Approaches to the measurement of fruit and vegetable quality parameters using near infrared spectroscopy

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Introduction

Some of the earliest work in the field of near infrared (NIR) used near-visible and visible radiation to provide information about fruit and vegetable quality. Birth and Norris[1,2] developed instrumentation to detect tomato and potato imperfections. More recently, Japanese workers have published research on applying NIR to the determination of peach quality.[3] Relatively recently, Norwegian researchers from MATFORSK examined the use of NIR transmission and reflectance spectroscopy of peas for correlation with sensory parameters and demonstrated reasonable success.[4]

Fruit and vegetable quality measurement using NIR at CCFRA

Over the last five years Campden staff have been conducting work for member companies in two particular areas: (i) Using NIR reflectance spectroscopy to measure vining pea maturity and quality parameters and (ii) the measurement of melon ripeness using a NIRSystems fibre optic interactance probe.

The measurement of pea maturity factors by NIR reflectance spectroscopy

The pea vining industry requires techniques to assess the maturity of the peas in order to be able to time the harvest to optimise the final product quality. The traditional technique is to take samples and submit them to a tenderometer test. This is essentially a shear force gauge which gives information about the sample's tenderness or toughness. There has been, and is, however, concern in the industry that this method is not sufficiently reliable and a more reliable but rapid technique is required. In consequence, a consortium of UK pea producers commissioned work at CCFRA in 1993 to examine the use of NIR to provide the maturity measurements they require.

In recent years instruments have appeared on the market that use near-visible/visible transmission geometry to obtain measurements of components in grain and meat for example. When solid irregular objects are placed in a cell and scanned in transmission it is likely that much of the radiation that reaches the detector is in fact derived from reflectance data as the light bounces from one grain or pea to another through the interstices of the sample. Furthermore, a reflectance geometry is often less problematic for instrument design and for ease of presentation by the user.

It was thus decided at the beginning of the NIR spectroscopy pea maturity Research Club at CCFRA in 1994 to at least see if the peas to be scanned could be presented in reflectance in the

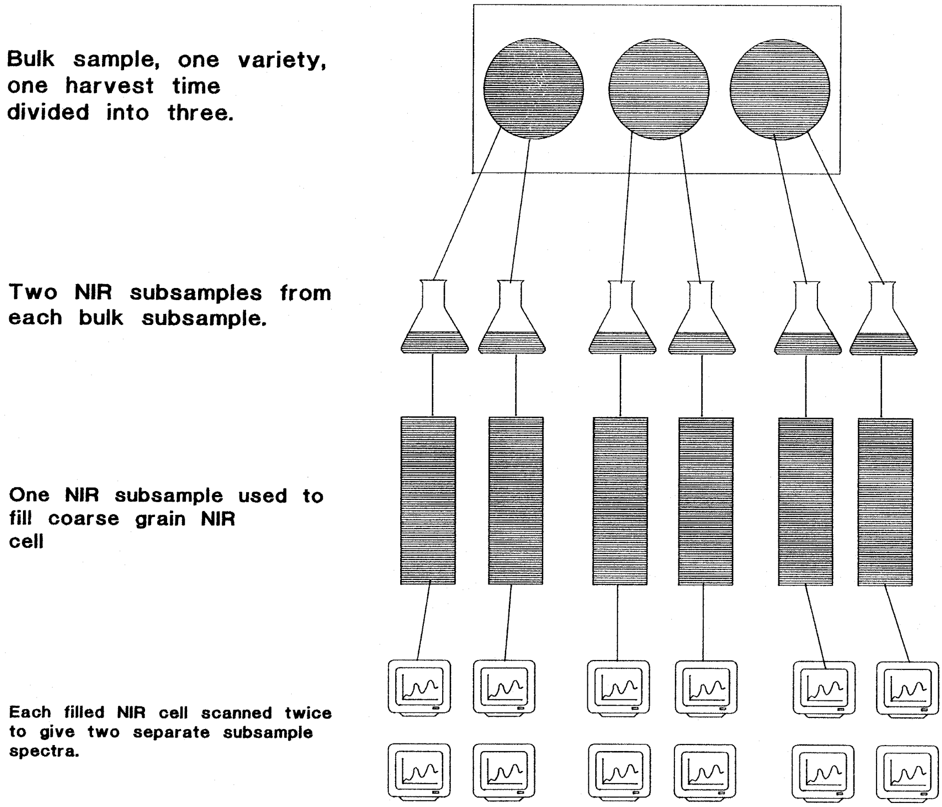

Figure 1. Division process of the bulk sample.

1100–2500 nm region in a coarse grain cell with a transport mechanism, without any preparation (e.g. maceration), and still provide good quality data.

Initial calibration experiment

Pea samples from CCFRA commercial trials were harvested, vined and washed producing a bulk 5 kg sample. The bulk sample was then divided as noted in Figure 1 and whole samples were scanned in a coarse grain cell in reflectance, at 1100–2500 nm in an NIRSystems 6250 monochromator. The only preparation step was to remove surface water with layers of tissue. Figure 2 shows examples of the reflectance spectra of the whole peas. Six varieties of peas were harvested at varying maturities, giving a total of sixteen harvest data, variety bulk samples. Tenderometer units, alcohol insoluble solids (AIS) and twelve sensory parameters were provided as calibration data. The preliminary standard mulitple linear regression (SMLR) and partial least squares (PLS) calibrations based on the fourteen variables produced eight calibrations well above a coefficient of determination of 0.9000, and although the calibration set was small, the degree of sampling replication noted in Figure 1 made this a valid preliminary experiment. It was noted that many of the sensory variables were highly intercorrelated, as was AIS with tenderometer values, so that in the SMLR calibrations the same or very similar wavelengths were used for variables that were intercorrelated to a high degree. The members of the consortium regarded the results of 1994's

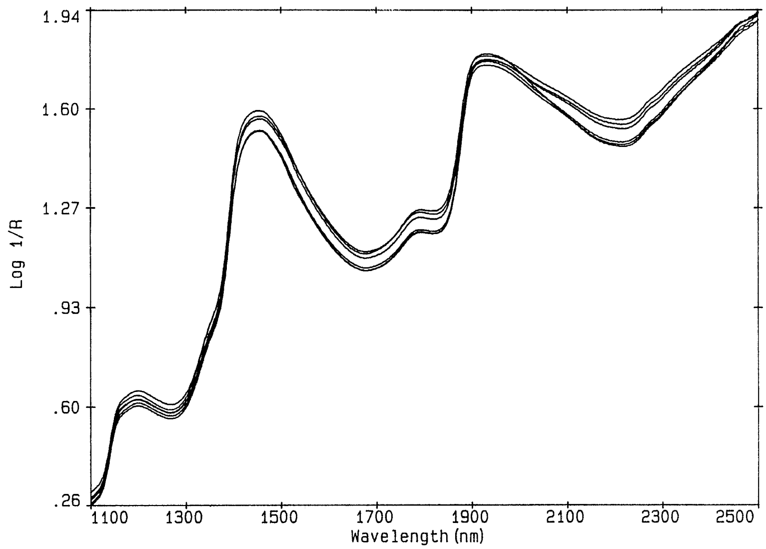

Figure 2. Reflectance spectra of whole peas.

work as sufficiently promising that they have funded a further two years work to extend the numbers of varieties and harvest dates so that full calibration and prediction experiments can be performed.

A further development in this work is that in February 1995 the European Commission funded a three year shared cost project under the Copernicus joint research programme, to research the use of NIR for the measurement of vegetable maturity parameters. The project group led by CCFRA includes a Hungarian Food Research Institute, a Hungarian freezing company, The Bulgarian Canning Research Institute and the Optoelectronics Laboratory of VTT at Oulu in Finland.

The two examples in the project are peas and sweet-corn. The pea harvest has been completed in the UK, Hungary and Bulgaria and samples will be frozen, transported and thawed for NIR analysis. The Research consortium in the UK and the Central and Eastern European partners in the Copernicus project have agreed to exchange information about their work.

The final objective of the EC project is to attempt to calibrate for final product quality for pea and sweetcorn samples based on spectra obtained from samples as close to the field as possible. The VTT laboratory will be assessing the feasibility of using a portable solid-state LED approach to obtaining spectra in the field.

The work outlined above indicates that the NIR approaches taken are likely to provide rapid, easily acquired spectral data which can be used to make judgements about product quality in fruit and vegetables to optimise their commercial value and quality.

NIR measurement of melon ripeness

At present there is no reliable way of determining melon ripeness without damaging the surface of the fruit. Destructively sampling a batch or obtaining juice from the inner flesh by means of syringe are current methods of assessing the fruits readiness for sale to the consumer. What is needed is a rapid on-line non-destructive technique to provide a measurement for each fruit which would reliably determine its readiness for sale. A visible/near-visible optic fibre probe offers the potential for providing such a requirement. The approach used, to attempt to fulfil the member company's requirements noted above, was to obtain spectra from 400–1100 nm via an NIRSystems model 6500 and a fibre optic attachment.

Several experiments were conducted:

(a) A block of melon tissue was scanned to obtain data on the depth of penetration of the radiation.

(b) A preliminary calibration was generated based on two melon varieties.

(c) The calibration in (b) was tested using a new set of samples.

The results of the experiments demonstrated clearly that an NIR fibre optic probe could be used to obtain measurements of melon ripeness to the required degree of accuracy, i.e. ±2.5 Brix°.

References

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