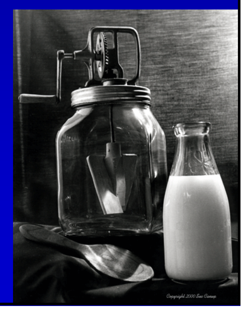
# Feed and Forage Analyses – Issues in characterizing inputs needed for CNCPS/CPM Dairy and NRC models

Mike Van Amburgh, Emiliano Raffrenato, Erin Recktenwald, Debbie Ross, James Robertson

Cornell University



## Feed Chemical and Biological Characteristics Required

- The CNCPS/CPM Dairy approach:

  To be successful with a usable formulation model we need chemical components that can be routinely measured in a commercial lab in an affordable manner.

## My Charge: Given by Dan Undersander

- **Address the issues of NDF with and without NaS04.**

  **Which method is recommended in the models and how much does the method influence the final output?**

- **What is the preferred method for determining (ND-ICP and AD-ICP) for prediction of the protein pools in the models**

## My Charge - continued

- Lignin as % of NDF and NDFD 24, 30 and 48hrs are options for calculating kd.
- What is the “standard error” of Lignin, NDFD 24, NDFD 30 and NDFD 48?
- How much does the “Standard error” influence the final kd calculation?

## NDF with or without sulfite

- Depends on which model….
- We are evolving the model(s) to reflect
  - New understanding
  - Mistakes and offsets

## Use of Sulfite in NDF and NFC Pool Size – CNCPSv6.1

- We recognize the importance of applying standardized and approved chemical methods – especially for NDF (Mertens, J. AOAC, 2002)
- We recommend use of the approved method for most if not all feeds

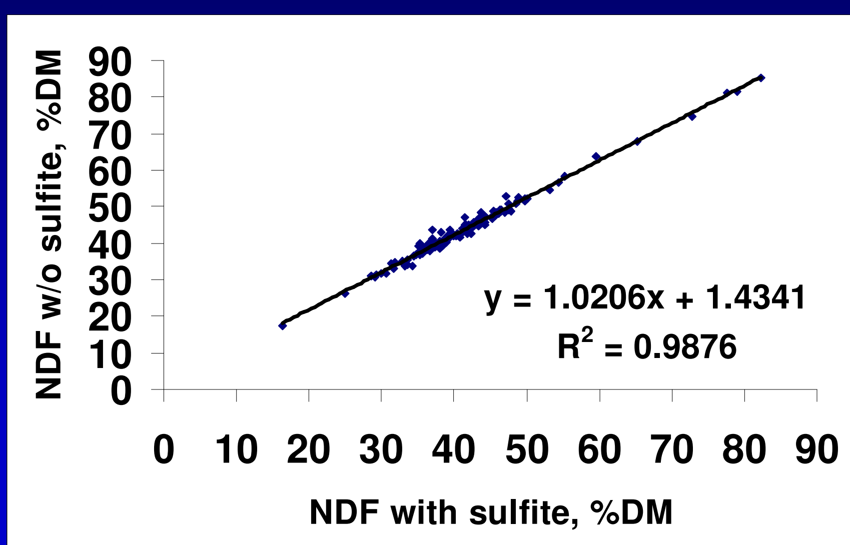
# Use of Sulfite in NDF and NFC Pool Size – CNCPSv6.1

- CNCPS v6.1 equation for NFC

  NFC = 100 – (aNDF + CP + EE + Ash)

- The equation is used to calculate the NFC only for use on the report page – no energy or pool estimations

Comparison of NDF with and without Sulfite – Cornell Lab (150 samples) (aNDF vs NDR)



## Effect of Sodium Sulfite on NDF

| Reference | Type | n | W/o sulfite | With sulfite | Difference |
|---|---|---|---|---|---|
| Moir | Grasses | 23 | 76.7 | 75.2 | -1.5 |
| Moir | Legumes | 5 | 52.6 | 46.1 | -6.5 |
| Moir | Feces | 28 | 70.6 | 66.4 | -4.2 |
| Robertson | Mixed | 9 | 57.7 | 53.5 | -4.2 |
| Mertens | Forages | 7 | 53.3 | 51.9 | -1.4 |
| Mertens | Animal | 2 | 24.4 | 19.9 | -4.5 |
| Mertens | Dried conc | 3 | 44.8 | 36.5 | -8.3 |
| Hintz et al. | Animal | 2 | 30.6 | 14.2 | -16.4 |
| Hintz et al. | Dried byprod | 2 | 45.4 | 34.8 | -11.0 |
| Hintz et al. | Oilseed meal | 3 | 26.9 | 22.8 | -4.1 |
| Hintz et al. | Forages | 9 | 56.1 | 54.6 | -1.5 |

USDA-ARS US Dairy Forage Research Center

## Comparison of aNDF and NDR values

| | n | NDR | aNDF | Abs. diff | % diff |
|---|---|---|---|---|---|
| Alfalfa | 22 | 37.0 | 35.0 | 2 | 5.4 |
| Corn silage | 80 | 42.2 | 39.9 | 2.3 | 5.5 |
| Grasses | 33 | 49.5 | 51.9 | 2.4 | 4.8 |

Approximately 45 to 52% of the difference is in the NDICP in these forages

Among all feed types, 49% of the difference was NDICP (Hintz et. al, 1996)

## Use of Sulfite in NDF

- In CNCPS, the effect on ME allowable milk is approximately +/- 1 kg
- For MP allowable milk, it is variable.
- Use of sulfite to analyze forages has little effect – because of the change in the kd's.

## ND Insoluble Protein (ProtB3)

- For forages, we have linked the NDF kd to the NDICP kd
- Prior to this release, if the NDF kd was 5, the NDICP kd was 0.1 to 0.3
- This implied protein would accumulate in the residual as ND CHO disappeared
- We plan to do a series of sensitivity analyses to determine if a similar approach should be taken for concentrates and animal protein feeds

## What to do with negative numbers in the soluble fiber pool?

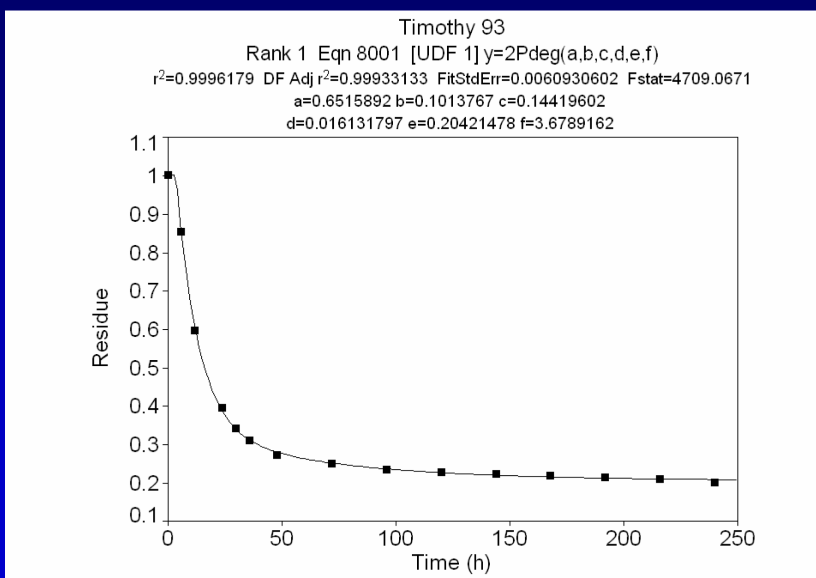
- The soluble fiber pool is done by difference so any error in VFA's, organic acids, sugar, and starch accumulates there
- Within the model, any negative number is considered zero
- To "correct" requires user to understand variation in other pool inputs (e.g. how good are the VFA values – NIR on dry samples)

## Estimating Rates – Variation in NDF, lignin and Digestibility

# NDF Digestibility

- We have identified three pools
  - Pool 1 with a fast rate
  - Pool 2 with a slower rate
  - Pool 3 – indigestible
- BMR forages blur this a little
- Might be recovery issues
- We have conducted very long-term fermentations – problems with recovery
- We have modified our system to deal with losses – use of filter papers in crucibles
- Whatman AH-934

## Curve Fit and Rate Calculation for a Two-Pool Degradation with First Pool Lag

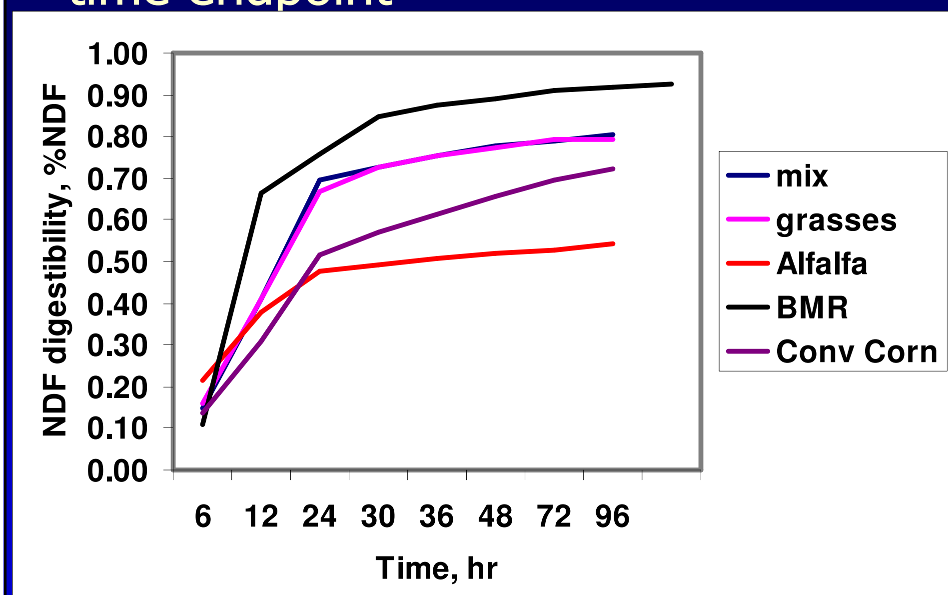


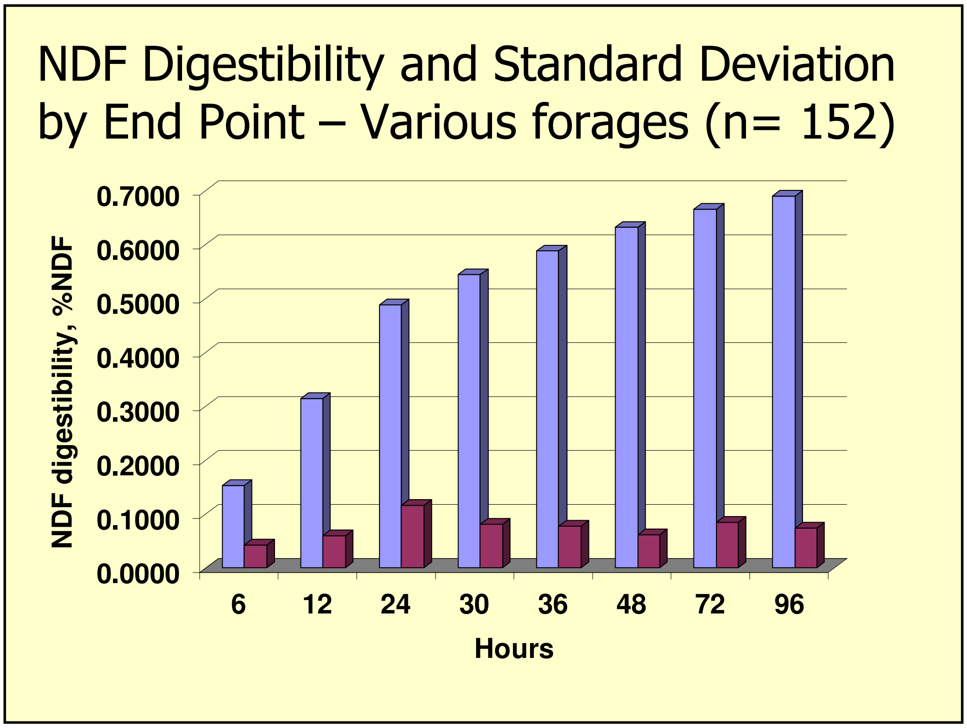
**Mathematical Approach - Assumptions**

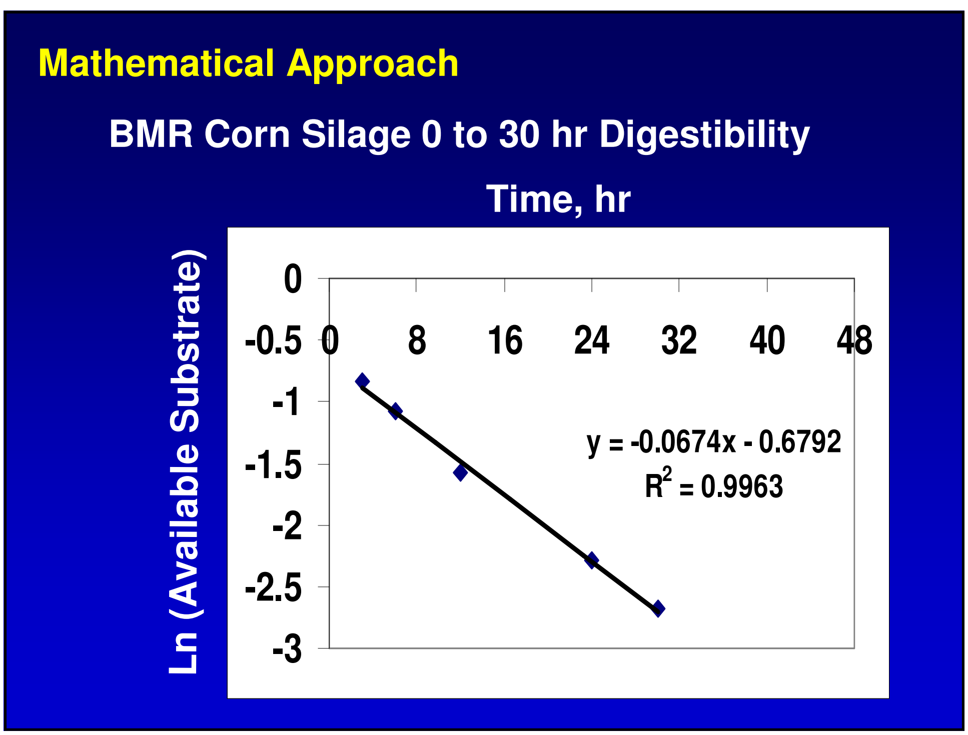
Approach used a ln conversion of available substrate against time

1. Only for NDF
2. Assume exponential decay function
3. Consistent with mean rumen retention times of 30 to 48 hr
4. Consistent with the current framework of the CPM/CNCPS approach – first order, single pool

## Variation in NDF digestibility by time endpoint



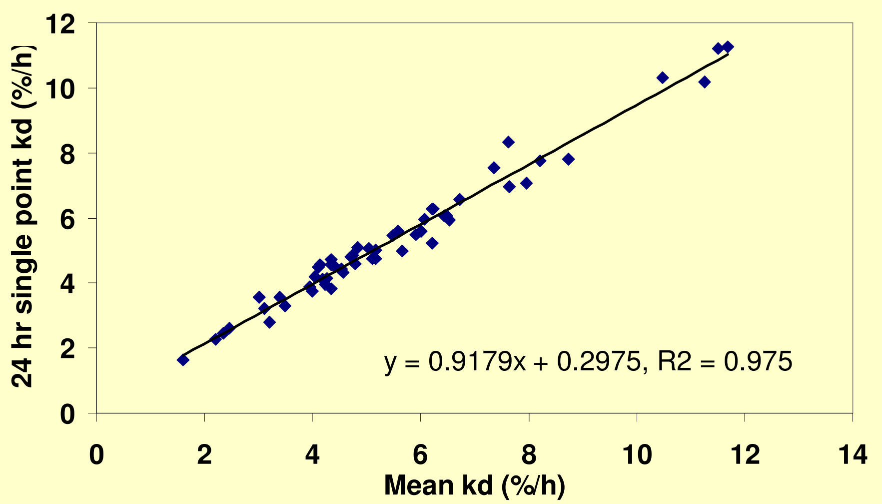

NDF Digestibility and Standard Deviation by End Point – Various forages (n= 152)
NDF digestibility, %NDF
0.7000
0.6000
0.5000
0.4000
0.3000
0.2000
0.1000
0.0000
6
12
24
30
36
48
72
96
Hours


Mathematical Approach
BMR Corn Silage 0 to 30 hr Digestibility
Time, hr
Ln (Available Substrate)
0
-0.5
-1
-1.5
-2
-2.5
-3
0
8
16
24
32
40
48
y = -0.0674x - 0.6792
R2 = 0.9963

## Time Point Fermentation Data and Calculations from Corn Silages based on 6 to 36 hr Fermentations

| Time, h | Substrate Residue (S) | Unitized Substrate (A) | Lag, h | $k_d$, %/h |
|---|---|---|---|---|
| 6 | 0.895 | 0.884 | (4.21) | 6.91 |
| 12 | 0.594 | 0.551 | 4.43 | 7.87 |
| 24 | 0.322 | 0.250 | 4.23 | 7.02 |
| 30 | 0.260 | 0.182 | 4.12 | 6.59 |
| 36 | 0.215 | 0.132 | 4.05 | 6.34 |

**Comparison of the overall mean kd with 24 hour single point calculation. Values are in percent per hour. Data from Mertens' thesis and current work.**



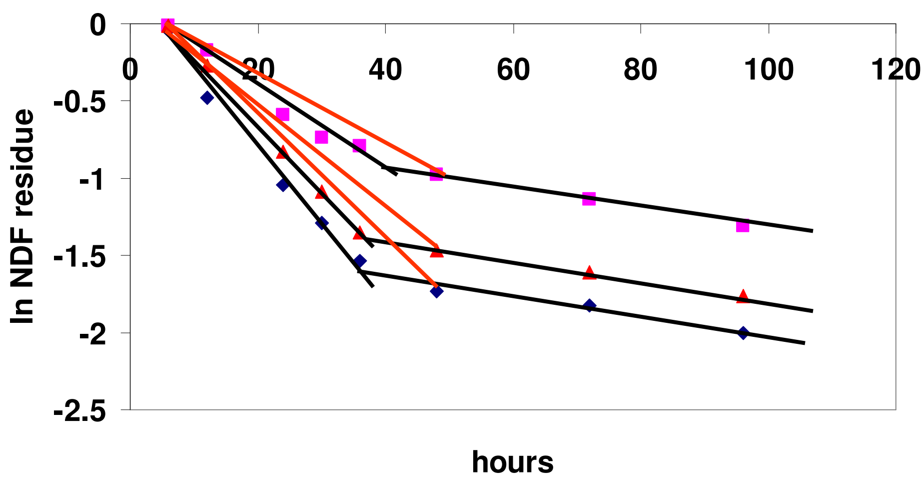
## Rates of Fermentation (kd, %h) based on Various Time Points, Fixed or Variable Lag and Lag

| Forage | 24 h, fixed | 6 & 24 h, variable | 12 & 24 h, fixed | 6 to 36 h, variable | Lag,h |
|---|---|---|---|---|---|
| Alfalfa ‘98 | 5.48 | 5.51 | 5.27 | 5.02 | 2.74 |
| Alfalfa ‘93 | 7.70 | 7.19 | 9.43 | 8.19 | 1.64 |
| Timothy ’68 | 2.96 | 2.82 | 2.52 | 2.27 | 1.87 |
| Timothy ’93 | 6.28 | 6.28 | 6.89 | 6.59 | 2.87 |
| Orchard grass | 3.22 | 3.31 | 3.19 | 3.26 | 3.45 |
| Wheat straw | 1.88 | 1.72 | 1.97 | 1.74 | 1.20 |

## Rates of Fermentation (kd, %h) based on Various Time Points, Fixed or Variable Lag and Lag

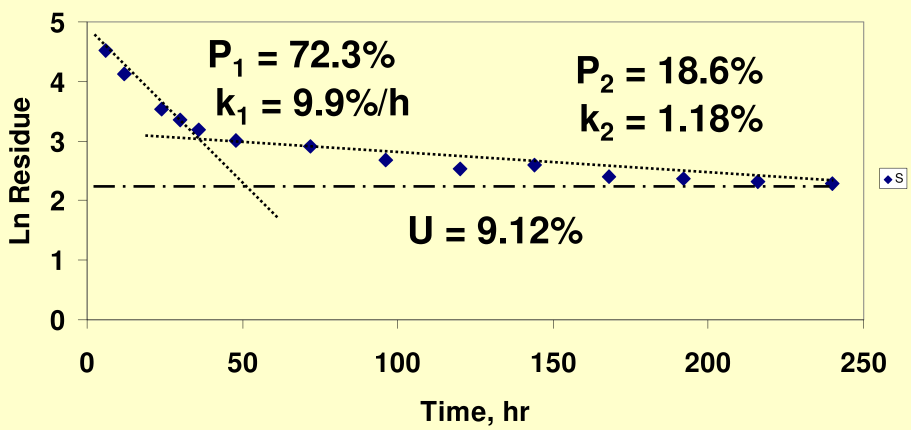
| Corn Silage | 24 h, fixed | 6 & 24 h, variable | 12 & 24 h, fixed | 6 to 36 h, variable | Lag,h |
|---|---|---|---|---|---|
| 1 (BMR) | 6.61 | 7.02 | 6.62 | 7.10 | 4.21 |
| 2 | 5.23 | 5.40 | 5.47 | 5.67 | 3.77 |
| 3 (BMR) | 6.59 | 6.85 | 6.93 | 7.25 | 3.87 |
| 4 | 4.81 | 4.87 | 5.12 | 5.02 | 3.23 |
| 5 (BMR) | 4.57 | 4.67 | 4.26 | 4.29 | 3.22 |
| 6 | 6.15 | 6.45 | 5.78 | 6.05 | 3.82 |

## The ln of NDF residue plotted by time of digestion – corn silage example




## Partition of Corn Silage NDF into Pools and Rates

**Pool 1 is exhausted by 48 hr and produces an inflection point**



## NDF Digestibility by NDF and Lignin Content

| NDF, %DM | Lignin, %DM | NDFd (30hr) | Est. NDF Kd, %hr |
|---|---|---|---|
| 36.5 | 3.50 | 34.6 | 2.21 |
| 37.0 | 2.69 | 39.5 | 2.42 |
| 37.1 | 2.69 | 39.5 | 2.41 |
| 37.2 | 3.01 | 39.9 | 2.53 |
| 37.4 | 3.30 | 46.6 | 3.31 |
| 37.6 | 2.59 | 47.3 | 3.10 |
| 36.8 | 2.43 | 53.0 | 3.68 |

## NDF Digestibility by NDF and Lignin Content

| NDF, %DM | Lignin, %DM | NDFd (30hr) | Est. NDF Kd, %h |
|---|---|---|---|
| 42.1 | 5.04 | 35.2 | 2.52 |
| 42.3 | 3.01 | 42.2 | 2.63 |
| 42.6 | 3.32 | 44.1 | 2.90 |
| 42.6 | 3.24 | 44.6 | 2.92 |
| 42.6 | 3.24 | 50.8 | 3.60 |
| 42.3 | 3.18 | 56.7 | 4.36 |
| 42.3 | 3.00 | 57.0 | 4.30 |

## NDF Digestibility by NDF and Lignin Content

| NDF, %DM | Lignin, %DM | NDFd (30hr) | Est. NDF Kd, %h |
|---|---|---|---|
| 45.0 | 3.52 | 46.0 | 3.09 |
| 45.0 | 3.26 | 48.4 | 3.27 |
| 45.0 | 3.32 | 54.4 | 4.01 |
| 45.1 | 3.18 | 55.0 | 4.02 |
| 45.0 | 3.43 | 67.3 | 6.42 |

## NDF Digestibility by NDF and Lignin Content

| NDF, %DM | Lignin, %DM | NDFd (30hr) | Est. NDF Kd, %/h |
|---|---|---|---|
| 51.8 | 5.23 | 24.7 | 1.46 |
| 50.1 | 4.13 | 37.6 | 2.34 |
| 50.7 | 5.62 | 37.8 | 2.68 |
| 50.6 | 3.68 | 60.5 | 4.89 |
| 50.8 | 3.57 | 60.6 | 4.83 |

## NDF kd Variation due to Methodology

- Rate estimation is relatively insensitive to variation in NDF and lignin measurements
  - A 10% difference in NDF results in less than a 10% difference in kd
  - Corn silage with 43.3% aNDF varied from 39 to 47% NDF at constant lignin and NDFD with 3 hr lag
  - Kd 4.15 to 4.35 (not significant in CNCPS)

## NDF kd Variation due to method

- Lag is similar within reason

We are working on publication –

Major concern – evaluated variance inflation with ln/ln conversions

- not an issue

Most important issue is lignin x 2.4 as a function of NDF

Our latest data says no, but not far off. Once we dealt with recovery issues.

## NDF kd Variation due to method

- NDF digestibility and recovery is also very important
  - There is obviously accumulation of errors
    - Lags with Ankom are generally 1 to 3 hours longer than flasks
    - We are concerned about particle loss – why we moved to the filter papers
    - Poor handling of rumen fluid is an issue
    - Should run a standard

## Our Initial Lab Recommendations

1. Laboratories adopting this approach should conduct short term fermentations (6 and 12 hr) to determine the lag specific to the system
2. Further, to determine the repeatability of the fermentation system at least two data points (24 – 30 hr) should be measured and rates calculated – looking for uniformity.
3. Sodium sulfite should be used for time zero NDF (aNDF)

## Our Initial Lab Recommendations

4. **aNDF should not be used in on early fermentation times (up to 24 hr) – loss of protein and lignin appears to over-estimate NDF digestion – especially for high quality alfalfas and immature grasses.**

5. **There must be a set of standards or reference samples among fermentations and laboratories should be considered.**

6. **Everything else that Mertens' says to do.**

## Recovery of insoluble fibre fractions by filtration and centrifugation
P. Uden Anifeed, 2006

| Sample[b] | NDF | | | | |
|---|---|---|---|---|---|
| | Glass | Centr | Paper | S.E.M. | P |
| Dehulled barley | 44 | 92 | 104 | | |
| Linseed cake | 185 | 257 | 328 | | |
| DDGS | 175 | 313 | 364 | | |
| Cow faeces | 330 | 454 | 492 | | |
| White clover | 192 | 245 | 252 | | |
| Mean | 185a | 272b | 308c | 5.1 | <0.001 |

Means with different letters (a–c) differ at P<0.05.

66% increase in NDF recovery with filter paper

## Recovery of insoluble fibre fractions by filtration and centrifugation
P. Uden Anifeed, 2006

| Sample[b] | ADF | | | |
|---|---|---|---|---|
| | Glass | Paper | S.E.M. | P |
| Dehulled barley | 7 | 13 | | |
| Linseed cake | 129 | 168 | | |
| DDGS | 104 | 173 | | |
| Cow faeces | 310 | 336 | | |
| White clover | 163 | 196 | | |
| Mean | 143a | 177b | 1.7 | <0.001 |

Use of 6 µm filter paper increased ADF recovery by 24%

## ADL Recoveries with and without 6 µm filter papers

| ADL - crucible | ADL – crucible w/filter | difference | % difference |
|---|---|---|---|
| 1.90 | 2.52 | 0.62 | 34.4 |
| 2.94 | 3.61 | 0.62 | 24.0 |
| 5.59 | 5.84 | 0.26 | 5.8 |

**(>15 samples/comparison, in triplicate)**

# Questions?