APPLICATION NOTE

FT-NIR Spectroscopy

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Analysis of Properties of Corn Using FT 9700 FT-NIR Analyzer

Introduction

Corn is the most plentiful grain grown worldwide with over 1.09 billion metric tons produced in 2018.[1] It is a versatile crop and can be found in a wide range of products such as foodstuffs, animal feed, ethanol and even bio-based plastics.[2] Therefore, evaluating the quality of corn is an important procedure in many industries.

Moisture, starch, protein and fat are important parameters to consider when assessing the quality of corn. The specialty end uses for corn often require these parameters to fall within a certain range. More worryingly, particularly high or low concentrations of these parameters could lead to health or economic issues. For example, high levels of moisture may result in the formation of mold that could contaminate a whole batch of corn.[3]

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The standard laboratory procedure traditionally used to measure these key values varies depending on the parameter being analysed.[4] However, these traditional methods can often require time-consuming sample preparation and may produce hazardous chemical waste.[5]

Near-infrared (NIR) spectroscopy is already widely used in the food industry for quantitative analysis of nutritional and quality parameters. When combined with chemometric techniques, such as partial least squares (PLS), NIR spectroscopy can provide a fast and accurate method to quantify these parameters in corn at any stage of the production process. FT 9700™ is a new PerkinElmer FT-NIR analyzer and its' performance analysing corn was evaluated.

Experimental

Over 115 samples of corn were collected from a variety of countries of origin, including US, France, South Africa, Turkey, Denmark and China, therefore maximising the natural variation present within the samples. Reference values for the fat, moisture, protein and starch for each sample were obtained from Eurofins Scientific testing laboratory using the standard method used to analyze each parameter.

The samples were ground using a LM 3310 disc mill in order to minimize moisture loss within the milling process. The ground samples were then scanned in replicate using multiple PerkinElmer FT 9700™ NIR analyzers. A plastic sample cup with a sapphire glass base was filled with the ground sample, placed on the sample spinner and scanned using the settings shown in Table 1.

Table 1. Scanning parameters for ground corn samples.

Scanning Parameters	
Spectral Range	10,600 – 4,000 cm^{-1}
Resolution	16 cm^{-1}
Number of Scans	32

Figure 1. Sapphire glass-based plastic sample cups.

35 samples (120 collected spectra) were used as a validation set and the remaining spectra were used to create the calibration models. The calibrations were stabilized for natural temperature variations that may be present in the samples.

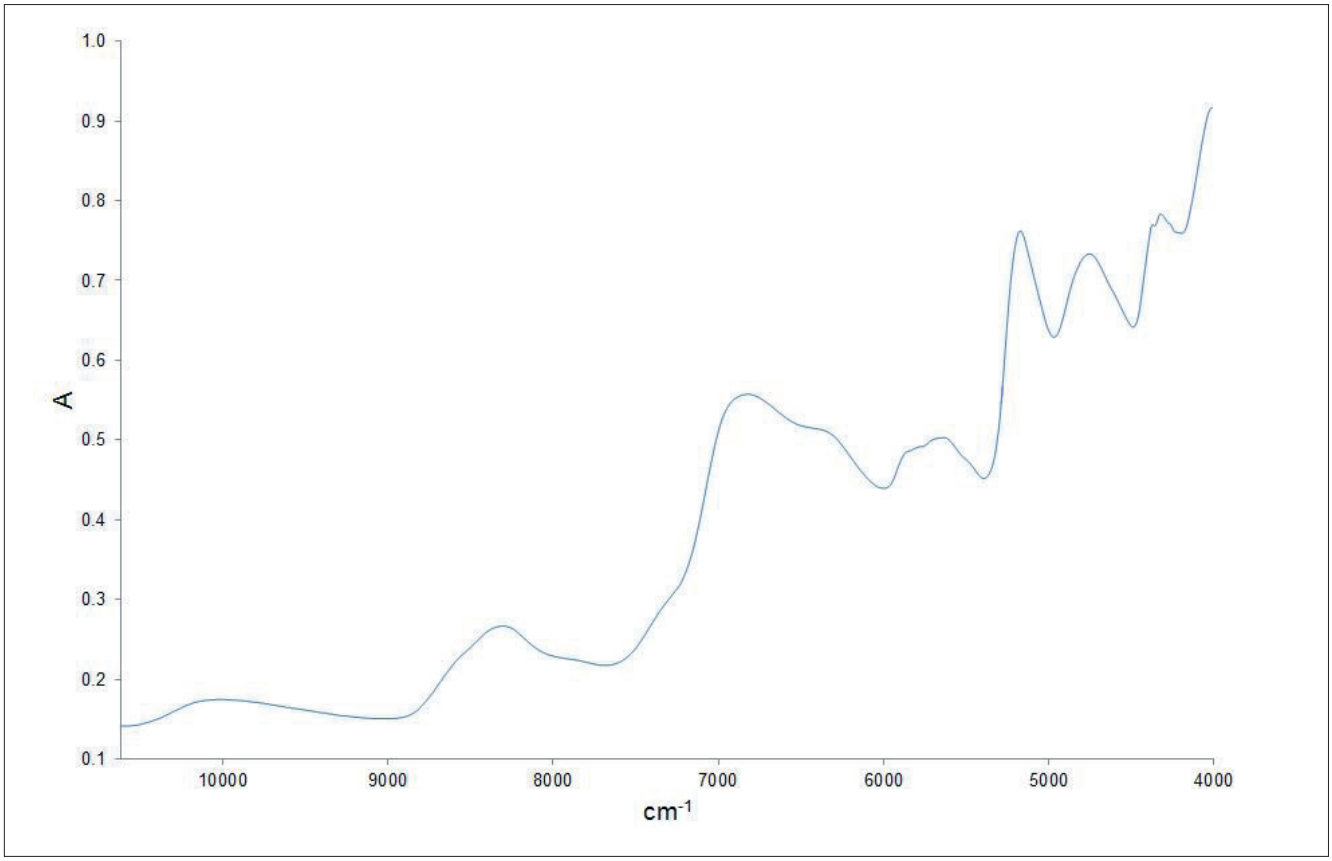

Figure 2. Example NIR spectrum of ground corn.

Results

The calibration plots for each parameter can be seen in Figures 3-6. The calibration (blue) and validation (red) data points are evenly distributed around the unity line, showing that there is a good level of agreement between the reference and predicted values for each parameter.

Table 2 illustrates the overall regression data for each of the calibration models. The standard error of prediction (SEP) is relatively low for each of the models, indicating they have good prediction capabilities.

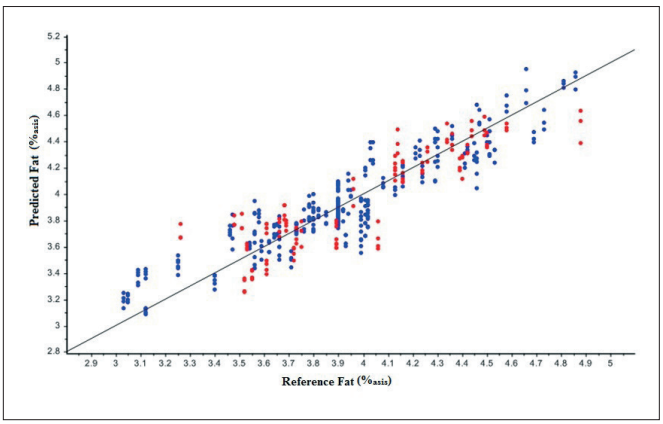

Figure 3. Correlation plot for fat analysis of ground corn.

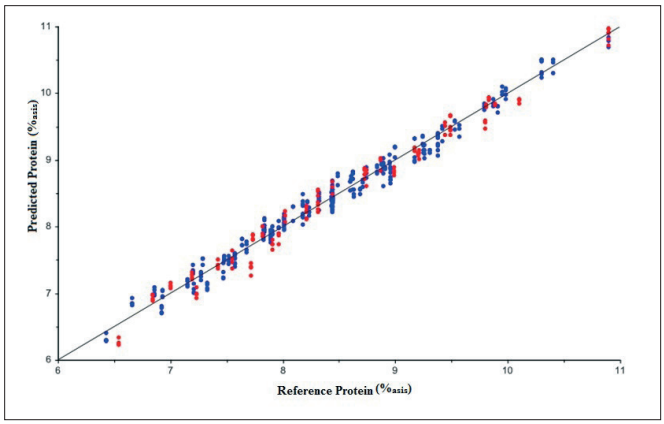

Figure 5. Correlation plot for protein analysis of ground corn.

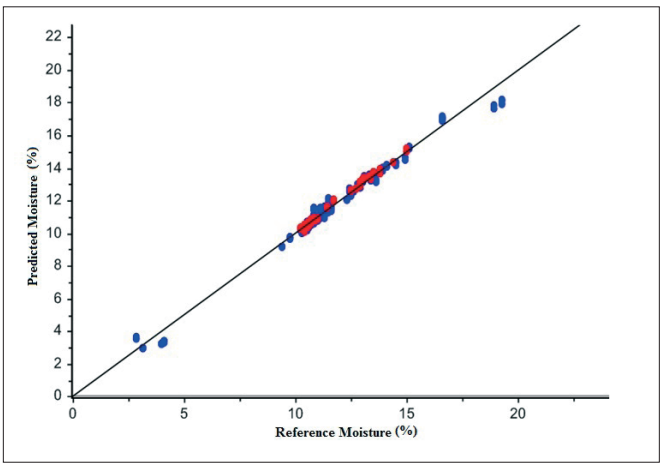

Figure 4. Correlation plot for moisture analysis of ground corn.

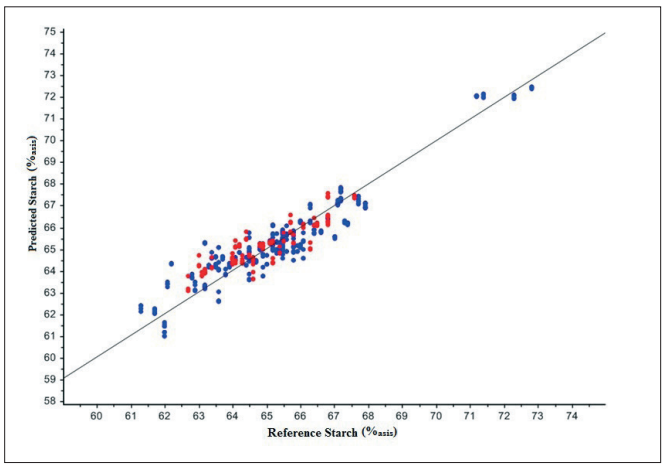

Figure 6. Correlation plot for starch analysis of ground corn.

Table 2. Regression summary for ground corn parameter models (where SEC is standard error of calibration and SEP is standard error of prediction).

Parameter	Range	R^2	SEC	SEP
Fat ($\%_{asis}$)	3.03 – 4.86	0.84	0.16	0.19
Moisture (%)	9.4 – 16.6	0.98	0.31	0.16
Protein ($\%_{asis}$)	6.4 – 10.9	0.98	0.12	0.15
Starch ($\%_{asis}$)	61.3 – 72.8	0.89	0.67	0.62

Conclusion

The results show that the FT 9700 NIR analyzer is capable of accurately determining multiple parameters of ground corn samples. The calibration models produced show good prediction capabilities, indicated by the low SEP values. The results are repeatable as the wide range of countries of origin allows the samples to show as much natural variation as possible. Additionally, the results are transferable as the spectra were collected on a number of different instruments.

Overall, it can be seen that the FT 9700 NIR analyzer is suitable for accurately and rapidly quantifying a variety of quality and nutritional parameters of ground corn samples. This technique could be utilized for quality control at any stage of the production process.

References

1. *Worldwide production of grain in 2018/19, by type (in million metric tons)*, Statista, 2019.
2. J. Foley, I*t's Time to Rethink America's Corn System*, Scientific American, 2013.
3. C. Tevis, Corn Quality Control, Successful Farming, 2012.
4. *Food energy – methods of analysis and conversion factors*, Food and Agriculture Organization of the United Nations, 2003, 77.
5. C. Egesel, F. Kahriman, *Determination of Quality Parameters in Maize Grain by NIR Reflectance Spectroscopy*, Journal of Agricultural Sciences, 2012, 18, pp 31-42.

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