Marketing of Hay Based upon Quality… What Makes Sense?

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(Photo: Steve Orloff)
What is quality?:

- Green Hay?
- Crude Protein?
- Fiber (ADF, NDF)?
- TDN?
- RFV?
- RFQ?

- How should quality hay be priced?
Humans buy hay....
But The Cow is the Final Judge
Outline

- Production of Hay in Western USA for export or domestic consumption
- Defining Quality
- How markets define quality in USA
- What do nutritionists say SHOULD be done?
- Importance of Sampling
- Conclusions
# Top US Crops (Value of Production)

<table>
<thead>
<tr>
<th>Crop:</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>Rank($)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-------</td>
<td>--------</td>
<td>--------</td>
<td>---------</td>
</tr>
<tr>
<td>Corn Grain</td>
<td>$54.7</td>
<td>$49.3</td>
<td>$48.6</td>
<td>(1)</td>
</tr>
<tr>
<td>Milk &amp; Cream</td>
<td>$35.6</td>
<td>$34.9</td>
<td>$24.4</td>
<td></td>
</tr>
<tr>
<td>Cattle &amp; Calves</td>
<td>$50.2</td>
<td>$48.9</td>
<td>$44.1</td>
<td></td>
</tr>
<tr>
<td>Soybean</td>
<td>27.0</td>
<td>29.5</td>
<td>31.8</td>
<td>(2)</td>
</tr>
<tr>
<td>Hay (all)</td>
<td>16.8</td>
<td>18.6</td>
<td>15.0</td>
<td>(3)</td>
</tr>
<tr>
<td>Hay (alfalfa)</td>
<td>8.9</td>
<td>10.7</td>
<td>8.0(4)</td>
<td></td>
</tr>
<tr>
<td>Wheat (all)</td>
<td>13.3</td>
<td>16.6</td>
<td>10.6(3)(4)</td>
<td></td>
</tr>
<tr>
<td>Cotton (all)</td>
<td>5.6</td>
<td>3.0</td>
<td>3.7</td>
<td>(5)</td>
</tr>
<tr>
<td>Potatoes</td>
<td>3.3</td>
<td>3.8</td>
<td>3.4</td>
<td>(6)</td>
</tr>
<tr>
<td>Rice</td>
<td>2.6</td>
<td>3.6</td>
<td>3.1</td>
<td>(7)</td>
</tr>
<tr>
<td>Sorghum</td>
<td>1.9</td>
<td>1.6</td>
<td>1.2</td>
<td>(8)</td>
</tr>
<tr>
<td>All Field Crops</td>
<td>$135.6</td>
<td>$137.7</td>
<td>$128.0</td>
<td></td>
</tr>
<tr>
<td>All Fruit &amp; Nut Crops</td>
<td>$ 18.9</td>
<td>$ 18.3</td>
<td>$ 17.1</td>
<td></td>
</tr>
</tbody>
</table>

*Hay & Alfalfa ranked 3rd crop in US in Value, linked to Dairy and Beef Industries*
Western Hay Production
(about 40% of US alfalfa)
There is a lot that goes into Hay Quality

Soil Preparation
Variety Selection
Planting

Standardizing Forage Quality for Markets-Putnam, 2012
Irrigate and Fertilize Properly
Control Weeds and Pests

Weeds

Alfalfa Weevil

Spotted Alfalfa Aphids
Proper Harvest Scheduling
Raking
Baling to maintain quality
Sampling for forage quality
Are we just producing “Stuff that cows eat?”

Or specific nutrients that produce milk?
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CHANGE IN MILK PRODUCTION - CALIFORNIA 1970-2008

\[ y = 0.0014x^2 - 5.6563x + 5539.4 \]
\[ R^2 = 0.9919 \]

\[ y = 0.0394x - 76.797 \]
\[ R^2 = 0.9642 \]

\[ y = 0.0214x - 41.071 \]
\[ R^2 = 0.9826 \]
Production per Cow

23,025 lbs
10,134 liters/year
5,870 lbs
2,584 liters/year

NASS Data - CA
Dairy Efficiency

Change in Milk Production/Cow/Year (CA)

2.1% Per Year
Increase in milk production per cow

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Why Such Increase in Dairy Production Per cow?

- Improved Bovine Genetics
- Better Dairy Management
  - Cow Comfort/ Veterinary
  - Culling Rates
- Better Feeding Strategies
  - High Quality Alfalfa Hay
  - Concentrated Feeds/ Grains
  - Scientific Ration Balancing
Dominant US Feeding Systems:

- Alfalfa Hay
- Corn silage
- Small Grain Forage or grasses (Wheat/ Oat/ Barley/ Triticale/ ryegrass)
- Corn grain
- Soybean/ Canola Meals
- Mineral Supplements
Major Milk Production Areas:

- **Northwest**
- **Upper Midwest**
- **Northeast**
- **Southwest**
No Coincidence: Alfalfa Hay is Associated with Dairy!!
Export
Buying and Selling Hay Requires a system to determine quality.
Dairy Cows are the Judge
(Overseas or in America)
Key Perspective on Markets:

- Dairy markets dominate and (mostly) set quality standards
- Hay is often tested 3x (grower, broker, dairy) in Western states.
- People frequently argue over quality and price, but the system seems to work
- The definitions of forage quality are highly flexible.
- Quality will be increasingly important in the future.
Changing Concepts of Forage Quality Prediction

Subjective Evaluation (color, odor) (1950s)

↓

Proximate Analysis, Crude Protein

↓

Crude Fiber, Modified Crude Fiber (1960s)

↓

Detergent Fiber System (1970s) (CP, ADF/ NDF, TDN, RFV)

↓

Rate Related or Digestibility estimates

Summative Equations
Demand for Quality has Changed over time
1970-2000

\[ y = 0.0665x + 53.024 \]

\[ R^2 = 0.7606 \]

Ave. all cuttings, data from Petaluma Labs, CA
mostly N. California (Intermountain) samples

Standardizing Forage Quality for Markets-Putnam, 2012
## Current USDA Hay Quality Guidelines

<table>
<thead>
<tr>
<th>Category</th>
<th>ADF</th>
<th>NDF</th>
<th>RFV</th>
<th>TDN (90)</th>
<th>CP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supreme</td>
<td>&lt;27</td>
<td>&lt;34</td>
<td>&gt;180</td>
<td>&gt;55.9</td>
<td>&gt;22</td>
</tr>
<tr>
<td>Premium</td>
<td>27-29</td>
<td>34-36</td>
<td>150-180</td>
<td>54.5-55.9</td>
<td>20-22</td>
</tr>
<tr>
<td>Good</td>
<td>29-32</td>
<td>36-40</td>
<td>125-150</td>
<td>52.5-54.5</td>
<td>18-20</td>
</tr>
<tr>
<td>Fair</td>
<td>32-35</td>
<td>40-44</td>
<td>100-125</td>
<td>50.5-52.5</td>
<td>16-18</td>
</tr>
<tr>
<td>Utility</td>
<td>&gt;35</td>
<td>&gt;44</td>
<td>&lt;100</td>
<td>&lt;50.5</td>
<td>&lt;16</td>
</tr>
</tbody>
</table>

*Guidelines are based upon Visual Analysis as well as test results.*
Prices depend upon quality

California Alfalfa Hay Price Trends (10 Years)

Note: To convert from price per short ton to price per tonne (Mg), multiply by 1.102
Quality is more important in a low price year!

Influence of Hay Price on Quality Price Premium (California Marketplace)

Data are average of 13 CA market reporting districts, ave. of individual years, 1996-2011. Approximate volume of 7.4 million short tons (6.7 million Mt) per year. *2011 projected

Note: To convert from price per short ton to price per tonne (Mg), multiply by 1.102

y = 1068.6x^{-1.574}
R² = 0.5916
Average Effect on price of fiber measurements (also = TDN or RFV)

Influence of Quality on Alfalfa Hay Price
Long Term Average, all California Markets, 1996-2012

Average Difference due to Quality top-bottom: $65/ton
Average Difference per unit ADF: $6.80/unit %ADF

(Ave. 13 reporting regions, approximate volume 6.5 - 7.5 million tons/year)
Alfalfa is not subsidized. Average Price Determined by

- **Supply**
  - Acreage, Competing crops, Yield, weather

- **Demand**
  - Milk Price, cow number
  - Price of other commodities
  - Exports, horse

- **Quality**
Why is $RFV = \text{fiber}$? $RFV$ is calculated from $NDF$ & $ADF$.

Figure 6. RFV as a function of NDF
(CA Data)

$y = 20032x^{-1.3297}$

$R^2 = 0.992$

Although RFV is calculated from ADF and NDF, it can almost entirely be predicted from NDF alone. RFV is essentially $= NDF$ (Weiss, 2002)
TDN is calculated directly from ADF (TDN = ADF)

\[
\text{TDN (90\% dm)} = 82.38 - (0.7515 \times \text{ADF}\%)
\]

(x.9 for 90\% DM)
Currently in US: Mostly A Fiber-based Marketing system

- **RFV Method**
  - Essentially 100% related to NDF alone
- **TDN Method**
  - Exactly 100% related to ADF alone
- **CP**
  - Generally less important that fiber, but is considered

In the US we have a **Fiber-Based Marketing System**
Does the Fiber-Based Marketing System Work?

- Generally yes, since low fiber hays are largely better in quality and produce more milk.
- There are several important aspects that this misses.
- Protein has a secondary influence on price.
- What are its limitations?
Note: Needs for Testing are Different:

Markets:
- Simple
- Within Commodity
- Few Analyses
- High Repeatability
- Between Buyer & Seller

Ration Balancing:
- Complex
- Between Commodities
- Many Analyses
- Must Predict Animal Performance
- On Farm (e.g. dairy)
What is Hay Quality?
What is a quality Car?

Many Aspects of Quality!!

- Safety Airbags
- Nice Styling
- Good Milage
- Repair Problems?
- Engine Power
- Good Paint Job:
- Great Suspension
- Quality Wheels:
- Nice Styling
- Safety Airbags
- Engine Power
- Good Paint Job:
- Great Suspension
- Quality Wheels:
Alfalfa has Several Quality Attributes

- Intake Potential
- Functional Fiber
- Protein
- Palatability
- Leaf Percentage
- Energy
- Minerals
- Fiber Digestibility
Ask a nutritionist: 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!!!
(Leaves: 12-18% ADF, 22-30% CP)

(Stems: 28-45% ADF, 12-18% CP)

(Cell Solubles-(NSC) 100% digestible)

(ADF/NDF)

25-35%

30-50%

15-25%

2-3%

8-13%

NON-STRUCTURAL CARBOHYDRATES (NSC-Sugars, Starch, pectin)

STRUCTURAL CARBOHYDRATES (NDF-Cellulose, hemi-cellulose, lignin)

PROTEINS (Soluble & bound)

OILS (lipids)

ASH (minerals)

Whole Plant

Plant Cell

Whole Plant Analysis

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### Production response of cows fed diets with varying forage quality

<table>
<thead>
<tr>
<th>Alfalfa maturity</th>
<th>% Concentrate</th>
<th>Pre</th>
<th>Early</th>
<th>Mid</th>
<th>Full</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>FCM, lb/d</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>79.2</td>
<td>68.2</td>
<td>57.2</td>
<td>52.8</td>
</tr>
<tr>
<td>37</td>
<td></td>
<td>83.6</td>
<td>68.2</td>
<td>63.8</td>
<td>55.0</td>
</tr>
<tr>
<td>54</td>
<td></td>
<td>85.6</td>
<td>77.0</td>
<td>66.0</td>
<td>63.8</td>
</tr>
<tr>
<td>71</td>
<td></td>
<td>85.8</td>
<td>77.0</td>
<td>63.8</td>
<td><strong>70.4</strong></td>
</tr>
</tbody>
</table>

Adapted from Shaver and Jorgensen, 1985. 
Hoard’s Dairyman
## 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)
What about Intake??

![Graph showing the dry matter intake of cows over time, with lines for Multi-MF, Primi-MF, and Multi-HF groups.](image)

The graph illustrates the dry matter intake (kg/d) for cows in different groups over time, relative to calving. The data shows a trend in intake with time, indicating variations in forage quality and its impact on intake across different groups.
The importance of time in estimating energy yield

Digestible Energy

Hours of Fermentation

0 12 24 36

Timothy

Alfalfa

(Adapted from Van Soest, 1995)
NDF Digestibility - important!

NDF Digestibility and ADF Values - Western Hays in Relationship to hay Marketing Categories

- Supreme
- Premium
- Good
- Fair
- Utility

NDF Digestibility (%) vs. ADF Concentration (%)
Ash Content of Alfalfa

RELATIONSHIP BETWEEN ADF AND ASH - 560 Western hay samples

\[ y = 0.0538x + 10.089 \]

\[ R^2 = 0.0128 \]
Arguments over small changes in fiber as affecting price ignore other important measurements.
Limitations of Current System

- Need to incorporate digestibility, fermentation, fate of protein, dynamic aspects of quality
- Overemphasizes small differences in fiber, which cannot be measured practically
- Need to include visual analyses

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Visual Evaluation Still important!

- Leaf/Stem Ratio (subjective)
- Maturity (presence of bloom)
- Stem Thickness
- Weeds
  - Poisonous, noxious, irritants
- molds/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
Is Bleaching Important?

Sun bleached

Green

Standardizing Forage Quality for Markets-Putnam, 2012
Sunbleaching (discoloration) - not rain damage
### Effect of Sunbleaching on Forage quality (recent UC data)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>ADF</th>
<th>NDF</th>
<th>CP</th>
<th>dNDF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunbleached</td>
<td>32.8</td>
<td>38.1</td>
<td>20.2</td>
<td>39.1</td>
</tr>
<tr>
<td>Unbleached</td>
<td>32.6</td>
<td>38.5</td>
<td>19.7</td>
<td>38.8</td>
</tr>
<tr>
<td>Frozen</td>
<td>32.2</td>
<td>38.6</td>
<td>20.0</td>
<td>43.1</td>
</tr>
</tbody>
</table>

Harvest (cut)  
Bleaching  
H x B  

- *** indicates significant difference at the 0.01 level.
- ** indicates significant difference at the 0.05 level.
- Ns indicates no significant difference.

2 Years Data, 2010, 2011. 4 cuttings
Does Yellow Color Matter?

- No!
- Color matters only to humans
- Leaf-stem Ratio much more important
- Discoloration due to rain or mold is a different matter.
- Odor and texture (‘softness of stems’) is much more important to animals.
How to Use Lab Values for Marketing?
(Survey of 33 Animal Nutritionists - Nov. 2011)

- These are professional Animal Nutritionists who make recommendations on purchasing Feeds
- Average 62,000 animals each, 100s of dairies
Key Findings (recommendation of nutritionists):

- Use only **100% DM Data** (use only 100% DM quality data)
- Use lab value not calculated value such as RFV, TDN or RFQ.
- 75-80% of Price should be based upon lab data, 20-25% on visual analysis
Key Findings: What is Most Important?

- Use NDF or ADF (fiber) first
- Use CP (Protein) as a second consideration
- NDFd (Digestibility estimates) are very useful but need further standardization.
- Ash, lignin may be helpful
So, What to test for Alfalfa?:

**Core Quality Analysis:**
- DM - Not for quality - but for yield
- NDF - Neutral Detergent Fiber
- CP - Crude Protein
- NDFd - NDF digestibility
- Ash (perhaps)

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

**Calculations:**
- TDN, NEI (energy estimates)
- RFV, RFQ, Summative Equations

**Emphasize:** What is actually measured!

**Remember:** Only as good as the sampling procedure.
The Future:

- Better methods of measuring, sampling and predicting:
  - Intake, digestibility (dynamic aspects of energy utilization) will be more important
  - Protein Utilization & protection (not just CP)
  - Physical and olifactory aspects of quality
  - Better Sampling
Sampling is critical:
The lab results are only as good as the sample.
Commonly-Observed Variation in Hay Testing

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

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Putnam & Tombaugh

UC Davis Aggies
Variation Between cores in a stack

TDN (90% dm)

Mean: 56.6

Pure alfalfa hay from a single ‘uniform’ stack, 20 separate cores from separate bales

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Putnam & Tombaugh
Variation Between cores in a stack

Variation between cores in alfalfa hay. Crude protein%
Take enough Probes (20)!

If only one core is taken, a 5-point spread is possible. However, with 18-20 cores, this is reduced to +/-0.5 point (normal variation is 0.25 points). These are from actual data taken from a seemingly uniform stack.
Take enough Probes!

RFV- Effect of Sampling

Number of Samples

RFV Result

St.Dev+Mean
St.Dev-Mean
Max Result
Min Result
Average

Normal
A Standardize Sampling Protocol

- Includes:
  - Sharp Coring Device
  - Defining a ‘Lot’ (single cut, field)
  - 20 probes (composite)
  - Using certified labs

- On line Protocol, test (http://foragetesting.org)

- Assures markets of the proper sampling methods

- Free

- Currently 1500 certified samplers
Probing Technique

- Sharp Coring Device (90 degree angle)
- Keep tip sharp
- Diameter 3/8”-3/4”
- 12-16” within bale - eliminate surface
- Sample 90 degrees to butt-end of bales
- Random process (don’t eliminate bales)
- Can use spiral assist with power tools
Proper hay sampling
http://foragetesting.org
So what to measure?

- Is CP sufficient? (No, but a useful number)
- Fiber (ADF, NDF) powerful predictors of quality and useful.
- Fiber Digestibility & intake estimates becoming more important
- Remember – medium quality but weed-free alfalfa hay is very appropriate for different classes of animals
Quality is a complex trait, not readily reduced to a single number. It is important to utilize several attributes (fiber, protein, digestibility). Necessary for markets to have simplicity & Transparency. Fiber based marketing systems dominate, utilizing CP as second tier criteria, then digestibility. Quality demand depends upon the class of animal.
Need Standardize Sampling Methods
- (Certify your sample – foragetesting.org)

For Alfalfa, Key measurements:
- NDF, CP, NDFd, Ash, Primarily
- Use 100% DM standardized Values

Visual Evaluation still important (weeds, mold, odor)
THANK YOU!

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http://alfalfa.ucdavis.edu

Slide: Jim Kuhn

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