Jens Rademacher, Kiel

Effects on the Accuracy of Online Protein Measuring in the Combine

The use of NIR-spectroscopy on a combine makes it possible to continuously record protein content directly during threshing [1]. This system was developed in the institute. With extended calibration in the 2nd experimental year, the accuracy could be improved. Because the NIR-technique reacts sensitively to external effects, it was expected that adjusting the technology would cause considerable difficulties. In the field good results were attained, contrary to expectations, which meant that the expected influences on the measurements were insignificant.

Dipl.-Ing. agr. Jens Rademacher works at the Institute of Agricultural Engineering (Head: Prof. Dr. E. Isensee) at the University of Kiel, Germany, Max-Eyth-Straße 6,D-24118 Kiel;
e-mail: *jrademacher@ilv.uni-kiel.de*

Keywords

NIR-measurement, combine harvesting, protein content

Literature

[1] *Rademacher, J.*: Messung des Proteingehaltes während des Mähdrusches. Landtechnik 57 (2002), H. 6, S. 354-355

The NIR spectroscopy is based on the interaction of matter with energy. The material to be examined is illuminated with light and the reflected energy in the wavelength band of 960 nm to 1690 nm used. Before beginning of a series of measurements, the energy is to be indicated to the spectrometer with 100 % reflection; in addition a white special plastic is used, which reflects 100 % of the irradiated energy. With the determination of the protein content the energy up-to-date reflected by the examined material is measured and the difference to the energy measured with 100 % reflection is determined. This difference equals the energy absorbed by the material.

For the quantification of the influence of the results of measurement - by varying grain temperature and velocity of flow - these were simulated in one for this purpose developed test systems. To do so, a measuring channel was designed, which corresponds to the dimensions of the unit installed in the combine. The channel is provided in the lower section with an aperture, through which the flowing material is illuminated.

From general laboratory practice it is well-known that the temperature of the material to be examined possesses a substantial influence on the result of measurement. Varying temperatures effect the physical characteristics of the matter, which leads to changed absorptive properties. Since the result of measurement for the protein content is deduced directly by the current absorption over the calibration formula [1], changes with the absorptive properties also effects the measurement.

By own investigations at the test system the influence of the temperature could be confirmed. An increased temperature of the grain led also to higher measured values for the protein content. The increase of 14°C - 16°C to 30°C - 32°C increased the measured value on the average by 1.1 %-points. The biased corrected error of the measurements (SEP(C)) of both temperature ranges rises only around 0.01 %-points.

During the on-line measurement in the field this effect could not be proven any longer. But it could be used for a one data year extended calibration, which included more factors of influence. *Figure 1* may clarify this. Here the temperature of the grain measured at the measuring instrument is represented by the x-axis, while the ordinate represents the difference in the protein content between reference-value and measured NIR-value. Only when starting from temperatures of more than 33°C the error increases, the protein content is overrated. However: These data come all from only one field, thus they can be specifically influenced.

Influence of throughput

Due to the measurement principle, also the throughput can exert an influence. Because

Table 1: Troughput with various slide adjustments on the measuring channel

Throughput-Level	Throughput g/s
1	~ 90
2	~ 220
3	~ 400
4	~ 580
5	~ 650

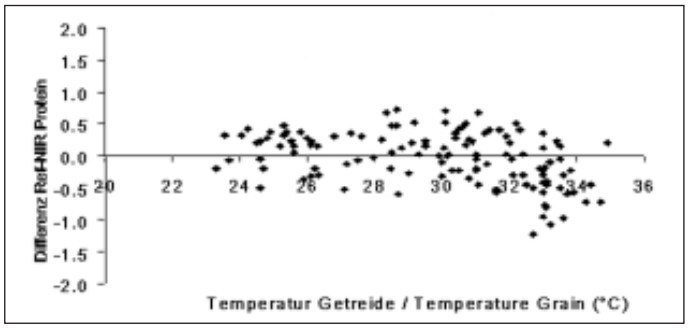

Fig. 1: Influence of grain temperature measurement errors

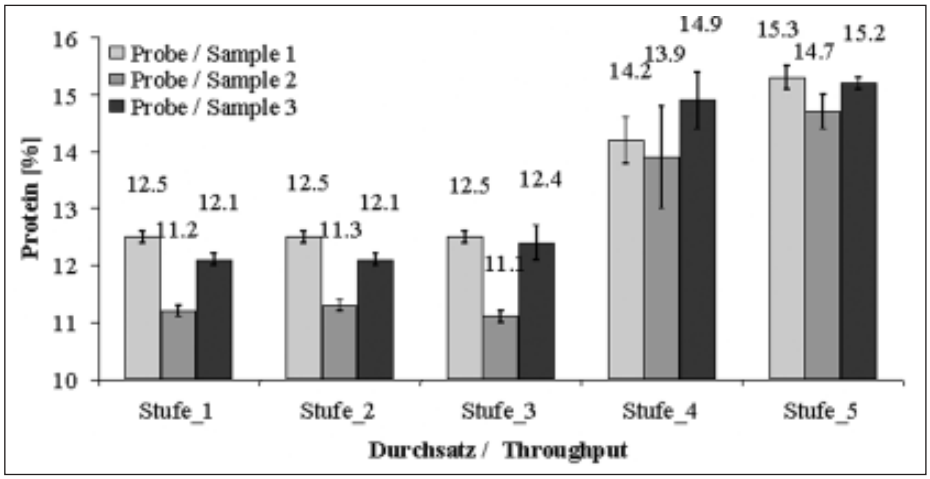

Fig. 2: Influence of throughput on measuring protein (calibration 1)

speed and arrangement of the kernel could have influence on the reflection. Therefore the test stand was driven with varied throughput. The gradations were over and under the value, which is realised in the combine with ~ 200 g/s (*table 1*).

Figure 2 shows the results of the examinations. At the ordinate the protein content is presented, at the abscissa the sample ID. Everyone of the shown columns represents the average value from 5 individual measurements for each sample and throughput level. The fluctuations of the individual measurements are represented by the standard deviations. They are very small, with the exception of the measurements of the sample 2 at level 4; 80 % of the values are smaller or equal 0.3 %. That shows hat the measurements exhibit high reproducibility, despite the flowing material. The differences of the results of a sample between the first three throughput levels are low. The measured protein content of the sample 1 remains constant over all three stages at 12.5 %. The difference is in view of the standard deviation of 0,1 extremely small and to be neglected. Also the indicated contents of the two other samples vary only small.

Between third and fourth throughput level, a very clear jump of the measured values arises upward. That shows the sensitivity of the measurement to the speed or loose bulk of the grains.

On the other hand another calibration lifts this effect on (*fig. 3*). The values of the individual samples at a low throughput level are characterised again by small differences; however the difference of the two high throughput levels to the lower omits clearly smaller.

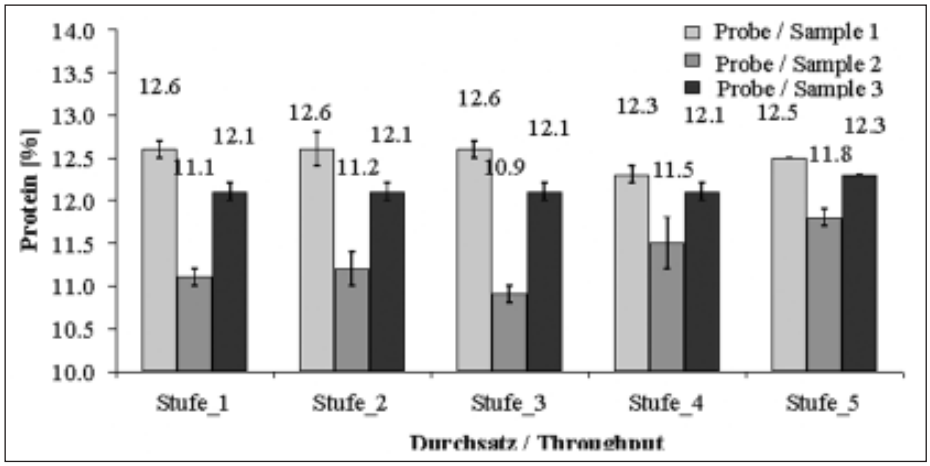

Fig. 3: Influence of throughput on measuring protein (calibration 2)

The conformity alone is not sufficient, the quality of a measured value is expressed by using the m-distance. The m-distance is indicated and by the measuring instrument software for each measurement and informs about the quality of the current measurement. A complex mathematical procedure compares the current absorption spectra with those in the calibration file: If the data do not coincide, an increased m-distance is set and marks this result to be a problematic one. Such result does not have to be inevitably wrong, however its interpretation has to be undertaken carefully. With this measurement exactly this occurs: With low throughput level the m-distances for both calibrations are on a low level (although: in laboratory-use a value already starting from 5 applies as too high). The higher flow velocities settle with both calibrations in clearly increased values for the m-distance, with the 2. calibration clearly lower. The three low throughput levels ensure a grain column, which by-flows at the measuring instruments. With higher flow velocities , the column dissolves, it develops gaps between the grains. The light is reflected by the material of the measuring channel, the spectra resulting from it do not coincide with the data in the calibration data-set.

Sample	Calibration 1 Throughput Level					Calibration 2 Throughput Level				
	1	2	3	4	5	1	2	3	4	5
1	16.3	16.7	17.2	66.6	130.9	13.9	14.2	14.6	26	35.2
2	18.9	19.2	19.9	119.9	161.2	14.8	15	15.4	32.6	38.9
3	17.8	18.7	19.5	128.9	147.1	14.8	15.4	16.6	33.2	36.9

Table 2: M-distances at different throughput levels and 2 calibrations