Application Note AN-NIR-132

Almond analysis with near-infrared (NIR) spectroscopy

Multiparameter determination of moisture, fat, and protein

Almonds are nutritious edible nuts from the almond tree and can be eaten whole or processed in other foods. During processing, quality control (QC) parameters like moisture levels are checked to ensure that the correct percentage is reached before moving on to other stages (e.g., grinding or packaging). When determining almond quality, destructive analytical techniques are helpful but can involve extensive sample preparation and solvent extractions. These traditional techniques are also slow and expensive. Nondestructive near-infrared spectroscopy (NIRS) is a great alternative because it is fast, simple, and cost effective [1]. In this study, almond moisture content (water content), protein content, and fat have been measured using NIRS. NIR spectroscopy offers the **rapid and reliable prediction** of several quality parameters in seconds without any sample preparation

EXPERIMENTAL EQUIPMENT

60 samples of ground almonds and 60 samples of whole almonds were measured on a Metrohm NIR Analyzer. All measurements were performed in reflection mode (1000–2250 nm) using the large cup accessory. The samples were measured in rotation to collect spectral data from diverse areas. Spectral averaging of signals from several spots helped to reduce sample inhomogeneity. Metrohm software was used for all data acquisition and prediction model development.

RESULT

The obtained NIR spectra of whole almonds (Figure 1) and ground almonds (Figure 2) were used to create prediction models for the quantification of protein, fat, and moisture content. The quality of the prediction models was evaluated using correlation diagrams (Figures 3–8) which display a very high correlation between the NIR prediction and the reference values. The respective figures of merit (FOM) display the expected precision of a prediction during routine analysis.

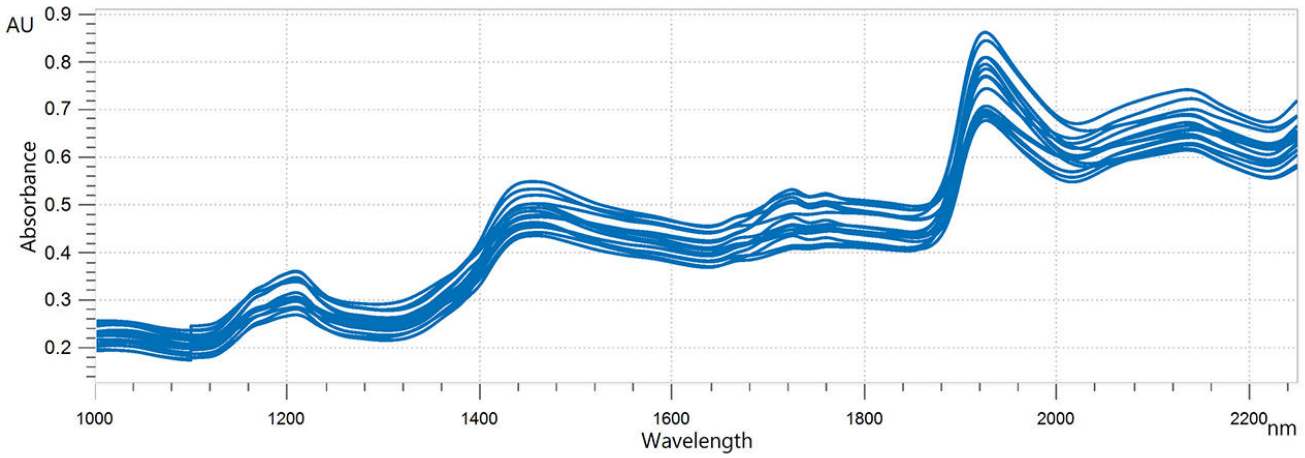

Figure 1. Overlaid NIR spectra of whole almonds analyzed on a Metrohm NIR Analyzer.

RESULT

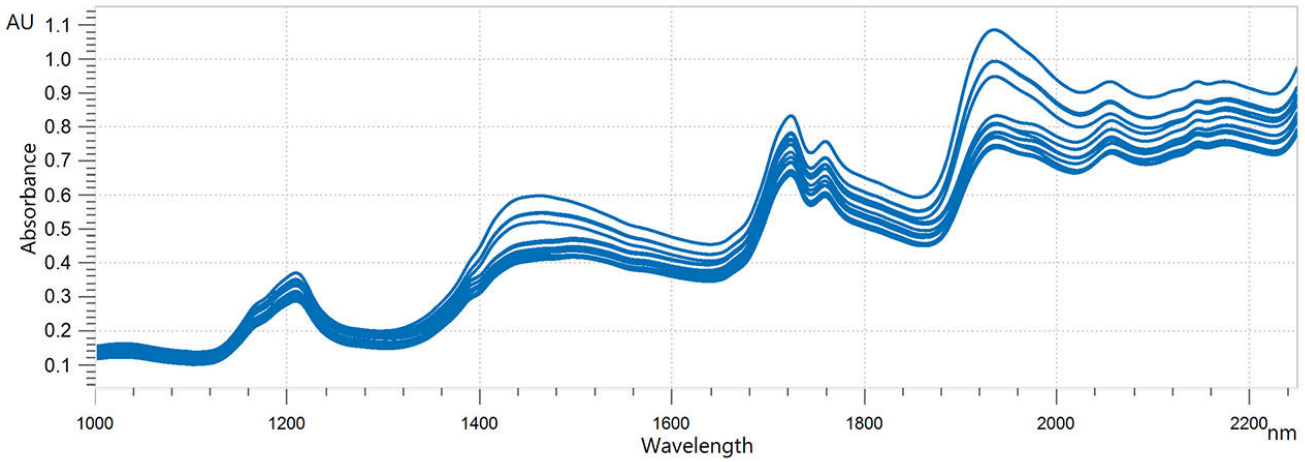

Figure 2. Overlaid NIR spectra of ground almonds analyzed on a Metrohm NIR Analyzer.

Result protein content in whole almonds

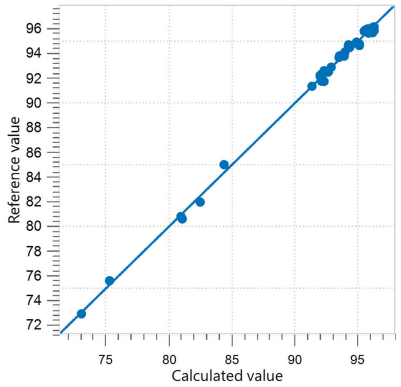

Figure 3. Correlation diagram and the respective figures of merit for the prediction of protein content in whole almonds.

R^2	SEC (%)	SECV (%)
0.997	0.23	0.28

Result moisture content in whole almonds

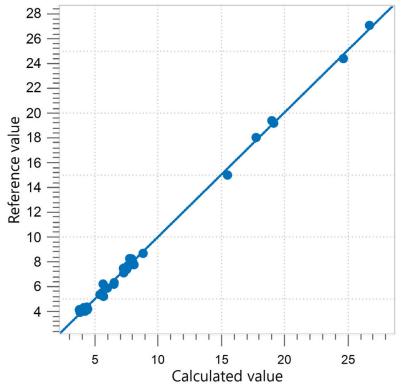

Figure 4. Correlation diagram and the respective figures of merit for the prediction of moisture content in whole almonds.

R^2	SEC (%)	SECV (%)
0.998	0.22	0.25

RESULT

Result fat content in whole almonds

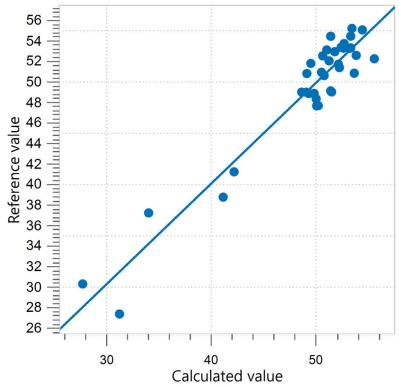

Figure 5. Correlation diagram and the respective figures of merit for the prediction of fat content in whole almonds.

R^2	SEC (%)	SECV (%)
0.917	1.56	1.84

RESULT

Result protein content in ground almonds

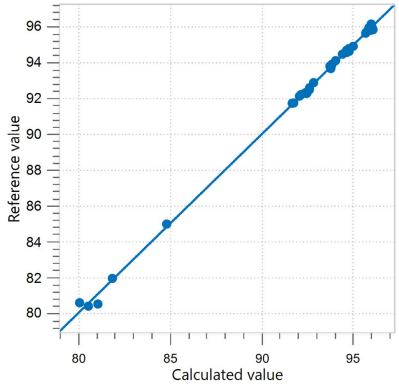

Figure 6. Correlation diagram and the respective figures of merit for the prediction of protein content in ground almonds.

R^2	SEC (%)	SECV (%)
0.999	0.10	0.14

Result moisture content in ground almonds

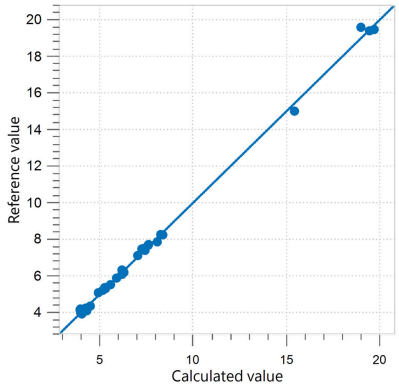

Figure 7. Correlation diagram and the respective figures of merit for the prediction of moisture content in ground almonds.

R^2	SEC (%)	SECV (%)
0.999	0.09	0.15

RESULT

Result fat content in ground almonds

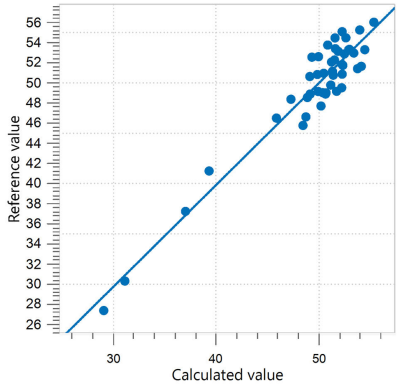

Figure 8. Correlation diagram and the respective figures of merit for the prediction of fat content in ground almonds.

R^2	SEC (%)	SECV (%)
0.914	1.62	1.67

CONCLUSION

This Application Note demonstrates that almond protein content analysis, almond fat content analysis, and almond water content (or almond moisture content) analysis can be done with NIRS. NIR spectroscopy offers users a faster, simpler, highly accurate alternative to standard analytical methods for the analysis of ground and whole almonds during processing and final product quality control (Table 1). By using NIRS, all of these parameters can be measured simultaneously without sample preparation, saving time and money.

Table 1. Overview of standard methods used for the determination of reference values in almonds.

Parameter	Norm	Method
Crude protein	AOAC 950.48	Kjeldahl digestion
Moisture	AOAC 925.40	Loss on drying
Fat	AOAC 948.22	Soxhlet extraction

REFERENCE

1. Duduzile Buthelezi, N. M.; Tesfay, S. Z.; Ncama, K.; et al. Destructive and Non-Destructive Techniques Used for Quality Evaluation of Nuts: A Review. *Scientia Horticulturae* 2019, *247*, 138–146. DOI:10.1016/j.scienta.2018.12.008

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