01-06: Contribution of infrared spectroscopy to evaluate the variability of quality traits of the fresh and processed apples

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1 Introduction

Fruits purees quality is influenced by both apples characteristics, genetic, environmental and processing factors. The mechanism of purees processing is well-known but not the impact of the initial fruit quality on the obtained purees. A good understanding of this phenomenon is then crucial.

The most used analytical methods to determine the quality characteristics are based on the determination of soluble solids content (SSC), titratable acidity (TA), dry matter, individual sugars and organic acids and insoluble solids content (ISC). NIRS (800-2500 nm) and MIRS (4000-700 cm^{-1}) have not been applied for evaluating the link between the fresh fruits and their corresponding purees after grinding and cooking. The objective of this work is to use both the classical biochemical measurements listed above, and the spectral NIRS and MIRS ones to estimate the impact of fruit quality variability on the purees characteristics. To do that, apples were harvested over two seasons. Some factors were modulated: genetics with two varieties, agricultural practices with two levels of fruit thinning and water stress, postharvest with different time of a cold storage, and processing conditions with three levels of puree refining after cooking.

2 Material and methods

2.1 Description of the apple materials

In 2016, Golden Smoothee apples were from Gotheron an experimental INRA orchard (Drôme, France) and were harvested at maturity. In 2017, Golden Delicious apples were from La Pugère, an experimental orchard (Bouches du Rhône, France) and were harvested at 6 stages during growth and ripening and at maturity. In 2017, two agricultural practices were compared: fruit thinning (thinning with 50% of fruits removed named C- or non-thinning named C+) and irrigation (stress with 50% of water named S+ and non-stress with 100% of water named S-).

Apples harvested at maturity were stored at 4°C during 1, 3, 6 months in 2016, and until 9 months in 2017. At harvest and after each storage period, apples were processed to obtain purees. Apples were cooked at 95°C for 5 min and were then refined using three levels of refining, non-refined (NR), refined R1 at 0.5 mm and refined R2 at 1 mm. Apples and purees were characterized by infrared spectroscopy and reference measurements.

2.2 Reference measurements and Infrared spectroscopy

For fresh fruits, apples were cut, frozen in liquid nitrogen, and ground to obtain a homogenate for MIRS and biochemical measurements such as SSC, TA, dry matter and ISC and so on. Furthermore, the size and shape of fresh apple cells and puree particles were measured by colouring the cell wall and taking macroscopic images which were treated with an automated script in ImageJ software.

Infrared spectra were recorded using NIRs on two opposite sides of intact fruits as described by Bureau et al. (2009a) and using MIRS on fresh apple homogenates and purees as described by Bureau et al. (2009b).

2.3 Data pre-processing and processing

For spectral pre-processing and data treatment, PLS (Partial Least Squares), PCA (Principal Component Analysis) and FDA (Factorial discriminant analysis) were performed with Matlab 7.5 software using the "SAISIR" package developed by Bertrand (2007). The MIR data were transformed with standard normal variate (SNV) to correct multiplicative interferences and variations in baseline shift. For model development two-thirds of data were used for calibration and a third for validation. The performance of the models was evaluated by the determination coefficient (R^2), the error of prediction and the RPD (Residual Predictive Deviation), defined as the ratio of the standard deviation of the response variable to the RMSECV (Root Mean Square Error of Cross-Validation).

3 Results and discussion

3.1 Apple quality change during growth and maturation

On the one hand, ISC decreased during the maturation, on the other hand thinned apples (C-) had more ISC than non-thinned ones (C+). Moreover, the effect of fruit thinning on the fruit structure was stronger than the irrigation one. This discrimination of maturation stages of Golden Delicious apples is also highlighted with NIRS on intact apples.

In accordance with the biochemical measurements, MIRS performed on the fresh apple homogenates allowed to discriminate not only the ripening stages but also the apples from the thinning (C-) and non-thinning (C+) practices.

3.2 Effect of cold storage on apple and impact on the corresponding purees

MIRS performed on purees highlighted a clear change of puree composition and structure with increasing storage time. Whereas the clear separation of the three levels of refining (0.5 mm, 1mm and not refined) at the beginning of storage, the separation was gradually reduced with the time of storage to reach an overlapping of all samples at the end of storage after 9 months. By considering the macroscopic images of the same samples, at the beginning of storage, purees were composed of large particles and a few separated cells and the refining levels mainly lead to a clear variation of the particle sizes. However, after 9 months of storage, the purees were mainly composed of individual cells and were thus not different according to the refining levels.

3.3 Relationships between quality traits of apples and processed purees

Partial least squares (PLS) regressions were performed to evaluate the predictive ability of the internal quality parameters of apples during growth and ripening of apples and processed purees after different storage periods. During growth and maturation, a good prediction of SSC, TA and AIS was obtained in NIRS on intact fruits (R^2 respectively of 0.95, 0.8 and 0.9) and in MIRS on homogenates (R^2 respectively of 0.98, 0.98 and 0.93). Similar results were obtained during storage.

4 Conclusion

NIRS and MIRS appeared to be very interesting and convenient tools to pilot the fruit management in orchards and during postharvest storage as well as in processing.

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