Getting More from Forages

Targeted feeding strategies:
Accounting for variability

Adjusting for forage variability
via on-farm analysis

David Mertens
Paolo Berzaghi
Introduction

Forage composition has large variability, within the lot (Collins, 2000; Stone et al., 2003) and over time (Undersander et al., 2005);

Variability in forages is unavoidable, but can be managed using sampling protocols (St. Pierre and Cobanov, 2007) and adequate analytical tools (Near infrared)
Forage variability: hay

<table>
<thead>
<tr>
<th>Constituent</th>
<th>AVG</th>
<th>SD Between bales</th>
<th>Min - max Between bales</th>
<th>SD Within bales</th>
</tr>
</thead>
<tbody>
<tr>
<td>NDF</td>
<td>40.2</td>
<td>2.0</td>
<td>36.3 – 44.1</td>
<td>2.1</td>
</tr>
<tr>
<td>CP</td>
<td>17.2</td>
<td>0.8</td>
<td>15.7 – 18.7</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Figure 1. Sampling patterns of round and rectangular bales.
## Haylage NDF – Sampling and Laboratory Consistency Evaluation

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>43.3</td>
<td>43.3</td>
<td>43.3</td>
</tr>
<tr>
<td>44.4</td>
<td>43.6</td>
<td></td>
</tr>
<tr>
<td>45.7</td>
<td>43.7</td>
<td></td>
</tr>
<tr>
<td>40.7</td>
<td>41.6</td>
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<tr>
<td>41.0</td>
<td>42.9</td>
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<td>41.8</td>
<td>43.0</td>
<td></td>
</tr>
<tr>
<td>36.0</td>
<td>36.4</td>
<td></td>
</tr>
<tr>
<td>36.3</td>
<td>37.7</td>
<td></td>
</tr>
<tr>
<td>37.8</td>
<td>37.9</td>
<td></td>
</tr>
</tbody>
</table>

Stone, 2004
Variation in forages over time

Changes in DM content of Alfalfa haylage – USDFRC Praire du Sac

(modified from Undersander et al., 2005)
Variation in forages over time

Changes in Moisture content of Alfalfa silage – USDFRC Praire du Sac July 18-August 22 2006

ALFALFA SILAGE

Bag5-04
Linear trend

%  

45  50  55  60  65  70  75  80


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Variation in forages over time

Changes in Moisture content of Corn silages – USDFRC Praire du Sac July 18-August 22 2006

CORN SILAGES

%  
80 75 70 65 60 55 50  

August 18th - Rain

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In 2008 in Dane county there were 27 rain events averaging about 20mm of rain.
Effect of rain (20mm) on a 30% DM Forage

In 2008 in Dane county there were 27 rain events averaging about 20mm of rain
## Effects of forage DM changes

<table>
<thead>
<tr>
<th>Feed</th>
<th>kg/d</th>
<th>Chem. Comp</th>
<th>CS DM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>As is, kg</td>
<td>38%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DM, kg</td>
<td>32%</td>
</tr>
<tr>
<td>Corn Silage</td>
<td>26.0</td>
<td>43.5</td>
<td>43.5</td>
</tr>
<tr>
<td>Grass hay</td>
<td>2.0</td>
<td>23.1</td>
<td>21.5</td>
</tr>
<tr>
<td>HMC</td>
<td>3.0</td>
<td>53.1</td>
<td>49.5</td>
</tr>
<tr>
<td>Ground Corn</td>
<td>2.0</td>
<td>16.4</td>
<td>17.1</td>
</tr>
<tr>
<td>Cotton seed</td>
<td>1.5</td>
<td>30.9</td>
<td>29.9</td>
</tr>
<tr>
<td>SBM</td>
<td>3.0</td>
<td>26.4</td>
<td>26.0</td>
</tr>
<tr>
<td>Extr. Soy</td>
<td>1.5</td>
<td>4.9</td>
<td>5.1</td>
</tr>
<tr>
<td>Prot-min-vit conc.</td>
<td>2.5</td>
<td>8.6</td>
<td>8.5</td>
</tr>
<tr>
<td>Water</td>
<td>2.0</td>
<td>1Milk. Kg/d</td>
<td>40.5</td>
</tr>
</tbody>
</table>

1 Predicted by the Dairy NRC 2001

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Effects of Feed Variability

Animal performance
Animal health
Excretion of nutrients
Farm profitability

Managing feed variability:
is worth $0.27/cow/day
or about 1kg of milk/d

(St-Pierre, 2006)
Value of analysis: a farm experience

• Frequent adjustments would result in an increase in productivity (value per 100 cows):

  • 1095 $/yr with the determination of DM;
  • 2190 $/yr with chem. analysis of forages;
  • 1095 $/yr with complete analysis of concentrates;

• TOTAL $4380 gained per year for 100 cows

(Tylutki et al. 2002)
Why do we need to feed cows precisely every day?

High producing cows are fed a very narrow range in diets

• The conflict between high nutrient demand and minimum fiber requirements means that dairy rations are finely tuned (balanced) to meet numerous nutrient requirements
NDF-Energy Intake System
Ration options decrease as milk production increases

Too little fiber
Feasible ration
Too much fiber
20 kg FCM/d
30 kg FCM/d
40 kg FCM/d
50 kg FCM/d

Getting More from Forages – July 29-30, 2009
Why do we need to feed cows precisely every day?

High producing cows are fed a very narrow range in diets

• Like a race car – everything is tuned for maximum power and traction – change anything (blown tire) and disaster happens!
Isn't this ration is GREAT!

Safety factor
Why do we need to feed cows precisely every day?

Difficult to over-formulate rations like we did in the past

- Can’t maintain balance of nutrients in rations for high production
  - Putting in one nutrient in excess requires the removal of another required nutrient

- Environmental concerns related to excessive nutrient excretion
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Classical Dose-Response

I sure hope they know what they are doing!
Feed Quality Control Program

• Requires
  • Frequent sampling
  • Rapid return of results
  • Accurate analytical method
  • Simple to implement
  • Low cost
NIRS Options

- **Laboratory instruments**
  - Monochromators (grating instruments)
  - Interferometers (Fourier Transform – FT)

- **Portable sensors**
  - Diode arrays
Slit - monochromator systems

- Moving parts
- Pre-dispersive
- PbS or InGaAs detectors
- Slow scanning (1 sec)
- Highly accurate
- 400-1098; 1100-2498nm
- Every 2nm
Laboratory Instruments
Diode Array

- No moving parts
- Post-dispersive
- 800-1100nm
  - Silicon detector (low cost)
- 900-1700nm
  - InGaAs detector (expensive)
- Fast scanning (10 ms)
- Very accurate
Diode Array Sensors
Water Has a Strong NIR Absorbance

Spectral changes of a forage during drying

[Graph showing spectral changes during drying]
## Monochromator vs Diode array

<table>
<thead>
<tr>
<th>Monochromator</th>
<th>Diode arrays</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab bench instrument</td>
<td>Rugged instrument</td>
</tr>
<tr>
<td>Dedicated (sample presentation not modifiable)</td>
<td>Sample presentation more flexible</td>
</tr>
<tr>
<td>Expensive (35-50K USD)</td>
<td>Less expensive (15-35K USD)</td>
</tr>
<tr>
<td>Good equation transferability</td>
<td>Equation transferability is more difficult</td>
</tr>
</tbody>
</table>
Objectives

Develop rapid on-farm DM method of analysis based on diode array near infrared sensors

Monitor forages and TMR composition overtime

Evaluate effects of single day changes in feed composition and feed allowance on milk production
Materials and Methods

10 weeks: 8 experimental wks + 2 wks of rest
Daily sampling of forages (corn and alfalfa silages) and TMRs;
Weekly sampling of concentrates;
Immediately after collection, forage samples were scanned in duplicate using a diode array sensor (HarvestLab™, Deere & Company);
In-house DM calibration for the sensor was developed with Unscrambler 9.7:
  • SECV=2.2 % R²=0.95
John Deere HarvestLab™

- Diode array w/ 128 diodes
- Range 960-1550nm
- Fast scanning (11.5 ms)
- Internal reference

- Large glass bowl (200 mm)
- Spinning bowl
- 5s scan per bowl
- Disclaimer – information provided for description only
Material and Methods

After scanning, samples were dried (55 °C), ground (1mm Wiley), and scanned on a Foss 6500 grating monochromator NIRS (Foss NorthAmerica);

Forages and TMR analyzed by NIRS using an updated (30 samples) in-house (USDFRC) calibration equation:

• aNDFom SECV = 0.89%DM \( R^2 = 0.99 \)
• CP SECV = 0.42%DM \( R^2 = 0.99 \)

Weekly samples of concentrates were analyzed by AOAC Official Methods
Material and Methods

48 cows (selected to represent a typical herd distribution)

- Parity = 2.3 ± 1.1
- Days-in-lactation = 138 ± 52
- Body weight = 592 ± 63 kg

Blocked by parity and DIM and assigned to either a Control or a Treatment (TRT) group;

Control: TMR adjusted for forage DM changes daily using an exponential moving average

Treatment: Forage DM changed one day per experimental week
### Ingredient Composition of the TMR

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>% of DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa Silage</td>
<td>27.00</td>
</tr>
<tr>
<td>bmr Corn silage</td>
<td>25.00</td>
</tr>
<tr>
<td>HM Corn</td>
<td>28.00</td>
</tr>
<tr>
<td>Roasted SB</td>
<td>10.00</td>
</tr>
<tr>
<td>SBM, 48%</td>
<td>2.50</td>
</tr>
<tr>
<td>Distillers grains</td>
<td>5.00</td>
</tr>
<tr>
<td>Blood meal</td>
<td>1.00</td>
</tr>
<tr>
<td>LactoMin</td>
<td>1.50</td>
</tr>
</tbody>
</table>
### Experimental week

<table>
<thead>
<tr>
<th></th>
<th>BASELINE</th>
<th>CHG</th>
<th>RECOVERY</th>
</tr>
</thead>
<tbody>
<tr>
<td>d1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d3</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>d4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d7</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**BASELINE** – *ad-lib.* (110% of intake)

**Change (CHG)** – ↓ offered feed or forage DM chg

**RECOVERY** – *ad-lib.* (110% of intake)
Treatments During the Day of Change

- Experimental ration with feed reduced to 88%
- Reduce the DM of CS & AS by 8%-units by adding water (repeated)
- Diet equal to Trt 2 without adding the water
- Reduce DM of CS only by 16%-units by adding water (repeated)
- Reduce DM of AS only by 16%-units by adding water
- Reduce the DM of CS & AS by 16%-units by adding water
Materials and Methods

Cows were fed individually once a day
Feed offered and refusals were measured daily
Milking 2X
Milk samples at each milking on d2-d6
Intake and milk production expressed as difference from baseline (d2 and d3)
Proc Mix with Cow as random variable within Block X Treatment group;
Variation in DM content of corn silage

AVG = 31.4 % ; SD = 0.74
Variation in DM content of alfalfa silage

AVG = 41.0 % ; SD = 3.04
Variation in DM content of TMR
Variation in aNDFom content of TMR
## Stats of Composition

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>AVG</th>
<th>SDEV</th>
<th>Min</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DM, %</td>
<td>68</td>
<td>41.0</td>
<td>3.04</td>
<td>32.4</td>
<td>47.3</td>
</tr>
<tr>
<td>aNDFom, %DM</td>
<td>53</td>
<td>37.0</td>
<td>2.30</td>
<td>32.7</td>
<td>41.0</td>
</tr>
<tr>
<td>CP, %DM</td>
<td>53</td>
<td>22.0</td>
<td>1.25</td>
<td>19.4</td>
<td>24.2</td>
</tr>
<tr>
<td><strong>CS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DM, %</td>
<td>68</td>
<td>31.4</td>
<td>0.74</td>
<td>28.9</td>
<td>33.0</td>
</tr>
<tr>
<td>aNDFom, %DM</td>
<td>50</td>
<td>40.4</td>
<td>1.77</td>
<td>37.0</td>
<td>44.7</td>
</tr>
<tr>
<td>CP, %DM</td>
<td>50</td>
<td>7.8</td>
<td>0.26</td>
<td>7.3</td>
<td>8.3</td>
</tr>
<tr>
<td><strong>TMR_CON</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DM, %</td>
<td>55</td>
<td>48.5</td>
<td>1.33</td>
<td>44.8</td>
<td>50.9</td>
</tr>
<tr>
<td>aNDFom, %DM</td>
<td>55</td>
<td>27.5</td>
<td>1.13</td>
<td>25.7</td>
<td>30.7</td>
</tr>
<tr>
<td>CP, %DM</td>
<td>55</td>
<td>17.0</td>
<td>0.62</td>
<td>15.6</td>
<td>18.6</td>
</tr>
<tr>
<td><strong>TMR_TRT</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DM, %</td>
<td>55</td>
<td>47.7</td>
<td>2.58</td>
<td>37.9</td>
<td>51.1</td>
</tr>
<tr>
<td>aNDFom, %DM</td>
<td>52</td>
<td>27.1</td>
<td>1.78</td>
<td>21.8</td>
<td>30.5</td>
</tr>
<tr>
<td>CP, %DM</td>
<td>52</td>
<td>17.0</td>
<td>0.68</td>
<td>15.6</td>
<td>19.3</td>
</tr>
</tbody>
</table>
Changes in DM Intake: by TRT

TRT*PER*WK P<0.001

Control

Treatment

DMI, kg/d

Baseline

CHG

Recovery

Baseline

CHG

Recovery

Baseline

CHG

Recovery

Baseline

CHG

Recovery
Changes in DM Intake relative to baseline

TRT*PER P<0.001

Baseline Change Recovery

DMI, kg/d

P<0.001

-2.5 -2.0 -1.5 -1.0 -0.5 0.0 0.5 1.0

Baseline Change Recovery

CON

TRT

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Changes in milk fat relative to baseline

Treatment NS
day NS

Fat, %

Baseline  Rec_d5  Rec_d6

Getting More from Forages – July 29-30, 2009
Changes in milk protein relative to baseline

Treatment NS
day P<0.001

Baseline Rec_d5 Rec_d6

Protein, %

CON

TRT

Baseline Rec_d5 Rec_d6

Getting More from Forages – July 29-30, 2009
Changes in Milk Yield relative to baseline

Treatment P<0.001

Baseline  Rec_d5  Rec_d6

Milk kg/d

CON  TRT

Treatment P<0.001

P<0.06

P<0.1

NS
Day to day DM variation in forages is unavoidable and can be large.

On-farm, rapid methods of analysis based on rugged NIR instruments can help managing such variation.

Use of these instruments must also consider integration of feed composition with feed mixing software (i.e. EZfeed, Feedwatch,......)
Cycle of Feeding
What ration is the cow really getting?

Feed DM amounts → Nutritionist’s ration

Nutritionist’s ration → Feeder’s mixed ration

Feeder’s mixed ration → Cow’s diet

Cow’s diet → Milk & Meat

Silage → Lab Analysis

Milk & Meat → Manure

Feed as-fed amounts

DM Assay
Conclusions

Single day variations in forage composition have an immediate effect on DM intake;

For decrease in DMI of one kg in a single day, 0.8 kg of milk is lost in each of the following two days

Other detrimental effects of forage variation not accounted in this trial include animal health and nutrient excretion
Getting More from Forages

Targeted feeding strategies:
Accounting for variability

Adjusting for forage variability via on-farm analysis

Questions?

David Mertens
Paolo Berzaghi