

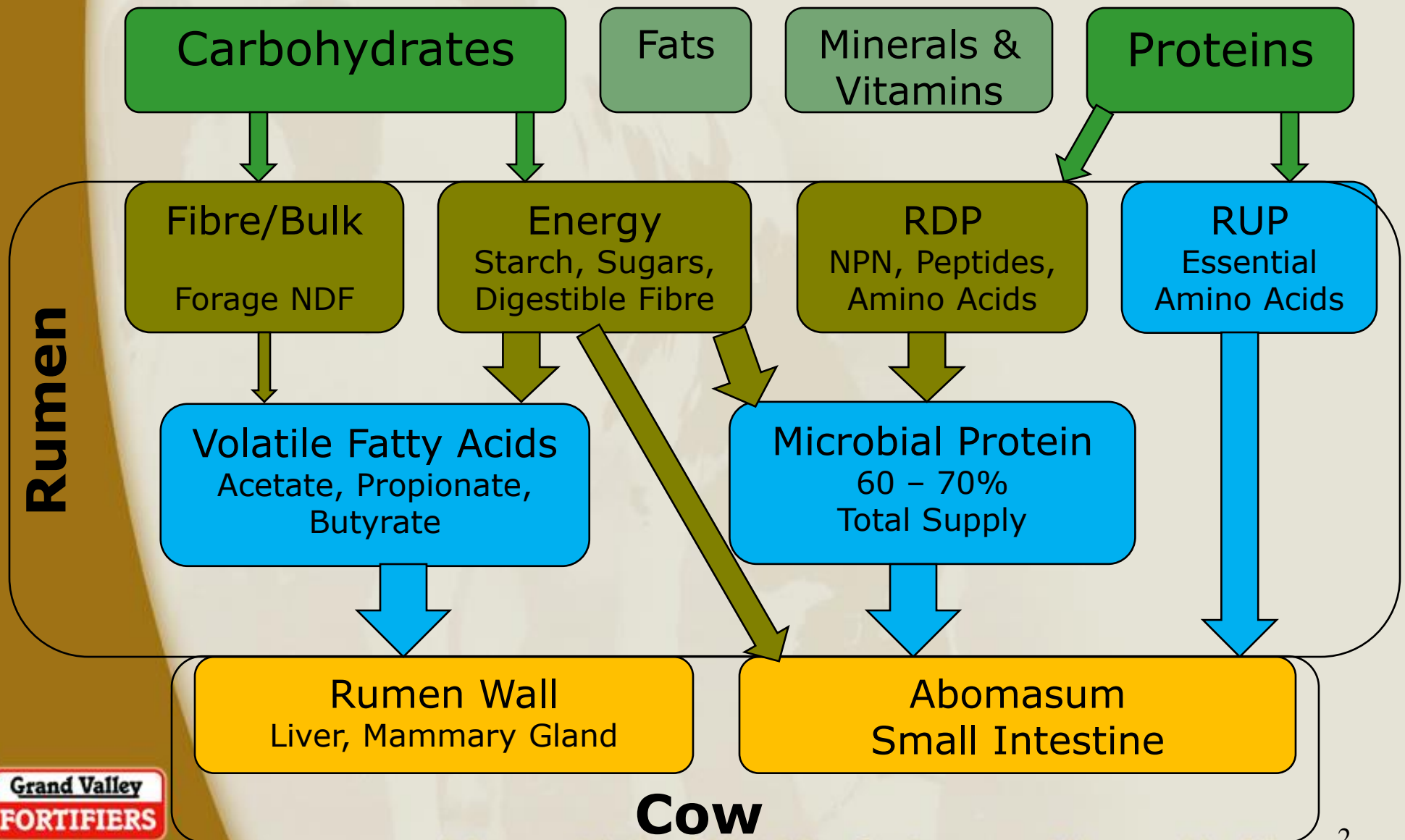
Forage Quality From a Nutrition Perspective

Mark Bowman, MSc
Ruminant Nutritionist
Grand Valley Fortifiers Ltd
Cambridge, Ontario

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Feed the Rumen

.....Feed the Cow



Forages Supply

1. Fibre (Roughage)
 - ❖ Physically effective fibre
 - ❖ Bulk, rumination & cud chewing
2. Digestible (Fermentable) Energy
 - ❖ Rumen fermentable starch, sugars, digestible fibre
3. Protein
 - ❖ Rumen Degradable & Undegradable
4. Minerals
 - ❖ Ca, P, Mg & K

Foundation of Ration

High quality forages supply large amounts of energy and protein in addition to fibre resulting in:

1. High Forage Intake
2. High Milk Production
3. Healthy Cows
4. Lower Feed Cost



Milk From Forages Formula

High Quality Forages

+

High Forage Intake



High Milk Production

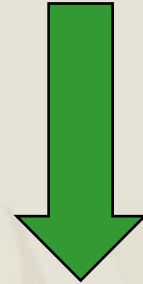
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Healthy Cows

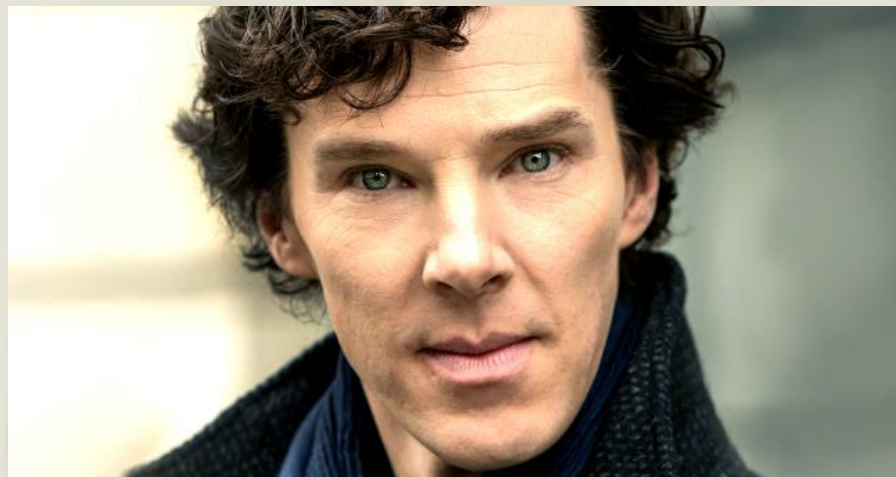
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Higher Profits

High Quality Forages



Make a Smart Nutritionist



The Big Two Questions about Forage Quality

1. How much will she eat?
2. How much will she milk?



Forage Intake Thumb Rule

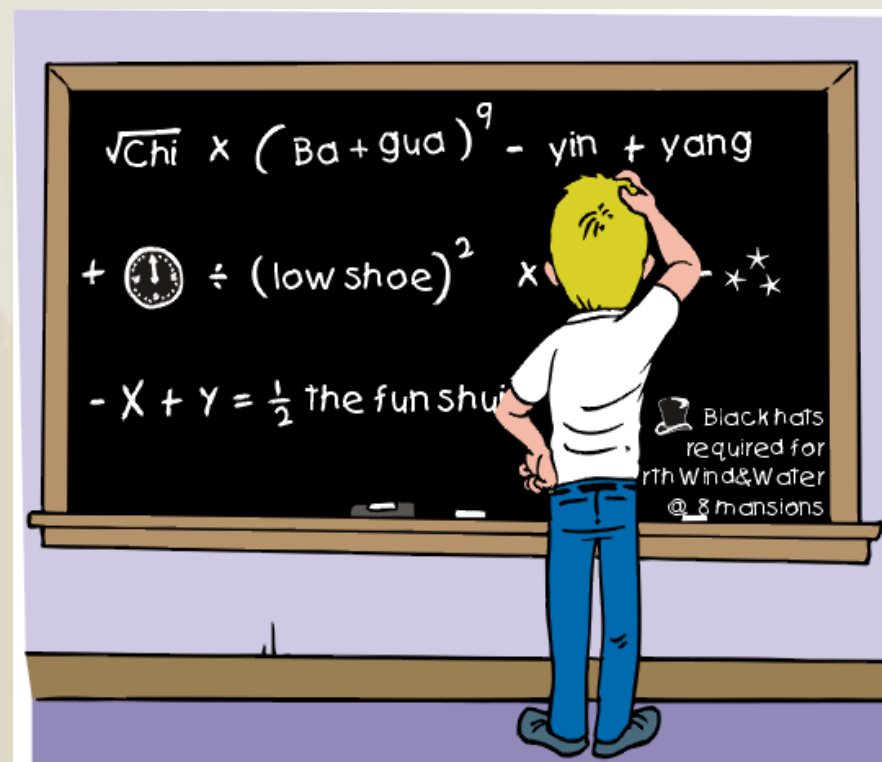
30 – 40 years ago.....

Forage dry matter intake = 2 percent of body weight

1. 750 kg Holstein Cow 15 kg
2. 600 kg 1st Calver 12 kg
3. 300 kg heifer or steer 6 kg

Today.....Well, it's more complicated!

- ❖ Comprehensive lab assays (NIRS)
- ❖ Ration formulation models (eg. CNCPS)
- ❖ Neutral Detergent Fibre (NDF)
- ❖ Undigestible NDF (uNDF)
- ❖ NDF digestion rates (kd values)



High Quality Forages Characteristics



Laboratory Assays

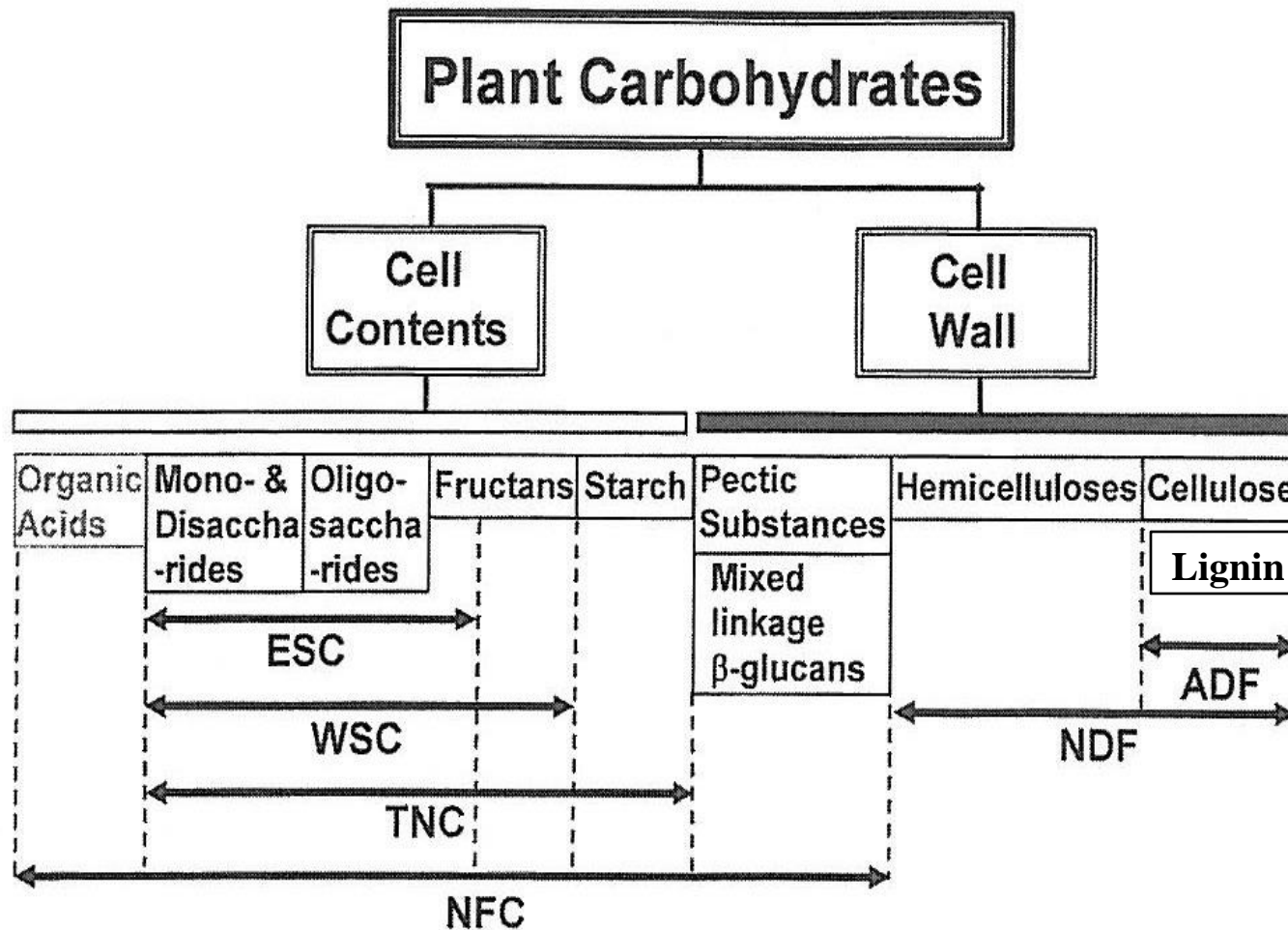


Figure 2. Carbohydrates as partitioned by different carbohydrate analyses. ESC = 80% ethanol-soluble carbohydrates, WSC = water-soluble carbohydrates, TNC = total nonstructural carbohydrates, NFC = nonfiber carbohydrates, ADF = acid detergent fiber, NDF = neutral detergent fiber.

Acid Detergent Fibre (ADF)

- ❖ Cellulose & Lignin
- ❖ Now used less in ration formulation
- ❖ ***Similar levels in legumes and grasses***
- ❖ Best single measure of optimal forage maturity at harvest

Neutral Detergent Fibre (aNDF)

- ❖ Hemi-cellulose + Cellulose + Lignin
- ❖ ***Much higher in grasses than legumes***
- ❖ aNDF is the best measure of insoluble fiber for ruminants
 - Dry matter intakes
 - Digestibility
 - Rate of passage
 - Rumen function and health

Mertens, D.R. 2015 Cornell Nutrition Conference

Forage NDF

- ❖ Establishes forage level in the ration
- ❖ 6 – 7 kg per day in Holstein cows (20 – 30% of DMI)
- ❖ Provides physically effective fibre (peNDF)
- ❖ Stimulates rumination and cud chewing
- ❖ Avoid acidosis and keep butterfat up

Forage Quality Benchmarks



Forage Quality Benchmarks

	Alfalfa	Grasses
Excellent Quality		
CP	20	15
ADF	30	30
aNDF	40	50
Low Quality		
CP	15	10
ADF	40	40
aNDF	52	65

Measuring aNDF Digestibility (aNDFD)

In vivo



“Gold Standard”
older published data
Varying techniques
Been used for TTNDFD

In situ



Replaced In Vivo
Pricey
Grind size
Bag pore size

In vitro



More widely available
More price competitive
Source of rumen fluid
“Expectations”

NIRS



Now widely available
Very price competitive
Quick turn around
Expectations &
Limitations

**Tony Hall, Lallemand Animal Nutrition,
Orlando 2017**

NDFD 30hr (% of aNDF) Digestible NDF

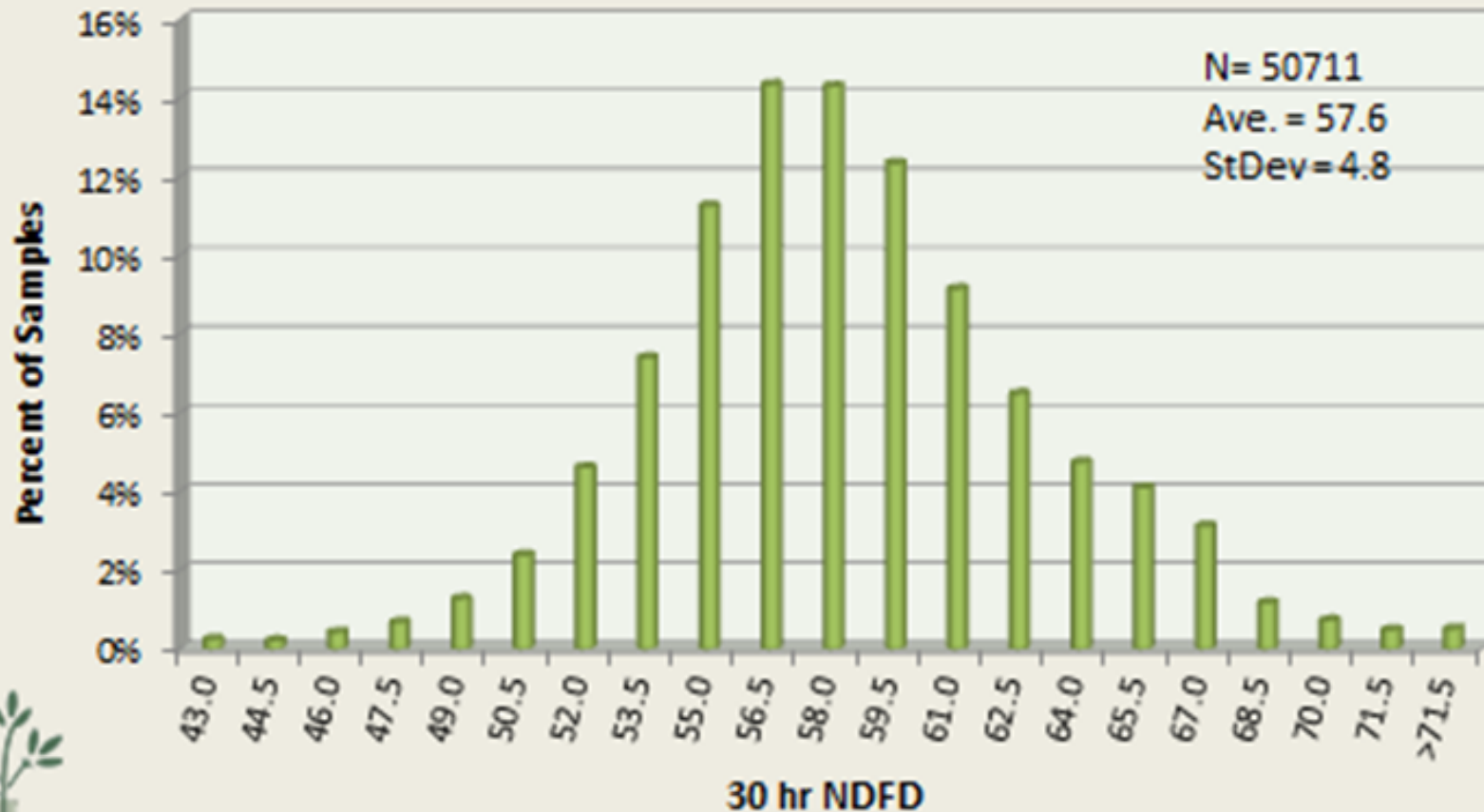
- ❖ A major determinant of forage NDF intake potential
- ❖ High NDFD 30hr allows higher forage and higher total NDF rations
- ❖ Typical levels in forages are 40 – 70%
- ❖ ***Grasses have higher NDFD 30hr than legumes***

NDFD 30hr



	Alfalfa	Grasses
Excellent Quality		
NDFD 30hr	55	70
Low Quality		
NDFD 30hr	40	50

30 hr NDFD of Corn Silage (CVAS, 2016 data)



Courtesy of R Ward 2017 Pers.Comm.

Tony Hall, Lallemand Animal Nutrition,
Orlando 2017

uNDF 30hr (% of DM)

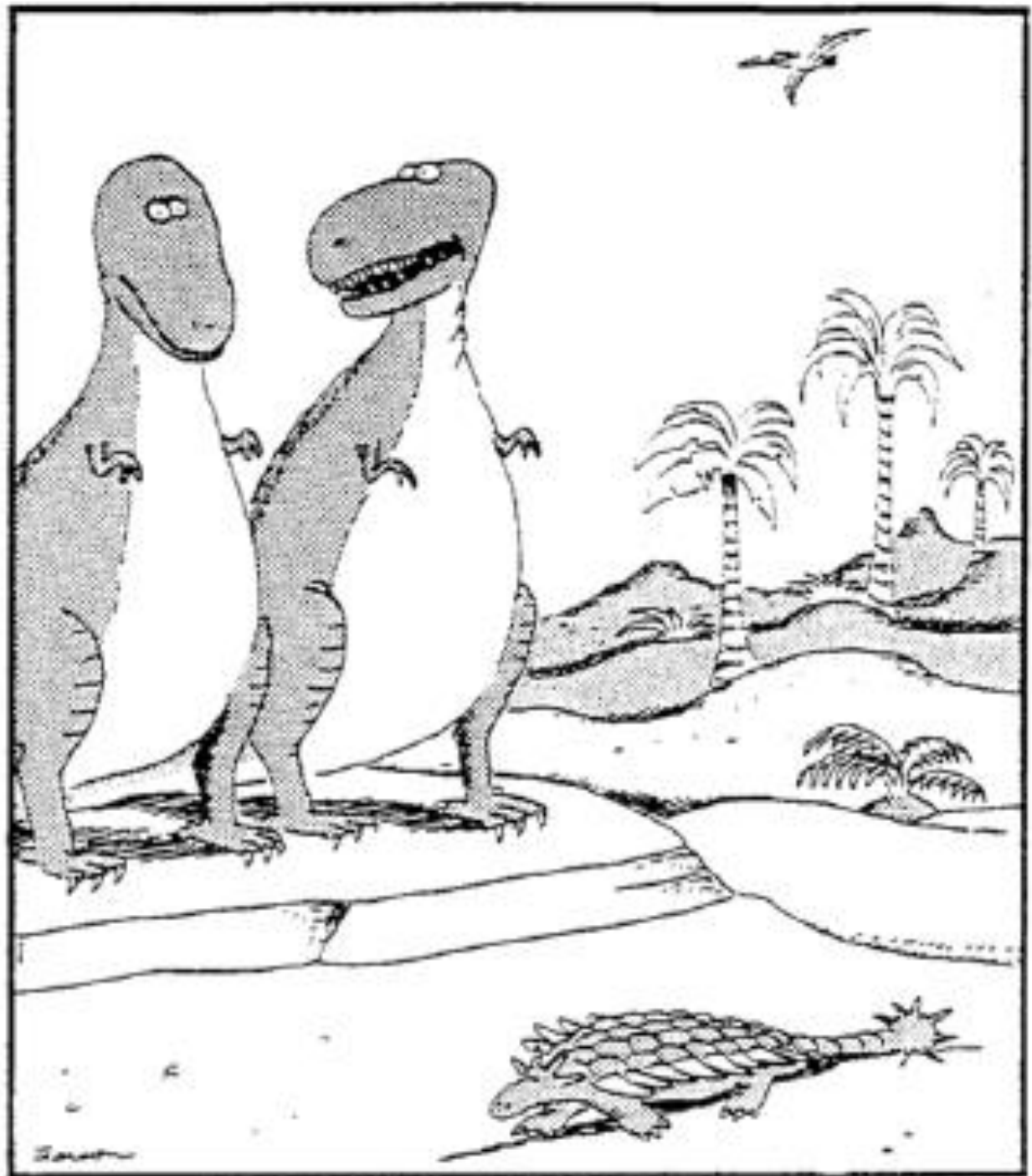
- ❖ Undigested aNDF at 30 hr
- ❖ Calculated from aNDF and NDFD (30hr)
$$\frac{\text{aNDF (\% of DM)} \times (100 - \text{NDFD30hr (\% of NDF)})}{100\%}$$
- ❖ Example:
$$\frac{50\% \text{ NDF} \times (100 - 55\% \text{ NDFD 30hr})}{100\%}$$
$$= 22.5\% \text{ uNDF 30hr}$$
- ❖ 2.3 – 3.5 kg/day intake by Holstein cows

uNDF30 Hours as %DM by Feed Class CVAS, 2014

Forage Type	Number	uNDF30, %DM		uNDF30, %DM, Lower 25% of Samples	
		Average	St. Dev.	Average	St. Dev.
Legume	24,412	22.7	4.18	17.9	1.39
Mixed M. Legume	4,287	23.2	4.65	17.7	1.87
Mixed M. Grass	17,165	25.4	6.72	17.8	2.17
Grass	2,572	31.6	8.47	21.2	3.25
Pasture	642	20.8	6.86	13.9	1.93
Small Grain	5,779	22.7	6.13	15.5	1.61
Sorghum	937	25.4	5.15	19.7	1.67
Corn Silage	59,626	17.1	2.93	13.8	1.03

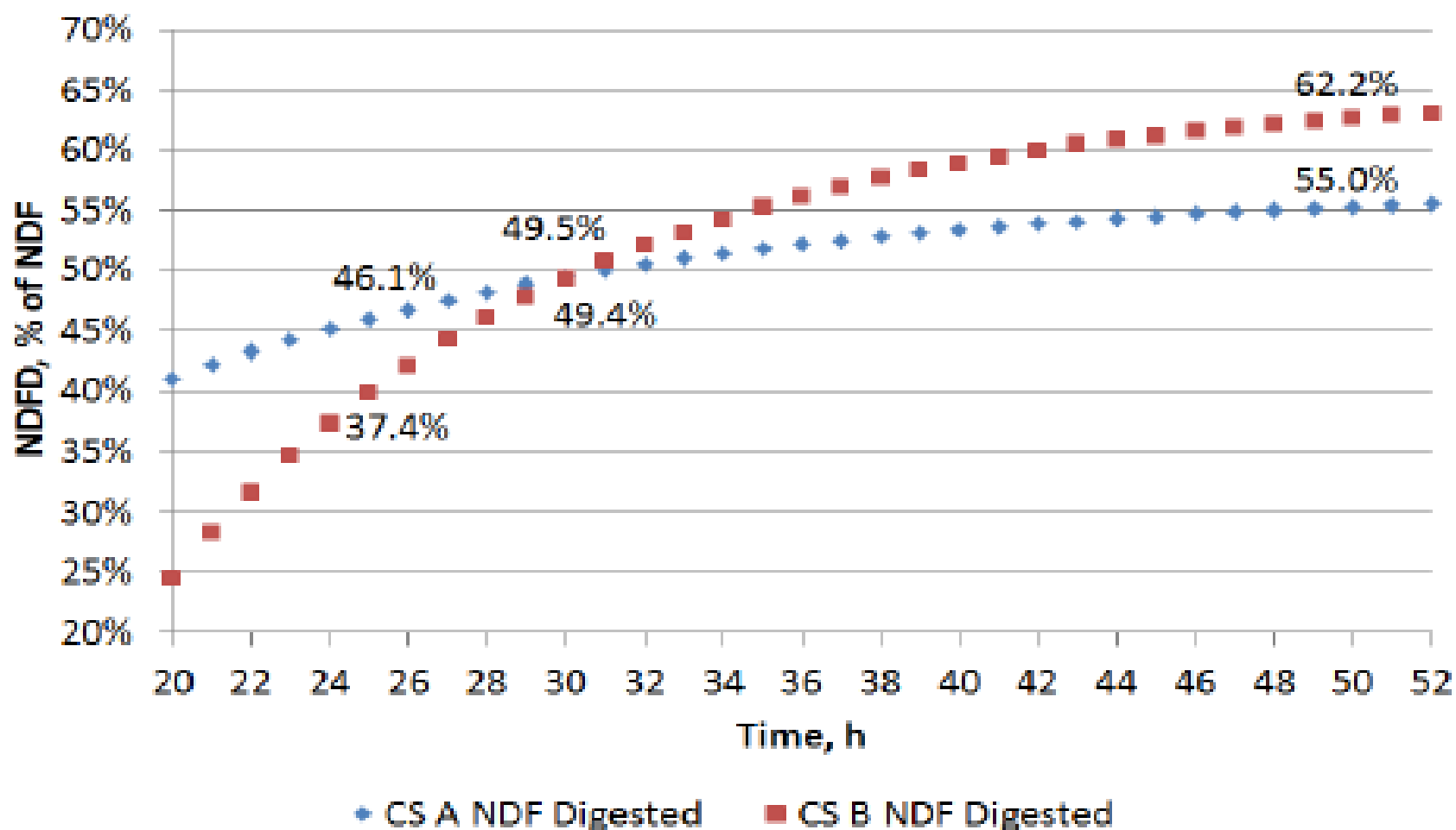
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Nutritional role of forage- fiber?



"It's roughage, and that's about it."

Rate of NDF digestion (kd values) also important



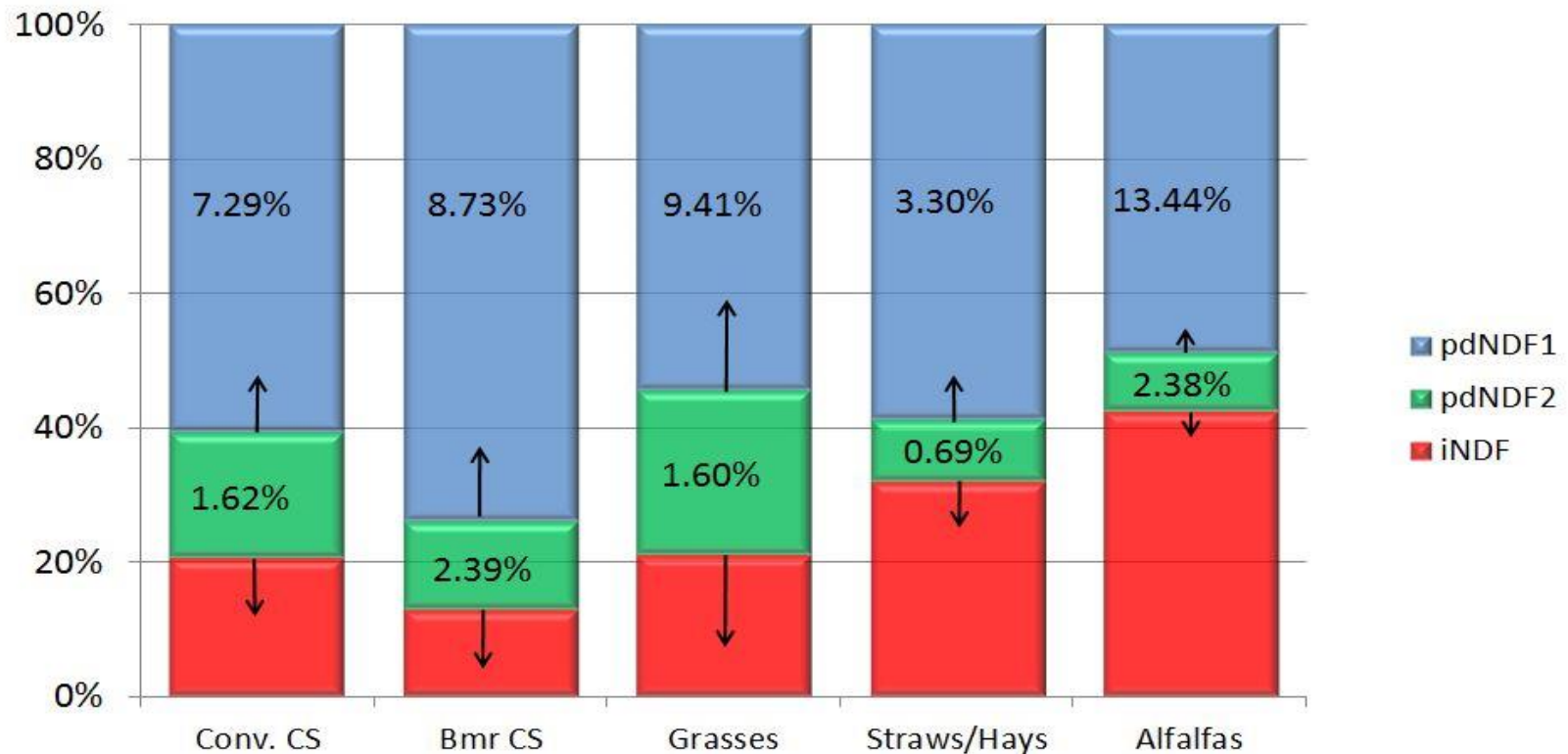
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aNDFom Multiple Time Point Digestibilities

- ❖ aNDFom (ash corrected)
- ❖ NDFDom at 30 , 120 and 240 hr
 - Digestible NDF on multiple time points (% aNDFom)
- ❖ uNDFom at 30, 120 and 240 hr
 - Undigestible NDF on multiple time points (% DM)
- ❖ Allows calculation NDF digestion rates (kd values) with much more accuracy

NDFD pools & rates by forage type

Summary of rates and pools by forage type

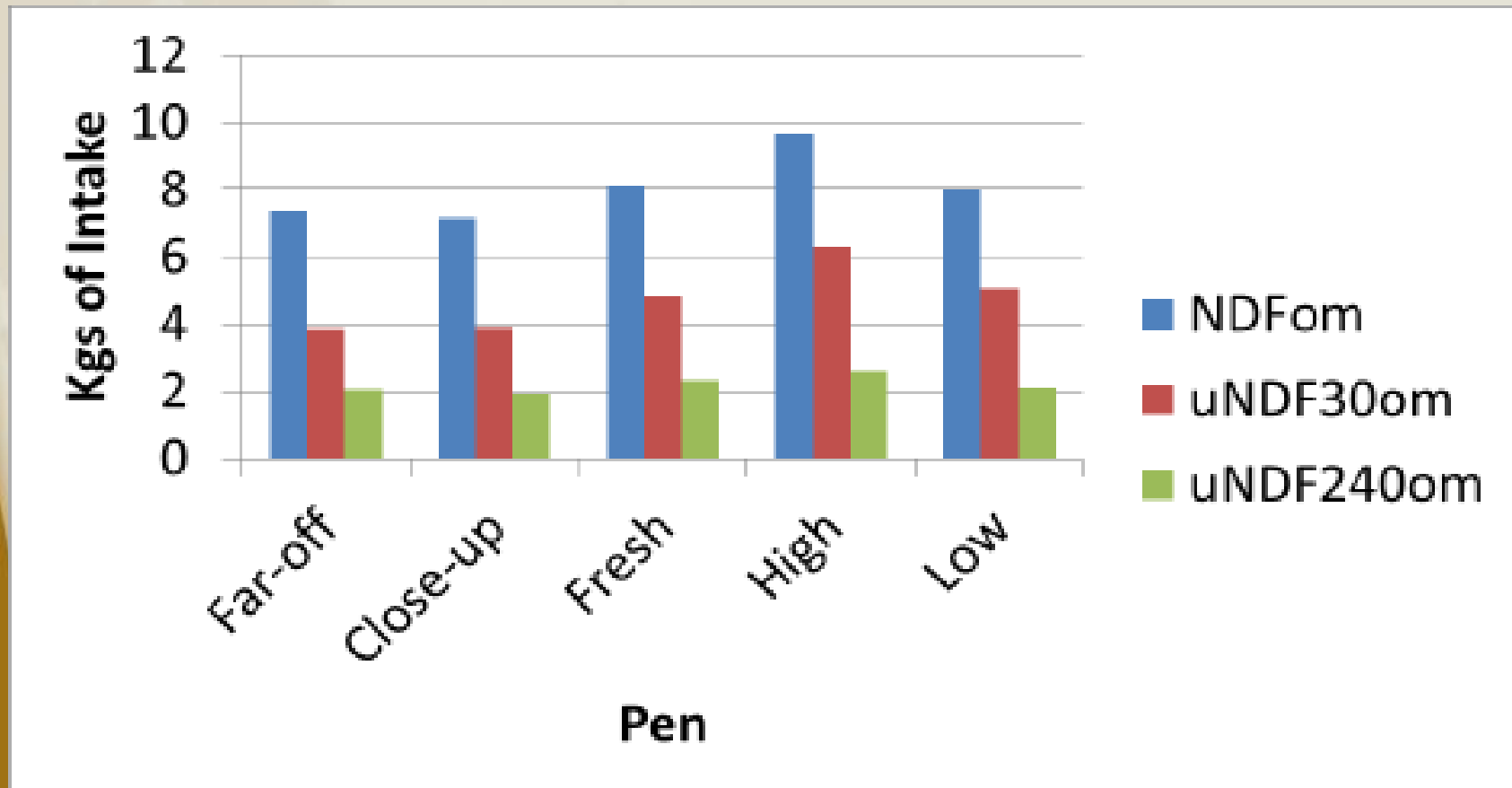


uNDFom 240 hr

- ❖ Undigestible aNDFom
- ❖ Predicts forages digestibility and ME milk potential
- ❖ Predicts forage intake potential in dairy cows
 - 2.0 – 2.7 kg DM optimum
 - 0.30 – 0.45 % of BW optimum

uNDFom and dry matter intake in dairy cows

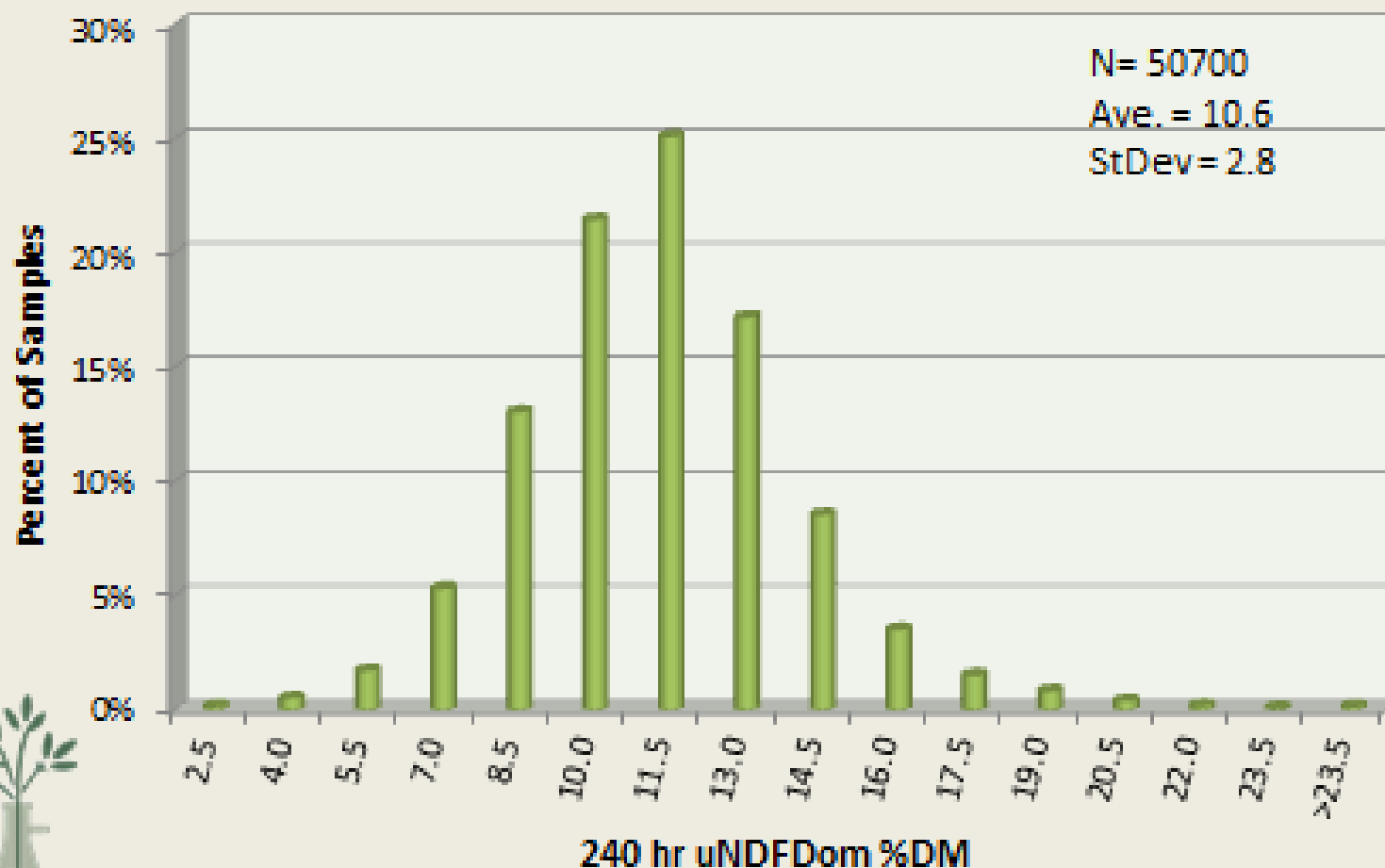
Intake of NDFom, 30 hr uNDFom and 240 hr uNDFom by stage of lactation



From: K Cotanch, Miner 2015 CNC

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240 hr uNDFDom %DM of Corn Silage (CVAS, 2016 data)



Courtesy of R Ward 2017 Pers. Comm.

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MML Haylage Averages

Parameter	aNDFom
aNDFom (% DM)	44.9
NDFDom 30 (% NDF)	50.2
NDFDom 120 (% NDF)	55.5
NDFDom 240 (% NDF)	59.2
uNDFom 30 (% DM)	22.3
uNDFom 120(% DM)	19.9
uNDFom 240(% DM)	18.2

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Corn Silage Averages

Parameter	aNDFom
aNDFom (% DM)	39.3
NDFDom 30 (% NDF)	55.2
NDFDom 120 (% NDF)	72.8
NDFDom 240 (% NDF)	78.2
uNDFom 30 (% DM)	17.7
uNDFom 120(% DM)	10.7
uNDFom 240(% DM)	8.5

Grand Valley Fortifiers Ltd, 2013-16

Corn Silage



Corn Silage

1. Forage (fibre) + Energy (starch)
Forage + Concentrate
2. Intake potential increases when:
 - a) Fibre (aNDFom) content ↓
 - b) Digestible fibre (NDFDom 30hr) ↑
 - c) Undigestible fibre (uNDFom 30hr) ↓
3. Energy (NEL) increases when:
 - a) Grain (starch) content ↑
 - b) Digestible fibre (NDFDom 30hr) ↑
 - c) Digestible starch ↑

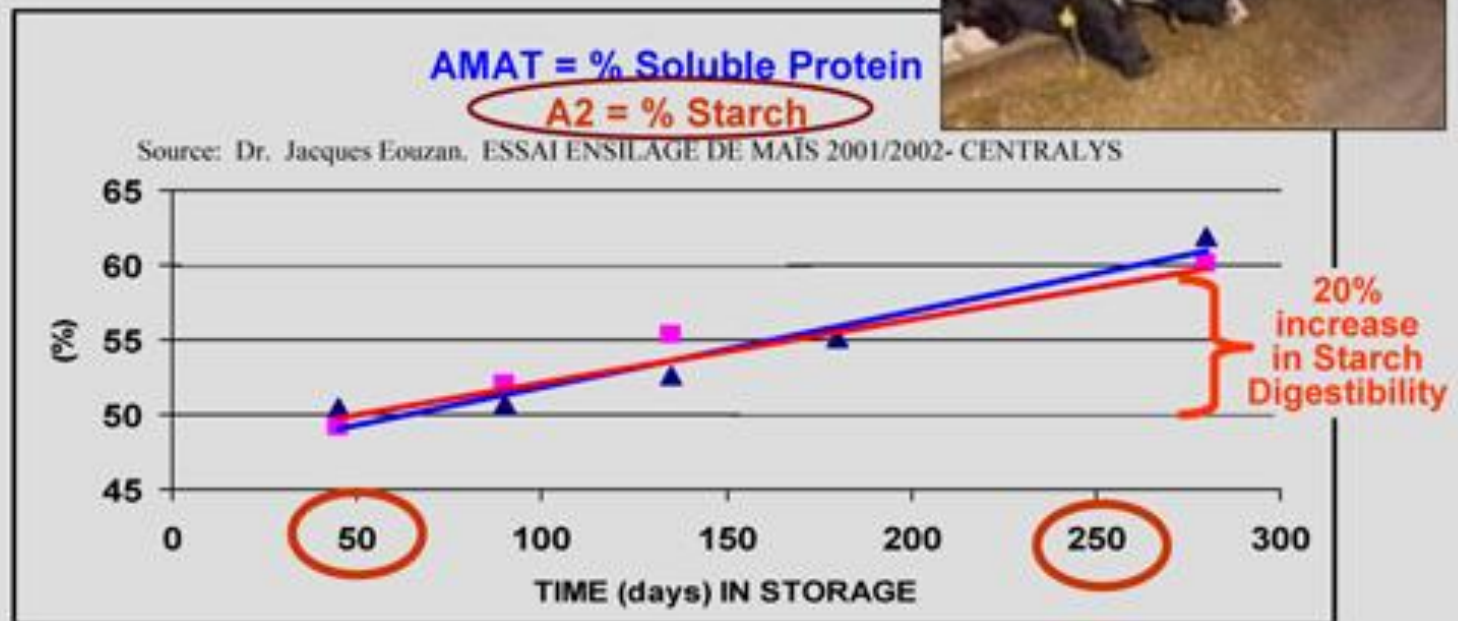
Corn Silage Starch Digestibility

- ❖ Kernel processing increases starch digestibility and NEL
 - Most effective above 33% DM
- ❖ Higher DM at harvest reduces digestibility and NEL
 - Ideal range is 32 – 38% DM
- ❖ Digestibility increases with length of time fermented in the silo
 - Ideal is 6+ months

Corn Silage Fermentation Time

Starch in corn silage gets more digestible over time in storage...

CS data from France....some of the first published research showing this effect



Corn Silage Benchmarks

	Excellent Quality	Low Quality
Dry Matter	33 - 38	< 30 or > 40
Starch	> 38	< 30
NDF	< 38	> 46
NDFDom 30hr	> 60	< 50
uNDFom 30hr	< 15	> 23
NEL	> 1.72	< 1.58

Forage Quality Effect on Intake and Milk Production



1) Milking Cow Rations Balanced For

- Holstein Cow – 650 kg
- 135 days in milk
- 40 kg milk
- 3.9% fat
- 3.3% protein



Poor vs Excellent Quality Forages

Feed ingredient	Poor Quality Forage Kg (as fed)	Excellent Forage Kg (as fed)
Corn silage (35% DM)	16.0	25.0
Alfalfa silage (45% DM)	12.5	19.5
Straw, chopped	0.5	0.5
HM Corn (75% DM)	10.5	4.2
Soybean meal	3.3	1.6
Corn distillers grains	2.0	2.0
Dairy Premix	0.7	0.7
	45.5	53.5

Poor vs Excellent Quality Forages

Nutrient	Poor Quality Forages	Excellent Forages
DM Intake - kg	25.0	25.0
Forage DMI - kg	11.7	18.0
Forage (% DM)	46.7	71.8
aNDFom (% DM)	31.0	33.4
Forage NDF (% DM)	24.6	29.3
uNDFom 30hr - kg	3.2	3.0
Starch (% DM)	28.6	21.4
NEL (Mcal/kg)	1.67	1.69

2) Milking Cow Rations Balanced For

- Holstein Cow – 650 kg
- 150 days in milk
- 35 kg milk
- 4.0% fat
- 3.3% protein



Average vs Low NDFDom Forages

Feed ingredient	Ave NDFDom Forages Kg (as fed)	Low NDFDom Forages Kg (as fed)
Corn silage (35% DM)	24.0	21.1
MML silage (45% DM)	12.5	11.0
Straw, chopped	0.5	0.5
HM Corn (75% DM)	6.3	8.2
Protein Supplement	4.1	4.4
Dairy Premix	0.68	0.68
Palm Fat	0.25	0.25
	45.5	53.5

Average vs Low NDFDom Forages

Nutrient	Ave NDFDom Forages	Low NDFDom Forages
DM Intake - kg	23.8	23.8
Forage DMI - kg	14.5	12.8
Forage (% DM)	60.8	53.6
aNDFom (% DM)	30.9	28.8
Forage NDF (% DM)	26.0	23.0
peNDF (% DM)	23.6	21.5
uNDFom 30hr - kg	3.0	3.1
uNDFom 240hr – % BW	0.34	0.40
Starch (% DM)	27.2	30.2

**How much will she eat and
how much will she milk?**

**With excellent quality
forages.....**



A Whole Lot!!!