Getting More from Forages

Targeted feeding strategies:

Accounting for quality

Non-fiber carbohydrates: What sets the right quantity and quality for rations?

Mary Beth Hall

To do anything well (and repeatably), we need to understand what we are dealing with.

2001 Dairy NRC Recommendations

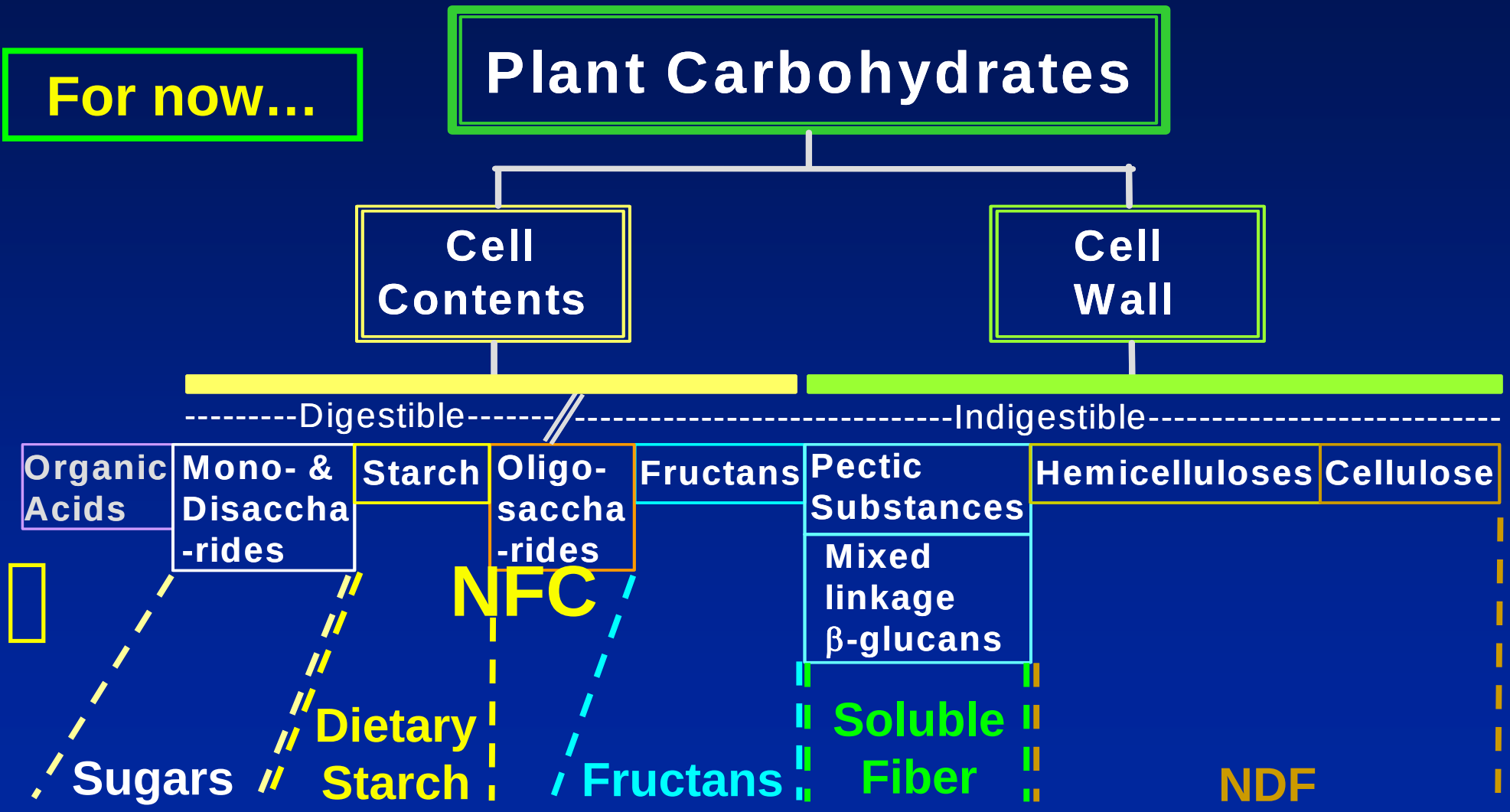
Min. Forage NDF	Min. Dietary NDF	Max Dietary NFC
19	25	44
18	27	42
17	29	40
16	31	38
15	33	36

- +/- Reserves
- N utilization
- Slug feeding
- Empty bunks
- Cows sorting
- Heat stress

Think:
Energy Supply &
"Risk Management"

Nutritionally Relevant Carbohydrates

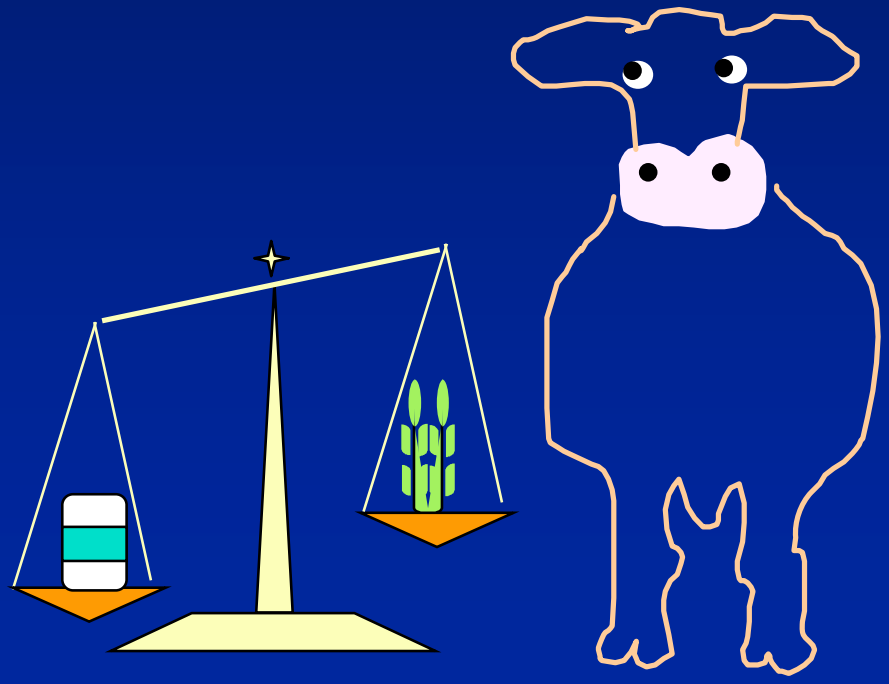
For now…



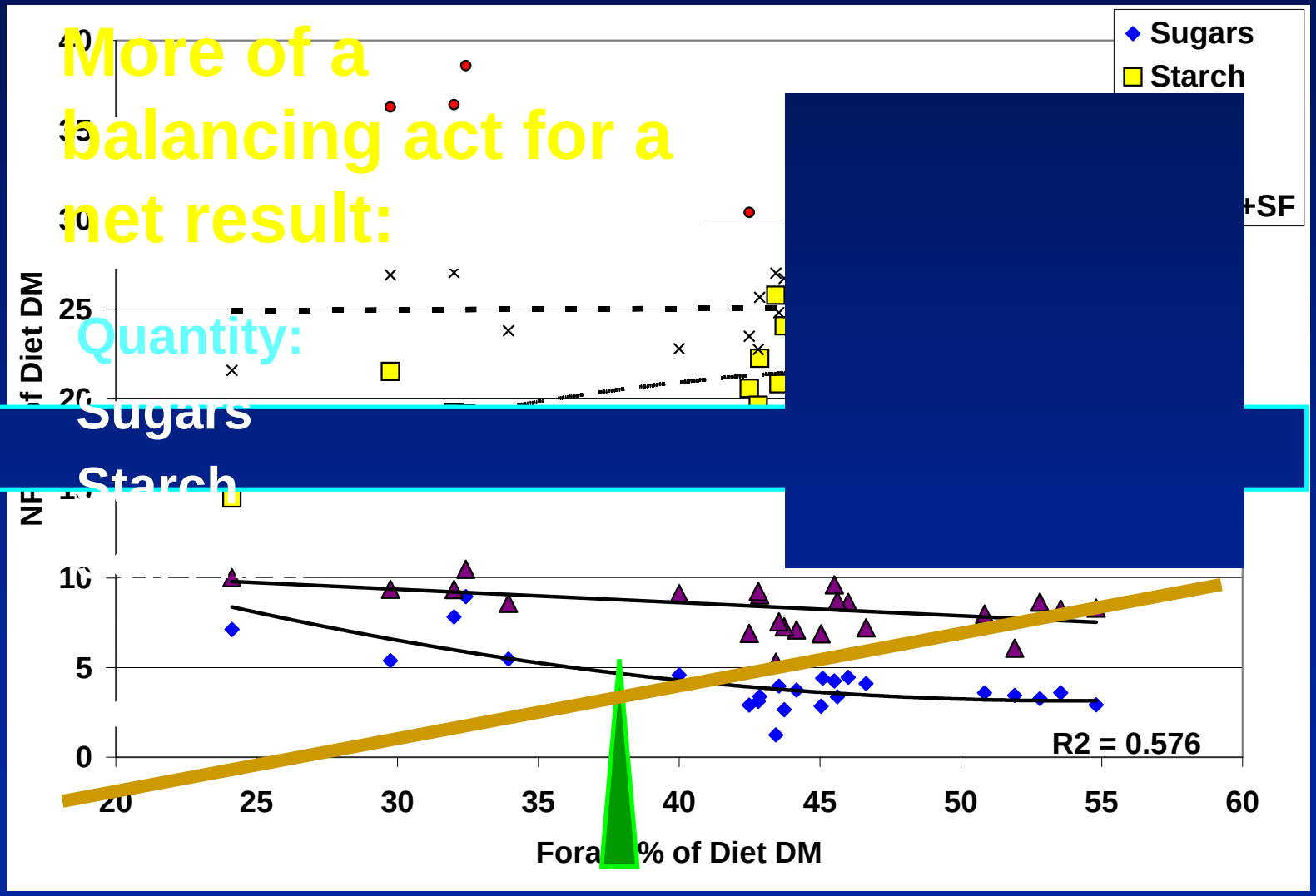
NFC Recommendations (DM basis)

- Sugars: 5 - 7%
- Starch: 22 - 27%
- Soluble Fiber: 7 - 9%

- Use analyses, don't just supplement.
- The recommended amount will also depend on how it was measured. ESC, WSC, ……



NFC Recommendations (DM basis)



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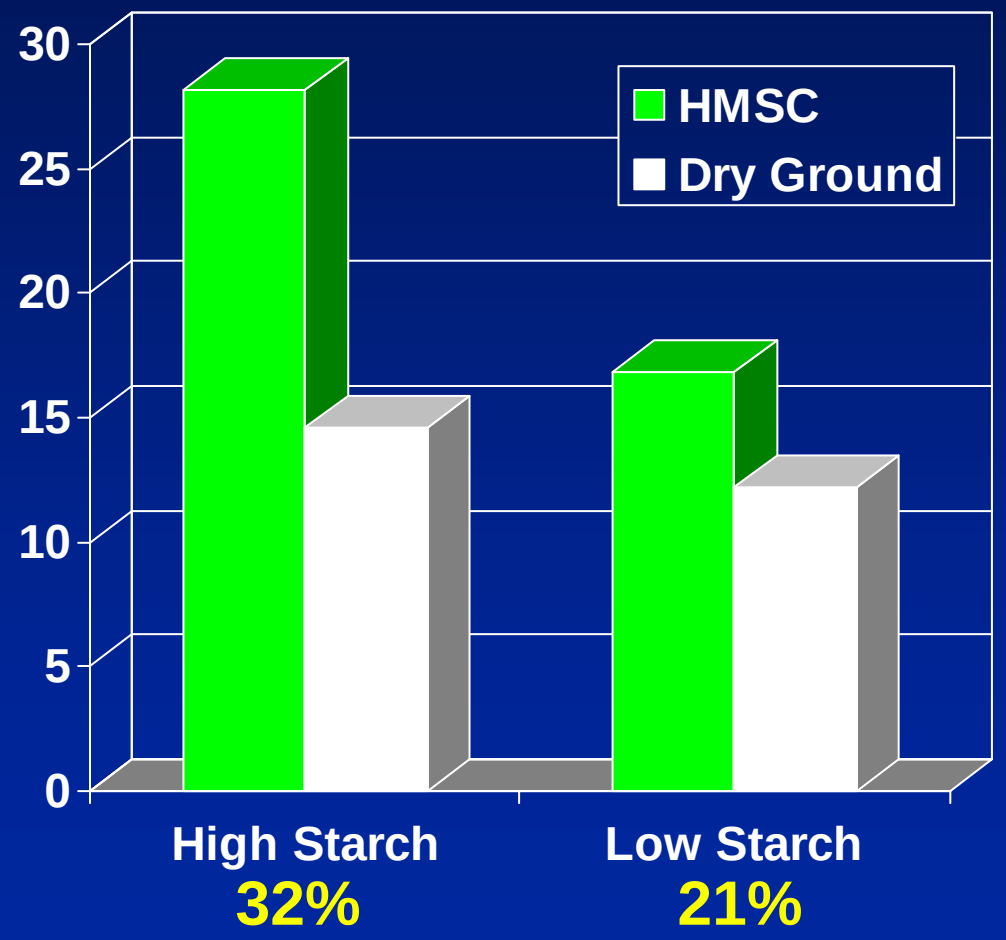
What factors alter desirable NFC levels?

Hall and Van Horn, 2001

1. Starch: Rates Subject to Change?

Rates of Total Starch Fermentation, %/h



- Ruminal fermentation rates were increased at higher dietary starch levels.
- Change greater for rapid than slow rate. Starch enzyme activity ~68% on low starch diet?
- Blend starch feeds to take advantage & be safe.

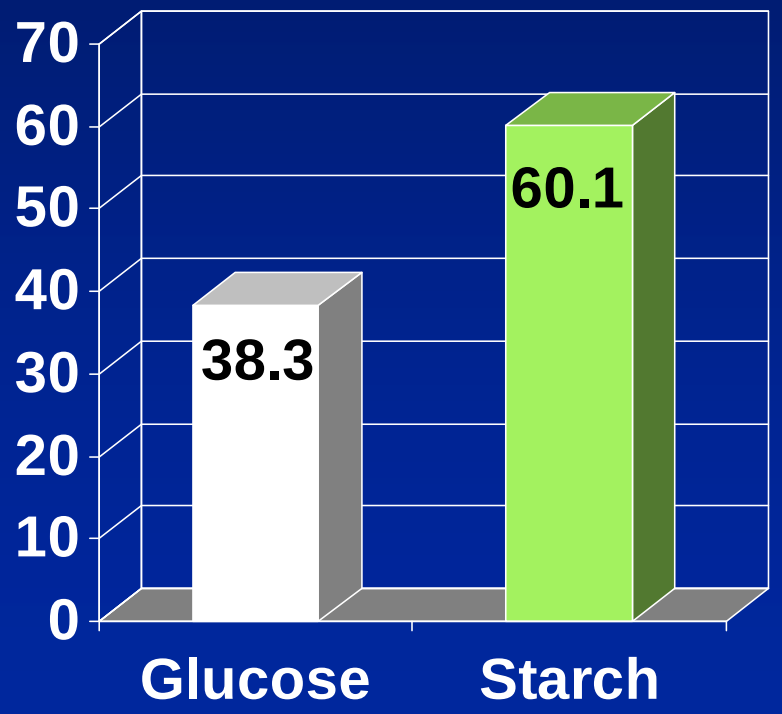
Oba and Allen, 2003

Starch $P<0.001$, Corn $P<0.001$, Starch x Corn $P<0.01$

2. NFC x Protein Rumen Needs?

- More rapidly fermented substrate should require more rapidly degraded nitrogen source. Does type matter?
- NH_3 available from recycling & protein degradation.

NH_3-N% of Bacterial N



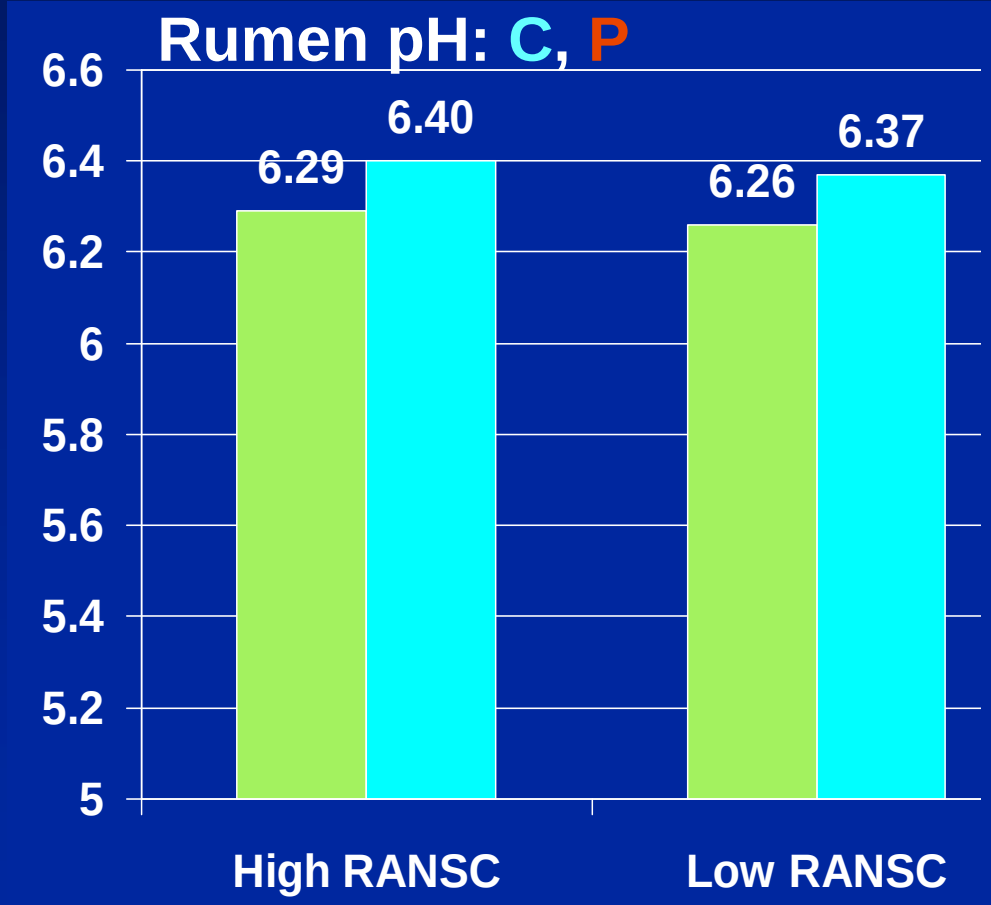
P<0.05, SEM = 3.51

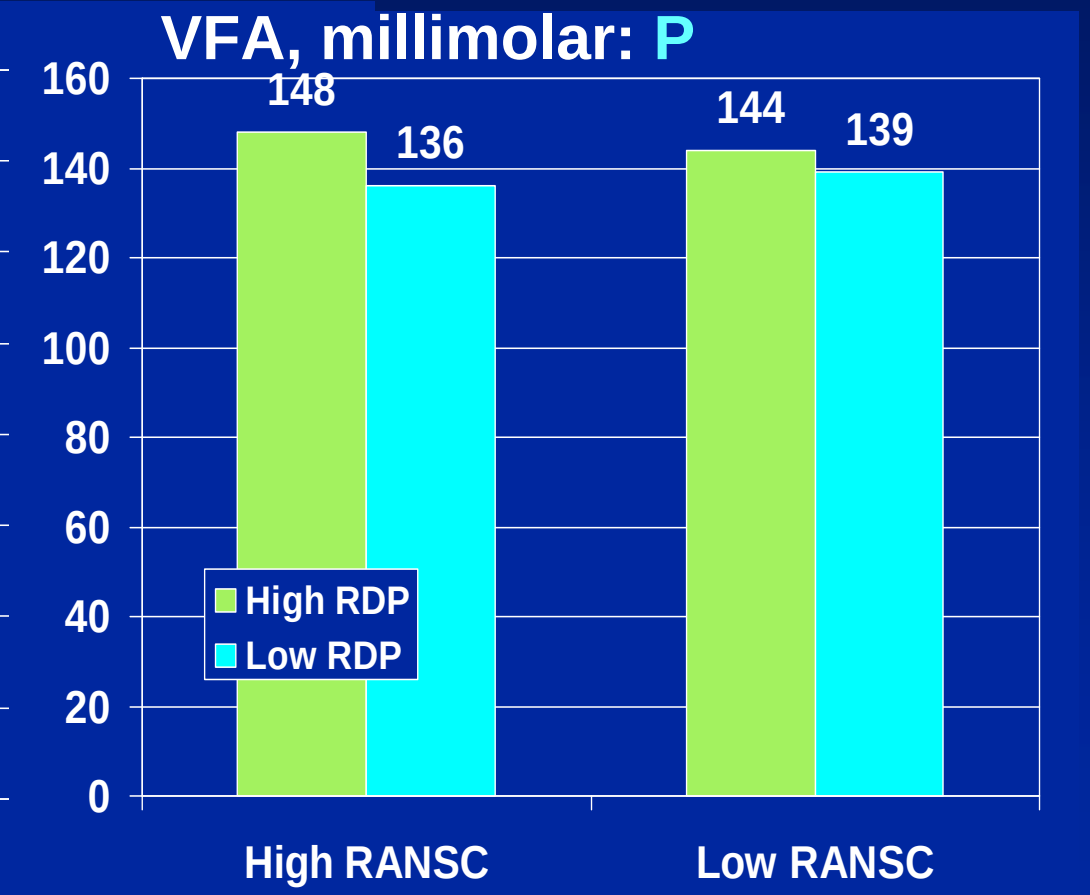
Sugar utilizers have a preference for amino acids / peptides?

Hristov, et al.,
J. Anim. Sci., 2005 83:408

3a. NFC x Protein Changes pH & VFA?

RANSC	High		Low	
RDP	High	Low	High	Low





Aldrich et al., 1993, J Dairy Sci 76:1091-1105

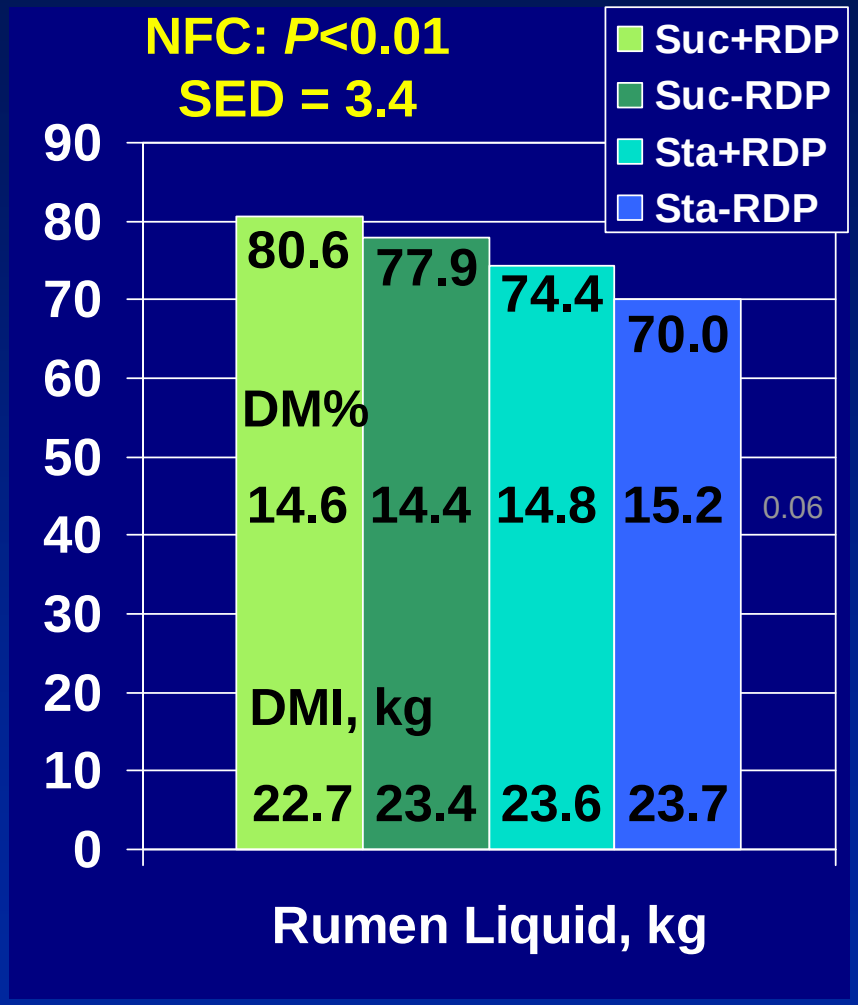
Matter is neither created or destroyed, even in cows.

Did the microbes make other products because of protein:CHO?

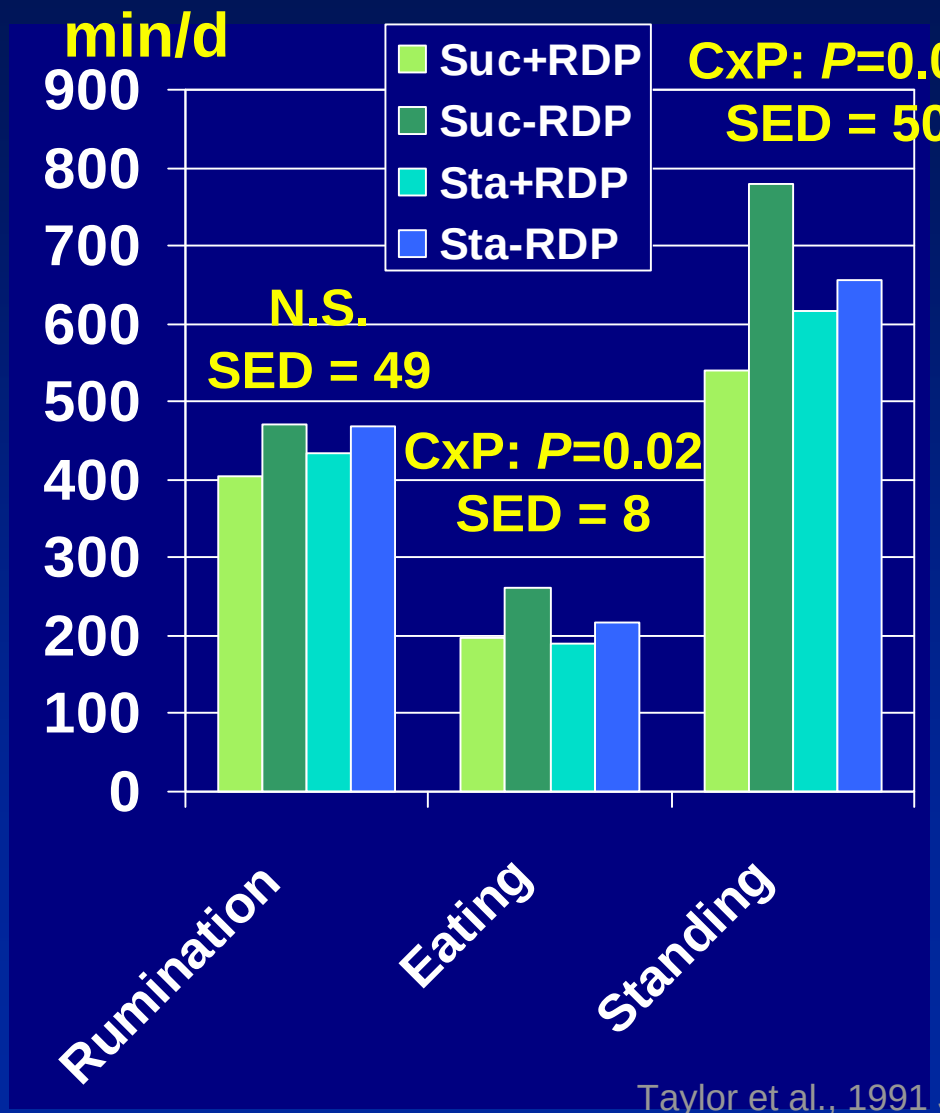
What caused the change?

Good or bad?

3b. NFC and Protein



Hall, 2009



Taylor et al., 1991 JDS

3c. Sugar v. Starch

	Sugar:Starch (% Diet DM)			
	0:7.5	2.5:5.0	5.0:2.5	7.5:0
DM intake, lb[L]	54.0	56.4	57.3	57.3
Milk, lb[L]	85.8	89.1	88.2	86.9
Fat, lb[L]	3.24	3.37	3.64	3.57
Protein, lb	2.73	2.82	2.84	2.82
Rumen pH	6.19	6.16	6.19	6.21

CP 16.8
NDF 30
For. 60
Sug 3-10
Sta 21-28

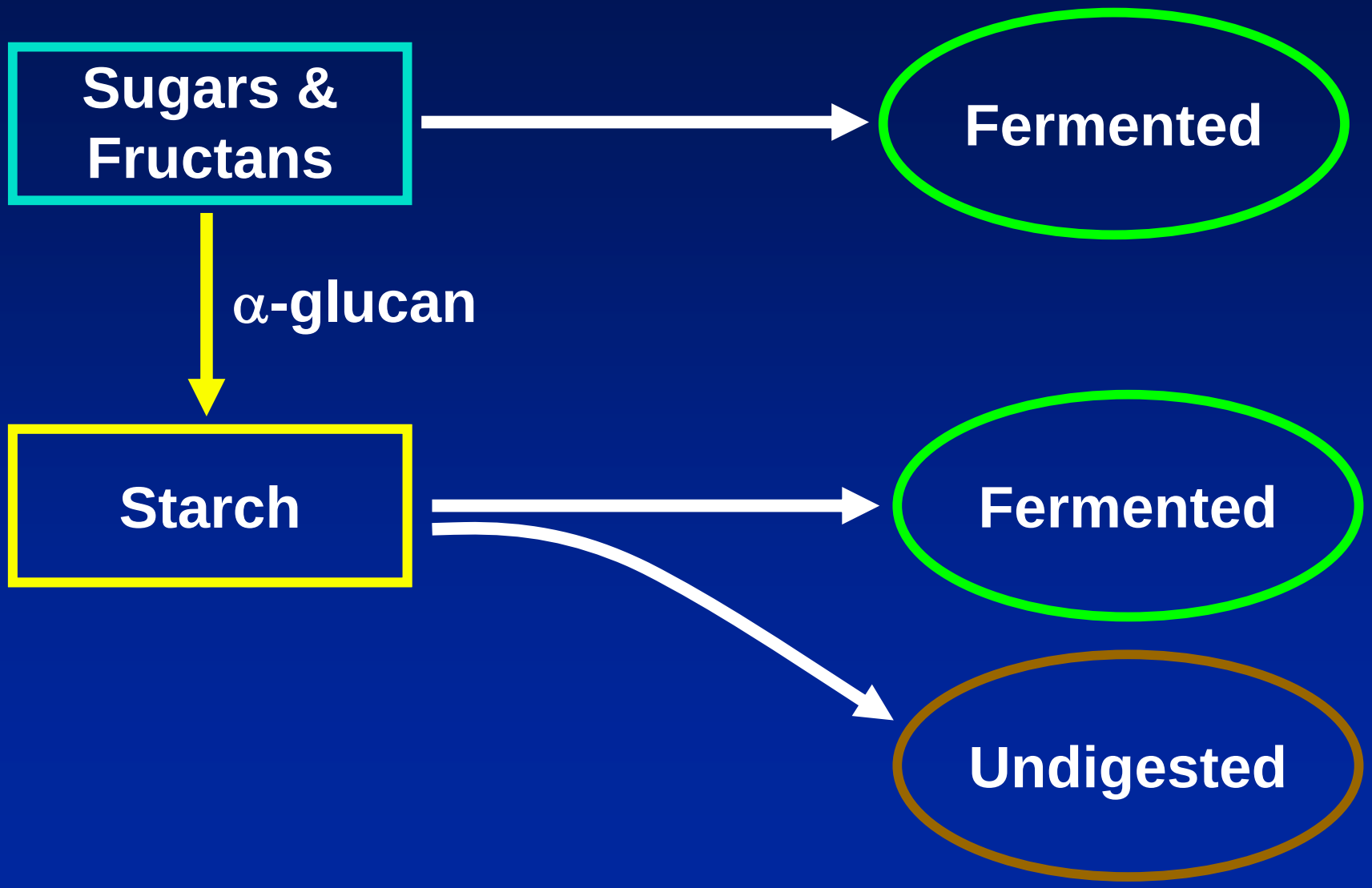
Corn or Molas.	+RDP	-RDP	+RDP	-RDP
DM intake, lb	55.0	55.4	55.4	54.1
Milk, lb[CxP]	90.2	86.0	88.2	90.0
Fat, lb[CxP]	3.01	2.86	3.01	3.08
Protein, lb[C]	2.51	2.33	2.33	2.29
Rumen pH	5.98	5.99	5.76	5.97

CP 17-18
NDF 31-34
For.38(42)
Sug 3-12
Sta 12-24

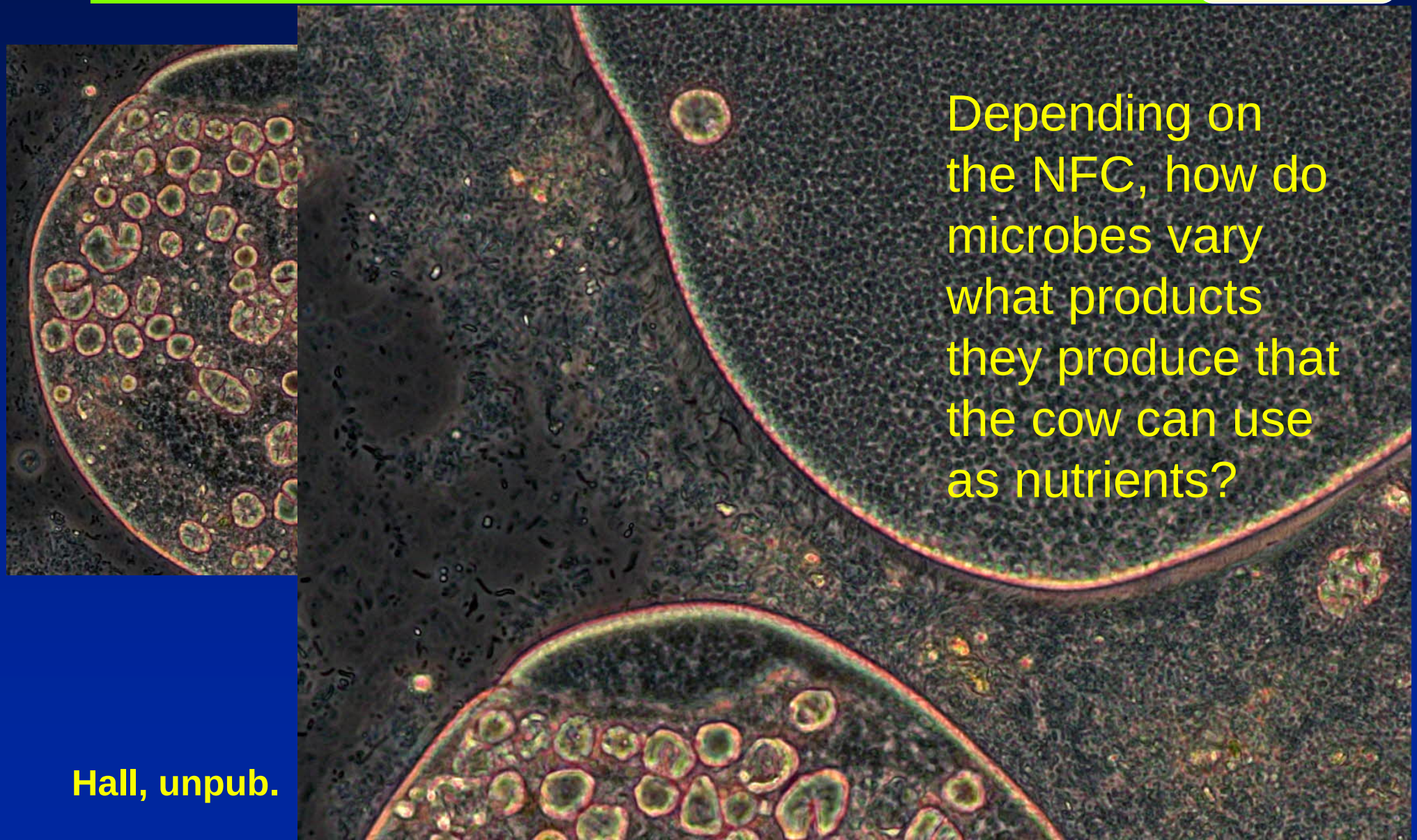
P=<0.05, *P* < 0.10

Broderick et al., 2002; Hall et al. submitted

4. Ruminal Sucrose + Starch



4. Rumen Protozoa & Carbohydrates



Depending on the NFC, how do microbes vary what products they produce that the cow can use as nutrients?

Hall, unpub.

5. B-Vitamin Apparent Synthesis

Forage:NFC

35:30, 35:40, 60:30, 60:40

50% corn silage, 33% alfalfa hay, 17% grass hay

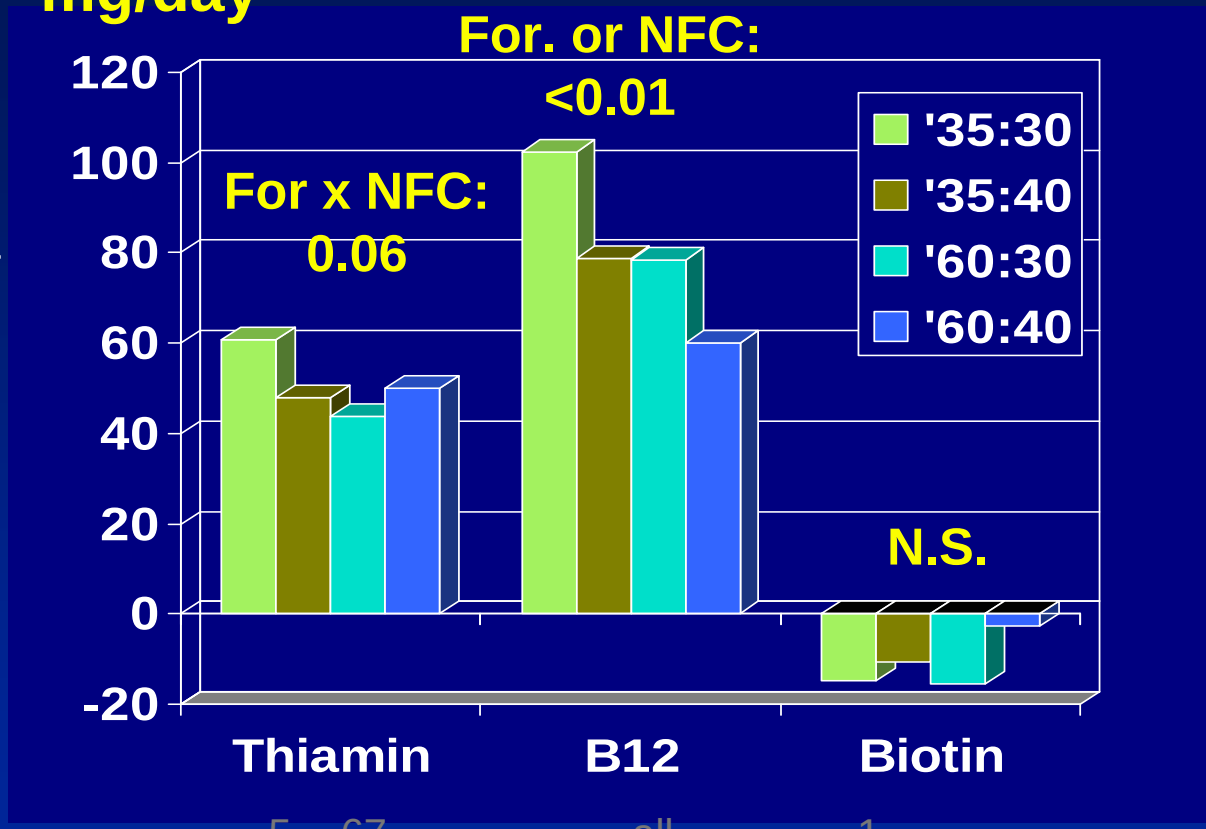
2:1 beet pulp:soyhulls or corn:barley

CP% ~16.5

NDF% 35-47%

Starch% 5-21

Sugar% 7-8

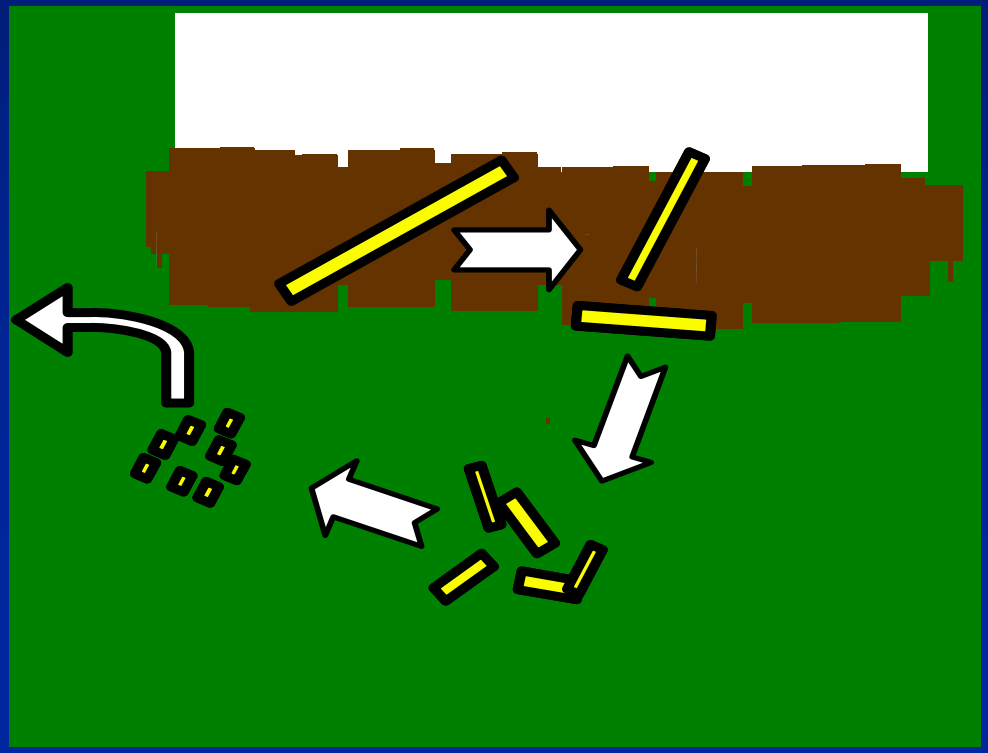


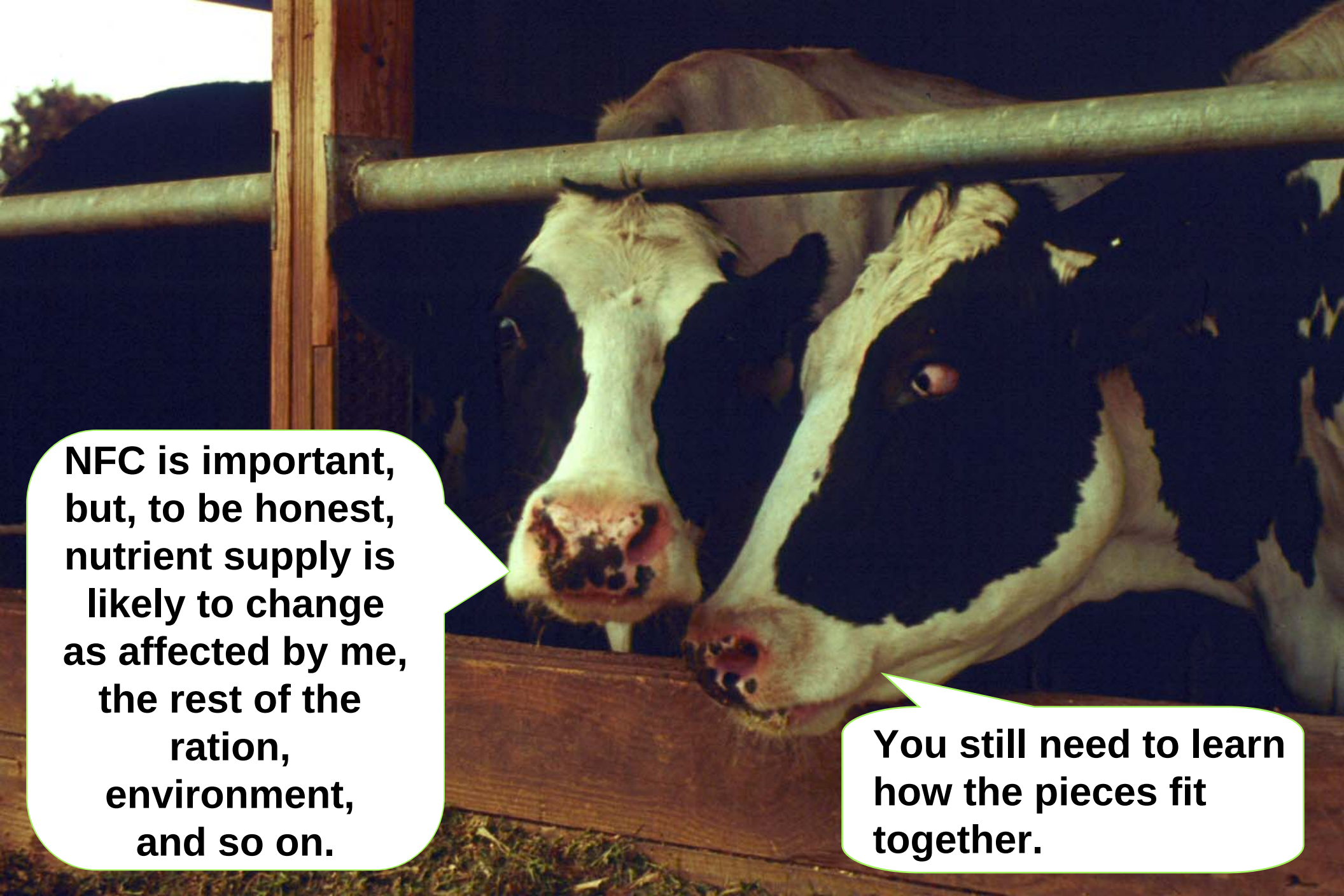
.5 - .67 all -.1

Schwab et al., J. Dairy Sci. 89:174–187

Nutrient Supply

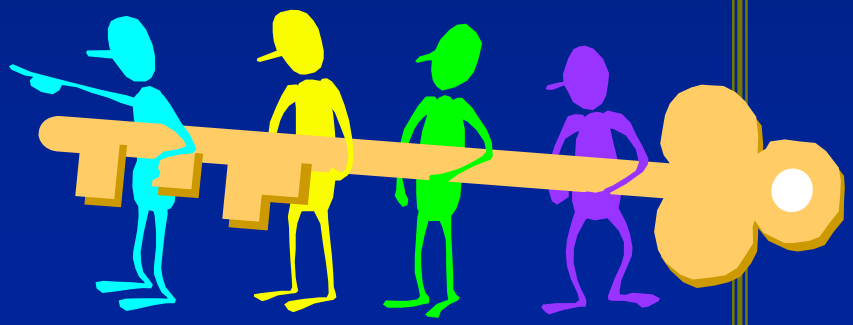
- Intake
- Digestion → Which products?
- Passage → Digestion where?
- Interactions NFC source and….
  - NDF form & amount
  - RDP, RUP
  - pH
  - …..




NFC is important, but, to be honest, nutrient supply is likely to change as affected by me, the rest of the ration, environment, and so on.
You still need to learn how the pieces fit together.

Carbohydrate Formulation

- Carbohydrates are not created equal
- We need to explore interactions:
  - Other dietary components
  - Physical, chemical, & microbial
  - Passage effects
- Feed vs CHO effects
- We have more to learn



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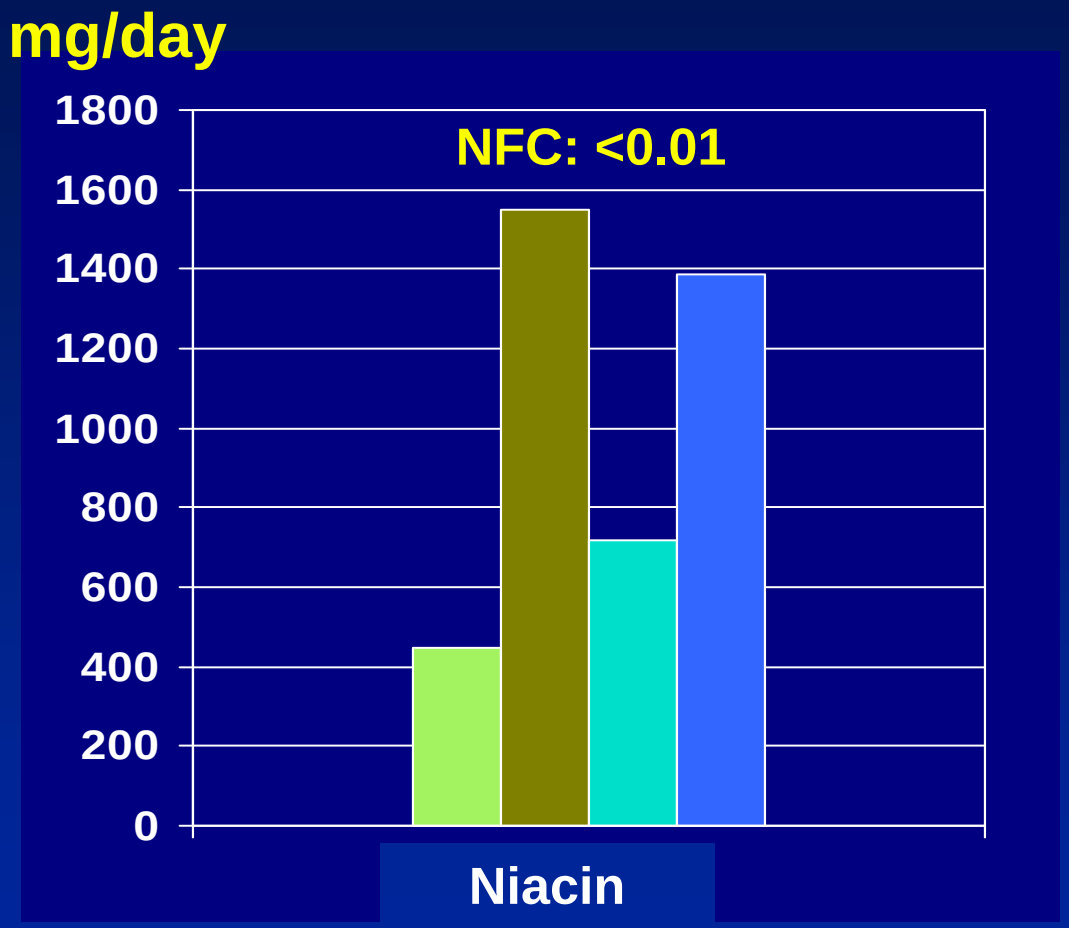
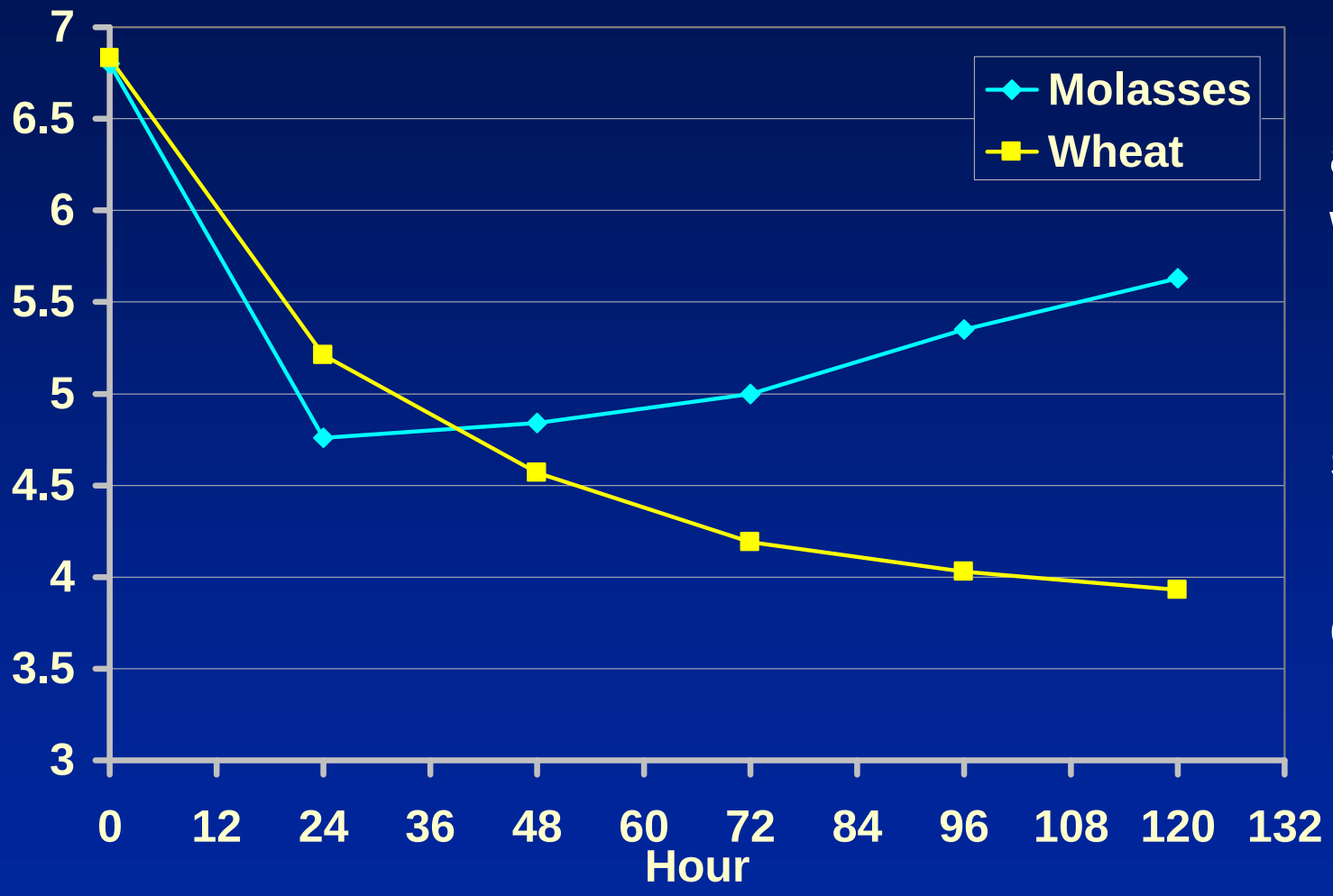


.18-.7

Schwab et al., J. Dairy Sci. 89:174–187

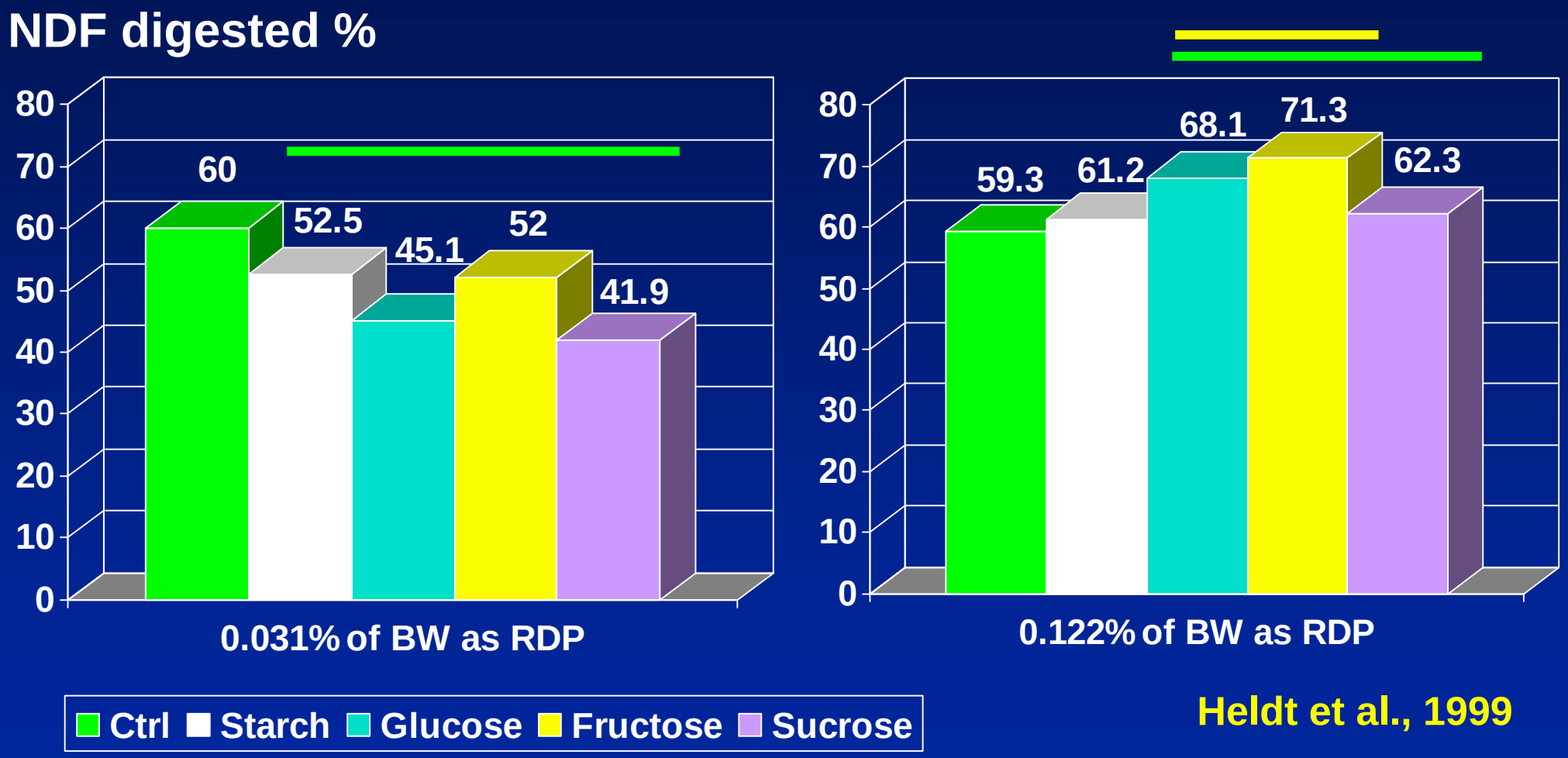
4a. Induction of Acute Ruminal Acidosis



- Exfoliation and ulceration with wheat but not molasses
- Liquid vs. solid passage?
- Sugar to glycogen?

Randhawa et al., 1982

2a. NFC x RDP Changes Fiber Digestion



Heldt et al., 1999

NFC at 0.3% of BW

pH, competition, bacteriocins, cross-feeding…

3a. NFC x Protein Changes VFA?

High N or Low N pastures supplemented with a glucose monohydrate + corn flour drench (4x daily feeding of each).

Forage Composition	High N	Low N
Dry matter%	15.7	17.6
Organic matter%	90.4	90.8
Crude protein%	17.6	13.2
NDF%	46.0	45.7
Water-soluble CHO%	22.0	27.1

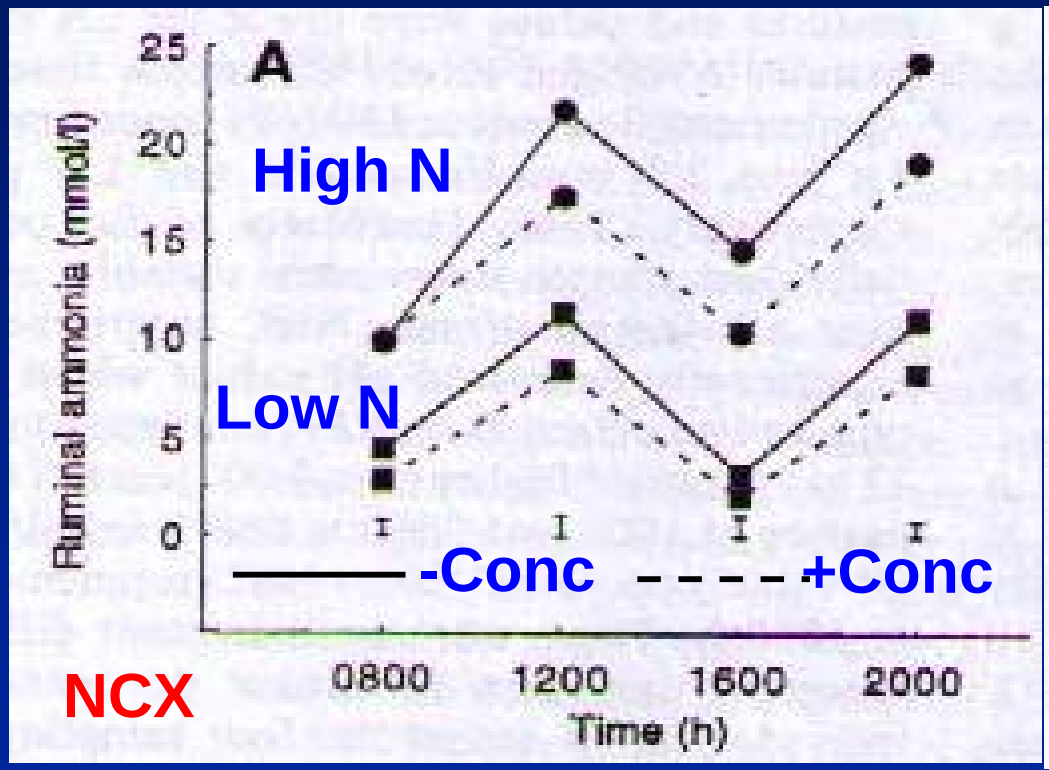
8 cows, 4x4 Latin square, 14 d periods

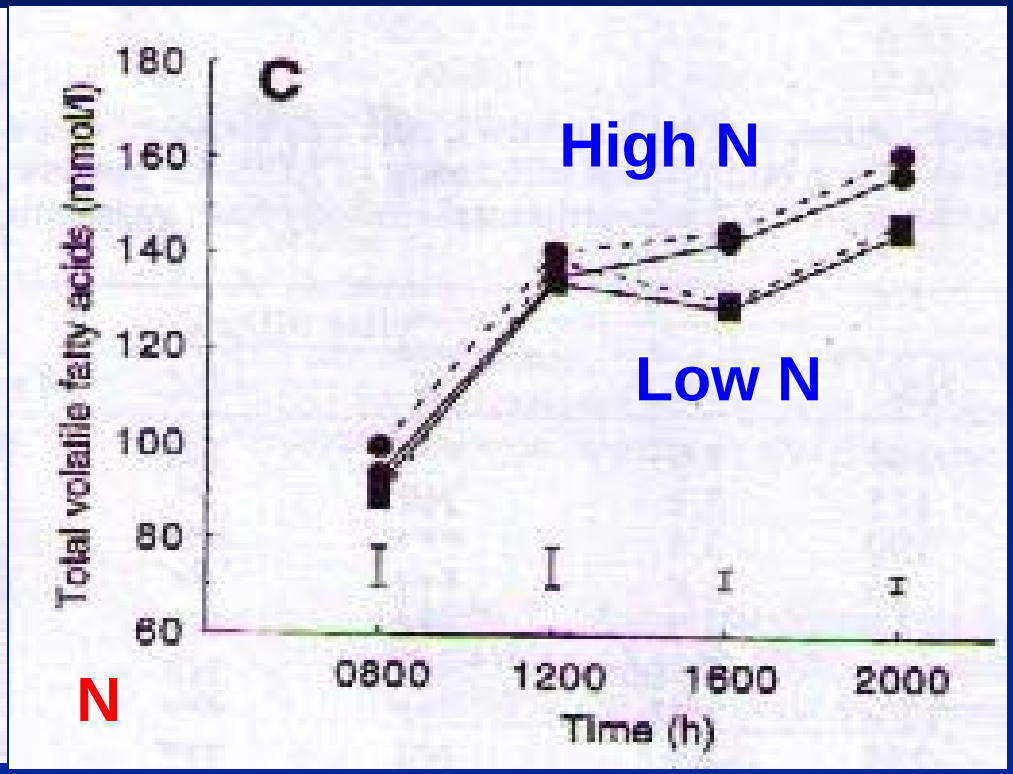
Carruthers and Neil, 1997

3a. NFC x Protein Changes VFA?

High N | Low N

+NFC | -NFC | +NFC | -NFC





NH_3, mmol/L

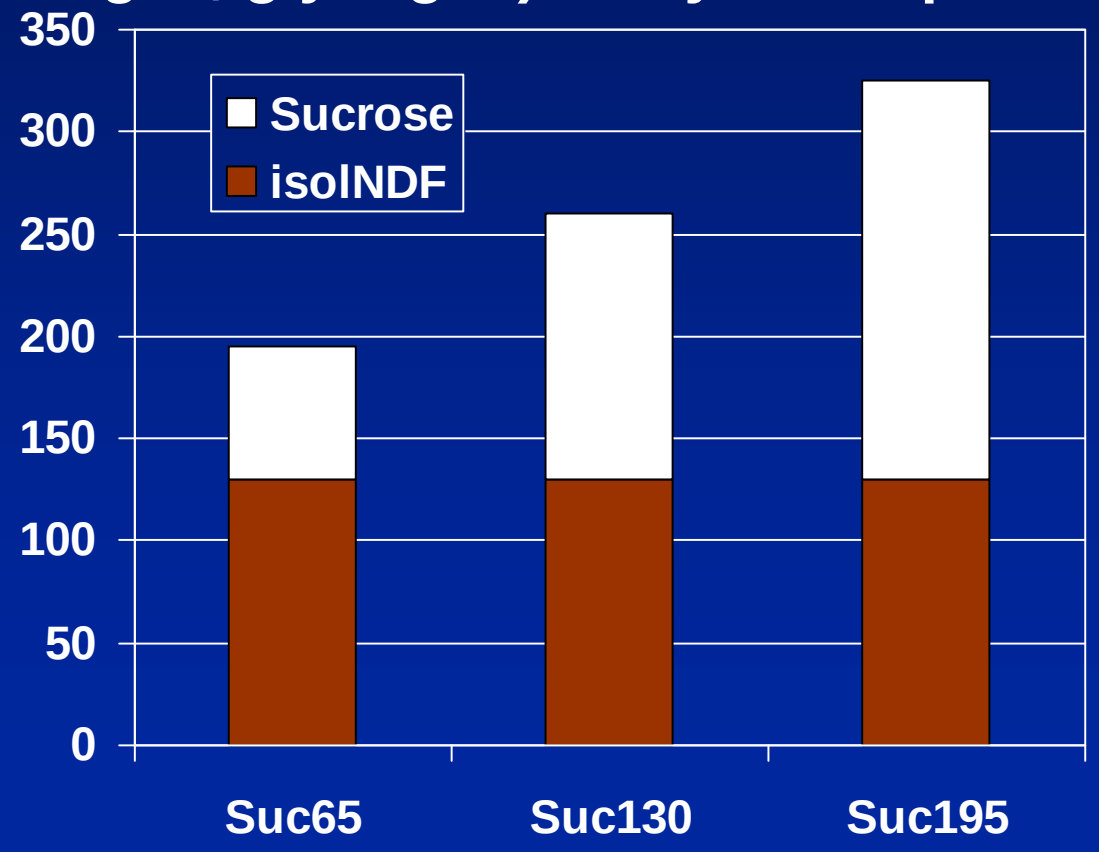
Total VFA, mmol/L

N = Nitrogen, C = NFC, X = Interaction *P*=<0.05

Carruthers and Neil, 1997

3c. Sucrose Amount Changes Yield?

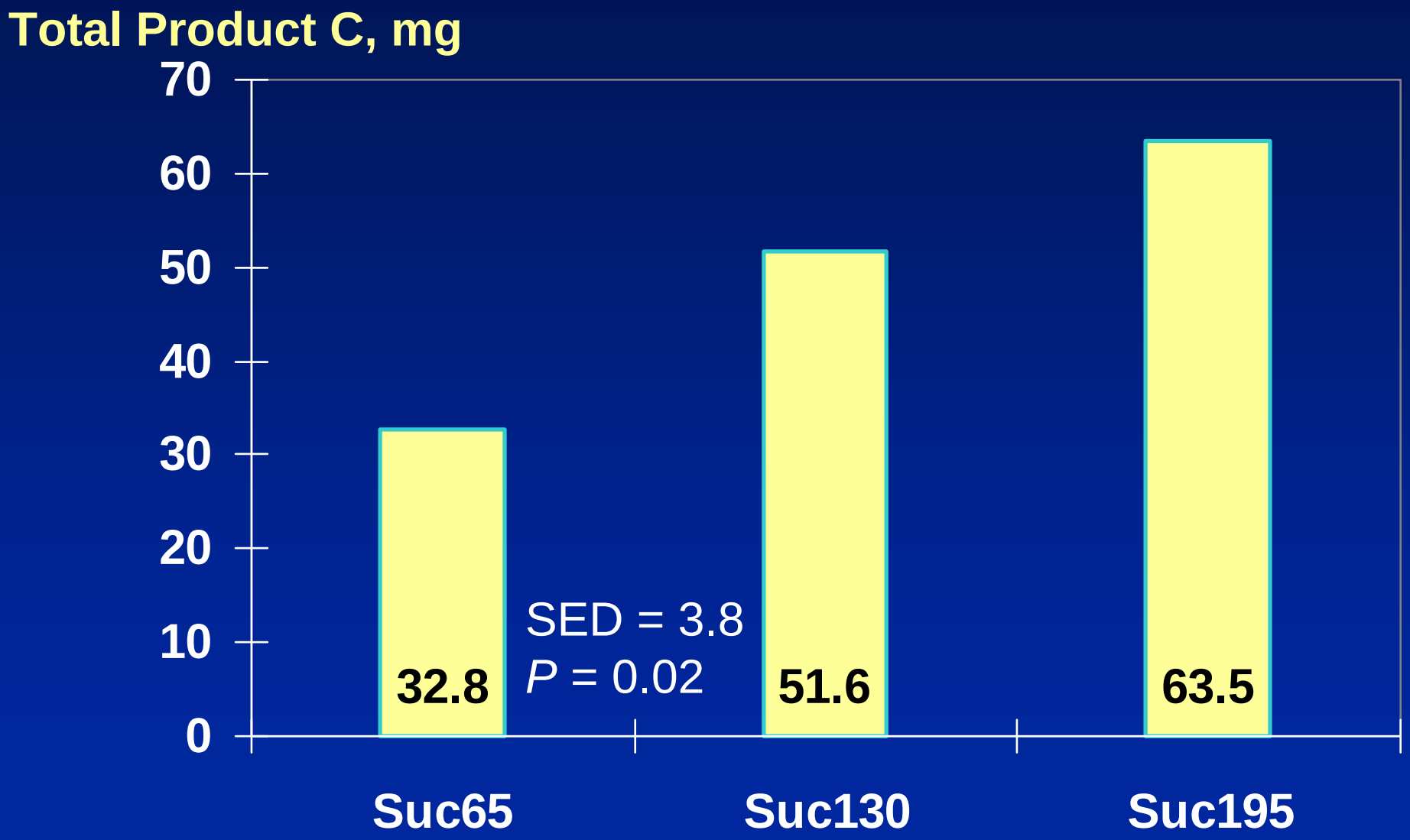
- Substrates: Isolated bermudagrass NDF & Sucrose
- Two 24 h in vitro fermentations (Goering & Van Soest, 1970)
- Assessed carbon in products (microbes calc from N, VFA, calc gas, glycogen) and yield of product / sucrose fermented



Ratios to sucrose of added N & amino acids in medium and microbes, etc. in inoculum also changed.

Hall and Weimer, 2008

3c. Sucrose Amount Changes Yield?



Hall and Weimer, 2008

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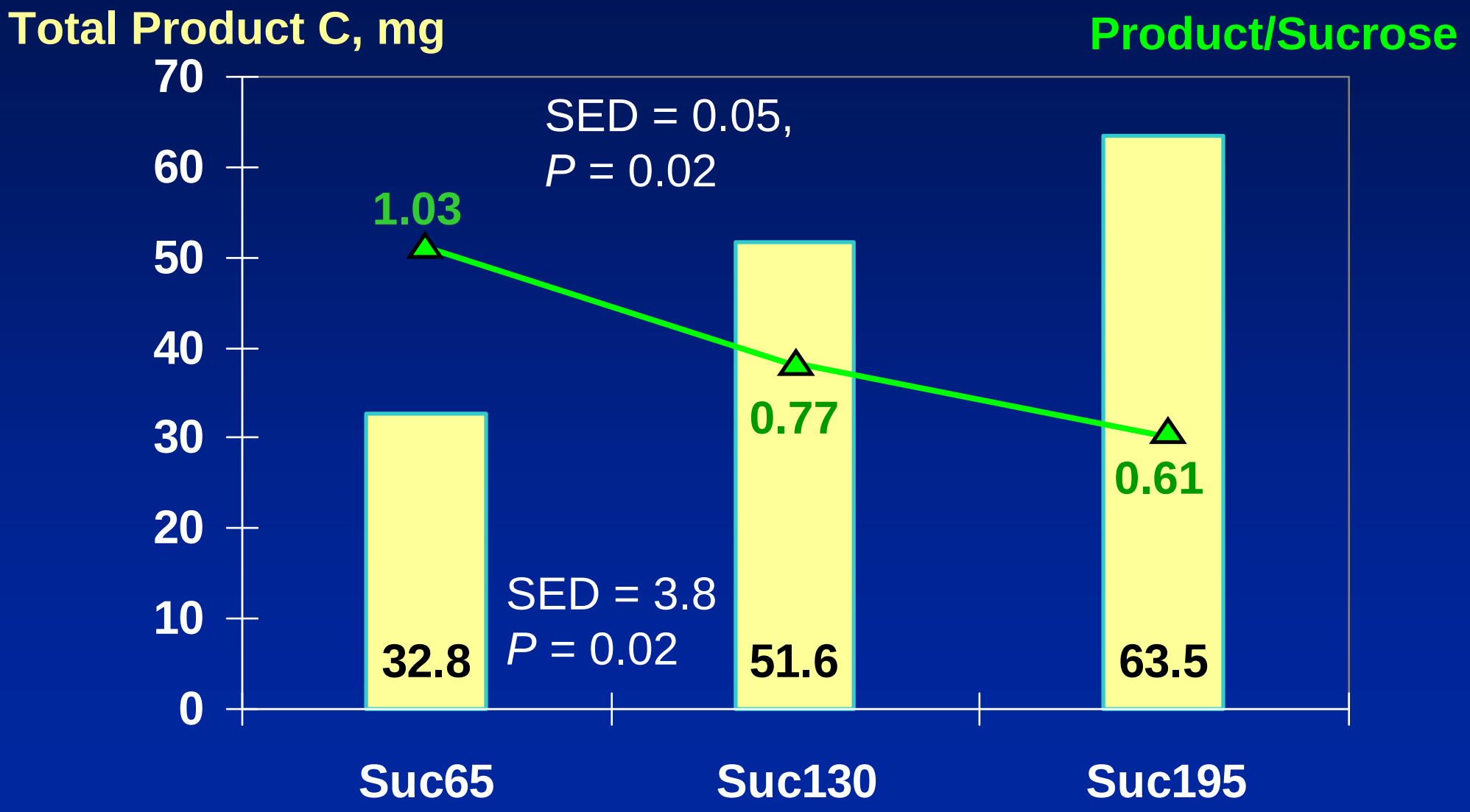
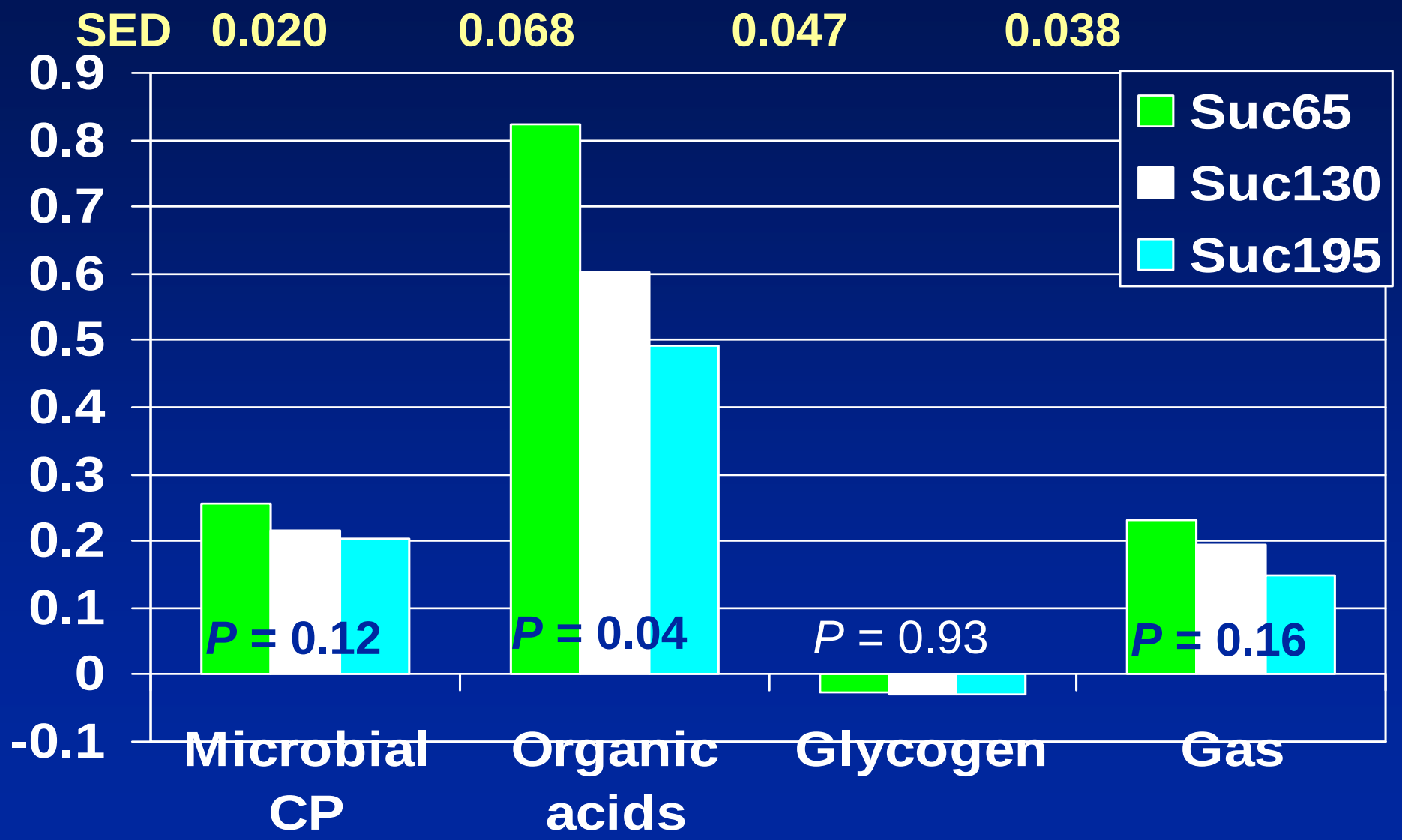


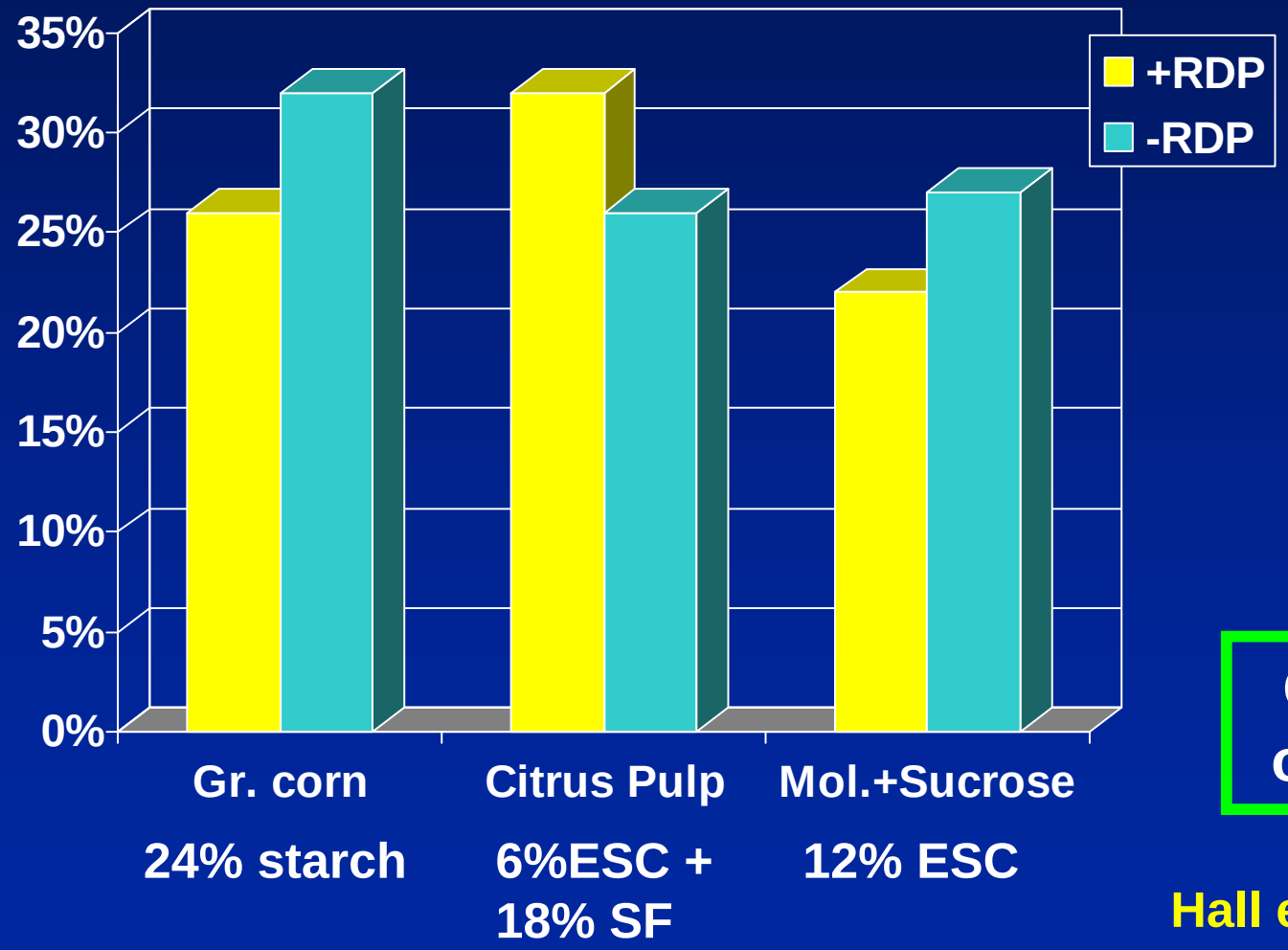
Hall and Weimer, 2008

3c. Yield of C: Products/Sucrose



2. NFC x RDP Changes Fiber Digestion

NDF digested %, 30 h in situ, sorghum silage



P-values

NFC	<0.01
RDP	0.07
CxP	<0.01
SED	0.02

Carbohydrate or feed effect?

Hall et al., submitted