Forage Analysis

Background

Forages are the key component of ruminant diets, and optimizing the rations is often the key to profitability for dairy and livestock producers. Poorly balanced rations can lead to low milk production in dairy cows and slow weight gain for beef cattle.

Forage is typically roughage (whole plant leaves and stems) that is fed to ruminant animals (dairy cows, beef cattle, and horses) to provide nutrition. Hay forages can be dry grass hay, legume hay and mixtures of the two. Haylage is hay that has been allowed to ferment in a silo for a period of time. Haylage and corn silage are forage materials and corn plants, respectively, that are partially dried and chopped for storage. These wet forages are then fermented separately in tower silos or air tight horizontal storage bunkers. Forages show wide variations in nutritional content, and frequent and accurate analysis is key to properly optimizing animal rations.

University researchers are leading the way to identify new analytical tests to predict animal performance from feeds and forages. Many of these analytical tests, such as various lignin assays and digestibility tests, have been used as reference methods for new NIR calibrations.

The forage testing laboratories are on the front lines in producing timely data for producers. The rapid testing time means that the nutritional values are available for real-time ration balancing, allowing for more precise control of the diet, efficient use of expensive supplements, and better animal performance. Many are developing innovative methods to return the data back to the producers over the internet for immediate use.

Forage testing laboratories are constantly developing and implementing new calibrations into their packages, giving producers instant access to new and novel parameters with each NIR analysis.

Sites with a larger number of dairy cows now frequently run their own testing of forages using NIR. The availability of starter calibrations and the simplicity of use of today’s analytical equipment offers the added advantage of “on the spot” optimization there by increasing yield and profitability.

Forage Analysis

Basic forage analysis consists of at least dry matter, crude protein, crude fiber, ADF, NDF, and ADP as well as several minerals. Often some measure of digestibility as well as calculated parameters for energy availability is included. These data are laborious, time consuming and expensive to obtain from traditional wet chemistry methods.

Near Infrared (NIR) analysis of forages can produce 20 or more compositional and property values in less than a minute from dried ground forage samples with an accuracy rivaling the wet chemistry methods but offering superior repeatability. Samples can be analyzed rapidly with one analyst and no dangerous procedures or chemicals.

NIR forage analyzers are in widespread use for larger livestock and dairy producers, analytical laboratories, plant breeders and university researchers. Most forage analysis is performed with dried and ground samples, though calibrations are available for fresh forage samples directly from the field.
Technology Options for Forage Analysis

Forage analyses are some of the most demanding of NIR applications, yet the amount and speed of the results offers some of the biggest and fastest payback potentials.

Forage analyses are demanding because of the complex nature of the sample types, along with the specificity and breadth of the constituents required. To model all of the sample variation and provide the spectral information necessary to predict these constituents requires many calibration samples with high quality spectral data. Noisy or low resolution spectral data will require many more calibration samples and be limiting in the accuracy and repeatability of the analysis.

For these reasons, a scanning monochromator such as the Unity SpectraStar XL™ is the best solution for laboratory or at-line analysis of forages. Scanning monochromator-based instrumentation is the most widely used technology in the world for forage analysis with thousands of analyzers in use and time proven results. Instrumentation of this type will provide the sample analysis capability to analyze many sample types for the most difficult parameters with the lowest calibration and validation requirements.

SpectraStar™ XL

Unity Scientific offers a variety of ready–to-use solutions tailored to the forage industry. All of our forage analyzer packages start with the SpectraStar XL analyzer, an advanced, high performance at-line scanning monochromator. All SpectraStar XL models come standard with the following features:

- TRUE NIR™ Spectrometer for ultra-performance
- Versatile RTW Rotating top window design for easy analysis of both ground and fresh forage samples
- Advanced TRUE NIR detector and electronics for low noise and high repeatability
- 17” high resolution touch screen for intuitive, easy operation
- Fast Windows®7 computer with Solid State Drive for reliability and speed
- Sealed case for reliable operation at-line
- 5 W 10,000 hr lamp
- Unity Check Cell for daily performance validation
- For high-throughput laboratories, the SpectraStar XL is offered with the SmartSampler™
Calibration Options for Forage Analysis

Forage calibrations are among the most complex NIR applications in routine use, and typically require hundreds or thousands of samples to properly model the sample variation. Unity Scientific has turn-key solutions for customers new to NIR forage analysis as well as those that have developed their own calibrations on other legacy NIR instrumentation.

**Plug and Go**

**INGOT® Calibrations from Aunir™**

For the ultimate in ready-to-use performance, Unity Scientific has partnered with Aunir, world leading NIR calibration providers for over 25 years. Aunir has over 500,000 samples in their calibration databases for outstanding robustness and performance. The forage calibrations include samples from around the world and offer robust predictions out of the box for pasture grasses, timothy, clover, rye, legume, maize, sorghum, whole crop wheat and other fermented and non-fermented forages.

INGOT calibrations are covered by a one year free calibration support and a performance guarantee to ensure that the calibrations function properly on every installation.

**Transfer and Go**

**Create and Go**

**UCal™ Chemometric Software**

For customers that have developed calibrations on legacy NIR instruments, the UCal software suite has advanced tools for transferring calibrations to the SpectraStar XL. The vast majority of forage NIR calibrations developed over the last 25 years are based on scanning monochromators such as NIRSystems and FOSS with a very similar optical design to the SpectraStar XL. UCal has advanced algorithms to ensure an accurate and complete transfer of your calibration data, preserving the time and money spent developing calibrations.

A typical process involves scanning a small number of samples (20) on both instruments and advanced algorithms are then used to model the instrument differences. The old calibration samples are then updated to the new SpectraStar XL instrument image and a new calibration is created. Depending on the samples, a small number of samples might be analyzed on the SpectraStar and added into the calibration set.

Using this simple process, it is possible to move an existing calibration set to a modern, high performance robust analyzer and not loose any valuable calibration samples. There is no longer any reason to be stuck in old technology!

For customers who wish to create their own calibrations, the UCal chemometric package contains a complete suite of advanced population, structuring and regression tools to optimize your calibration resources and make high performance, robust calibrations.

For a quick beginning, starter calibrations are available for most forages and UCal training from calibration experts is available in our Brookfield CT, USA headquarters, one hour from New York City.

**Partner and Go - Regional Calibration Providers**

There are many established forage laboratories and calibration centers that are distributing their proprietary calibrations to networks of satellite installations to provide local testing services to producers. This allows them to get a return from their calibration investment, and also provides a more diverse source of calibration samples for the databases.

Unity Scientific supports these providers with ULock, a tool that encrypts calibration and prevents unauthorized use. With ULock, these providers can share their valuable calibration with satellite laboratories around the world without fear of losing control of their valuable calibration databases.
The Value of NIR to Forage Analysis

As described above, the parameter values desired for a complete analysis of forage are numerous and diverse. In general, these tests are laborious and/or involve dangerous chemical or expensive apparatus. To estimate the monetary value of NIR in forage analyses, the average cost from analytical laboratories for the various parameters are listed below.

<table>
<thead>
<tr>
<th>Forage Quality Parameter</th>
<th>Euro</th>
<th>$ USD</th>
<th>Time (Hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Matter</td>
<td>10.00</td>
<td>13.00</td>
<td>24</td>
</tr>
<tr>
<td>DM, CP, NDF, ADF</td>
<td>30.00</td>
<td>39.00</td>
<td>48</td>
</tr>
<tr>
<td>Minerals</td>
<td>20.00</td>
<td>26.00</td>
<td>24</td>
</tr>
<tr>
<td>Lignin, Fat, Ash, Starch, ADICP, NDICP</td>
<td>40.00</td>
<td>52.00</td>
<td>72</td>
</tr>
<tr>
<td>Digestibility</td>
<td>70.00</td>
<td>91.00</td>
<td>120</td>
</tr>
<tr>
<td>TOTAL</td>
<td>170.00</td>
<td>221.00</td>
<td></td>
</tr>
</tbody>
</table>

Even accounting for package discounts, the costs above demonstrate that a Unity Deluxe Forage Analyzer can be paid for after only 500 samples.

However, the monetary cost analysis ignores the value of the data itself. Traditional wet chemistry testing will require days to return the data, meaning the forage tested has long been implemented into the rations and limiting the impact of the results on formulating the diet. NIR results can be ready in a matter of hours, requiring only drying and grinding the sample followed by a one minute analysis. The rapid testing time means that the nutritional values are available for real-time ration balancing, allowing for more precise control of the diet, efficient use of expensive supplements, and better animal performance. Low costs and quick results also allows for more frequent testing also contributing to better control of the animal diets.

Please contact your Unity account manager to find out how you can make money with the SpectraStar XL Forage Analyzer.

John S. Shenk, Ph.D.
NIR PIONEER AND VISIONARY

John Shenk was an agronomy professor at Penn State when he became interested in NIR technology after attending a lecture from Karl Norris in 1972. In 1983, he and Mark Westerhaus formed ISI and the software became the standard used worldwide for agricultural and food applications.

John's first NIR applications were forage calibrations, and he worked in this field all his life. John Shenk was a key contributor to the development of UCal and advanced chemometric algorithms. We were privileged to work with John during the last years of his life and help him witness his visionary concepts being put into practice. We are honored to carry on his vision.