



Forage Quality & Testing

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C&SS 310: Forages



Forage Quality & Testing Overview



This presentation will:

- define forage quality,
- explain why it's important,
- discuss factors affecting quality, and
- describe how forage quality is tested and matched to animal requirements

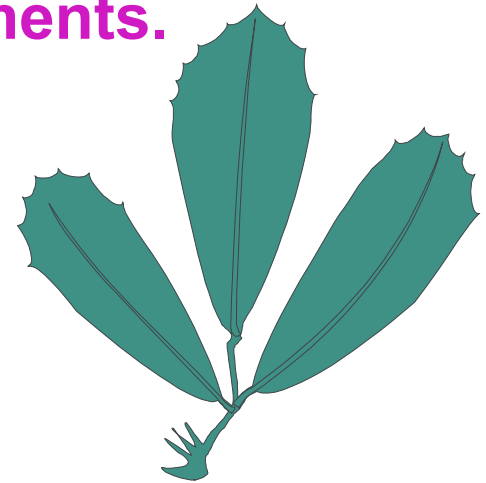


What is Forage Quality?

The capacity of a forage to supply animal nutrient requirements.

This includes:

- acceptability (palatability),
- chemical composition, and
- nutrient digestibility.



Will the animal consume it and be able to digest it?

Once digested, will the forage provide the needed nutrients for growth and good health?

What is Forage Quality?

The potential to produce milk, meat, wool, or work.

Animals are the most accurate forage quality testers.
Conversion of forage into animal product is the ultimate measure of forage quality.



What is Forage Quality?

Forage quality is:

the capacity of a forage to supply animal nutrient requirements.



“Forage quality is the extent to which a forage has the potential to produce a desired animal response.”

Ball, et al., 2001. “Understanding forage quality.” Land Grant Universities, American Farm Bureau, American Forage & Grassland Council, National Forage Testing Association, and National Hay Association collaborative publication.

Why is forage quality important?



- Forage quality has a direct affect on animal performance, forage value, and profits.
- Higher quality forage results in:
 - Greater weight gain,
 - Increased milk production,
 - Higher reproductive efficiency (conception rates).

What Factors Affect Forage Quality?

1. Species

- Legumes vs. grasses / mixtures
 - Legumes are higher in protein and have faster rates of fiber digestion.
- Cool-season vs. warm season
 - Cool season grasses are more digestible due to anatomy differences.

2. Cultivars

- Breeding can improve quality and maturity differences can be large.

3. Temperature

- Plants grown at high temperatures produce lower quality forage due to lignification.

4. Maturity stage

- Maturity stage at harvest is the most important factor determining forage quality of any species.



What Factors Affect Forage Quality?

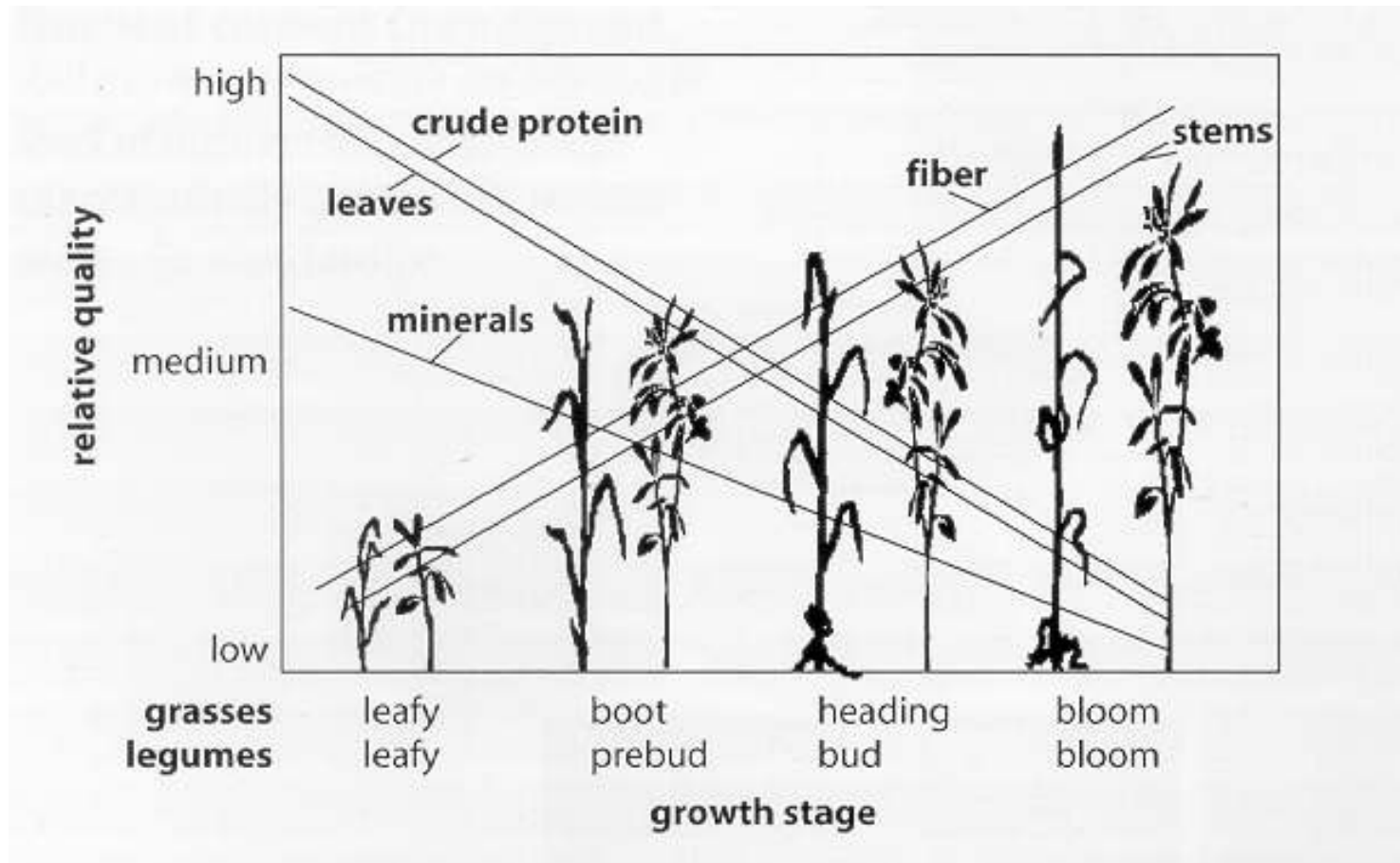
Maturity stage

Forage quality declines rapidly with advancing maturity.



Maturity stage:

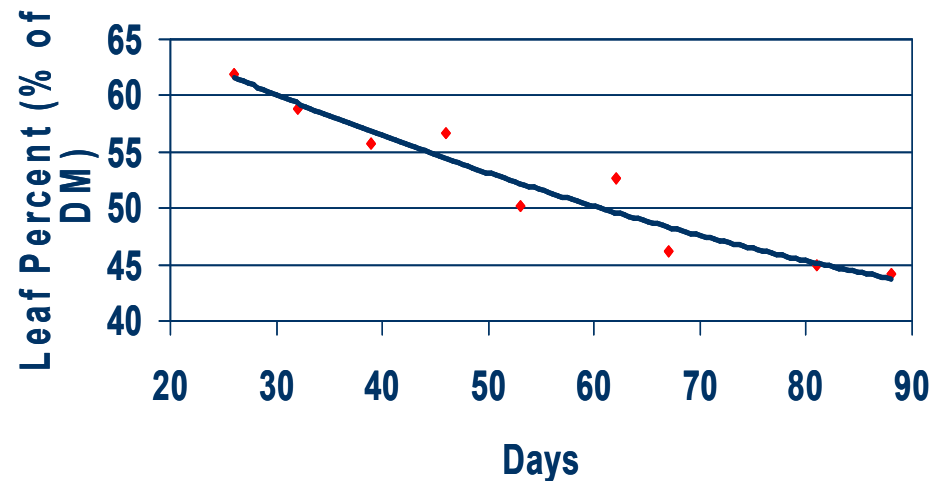
Forage quality declines rapidly with advancing maturity.



What Factors Affect Forage Quality?

5. Leaf-to-stem ratio

- Leaves are higher in quality than stems.



6. Fertilization

- Most important for grasses; N fertilization increases yield and crude protein ($\%N \times 6.25$).

7. Harvesting and storage techniques

- Field losses include rain damage, leaf loss, and plant respiration.
- Storage losses to uncovered bales can be 40%.

Managing for high quality:

- Choose adapted species
- Include legumes if possible
- Fertilize and control pests
- Harvest at early maturity stage
- Protect from deterioration
- Allow adequate re-growth time

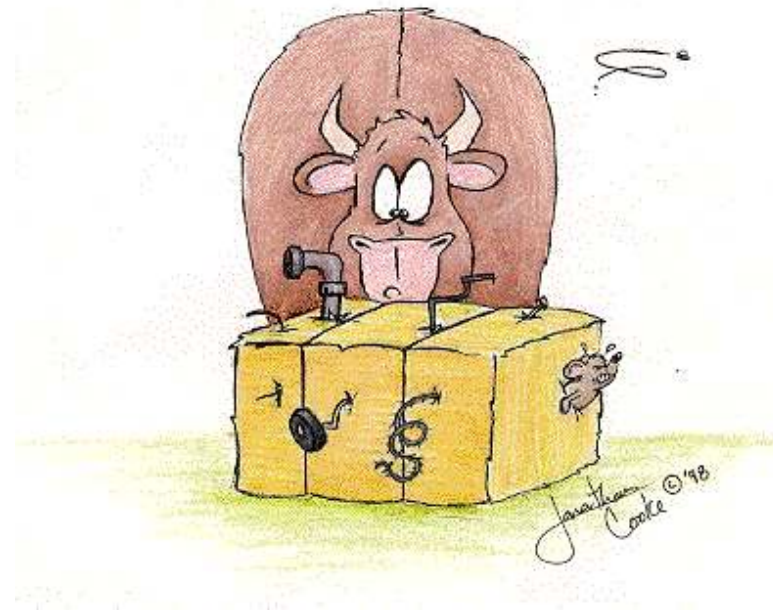


Timely operations are key to successful farming and ranching.

Forage Quality Evaluation

How are forages tested?

- Sensory (organoleptic) evaluation,
- Chemical analysis, and/or
- Feeding trials.



Forage Testing: Sensory (organoleptic)

What are the factors?

- Species
- Maturity stage
- Leafiness
- Color
- Odor & condition
- Foreign material



Key Forage Components

Forage quality: “the capacity of a forage to supply animal nutrient requirements.”

Those nutrients are many but the main components of interest are:

- Calories (energy),
- Protein,
- Vitamins,
- Minerals, and
- Water



Forage Testing: What are the tests?

<http://forages.orst.edu/topics/description.cfm?TopID=324>

- **Dry matter (DM):** the percentage of the feed that is not water. DM equals 100 percent minus percent water.
- **Crude protein (CP):** a mixture of true protein and non-protein nitrogen. $CP = \%N \times 6.25$.
- **Neutral detergent fiber (NDF):** the sample residue after treatment with neutral detergent; primarily hemicellulose. Predicts animal intake (higher NDF gives lower intake).
- **Acid detergent fiber (ADF):** the sample residue after treatment with acid detergent; primarily cellulose, lignin, and ash. Predicts forage digestibility (higher ADF gives lower digestibility).
- **ADF-N:** acid insoluble nitrogen. Predicts by-pass protein.
- **Lignin:** indigestible, complex carbohydrate.
- **Minerals:** required for animal growth and development; typically K, P, Ca, Mg, S, Se, Zn, Cu, Mn, Mo.



Forage Testing: Chemical Analysis

Two techniques:

- Traditional laboratory
- NIRS (near infrared reflectance spectroscopy)




Forage Testing: Chemical Analysis – Traditional

<http://forages.orst.edu/topics/description.cfm?TopID=324>

Also called “wet chemistry”

- Uses acids, detergents, solvents, extractions, drying ovens, and balances
- Standard procedures defined by professional association (AOAC; now the Association of Analytical Communities: <http://www.aoac.org/>)





Forage Testing: Chemical Analysis – NIRS (Near Infrared Reflectance Spectroscopy)

- Techniques developed by years of applied research by USDA ARS scientists.
- Improved and has become popular in last decade.
- Fast and precise, but must be adequately calibrated to be accurate.
- NIRS works like this: A special lamp emits energy into a grating that separates it into a rainbow of wavelengths between 1100 and 2500 nanometers. The energy is focused onto a sample of material, and detectors read the patterns of reflectance.

<http://mark.asci.ncsu.edu/nutrit~1/Miscellaneous/theo96csnc.htm>



Forage Testing: Feeding Trials

The “truest” method:

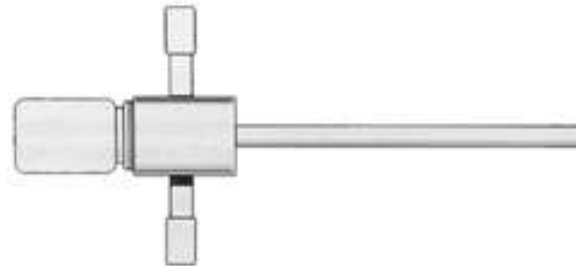
- Based on animal performance measures
- Used to calibrate other methods
- Expensive, lengthy



Forage Sampling: the basis of all analyses

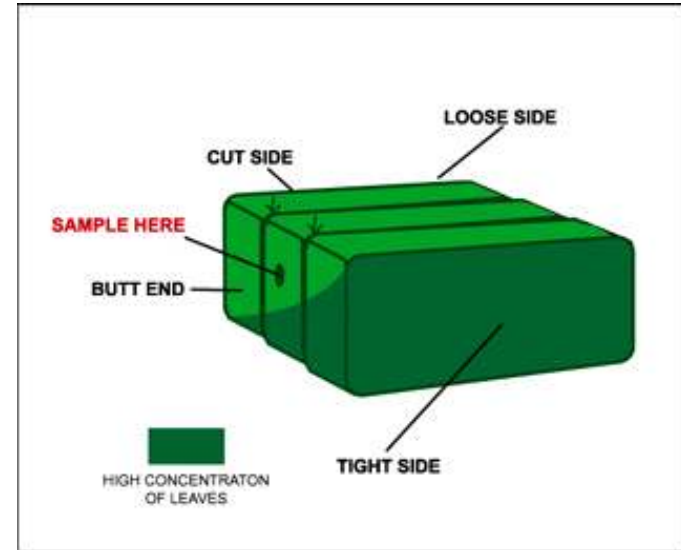
Sample must be:

- Representative of what's being predicted



Forage Sampling: How to sample hay?

- Use a core sampler
 - Internal diameter 3/8 – 5/8"
- Take “enough” samples
 - At least 20 per “lot”
- Use a sampling plan
 - Obtain random sample
- Don't subsample
 - Unground samples should not be split



<http://alfalfa.ucdavis.edu/SUBPAGES/ForageQuality/ListofHayProbes.htm>

<http://www.agr.okstate.edu/alfalfa/webnews/quality6.htm>

<http://www.ag.state.co.us/mkt/hay/2001/ForageSampling.html>

http://www.oznet.ksu.edu/pr_forage/pubs/97notebook/fora36.pdf

Forage Sampling: How to sample silage?

- Collect 3-5 handfuls of chopped forage from the middle of a load during unloading
- Place in plastic bag
- Refrigerate immediately
- Repeat several times during the day
- Combine samples from single field and mix well
- Store in refrigerator until submitting to laboratory



Forage Sampling: How to sample pasture?

- Collect forage randomly from 10-20 places in the pasture
- Observe animals and collect sample to same height as they are grazing
- Refrigerate or air-dry if not sent immediately to laboratory



Anti-quality Components

Things that contribute to illnesses, poor animal gains, low consumption, and reproductive difficulties.

Important anti-quality factors of forages:

- Foreign material: nails, wire, weeds, etc.
- Biophysical factors: thorns, barbs, etc.
- Biochemical factors:
 - Lignin
 - Tannins
 - Nitrates
 - Saponins
 - Coumarin
 - Flavonoids
 - Hydrocyanic glycosides
 - Alkaloids
 - Endophytes

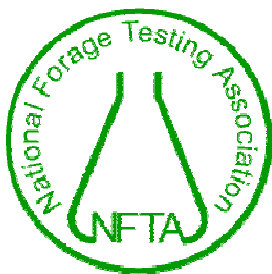
Nationally Standardized Testing

Need for: Hay is often sold for use in other states and countries. Thus, standardized measures of quality evaluation are needed for buyers and sellers.

Progress toward:

- Initial efforts pioneered in the west (CA) and PNW (OR, WA, ID).
- Standardized alfalfa hay test now used including sampling, testing, and reporting methodologies.
- Certified “Proficient” laboratories using accurate methods.
- Organization established for collaboration between industry and university and USDA activities.





National Forage Testing Association

<http://www.foragetesting.org/>

The National Forage Testing Association (NFTA) was founded in 1984 as a joint effort of the American Forage and Grassland Council, the National Hay Association, and forage testing laboratories in a concentrated effort to improve the accuracy of forage testing and build grower confidence in testing animal feeds.

Standardized tests are now used and a searchable list of certified “proficient” laboratories is posted to the web site.

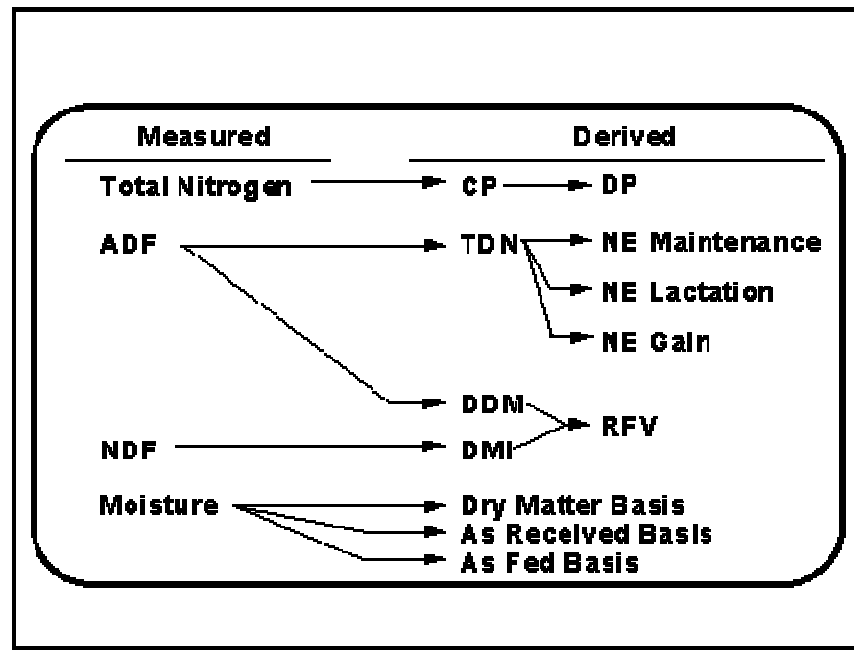


Understanding Laboratory Reports

- Analytical results should be **reported on a 100% dry matter (DM) basis**. Additional columns may be included for reporting results on an as-is (as-received) or an air-dry (90% DM) basis.
- **Dry matter**. Low moisture (<10%) could indicate brittleness. High (>18%) indicates risk of mold.
- **Detergent fiber analysis**. ADF and NDF is residue after boiling in detergent solution. (NDF approximates total cell wall constituents, including hemicellulose; ADF represents cellulose, lignin, and ash. NDF is used to predict intake potential. ADF is often used to calculate digestibility.)
- **Protein**. Commonly measured as crude protein (CP) which is $\%N \times 6.25$. (Rumen microbes can convert non-protein N to microbial protein.)
- **ADIN**. Acid detergent insoluble nitrogen – estimates low digestibility nitrogen.
- **Digestible energy estimates**. Calculated from ADF values.
- **Intake estimates**. Calculated from NDF values.

Understanding Laboratory Reports

- **Forage Quality Interpretations:**
 - <http://agweb.okstate.edu/pearl/plantsoil/crops/f-2117.pdf>
- **Relative Feed Value (RFV):**
 - <http://www.agr.okstate.edu/alfalfa/webnews/quality5.htm>
 - <http://web.aces.uiuc.edu/aim/IAH/ch8/rfv.html> (calculator)
- **Measure vs. derived values:**
 - <http://www.agr.okstate.edu/alfalfa/webnews/quality4.htm>



Forage Quality: Matching with animal requirements

NRCS publications for:

- Dairy
- Beef
- Sheep
- Horses
- Etc. etc. etc.



Publisher for THE NATIONAL ACADEMIES

 **nap.edu**



C&SS 310 Forages: Forage Quality and Testing



Key Concepts to Remember

- Ultimate measure of forage quality is animal performance.
- Most important factors are: forage species, stage of maturity at harvest, harvesting and storage techniques.
- Forage quality varies greatly and nutritional needs vary among and within animal classes.
- Leaves are higher in quality than stems.
- Legumes are usually higher in quality than grasses.
- Cool season forages are usually higher in quality than warm season forages.
- Delayed harvest due to concern about rain probably results in more forage quality loss than does rain damage.





Key Concepts to Remember (continued)

- Sensory evaluation provides important information but lab testing is required to formulate rations.
- Lab analysis uses only a few grams of material, so sampling technique is extremely important.
- Lab values are valuable but not absolute.
- Digestible energy is usually the limiting factor from forage for livestock performance.
- Lower quality forages, more mature and fibrous, take longer to digest and result in lower intake.
- Major losses in forage quality occur due to poor storage and feeding techniques.

Resources for Additional Information

1. Web sites

- **Forage Information System** <http://forages.orst.edu/>
Chemical analysis:
<http://forages.orst.edu/topics/description.cfm?TopID=324>
Sampling: <http://forages.orst.edu/topics/description.cfm?TopID=323>
- **National Forage Testing Association**
<http://www.foragetesting.org/contact.php>
- **Penn State University**
<http://www.cas.psu.edu/docs/casdept/agronomy/forage/docs/quality/quality.html>
- **Oklahoma State University**
<http://www.agr.okstate.edu/alfalfa/images/sampling/samplingphotos.htm>

2. Publications

- Understanding Forage Quality

3. Experts

- Dan Putnam (University of California-Davis;
dhputnam@ucdavis.edu)
- Dan Undersander (University of Wisconsin;
djunders@facstaff.wisc.edu)

