life and quality evaluation (Eccher Zerbini et al., 2009; Rizzolo et al., 2009).

MATERIALS AND METHODS

In 2006 nectarines (*Prunus persica* L. Batsch 'Spring Bright') were harvested from a commercial orchard in Faenza (Italy). Fruit with defects and bruises were removed and the absorption coefficient at 670 nm (μ_a) was measured on 996 fruit according to Torricelli et al. (2008). Fruit were ranked according to decreasing μ_a value (i.e., from less to more mature). Firmness was measured on 38 selected fruit, covering the whole maturity range, using the Texture Analyzer TA.Xtplus, Stable Micro Systems (plunger: ∅ 8 mm, speed 200 mm/min). The measured μ_a values were expressed as biological shift factor (Δt^*, Tijskens et al., 2007) with $\mu_{a,max}$ fixed to 0.65 cm^{-1} (taken from previous years) using Eq. 1.

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$$\Delta t^* = \ln\left(\frac{\mu_{a,max}}{\mu_a} - 1\right) \qquad \text{Eq. 1}$$

The dimensionless biological shift factor (Δt^*) for μ_a is linearly related to the corresponding biological shift factor for firmness decay. Both can be converted into the normal time dimension using Eq. 2, where Y represents either firmness or μ_a, and k_Y is the decay rate of the process under consideration.

$$\Delta t_Y = \frac{\Delta t^*}{k_Y \cdot (Y_{max} - Y_{min})} \qquad \text{Eq. 2}$$

Based on μ_a and the corresponding calculated values of Δt^*, fruit were graded into six classes of usability ('never ripe' (N), 'dangerously hard' (H), 'transportable' (T), 'ready to eat-firm' (RF), 'ready to eat-ripe' (RS) and 'overripe' (O)). Δt^* limits of each class are reported by Eccher Zerbini et al. (2009) (Table 1).

Graded nectarines were packed in one-layer cardboard boxes with rigid plastic insert trays for mechanical protection of individual fruit, cooled to 0ºC and transported from Faenza (Italy) to Wageningen (The Netherlands) using a standard temperature-controlled truck. On arrival in Wageningen, fruit was brought to 20ºC and tested for softness by sensory evaluation (finger feeling on a scale 1-7, see Table 1) after 5, 6 and 13 days of shelf life.

RESULTS AND DISCUSSION

It has been demonstrated clearly that the absorption coefficient measured at 670 nm (near to the chlorophyll peak) using TRS is related to maturity of individual fruit. The higher the absorption, the more chlorophyll is present and the less mature the fruit are (Eccher Zerbini et al., 2006; Tijskens et al., 2006).

The distribution of measured μ_a values was clearly not normal and positively skewed (Fig. 1), which makes this variable very difficult to work with. The distribution of the biological shift factor (Δt^*), however, converted from the measured μ_a values using Eq. 1, was normally distributed (Fig. 2) confirming results from previous years (Tijskens et al., 2007). From Fig. 1, it can be seen that firmness of just harvested fruit hardly changes from high values of μ_a down to a value of about 0.1 cm^{-1}, that is fruit classified from 'never ripe' to 'ready to eat-firm' were equally firm (>50 N), whereas fruit classified as 'overripe' were already partially soft at harvest having firmness <40 N. So, firmness at harvest is unsuitable for assessing the maturity of nectarines and for actual grading of fruit.

The sensory softness was assessed after transport and shelf life (Fig. 3). 'Never ripe' fruit remained very firm even at the end of shelf life. Only a small part of the 'dangerously hard' fruit was scored 'seems soft', while most were judged 'firm'. The 'transportable' and 'ready to eat-firm' classes behaved in a similar way, ripening and softening during shelf life reaching softness score 4 with no fungal decay ('transportable') or as little as 5% at day 13 ('ready to eat-firm'). The 'ready-ripe' fruit softened more quickly, being 'soft' already after transport, and, at the end of shelf life, they showed a 40% fungal decay, similarly to the 'overripe' fruit. Twenty-five percent of the 'overripe' fruit showed fungal decay after 5 days of shelf life. Results are summarized in Figure 3. The sensory panel estimated that the time required for fruit to ripen to an edible stage differed only 1 to 2 days on average with time to ripen estimated based on the biological shift factor, independent of stage of fruit maturity. Of course the individual preferences of the panellist are not the same.

These results correspond to the predicted firmness according to the firmness decay model (Rizzolo et al., 2009) based on firmness data at harvest and on previous years results (Fig. 4). In fact, at the first day of sensory evaluation (day 5), the 'transportable' class has a predicted firmness around 35 N, the 'ready to eat-firm' class between 9 and 17 N, and the 'ready to eat-soft' between 4 and 9 N. This is in agreement with Crisosto et al.

(2004, 2006), who stated that nectarines with firmness of about 35 N are ready-to buy, while those below 13 N are ripe and soft. The firmness value of 35 N almost coincides with the midpoint of the firmness decay curve and it can be assumed that this firmness value corresponds to the sensory softness score between 3 and 4.

CONCLUSION

Chlorophyll in nectarine fruit flesh, as measured by TRS absorption at 670 nm, is indeed a useful indicator of fruit maturity and for predicting when the edible state will be reached. The technology is applicable in practice. All information on a specific batch of fruit can be gathered at harvest time or at the grading lines in the packinghouses.

ACKNOWLEGEMENTS

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Tables

Table 1. Descriptions of sensory softness scores.

Score	Description	Comments
1	very firm	
2	firm	
3	seems soft	some spots yield slightly
4	softer	the whole fruit is somewhat soft all around
5	soft	both sides yield
6	overly soft spots	
7	spots with decay	

Figures

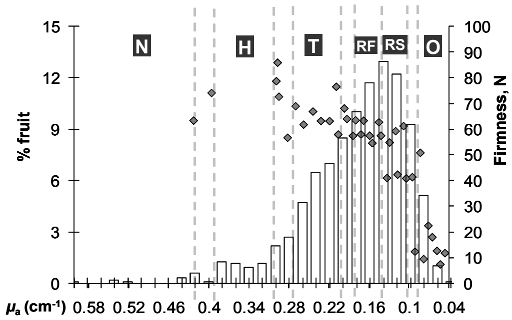

Fig. 1. Frequency distribution of μ_a (bars) at harvest in 'Spring Bright' nectarines (996 fruits) and individual fruit firmness (symbols) of the 38 fruit subset covering the whole μ_a range.

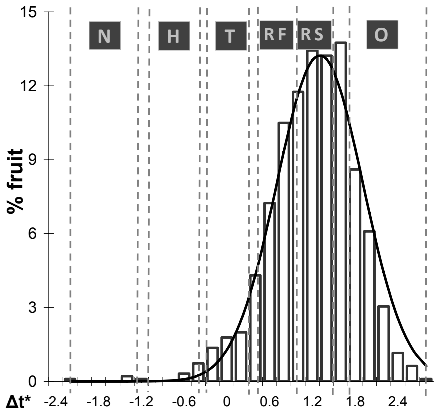

Fig. 2. Frequency distribution of Δt* and classes of usability at harvest in ‘Spring Bright’ nectarines.

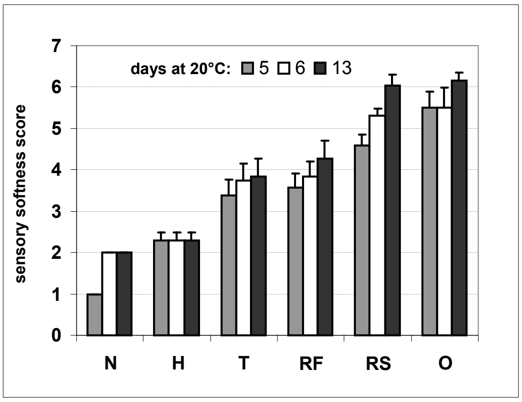

Fig. 3. Average scores of sensory softness (see Table 1) of fruit in each maturity class after 5, 6 and 13 d of shelf-life at 20ºC. Bars refer to standard error.

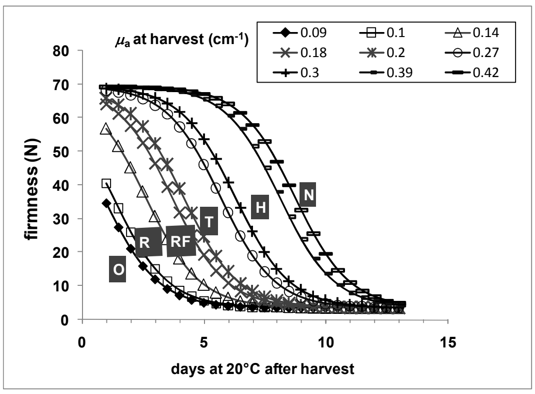

Fig. 4. Predicted firmness decay for fruit of the different classes.