NIRS Measurement for the Grain Industry

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ISU Extension Value Added Agriculture Program

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25 years ago...

- The grain handling industry used near infrared spectroscopy (NIRS) to measure grain moisture and wheat protein. Still true today.

Ground grain analyzers, fixed filters (~10-20) required a preground sample

Dickey-john Instalab 800
Why are companies testing today?

• More value in agricultural products brings demand for *high quality*

• Quality control factors contribute to a company’s *ability to track and trace* products

• Increased local processing demands *efficiency and consistency*
What are they testing? Some examples...

- Ethanol plants measure inbound corn for hybrid selection and to estimate distillers grains quality and ethanol yield.

$0.1 \text{ gal/bu} = $6,000,000/yr (100 mgy plant)

Also 4% yield increase
**What are we testing? Some examples...**

- Feed mills find value in measuring protein, fat, and fiber levels in inbound corn, soybean meal, distillers grains.

<table>
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<th>Deviation from Spec</th>
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<tr>
<td>Moist.</td>
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<tr>
<td>-1.8</td>
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<td>-1.3</td>
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<td>-1.4</td>
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<td>-0.9</td>
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<td>-1.0</td>
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What other applications are likely to use NIRS to measure nutrient or functional properties?

- Measurement of oil quality in biodiesel, herbal extracts and specialty food oil blends.
- Measurement of nutrients in corn fractionation products.
**Identifying unique traits that require segregation**

- Low linolenic and low saturate soybeans –
  - Inbound loads sampled for linolenic acid levels of 1-3%; saturates levels below 9%. Classification.
  - Local networks of selected buyers/processors
    - Asoyia, Innovative Growers, Zeeland Farm Service
Ground product measurement examples

• Iowa soybean meal and flour processors
  – Testing expeller meal
    • Protein, oil, fiber, etc...
  – Testing soy grits and soy flour
    • Protein, oil, fiber, etc...
How NIRS analyzers work

100-1000 samples

Prediction model:
\[ \hat{Y} = b_0 + b_1 x_1 + b_2 x_2 + \ldots + b_k x_k \]

Protein content: 14 g.kg\(^{-1}\)
What are the scientific challenges?

• Measurement of subunits
  – Amino acids
  – Fatty acids
  – Correlated with the proximate factor

• Dealing with non-linear responses of the analyte
What are the usual challenges for a company?

• Training of personnel and manufacturer support
• Daily instrument and data maintenance
• Matching the technology with expectations
• Understanding moisture basis
• Calibration maintenance
**What is a typical problem?**

- High protein corn varieties read lower than they should read on my analyzer. *(Are any of the calibration samples high protein?)*

- Protein and oil measurements on selected samples do not match the lab values. *(Moisture basis? Is lab using same method as reference lab used?)*

- Measurements seem suddenly unreasonable. *(Look at the daily check sample data.)*
Differences among reference labs
These things take most of our time

- Too many steps with data handling and equipment operation
- Sample identification
- Slow computers and over-controlling operating systems
Can’t We Get Better Computing in Instruments?
The nightmare of file formats

• Many file formats, some proprietary, few compatible.
  – .csv, .uns, .spc/cfl/txt, .dat, jcamp, .cal, .nir, .m, etc!!
  – Few manage IDs and other info very well.

Then there are the calibration model file restrictions!!!!
And then the “updates”!

80% of chemometric time is spent on data handling; 20% on actual chemometrics
A note about validation...

• VALIDATION is very important in any measurement system – particularly NIRS.

• The NIRS analyzer must be able to make accurate measurements on new samples time after time.

• No revenue stream for vendors for calibration update but .. preinstalled calibrations often fail.
**NIRS analyzer quality control routine**

1. Track daily check sample data
2. Repeat (duplicate) selected samples during routine tests
3. Select VALIDATION samples periodically and send to lab for chemistry
What can ISU Extension do for clients?

• Develop initial NIRS calibrations and protocol for updating.
• Train company personnel in calibration updates and maintenance.
• Plan how to use routine measurements in a quality control program.
• Apply measurements to process control.
• Beta-test new equipment and software.
Our clients are usually from:

- Grain elevators
- Feed mills
- Seed breeders
- Equipment manufacturers
- Food and feed ingredient companies

*All work done on a “fee-for-service” contract basis at ISU Extension hourly rates.*
Where to Find Us

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