Near infrared analysis of milk-based liquid by-products used as animal feedstocks

I.J. Wesley, P.H. Brooks and A.E.J. McGill

Department of Agriculture and Food Studies, University of Plymouth, Newton Abbot, Devon TQ12 6NQ, UK.

Introduction

The by-products of foodstuffs manufactured from milk are used extensively as a base for many animal feedstocks. The exact composition of the material is dependent on the original process and varies significantly between batches from the same process and between manufacturing sites using the same process. This variability causes considerable problems when expensive food supplements are required. A rapid method for measuring quantities such as dry matter, salt content and protein content would be of considerable interest, particularly where the information can be used to supply a more consistent product. Near infrared (NIR) spectroscopy offers the possibility of measuring all of the quantities of interest in a short time.

Experimental

In the first instance, it was decided to study whey by-products. These are typical of the type of material regularly used as a feed-stock base. Initial experiments have concentrated on determining the optimum conditions for recording the NIR spectrum of this material and developing acceptable calibrations. To this end, a set of 48 samples of varying dry matter and salt content (on a wt/wt basis) were made using Lactalbumin Ultra Filtrated Whey Powder Concentrate, sodium chloride and distilled water. Spectra were recorded in both reflection and transmission mode using a NIRSystems 6500 extended range spectrometer fitted with a sample transport accessory. In reflection mode, samples were placed in a 4 mm quartz cuvette. Three spectra with an RMS difference of less than 5000 were averaged to give a single spectrum of each sample. In transmission mode, a 0.5 mm quartz cuvette was used and one spectrum of each sample recorded.

Results

The spectra were analyzed using ISI3 Near Infrared Software. All 48 samples were used to develop the calibration and the performance of the calibration was assessed by the cross-validation method. A first derivative function was applied to the spectra using an 8 point gap and an 8 point smoothing function. SNV and Detrend scatter correction was used and the calibration was developed using data points at 10 nm intervals over the spectral range 1100–2400 nm. 15 cross-validations were used and outliers were downweighted. This analysis proved to give the best results for both the reflection and the transmission data. Best results were obtained from the transmission spectra which gave rise to a one term equation for whey content and a seven term equation for salt content. A sample of whey by-product was obtained from a supplier and used as a basis for an independent set of samples. A set of samples was made by dilution with distilled

Table 1. Statistics for prediction of whey and salt content.

	Artificial samples		Real samples[a]		All samples	
	Whey	Salt	Whey	Salt	Whey	Salt
Number of spectra	44	48	14	14	53	57
Mean of lab values	3.68	0.22	3.12	0.09	3.55	0.19
Standard deviation of lab values	1.59	0.12	1.20	0.03	1.51	0.12
Variance explained by model (R^2)	0.99	0.99	0.99	0.33	1.00	0.99
Slope of line of best fit	1.00	1.01	0.86	0.36	1.01	0.99
Standard error of cross-validation	0.12	0.01	0.40[b]	0.25[b]	0.10	0.01

[a]Predicted using artificial equation.
[b]Equal to standard error of prediction.

water and their NIR transmission spectra recorded as before. The dry matter of each sample was calculated from the weight loss due to drying in an oven thermostatted at 65°C and the salt content was measured using the Volhard method. The whey and salt content of these samples were predicted using the artificial equation and compared to the actual value. Finally, the two sets of spectra were combined and new equations calculated. The statistics for the three experiments are given in Table 1. The cross-validation results for the combined data set are illustrated in Figures 1 and 2.

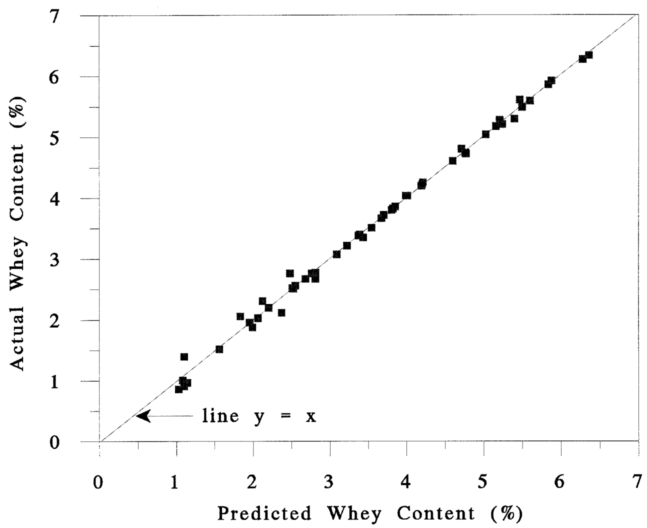

Figure 1. Cross-validation results for the prediction of whey content.

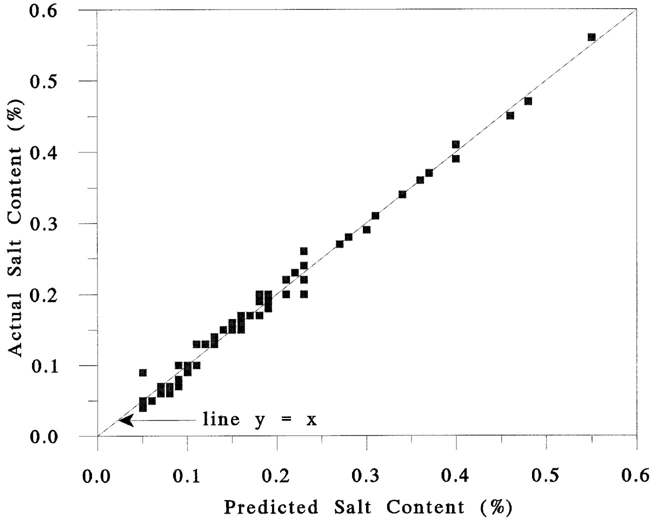

Figure 2. Cross-validation results for the prediction of salt content.

Conclusions

The results suggest that the characterisation of whey by-products is possible using NIR spectroscopy. Further, it appears that on the basis of these experiments alone, it may be possible to develop calibrations without the need for extensive sampling of real product, but rather that it may be possible to use artificial samples as a basis for the calibration set. This could have important consequences for the subsequent development of this particular application. In general, whey by-product and similar materials are not stable, degrading rapidly over a few days due to microbiological activity. As a consequence, it can be difficult to obtain samples which are in a similar condition to those produced at the factory or used at the farm. Further work will concentrate on developing NIR methods for monitoring the degradation of these products.

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