United States Department of Agriculture

Protein Does WHAT ?!?

Protein Effects on Rumen Fermentation

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4-State 6/12/13

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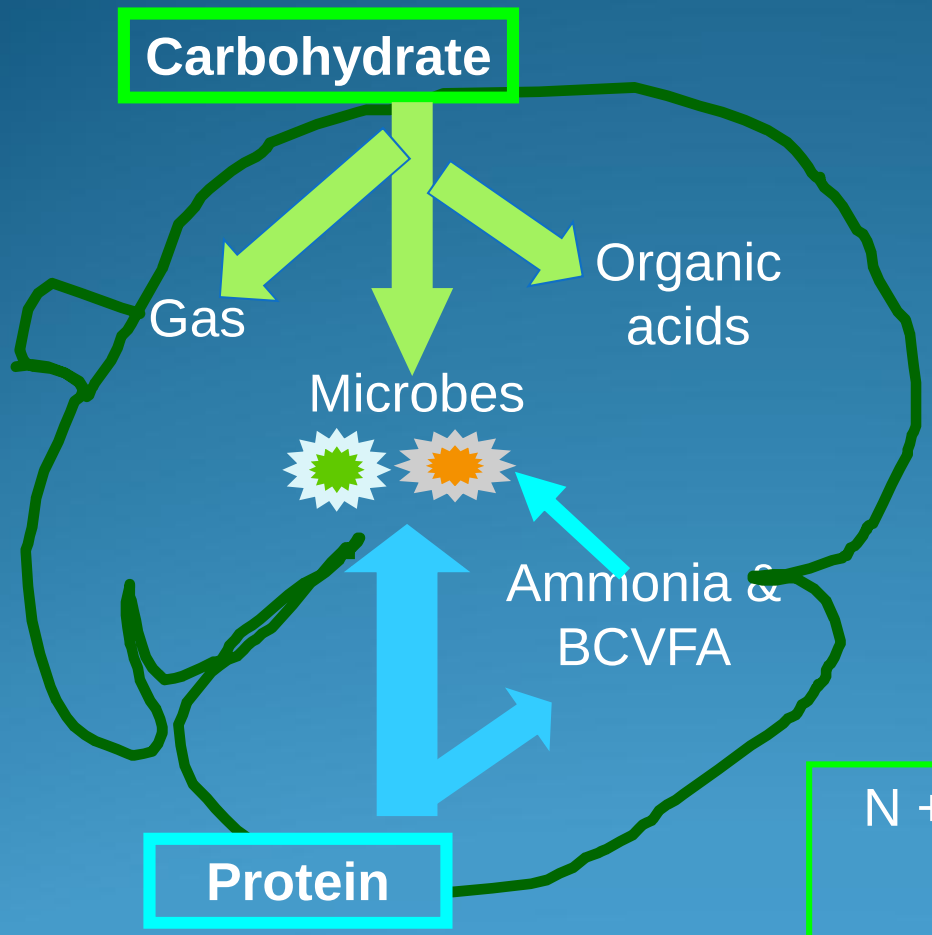
Feed Digestion in the Rumen



Organic acids **pH**

High quality protein

N + carbohydrate gives microbial protein.

More carbohydrate fermentation = more organic acids and lower pH.

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

Are there other effects & interactions going on that we might want to consider?

Protein Changes Microbial Yield

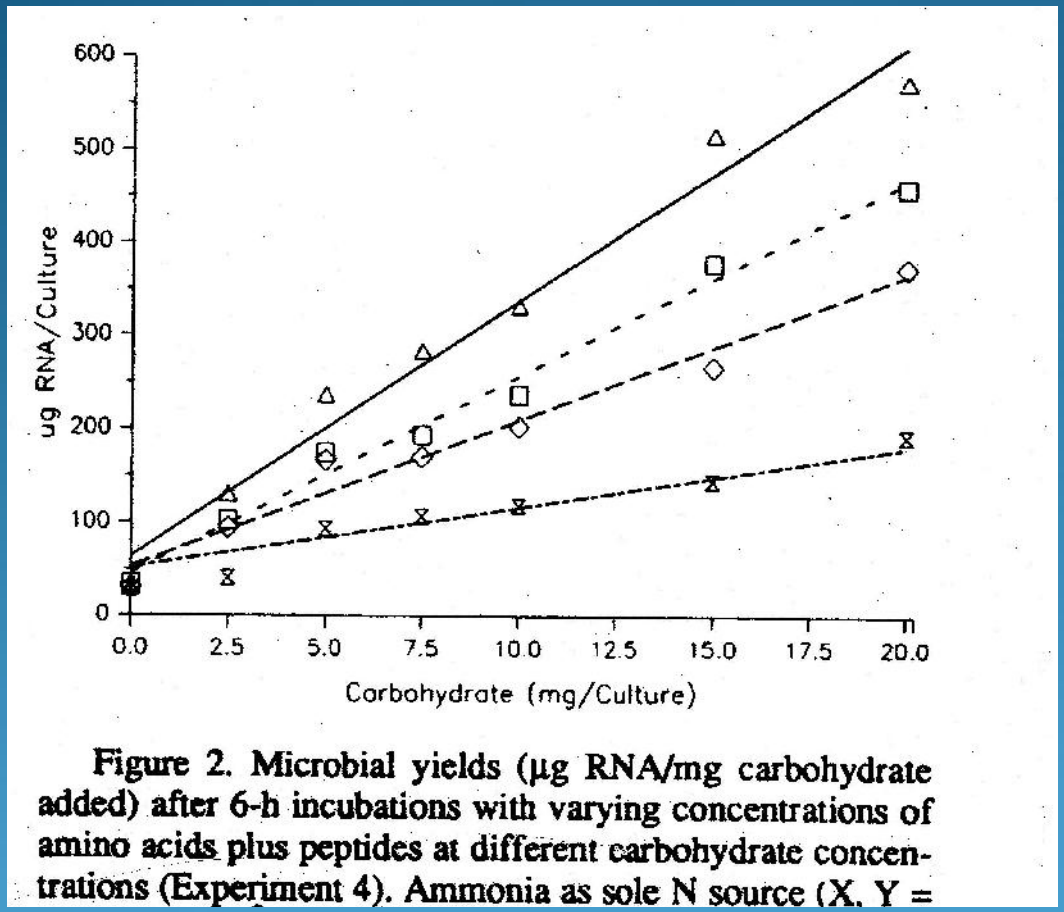


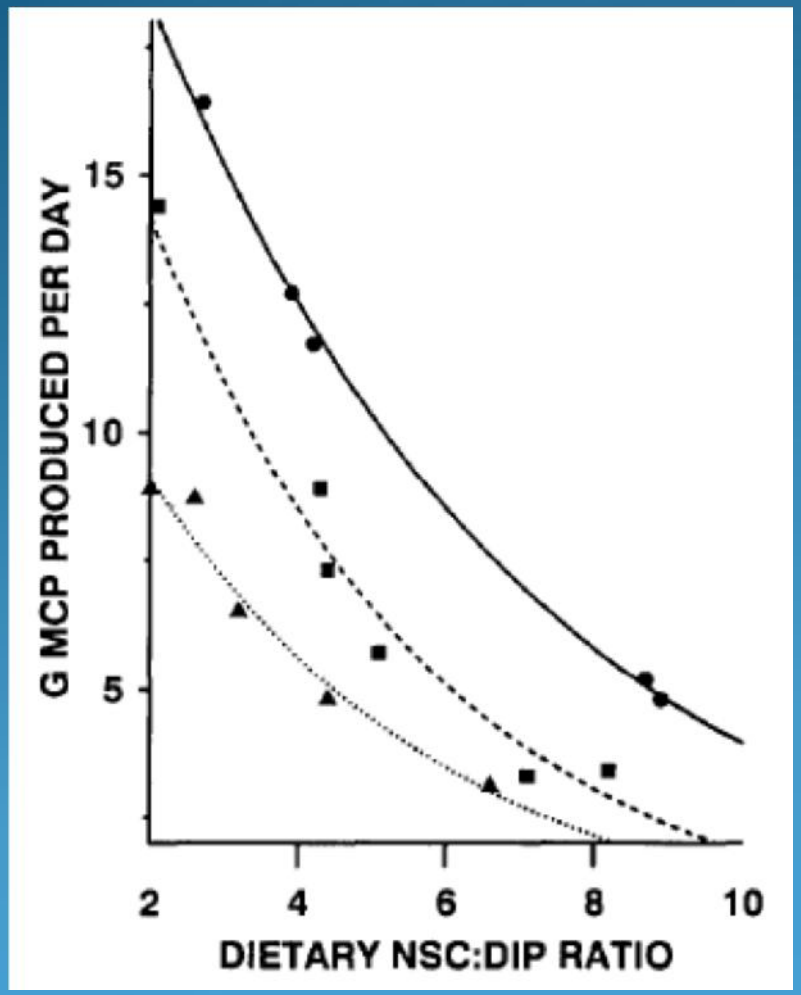
Figure 2. Microbial yields (µg RNA/mg carbohydrate added) after 6-h incubations with varying concentrations of amino acids plus peptides at different carbohydrate concentrations (Experiment 4). Ammonia as sole N source (X, Y =

- Increases in protein supply gave increased microbial YIELDS at each amount of carbohydrate in vitro.

Argyle and Baldwin, 1989

NSC:DIP

- 54, 37, or 25% NFC in vitro, NFC:DIP ratio of 2 to 9



Microbial protein, g/day

WHY the increase in yield for all [NSC]? No plateau?

Degradable protein & AA save cells energy?

ATP demands:
Protein synthesis: 4x more than transport ,14x more than amino acid formation.
(Stouthamer,1973)

Stokes et al., 1991

Protein supplementation changed yield of microbial protein from carbohydrate.

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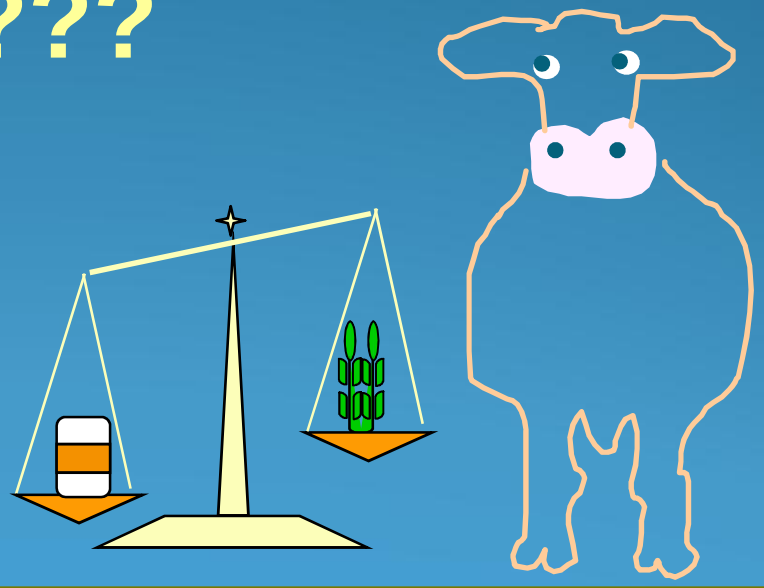
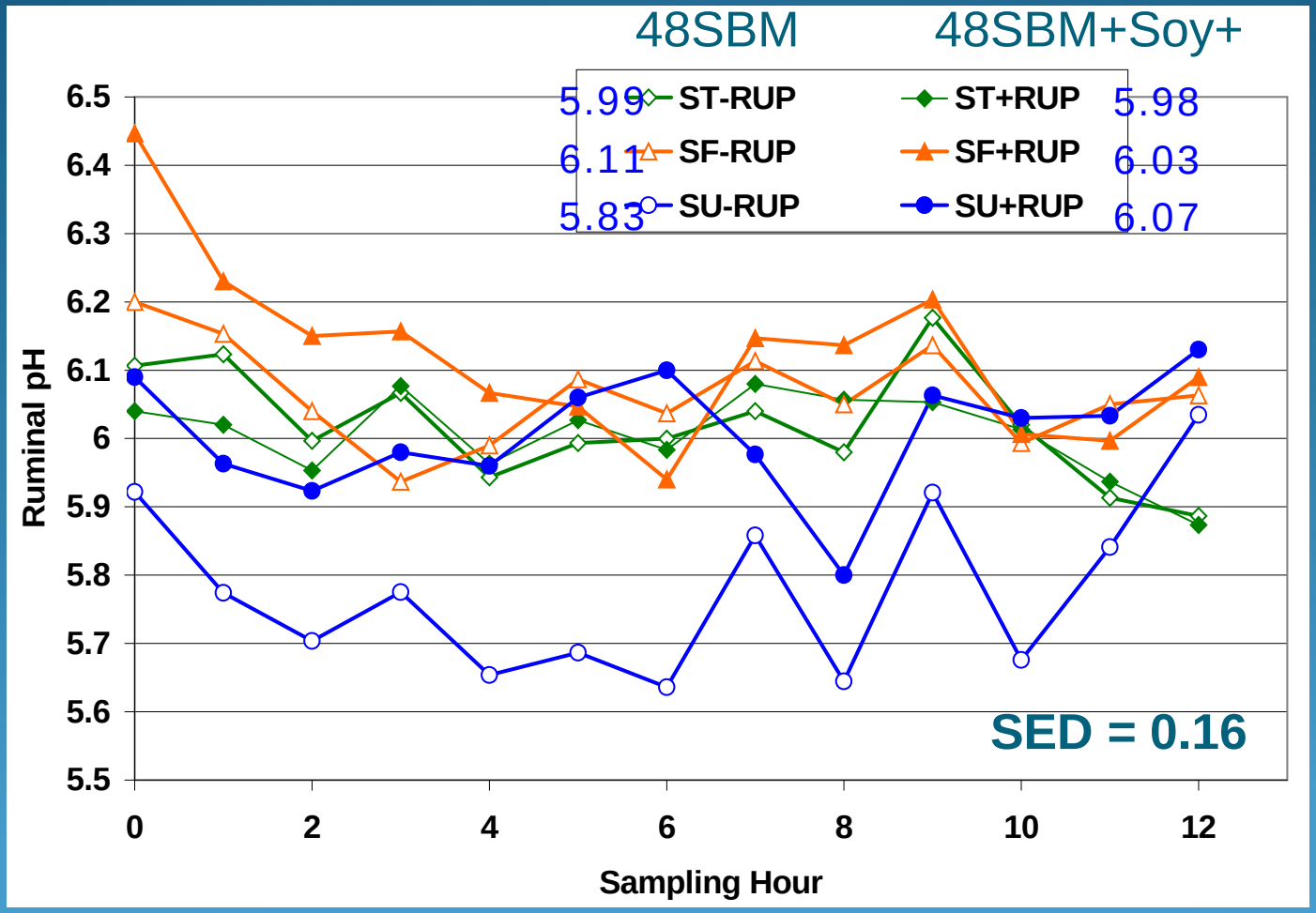


Protein and Rumen pH

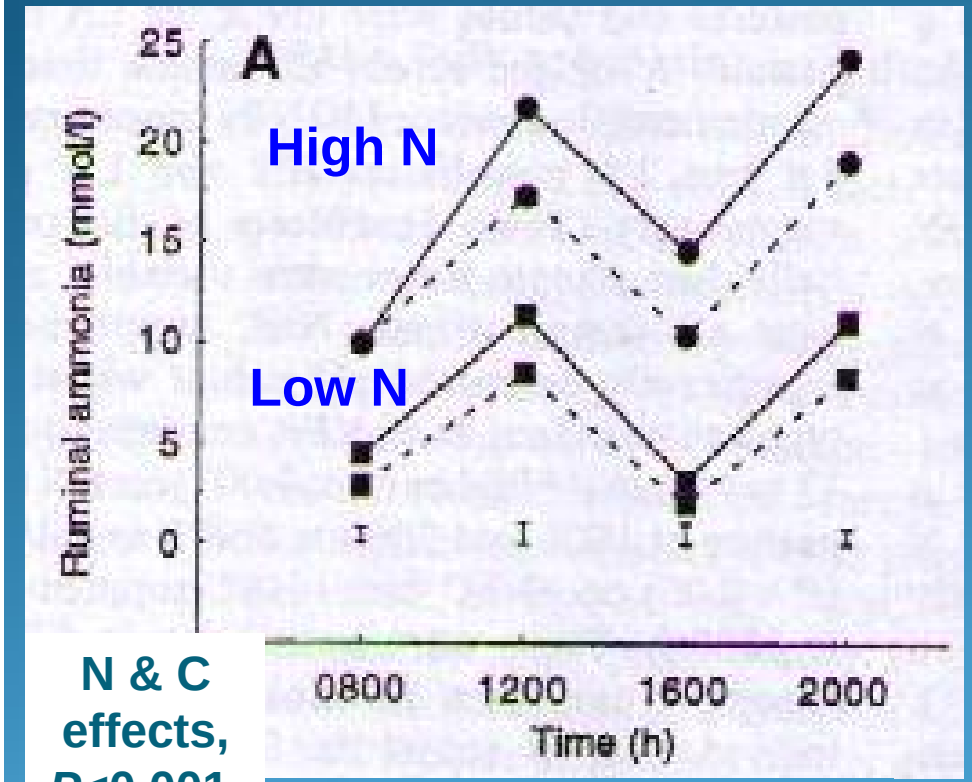


NFC x RDP for Sugar v Citrus *P* = 0.02

Hall et al., 2010

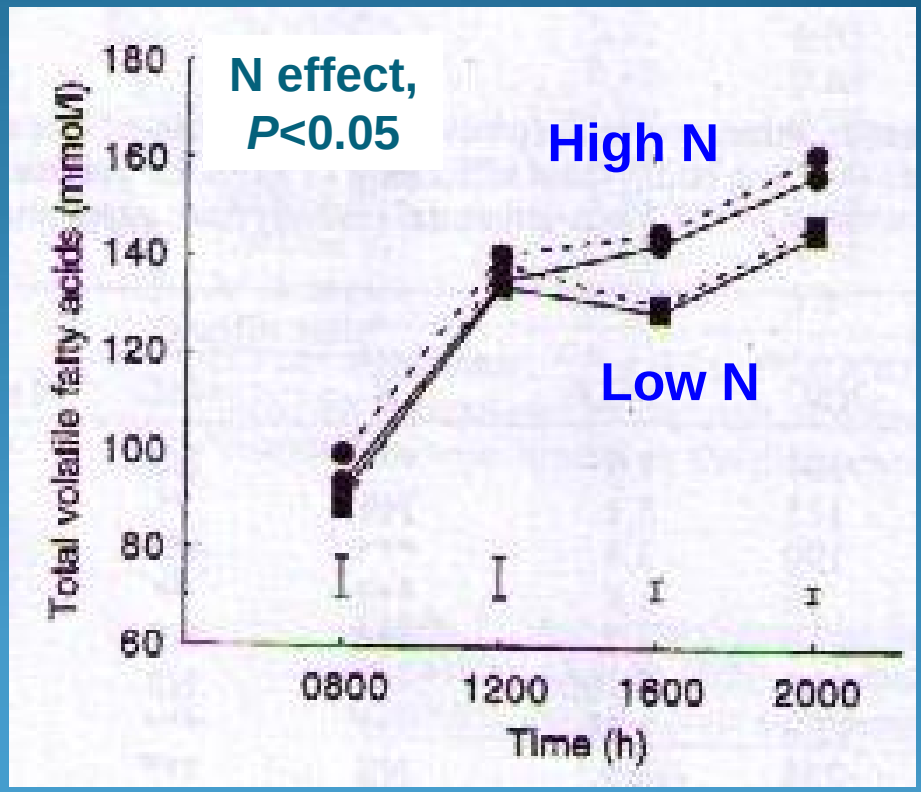
Protein Changes VFA?

- Sometimes, even when protein looks adequate, when we increase rumen degradable protein unexpected things happen…



N & C effects, *P*<0.001, NxC *P*<0.05

NH_3, mmol/L



Total VFA, mmol/L

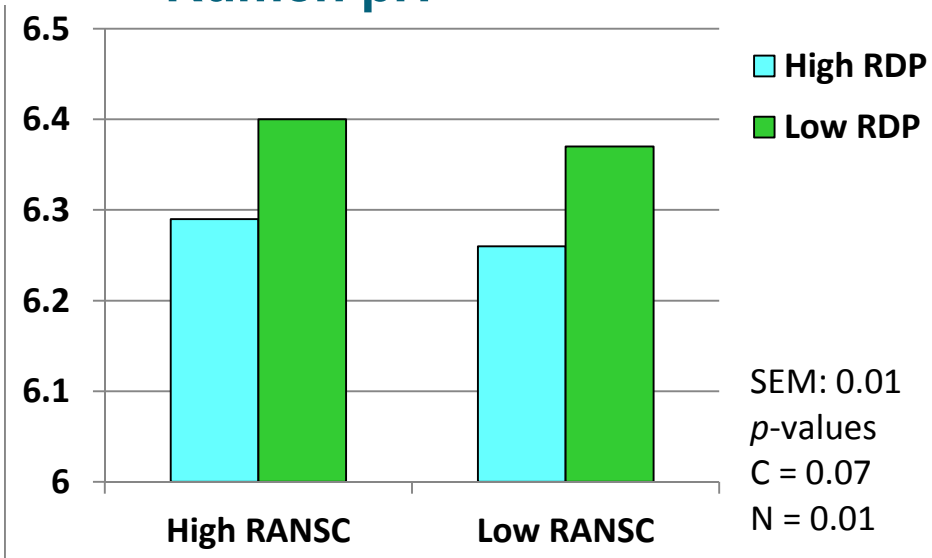
8 cows, 4x4 Latin square, 14 d periods

Carruthers and Neil, 1997

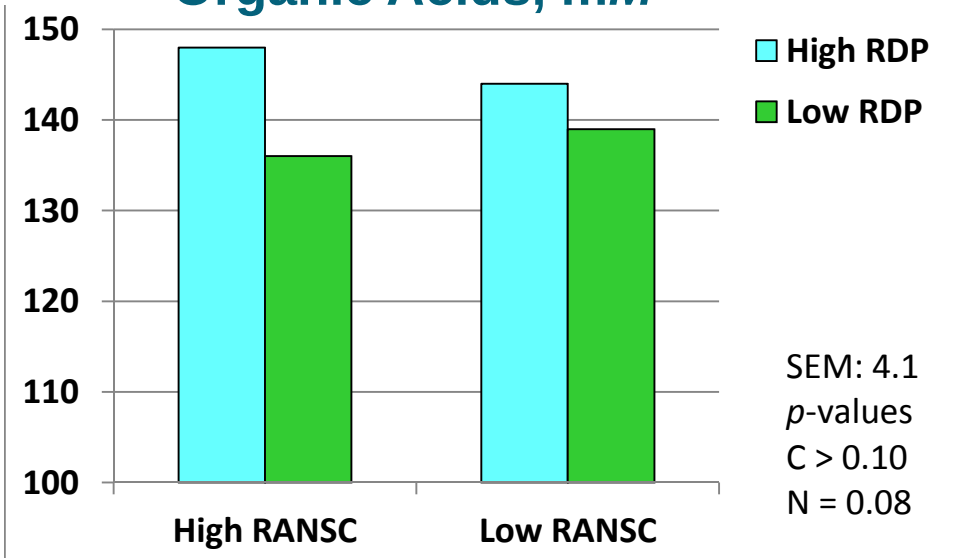
Carbohydrate, protein and pH

Rapidly Avail. NSC	High		Low	
Rumen Degr. P	High	Low	High	Low
RANSC:RDP	2.5	3.4	2.2	2.6
DM Intake, kg/d[C]	25.0	24.9	26.7	25.3

Rumen pH



Organic Acids, m*M*



Diet DM: NSC = 35-38%; CP = 17.3-17.8%, NDF: 34 – 36%

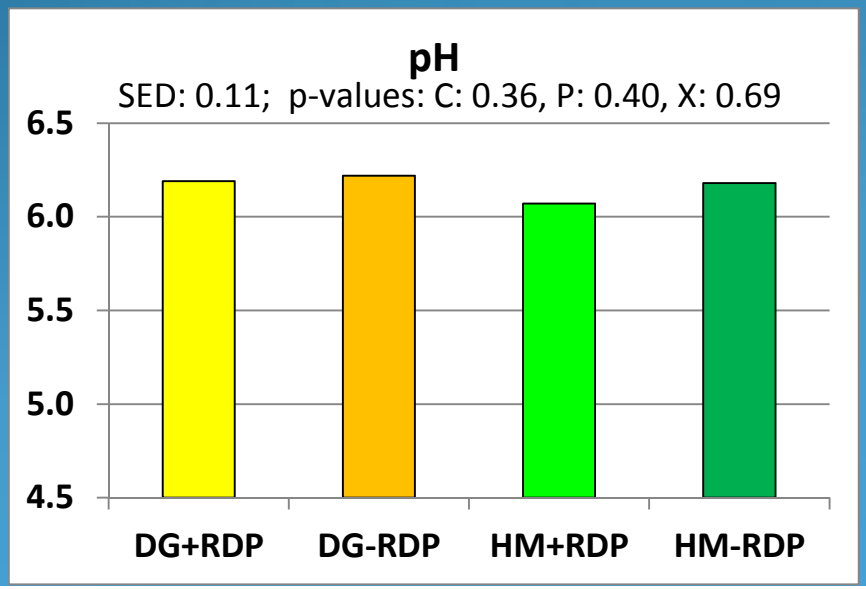
HMSC v. EC, Blood M v. SBM+ Canola

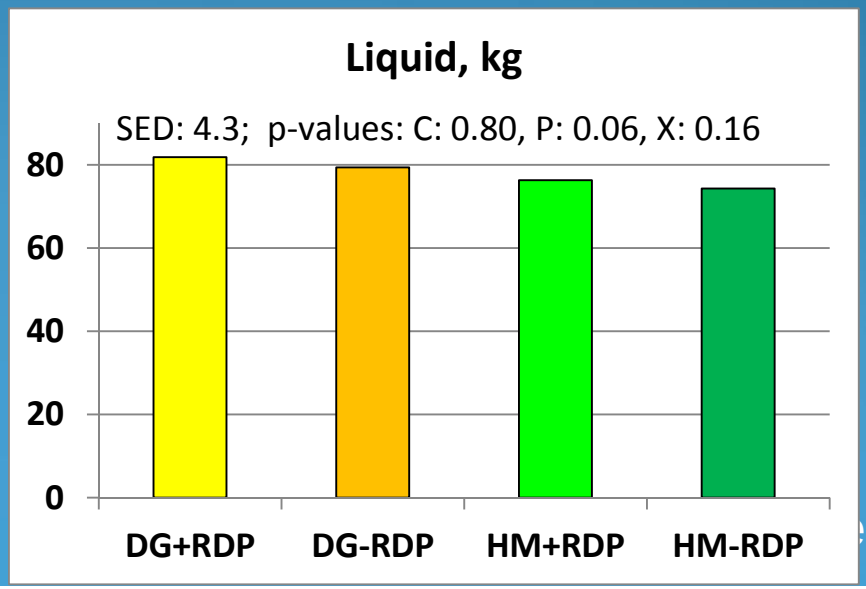
Aldrich et al., 1993

Protein and Organic Acids

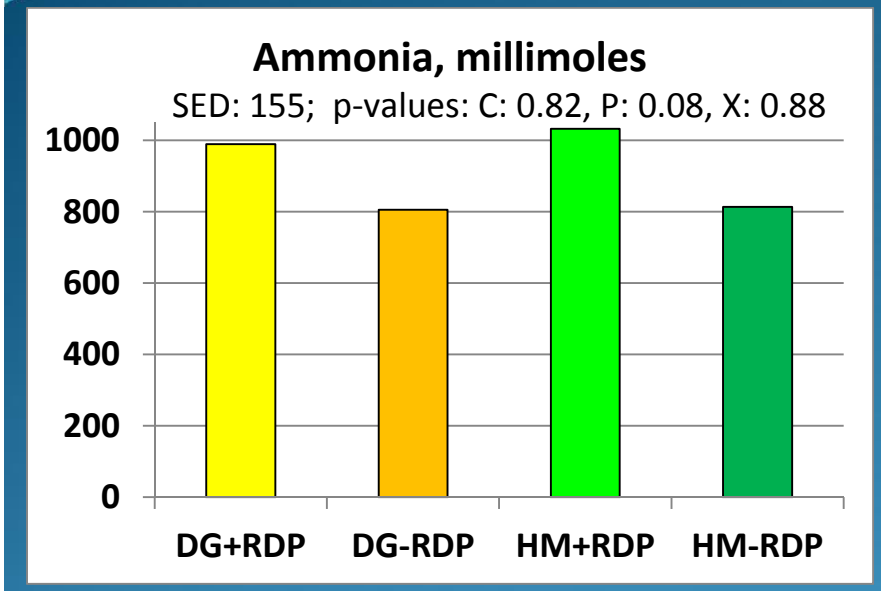
- 8 lactating cannulated cows
- Dry ground or HM corn x more or less RDP
- 55% forage, 16.8% CP, 29% NDF, 20% starch

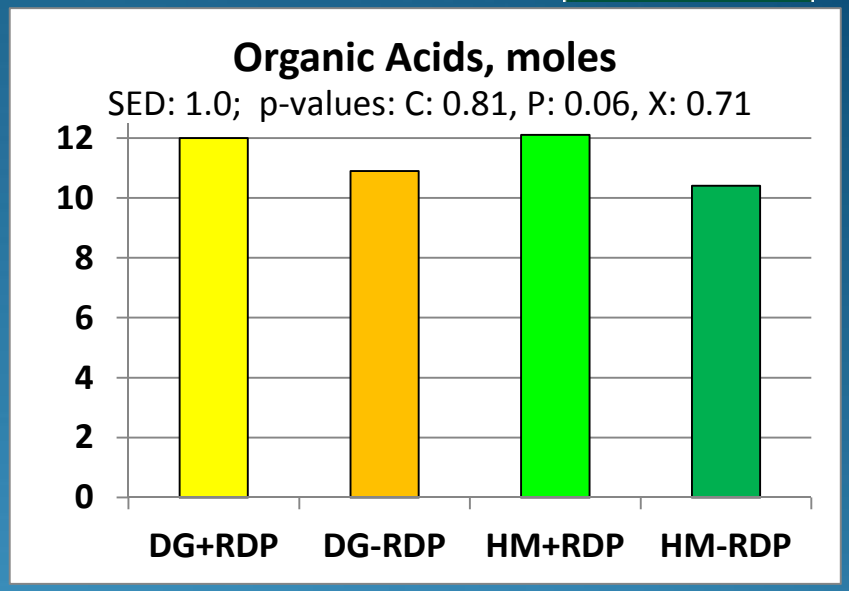
Starch Source	Dry Ground		High Moist.		
Rumen Degr. P	High	Low	High	Low	SED
DM Intake, lb/d[P]	57.1	54.9	57.3	55.1	1.4
Milk, lb[P,C]	90.6	94.8	90.4	90.6	1.9
3.5% FPCM	91.3	94.8	93.5	91.7	3.8

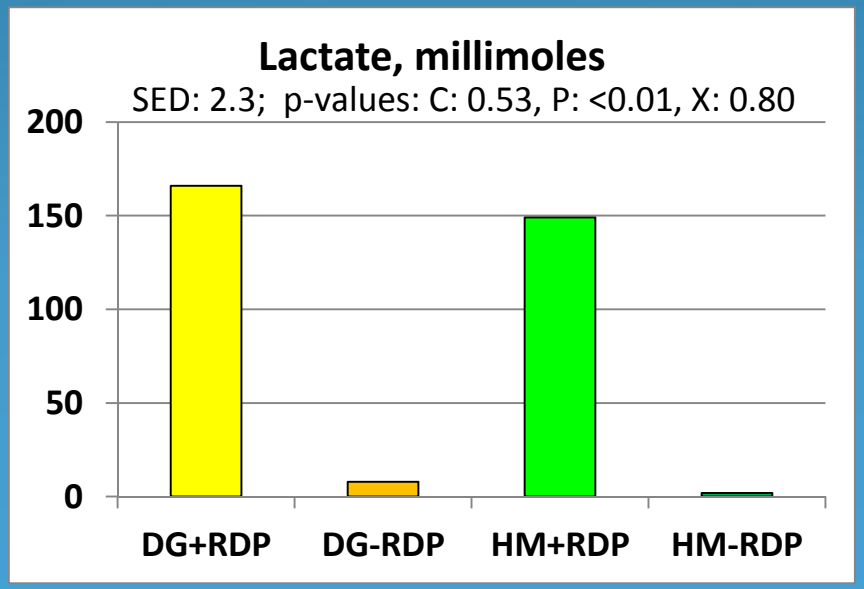




Protein and Organic Acids







Hall, Submitted.

How does protein supplementation change organic acid concentrations & pool size and pH in the rumen.

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Fates of R. A. Carbohydrates

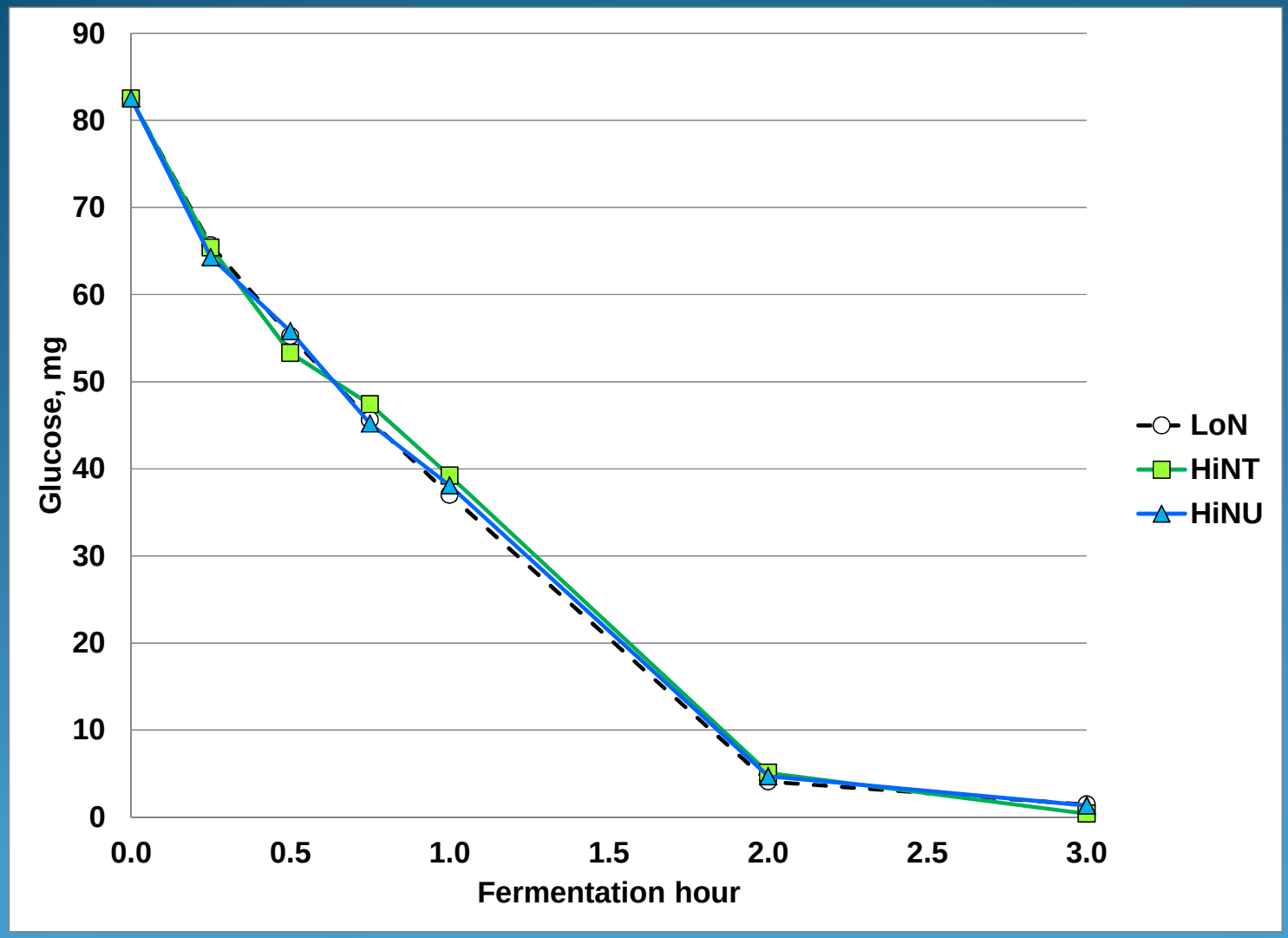
+glucose -glucose

- glucose
- fructose
- sucrose
- fructan
- starch

Not lactose

Rapidly Available Carb. = Organic acids + Microbes + Gas + Glycogen

Residual Glucose, mg

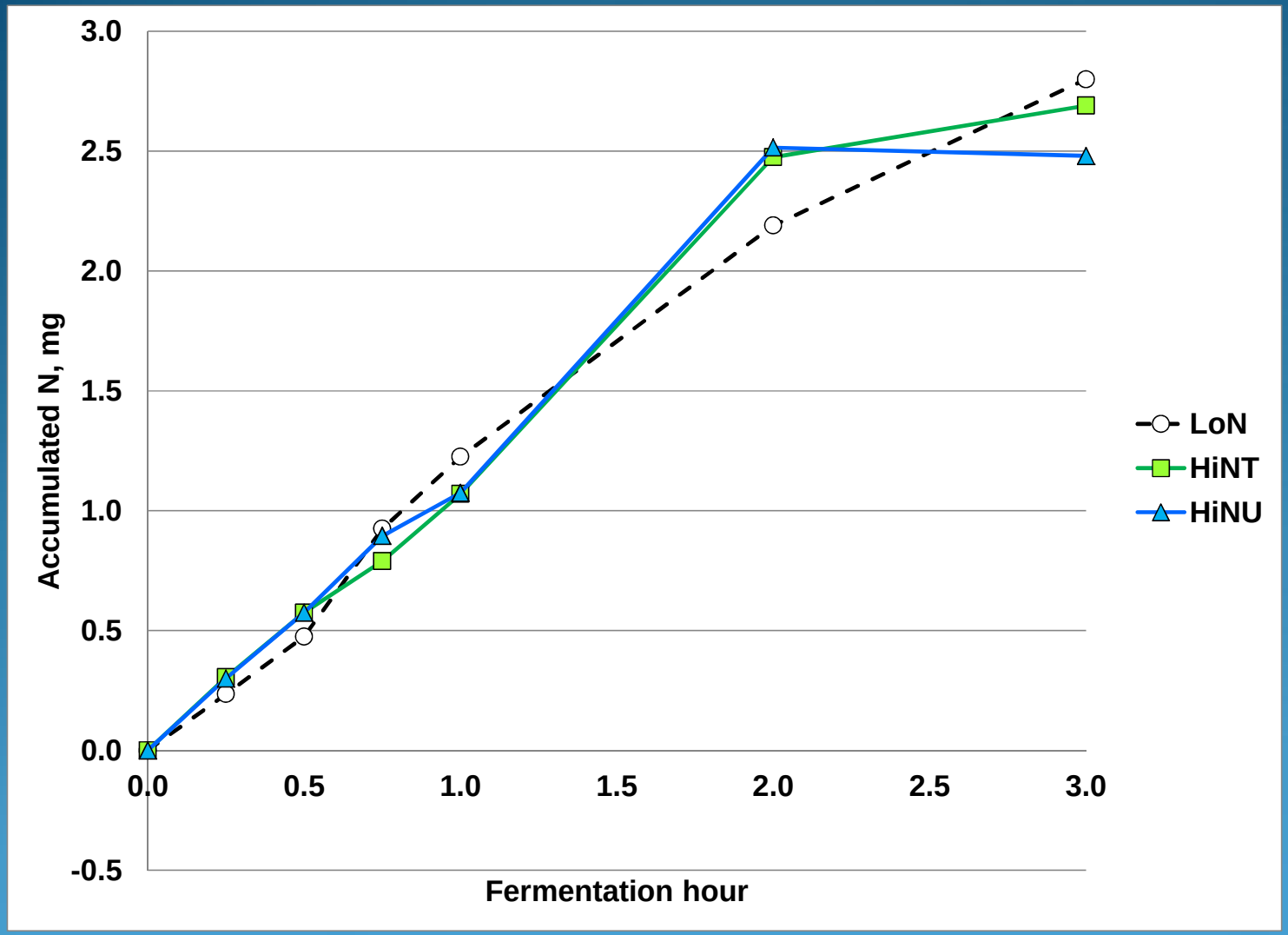


P- values

N	0.94
H	<.01
NxH	0.93
SED	2.0

Hall, 2012

Microbial N, mg



P- values

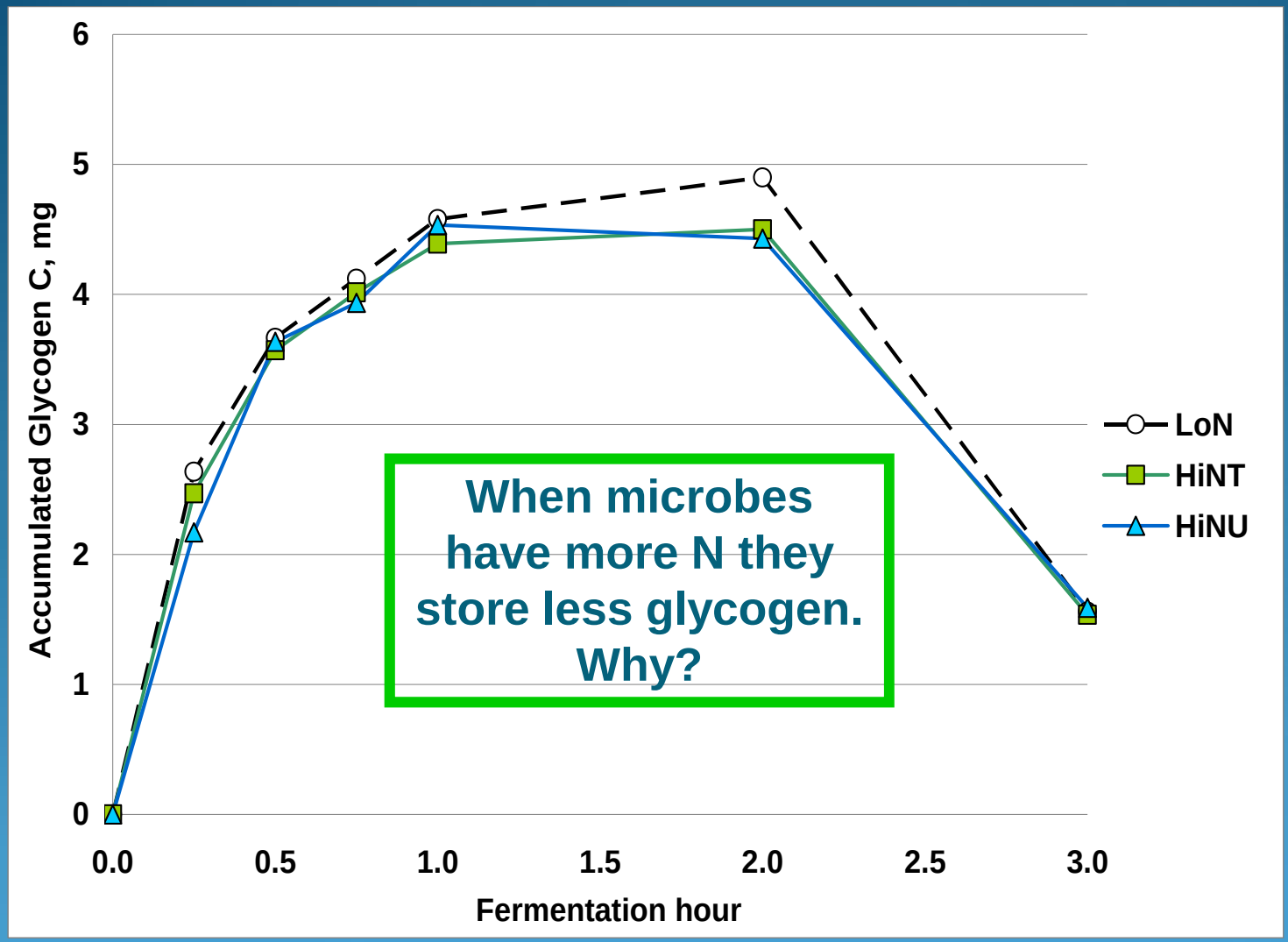
Maxima

N	0.04
SED	0.03
Lo v Hi	0.03
T v U	0.09

Not just a peptide response.

Hall, 2012

Glycogen C, mg



Max 12-13% of glucose to glycogen

p-values

Maxima

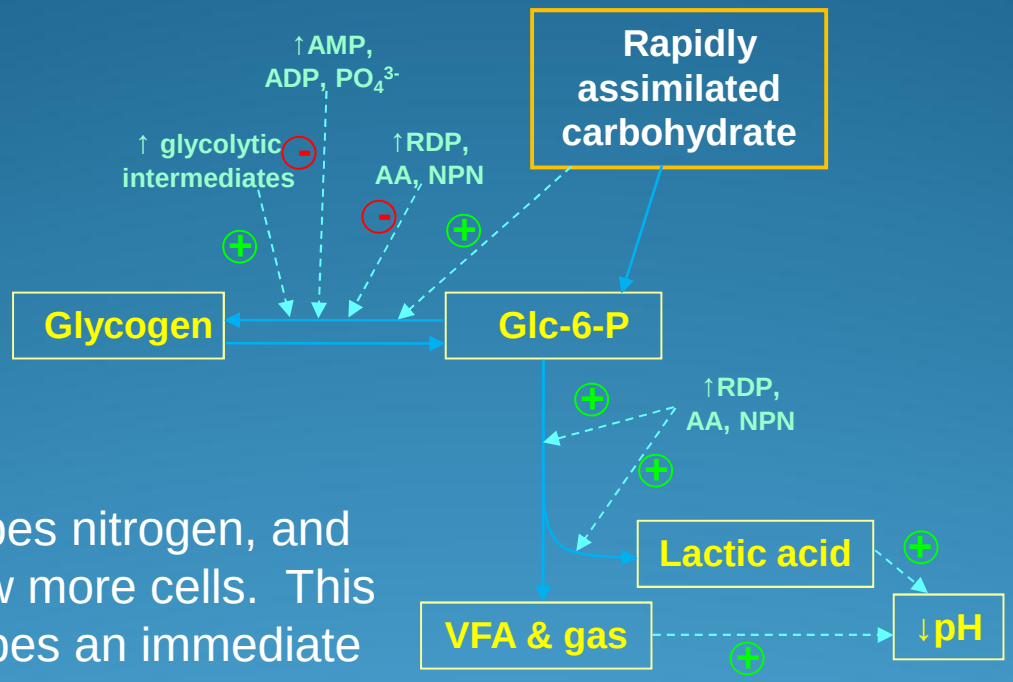
N	0.03
SED	0.04
Lo v Hi	0.02
T v U	0.04

Hall, 2012

Ball and Morell, 2003

Williams et al., 1973

Prins and Van Hoven, 1977



Give microbes nitrogen, and they will grow more cells. This gives microbes an immediate use for the energy rather than storing substrate for later.

Counotte and Prins, 1981

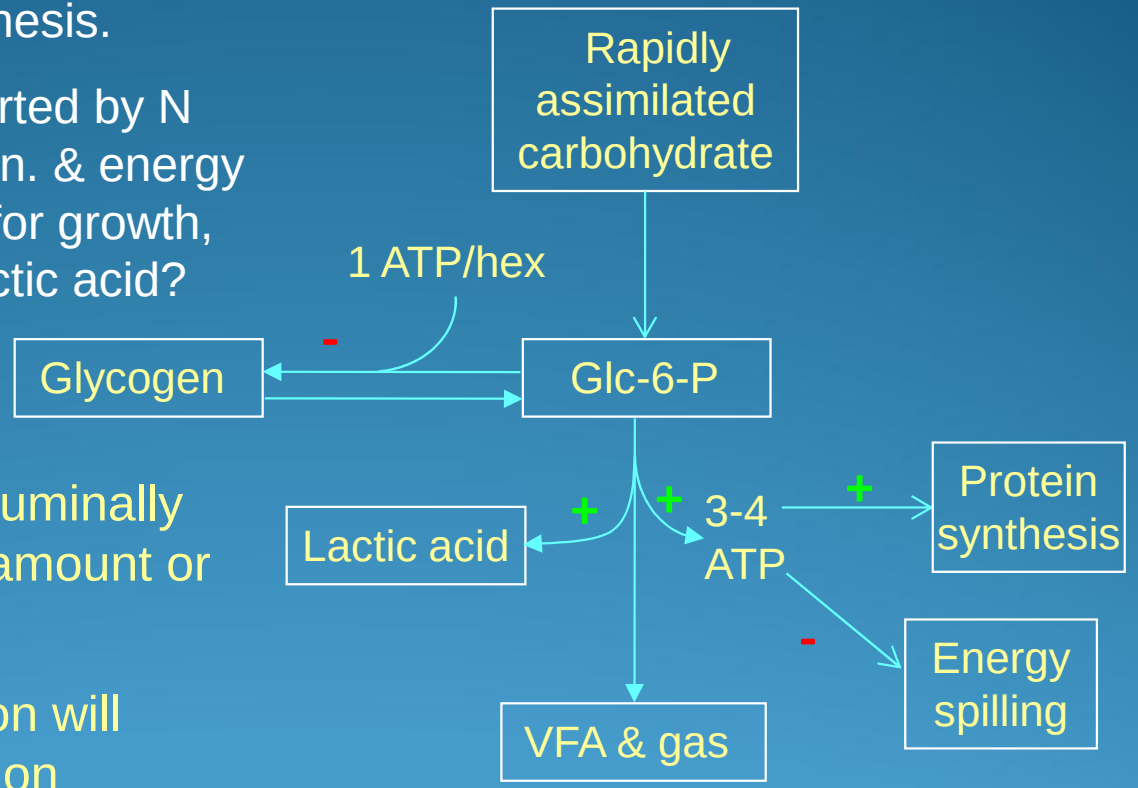
Malestein et al.,1984

Hall, Submitted.

Microbial Efficiency Implications

¼ to ½ of ATP may be used for glycogen synthesis.

Cell growth supported by N reduces glycogen syn. & energy spilling; more ATP for growth, more efficient. Lactic acid?



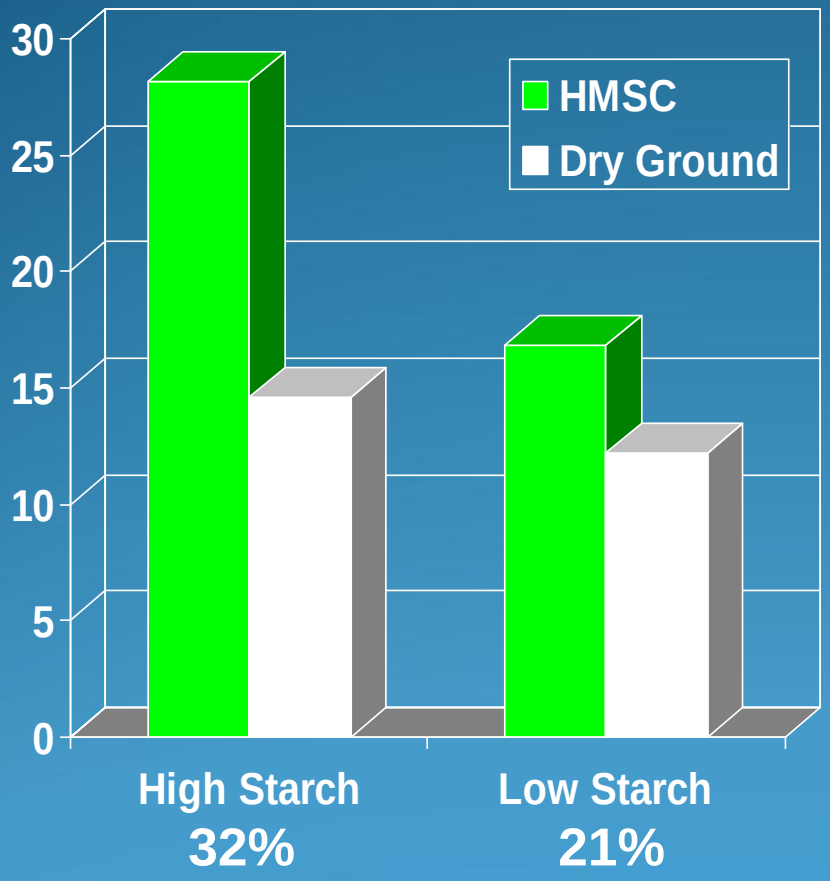
Effect of increased ruminally degradable protein amount or timing **+ / -**

Lactic acid production will reduce ATP production

Hall, Submitted.

Starch: Rates Subject to Change?

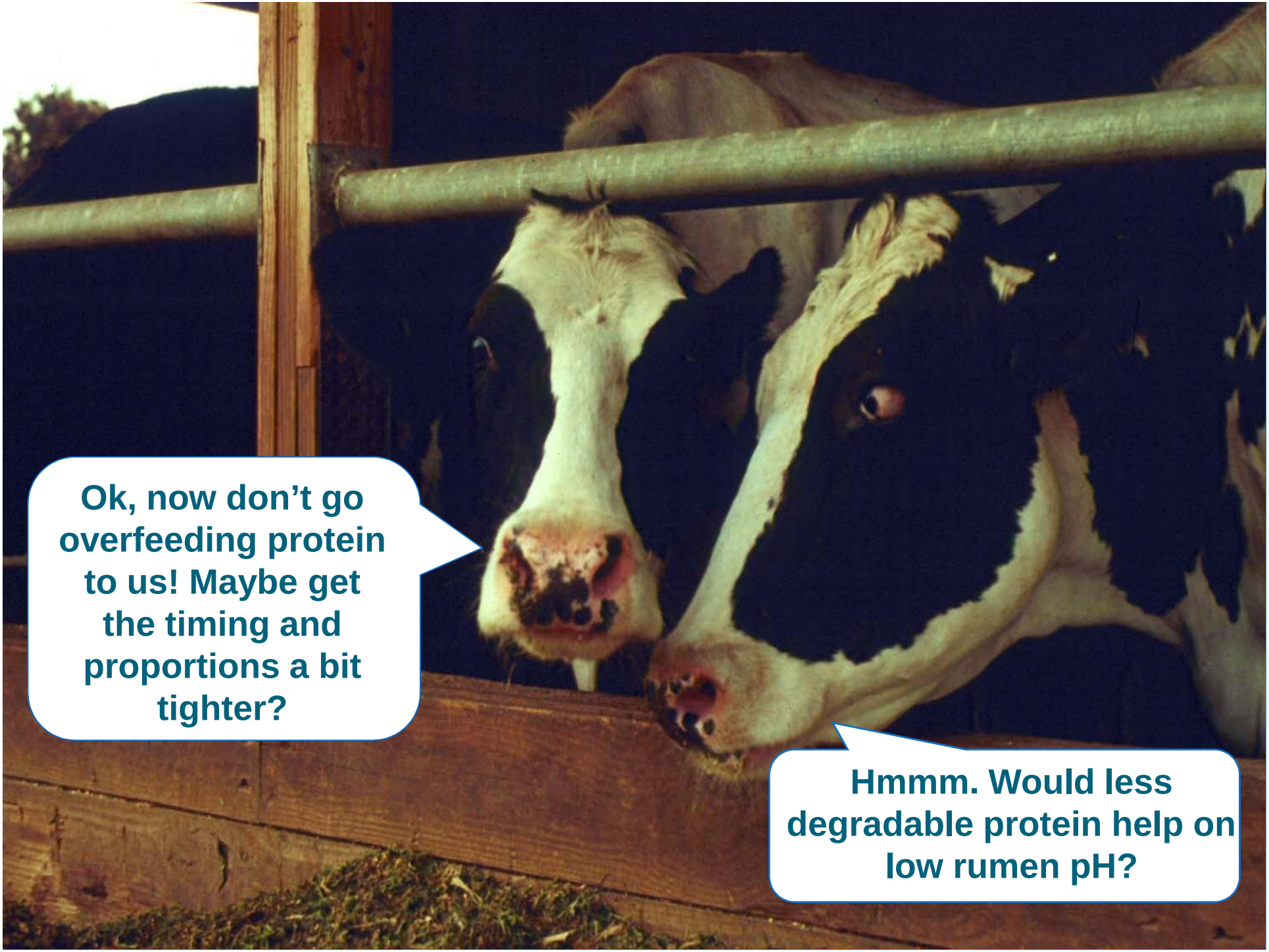
Rates of Total Starch Fermentation, %/h



- Fermentation rates were increased at higher dietary starch levels.
- Change greater for rapid than slow rate.
- Greater protein degradability in HMSC affecting kd?
- Basis for rapidly fermented grains being “touchy”?

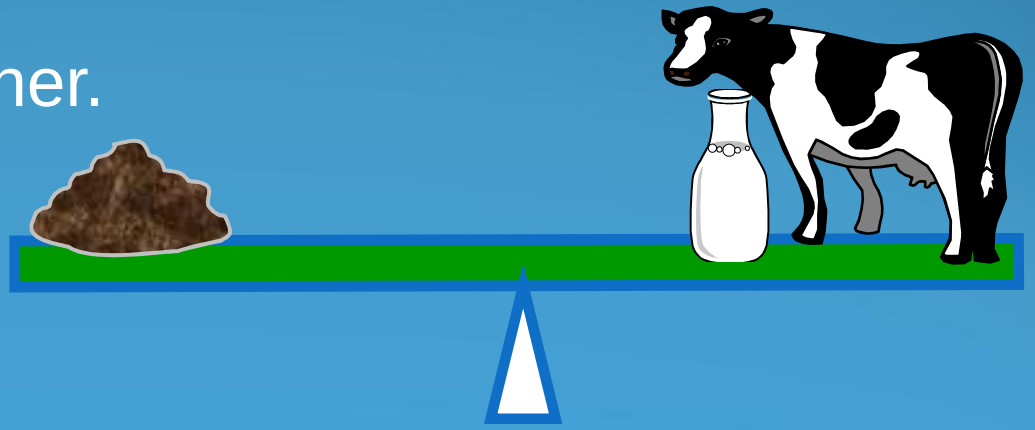
Oba and Allen, 2003

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


Ok, now don't go overfeeding protein to us! Maybe get the timing and proportions a bit tighter?
Hmmm. Would less degradable protein help on low rumen pH?

Summary

- Degradable protein affects carbohydrate use by rumen microbes, their efficiency, and potential nutrient supply.
- Don’t go and overfeed protein!!! Adjust timing for rapidly available protein relative to rapidly available carbohydrate?
- Rumen products need to be delivered to cow to be useful. How will kp affect net results?
- Need to explore further.



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Questions?

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