World Dairy Expo Forage Superbowl Seminar:

Undigested fiber in forages– What does it mean to a dairy cow?

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1:30 PM

New Technologies and Innovations in Forage Feeding Programs for Livestock:

DIGESTIBILITY

Corn Silage

- Shredlage (↑ starch digestibility, ↑ NDF digestibility?)
- BMR (↑ NDF digestibility)

Alfalfa

- Reduced lignin (↑ NDF digestibility)

Grasses

- Improved grasses for high producing dairy cows (Higher fiber digestibility than alfalfa or corn silage)

Forage testing/analysis

- Amount of fiber (NDF_{om})
- Indigestible fiber ($uNDF_{240}$)
- Undigested fiber ($NDFD_{(24, 30, or 48)}$ or $uNDF_{(24, 30, or 48)}$)
- Rate of fiber digestion (kd)

- ✓ **Forage fiber tests**
  - ✓ **NDF vs NDF digestion**
  - ✓ **Tests used to assess fiber digestibility**
  - ✓ **Relationships of fiber digestibility tests to animal performance**

What causes performance swings in dairy diets?

Diet Energy is impacted largely by:

- ✓ **Quantity of carbohydrates**
  - ✓ Fiber vs Starch, NSC
- ✓ **<u>Digestibility</u>**
  - ✓ Fiber is always lower energy than starch (grain) because fiber is less digestible than starch
  - ✓ 2-3 unit drop in either Fiber or Starch digestibility will decrease milk by 1 pound

Balancing rations for carbohydrates (starch and NDF) are critical for health and production in high producing dairy cows.

Milk production is affected by variations in:

Fiber digestibility => 6-7 lbs of milk

Starch digestibility => 3-5 lbs of milk

Assessing fiber digestion

Poor digestion < 40%

Excellent digestion > 50%

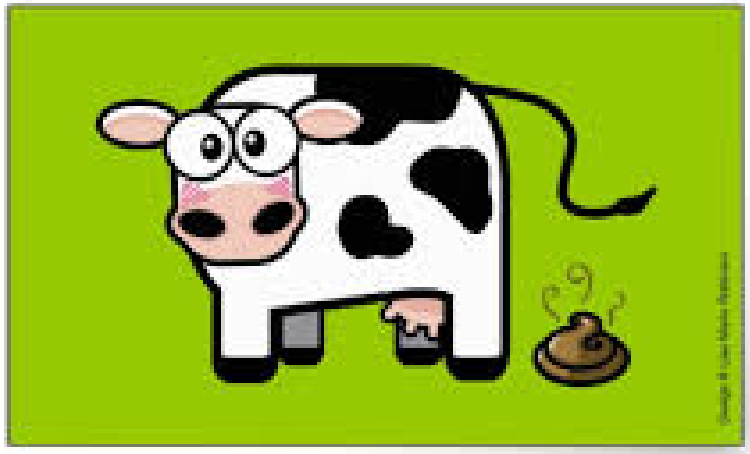
A 2-3 unit change in fiber digestibility corresponds to 1 lb change in milk yield.

The Process of Fiber Digestion

Feed and cow factors both affect fiber digestion

How Can We Equate Feed Fiber Measurements to Animal Utilization of NDF

?



Common Forage Fiber Tests and Their Utility

Test	Rumen Fill/intake	TDN Estimation	Diet Formulation	Quality Index
NDF, NDF_{OM} Total fiber	X	X	X	X
$NDFD_{30}$ undigested fiber after 30 h				X/?
TTNDFD Predicted total tract fiber digestion	X	X	X	X
$uNDF_{240}$ Predicted indigestible NDF	X	?		?
RFQ Quality index: NDF and NDF digestibility				X
Milk/ton Quality index: NDF and NDF digestibility		X		X

Nutritional importance of $uNDF_{240}$?

- ✓ Total NDF – $uNDF_{240}$ = pdNDF
- ✓ $uNDF_{240}$ is variable (NDF is not uniform) amongst forages
- ✓ uNDF thought to be related to rumen fill

Variation in $uNDF_{240}$ and kd of forages harvested in 2015

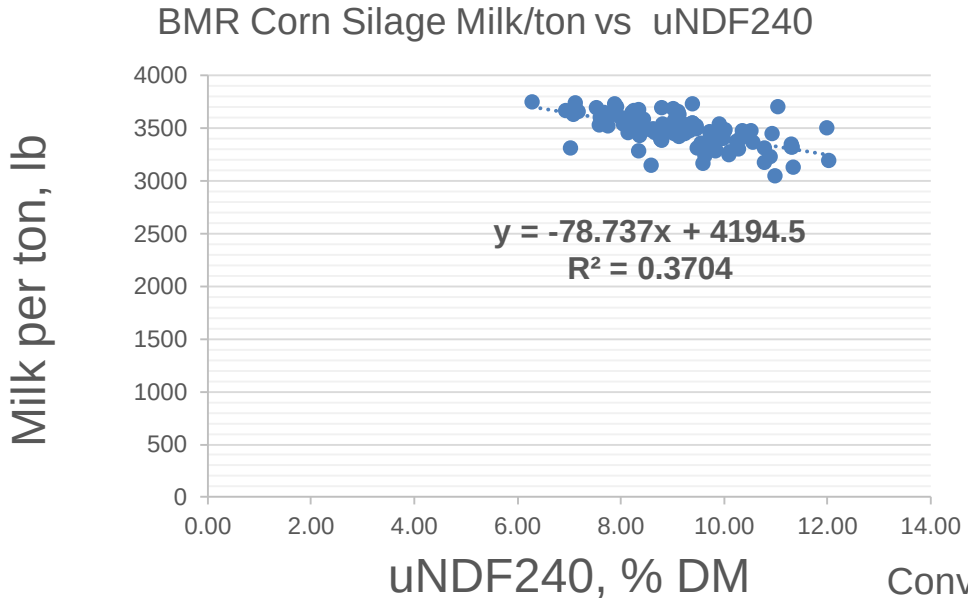
Forage	Average iNDF, % of NDF	Range in iNDF	Average kd, %/h	Range in kd
Corn silage	26.5	12.5 to 40.8	2.73	1.7 to 4.7
Alfalfa silage	40.5	26.5 to 54.5	5.3	1.56 to 9.04
Grass silage	25.5	0 to 51.5	4.46	2.08 to 6.84

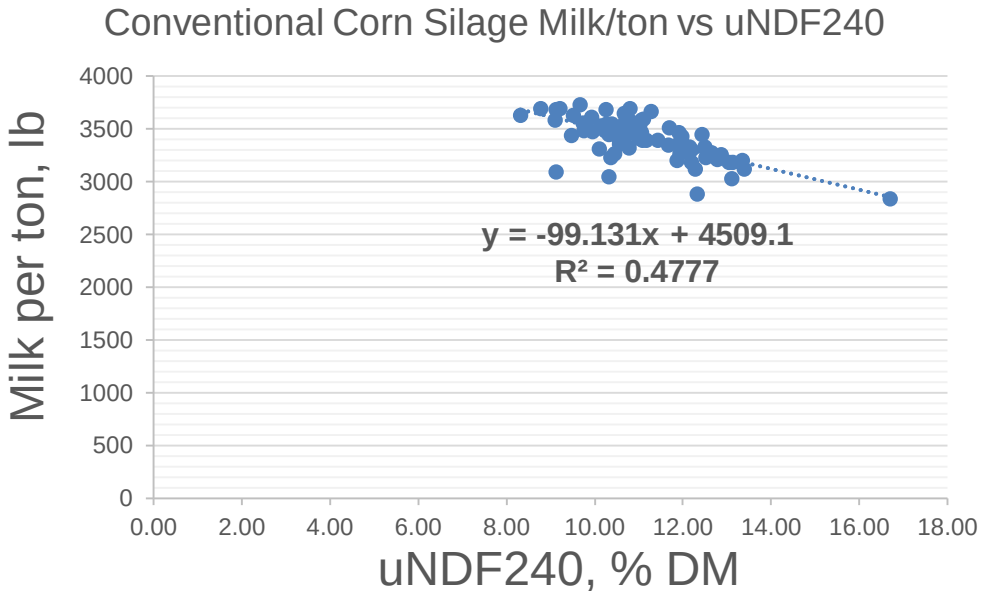
* mean value ± 2 standard deviations

Samples submitted to Rock River Laboratories in 2015 and 2016

The proportion of iNDF and rate of fiber digestion (kd) vary in forages

2015 WDE Corn Silage Milk per ton v $uNDF_{240}$





Even though forages vary in $uNDF_{240}$, the correlation of $uNDF_{240}$ to forage quality is low

$uNDF_{240}$ to predict rumen fill (intake)

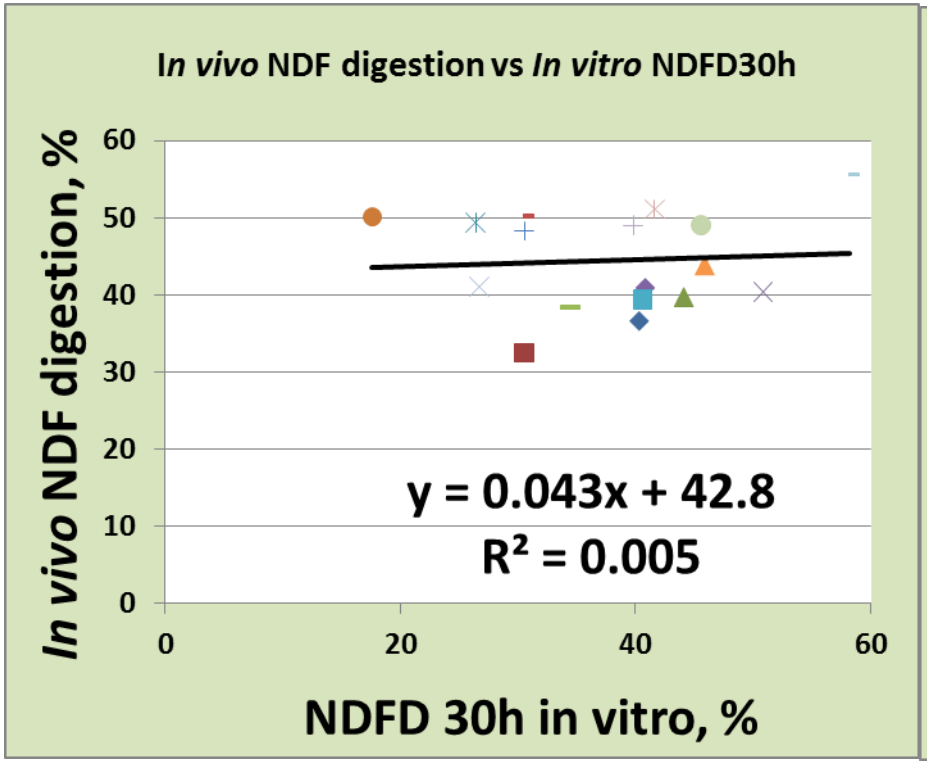
"Range of mass of uNDF in rumen is .48 to .62 % of BW" (Cornell Nutr. Conf. 2014)

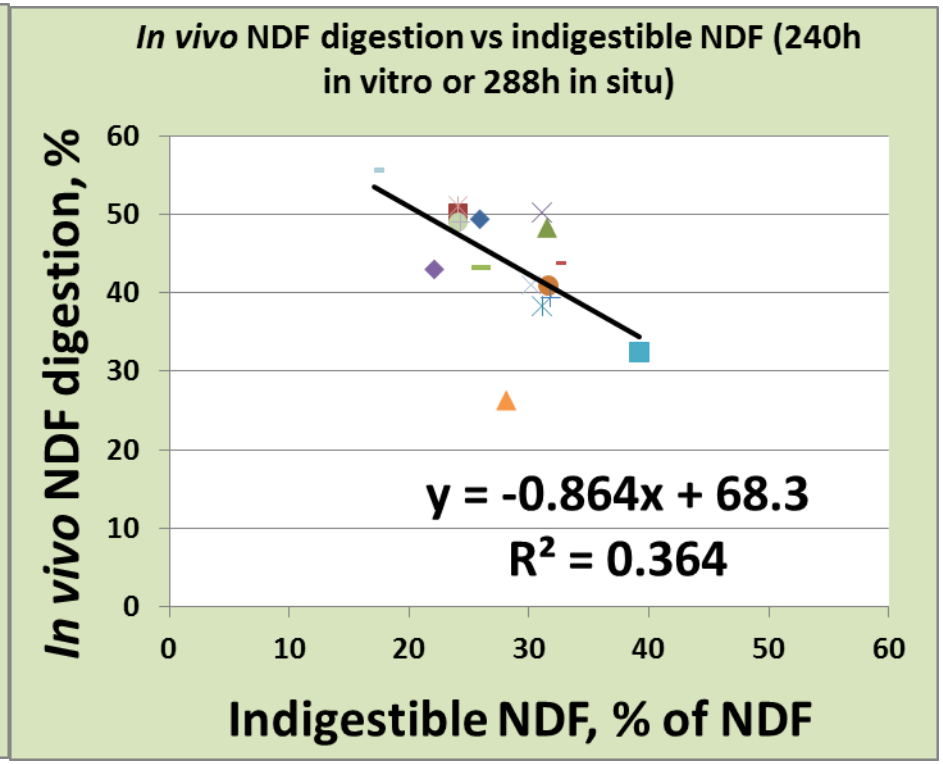
Dorea et al 2017, meta analysis (19 dairy cow studies, 73 diets).

Range of mass of uNDF in rumen was 0.25 to 0.99% of BW

uNDF does not appear to be highly correlated to rumen fill

Stand-alone *in vitro* NDFD30 or uNDF values are poor predictors of in vivo fiber digestion





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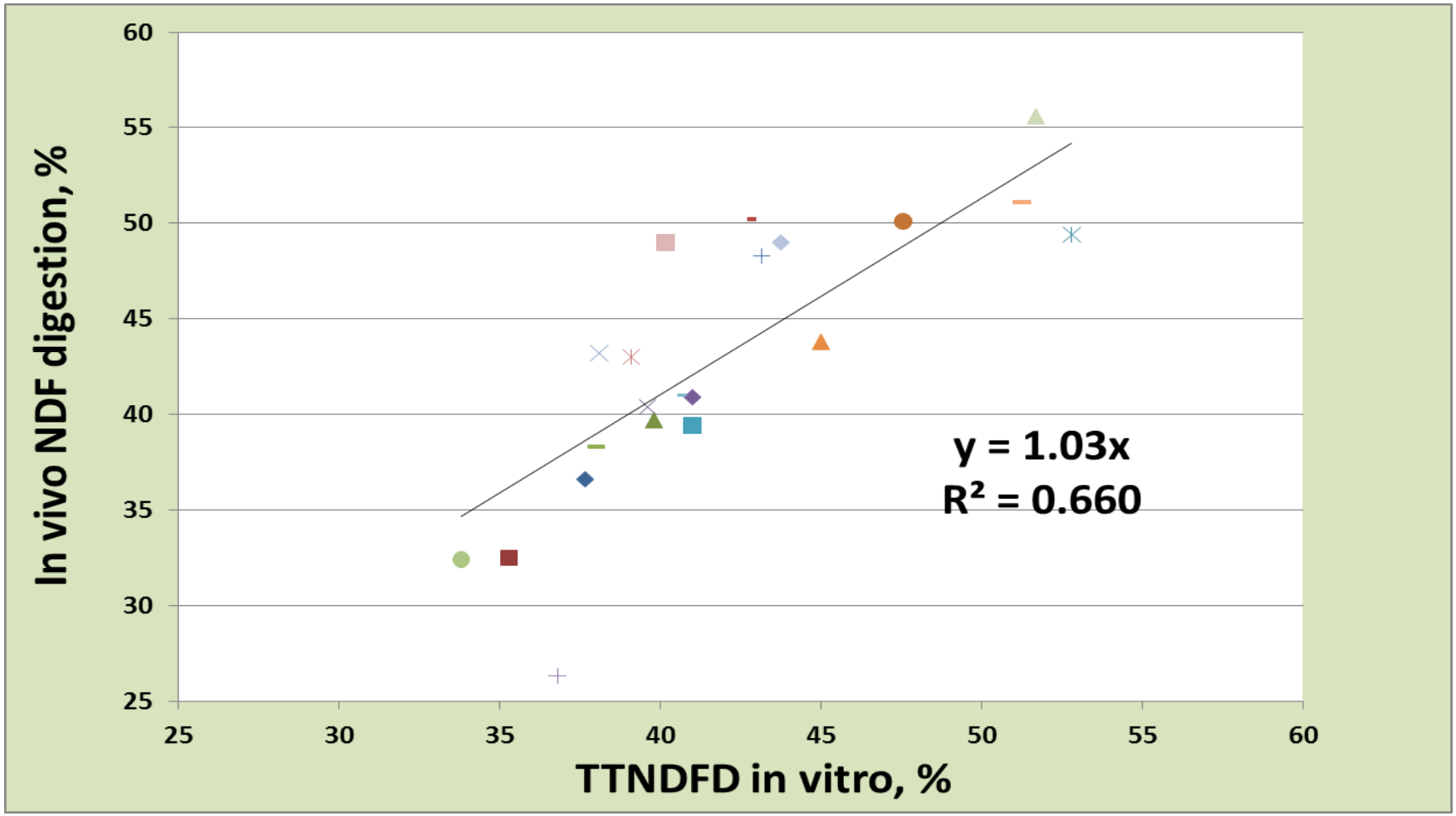
Integrating *in vitro* rate of NDF digestion with *iNDF* improves the prediction of *in vivo* fiber digestion



The Process of Fiber Digestion

Feed and cow factors both affect fiber digestion

Fiber digestion is affected by:

Feed characteristics

- ✓ The amount of fiber (NDF, or NDF_{om})
- ✓ Potentially digestible fiber (pdNDF)
  (pdNDF = NDF-$uNDF_{240}$)
- ✓ Rate of fiber digestion (kd)

Animal and diet

- ✓ Intake affects rate of fiber passage (kp)
- ✓ Approx. 90% of NDF digestion is in rumen

The Math:

1. NDF digestion = pdNDF x $\frac{kd}{(kd + kp)}$

- ✓ pdNDF = (NDF – $uNDF_{240}$)
- ✓ Kd = Digestion rate of the fiber (kd)
- ✓ kp pdNDF = Passage rate of the digestible fiber

Rumen fiber digestion must account for pdNDF, kd and kp

Alfalfa and corn have the same fiber digestibility (42%) but different fiber digestion properties

$$\text{NDF digestion} = \text{pdNDF} \times \frac{kd}{(kd + kp)}$$

Typical alfalfa 40% of DM NDF, $uNDF_{240}$ = 16 % of DM

pdNDF = 59.3 % of NDF, kd = 4.72%/h, kp = 2.67% /h

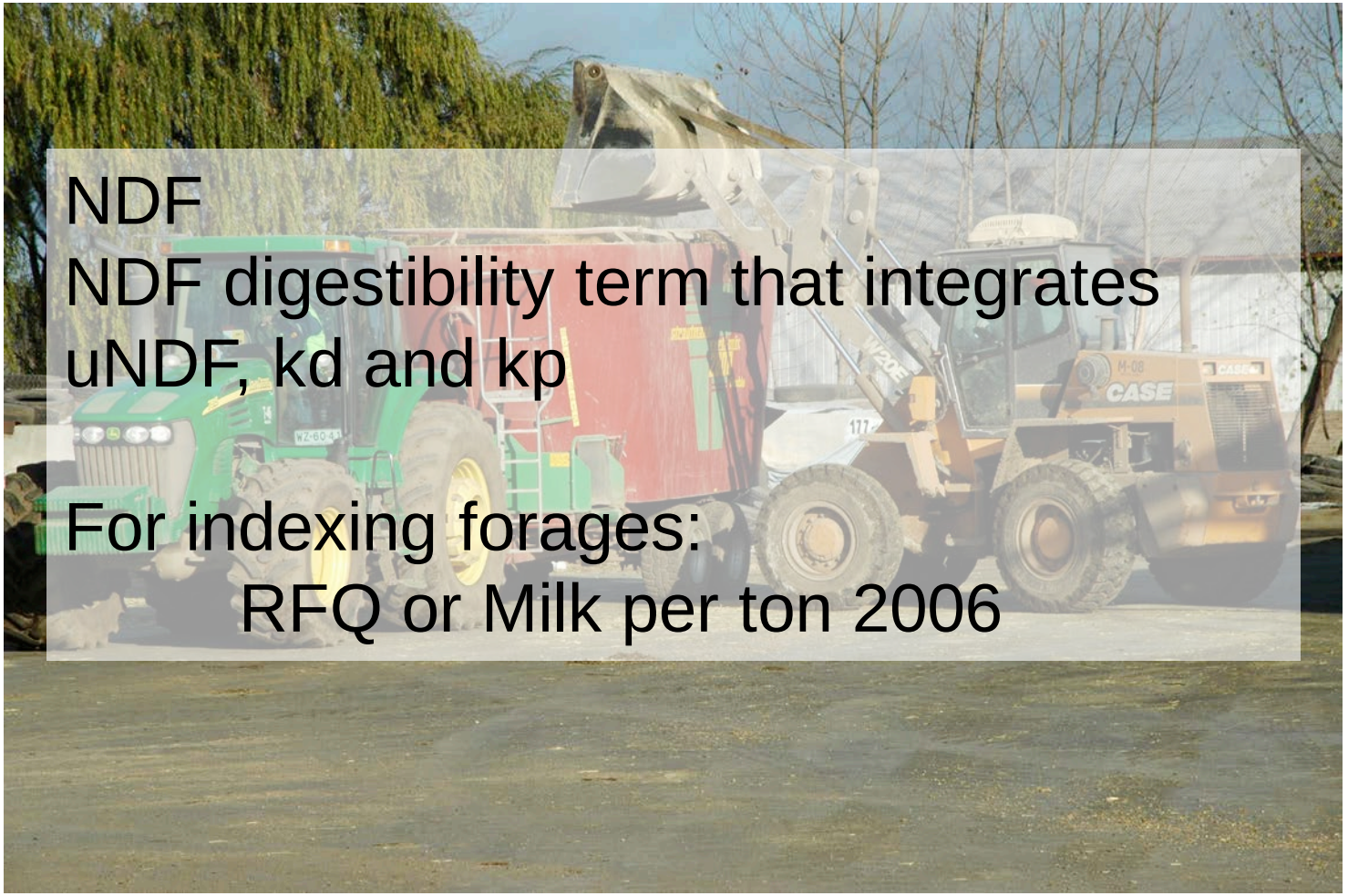
$$\text{Rumen digested fiber} = 59.3 \times \frac{4.72}{(4.72 + 2.67)} = 0.42$$

Typical corn silage 40% of DM NDF, $uNDF_{240}$ = 10.3

pdNDF = 74.0% of NDF, kd = 2.80%/h, kp = 2.67%/h

$$\text{Rumen digested fiber} = 74.0 \times \frac{2.80}{(2.80 + 2.67)} = 0.42$$

Which forage tests are most relevant to predicting forage quality



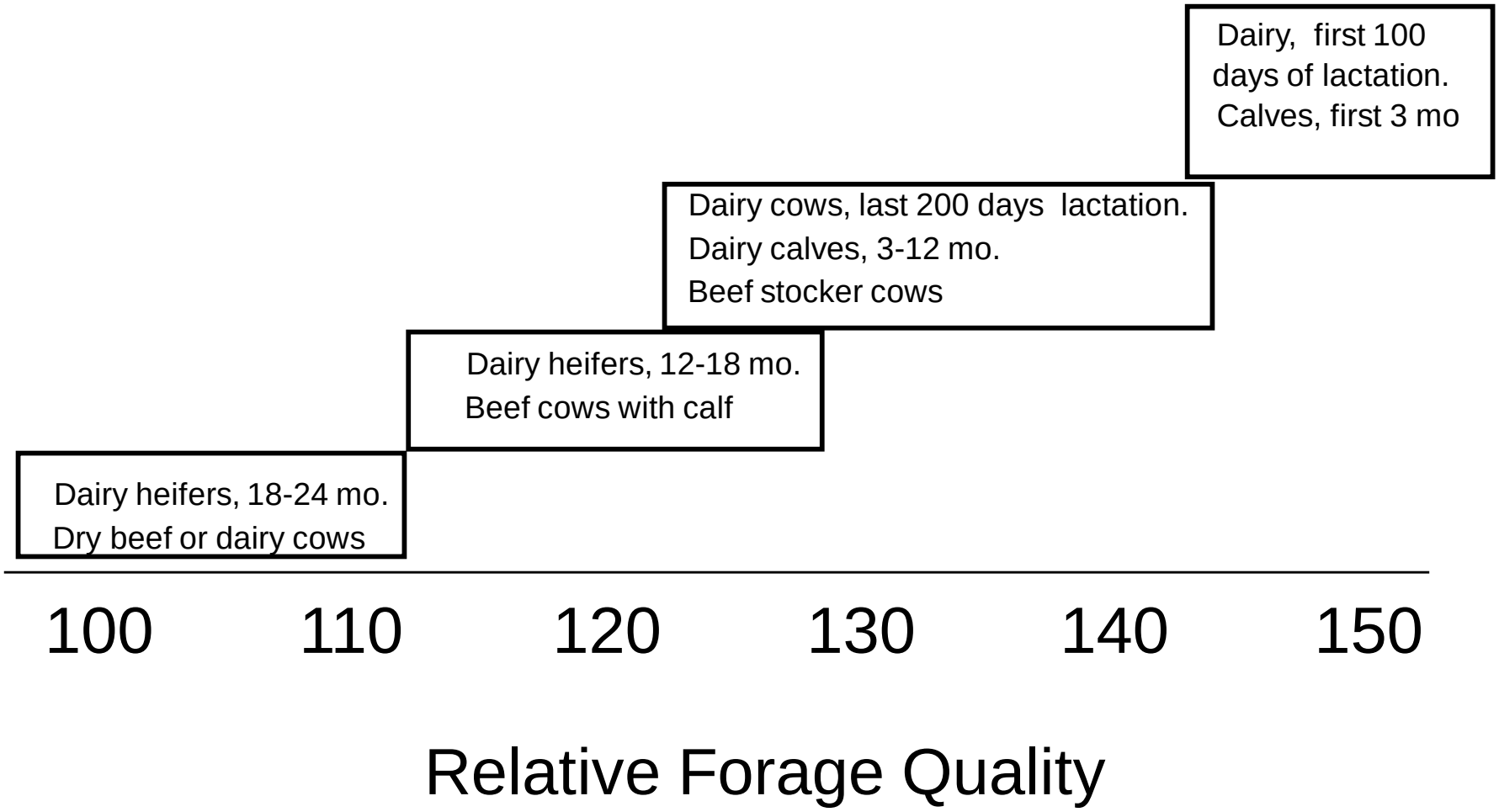
NDF
NDF digestibility term that integrates uNDF, kd and kp

For indexing forages:
RFQ or Milk per ton 2006

Relative Forage Quality (RFQ)
or Milk per Ton

Indexing tools that combine NDF and an estimate of NDF digestion into one quality term.

Matching Relative Forage Quality to Animal Needs



RFQ and Milk per ton are useful indexing tools within forage type

- ✓ Can’t be used to formulate diets or predict animal performance
- ✓ Primary value is as a means of forage marketing or seed selection

What makes a better forage?

- ✓ Low fiber ($aNDF_{om}$)
- ✓ High fiber digestibility

BOTH NDF and NDF digestibility are needed to assess forage quality

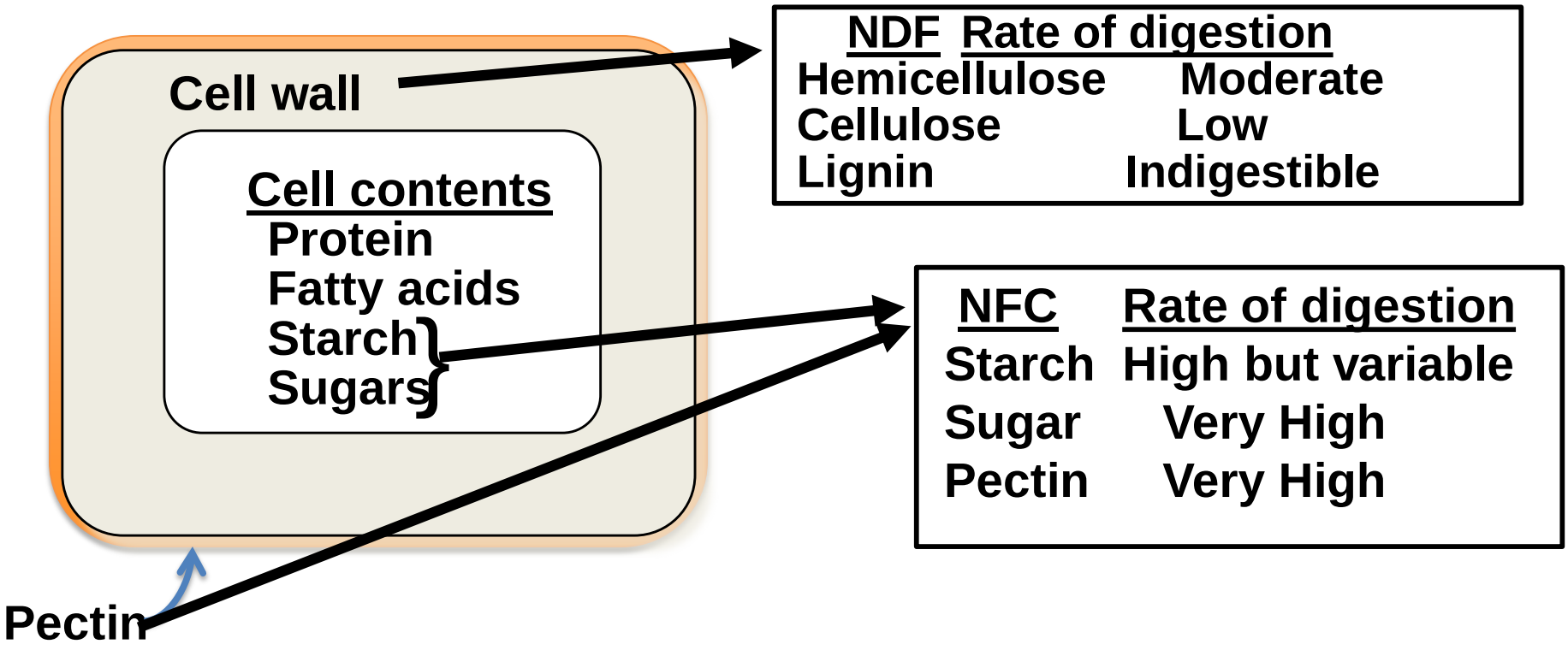
Typical dietary profiles for high producing dairy cows

Item	
NDF, % of DM	28-30
TTNDFD, % of NDF	> 42%
Starch, % of DM	21-28
Starch Digestibility, % of starch	>95%
CP, % of DM	16-18% *
Fat, % of DM	3-7%

THE WISCONSIN IDEA

*The **Wisconsin Idea** is a philosophy embraced by the University of Wisconsin System, which holds that research conducted at the University of Wisconsin System should be applied to solve problems and improve health, quality of life,*

Plant Cell Schematic



$$pdNDF = NDF - uNDF_{240}$$

Four things you need to know to measure fiber quality

- ✓ NDF or NDF_{om} MOST IMPORTANT
- ✓ (PDNDF) Potentially digestible NDF
- ✓ (Kd) Rate of NDF digestion
- ✓ (Kp) Rate of passage of PDNDF in the cow
  - ✓ Integrate PDNDF, kd and kp into one term

You can't accurately predict how cows will perform without measuring and integrating all four terms!