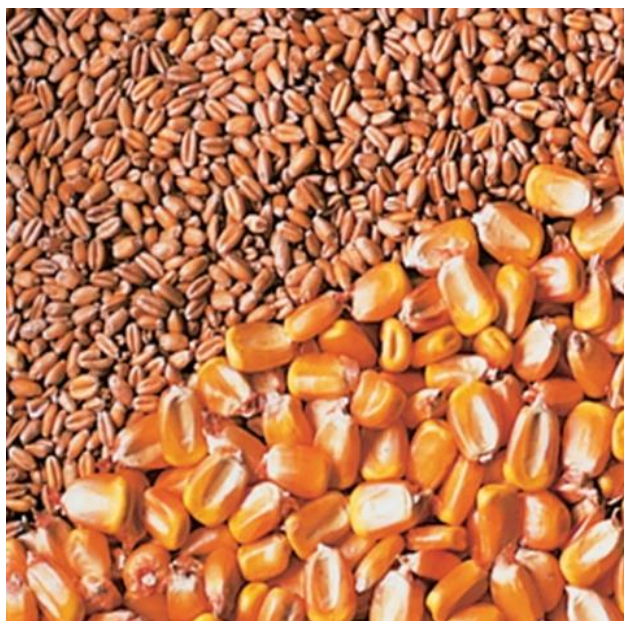


**AN 5377**

Rev. 6

**NIRS™ DS2500 / DS2500 F / DS3 / DS3 F****Cereals / Grains**

NIRS™ DS2500/DS2500 F/DS3/DS3 F provides fast and accurate results for feed ingredients such as cereals/grains.

With the NIRS DS2500/DS2500 F/DS3/DS3 F you will get results almost instantly instead of waiting hours for results from standard wet chemistry analysis in the laboratory.

This application note describes the calibrations and the results that can be expected when analysing cereals/grains.

This application handles mainly samples from Europe, China, South East Asia, India and North America.

**Samples Used in Calibration Set**

The application is developed with following sample types:

- **Barley:** barley grain, barley whole grain
- **Corn:** corn grain ground, corn grain un-ground
- **Wheat:** Wheat whole grain, wheat grain, wheat whole grain ground
- **Others:** oat grain, oat whole grain, rye whole grain, triticale whole grain
- **Cassava/Tapioca**

# Calibration Information

The application covers the following parameters and ranges:

| Parameter                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Model | PM version | Moisture Basis | N    | Min  | Max  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|------------|----------------|------|------|------|
| Protein *                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | ANN   | 3.0.0.0    | As Is          | 5518 | 1.42 | 20.5 |
| Moisture                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | ANN   | 3.0.0.0    | n/a            | 9014 | 1.72 | 20.0 |
| Fat                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | ANN   | 3.0.0.0    | As Is          | 2796 | 0.37 | 6.90 |
| Fibre                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | ANN   | 3.0.0.0    | As Is          | 2122 | 0.50 | 15.3 |
| Ash                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | ANN   | 3.0.0.0    | As Is          | 5148 | 0.89 | 5.62 |
| Starch                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | ANN   | 3.0.0.0    | As Is          | 2545 | 26.1 | 77.2 |
| <p>*The Nitrogen conversion factor for Feed applications is 6.25</p> <p>Model: ANN calibration technique (Artificial Neural Network)</p> <p>PM version: Prediction model version number</p> <p>Moisture Basis: As Is = no moisture compensation; not applicable for the moisture parameter</p> <p>N: Number of individual samples in the calibration set</p> <p>Min: Minimum reference value in the calibration set</p> <p>Max: Maximum reference value in the calibration set</p> |       |            |                |      |      |      |

Table 1

## Performance

The prediction models in this application were developed using the Artificial Neural Networks (ANN) technique. Performance has been evaluated using independent validation test sets which are not included in the calibration set and which represent data from different instruments and a different reference laboratory.

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## Total Validation Test Set

### Mix of All Cereals

| Parameter                                                                                                                                                                                                                                                                                                                         | N    | Acc. | Min   | Max   | RSQ  |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|-------|-------|------|
| Protein                                                                                                                                                                                                                                                                                                                           | 1323 | 0.59 | 1.98  | 15.7  | 0.96 |
| Moisture                                                                                                                                                                                                                                                                                                                          | 1814 | 0.65 | 2.17  | 19.9  | 0.93 |
| Fat                                                                                                                                                                                                                                                                                                                               | 470  | 0.32 | 0.37  | 5.38  | 0.93 |
| Ash                                                                                                                                                                                                                                                                                                                               | 766  | 0.22 | 0.91  | 5.24  | 0.87 |
| Fibre                                                                                                                                                                                                                                                                                                                             | 375  | 0.63 | 0.51  | 15.4  | 0.93 |
| Starch                                                                                                                                                                                                                                                                                                                            | 637  | 1.65 | 27.83 | 75.53 | 0.94 |
| N: Number of individual samples in the validation set<br>Acc. Accuracy expressed as Standard Error of Prediction (SEP) corrected for bias<br>Min: Minimum reference value in the validation set<br>Max: Maximum reference value in the validation set<br>RSQ: Linear correlation between predicted results and reference results. |      |      |       |       |      |

Table 2

### Validation Data for Specific Sub-Classes

#### Wheat

| Parameter | N   | Acc. | Min   | Max   | RSQ  |
|-----------|-----|------|-------|-------|------|
| Protein   | 482 | 0.61 | 7.7   | 15.7  | 0.87 |
| Moisture  | 594 | 0.57 | 3.04  | 21.4  | 0.95 |
| Fat       | 93  | 0.23 | 1.18  | 2.21  | 0.40 |
| Ash       | 311 | 0.17 | 0.99  | 2.43  | 0.48 |
| Fibre     | 118 | 0.35 | 1.50  | 4.20  | 0.63 |
| Starch    | 300 | 1.59 | 50.69 | 66.15 | 0.63 |

Table 3

#### Corn / Maize

| Parameter | N   | Acc. | Min  | Max   | RSQ  |
|-----------|-----|------|------|-------|------|
| Protein   | 464 | 0.49 | 6.00 | 13.0  | 0.66 |
| Moisture  | 668 | 0.59 | 8.86 | 16.44 | 0.82 |
| Fat       | 239 | 0.39 | 1.5  | 4.8   | 0.45 |
| Ash       | 257 | 0.17 | 0.91 | 1.8   | 0.17 |
| Fibre     | 173 | 0.52 | 1.51 | 3.90  | 0.17 |
| Starch    | 167 | 1.16 | 54.5 | 68.66 | 0.72 |

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Table 4

**Others**

| Parameter | N   | Acc. | Min  | Max   | RSQ  |
|-----------|-----|------|------|-------|------|
| Protein   | 307 | 0.70 | 6.23 | 14.42 | 0.78 |
| Moisture  | 420 | 0.78 | 2.96 | 19.8  | 0.92 |
| Fat       | 54  | 0.35 | 1.5  | 5.38  | 0.91 |
| Ash       | 102 | 0.31 | 1.3  | 3.84  | 0.64 |
| Fibre     | 83  | 0.95 | 1.8  | 15.23 | 0.95 |
| Starch    | 375 | 0.63 | 1.50 | 15.23 | 0.93 |

Table 5

**ANALYTICS BEYOND MEASURE**

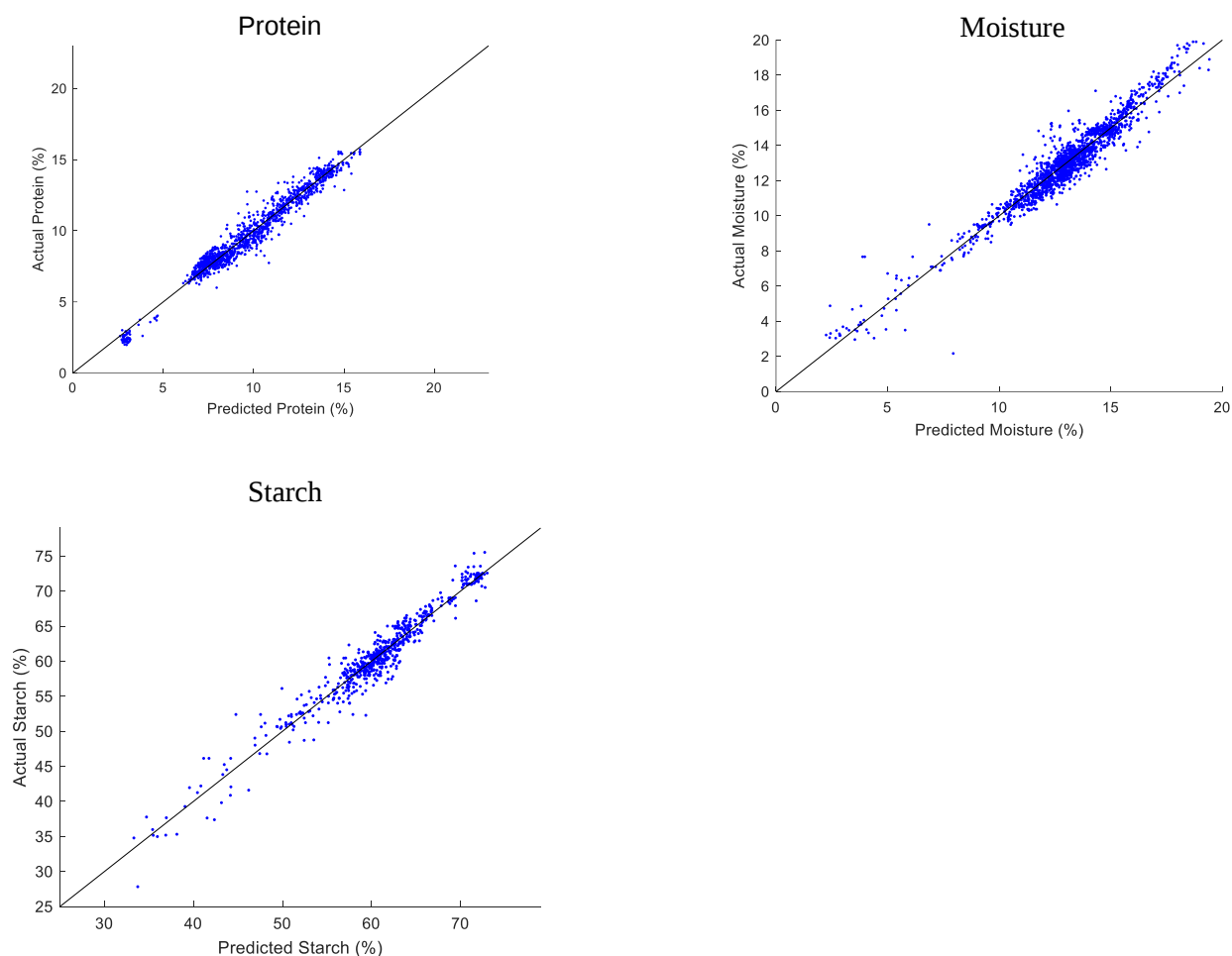
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**Note:**

**Graphics showing predicted results vs. reference analysis (examples).**

**Total Validation Set**



*Fig. 1*

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## Wheat

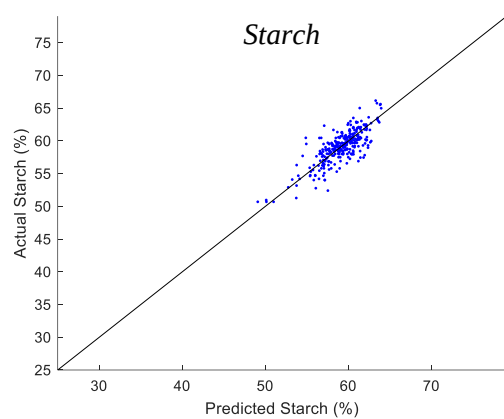
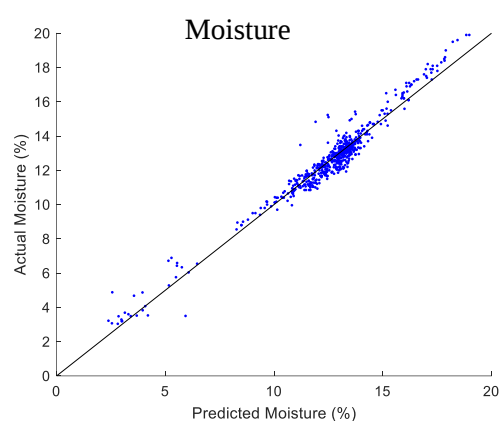
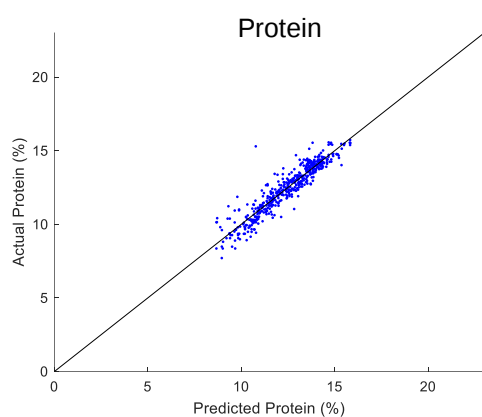


Fig. 2

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## Corn / Maize

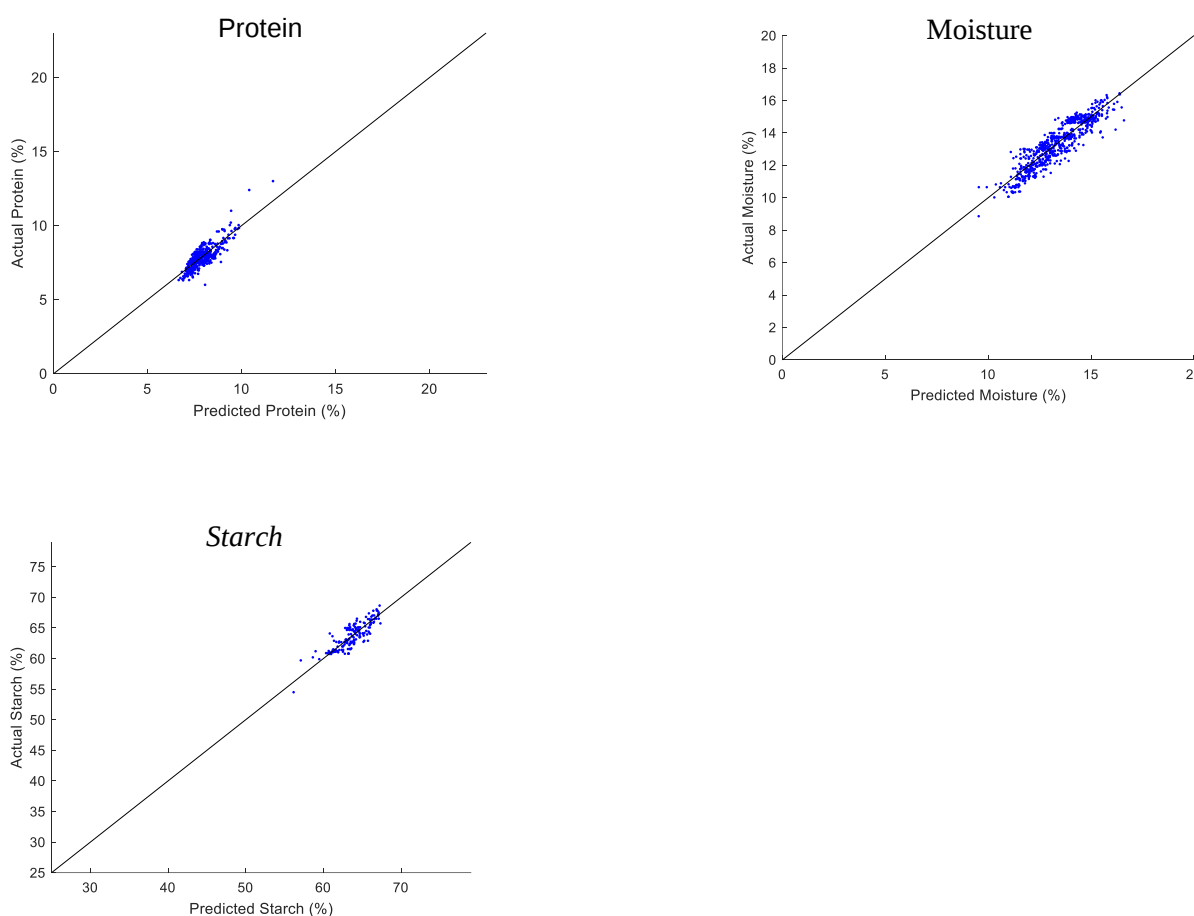


Fig. 3

### Note:

**The performance example outlined in this note should only be regarded as a guideline for the expected performance of new installations. The performance will always depend on the uniformity of the sample preparation and the homogeneity of the product, as well as the accuracy of the reference method used and the range for the test samples. An indication of the obtainable performance can be found as approximately 1.5 to 2 times the reproducibility of the reference method.**

If the samples you are measuring exceed the stated calibration ranges, or have non-common variations of other components, this might also influence the performance of the calibrations. For each unknown sample analyzed the spectra of it will be compared to the samples in the calibration database. Two key values will be given as an indicator to how well the unknown sample fit the calibration samples:

- Global H value (GH)- measures how far the sample is from the center of the database

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- Neighbourhood H value (NH)- measures how close the sample is to the nearest sample in the database  
(Default Warning and Action limits for these NH / GH values are set for each prediction model in the software.)

## Sampling, Sample Preparation, Sample Cup and Analysis

If grinding of the product is required, we recommend a cyclone mill such as Retch or Cyclotec, with a 1 mm sieve (see "Note on grinding" below).

The recommended way to analyse ground samples with NIRS DS2500/DS2500 F is to use the standard Small cup and for unground samples the recommendation is to use the Large cup.

Sample volumes (volumes will vary with sample density):

- Small cup: 30 grams
- Large cup: 200 grams

Compressing the sample is not necessary.

We recommend that the analyser lid is closed during analysis.

### Note on Grinding

Homogenous samples do generally not require grinding. Inhomogeneous samples can be measured unground but performance and repeatability will benefit from grinding. For some seeds where the hulls do not allow enough light to penetrate the recommendation is to always grind the sample.

If in doubt, scan the unground sample 10 times, refilling the sample cup between each scan. Calculate the standard deviation across the 10 repacks. If the standard deviation is larger than the accuracy presented above, grinding is recommended.

### Sample Temperature

The calibrations have been stabilised to be able to analyse samples at sample temperatures between 10-30 °C.

For optimum performance, the sample temperature should be as close as possible to the ambient temperature. Analysing at a temperature higher or lower than the environment temperature increases the risk for moisture condensation or moisture evaporation from the sample and temperature drift during the analysis.

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