Forage Quality I: Nutritional Quality

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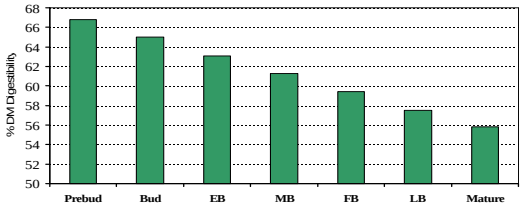
Effect of stage of maturity of green chopped alfalfa-bromegrass forage on DM digestibility

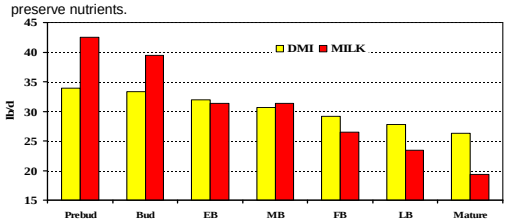
Research has demonstrated that forage digestibility decreased with forage maturity. This occurs for all types of forage crops.



Hibbs and Conrad. 1974. Ohio Rpt. 59(2):33.

Stage of maturity of green chopped alfalfa-brome forage and performance

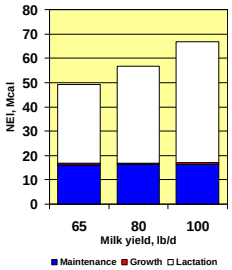
As forage quality declines, so does DM intake and milk yield. Because of this, dairy producers and research have worked to develop improved forages which have higher quality potential and identify management practices to harvest and preserve nutrients.



Hibbs and Conrad. 1974. Ohio Rpt. 59(2):33.

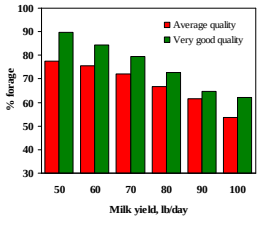
Energy Requirements for Milk Production

- ✓ Lactating dairy cows required large quantities of energy to produce milk. As milk yield goes up, so does the total energy requirement.
- ✓ High milk yield, reproduction, and cow health can be best sustained when high quality



Forage quality influences ration formulation and performance

- ✓ Forage quality determines how much forage can be fed in the ration to maintain production or growth.
- ✓ Low quality forage limits intake and reduces milk yield (or ADG) below that expected and increases feed cost.
- ✓ As animal performance increases, the effects of forage quality are more pronounced.



Dairy producers use a variety of forages

- Corn silage
- Alfalfa hay or silage
- Orchardgrass
- Ryegrass
- Winter annuals
- Clovers
- Forage sorghum
- Summer annuals
  - Millet
  - Sorghum silage
- Bermudagrass
- Bahia grass
- Other

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Defining Forage Quality

- ✓Quality should be defined in terms related to how the animal can use the forage to meet its nutrient requirements for maintenance, growth, production, and/or reproduction.
- ✓Forage must be palatable, provide a desirable nutrient balance, and the nutrients must be digestible.

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Defining Forage Quality

✓Physical Evaluation
- Maturity
- Leafiness
- Texture (soft or harsh)
- Color
- Odor
- Dusty
- Foreign matter

✓Chemical Analysis
- DM
- CP
- ADIN (bound protein)
- ADF
- NDF
- *In vitro* NDF digestibility
- Ash
- Mineral content
  - Ca, P, Mg, K, Cl, S, etc.

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Physical Evaluation

- ✓Provides a good general characterization of the forage
  - Maturity (presence of seed heads)
  - Potential weather damage
  - Presence of any mold or dust
  - Presence of weeds
  - Etc.
- ✓Physical evaluation does not replace chemical analysis
  - Can not visually estimate nutrient content or catch potential problems (ex. nitrates)

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Chemical Analysis

- ✓Representative samples of the forage are essential for obtain useful information
- ✓Use the same laboratory for analysis as results may vary between labs because of different methods.
- ✓If the laboratory does not have a good data base for your forage, use wet chemistry rather than NIR.

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Which analysis are important?

- ✓Dry matter content (results expressed on DM basis)
- ✓Crude protein
  - Degradable or soluble protein concentrations are desirable to balance protein fractions
- ✓Unavailable or bound protein (if heat damage is suspected)
  - Acid detergent insoluble nitrogen (ADIN)

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Unavailable or bound protein

- ✓ Not all protein in forage is available.
- ✓ Protein is component of the cell wall (fiber) and is not digested. This is typically a small fraction and is measured as neutral detergent insoluble protein (NDFCP).
- ✓ If forage undergoes prolonged heating, some of the protein binds with sugar to form an undigestible product through the Maillard reaction. This is similar to the process of making caramel candy, so the forage has a sweet, caramelized smell. The bound protein is excreted by the animal and does not contribute to protein requirements.
- ✓ Measured as acid detergent insoluble nitrogen (ADIN) or crude protein (ADICP)

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Which analysis are important?

- ✓ Neutral detergent fiber (NDF) and acid detergent fiber (ADF)
  - Used for estimating energy content (net energy for lactation or NE_L. Dairy industry does not use crude fiber or TDN.
  - Important for estimating intake potential or fill
- ✓ In vitro NDF digestibility
  - Determines the digestibility of the NDF fraction and is used to adjust the energy content of the forage
- ✓ Mineral concentrations
  - Rations are balanced for individual macro mineral concentrations as well as select micro minerals (esp. copper, iron, manganese, zinc).
  - Need to limit potassium concentrations in rations fed to close-up dry cows

Additional Chemical Analysis

These are occasionally run to provide more detailed ration formulation.

- ✓ Neutral detergent fiber protein (NDFCP) and acid detergent fiber protein (ADFCP)
- ✓ Fat or ether extract
- ✓ Starch and sugar
- ✓ Lignin
- ✓ Sulfur and chlorine
- ✓ Kd analysis (rate of in vitro NDF digestion)
- ✓ In situ protein digestibility

Calculated Analysis

- Net energy of lactation, maintenance, and gain are calculated using ADF and/or NDF concentrations.
- Non-fibrous carbohydrate (NFC) is an estimate of the starch and sugar content and is calculated as100 - (ash + CP + NDF + fat).
- Relative forage value (RFV) and relative forage quality (RFQ).

RFV and RFQ

- RFV and RFQ are indexes used to describe the quality of forage within forage type
  - Can not compare RFV or RFQ of an alfalfa to an alfalfa-grass hay mix or bermudagrass. Must use within forage types.
- RFQ attempts to improve RFV by including estimated nutrient digestiblity for fiber and should do a better job of indexing potential energy available from the forage than RFV.
- Neither index includes considerations for protein and other nutrients (sugar, starch, etc.) that may be important, depending on the type of forage.

In vitro NDF Digestibility

- ✓ Increasing NDF digestibility reduces rumen fill and increases passage rates which supports higher dry matter intake (greater nutrient intake to support milk production).
- ✓ For each unit increase in NDF digestibility, the following response is observed:
  - 0.37 lb DM intake
  - 0.51 lb milk yield
  - 0.55 lb 4% FCM
- ❖ Two forages with similar NDF will support different DM intake and milk yield when fed because of differences in NDF digestibility

Oba and Allen. 1999. JDS 82:589-596.

Interpreting 30 hour forage *In vitro* NDF digestibility results

	Alfalfa	Grass	Corn silage
Excellent	**>40**	**>45**	**>45**
Good	30 – 40	35 – 45	35 – 45
Poor	**<30**	**<35**	**<35**

Sniffen and Emerich, 1999

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Average 30 hour NDF digestibility results

Cumberland Valley Analytical Services

- ✓ Digestibility of grass is high than that of legumes
- ✓ Winter annuals are more digestible than perennials

	Mean	SD
Legume	45.91	9.38
Grass	51.64	11.37
Small grain	56.04	9.86
Corn silage	58.65	6.13
Sorghum	52.67	9.92

Using in vitro NDF digestibility

- ✓ Can not compared results between labs.
  - Differences in methods and source or inoculant
- ✓ Use the same time (24, 30 or 48 hour) for evaluating different lots of forage.
- ✓ The results are only as good as the sample, so a representative sample is essential.

Dairy cattle and NDF

- ***High producing dairy cows***
  - Must consume large quantities of feed (dry matter) each day to meet the energy (NE_l) and protein (degradable and undegradable) requirements of milk production.
  - Intake is limited by fill (NDF) in early lactation, so feed ingredients must be highly digestible so the cow can consume adequate nutrients and doesn't lose excessive body weight.
  - Adequate effective forage (NDF) is required to maintain a healthy rumen environment and prevent metabolic problems such as acidosis or displaced abomasum.
- ***Young calves and replacement heifers***
  - Rumen is limited in size in young calves, so forage fiber (NDF) should be highly digestible to allow proper rumen development and growth.

Forage NDF intake potential

Optimum NDF intake as a % of BW

	Week of lactation	1st Lactation	Mature Cows
1.	2	0.78	0.87
	4	0.91	1.00
	8	1.05	1.17
	12	1.12	1.26
2.	16	1.14	1.29
	20	1.14	1.30
	24	1.13	1.27
	28	1.11	1.24
	32	1.08	1.19
	36	1.04	1.13
3.	40	1.01	1.08
	44	0.97	1.01
4.	Dry	0.92	0.95

Dairy Nutrition Basics

1. Immediately after calving, cows do not have the capacity to consume large quantities of NDF. The rumen is limited in size and by fill.
2. As lactation advances, NDF intake potential increases and more forage can be fed.
3. In late lactation, milk production typically declines so that additional forage can be fed to meet nutrient requirements, but quality is still important.
4. Cows in the dry period can consume more feed (energy) than they need, so lower quality (higher NDF) forages can be fed, but not extremely low quality.

What does this mean?

- Example: 1400 lb mature Holstein cow in 8th week of lactation would be expected to consume 1.17% of her BW as NDF or 16.38 lbs. NDF. If 75% is from forage, then:
- If two alfalfa hays are available to feed, a high quality (40% NDF) and a lower quality (50% NDF), then 30.7 lbs DM of the high quality alfalfa could be fed compared with 24.6 lbs DM of the lower quality alfalfa. More concentrate would be needed with the lower quality alfalfa to provide the same energy and protein provided as the high quality alfalfa.

Effect of increased NDF from Tifton 85 on intake and performance

	Low	Medium	High	SE
T85, % of DM	8.5	15.9	23.3	
NDF, % of DM	31.7	41.6	44.7	
DMI, lb/d[a]	47.6	45.4	42.5	0.9
Milk, lb/d[a]	60.6	58.4	56.7	1.1
Fat, %	4.44	4.42	4.31	0.03
FCM, lb/d[a]	68.1	65.0	62.4	1.1

[a]Linear effect (P < 0.01).
West et al. 1998. JDS 81:1599-1607

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Application

- ✓When a forage with a high NDF concentrations is added to the diet, total NDF goes up. The cows ability to consume adequate nutrients is limited by fill caused by the low quality forage. This results in reduced milk yield.
- ✓Nutritionist normally work to formulate diets that will not limit intake by avoiding low quality forages for lactating cows.

Other constraints

- ✓ In practice, most dairy producers in the Southeast normally feed corn silage plus several high fiber by-products (cottonseed, soybean hulls, citrus pulp, brewers grains, etc.) that also contribute to the total NDF consumed.
- ✓ Although the NDF provided by these feeds does not have the same rumen fill properties as forage because of higher digestibility and greater passage rates, but there is a limit.
- ✓ This means that forage quality needs to be very good to excellent to prevent reductions in intake and milk yield.

What type of hay do dairy producers need?

- ✓ Most dairy producers use Prime or No. 1 grade alfalfa for their lactating dairy cows. Similar quality standards should be used for perennial peanut hay.
- ✓ Bermudagrass hay should be harvested at peak of quality, usually 3 to 4 weeks of regrowth. Fiber concentrations will be much higher than other forages, but the NDF in improved cultivars such as Tifton 85 is much more digestible.
- ✓ Winter annuals should be harvested in vegetative, boot, or early heading stage of maturity.

Hay Quality Grades

Grade	CP	ADF	NDF	DMD
Prime	>19	<31	<40	>65
1	17 – 19	31 – 35	40 – 46	62 – 65
2	14 – 16	36 – 40	47 – 53	58 – 61
3	11 – 13	41 – 42	54 – 60	56 – 57
4	8 – 10	43 – 45	61 – 65	53 – 55
5	<8	>45	>65	<53

Hay Market Task Force, American Forage and Grassland Council.

Bermudagrass

- ✓ There are many cultivars to select from, but Tifton 85 was the best cultivar developed by Dr. Glen Burton. Although this cultivar has high NDF concentrations, the NDF is more digestible than that of other cultivars because it has lower concentrations of ether ferulic acid (a specific type of lignin)
- ✓ For dairy quality hay, bermudagrass must be cut at 3 to 4 weeks of regrowth to prevent reductions in intake and milk yield.

Tifton 85 compared with Coastal

	Tifton 85	Coastal
	-------- % of DM --------	
IVDMD	63.2	59.4
NDF	75.1	70.9
ADF	32.8	30.6
	---- g/kg cell wall ----	
Acid lignin	174.5	202.8
Ether ferulic acid	6.9	8.1

Mandebvu et al. 1999. JAS 77:1572-1586.

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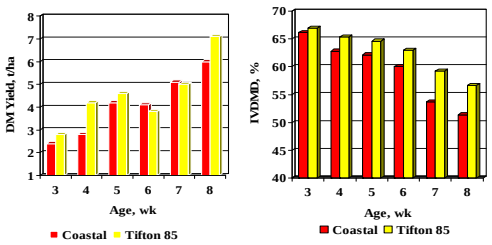
Effect of harvest age on yield and IVDMD of Coastal and Tifton 85



DM yield increases as harvest is delayed, but digestibility declines.

Effect of harvest date on composition and IVDMD

	Tifton 85		Coastal	
Item	**1 wk**	**4 wk**	**1 wk**	**4 wk**
NDF	**69.7**	**73.3**	**64.2**	**72.4**
Lignin	**2.7**	**4.4**	**2.5**	**4.8**
IVDMD	**73.3**	**71.5**	**73.2**	**65.2**

West et al., 1999. UGA Animal & Dairy Sci. Ann. Report.

Performance of lactating dairy cows fed Tifton 85 or Alfalfa hay at 15 or 30% of ration DM

		Tifton 85		Alfalfa	
Item	**Control**	**15**	**30**	**15**	30
DMI, lb/d	**50.4**	**48.7**	**48.5**	**49.6**	49.6
Milk, lb/d	**75.1**	**72.7**	**70.7**	**75.1**	71.8
Fat %	**3.33**	**3.73**	**3.72**	**3.54**	3.99
3.5% FCM, lb/d	**74.0**	**74.7**	**73.8**	**75.6**	74.9

West et al., 1997. JDS. 80:1656-1665.

Tifton 85 hay or silage Either can work well!

	Hay	Silage	SE
DMI, lb/d	**45.9**	**44.5**	**0.7**
Milk, lb/d	**59.1**	**58.2**	**0.9**
Fat, %[a]	**4.31**	**4.47**	**0.02**
Protein, % [a]	**3.50**	**3.47**	**0.01**
3.5% FCM, lb/d	**65.3**	**65.3**	**0.9**

[a]Means differ (P < 0.05)
West et al. 1998 JDS 81:1599-1607.

Winter annuals

- ✓ Many producers feed winter annual forages which can produce very high quality forage. The challenge is harvesting without weather damage.
- ✓ Examples
  - Annual ryegrass
  - Oats
  - Wheat
  - Triticale or rye

In vitro DM digestibility of forage from winter annuals cereal grains

	Barley	Oats	Rye	Wheat
	---------- % ----------			
Vegetative	80.80	83.35	79.40	80.20
Boot	77.75	80.30	77.35	75.50
Heading	72.70	71.55	63.15	69.85
Milk	63.70	63.60	53.60	62.50
Soft Dough	62.55	54.30	53.15	59.15
Hard Dough	60.75	51.50	46.40	51.65

Adapted from Edmisten. 1985. NCSU MS Thesis.

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Winter annuals

- ✓The challenge is to get winter annuals harvested at the right stage of maturity which is difficult to do without rain.
- ✓Silage or baleage works well for these forages because of the higher probability of harvesting at the right stage of maturity without rain.

Forage quality of ryegrass harvested as silage, baleage, or hay

	Storage Method		
	Silage	Baleage	Hay
DM, %	36.2	33.5	87.5
	---------- % of DM ----------		
CP	19.2	19.8	13.1
NDF	58.1	56.2	70.5
IVDMD	79.2	78.7	71.1
NEl, Mcal/lb	0.64	0.64	0.56

McCormick et al., 2002

Performance of lactating Holstein fed ryegrass harvested as silage, baleage, or hay

	Storage Method		
	Silage	Baleage	Hay
DMI, lb/d	40.1	37.5	40.6
3.5% FCM, lb/d	60.5	60.4	58.2
Fat, %	3.5	3.6	3.4
Protein, %	3.4	3.3	3.3

McCormick et al., 2002

Summary

- ✓Dairy cattle require high quality forage to be able to consumed adequate amount of DM and nutrients to meet the demands for milk production.
- ✓From the cows perspective, the NDF content and its digestibility are key to utilization of the forage. Forage with highly digestible NDF will support higher intake and can be fed in greater amounts.

Summary

- ✓High quality forage can be produced from a variety of forage crops and used in diets for lactating cows.
- ✓It is important to obtain a nutrient analysis of the hay so the dairy producer knows how it will fit into their feeding program and lets the grower monitor how well they are doing related to forage quality.

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