Forage and Pasture Quality

Forage Quality of Forage
Plants and Weeds

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Definition of “Forage Quality”

1. Forage quality reflects an animal’s response such as growth, maintenance, reproduction, work, lactation, animal product (milk, meat, wool, etc.) yield and quality when fed a particular forage.

2. Sum total of the plant constituents that influence an animal’s utilization of the feed.

3. Forage quality (i.e., the animal response when fed a forage) is influenced by the form it is fed, the palatability of the forage, and by the quality of other feeds in the diet (associative feed affects).
Forage and Pasture Quality

**Components of “Forage Quality”**

- Palatability
- Forage intake
- Digestibility
- Nutritive value
- Non-nutrient factors
  - Anti-quality factors
  - Beneficial factors

**Components of “Forage Quality”**

- Palatability – Will the animal eat it?
- Intake (dry matter basis) – How much of the forage will the animal consume?
- Digestibility – What proportion of the forage will be digested and utilized by the animal?
- Nutritional Value – Of the digested material, what amounts of nutrients (protein, energy, vitamins, minerals, etc.) are provided?
- Anti-quality factors – Are there chemicals in the forage that can deter intake, digestibility, poor utilization or cause animal disorders?

**Components of “Forage Quality”**

- Palatability - relates to forage selection (animal behavior) when there is a choice of one plant or plant part over another.

  **Examples:**
  - Thorny/bitter weeds
  - Horsenettle in hay
  - Acid preservative treated hay
  - Alkaloids in reed canarygrass
  - Tannins in birdsfoot trefoil

**Components of “Forage Quality”**

- Palatability – affected by both plant factors and animal experience

  - Smooth bedstraw contains anthraquinone compounds causing irritation or sensitization in mammals
Forage and Pasture Quality

Teaching Livestock to Eat Weeds

- Forage Intake – amount of forage dry matter consumed per day
  - Measured in lbs. d.m./day or % body weight

  Example: 1200 lb. cow eating 2.5% of her body weight
  
  1200 lbs x 0.025 = 30 lbs. forage dry matter per day

  Forage intake is greatly affected by the fiber content and fiber digestibility of the forage.

Available Pasture and Intake

- Forage Digestibility
  - Biological/Bioassay Methods
    - In vivo - whole animal studies
    - In situ - Using dacron bags placed in the rumen via a fistula to measure dry matter disappearance
    - In vitro - “test tube” method using rumen fluid and buffers to measure in vitro dry matter digestibility

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Forage and Pasture Quality

Measuring/Testing for Forage Digestibility

Digestibility (Fermentation) Kinetics

Typical in vitro dry matter digestion curves for grasses and legumes.

http://amaferm.com/2014/09/18/digestion-takes-time/

Components of “Forage Quality”

• Nutritive Value
  – Forages can meet much of the protein, energy, minerals, and vitamin needs

Components of “Forage Quality”

• Non-nutritive factors
  Examples:
  – Tall fescue endophyte
  – Phytoestrogens in clovers
  – Saponins in alfalfa
  – Alkaloids in reed canarygrass
  – Tannins in birdsfoot trefoil

Plant Constituents of “Forage Quality”
Forage and Pasture Quality

Plant Constituents of “Forage Quality”

- Cell Wall
  - Primary
  - Secondary

- Cell Interior
  - Nucleus
  - Cytoplasm

- Cell membrane

A Plant Cell

Vacuole

- Cell Wall
  - Cellulose
  - Hemicellulose
  - Lignin
  - Pectin

- Cell Interior
  - Proteins
  - Soluble CHO’s
  - Vitamins
  - Minerals
  - Non-protein N

Varies in Digestibility

> 98% Digestible

A Plant Cell

- Young Cell or Mesophyll cell
  - Low in total fiber
  - Fiber is low in lignin
  - Highly digestibility

- Mature Cell or Structural Cell
  - High in total fiber
  - Fiber is high in lignin
  - Low digestibility

The digestibility depends on the age and type of cell

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Measuring/Testing for Nutritive Value

**Chemical Methods**

- **Crude Protein (CP)**
  - Measures total nitrogen (true and non-protein N)
  - Multiply total N by 6.25 to predict “crude” protein

- **Neutral Detergent Fiber (NDF)**
  - Measures total cell wall (cellulose, hemicellulose, lignin)
  - Used to predict potential dry matter intake

- **Acid Detergent Fiber (ADF)**
  - Measures cellulose, lignin and some cell wall protein and ash fractions
  - Used to predict digestibility and energy content

- **Energy units vary according to use**
  - NE_M, NE_G, NE_L, TDN (total digestible nutrients), Digestible Energy
  - Usually “estimated” by indirect measures of digestibility or fiber content

Neutral Detergent Fiber

NDF is basically the cell wall content of the forage

As NDF goes up, intake goes down!

NDF Digestibility

Varies in Digestibility

- Cell Wall
  - Cellulose
    - Hemicellulose
    - Lignin

- Cell Interior
  - Proteins
  - Soluble CHO’s
  - Vitamins
  - Minerals
  - Non-protein N

> 98% Digestible

Vacuole

A Plant Cell

NDF Digestibility

Changes in Grass NDF and Digestible NDF

- Reed Canarygrass
  - 75 – 80% digestible NDF
  - > 98% Digestible

(NFD) % of dry matter

4-May 14-May 24-May 3-Jun 13-Jun 23-Jun

(Canton, NY)

Cows
Using NDF for targeting when to harvest your haycrop?

- Legume: 40%
- Grass: 50%
- Mixture: varies
  - MML: 42 - 44%
  - MMG: 46 - 48%

Acid Detergent Fiber

ADF has been the primary measurement to predict digestibility and energy of forages

Forage Quality Index

% ADF

... but there are problems
Forage and Pasture Quality

Forage Quality Index

The goal of a forage index is to have a single number that represents the quality of a given forage.

- **Relative Feed Value (RFV)** - Developed in the early 1980's (best for pure legumes)
- **Relative Forage Quality (RFQ)** - Developed in the early 2000's (best for legume/grass mixtures)

A unitless number in which 100 equals the feed value of full bloom alfalfa.

Factors that Affect Forage Quality

- Plant maturity at time of harvest
- Forage crop species/variety
- Climate, season and weather conditions
- Soil fertility
- Weeds, Diseases and Insects
- Harvest and storage factors
- Forage form and particle size
- Associated feeds

Forage Quality and Plant Maturity

CP: 25 20-22 18 16 10 9 8
NDF: 38 45 50 58 55 53 49
Vegetative Jointing Boot Early Head Full Head

Working horse Nursing mare
DAIRY, 1ST TRIMESTER DAIRY CALF
DAIRY, LAST 200 DAYS, HEIFER, 3-12 MO.; STOCKER CATTLE
HEIFER, 12-18 MO.; BEEF COW WITH CALF
HEIFER, 18-24 MO.; DRY COW

Idle horse

100 = feed value of full bloom alfalfa
Forage and Pasture Quality

As plants mature:

• Increase in cell wall content particularly in stems

Young Cell or Mesophyll Cell:
- Low in total fiber
- Fiber is low in lignin
- Highly digestible
- Predominant in leaves

Mature Cell or Structural Cell:
- High in total fiber
- Fiber is high in lignin
- Low digestibility
- Predominant in stems

• Decrease in cell wall digestibility

• Decrease in leaf-to-stem ratio

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Leaf-To-Stem Ratio

Alfalfa Quality

- Leaf
  - 23% CP
  - 27% NDF
  - 18% ADF

- Stem
  - 10% CP
  - 66% NDF
  - 51% ADF

Whole plant quality will depend on leaf-to-stem ratio

Factors the Affect Forage Quality

- Maturity at time of harvest
- Forage crop species/variety
- Climate, season and weather conditions
- Soil fertility
- Weeds, Diseases and Insects
- Harvest and storage factors

Species and Forage Quality

Forage Crop Species
- Legumes verses Grasses

Species and Forage Quality

Legumes Verses Grasses
- Generally, legumes maintain their quality longer as plants mature
Variety and Forage Quality

Variety

• Generally, variety has less impact on quality than most other factors, except...
  – If a variety improves palatability or decreases anti-quality factor
  – Varieties may differ in heading date which can affect ease of making good hay

What about quality and palatability issues with tall fescue?

• Endophyte levels?

Most all newer tall fescue varieties sold for haylage or pasture is either endophyte-free or has a “novel” endophyte

Endophyte Infected Tall Fescue

Fungal hyphae grow between total cells, with the highest concentrations in the stem and seedheads.

Species/Variety and Forage Quality

Forage Crop Species/Varieties

Anti-quality factors

• Fescue endophyte
• Reed canarygrass alkaloids
• Red clover slobbers
• Nitrates
• Clover estrogens
• Etc.
Forage and Pasture Quality

Tall Fescue Alkaloids

Ergovaline
One of the Ergot Alkaloids

Loline

Northeast study conducted by USDA-ARS

Abundance in the Northeast: Tall fescue was found on 89% of the farms sampled and 84% of the pastures. Its average cover was 17.3%, while present (range 0.1 - 89.9%).

Testing for endophyte
• ELISA test
• Randomly collect 60 to 100 fresh tillers
• Cut out and save the lower portion (crown and lower three inches of the tiller)
• Keep cool and fresh

Stem cross sections are placed in ELISA cells for detection

What about quality and palatability issues with tall fescue?
• Endophyte levels
• Leaf coarseness

Leaf coarseness is not likely an issue with haylage put up at high quality but it can be an issue for pasture mixtures especially with dairy cows.

Northeastern United States 2014
Research Unit, Blag, 3752 Overton Rd., University Park, PA 16802

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**Forage and Pasture Quality**

- **Tall Fescue Leaves Can Be Very Coarse**
- **Soft-Leaved Tall Fescue**
- **The Fescues**
  - Tall Fescue
  - Meadow Fescue
  - Characteristics
    - More palatable than tall fescue
    - Higher NDF digestibility
    - More winter hardy
    - Lower yielding than tall fescue
- **Meadow Fescue**

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Factors that Affect Forage Quality

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- Forage crop species/variety
- Climate, season and weather conditions
- Soil fertility
- Weeds, Diseases and Insects
- Harvest and storage factors

Weather and Forage Quality

- Warm, sunny conditions promote photosynthesis which improves growth and energy
- Cool, cloudy weather decreases energy
- Hot temperatures increase lignin content
- Dry weather often increases sugar content and legume content
- Generally, excessive rainy seasons are the worse on forage quality

Are all weeds bad?

Pasture Yield = Forage Crop + Weeds
Weeds

- Weeds can have similar forage quality to forage plants
- Their quality response to maturity is similar
- Weeds tend to mature quicker than most crops

Weeds Can Be Nutritious

<table>
<thead>
<tr>
<th>Weed</th>
<th>% Crude Protein</th>
<th>% Fiber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Redroot Pigweed</td>
<td>20±3.2</td>
<td>18±7.5</td>
</tr>
<tr>
<td>Virginia Sedge</td>
<td>21±4.1</td>
<td>15±6.9</td>
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Weeds Can Be Unpalatable or Toxic

- Numerous books, fact sheets, and websites on toxic plants
  - Trust university or science-based publications
- Consult with veterinary scientist if you have concerns

Info on Poisonous Plants

http://research.vet.upenn.edu/poisonousplants/Home/tabid/5034/Default.aspx

www.extension.purdue.edu/extmedia/WS/WS_37_ToxicPlants08.pdf
Sampling and Testing For Forage and Pasture Quality

Sampling Procedure
Modified from Dairy One:
• Randomly select 12-20 sites where the animals will soon be grazing and clip a handful of forage at grazing height.
• All subsamples should be combined and thoroughly mixed in a clean plastic bucket to form a composite (further cutting the forage into 2 - 3 inch (5 - 8 cm) pieces aids in blending).
• Take a one pound (0.5 kg) sample, pack tightly in a plastic bag and freeze for 12 hours prior to submitting for analysis.
• Freezing will help prevent marked chemical changes due to respiration or fermentation.

Testing For Forage Quality
• Wet chemistry
  - Crude Protein (N)
  - ADF, NDF
  - Starch
  - Minerals
• In vitro methods (DDM, Dig. NDF)
• Near Infrared Reflectance Spectroscopy (NIRS)

Methods of Analysis

Testing For Forage Quality
• Near Infrared Reflectance Spectroscopy (NIRS)
  - Used to predict wet chemistry and in vitro constituents
Forage and Pasture Quality

Any questions?