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BRIEF COMMUNICATION

Analysis of milk constituents by near infrared and visible light

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Herd testing, in which individual cow's production performance is measured, is infrequently carried out in New Zealand with at least a month between tests. A composite sample is collected from each cow and is analysed for fat, protein, and somatic cell count (SCC). The process is time consuming, and provides only a snapshot of these components. To create a more frequent, automated, on-farm system, sensors need to be developed that measure fat, protein, SCC, and other milk components inexpensively and easily. One potential measurement method which could be used in these devices is visible to near infrared (NIR) spectroscopy.

The industry currently uses a range of sophisticated machines (Fossomatic, Foss, Hedehusene Denmark) for the determination of milk constituents. These machines homogenise milk and use infrared (IR) spectroscopy in the wavelength range 3500-9600 nm to determine fat, protein, and lactose concentrations. SCC is determined by an integrated flow cytometer. The NIR region (1000-2500 nm) has also been successfully used to determine constituents of milk and milk products (Rudzik & Wüst, 1998). Any inexpensive, on-line sensor based on NIR spectroscopy should function without the requirement for homogenisation and use low-cost silicon photodetectors, which are sensitive from 400-1100 nm.

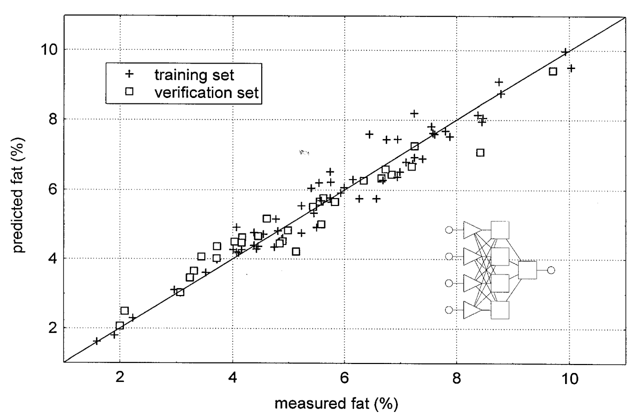
Tsenkova *et al.* (1992) successfully employed the 680-1235 nm wavelength range to predict constituents in unhomogenised milk using a partial least squares (PLS) model for each individual cow. They found, when all the data was combined in an overall model, the accuracy decreased relative to the model for individual cows. Chen *et al.* (1999) successfully investigated unhomogenised milk from eight different cows using the 400-1000 nm range and PLS regression.

We have explored the potential of low-cost equipment based on visible to NIR spectroscopy to predict relevant milk constituents. Ten cows were milked morning and night for five consecutive days. A composite milk sample was collected. One portion was pumped through a flow cell that had 3 mm sample thickness and was illuminated with light from an incandescent lamp (AS220-F, CVI Spectral Instruments, Putnam, CT, USA) via a 500 mm fibre optic cable. The transmitted light was collected using a visible to near infrared miniature spectrometer (MMS-1, Zeiss, Oberkochen, Germany), which had a spectral resolution of 256 pixels over 350-1150 nm wavelength range and a bandwidth of ~10 nm. The second portion of the sample was analysed for fat, protein, and lactose by IR analysis at Dairying Research Corporation's Milk Analysis Laboratory and for SCC by a flow cytometer at Livestock Improvement Corporation's Herd Testing Laboratory. Ninety-one spectra and reference data were available for analysis.

Calibration models were generated using PLS regression as well as neural network analysis provided by a statistical software package. The data set was split randomly into 61 samples for calibration and 30 samples for verification. No significant correlation between predicted and measured values was found for SCC, and only a minor trend was observed for lactose. However, promising results were obtained for predicting protein and fat content.

To improve the predictions, the wavelength range 664-954 nm was used in the PLS analysis for fat. High correlations for calibration (R^2=0.98) and for verification (R^2=0.92) were obtained between the values predicted by the model and the reference data. The neural network analysis required only four wavelengths (spectrometer pixels) as inputs to a three-layer multilayer perceptron (MLP). Both the calibration set and the verification set gave correlation coefficients of R^2=0.95 and a root mean square error (RMSE) of 0.41 % and 0.45 %, respectively. Figure 1 illustrates the correlation between the measured and predicted values for fat obtained with a three-layer MLP neural network.

FIGURE 1: Fat prediction by MLP network.



The PLS regression for protein produced correlations of R^2=0.80 over the data range 3.0-4.3 %. Again, the three-layer MLP network only required four wavelengths as inputs. R^2 values of 0.83 for the calibration set and 0.78 for the verification set were achieved with an RMSE of 0.14 % and 0.17 %, respectively.

It can be concluded that regression models based on NIR spectra of raw unhomogenised milk can be developed for a herd and can be used to predict fat and protein concentration of milk from individual cows. With further improvement in the technique, it might be possible to predict lactose concentration. However, SCC showed no correlation, which would indicate that this is not a suitable measurement method.

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