Non-destructive determination of the optimum harvest time of the sweet cherry cultivar 'Cashmere' through CIELab colour coordinates and the principal component analysis (PCA)

V. Lafuente^{1,2,a}, J. Val^{1,b} and A.I. Negueruela^{2,c}

¹Estación Experimental de Aula Dei (EEAD-CSIC), Departamento de Nutrición Vegetal, Avda. Montañana, 1005 50059-Zaragoza, Spain; ²Department of Applied Physics, Faculty of Veterinary, University of Zaragoza, Miguel Servet 177, 50013, Zaragoza, Spain.

Abstract

A principal components analysis (PCA) carried out on the L*, a* and b* color coordinates, allows a good discrimination among maturity stages of the 'Cashmere' sweet cherry cultivar. Physical-chemical parameters were determined by conventional destructive methods that were used as a reference to compare with statistically treated optical data. The study was carried out during two consecutive campaigns 2010 and 2011. Samples were taken at optimum harvest time following the criteria of firmness, soluble carbohydrates and expert visual estimation of color. In the first season, two other samples of 200 fruits each, were picked at random in the plot from several trees, a week before and a week after the estimated optimal date. In 2011, sampling was made as in 2010 but timing was as follows: two days before harvest, at harvest and 2 and 4 days after. In both seasons, a simple representation of fruit color in the a* b* space of the whole set of samples in a single year, did not permit differentiation of fruits on a maturity stage basis. However, a principal component analysis including not only a* and b* but also the luminosity L*, allowed the classification of fruits according their ripeness using only the first component PC1. This work demonstrates that a simple colorimeter can be a suitable alternative to destructive methods to determine the optimum harvest time and also may permit the prediction of the shelf life of this commodity (very short indeed, 1 week approximately).

Keywords: cherry, colorimetry, fruit maturity, PCA, statistics

INTRODUCTION

Cherry cultivation is continuously expanding, with 24,300 ha currently under cultivation in Spain. Sweet cherry is not a climacteric fruit, do not ripe once picked from the tree, so it should be harvested after displaying the desired physico-chemical and organoleptic characteristics. This leaves about 7 days for sale and consumption. As the cherry ripens on the tree, the content of soluble solids increases, while the acidity and firmness decrease (Mitcham et al., 1998).

The most commonly used indexes to determine the right time for picking cherries are soluble solids content and skin color (Crisosto et al., 2003), which changes ranging from green to a purplish. During the change in color, anthocyanins and carotenoids are accumulated as chlorophyll degrades. For color specification, some researchers have used colour charts to determine the optimal time of harvesting (Timm et al., 1993) while others used CIELAB coordinates (Gao and Mazza, 1995; Heredia et al., 1998).

In cherries, one of the limiting factors regarding fruit quality and maturity is color. From red to purple, color serves as an index to determine the degree of ripeness.

^aE-mail: jesus.val@csic.es

^bE-mail: negueruela@unizar.es

^cE-mail: mvlafuente@ipe.csic.es

The aim of this work is the use of the CIELAB coordinates to investigate color changes during the process of ripening in the 'Cashmere' sweet cherry cultivar. In addition, the optimal harvest date was investigated to find the greatest time span between harvest and fruit consumption.

MATERIALS AND METHODS

Sweet cherries (*Prunus avium* 'Cashmere') used for this study were harvested from a commercial orchard owned by Orchard, S.L. located at the area of La Almunia de Doña Godina (Zaragoza, NE Spain).

The study spanned two years: 2010 and 2011. A total of 150 samples per sampling date were picked at random in the plot from several trees, at the optimal harvest date, a week before, and a week after, for a total of 450 samples. In 2011, sampling was made as in 2010 but timing was as follows: four days and two days before harvest, at harvest, and 2 and 4 days after. The optimal harvest time was determined in a traditional way: by measuring firmness, solid soluble content, and color. These samples were immediately transported to the laboratory, where the reflection spectra, in the range 360-780 nm, were measured at two opposite points on the fruit. A spectrophotometer CMS 700 Konica Minolta was used to measure visible spectra and color coordinates were established in the CIELAB space (CIE64 Observer and D65 Illuminant). In this way, measurements were made of L^* as a parameter of lightness, a^* as a measure of redness and b^* of yellowness.

Multivariate analysis was carried out by the software The Unscrambler X.1.

RESULTS AND DISCUSSION

Figure 1 shows different cherry colors coordinates in the a^* , b^* diagram, according to their dates of harvesting. Colors ranged from yellow to reddish-purple (high chroma). In overripe fruits, the color evolves from yellow to dark reddish-purple (low chroma). Meanwhile, L^* values (lightness) decreased over the sequence (data not shown).

Figure 1. Color coordinates a^* and b^* obtained from cherries during the first (left) and second (right) seasons (2010-2011) distinguishing the different harvest dates according to the legends.

Sweet cherries from different harvesting dates can be segregated by their color coordinates in the a^* , b^* space. In the first year of experiments, the b^* value indicates the degree. However, in 2011, the overlapping among samples from different harvest times is larger than in the previous season. This is clearly due to shorter period between sampling dates which only permits negligible variations in fruit color.

Principal component analysis (PCA) is a powerful tool to explore the dimensional structure of scale variables. A PCA using the three coordinates L^* , a^* , and b^* was performed in order to explore the possibility to stablish an optimal harvest time to lengthen the shelf

life of the fruit harvested.

Representation of samples in the first two components of PCA (Figure 2) permits a separation of samples as a function of the different harvesting dates. Prematurely harvested berries in both seasons, 2010 and 2011, are all allocated in a range of PC1 values higher than zero while samples harvested overripe spread their values towards the negative abscissa.

Figure 2. Principal component analysis using the first two components for different dates and years. Season 2010 (top); 2011 (bottom).

This graphical method allows to deduce that PC1 values of cherries ranging from -20 to 30 can be considered to correspond to the optimal harvesting date. This applies to both seasons studied and also constitutes a good indication that a simple $L^*a^*b^*$ color measurement and the right statistical treatment may indicate whether the fruit is ripe enough to be harvested. Nevertheless, data for more campaigns are needed to build up more reliable calibrations methods for prediction purposes and thereby higher variability comprising agroclimatic conditions, and other biotic and abiotic factors that influence maturity of fruits.

CONCLUSIONS

The color of some sweet cherry cultivars may be studied by graphical representation

in the a^* , b^* diagram. However, colors cannot be differentiated in days nearby the expected optimal harvest date because they overlap one another. As a non-climacteric fruit, sweet cherries must be picked ripe to be right. Principal component analysis may be applied to the CIE L^* , a^* and b^* coordinates to distinguish among different colors. The first component PC1 is enough to perform fruit classification in a color basis. A scoring range between -20 and 30 in PC1 establishes the optimal harvest time, which in turn represents longer shelf life for transportation, sales and consumption. Sensorial test evaluations, which will be undertaken in further investigations will complete the data sets of this studies.

ACKNOWLEDGEMENTS

We are indebted to volunteers in this study for their commitment and cooperation.

Literature cited

- Commission Internationale de l'Eclairage (CIE). (2004). Colorimetry, Publication CIE 15:2004 (Vienna: CIA).
- Crisosto, C.H., Crisosto, G.M., and Metheney, P. (2003). Consumer acceptance of 'Brooks' and 'Bing' cherries is mainly dependent on fruit SSC and visual skin colour. *Postharvest Biol. Technol.* 28 (1), 159-167 [https://doi.org/10.1016/S0925-5214\(02\)00173-4](https://doi.org/10.1016/S0925-5214(02)00173-4).
- Gao, L., and Mazza, G. (1995). Characterization, quantization and distribution of anthocyanins and colorless phenolics in sweet cherries. *J. Agric. Food Chem.* 43 (2), 343-346 <https://doi.org/10.1021/jf00050a015>.
- Heredia, F.J., Francia-Aricha, E.M., Rivas-Gonzalo, J.C., Vicario, I.M., and Santos-Buelga, C. (1998). Chromatic characterization of anthocyanins from red Grapes-I. pH effect. *Food Chem.* 63 (4), 491-498 [https://doi.org/10.1016/S0308-8146\(98\)00051-X](https://doi.org/10.1016/S0308-8146(98)00051-X).
- Mitcham, E.J., Clayton, M., and Biasi, W.V. (1998). Comparison of devices for measuring cherry fruit firmness. *Hortic. Sci.* 33, 723-727.
- Timm, E.J., Brown, G.K., Armstrong, P.R., and Beaudry, R.M. (1993). A portable instrument for measuring firmness of cherries and berries. ASAE Paper No. 93-6539 (St. Joseph, Mich.: ASAE).