New Analysis to Better Describe Feeds for Animal Agriculture

2012 VSFA / Cow College

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Objectives of Forage Analysis

- Diagnostic Evaluation / Characterization
- Providing nutritional inputs for ration balancing
- Marketing / Purchasing Decisions
- Process control: *understanding and measuring variation*

Elements of Qualitative Evaluation of Forages

- Moisture
- Fermentation – Acid and Ammonia Levels
- Heat Damage – ADF Protein
- NDF Digestibility
- Starch Digestibility
- Corn and Small Grain Particle Size
- Forage Particle Size
- Ash
- Mold /Yeasts/Mycotoxins

Qualitative Evaluations are of a Critical Economic Importance:

- Relate to efficiency of crop production and storage
- Relate to potential improvement or loss of dry matter intake
- Relate to milk production potential
- Relate to animal health
- They are a "report card" on forage production systems

New Analytical Technologies

- New technologies
- Old technology, new approach
- Information Technology Innovations

Qualitative Assessments

Let's review of some of the forage qualitative assessments routinely available.

Fermentation Acids by Dry Matter Range in Legume Silage Analyzed at CVAS in 2009-2011
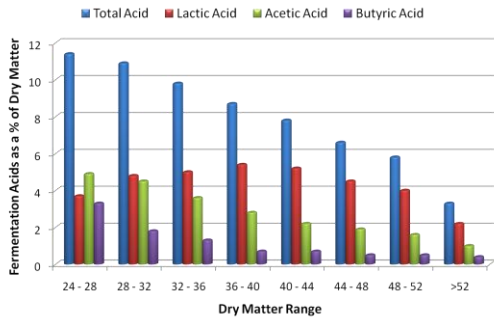
Distribution of 30h In Vitro NDF Digestibility in Corn Silage (CVAS 2011)
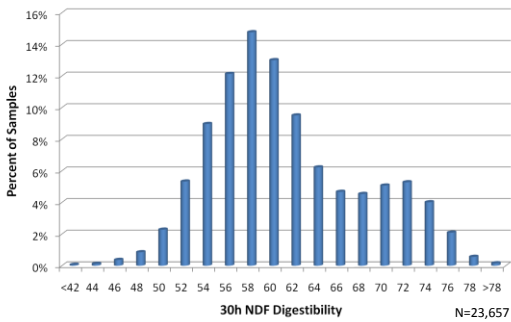
Rotap shaker showing 4.75mm screen and corn

Corn Silage Processing Score, 1131 Samples, CVAS 200 - 2011
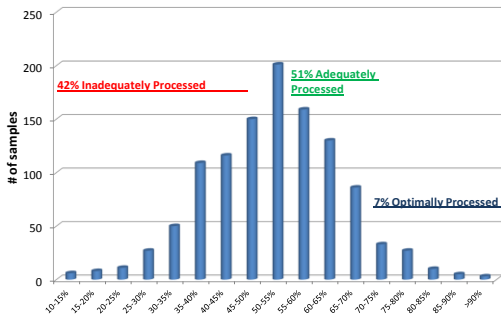
Distribution of Yeast Counts in Corn Silage Samples, CVAS, 2010-2011
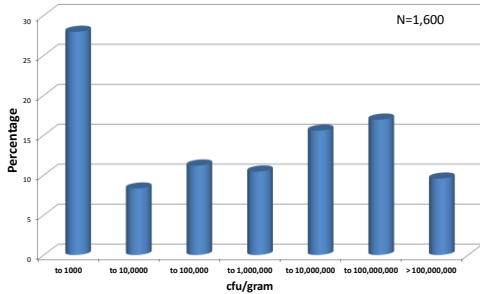
IT Innovations

- Web based opportunities
- Provides administrative, client, and farm access
- Ability to sort, summarize, graph data by different criteria

IT Innovations

- New web data system being developed by team in India
- Enhanced capability for data management
- Enhanced graphing capability
- Opportunity for customized reports for specific nutritional groups

IT Innovations

- Site logging of samples into the system from smart phones / tablets / PC
- Opportunity for more descriptive information to be associated with samples
- Source pictures can be associated with samples

IT Innovations

- Opportunity to bring significant statistics to bear on the sample evaluation process:
  - Cluster analysis of database
  - Sample nutrients qualified by distance from cluster mean, not by comparison to grand averages

IT Innovations

- Opportunity to bring significant statistics to bear on the NIR evaluation process:
  - New software will allow for us to provide statistics on the predictive power of the NIR for each nutirent in a sample

IT Innovations

- IT innovations: What does that mean for me?
  - Opportunity for much greater interpretive and predictive power from the data;
  - Opportunity to better understand what the individual data points mean – data is not an absolute but is a statistical representation of the true value
  - More opportunities to use data for research, process control

Nutritional "Process Control"

Problems with typical nutrition evaluations:

Snapshot of a point in time

- Difficult to define change
- May not capture nature of the problem
- Takes time to test and characterize problem
- Process is "reactive" instead of "proactive"

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Nutritional "Process Control"

Alternative nutritional process control scenario:

Frequent testing of all inputs and processes in the nutrition program that will allow for ongoing characterization of the feeds and processes associated with the farm nutrition program.

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Nutritional "Process Control"

What a process control program might look like:

- Pull samples of all forages and wet feeds every other day for moisture evaluation.
- Pull weekly samples of all forages for an inexpensive NIR evaluation.
- Pull monthly samples of all feeds for a full wet-chemistry evaluation.
- Test all incoming commodity ingredients for specific nutrients / quality parameters.

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Nutritional "Process Control"

What a process control program might look like:

- Maintain a revolving inventory of retained samples of commodity ingredients.
- Evaluate samples of TMR from all ration groups twice per month testing certain nutrients to evaluate the quality of the mixing and delivery process.
- Evaluate orts to determine sorting and as inputs if fed to other groups.
- Quarterly evaluation of all water sources.

Nutritional "Process Control"

Challenges to a process control program:

- Perceived cost.
- Labor requirements.
- Record keeping requirements.
- Data must be continually evaluated.
- Information generated must be used in the nutritional management process.

Nutritional "Process Control"

What would a process control mean to me?:

- Proactive instead of reactive.
- Truer understanding of nutrient levels and variability.
- Ability to define change.
- Ability to better control nutritional process.
- Ability to better define possible problem areas as they occur.
- Ability to better control purchase of inputs.

Cumberland Valley Analytical Services, Inc.
Quantitative and Qualitative Analysis of Feeds for the Dairy Industry

Feed Class: TMR
# of Samples: 5
Date Range: 4/22/2007 - 9/23/2008

NUTRIENT	AVERAGE	ST DEV	9/5/2008 TMR-1-A1 8322-063	9/12/2008 TMR-1-AI 8340-122	9/11/2008 TMR AI 1 8339-117	9/19/2008 TMR-1-AI 8360-127	9/23/2008 TMR-1-AI 8380-128
Dry Matter (%DM)	50.94	3.38	50.5	52.3	52.4	54.1	45.3
Moisture (%DM)	49.06	3.38	49.5	47.7	47.6	45.9	54.7
Crude Protein (%DM)	17.73	0.71	17.1	17.3	17.4	18.8	18.2
Adjusted Protein (%DM)	17.73	0.71	17.1	17.3	17.4	18.8	18.2
Soluble Protein (%CP)	40.77	2.96	43.6	42.2	42.8	38.1	37.1
ADF Protein (ADICP) (%DM)	1.13	0.13	1.11	1.09	0.98	1.12	1.34
NDF Protein (NDICP) (%DM)	2.10	0.23	1.96	1.88	1.98	2.22	2.45
Rumen Degr. Protein (%DM)	70.39	1.48	12.28	12.27	12.41	12.96	12.45
Acid Detergent Fiber (%DM)	21.76	1.43	20.9	22.1	22.3	19.9	23.7
Neutral Detergent Fiber (%DM)	32.17	1.54	31.8	32.7	31.8	30.1	34.4
Lignin (%DM)	3.77	0.36	3.68	3.77	3.52	3.50	4.38
Lignin / NDF Ratio	11.70	0.62	11.6	11.5	11.1	11.6	12.7
Ethanol Soluble CHO (Sugar) (%DM)	4.74	1.63	5.4	5.2	3.1	6.9	3.1
Starch (%DM)	21.54	1.41	20.7	21.2	24.0	20.4	21.5
Crude Fat (%DM)	5.00	0.2	5.22	5.17	4.85	5.01	4.76
Ash (%DM)	8.88	0.19	9.14	8.99	8.79	8.85	8.64

Cumberland Valley Analytical Services, Inc.
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Feed Class: TMR
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NUTRIENT	AVERAGE	ST DEV	9/5/2008 WEIGHBACK 8322-061	9/15/2008 WEIGHBACK 8340-126	9/16/2008 WEIGHBACK 8357-146	9/19/2008 WEIGHBACK 8360-121	9/24/2008 WEIGHBACK 8380-133
Dry Matter (%DM)	52.96	2.19	53.6	52.6	56.4	50.7	51.5
Moisture (%DM)	47.04	2.19	46.4	47.4	43.6	49.3	48.5
Crude Protein (%DM)	17.11	0.52	16.8	16.6	17.0	18.0	17.2
Adjusted Protein (%DM)	17.11	0.52	16.8	16.6	17.0	18.0	17.2
Soluble Protein (%CP)	43.18	2.48	45.1	45.2	44.4	41.6	39.6
ADF Protein (ADICP) (%DM)	1.19	0.11	1.19	1.10	1.15	1.12	1.38
NDF Protein (NDICP) (%DM)	2.15	0.19	1.92	2.06	2.13	2.20	2.44
Rumen Degr. Protein (%DM)	71.59	1.24	12.17	12.08	12.29	12.72	11.98
Acid Detergent Fiber (%DM)	24.71	1.67	25.0	22.7	25.1	23.6	27.1
Neutral Detergent Fiber (%DM)	35.20	2.36	35.6	34.0	34.4	33.0	39.1
Lignin (%DM)	4.20	0.33	4.18	4.07	4.11	3.87	4.75
Lignin / NDF Ratio	11.91	0.17	11.8	12.0	11.9	11.7	12.2
Ethanol Soluble CHO (Sugar) (%DM)	3.42	1.09	4.8	2.8	3.4	4.1	2.0
Starch (%DM)	19.60	0.71	18.8	20.6	20.0	19.5	19.2
Crude Fat (%DM)	4.51	0.34	4.35	4.71	4.62	4.85	4.00
Ash (%DM)	9.49	0.12	9.37	9.38	9.65	9.55	9.51

Indigestible NDF Evaluation

- What is it?
- How is it run?

Indigestible NDF Evaluation

- Fiber undigested after invitro incubation to 240 hours.
- Incubation carried to 240 hours to insure degradation of all NDF in any feedstuff.

Indigestible NDF Evaluation

- Allows us to characterize forage material.
- Allows for more accurate determination of NDF digestion rates.
- For CNCPS, CPM, AMTS, and related models iNDF used to calculate rates is lignin x 2.4.

iNDF % of NDF
Average Values by Feed Class

	Lignin %NDF	iNDF % of NDF	iNDF/Lignin
Legume Silage	17.8	54.15	3.05
Mixed Mostly Legume Silage	14.5	44.39	3.08
Mixed Mostly Grass Silage	10.9	34.94	3.20
Grass Silage	9.1	31.60	3.47
Small Grain Silage	8.7	32.97	3.72
Sorghum / Sudan Silage	8.1	31.45	4.22
Corn Silage	7.9	26.49	2.4
BMR Corn Silage	3.9	18.48	2.7
Total Mixed Ration	11.6	32.70	2.9

iNDF estimation:
effect on pdNDF (g/kg NDF) and rate (%/h)

Forage group	$iNDF_{2.4}$		$iNDF_{240}$		$iNDF_{cal}$	
	pdNDF	k_d	pdNDF	k_d	pdNDF	k_d
Conv. corn silages	847	4.3	771	5.8	733	5.6
Bmr corn silages	838	6.4	788	7.3	768	7.2
Grasses (hays)	686	3.4	654	4.3	648	4.4
Alfalfas	594	10.2	559	10.7	527	10.4

*: $iNDF_{2.4}$ = iNDF estimated using the 2.4 ratio
$iNDF_{240}$ = iNDF estimated using 240 hrs as extent of NDFD
$iNDF_{cal}$ = iNDF estimated using calculated ratios

Indigestible NDF Evaluation

- **What does this mean for me?**
  - In the future labs will report out iNDF as a component of a forage test
  - Possible use of specific equations by feed class to estimate iNDF from lignin
  - Better prediction of NDF digestion rates from use of iNDF

Ash contamination of forage

- NDF includes ND insoluble ash
- Ash contaminated samples will cause NDF values to be elevated
- High ash contamination samples are routine
- Western states samples will have more ash than those from other parts of the county

Ash contamination of forage

- NIR may not predict sample components well with high levels present

Ash contamination of forage

- Problem:
  - Over prediction of NDF will lead to potentially insufficient fiber in the ration
  - Over prediction of NDF will cause under estimation of NFC in the ration
  - Over prediction of NDF will cause mischaracterization of forage
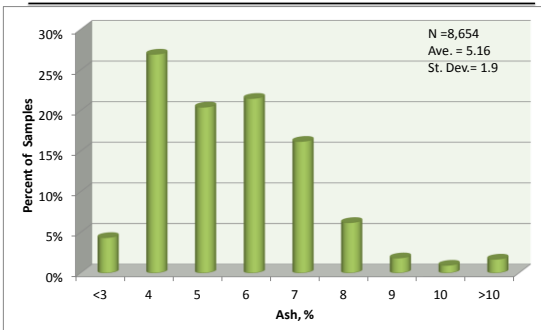 - Over prediction of fibers will distort

Distribution of Ash in Corn Silage, CVAS 2010-2011

N = 8,654
Ave. = 5.16
St. Dev. = 1.9

Percent of Samples

Ash, %

Distribution of Ash in Legume Silage, CVAS 2010-2011

N = 2,524
Ave. = 12.34
St. Dev. = 3.69
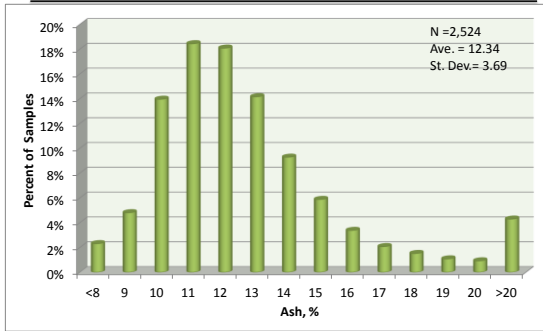
ND Insoluble Ash
(NDF - NDFom, Average Values by Feed Class, CVAS, 2010)

	ND Ins. Ash
Legume Silage	2.09
Legume Hay	1.58
Mixed Silage	2.38
Mixed Hay	1.53
Grass / Small Grain Silage	2.31
Grass Hay	1.92
Sorghum	3.77
Corn Silage	0.94

Distribution of NDF-NDFom Differences
In Hay Crop Forage - CVAS
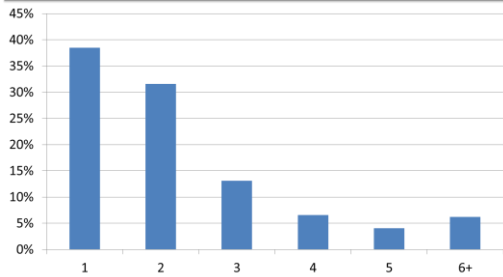
Distribution of NDF-NDFom Differences
In Corn Silage- CVAS
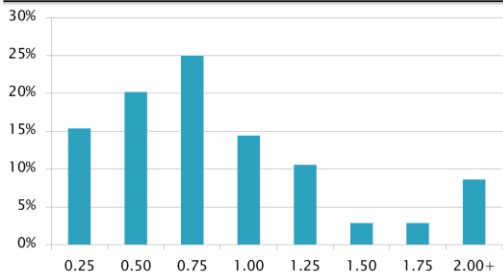
Ash contamination of forage

- What should the lab do to better characterize ash contaminated samples?
- Alternative approach is to run all samples on an organic matter basis (OM). This removes ash from the recovered fiber.
- In the future, labs will provide NDF on an organic matter basis routinely, both by chemistry and NIR

Ash contamination of forage

- What does the approach of reporting NDF on an organic matter basis mean to me?
  - New terminology: aNDFom
  - Better characterization of organic matter availability in forages
  - Better characterization for buying and selling decisions
  - Rations in the future run on an OM basis?

Key Forage Evaluations for Marketing

- Different approaches:
  - *rely on single nutrient*
  - *rely on multiple nutrients*
  - *combine multiple nutrients into an index*

Key Forage Evaluations for Marketing

- Requirements for a functional index:
  - *Simple*
  - *Easy to understand and communicate*
  - *Nutritionally relevant*
  - *Analysis: fast, low cost, high precision, repeatable across labs*

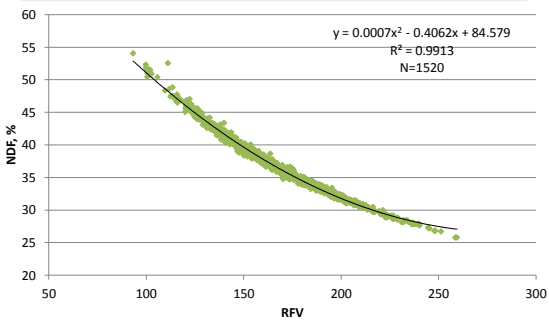## Regression of Relative Feed Value on NDF

$$y = 0.0007x^2 - 0.4062x + 84.579$$
$$R^2 = 0.9913$$
$$N=1520$$

Regression of Relative Feed Value on ADF

$$y = 0.0006x^2 - 0.3198x + 67.921$$
$$R^2 = 0.946$$
$$N = 1520$$
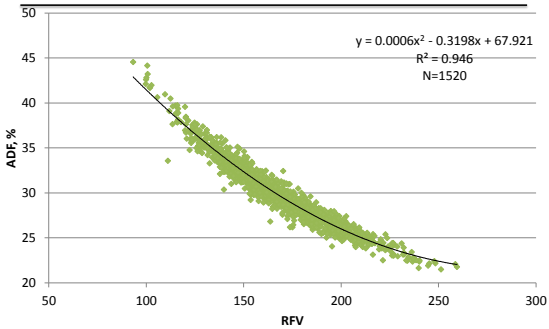
RFQ Index

RFQ = (DMIleg, % of BW) * (TDNleg, % of DM) / 1.23

DMILegume = 120/NDF + (NDFD − 45) * .374 / 1350 * 100

TDNlegume= (NFC*.98) + (CP*.93) + (FA*.97*2.25) +(NDFn * (NDFD/100) − 7

Where:
- CP = crude protein (% of DM)
- EE = ether extract (% of DM)
- FA = fatty acids (% of DM) = ether extract - 1
- NDF = neutral detergent fiber (% of DM)
- NDFCP = neutral detergent fiber crude protein
- NDFn = nitrogen free NDF = NDF − NDFCP,else estimated as NDFn = NDF*.93
- NDFD = 48-hour in vitro NDF digestibility (% ofNDF)
- NFC = non fibrous carbohydrate (% of DM) =100 − (NDFn + CP + EE + ash)

Key Point

- When you purchase forage for feeding to ruminants, generally you are looking for forage that maximizes the amount of rumen fermentable organic matter and promotes high intakes of that fermentable organic matter.

Nutrient Content of Legume Silage

Nutrient	Contribution	Digestible OM at 30 HRS
NDF (N free)	36 %	14 %
Soluble Fiber	11 %	11 %
Sugars	8 %	8 %
Starch	1 %	1 %
Organic Acids	4 %	4 %
Fermentation Acids	8 %	8 %
CP	21 %	19 %
Fat	2 %	
Ash	9 %	
Total	100 %	65 %

Figure 15. Distribution of Digestible Organic Matter Index,
Western States Alfalfa Hay
(Chemistry, CVAS 2011)

N =1,520
Ave. = 1353.25
St. Dev.= 66.77

Figure 16. Regression of Digestible Organic Matter
Index on NDF (CVAS, 2011)

$y = -14.067x + 1868.7$
$R^2 = 0.7678$
N = 1520

Implementation Opportunities

- What does this mean for me?:

    - **Better definition of quality through a nutritionally relevant index**
    - **Uniformity of information used for marketing**
    - **Reduction in buyer / seller conflicts**
    - **Reduction in number of samples taken**
    - **Increased confidence in information gained from testing**

Future NIR Opportunities

- Amino acids, total and insoluble
- Protein defined from AA values
- Better definition of sugar and fiber contents

Future Technologies

- Farm Based Diagnostics
- "Dip Stick" technology
    - Toxins
    - Histamines
    - Ammonia
    - Salmonella, Listeria

Future Technologies

- Real-time NIR
- Portable NIR
- Farm based standard NIR units

There *are* great opportunities through utilization of forage analytical evaluations... !

Thank you for your time and participation!