Feasibility of a Simplified Handheld Optical System for Blueberries Ripeness Field Evaluation

Roberto Beghi [1*], Riccardo Guidetti [1], Roberto Oberti [1], Luigi Bodria [1]

[1] Department of Agricultural Engineering, Università degli Studi di Milano. Via Celoria 2, 20133 Milano, Italy.

[*] roberto.beghi@unimi.it phone +390250316869 fax +390250316845

Written for presentation at the
2009 CIGR Section VI International Symposium on
FOOD PROCESSING,
MONITORING TECHNOLOGY IN BIOPROCESSES
AND FOOD QUALITY MANAGEMENT
Potsdam, Germany
31 August - 02 September 2009

Abstract. *During last years, small fruits farming and marketing have increased widely in Italy in response to consumer's interest in bioactive and health protecting compounds fruits rich. At present, the ripening stage and harvest time is normally estimated by a visual analysis based on grower's experience. Farm growers could be supported in their decisions by simple and portable devices, used to directly assess the berries ripeness in the field and accordingly to plan the best harvest time.*

The aim of this work was to study the feasibility of a simplified handheld and inexpensive optical device, based on measurements and processing of diffuse reflectance at a few wavelengths appropriately selected. This study is focused on selecting the most significant wavelengths able to identify in the field the blueberries ready to be harvested. To this aim Vis/NIR spectra in the range 445-970 nm were acquired for Vaccinium corymbosum ('Brigitta' cultivar) during two different growing seasons (2005 and 2006), harvested in Valtellina area (Lombardy, Italy). Spectra measurements were taken in the field on individual berries along their equator region. Fruits samplings were performed weekly, and picked fruits were divided in four ripeness classes according to external colour. The PCA of 634 fruits spectra highlighted two principal spectral bands (around 680 nm and 740 nm) in which differences among fully (class IV) and not completely ripe (classes I-III) samples spectra are maximized. Reflectance values at these wavelengths were used to obtain spectral ratios normalised to 850 nm reflectance. Based on these relations, a simple fruits classification algorithm was proposed. Berries ripeness grading based on the proposed index showed a high ability in discriminating fully ripe fruits from partially ripe fruits and unripe fruits. More then the 93% of samples were correctly classified in validation phase.

The results of this study demonstrate the feasibility of a simplified and low-cost handheld device, based on the use of only three wavelengths, able to quickly estimate blueberry ripeness in the field, with special reference to the last and most sensitive stages of ripening process.

Keywords. Vis/NIR spectroscopy, small fruits, non destructive analysis, blueberries ripeness evaluation

Introduction

In the last years, small fruits became a very interesting vegetables, thanks to their excellence and acknowledged nutritional properties and also to their different employment in confectionery industry. Small fruits farming and marketing have increased widely due to meet the consumer expectations of healthy food (Gosh, 2003). Pigmented small fruits, such as blueberry, blackberry and raspberry, are a rich source of antioxidant compounds, particularly of flavonoids and anthocyanins. Anthocyanins are red-violet pigments that give the typical colour to these fruits.

At present, the ripening stage and harvest time is normally estimated by a visual analysis based on grower's experience. Farm growers could be supported in their decisions by simple and portable devices, used to directly assess the berries ripeness in the field and accordingly to plan the best harvest time (Guidetti, Beghi, Bodria, Spinardi, Mignani & Folini, 2008; Ozaki, McClure & Christy, 2007).

The aim of this work was to study the feasibility of a simplified handheld and inexpensive optical device, based on measurements and processing of diffuse reflectance at a few wavelengths appropriately selected. This study is focused on selecting the most significant wavelengths able to identify in the field the blueberries ready to be harvested.

Materials and Methods

Vis/NIR spectra

Blueberry samples were analysed in the Vis/NIR range (450-970 nm), using a portable device. Samples were illuminated and the reflected light was measured by a spectrometer and recorded using acquisition software. The system consisted of five elements: 1. Lightning system; 2. Fiber optic probe; 3. Portable spectrophotometer; 4. Computer for data acquisition control; 5. Battery.

Blueberry samples

A total of 634 Vis/NIR fruits spectra in the range 445-970 nm were acquired for Vaccinium corymbosum ('Brigitta' cultivar) during two different growing seasons (2005 and 2006), harvested in Valtellina area (Lombardy, Italy). Spectra measurements were taken in the field on individual berries along their equator region. Fruits samplings were performed weekly, and picked fruits were divided in four ripeness classes according to external colour: green (class I), less than 50% blue-pigmented (class II), 50% to completely blue-pigmented except stem's end (class III), and fully ripe berries (class IV).

Principal Components Analysis (PCA, The Unscrambler® 9.6) was applied to acquired spectra to find possible clustering of the berries spectra belonging to the four different classes.

Results

The PCA of 634 fruits spectra highlighted two principal spectral bands (around 680 nm and 740 nm) in which differences among fully (class IV) and not completely ripe (classes I-III) samples spectra are maximized (Fig. 1).

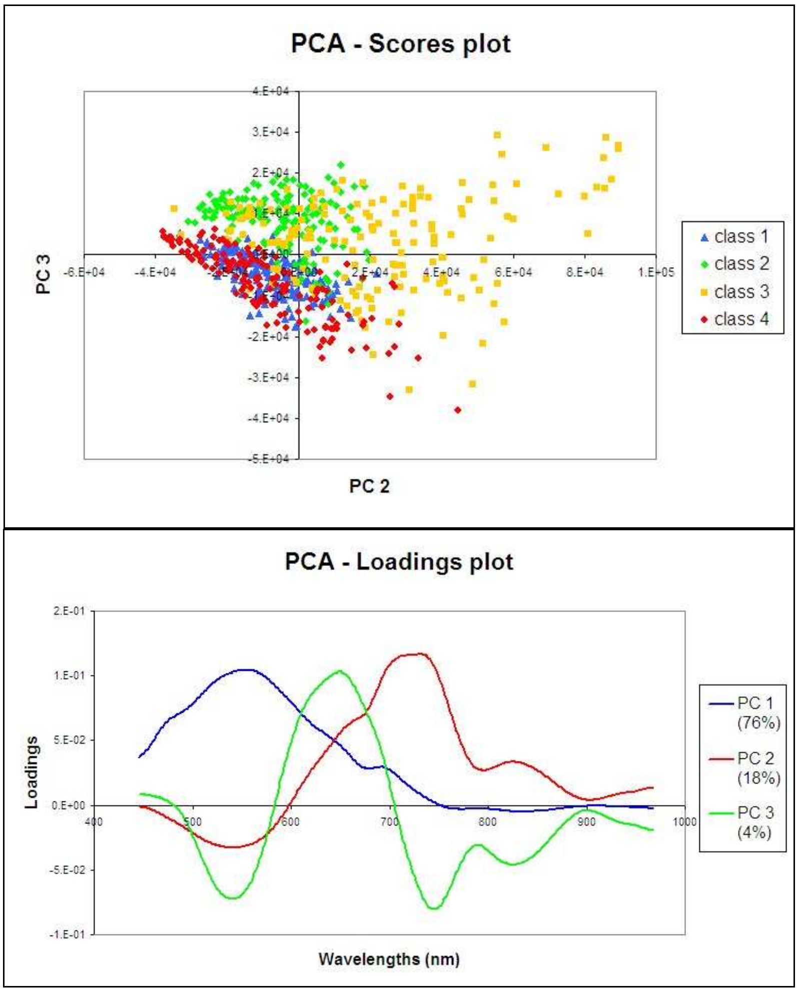

Figure 1. Scores plot (PC 2 vs PC 3) and loadings plot of PCA analysis

Reflectance values at these wavelengths were used to obtain spectral ratios normalized to 850 nm reflectance. Based on these relations, the 50% of the samples (calibration set) was used to propose a Ripeness Index (RI):

RI (Ripeness Index) = $\frac{I740}{I850} + 1{,}5 \times \frac{I680}{I850}$

Using this method, thanks to this simple fruits classification algorithm, it was possible to classify all samples with RI < 5,8 as ripe fruit and all samples with RI > 5,8 as not ripe fruits.

Then the other 50% of the samples (validation set) was used to test the algorithm on unknown samples, always using RI = 5,8 as threshold value. All normalized ratios for validation set samples were visualized on a bidimensional plot (Fig. 2). The two normalized ratios distribution in the graphic is similar to that obtained with calibration set and highlights a good ability in dividing III and IV class samples. This result could confirm with the validation samples the excellent percentage of correct classifications obtained during the calibration phase (Tab. 1).

Over 82% of the samples of the III class was properly classified as not ripe, while almost 95% of the samples of the IV class was properly classified as mature. According to RI, 100% of the samples of Class I and II were correctly classified as not ripe.

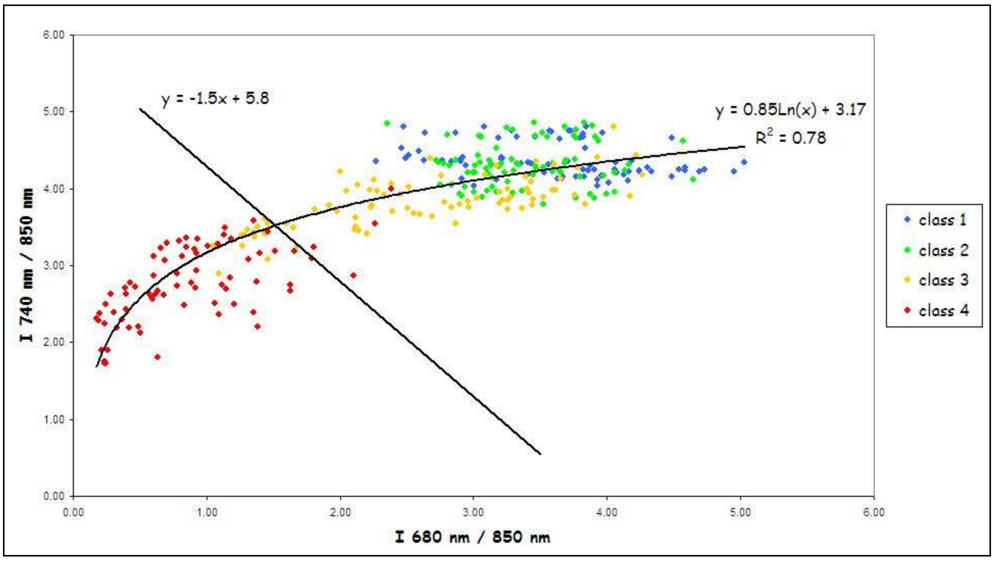

Figure 2. Bidimensional plot for the validation set for the 4 analysed classes

Table 1. Classification according to RI for validation set (classes III and IV)

	Classification according to RI		
Reference classification	Classes	Not ripe	Ripe
	III	82.5%	17.5%
	IV	5.3%	94.7%

Conclusions

Berries ripeness grading based on the proposed index showed a high ability in discriminating fully ripe fruits from partially ripe fruits and unripe fruits. More then the 94% of samples were correctly classified in validation phase. The results of this study demonstrate the feasibility of a simplified and low-cost handheld device, based on the use of only three wavelengths, able to quickly estimate blueberry ripeness in the field, with special reference to the last and most sensitive stages of ripening process.

Acknowledgements

Financial support by Regione Lombardia, Valorvì research project.

References

Guidetti R., Beghi R., Bodria L., Spinardi A., Mignani I., Folini L., 2009. Prediction of blueberry (Vaccinium corymbosum) ripeness by a portable Vis-NIR device. *Proceedings of the ISHS 9th International Vaccinium Symposium, Acta Horticulturae* **810**: 877-885.

Gosch, C. 2003. Antioxidative effects of blueberries (Vaccinium sp): an overview. *Erwerbs-Obstbau* **45**: 117-124.

Ozaki, Y., McClure, W.F., Christy, A. A. 2007. *Near-Infrared Spectroscopy in Food Science and Technology*, Wiley Interscience, Hoboken, New Jersey, USA.