Prediction of potato sensory properties by near infrared spectroscopy

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Introduction

Nowadays, the potato market is segmented and it differentiates the qualities searched for according to the type of use of the tubers.[1] In these circumstances quality has become a strategic variable for producers, packers or transformers in order to get new markets.[2] For this reason, the quality level of a potato type must be identified quickly.

At present, the culinary and technological potato quality is determined by sensorial analyses (flouriness, colour after frying, sensitivity to the bruises due to shocks). Although this type of analysis can give objective and repeatable results when it is carried out by a trained panel with several people,[3] subjectivity can be a problem when tests are made by one expert, as often happens in industry when the types are controlled. Moreover, sensory analysis is expensive and demands tedious sample preparation as well as a rather long wait for an answer.

Developing a global analytical system which could replace the current sensorial analyses and physical analyses would be a major asset to master quality. Therefore, near infrared (NIR) spectroscopy has a lot of advantages. Actually, this fast way of analysing enables the prediction of concentrations of several constituents simultaneously. The determination of potato constituents have already been discussed by several authors.[4–6] This survey intends to show that NIR can also predict culinary properties.

Material and methods

Selection of the samples

We worked on two sample sets. The first is composed of 20 potato varieties (*Solanum tuberosum L.*) grown in 1997 in 11 field trials and contains a total number of 88 samples. The second sample set includes only six varieties, harvested in 1998 on eight field trials. To include variations, some varieties were grown with different nitrogen supplies (0, 75, 150, 225 and 300 units ha^{-1}) and in irrigated and non-irrigated situations (planned irrigation based on the water balance of the crop). This second sample set contains a total number of 87 samples. Some varieties of the two sample sets are suitable for the fresh market while others are used in the processing industry.

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Sensorial analyses

Ten tubers for each sample are peeled and steamed for one hour. After that, a panel of eight trained assessors quote six descriptors on 11 point interval scales: disintegration, flesh colour, moisture, flouriness, granulation and taste intensity. French-fries have also been tested for browning after frying according to the protocol described by the Veereniging ter Behartiging van den Nederlandschen Aardappelhandel (VBNA) by using the USDA (United States Department of Agriculture) reference card.

NIR measurements and calibrations

Twenty tubers from each sample are washed, peeled and minced in a grinder (Hobart 8181 D) for 30 seconds. The spectra are collected by measuring the diffuse reflection of the ground sample in the vis-IR area between 400 and 2500 nm. The spectrometer used is a NIRSystems 6500 (NIRSystems Inc., Silver Spring, MD, USA). Sixteen spectra are taken at different places of the measured mobile cell and three cells are analysed for each sample.

The average spectra of the three repetitions are linked to the sensory results so that calibration models can be made. The relationships between spectral and sensory properties are calculated using a modified partial least squares (MPLS) method with the ISI 3 ver. 4.0 software (Infrasoft International, Port Matilda, PA, USA).

Statistical evaluation of the results

The different assessors of the panel were not always able to take part in all sensory analysis sessions. For this reason, we used the "lsmeans" routine of the SAS software, to adjust the sample means according to the marginal means.

To assess the prediction performance of NIR models, the main statistics were the determination coefficient of calibration (R^2C), the determination coefficient of cross-validation (R^2CV), the standard error of calibration (*SEC*), the standard error of cross-validation (*SECV*) and the standard error of the reference method (*SEL*).

Results and discussion

Sensory data

Generally, potato varieties are classified depending on their type of end-use. Therefore, it is of interest to wonder if the variety is not enough to evaluate tuber quality. We performed on three firm flesh varieties (Charlotte, Nicola, Francine) and three varieties used for frying processing (Bintje, Asterix, Agria), harvested in 1998, a principal component analysis (PCA) with sensory data (Figure 1). We observed that firm flesh varieties have, in general, a higher *frying index* and lower *disintegration*, *granulation*, *flouriness* and *moisture* quotations than varieties used for french-fries processing. But we also note great overlapping between these groups, which illustrate that quality depends not only on variety but

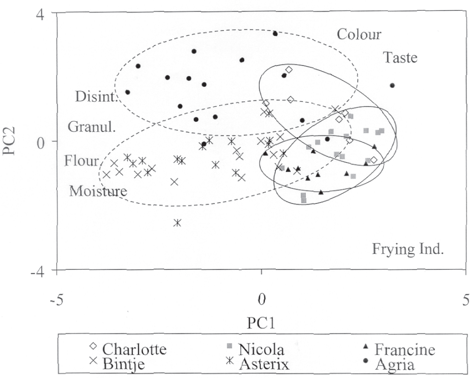

Figure 1. Sensory variations in axes 1 and 2 of the principal component analysis. —: firm flesh varieties; - - -: french-fries processing varieties.

also on external phenomena like crop management, soil type, storage, etc. For this reason, it is necessary to develop rapid methods to assess potato quality.

NIR calibrations

As we performed a PCA on spectra, we noted that samples harvested in 1997 were spectrally different from those harvested in 1998 (Figure 2). This difference can be explained by the fact that the first sample set is composed of 20 potato varieties whereas the second includes only six of them. Furthermore, many samples of '98 had been cultivated in irrigated situations and with different nitrogen supplies. Finally, differences are due to external factors like climatic conditions or field type. Each sample set includes some variations which are not represented in the other one. For this reason, it is preferable to elaborate NIR prediction models with all the samples ('97 and '98) to include the maximum of variation in the calibration set.

The NIR prediction performances of potato sensory properties are displayed in Table 1. We observe a strong correlation between sensorial values and NIR predictions for tuber *flesh colour* and *frying index* (Figure 3). Predicting texture descriptors is less precise but is rather good. Indeed, their *SECV* values are close to their *SEL* (standard error of the reference method or repeatability). *Taste intensity* does not present a good prediction model. This descriptor depends on several phenomena, like variety, crop management, sweetening during storage, etc. The chemical components responsible for this parameter could be at very low concentration and make any relation with the NIR spectra difficult.

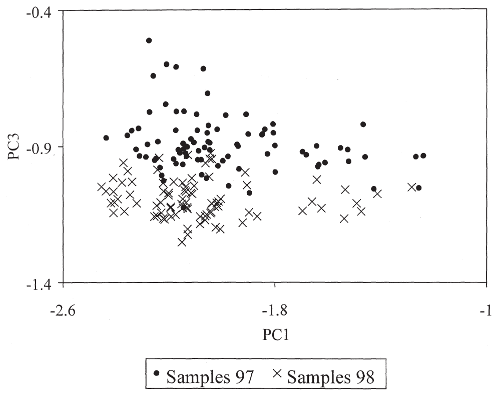

Figure 2. Spectral difference between samples harvested in 1997 and in 1998, expressed in axes 1 and 3 of the principal components analysis.

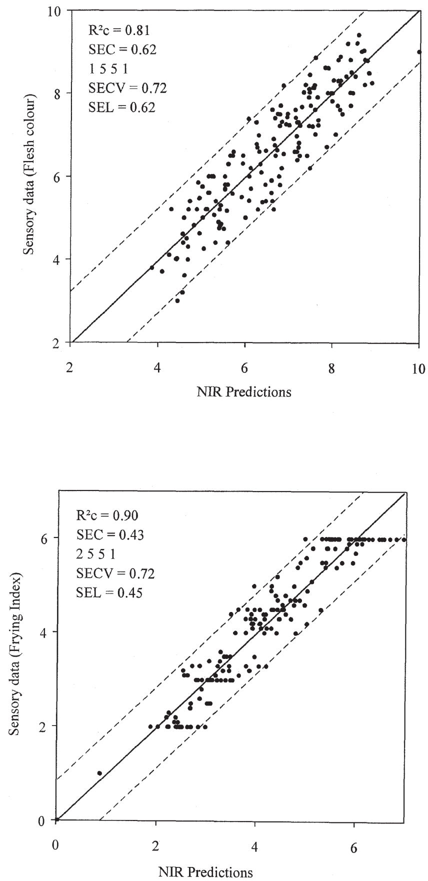

Figure 3. Regression between sensory measurements and NIR predicted values for (1) tuber flesh colour and (2) frying index.

Table 1. Performances of NIRS predictions.

Criteria	*n*	Mean	Range	SEC	*R²C*	SECV	*R²CV*	*SEL*	PLST
Desint.	153	2.49	0.0 – 7.7	0.69	0.75	0.80	0.67	0.57	9
Flesh Col.	163	6.64	2.5 – 9.4	0.62	0.81	0.72	0.74	0.68	7
Moisture	165	4.24	0.4 – 8.1	0.65	0.67	0.68	0.64	0.56	2
Flouriness	166	4.03	1.0 – 8.3	0.66	0.71	0.69	0.69	0.56	2
Granulation	163	3.99	2.1 – 8.1	0.58	0.64	0.61	0.59	0.45	3
Taste Int.	168	5.43	3.3 – 9.4	0.64	0.30	0.69	0.19	0.53	2
Frying Ind.	163	4.21	1.0 – 6.0	0.43	0.90	0.72	0.71	0.45	9

n: number of samples
SEC: standard error of calibration
R^2c: determination coefficient of calibration
SECV: standard error of cross-validation
R^2cv: determination coefficient of cross-validation
SEL: standard error of the reference method
PLST: number of PLS terms

Conclusions

As we observed previously, potato quality depends not only on variety but is also greatly influenced by external factors such as crop management. We have demonstrated how some sensorial characteristics (colour of tuber flesh, disintegration, moisture, flouriness, granulation and frying index) can be predicted by NIR. The advantages of this method are its low cost and its speed of measurement.

We note that standard errors of prediction of NIR are close to repeatability of sensory analyses and that it is very important to include the maximum of variation in the calibration sample set. So, to improve NIR predicting models, we have to increase precision of the sensorial analyses used as reference values and to enlarge the data base in order to include as many variations as possible.

References

1. E. Guyau, *La pomme de terre française* **491,** (1995).
2. E. Valceschini, *La pomme de terre française* **490,** (1995).
3. H. Nicod, in *Evaluation Sensorielle: Manuel méthodologique*, Ed by F. Depledt. Lavoisier, Paris, France, p. 46 (1998).
4. M.W. Young, D.K.L. MacKerron and H.V. Davies, *J. Near Infrared Spectrosc.* **3,** 3 (1995).
5. M.W. Young, D.K.L. MacKerron and H.V. Davies, *Potato Research* **40,** (1997).
6. R, Hartmann and H. Büning-Pfaue, *Potato Research* **41,** (1998).