NDF Digestibility: From the Lab to the Cow. Assessing in vitro analysis and its relation to cow performance.

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1. What should a Feed Analysis Laboratory provide?

a. Accurate and precise analysis for nutrients requested.
b. Information on analytical methods employed
c. Some index of analytical precision.
d. Comparison of analytical results with previous assays of similar feeds.
e. Advice for improving nutritive value.
f. *INTERPRETATION OF ANALYTICAL RESULTS*
g. Assistance in feed formulation.
h. Advice on increasing livestock productivity.
i. Develop new assay procedures.

2. What does NDF stand for?

a. Non-Deliverable Forward.
b. Neighborhood Development Foundation.
c. Nonproliferation and Disarmament Fund.
d. New Democracy Forum.
e. Nanocolloidal Detox Factors.
f. New Dapper Features.
g. Neutral Detergent Fiber.
h. National Drug File.
i. All of the above.

NDF

Wikipedia, the free encyclopedia: NDF may refer to:
National Development Front, an Islamic political organization in South India
Non-deliverable forward, a financial instrument
Neutral Detergent Fiber, a fiber evaluating method used in animal nutrition
National Democratic Front, a political organisation
Norwegian Defence Force, the military of Norway
neue deutsche Filmgesellschaft, a film production company in Germany

NDFD

National Digital Forecast Database, a NOAA product
Neutral Detergent Fiber Digestibility, an index of fiber digestion from a feedstuff

2. Why is NDF fed to ruminants?

a. Dilute dietary starch.
b. Stimulate chewing.
c. Provide ruminal bulk to increase rumination time/flow of salivary buffers.
d. Reduce cost of dietary NEl.
e. Increase rate of passage.
f. Provide intestinal bulk.
g. All of the above.

ALL NDF is NOT "CREATED EQUAL"

Corn Silage: Composition, Yield and Feeding Value

High Moisture Corn

A Grass Plant

3. What is NDF chemically?

a. Hemicellulose.
b. Cellulose.
c. Lignin.
d. Cutin.
e. Pectin.
f. Fiber-bound protein.
g. All of the above
h. a, b, c, and d above.

Assumptions and Calculations

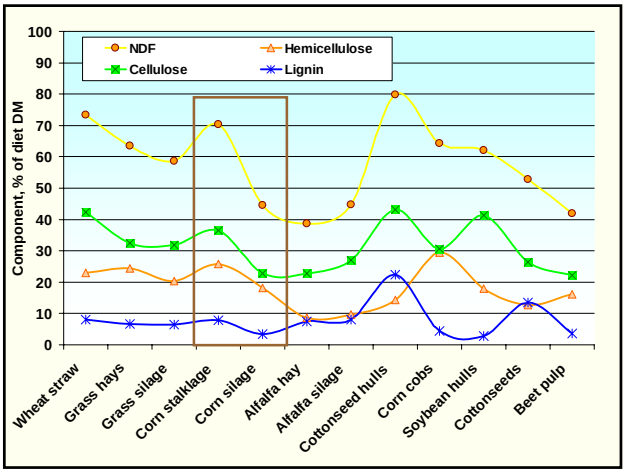
NDF = Hemicellulose + Cellulose + Lignin;

Compo:	*Pentosans*	*β 1,4-Glucosan*	*Polyphenols*
Digestion:	*High*	*Moderate*	*Indigestible*

NDF = Hemicellulose + Cellulose + Lignin;
ADF = Cellulose + Lignin;
Lignin = Acid detergent lignin;

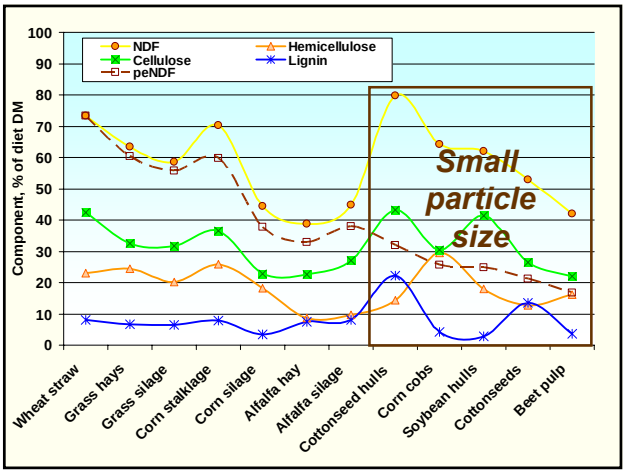
Hemicellulose = NDF – ADF;
Cellulose = ADF – Lignin;

DNDF = NDF * NDF Digestibility (%).
INDF = NDF * (100 – NDF Digestibility).



4. Why is "physically effective fiber" of interest?

a. Dilute dietary starch.
b. Stimulate chewing.
c. Provide ruminal bulk to increase rumination time/flow of salivary buffers.
d. Reduce cost of dietary NEl.
e. Increase rate of passage.
f. Provide intestinal bulk.
g. All of the above.



5. Except through digestion or combustion, "fiber (NDF) cannot be destroyed."

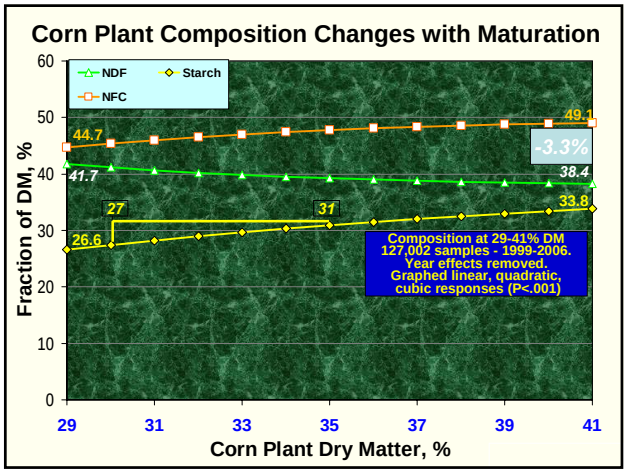
a. True.
b. False.
c. It depends.

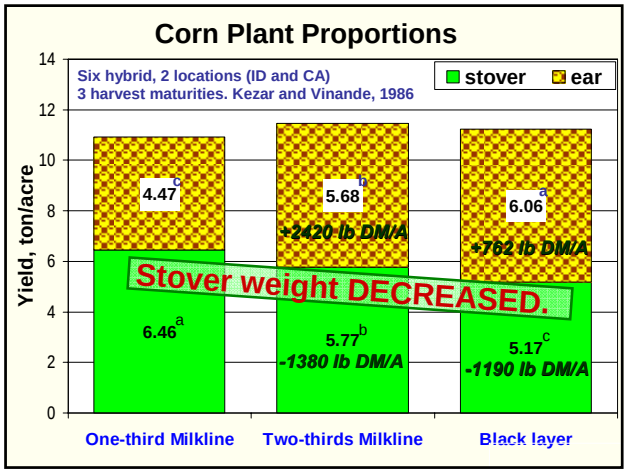
NDF is Defined by ANALYSIS

1. Methods that alter fragility can alter recovery by filtration.
   - Base treatment (Ammonia, NaOH, Alkaline Hydrogen Peroxide)
   - Ozone treatment
   - Strong acid treatment

6. Once deposited by a plant, NDF is retained permanently.

a. True.
b. False.
c. It depends.





Does NDF YIELD Change with Corn Plant Maturation?

Lewis et al., 2004. Agron. J. 96:267-274.

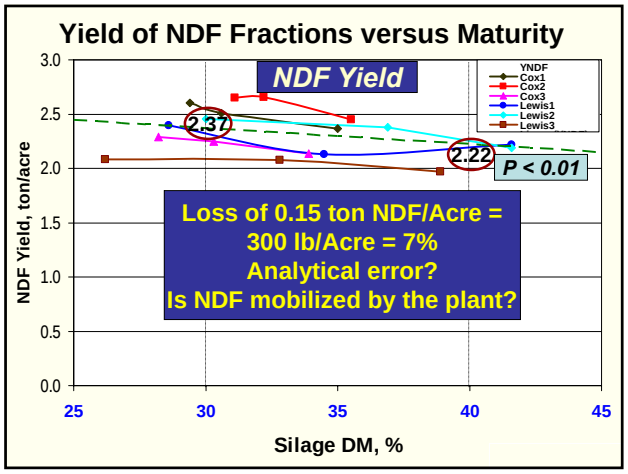
Cox and Cherney. 2005. Agron. J. 97:142-146.

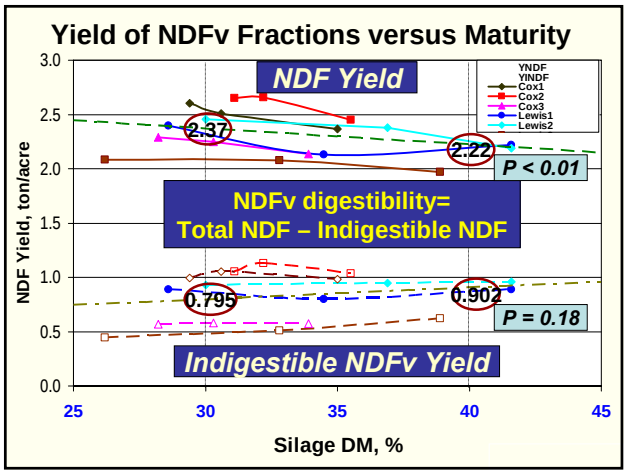
Three hybrids in each trial (one BMR, one leafy, one high grain).

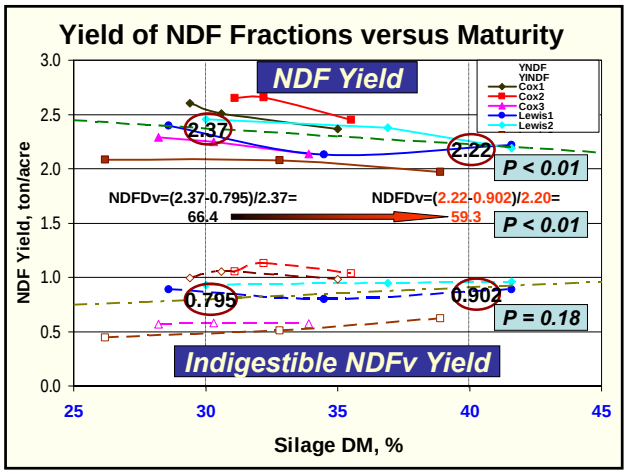
Three harvest dates (moisture levels).

Reported DM yield, starch, NDF, ADF, NDFD (in vitro).

Yields of NDF, and digestible NDF were calculated.







NDF Digestibility Measurements

Animal Dig:
Rumen *NDFDr*
L. intest. *NDFDi*
Total tract *NDFDt*
Class: Bovine, Ovine
Lactating cow, Steer

Laboratory:
Why?
Faster, less effort
Small sample size
Less cost

Feed Intake:
Lactating cow

Calculated:
NRC 01 *NDFDc*

Milk yield:
Lactating cow

NDFDx: 10 types.
Lab: 4 time periods
Animals: 3 species

13. What is the DIGESTIBILITY of fiber (NDFD) and how does it change as plant dry matter increases from 30 to 40%?

a. It increases.
b. It decreases.
c. That depends on how digestibility is measured.

Lab Measurements – NDFDv

a. Dry sample
b. Grind sample.
c. Digest with rumen fluid for one of various time periods.
d. Measure NDF before and after digestion.
e. Calculate NDF disappearance.

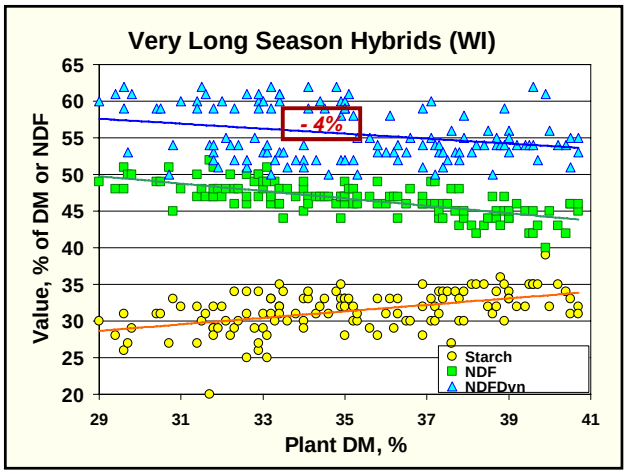
NDF Digestibility of Forages: Methods

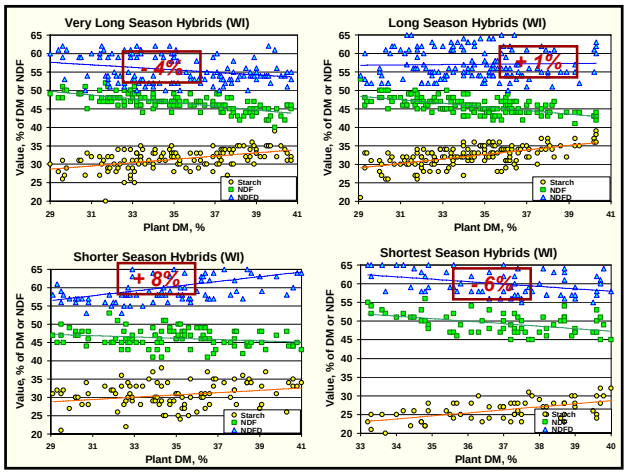
Lab measures
Sample * → Dried * → Ground

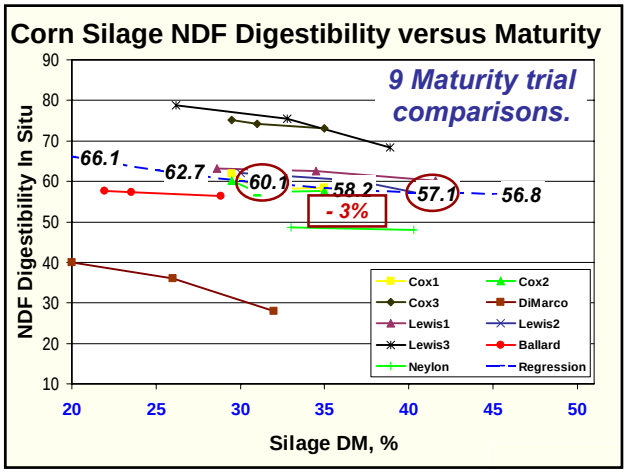
	Lignin	Enzymes	In situ	In vitro
Initial NDF *		X	X	X
Chemicals	X	X		
Animal/cannula			X	
Rumen fluid				
Source*				X
Incubation cond.*				X
Time (24-48hours)*			X	X
Filtration*				
Final NDF assay *		X	X	X

* Critical steps

NIRS Calibrations based on standard sample set.







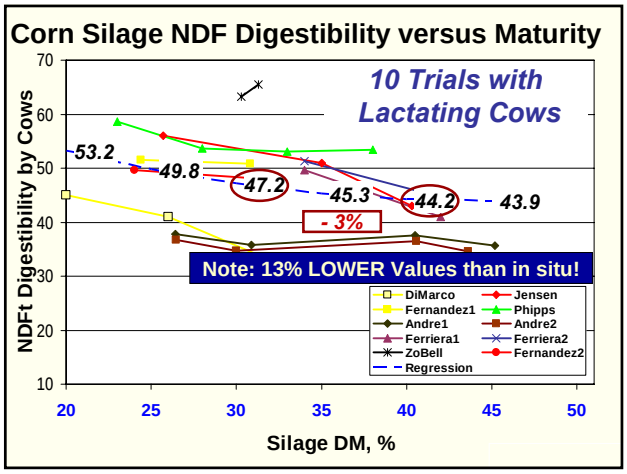
Lactating Cow Measurement – NDFD

a. Measure NDF of diet (primarily corn silage)

b. Measure NDF excreted.

c. Calculate NDF digestibility.

(Includes digestion in both the rumen and the large intestine)



14. How well is the cow's digestibility value for NDF of corn silage predicted by lab estimates of NDFD?

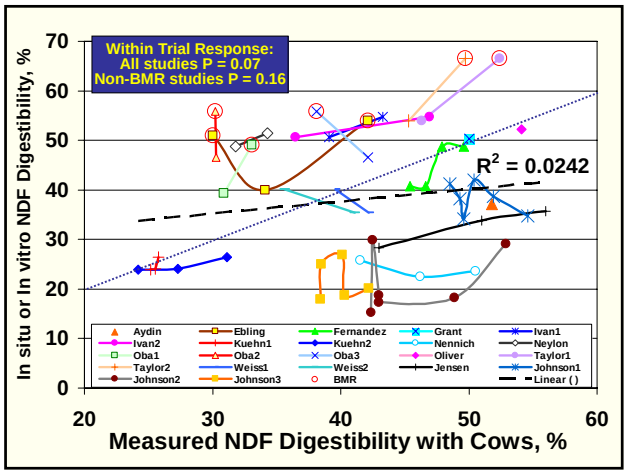
a. Quite closely.

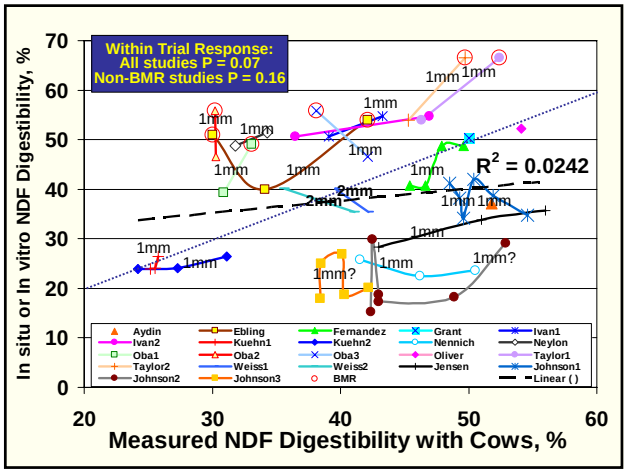
b. Strong trends.

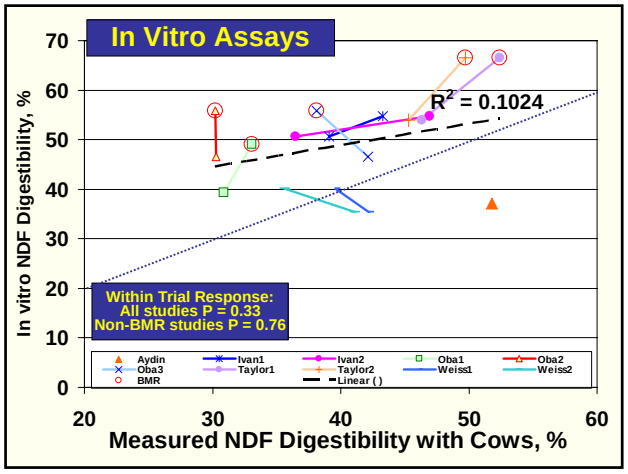
c. Poorly.

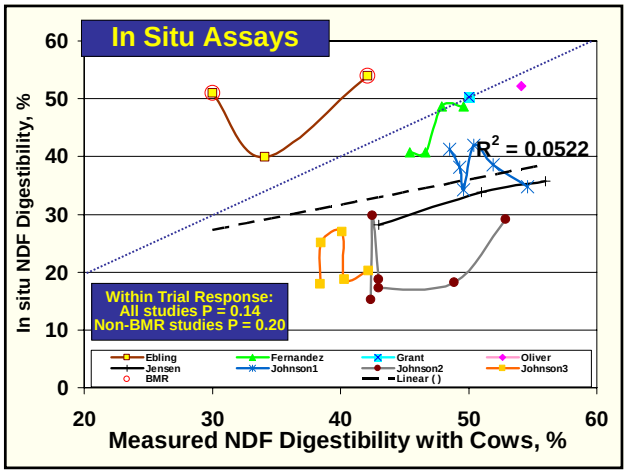
Direct Comparisons: Lab vs Cow

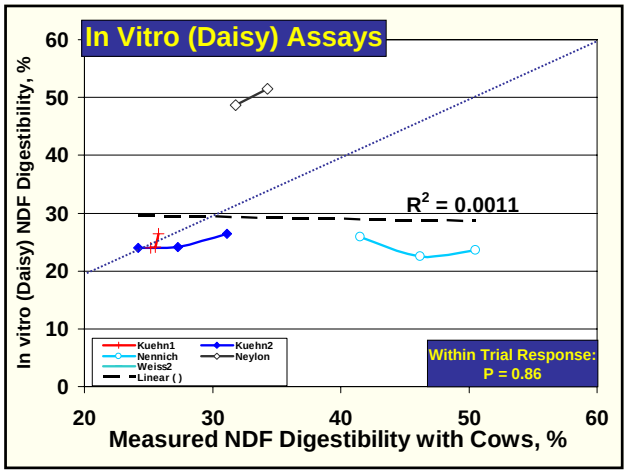
a. Corn silage samples; 27 comparisons from 18 publications.
b. Adjusted lab NDFD from the 5 comparisons with 48 hour incubations to 30 hours based on averaged rates of NDF digestion for corn silage (x0.697).
c. Separated various lab procedures (in vitro; in situ; Daisy incubations).
d. Calculated overall regressions.
e. Graphed response within each trial.
f. Calculated significance of response within each trial summed across trials.









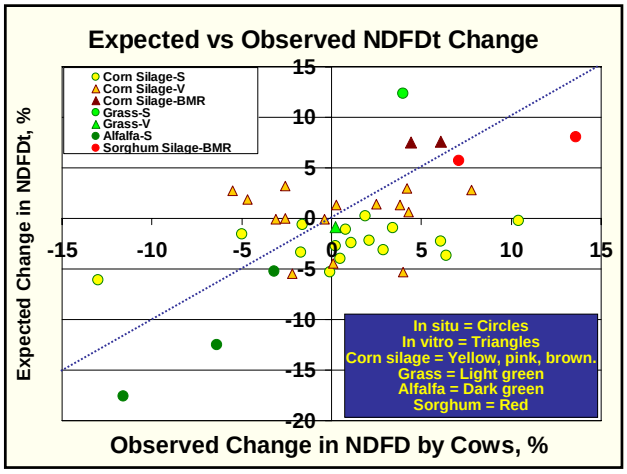


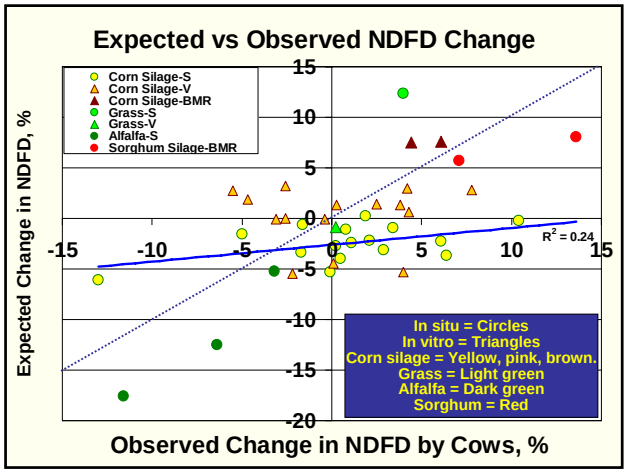
15. Forages supplied from 30 to 100% of the total NDF consumed. How well was the CHANGE in NDF digestibility by cows predicted by changes in lab NDFD ?

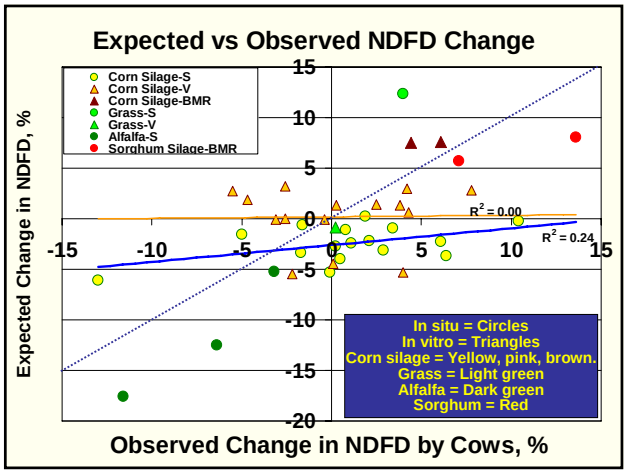
a. Quite closely.
b. Strong trends.
c. It varies with the forage.

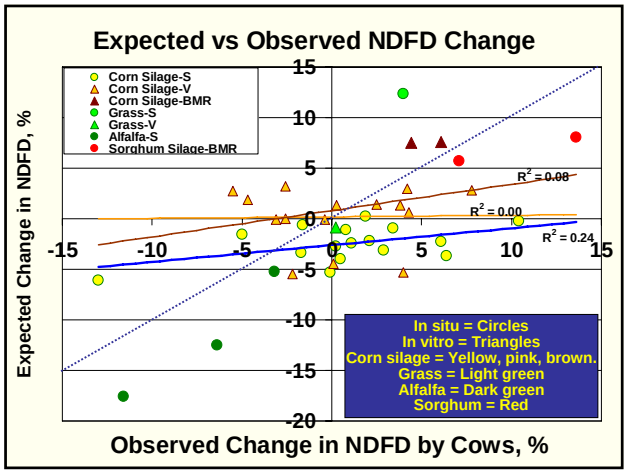
Expected vs Observed NDFDt Responses

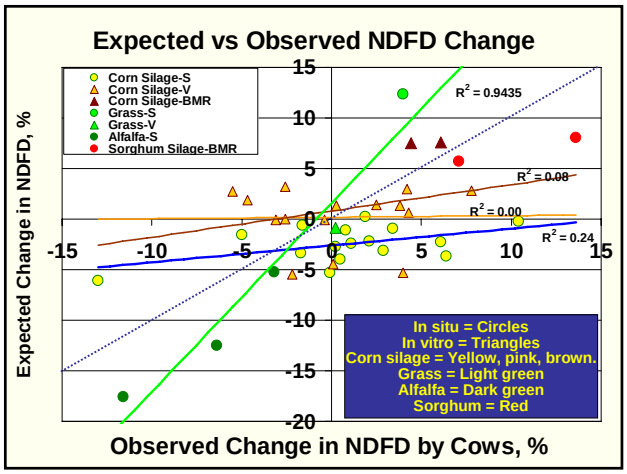
a. Observed cow response = NDF digestibility of each test diet minus NDF digestibility of the basal diet.
b. Expected cow response = [Lab NDF digestibility of each test diet minus Lab NDF digestibility of the basal diet] multiplied by the percentage of dietary NDF that came from the forage.
c. Plotted expected vs observed response (positive or negative).
d. Separated by lab assay type.
e. Regressed within each lab assay type.











16. Why is NDF digestibility by cows imprecisely predicted by lab methods?

a. Compensatory postruminal NDF digestion.
b. Imprecision of digestibility estimates by cows (intake, rate of passage, ruminal pH effects)
c. Sample preparation effects (drying, grinding)
d. Lab procedure limitations (microbial activity, culture conditions of pH, ammonia, time lag, specified incubation times).
e. Selective ruminal retention of more digestible feed particles.
f. All of the above.

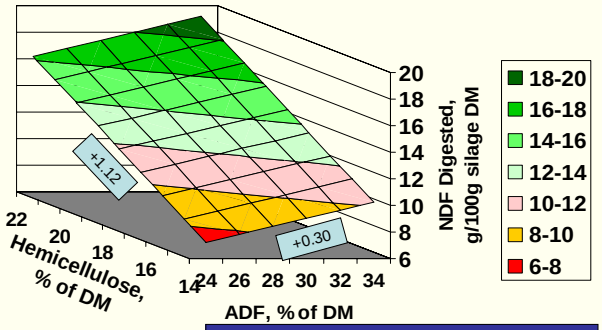
17. Hemicellulose usually is well digested in vitro and in situ. Is it well digested by cows?

a. It certainly should be.
b. If shielded by ADF, perhaps not.
c. If linked to lignin, certainly not.
d. All of the above.

Lab Digestion of NDF Components

a. Calculated the total amount of NDF digested in vitro from corn silage (multiple of dietary NDF and NDF digestibility)
b. Regressed ADF and hemicellulose contents against total NDF digested from corn silage.
c. Plotted values.
d. Slopes should represent ADF and hemicellulose digestibility.

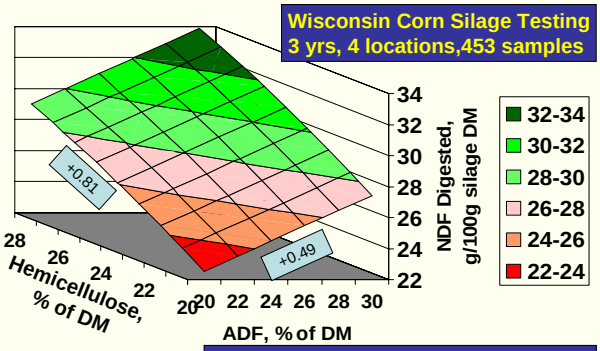
NDFv Digested vs ADF and Hemicellulose



Hemicellulose was over 3 times more digestible than ADF by lab assays

NDFv Digested vs ADF and Hemicellulose

Wisconsin Corn Silage Testing
3 yrs, 4 locations,453 samples

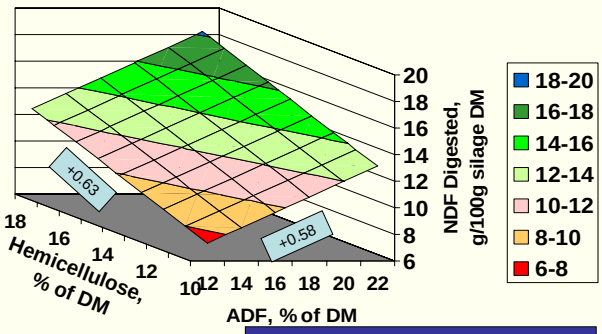


Hemicellulose was over 1.6 times more digestible than ADF by lab assays

Digestion of NDF Components by Cows

a. Calculated the total amount of NDF digested in vivo from diet (multiple of dietary NDF and NDF digestibility of total diet)
b. Regressed ADF and hemicellulose content of diets against total NDF digested for corn silage.
c. Plotted values.
d. Slopes should represent ADF and hemicellulose digestibility.

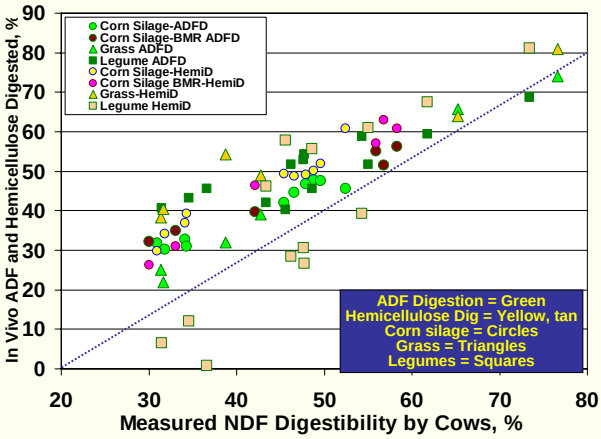
NDFt Digested vs ADF and Hemicellulose

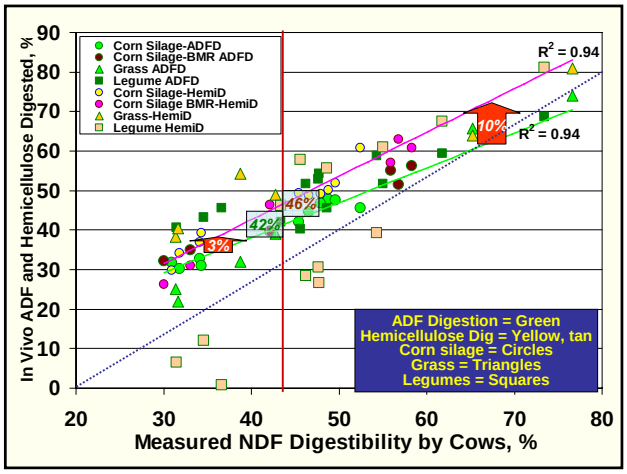


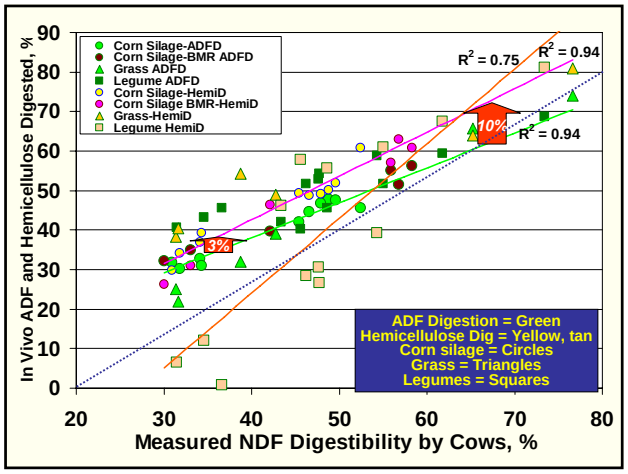
Cows did not digest hemicellulose much better than ADF (63 vs 58%).

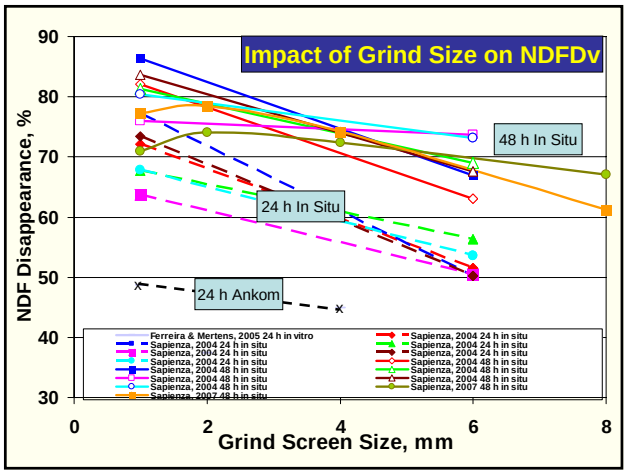
Direct Measurement of NDF Components by Cows

a. Diet hemicellulose = Diet NDF minus diet ADF.
b. Hemicellulose digestion = Diet NDF multiplied by NDF digestion MINUS diet ADF multiplied by ADF digestion by cows.
c. Hemicellulose digestibility = b/a.
d. Plotted cow's hemicellulose and ADF digestibility against NDF digestibility by cows.
e. Plotted regressions within forage type.







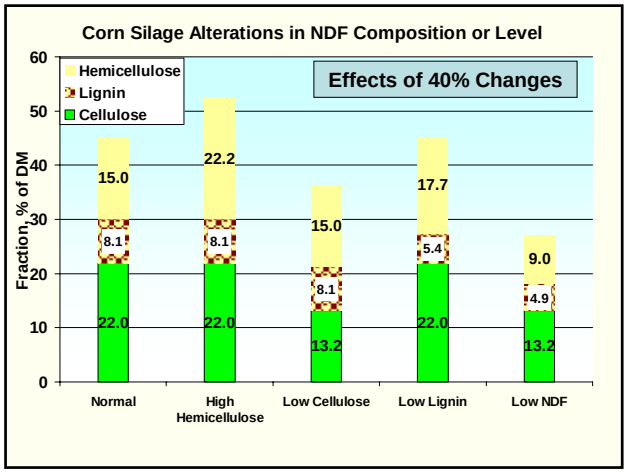


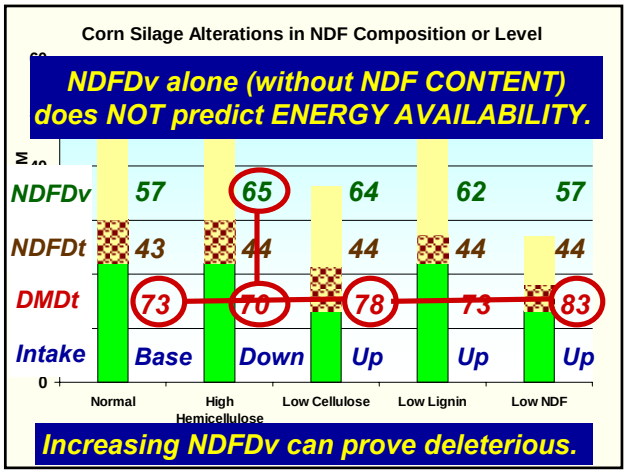
18. Will altering corn silage NDF composition to increase in vitro NDFD increase the supply of digested energy from the silage?

a. Yes.
b. No.
c. That depends upon which fraction is altered.

Altering NDF Components

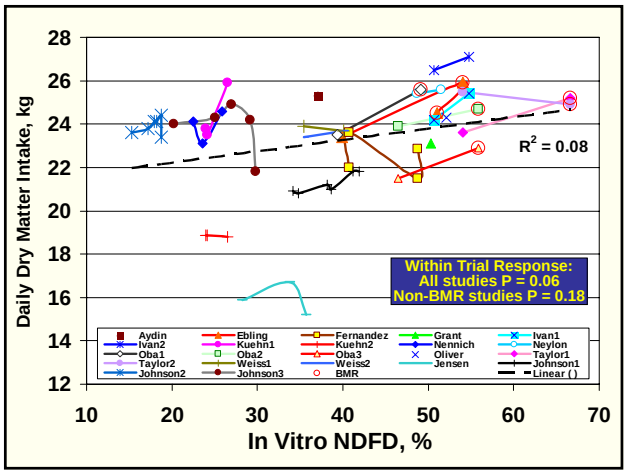
a. Increases or decreases by 40% (like BMR effect on lignin content).
b. In vitro NDFD based on regressions from data: NDFD = (0.30*ADF+1.12*Hemicellulose)/NDF.
c. Total tract NDFD based on regressions from data: NDFD = (0.42*ADF+0.46*Hemicellulose)/NDF.
d. True digestibility = 0.98*Cell contents + NDFDt*NDF.

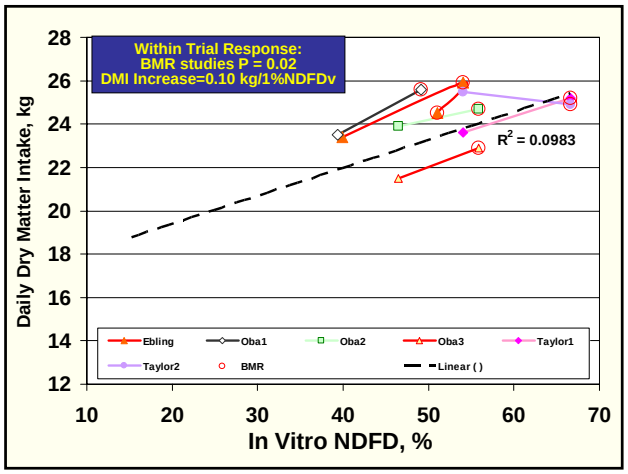


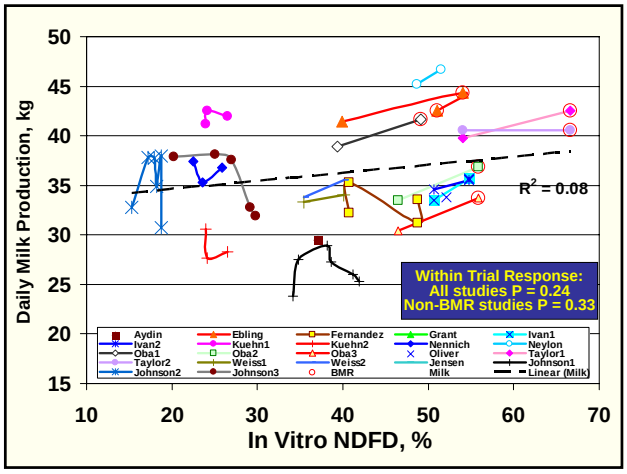


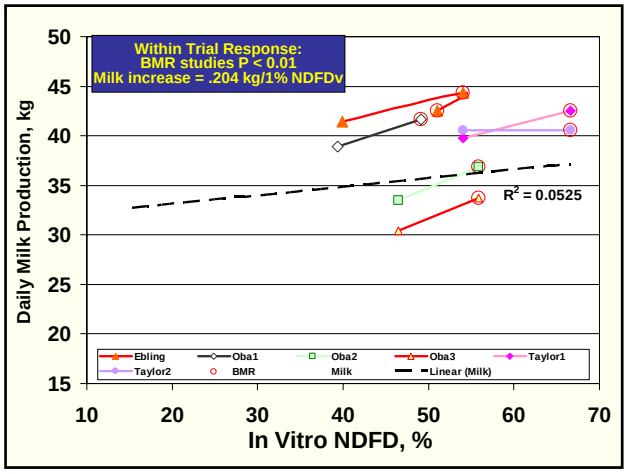
19. Will corn silage with greater in vitro NDFD significantly increase feed intake and milk production by lactating cows?

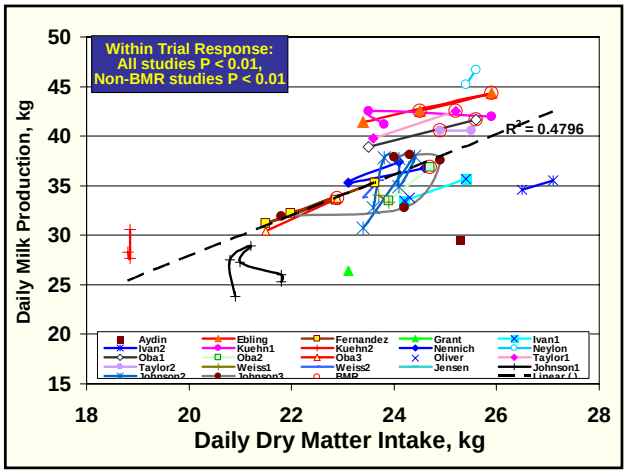
a. Yes for all corn silages.
b. Yes for BMR corn silage.
c. Not significantly for non-BMR corn silage.
d. If intake is increased, milk production will increase.

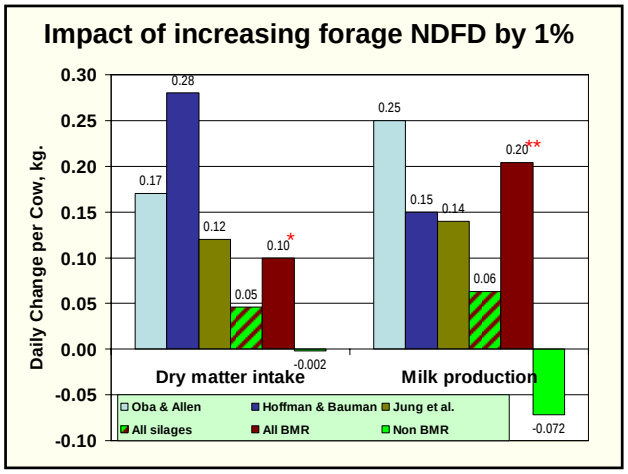

Within Trial Response:
All studies P = 0.06
Non-BMR studies P = 0.18
R^2 = 0.08
Daily Dry Matter Intake, kg
In Vitro NDFD, %
Aydin
Ebling
Fernandez
Grant
Ivan1
Ivan2
Kuehn1
Kuehn2
Nennich
Neylon
Oba1
Oba2
Oba3
Oliver
Taylor1
Taylor2
Weiss1
Weiss2
Jensen
Johnson1
Johnson2
Johnson3
BMR
Linear ( )


Within Trial Response:
BMR studies P = 0.02
DMI Increase=0.10 kg/1%NDFDv
R^2 = 0.0983
Daily Dry Matter Intake, kg
In Vitro NDFD, %
Ebling
Oba1
Oba2
Oba3
Taylor1
Taylor2
BMR
Linear ( )


Within Trial Response:
All studies P = 0.24
Non-BMR studies P = 0.33
R^2 = 0.08
Daily Milk Production, kg
In Vitro NDFD, %
Aydin
Ebling
Fernandez
Grant
Ivan1
Ivan2
Kuehn1
Kuehn2
Nennich
Neylon
Oba1
Oba2
Oba3
Oliver
Taylor1
Taylor2
Weiss1
Weiss2
Jensen
Johnson1
Johnson2
Johnson3
BMR
Milk
Linear (Milk)

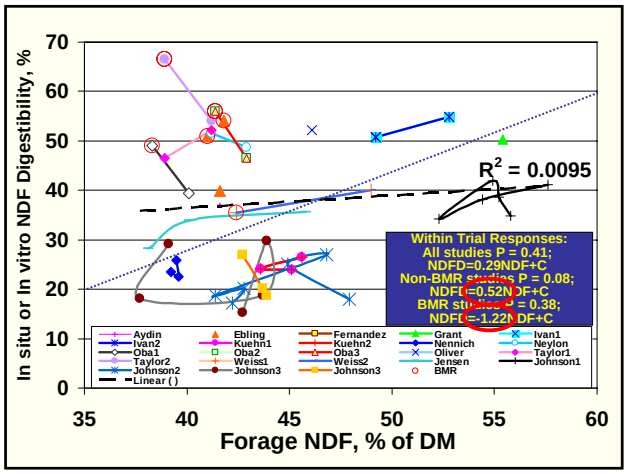

Within Trial Response:
BMR studies P < 0.01
Milk increase = .204 kg/1% NDFDv
R^2 = 0.0525
Daily Milk Production, kg
In Vitro NDFD, %
Ebling
Oba1
Oba2
Oba3
Taylor1
Taylor2
BMR
Milk
Linear (Milk)

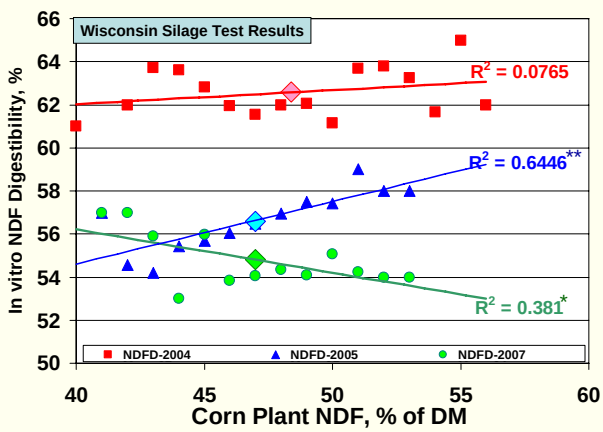

Within Trial Response:
All studies P < 0.01,
Non-BMR studies P < 0.01
R^2 = 0.4796
Daily Milk Production, kg
Daily Dry Matter Intake, kg
Aydin
Ebling
Fernandez
Grant
Ivan1
Ivan2
Kuehn1
Kuehn2
Nennich
Neylon
Oba1
Oba2
Oba3
Oliver
Taylor1
Taylor2
Weiss1
Weiss2
Jensen
Johnson1


Impact of increasing forage NDFD by 1%
Daily Change per Cow, kg.
0.17
0.28
0.12
0.05
0.10*
-0.002
0.25
0.15
0.14
0.06
0.20**
-0.072
Dry matter intake
Milk production
Oba & Allen
Hoffman & Bauman
Jung et al.
All silages
All BMR
Non BMR

Why is DMI INCREASED with BMR Corn Silage?

a. Decreased rumen fill due to less or faster clearance of indigestible NDF.
   But indigestible NDF fill is a function of NDF CONTENT and NDF digestion rate, not NDF digestion rate alone.
   With BMR corn silage, NDFD decreased when NDF increased.
   With non-BMR corn silage, NDFD increased when NDF increased.





Why is DMI INCREASED with BMR Corn Silage?

a. Decreased rumen fill due to less or faster clearance of indigestible NDF.
b. Magnitude of the NDFDv change is greater in BMR comparisons.
c. Lignin may have adverse effects on rumen fermentation.
d. Digested hemicellulose may benefit microbes or improve rumen wall health (Thonney, 2008).
e. BMR trait may have additional effects on particle fragility to increase rate of passage (like ammoniation; grinding and pelleting alfalfa).

Conclusions/Implications

1. NDFD is measured by multiple procedures that differ.
2. Laboratory digestion of dietary NDF:
   - Markedly exceeds NDF digestibility responses by cows.
   - Underestimates in vivo differences detected by cows.
   - Poorly predicts in vivo digestibility responses by cows.
3. Hemicellulose digestion in vitro markedly exceeds hemicellulose digestion in vivo.

Conclusions/Implications

4. If in vitro NDF digestion is increased because a silage contains more hemicellulose, it will have LESS true energy digestibility than corn silage with less hemicellulose.
5. Increasing in vitro NDF digestion by decreasing ADF, lignin, or total NDF will INCREASE true energy digestibility of corn silage.
6. Decreasing lignin content or increasing lignin digestibility (e.g., BMR) increases dry matter intake and daily milk production.
7. With non-BMR corn silages, responses in intake and milk production to greater in vitro digestion have been inconsistent.

Questions?