Changing Forage Quality
Testing for Alfalfa Hay Markets

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Thesis:
Hay Quality and Markets:

- Current System is nearly entirely based upon low fiber (ADF, NDF) = high quality
- This system is effective to some degree, but misses important quality attributes
- Prone to Abuses
What is Hay Quality?
What is it worth?
How should it be measured?
What is a quality Car?

Many Aspects of Quality!!

- Safety Airbags
- Nice Styling
- Great Suspension
- Good Milage
- Quality Wheels:
- Engine Power
- Good Paint Job:
What is Quality Hay?

A Nutritionist would say:

1. Total Digestible Energy (TDN, NEL, Total potential biological energy of forage)
2. Energy per unit time (Intake Potential)
3. Effectively Absorbed Protein (both rumen available and rumen undegradable)
4. Nutritionally Effective Fiber (physical value)
5. Mineral Content (ion balance)

Problem: Total Digestible Energy and feed intake are the most important issues, but cannot be directly measured!!!
Animal Performance
(True Feeding Value)

Potential Forage
Feeding Value
- Species
- Maturity
- Leaf/Stem Ratio
- Weeds, Climate, Soils,
  Pests, Variety, etc.

Potential Animal
Performance
- Species, Breed
- Genetics, Age, Sex,
  Stage of lactation,
  Health, Climate,
  Management

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Forage Quality is Multi-Faceted

- High Crude Protein
- Low Fiber
- High Fiber Digestibility
- High TDN
- Good mineral balance
- No Weeds
- Good texture/odor
But...

- Does our marketing System incorporate important aspects of quality?
- Is it subject to abuse?
What is Hay Quality Worth?

- California markets more hay than any other state
- >95% of hay is bought, sold
- Likely >80% of hay is tested at least once
- Fiber Based Marketing System
- Domestic: 95%, export <5%
Long-Term California Hay Prices (1999-2009, all markets)

Price/Ton ($)

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TDN is Predicted from ADF

TDN (90% dm)

Supreme Premium Good Fair

\[
\text{TDN} = 82.38 - (0.7515 \times \text{ADF})
\]

(x.9 for 90% DM)

ADF (100% dm)
RFV is calculated from NDF & ADF

Although RFV is calculated from ADF and NDF, it can almost entirely be predicted from NDF alone.

RFV is essentially = NDF (Weiss, 2002)
Influence of Quality on Alfalfa Hay Price
- Ten Year Average, all California Markets, 2000-2009

Average Difference due to Quality: $46/ton
Average Difference per unit ADF: $6.14/unit %ADF

y = -5.816x + 309.1
R² = 0.9987

(Ave. 13 reporting regions, approximate volume 6.5 - 7.5 million tons/year)
Does the Fiber-Based Marketing System Work?

- It works mostly, since low fiber hays are largely better in quality
- Does not incorporate other analysis
- Prone to Abuses
Abuses of Current System

- Demanding Unrealistic Precision in lab tests
- Arguments over a few tenths of a percent in lab values
Commonly- Observed Variation in Hay Testing

<table>
<thead>
<tr>
<th></th>
<th>Sampling Variation</th>
<th>Between Labs</th>
<th>Within Labs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probe-</td>
<td>Probe-</td>
<td>Lab-Lab</td>
<td>Run-Run</td>
</tr>
<tr>
<td>Probe</td>
<td>3.0 - 8.0</td>
<td>0.7 - 3.0</td>
<td>0.3 - 1.6</td>
</tr>
<tr>
<td>ADF</td>
<td>4.0 – 9.0</td>
<td>1.0 – 4.0</td>
<td>0.4 – 2.0</td>
</tr>
<tr>
<td>NDF</td>
<td>2.0 – 6.0</td>
<td>0.5 – 2.0</td>
<td>0.2 – 1.0</td>
</tr>
<tr>
<td>TDN</td>
<td>2.0 – 6.0</td>
<td>0.3 – 2.0</td>
<td>0.2 – 1.5</td>
</tr>
</tbody>
</table>

ADF 3.0 - 8.0 0.7 - 3.0 0.3 - 1.6
NDF 4.0 – 9.0 1.0 – 4.0 0.4 – 2.0
CP 20.60.0520.0
TDN 2.0 – 6.0 0.3 – 2.0 0.2 – 1.5

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Putnam & Tombaugh
Abuses of Current System

- Taking a Poor Sample
  - Follow Proper Protocols
  - 20 cores, sampling protocols
  - Certify your hay sample
Variation Between cores in a stack

Mean: 56.6

TDN (90%dm)

Pure alfalfa hay from a single ‘uniform’ stack, 20 separate cores from separate bales
The lab results are only as good as the sample.
Abuses of Current System

- Use of a Single Number
  - Overemphasis on (e.g.) TDN or RFV ignores protein, digestibility, ash, or other attributes
  - Important to incorporate visual judgement
Visual Evaluation

- Species (alfalfa)
- Leaf/ Stem Ratio (subjective)
- Maturity (presence of bloom)
- Stem Thickness (feel them - are they fibrous?)
- Weeds
  - Poisonous, noxious, irritants
- Molids/ Dustiness
- Anti-palatability Factors
  - Poor texture
    - Hard stems, coarseness
  - Evidence of heating (blackened color)
  - Evidence of excessive pests (black mold)
  - Unpleasant odors
# Relative Reliability of Visual Vs. Lab Analysis

<table>
<thead>
<tr>
<th>QUALITY FACTOR</th>
<th>VISUAL</th>
<th>LAB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage of Maturity</td>
<td>Poor</td>
<td>Excellent</td>
</tr>
<tr>
<td>Leafiness</td>
<td>Fair</td>
<td>Excellent</td>
</tr>
<tr>
<td>Fiber</td>
<td>Poor</td>
<td>Excellent</td>
</tr>
<tr>
<td>Protein</td>
<td>Poor</td>
<td>Excellent</td>
</tr>
<tr>
<td>Minerals</td>
<td>Poor</td>
<td>Excellent</td>
</tr>
<tr>
<td>Noxious Weeds</td>
<td>Excellent</td>
<td>Poor</td>
</tr>
<tr>
<td>Texture/Odor</td>
<td>Excellent</td>
<td>Poor</td>
</tr>
</tbody>
</table>

**Recommended:** Use Visual Evaluation Plus Lab Analysis
Abuses of Current System

- Encouraging Lab Bias
  - Double Check Lab Bias
  - Split Sample tests
  - Reduce demand-driven bias
Variation Between Labs—Split Sample Trial

- ADF (%) range from 24 to 36
- Average (Ave) = 30.5%
- Standard Deviation (S.D.) without outliers = 0.8%
Abuses of Current System

- Misinterpreting Calculated Values
  - Remember, RFV, TDN, RFQ, NEL, ME are all calculated values
  - Know the origins of these calculations, since it can be confusing
  - If confusion persists, refer to actual analyzed values.
Abuses of Current System

- Misinterpreting DM Data
  - DM data should be used to market for YIELD, not for quality
  - ALL forage analyses should be based upon 100% DM data for NDF, ADF, CP, NDFd, etc.
  - High moisture - look for mold or other difficulties
Abuses of Current System

- Failure to Consider Additional Analyses which may be more predictive
Intake:

- Very Important to High Producing Dairy Cows
- Less important to beef/ non-lactating cows
- Prediction difficult
What about Intake??

Dry Matter Intake (kg/d)

Time (Day Relative to Calving)

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## Alfalfa’s Value in a Ration

<table>
<thead>
<tr>
<th></th>
<th>Alfalfa</th>
<th>Corn</th>
<th>Bermuda</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk kg/day</td>
<td>23</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>Concentrate (%)</td>
<td>30</td>
<td>45</td>
<td>60</td>
</tr>
<tr>
<td>Intake (kg/day)</td>
<td>24</td>
<td>20</td>
<td>19</td>
</tr>
<tr>
<td>TDN (mix)</td>
<td>65</td>
<td>72</td>
<td>71</td>
</tr>
<tr>
<td>Net Energy (NEL)</td>
<td>1.50</td>
<td>1.61</td>
<td>1.53</td>
</tr>
<tr>
<td>TDN Intake (kg/d)</td>
<td>14.6</td>
<td>12.7</td>
<td>11.8</td>
</tr>
<tr>
<td>Milk (kg)/ Mcal NE</td>
<td>1.44</td>
<td>1.40</td>
<td>1.37</td>
</tr>
</tbody>
</table>

(Data from Mertens, 1983)

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The importance of time in estimating energy yield

(Adapted from Van Soest, 1995)
RELATIONSHIP BETWEEN ADF AND NDF DIGESTIBILITY
- 319 Samples, Western Hays

\[ y = 0.0222x^2 - 1.8041x + 77.565 \]

\[ R^2 = 0.1285 \]
Ash Content of Alfalfa

RELATIONSHIP BETWEEN ADF AND ASH - 560 Western hay samples

y = 0.0538x + 10.089
R² = 0.0128
PURPOSES OF HAY TESTING:

1) Formulate Rations
2) Determine Economic Worth
A fiber-based Market System:

EFFECT OF FIBER VALUE ON PRICE - Common Market Curve

TDN (CA equation, 90%DM):

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Hay Quality Concepts:
*(evolution of predictive tools)*

- Visual
- Proximate
- RFV for marketing (Midwest)
- ADF - TDN (Nutritionists/Marketers)

Major Question: Can Summative Equations be used for Marketing? RFQ?
### Standard Hay Test Report

#### Lab Analysis Results

<table>
<thead>
<tr>
<th>Component</th>
<th>As Rc'd</th>
<th>90% dm</th>
<th>100% dm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Matter (dm)</td>
<td>87%</td>
<td>90%</td>
<td>100%</td>
</tr>
<tr>
<td>ADF</td>
<td>26.1</td>
<td>28</td>
<td>31.0</td>
</tr>
<tr>
<td>NDF</td>
<td>33.5</td>
<td>34.7</td>
<td>38.5</td>
</tr>
<tr>
<td>CP</td>
<td>17.4</td>
<td>18.0</td>
<td>20.0</td>
</tr>
</tbody>
</table>

#### Calculated Values

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>TDN</td>
<td>52.1</td>
</tr>
<tr>
<td>NEL</td>
<td>0.53</td>
</tr>
<tr>
<td>DDM</td>
<td>57.0</td>
</tr>
<tr>
<td>RFV</td>
<td>59.0</td>
</tr>
</tbody>
</table>

#### TDN = CA Equation

### RFV = NFTA Equation

#### Category:

- **Supreme** (<27 ADF)
- **Premium** (27-30 ADF)
- **Good** (29-32 ADF)
- **Fair** (32-35 ADF)

1. A minimum of .5 percentage point variation is expected in lab results.
New Standard Hay Test:

Core Hay Analysis:
- DM - Not for quality - but for yield
- NDF - Neutral Detergent Fiber
- CP - Crude Protein
- NDFd - NDF digestibility
- Ash

Additional Analyses:
- Lignin - Many nutritionists value lignin
- DCAD - Close up animals

Calculate:
- TDN, RFV, RFQ, Summative Energy Values, NEL, RFV, RFQ, etc.

Emphasize: What is actually measured!
Remember: Only as good as the sampling procedure
What’s in a Forage Plant?

100% Dry Matter

Non Fiber Carbohydrates (NSC)
Sugars, Starches, Pectin 20-35%

Crude Protein (soluble, bound) 15-24%

Structural Carbohydrates (NDF)
(soluble, bound)

When ADF or NDF go up, Forage Quality goes down!

NFC – Non Fiber Carbohydrates need several analyses

Fat 1-3%

Ash 5-12%

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Marketing:

- Use of NDF as the first approximation of quality
- Additional interpretation of NDFd, CP, and ash
## Summary:

- **Quality is a complex trait, not conducive to a single number**

- **Fiber based marketing systems, while simple and effective, are prone to several abuses**

- **Shifting Largely to:**
  - Emphasis on NDF, Drop ADF
  - Use 100% DM values
  - Incorporate NDFd, Ash

- **Use calculated values (TDN, RFV, RFQ) but know where they come from.**

- **Visual Evaluation still important.**