Application Note AN-NIR-127

Feed analysis with near-infrared spectroscopy (NIRS)

Simple, fast multiparameter determination of animal feed

Livestock production is a complex process involving many independent and integrated operations. According to the World Health Organization (WHO), the foundations for successful livestock production are the availability of animal feed and efficient feeding. Quality control (QC) of feed and feed ingredients is crucial to ensure the production of safe and nutrient-rich animal feed. Typical QC parameters measured during the production of feed are fat, moisture, protein, fiber, ash, and starch. However, analyzing these parameters is usually done with wet chemistry, requiring different time-consuming procedures, complex analysis methods, and costly chemical reagents. Near-infrared spectroscopy (NIRS) offers rapid and reliable prediction of fat, moisture, protein, fiber, ash, and starch content of different feed types in a few seconds without any sample preparation.

EXPERIMENTAL EQUIPMENT

Around 500 samples of feed (e.g., for poultry, swine, cattle, goats, and sheep) were analyzed on a Metrohm NIR Analyzer. All measurements were performed in reflection mode using the large cup. The samples were measured in rotation to collect spectral data from several areas. Spectral averaging of signals from various spots helped to reduce influences from sample inhomogeneity. Metrohm software was used for all data acquisition and prediction model development.

RESULTS

All measured NIR spectra were used to create prediction models for quantification of the key quality parameters for feed.

In addition, prediction models for moisture, starch, fiber, protein, fat, and ash were created for individual feeds, e.g., cattle feed, poultry feed, and pig feed.

The quality of the prediction models was evaluated using correlation diagrams (Figures 2–7) 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 of NIR feed testing (Table 1 poultry feed, Table 2 swine feed, and Table 3 cattle feed).

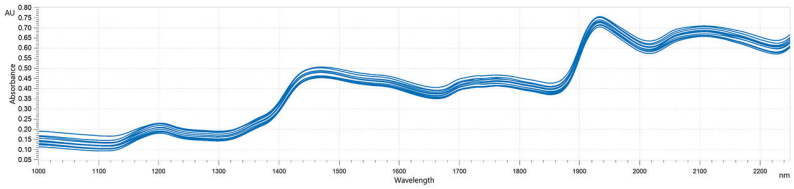

Figure 1. NIR spectra of different livestock feed samples analyzed on a Metrohm NIR Analyzer.

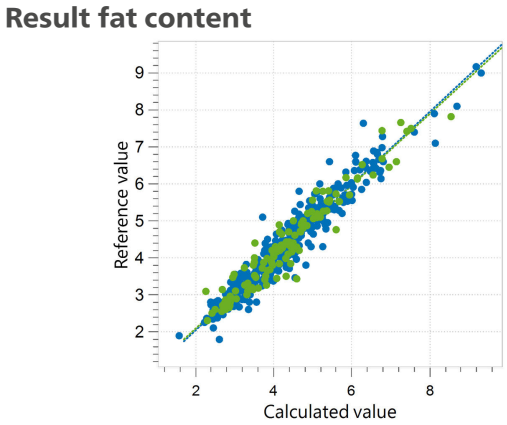

Figure 2. Correlation diagram and the respective figures of merit for the prediction of fat (crude) in animal feed.

R^2	SEC (%)	SECV (%)	SEP (%)
0.923	0.30	0.33	0.34

Result starch content

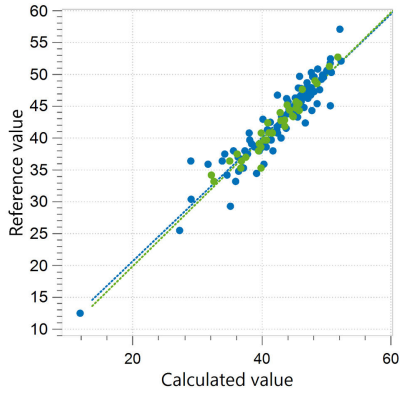

Figure 3. Correlation diagram and the respective figures of merit for the prediction of starch in animal feed.

R^2	SEC (%)	SECV (%)	SEP (%)
0.927	1.80	2.06	1.27

Result protein content

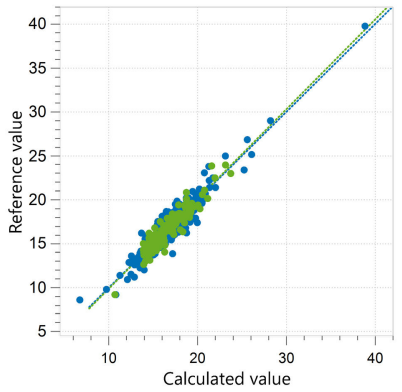

Figure 4. Correlation diagram and the respective figures of merit for the prediction of protein in animal feed.

R^2	SEC (%)	SECV (%)	SEP (%)
0.873	0.81	0.86	0.80

Result moisture content

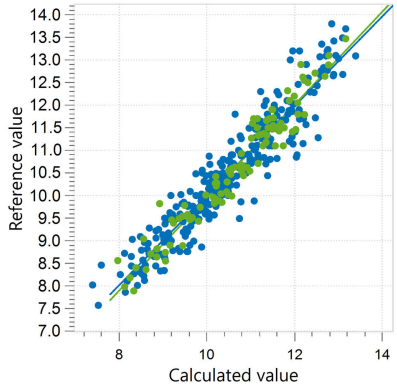

Figure 5. Correlation diagram and the respective figures of merit for the prediction of moisture in animal feed.

R^2	SEC (%)	SECV (%)	SEP (%)
0.938	0.41	0.42	0.31

Result fiber content

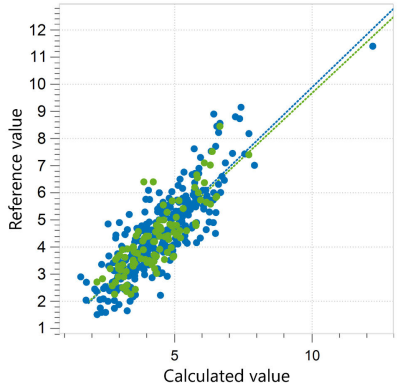

Figure 6. Correlation diagram and the respective figures of merit for the prediction of crude fiber in animal feed.

R^2	SEC (%)	SECV (%)	SEP (%)
0.650	0.77	0.80	0.70

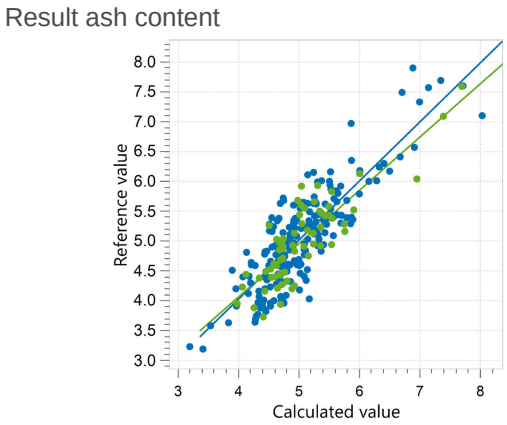

Figure 7. Correlation diagram and the respective figures of merit for the prediction of ash in animal feed.

R^2	SEC (%)	SECV (%)	SEP (%)
0.720	0.39	0.43	0.39

Figures of merit

The following tables display the figures of merit for the prediction models of specific feed products: poultry feed (**Table 1**), pig feed (**Table 2**), and cattle feed (**Table 3**).

Table 1. Figures of merit for the prediction of fiber, ash, starch, moisture, protein, and fat in poultry feed

Parameter (Range)	No. Spectra	SEC (%)	SECV (%)	SEP (%)	R^2
Fiber (2.4–5.2%)	182	0.15	0.15	0.18	0.917
Ash (3.9–5.9%)	159	0.18	0.19	0.17	0.790
Starch (41.7–48.2%)	158	0.66	0.75	0.79	0.667
Moisture (11.0–13.2%)	171	0.09	0.09	0.10	0.943
Protein (13.9–20.7%)	204	0.40	0.44	0.41	0.927
Fat (2.7–6.0%)	207	0.17	0.17	0.16	0.968

Table 2. Figures of merit for the prediction of fiber, ash, starch, moisture, protein, and fat in pig feed.

Parameter (Range)	No. Spectra	SEC (%)	SECV (%)	SEP (%)	R^2
Fiber (2.7–7.9%)	88	0.27	0.28	0.29	0.954
Ash (4.3–5.2%)	115	0.14	0.14	0.15	0.816
Starch (38.4–48.1%)	96	0.76	0.86	0.92	0.922
Moisture (10.7–13.2%)	106	0.08	0.08	0.11	0.961
Protein (14.9–17.6%)	108	0.25	0.29	0.27	0.765
Fat (2.4–6.0%)	121	0.10	0.12	0.13	0.986

Table 3. Figures of merit for the prediction of fiber, ash, starch, moisture, protein, and fat in cattle feed.

Parameter (Range)	No. Spectra	SEC (%)	SECV (%)	SEP (%)	R^2
Crude fiber (3.3–10.8%)	319	0.34	0.44	0.57	0.876
Ash (4.0–9.8%)	253	0.53	0.54	0.55	0.859
Starch (13.5–59.9%)	337	1.01	1.09	1.28	0.973
Moisture (10.4–13.0%)	329	0.12	0.12	0.13	0.915
Protein (9.9–33.7%)	336	0.53	0.55	0.56	0.988
Fat (2.5–6.5%)	331	0.21	0.21	0.24	0.908

This Application Note demonstrates the feasibility to determine multiple key quality parameters of feed with NIRS analysis. Several analytical methods are usually required to measure starch, ash, fiber, protein, moisture, and fat in animal feed (**Table 4**). NIR feed analysis offers an easier alternative with high accuracy and real-time results.

Table 4. Overview of ISO norms used for determining the reference values for the different quality parameters in the feed samples.

Parameter	Method
Starch	ISO 6493:2000 Animal feeding stuffs — Determination of starch content — Polarimetric method
Crude ash	ISO 5984:2002 Animal feeding stuffs — Determination of crude ash
Crude fiber	ISO 6865:2000 Animal feeding stuffs — Determination of crude fibre content — Method with intermediate filtration
Crude protein	ISO 5983:1997 Animal feeding stuffs — Determination of nitrogen content and calculation of crude protein content — Kjeldahl method
Moisture	ISO 6496:1999 Animal feeding stuffs — Determination of moisture and other volatile matter content
Fat	ISO 6492:1999 Animal feeding stuffs — Determination of fat content

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