Evaluation of "ready-to-eat" Lewiston cornsalad (*Valerianella locusta*) during shelf life by FT-NIR spectroscopy

G. Cabassi,[1] M. Facchetti,[2] K. Cremonesi[1] and T.M.P. Cattaneo*,[1]

1Research Centre for Fodder Crops and Dairy Production (CRA-FLC), Lodi 26900, Italy. E-mail: tiziana.cattaneo@entecra.it
2 La Linea Verde S.p.A. Manerbio, Italy

Introduction

The production of ready-to-eat leafy vegetables represents one of the most profitable and fast developing branches of the North-Italian agriculture. For this reason there is a need for the development of monitoring techniques to evaluate their ageing and nutritional quality. These techniques should also be able to discriminate among different batches of product, in order to predict their thermal age and senescence stage. Nowadays in Italy, shelf-life duration of 5 days is imposed upon processors by the large-scale retail trade, just to safeguard criteria, without considering good agricultural practice, transportation, storage conditions including refrigeration, handling and manufacturing practices. In other European Countries, such as France, shelf-life duration is 12 – 14 days. Quantitative relationships between leaf optical characteristics and plant biochemical properties, which themselves depend on many environmental and species factors, such as response to leaf aging, or environmental stresses, can be investigated empirically by means of chemometrics.[1,2]

The aim of the present work was to evaluate the effectiveness of NIR spectroscopic measurements to predict the biological age of fresh-cut Lewiston cornsalad, in order to extend shelf-life duration on the Italian market.

Materials and methods

Storage experiments lasting 13 days were set up on different batches of Lewiston cornsalad of three cultivars (*Trophy, Cambray* and *Ljublianski*). Each cultivar was grown on three different farms according to a full factorial design, as shown in Table 1.

Raw materials were harvested the day before processing (washing, drying and weighing) and packed. Packed product was stored at two different temperatures: 04°C and 08°C, the last in order

Table 1. Experimental setup.

Thesis_number	Farm	Cultivar	Notes
2221	A	Cambray	
2222	A	Trophy	
2223	A	Ljubljanski	not harvested
2235	B	Ljubljanski	
2236	B	Trophy	
2237	B	Cambray	
2244	C	Cambray	
2245	C	Ljubljanski	
2246	C	Trophy	

to simulate temperature abuse during transport and distribution. At each sampling point, 3 of the stored bags were opened in order to acquire NIR spectra.

Spectra were recorded using a NIRFlex FT-500 (BUCHI, Flavil, Switzerland), ranged from 1000 to 2500 nm, in reflectance mode (resolution = 8 cm^{-1}; 32 scans). Each spectrum was the average of three bags, for each bag 3 subsamples were scanned. Data analysis was performed using PLS Toolbox 5.2 (Eigenvector Research, Inc. Wenatchee, WA, USA).

Respiration rate was measured daily, applying the alkaline trap method. At each sampling date, 20 g of leaves for each treatment were stored in duplicate in individual sealed glass jars containing alkali traps (10 mL of NaOH 1N). The trapped CO_2 arising from biological respiration during incubation interval was quantified by back titration.

Results and discussion

Since the behaviors of cumulative respirations were strictly linear for both storage temperatures the feasibility was demonstrated for using CO_2 production in order to develop an index of the thermal age of the product. This was determined by using the cumulative respiration at 04°C, and day 10 as reference, assuming the value of 100 for the amount of CO_2 developed in this stage, and scaling all the other values accordingly. Figure 1 reports the cumulative respiration curves at 04° and 08°C.

Whereas the respiration rates were quite similar between different samples at 04°C, the amounts of CO_2 developed at 08°C showed bigger differences, mainly depending on the production farm.

The thermal age index was used as the dependent variable to develop NIR calibrations in order to predict the biological age of the product. Firstly, the scatter effects were removed from the spectra using EMSC. The mean spectrum was used as reference, and a second order polynomial equation for modeling the background. Then signals unrelated to thermal age, mainly due to water droplets remaining after washing process, were removed using orthogonal signal correction (OSC, 2 principal components, 6 iterations), as shown in Table 2.

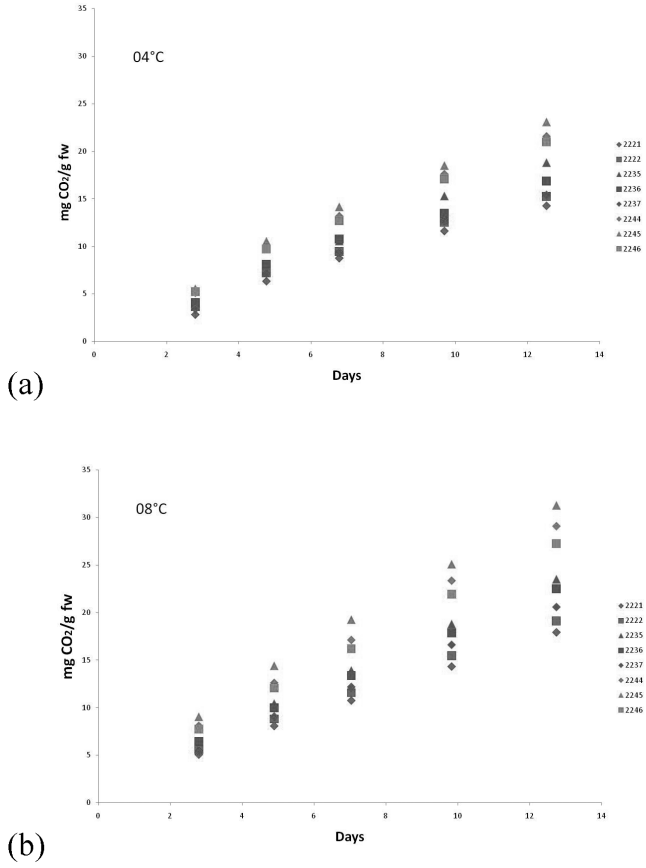

Figure 1. Cumulative respiration curves. (a) 04°C storage, (b) 08°C storage.

Robust models were then developed. No significant variations of chlorophylls, carotenoids and phenols were observed in the samples analysed, and in presence of minimal loss of mass (below 1%), these results showed that NIR spectroscopy, when applied to raw fresh materials (not

Table 2. Calibration result using three different calibration sets, *SEP* (standard error of prediction), MC mean centring.

n	Calibration set	Validation set (theses)	Preprocess	N° of factors	R^2 val.	*SEP* (days)
1	3 cultivars 3 farms	Random from farms and cultivar (2222, 2237, 2245)	EMSC, OSC, MC	4	0.982	7.94 (0.81)
2	3 cultivars, farms A and C	Farm B (2235, 2236, 2237)	EMSC, OSC, MC	9	0.890	24.8 (2.50)
3	2 cultivars, 3 farms	Cultivar Cambray (2221, 2237, 2244)	EMSC, OSC, MC	6	0.872	22.2 (2.16)

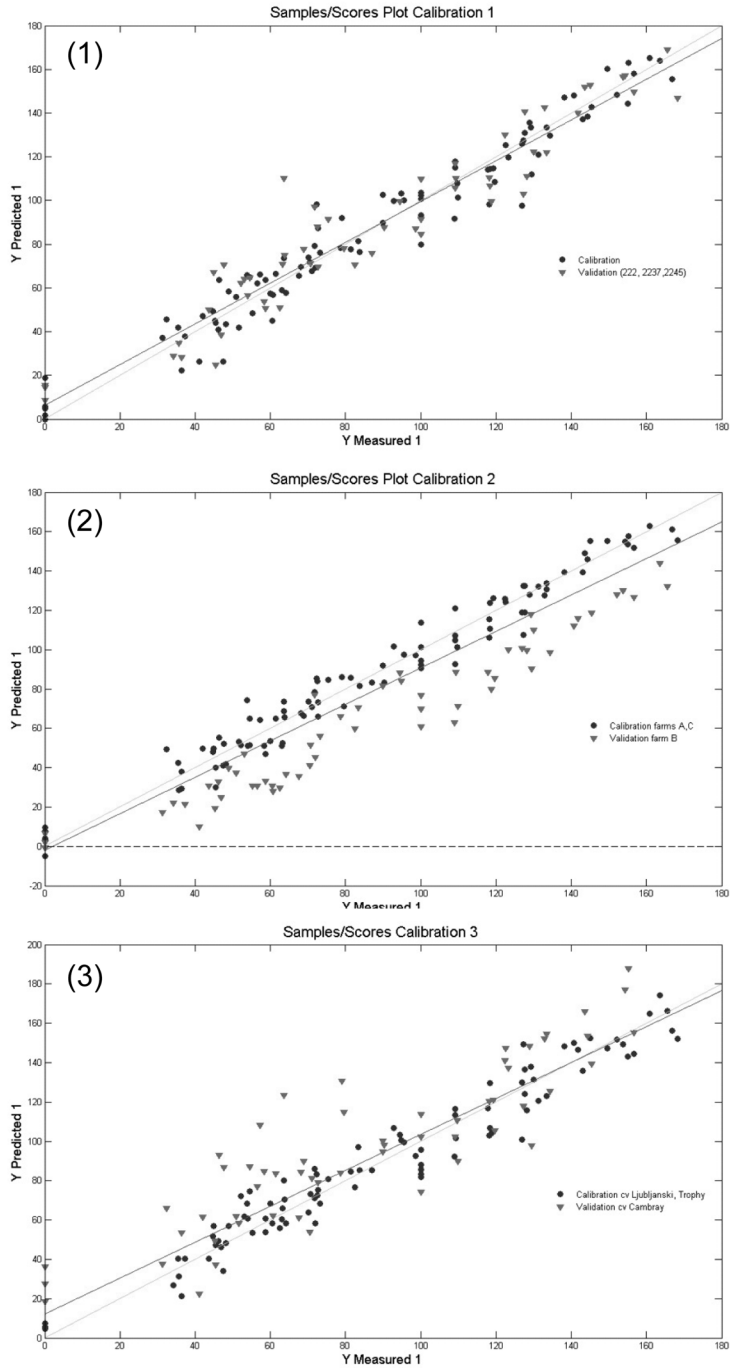

Figure 2. Scatterplots for calibration and validation set. (see Table 2 for details: n° 1, 2, 3).

ground or dried), coupled with chemometrics, could detect these minimal alterations and could be effective in predicting product ageing during storage. Better results were achieved when both the characteristics of farms and cultivars were modeled, by retaining in calibration sets all the farms and all the cultivars, as shown in Figure 2.1.

The prediction errors, estimated using different farms or cultivars for calibration and validation, were always lower than 2,5 days, as highlighted in Table 2 and Figures 2.2 and 2.3.

Conclusions

The feasibility of using the respiration data for developing an index of thermal age was demonstrated. This index can be used to calibrate NIR instruments in the temperature range from 04°C to 08°C, in order to judge whether the cold chain has been respected during product shelf-life.

Acknowledgements

This research is funded by Lombardy Region, Research Program 2007–2009, "Shelf IV" Project n. 1100 (2007–2009).

References

1. S. Jacquemoud, S.L. Ustin, J. Verdebout, G. Schmuck, G. Andreoli and B. Hosgood. *Remote Sensing of Environment* **56,** 194 (1996).
2. G.A. Cater and K. Knapp *Am. J. Bot.* **88,** 677 (2001).