

Application Note AN-NIR-144

Whey permeate analysis with NIRS

Monitor dairy production processes easily in seconds

Whey permeate, a byproduct of manufacturing whey protein powder, contains high amounts of lactose, phosphate, and minerals. Because of its sweet and mild taste, whey permeate is often used in bakeries and chocolate manufacturing.

The key to optimizing whey permeate production is to control production streams in real time. It is important to monitor the production process with high-throughput analytical techniques to maximize product yield and ensure high product quality. Near-infrared spectroscopy (NIRS) is a fast, and chemical-free analysis technique that can support this kind of testing. NIR spectroscopy can measure the most important quality parameters (i.e., protein, lactose, moisture, ash, pH, and phosphate) simultaneously in whey permeate without any sample preparation. The NIRS solution is fast, easy to operate, and can be used atline or offline in a quality control lab.

EXPERIMENTAL EQUIPMENT

158 whey permeate samples were analyzed on a Metrohm NIR Analyzer equipped with a small cup accessory. All measurements were performed in reflection mode (1000–2250 nm). Metrohm software was used for data acquisition and prediction model development.

RESULT

The obtained NIR spectra (Figure 1) were used to create prediction models for the parameters of lactose, moisture, pH, ash, phosphate, and protein content. Spectral data was preprocessed, and wavelength selection was used to improve the accuracy of the models. All models were validated using an independent validation set with a sample size of 25%. The quantification models show a high correlation with the laboratory data of > 0.80 (R2P), except lactose with a value of 0.70 (R2P).

Correlation diagrams, together with the respective figures of merit (FOM), are displayed in Figures 2–7 which display the expected precision for routine analysis.

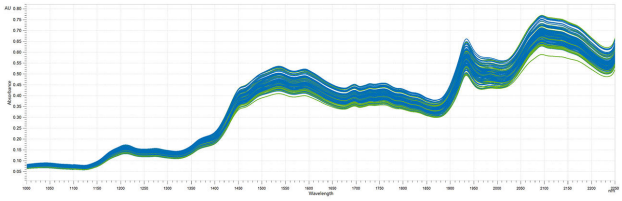


Figure 1. Selection of NIR spectra of whey permeate samples. Blue represents calibration samples, while green represents validation set samples. Data was obtained with a Metrohm NIR Analyzer.

Result protein content

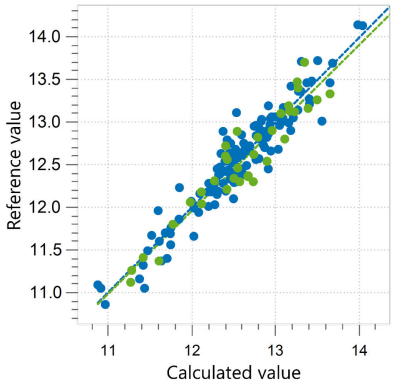


Figure 2. Correlation diagram and the respective figures of merit for the prediction of protein content in whey permeate using a Metrohm NIR Analyzer. The calibration dataset is shown in blue, and the external validation dataset is in green.

R^2	SEC (%)	SECV (%)	SEP (%)
0.899	0.18	0.19	0.21

Result lactose content

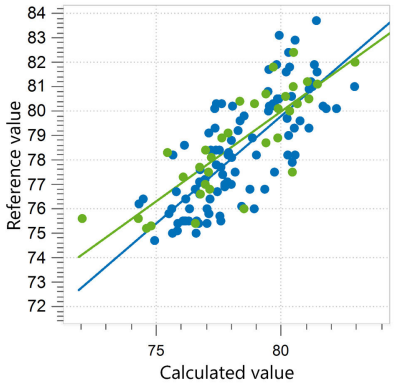


Figure 3. Correlation diagram and the respective figures of merit for the prediction of lactose content in whey permeate using a Metrohm NIR Analyzer. The calibration dataset is shown in blue, and the external validation dataset is in green.

R^2	SEC (%)	SECV (%)	SEP (%)
0.689	1.22	1.44	1.41

Result moisture content

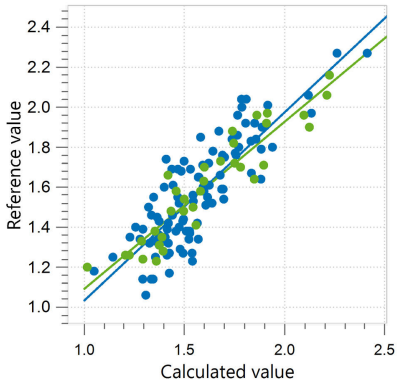


Figure 4 Correlation diagram and the respective figures of merit for the prediction of moisture content in whey permeate using a Metrohm NIR Analyzer. The calibration dataset is shown in blue, and the external validation dataset is in green.

R^2	SEC (%)	SECV (%)	SEP (%)
0.864	0.13	0.14	0.11

Result ash content

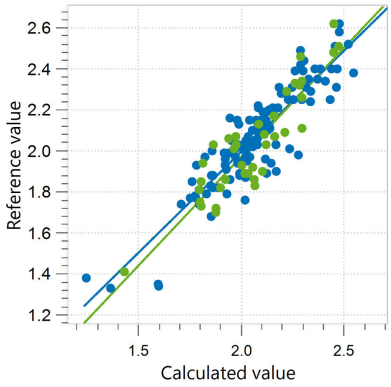


Figure 5. Correlation diagram and the respective figures of merit for the prediction of ash content in whey permeate using a Metrohm NIR Analyzer. The calibration dataset is shown in blue, and the external validation dataset is in green.

R^2	SEC (%)	SECV (%)	SEP (%)
0.813	0.09	0.10	0.11

Result phosphate content

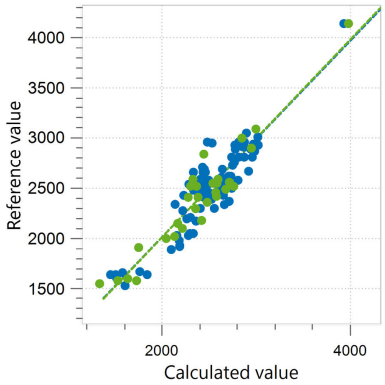


Figure 6. Correlation diagram and the respective figures of merit for the prediction of phosphate content in whey permeate using a Metrohm NIR Analyzer. The calibration dataset is shown in blue, and the external validation dataset is in green.

R^2	SEC (ppm)	SECV (ppm)	SEP (ppm)
0.909	158	171	156

Result pH value

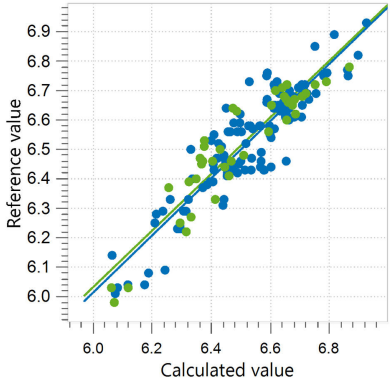


Figure 7. Correlation diagram and the respective figures of merit for the prediction of pH value in whey permeate using a Metrohm NIR Analyzer. The calibration dataset is shown in blue, and the external validation dataset is in green.

R^2	SEC	SECV	SEP
0.862	0.07	0.08	0.08

CONCLUSION

This Application Note demonstrates the feasibility of using NIR spectroscopy for whey permeate quality control. Near infrared-spectroscopy is a rapid, nondestructive analytical technique that can monitor the production process of dairy products. Aside from the analysis of whey permeate, the whey protein production stream can also be monitored by NIRS.

Table 1. Overview of ISO norms for the different parameters used for determining the reference values of the whey permeate samples.

Parameter	Method
Lactose	ISO 22662:2024 Milk and milk products – Determination of lactose content by high-performance liquid chromatography
Protein	ISO 8968-1:2014 Milk and milk products — Determination of nitrogen content Kjeldahl method
Moisture	ISO 5537:2023 Dried milk and dried milk products — Determination of moisture content with loss on drying
Ash	ISO/DIS 9877 Milk and milk products — Determination of ash content by incineration

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