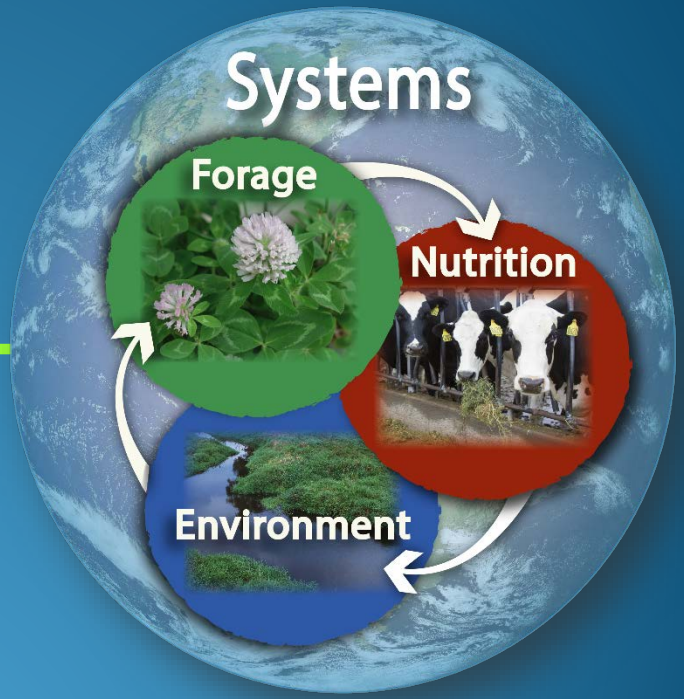
United States Department of Agriculture

Sugars in Dairy Cattle Rations



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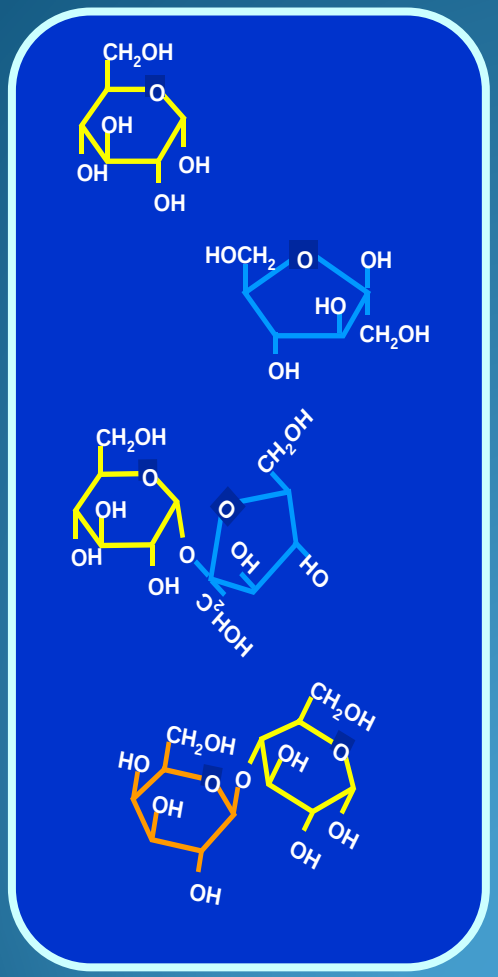
U.S. Dairy Forage Research Center
USDA - Agricultural Research Service

Tri-State 4/19/2017

Sugars: 6 Carbon

Sugars



Glucose / Dextrose

Fructose

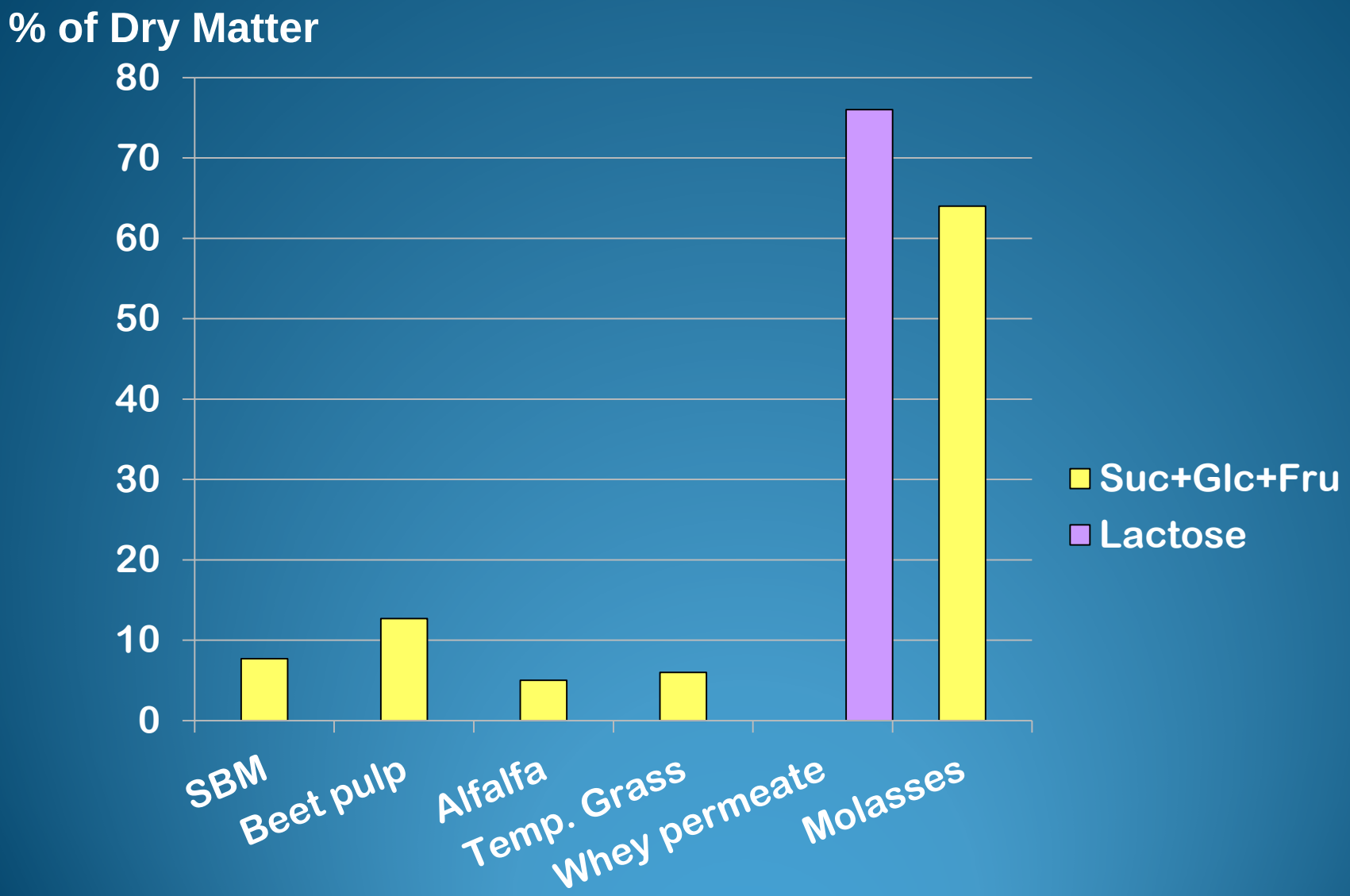
Monosaccharides
Simple sugars

Sucrose

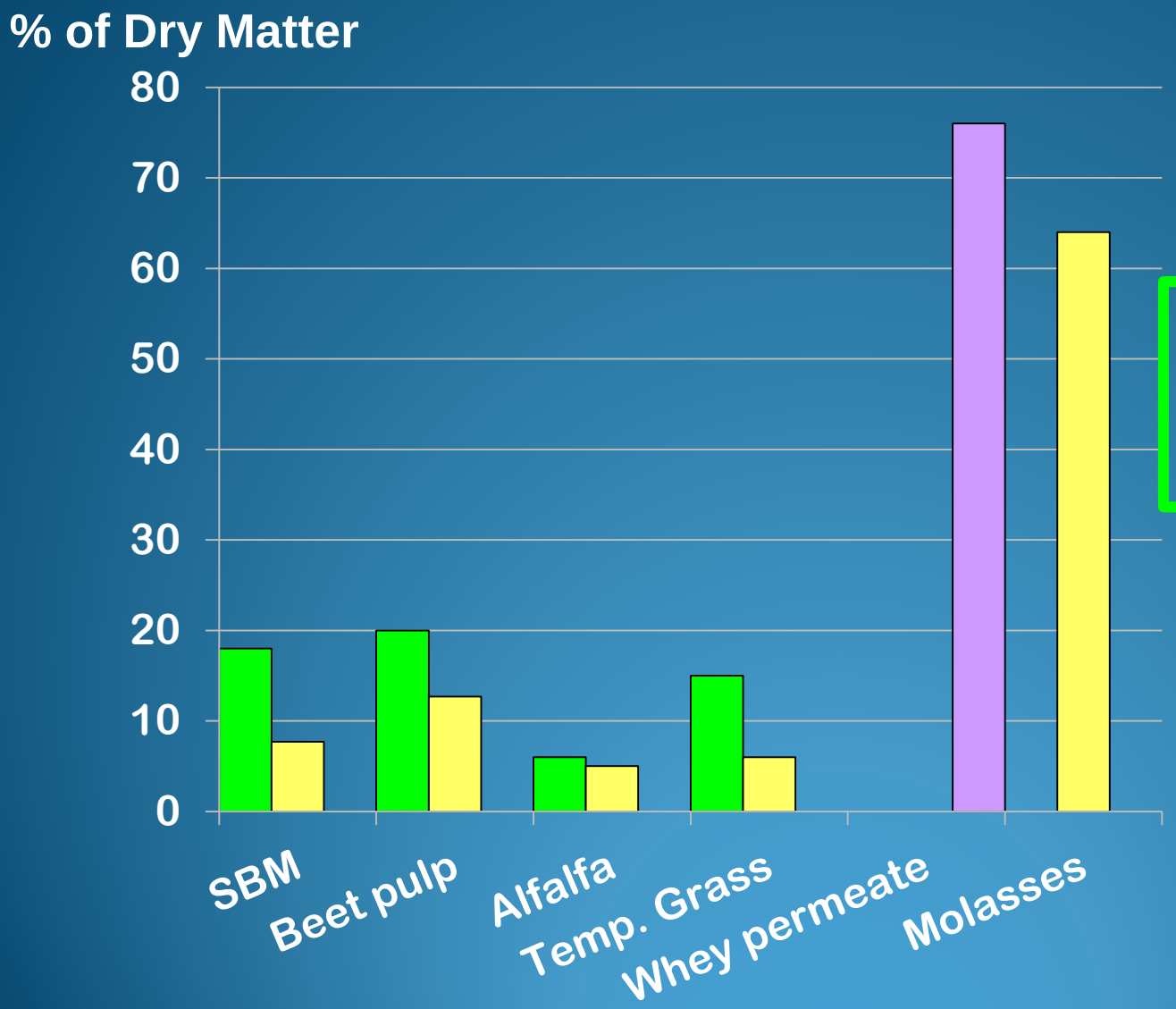
Lactose

Disaccharides

Sugars in Feed



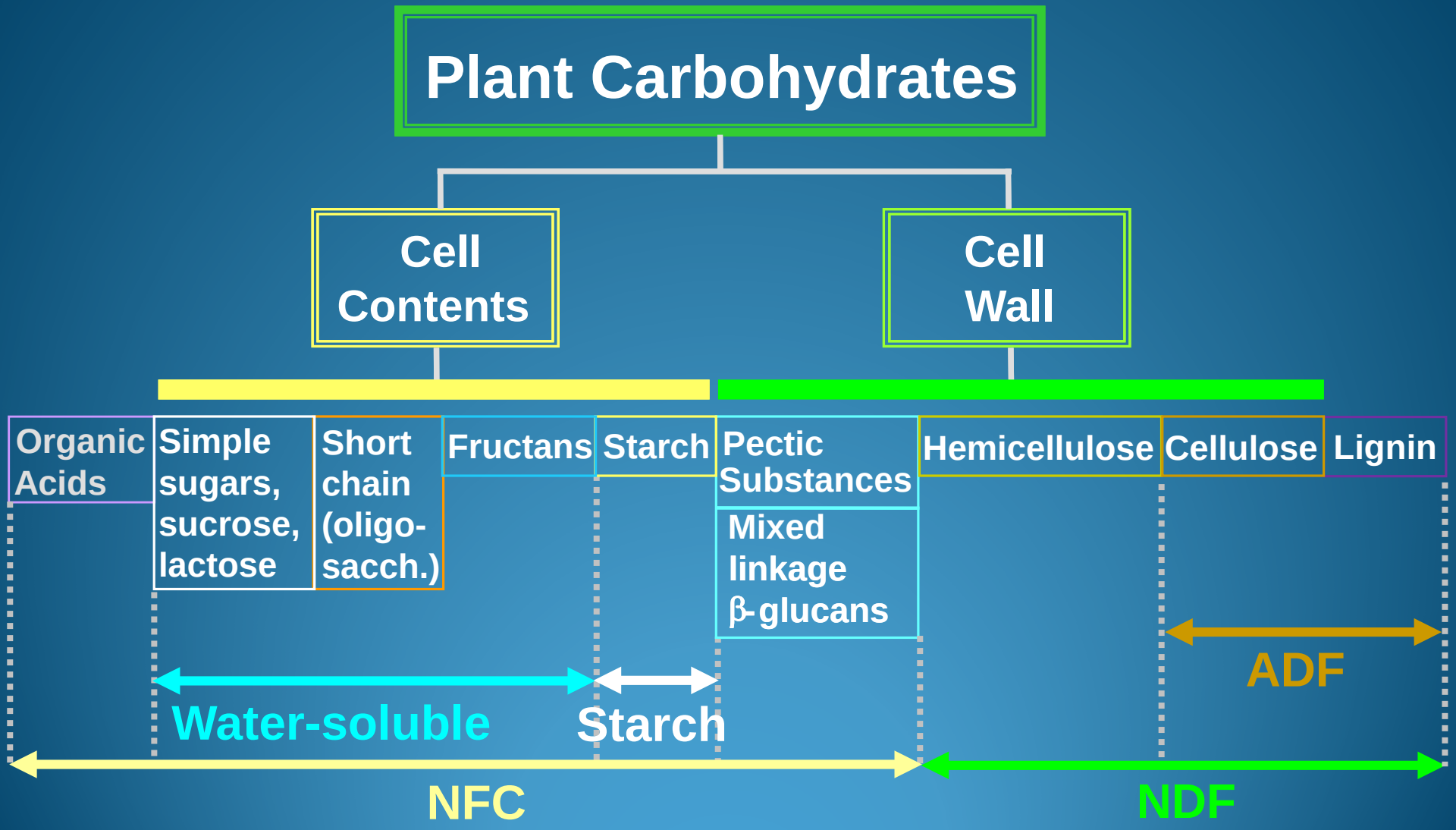
Sugars: WSC vs. “Sugars”



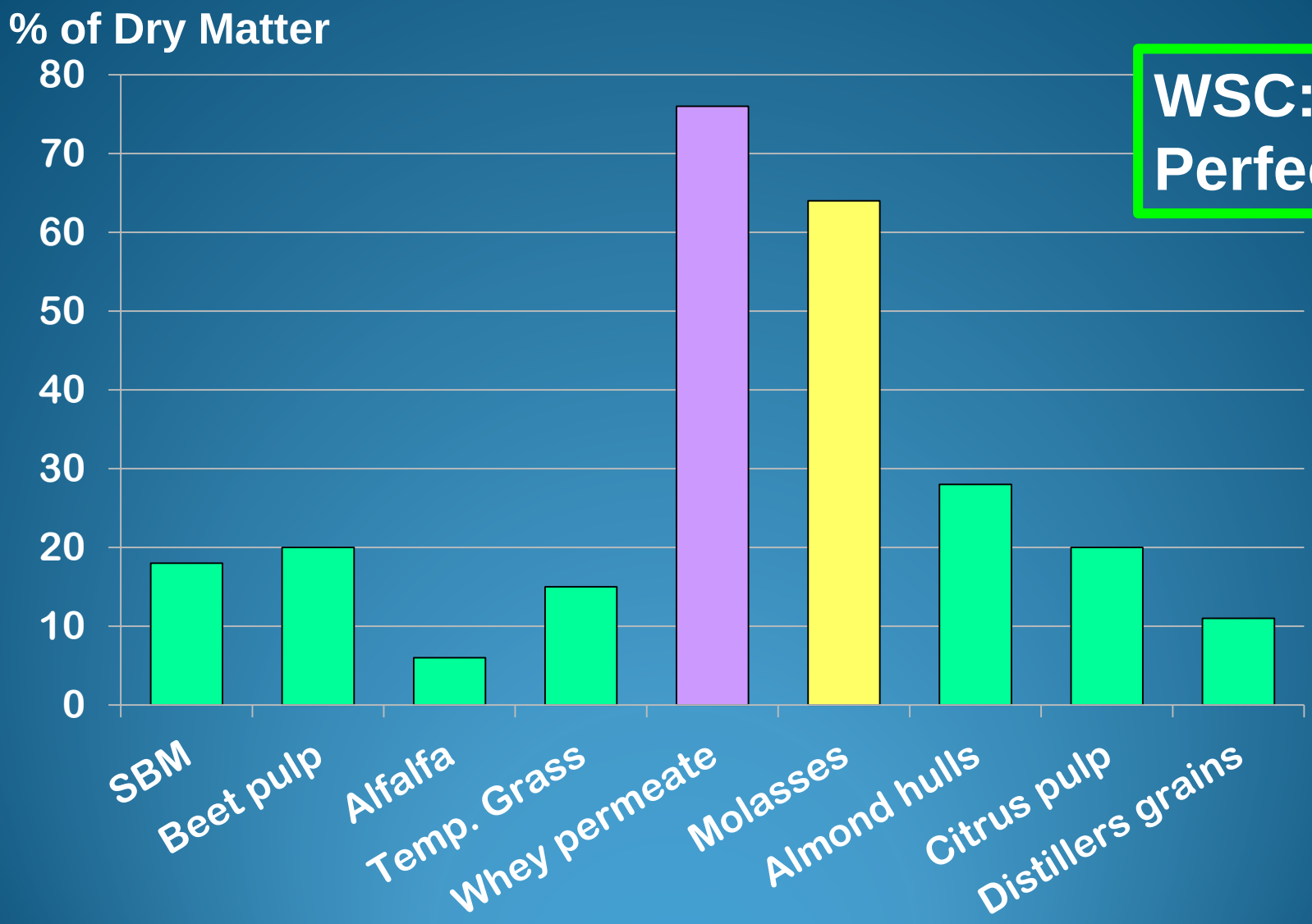
WSC includes more than mono- & di-saccharides.

Best measure of sugars in molasses is total sugars as invert.

Analyzing Carbohydrates



WSC, Soluble carbohydrates



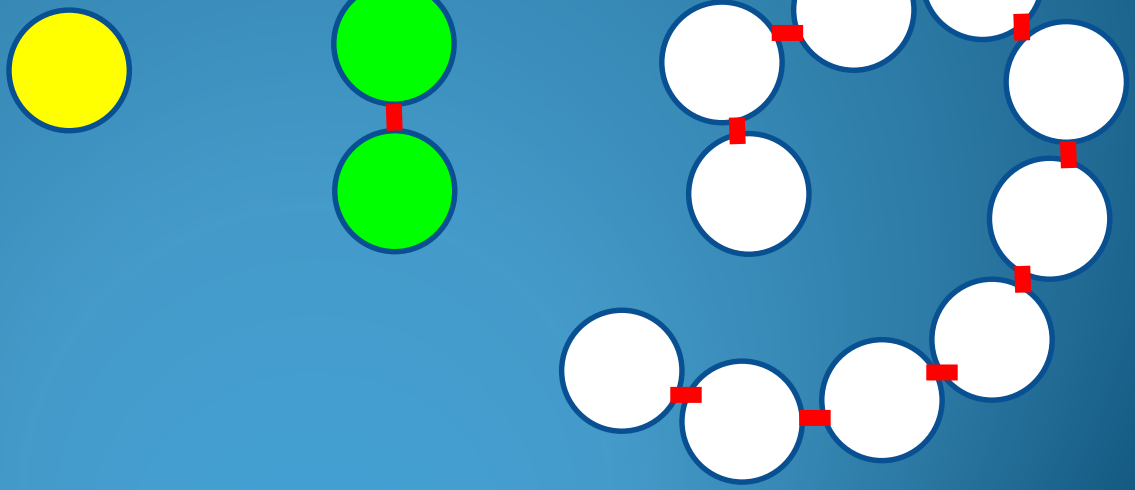
WSC: Perfect?

Sugars: What makes them tick?

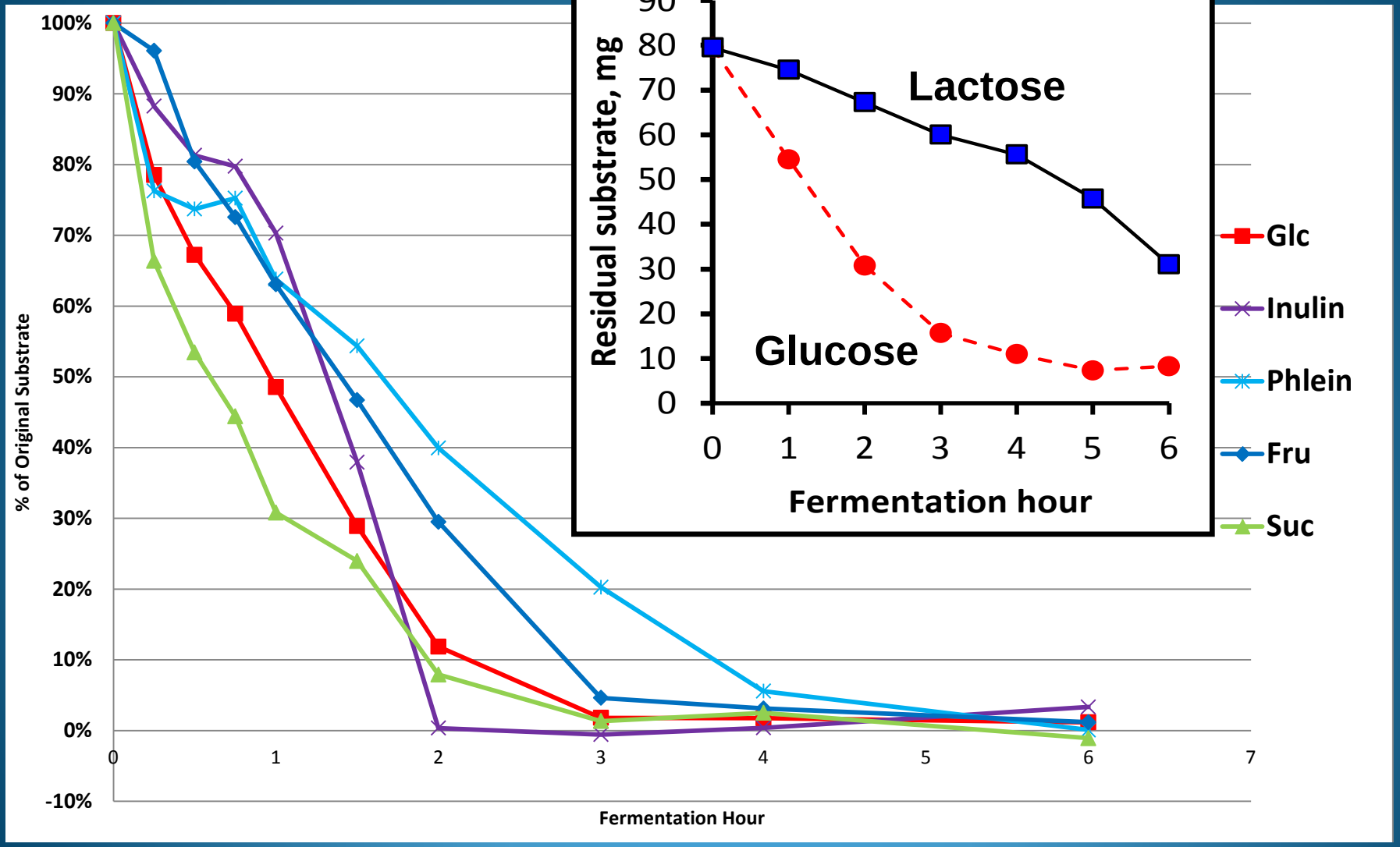
- How much is there?
- What do we feed with them?
- Rate of use & fates
- What else do the microbes do?
- What feed is it in?

Equivalence of NFC

	Glucose	Sucrose	Starch
1 lb DM	1.00	1.00	1.00
Hydrolyzed Monomers	1.00	1.05	1.11
% of Starch	90%	95%	100%



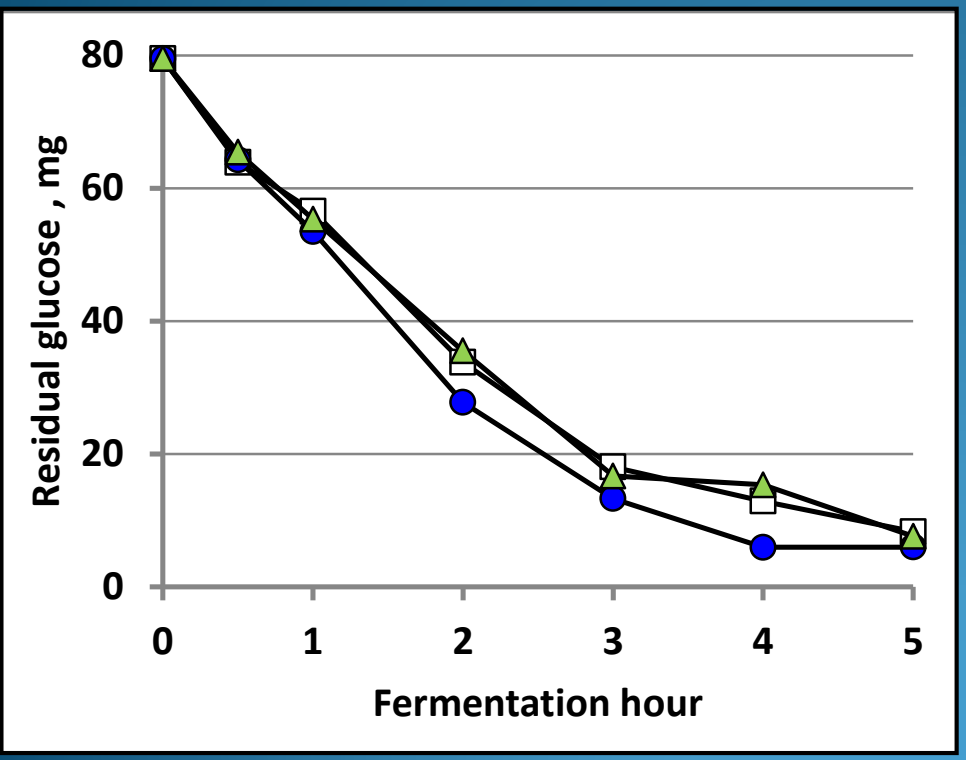
Rates of Microbial Use



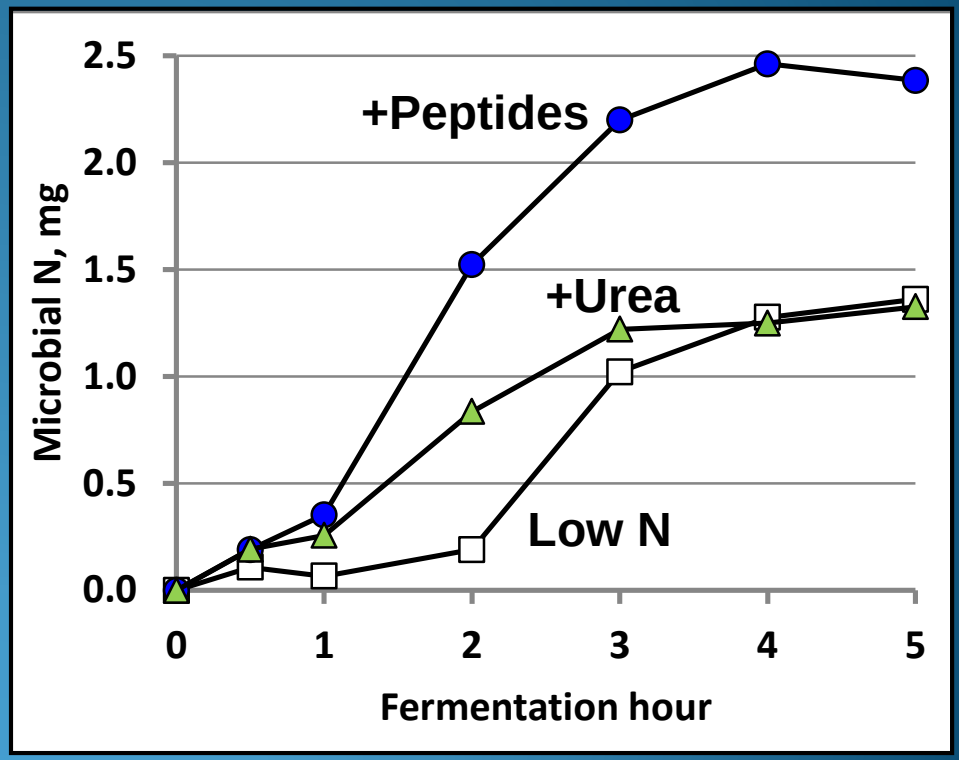
Hall, unpub., Hall 2016

Microbial Protein: Glucose

- More rapid fermentation >> more rapid growth >> greater growth (dilution of maintenance)
- Affected by protein source



Residual substrate, mg

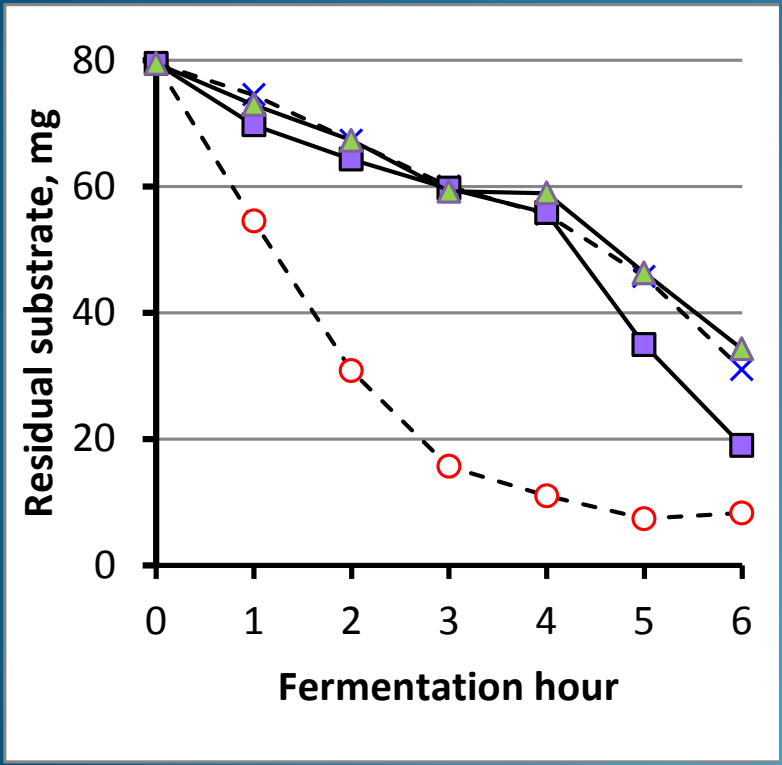


Microbial N, mg

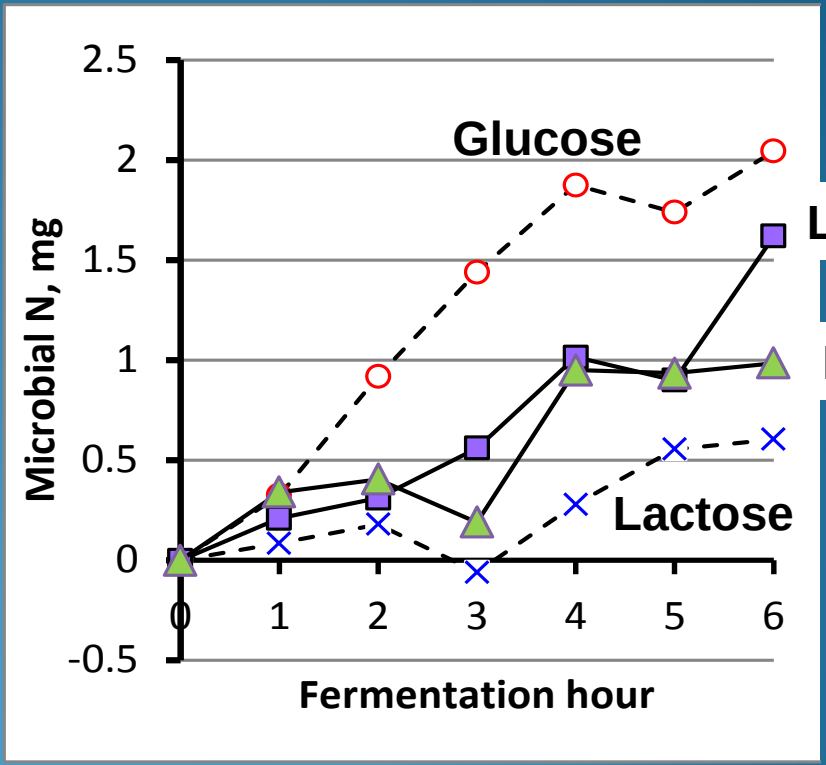
Hall, 2016
Hristov et al., 2005

Microbial Protein: Lactose

- More rapid fermentation >> more rapid growth >> greater growth (dilution of maintenance)
- Affected by protein source



Residual substrate, mg



Microbial N, mg

Hall, 2016

Protein Changes Microbial Yield

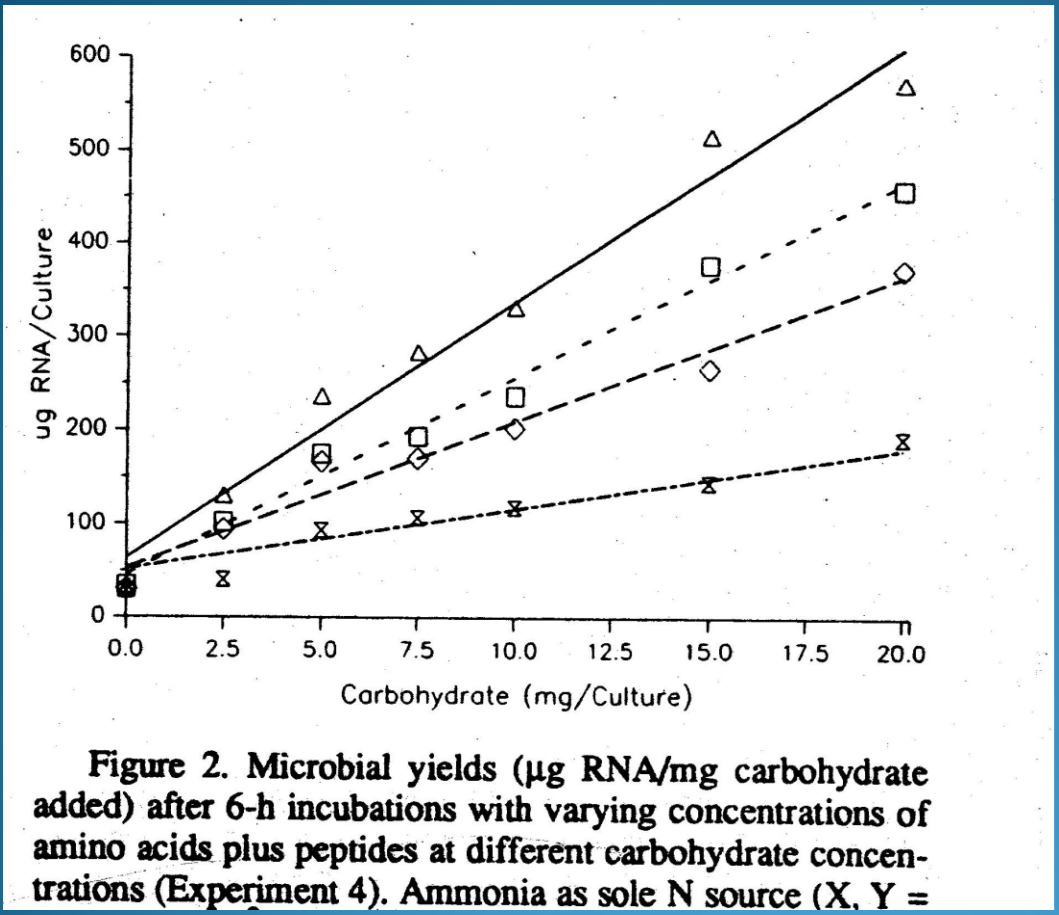


Figure 2. Microbial yields (µg RNA/mg carbohydrate added) after 6-h incubations with varying concentrations of amino acids plus peptides at different carbohydrate concentrations (Experiment 4). Ammonia as sole N source (X, Y =

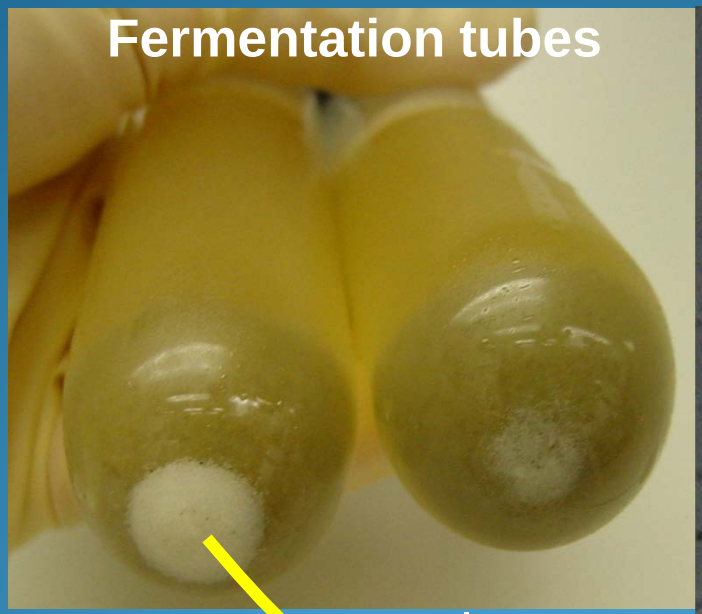
- Increases in protein supply gave increased microbial YIELDS at each amount of carbohydrate in vitro.

Argyle and Baldwin, 1989

Sugars: Use vs. Fermentation

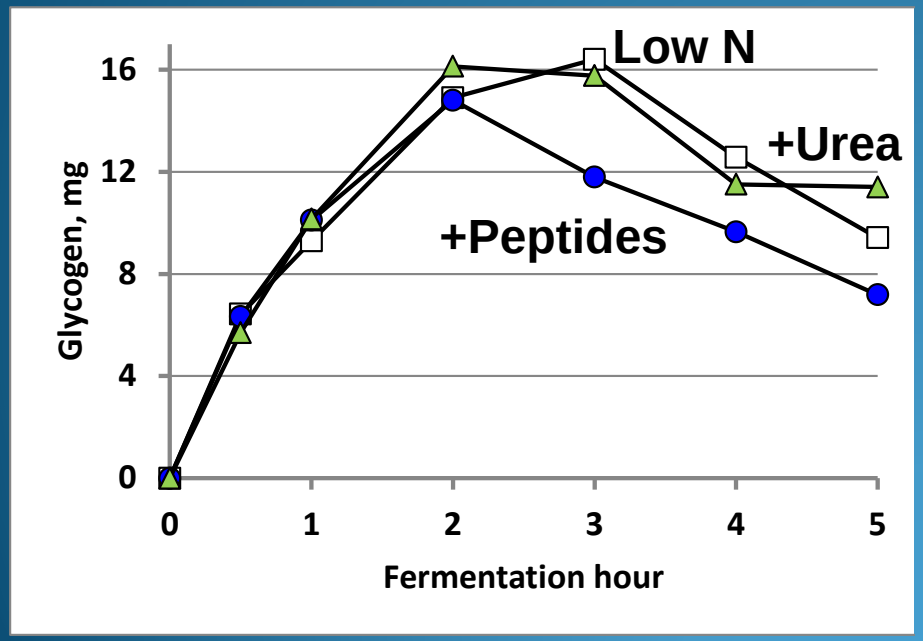
Readily Available Carbohydrates = **Organic acids** **+ Microbes** **+ Gas**

- glucose
- fructose
- sucrose
- lactose
- raffinose
- fructan
- starch

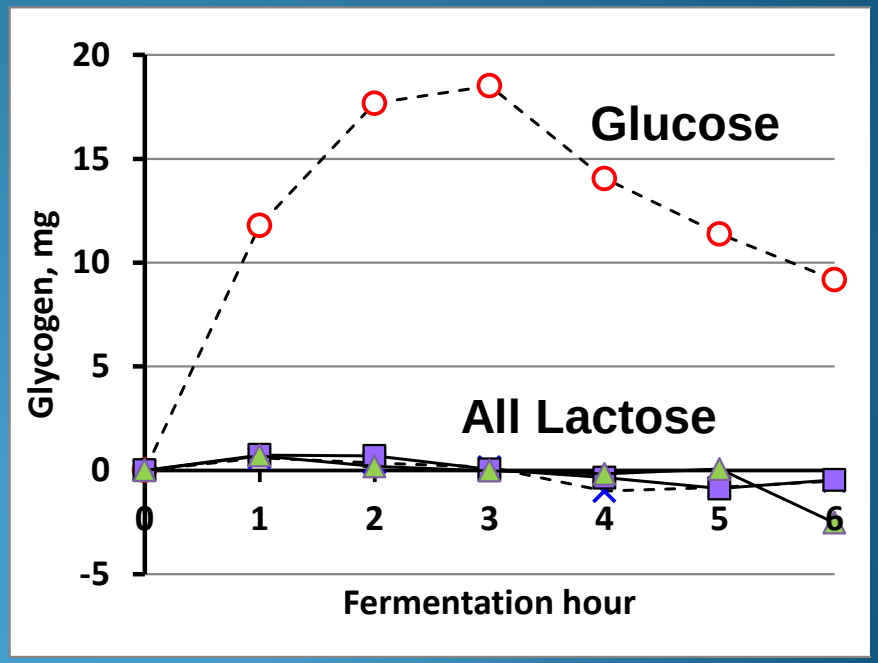


Glycogen Production

- Like starch
- 1 ATP per glucose added, -25 to 33% of ATP yield
- More RDP, less glycogen… type of RDP?
- More rapidly available >> more glycogen



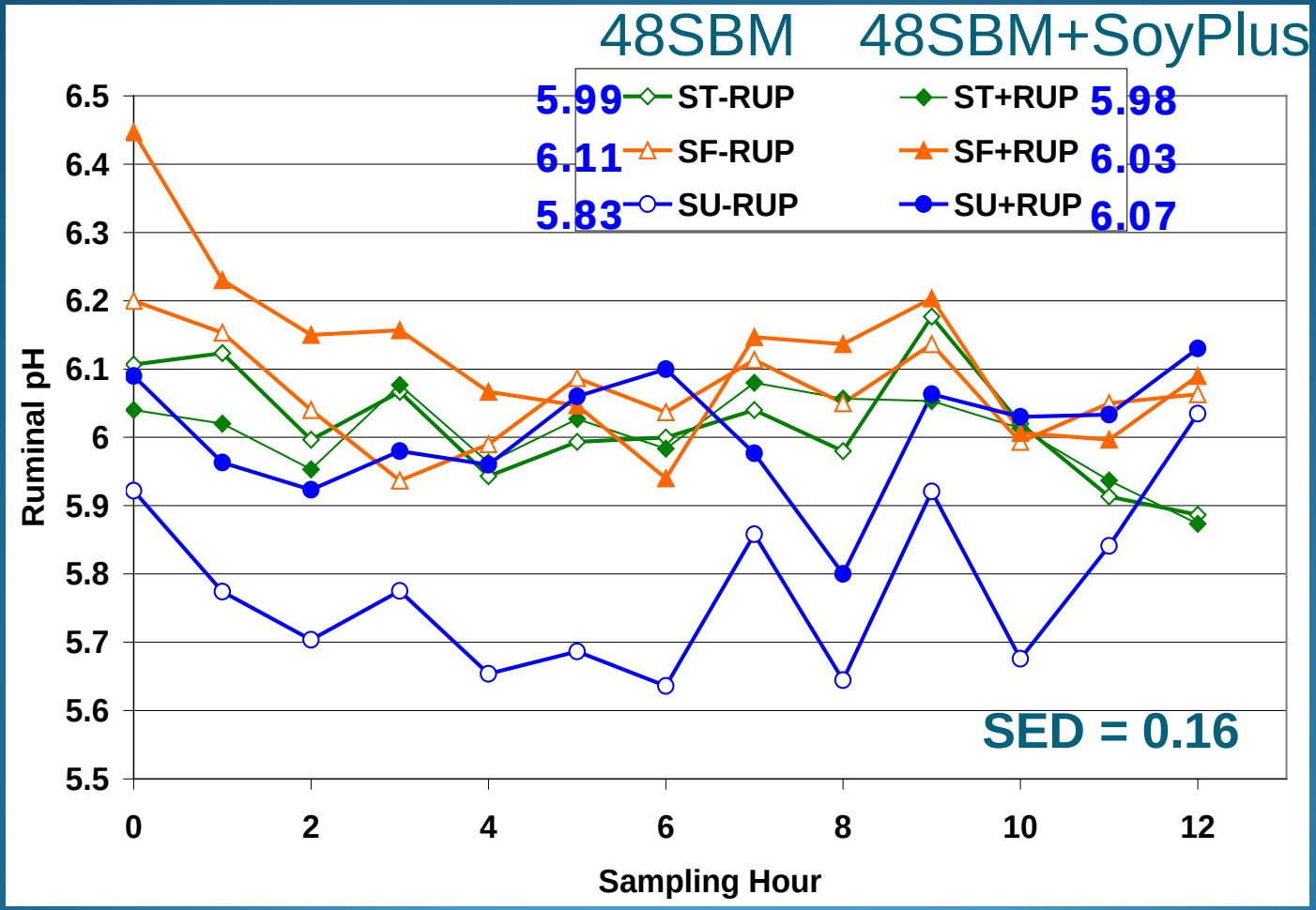
Glucose + Protein Sources



Glucose vs. Lactose

Hall 2016, 2017

Protein and Rumen pH



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

Hall et al., 2010

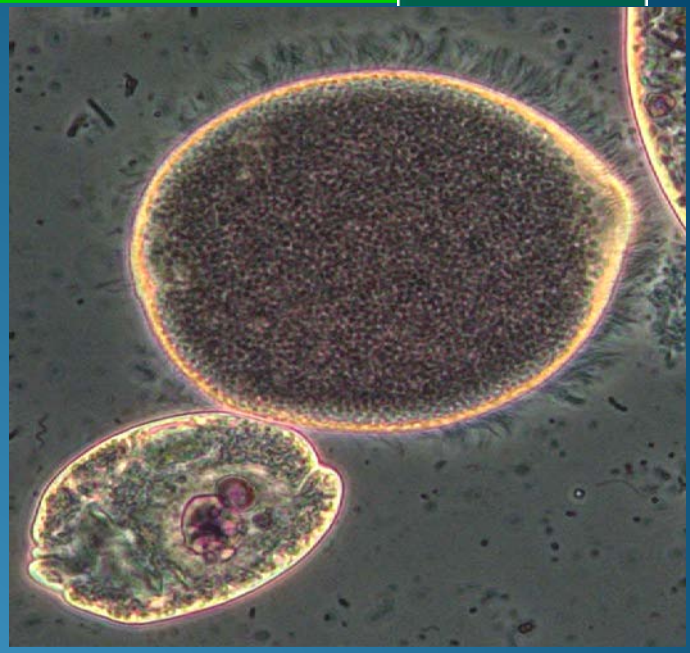
Glycogen: Pros & Cons

More Glycogen

- Less energy for microbial growth
- Slows fermentation
- Dampen pH drops
- Another SI “starch” source?

Less Glycogen…?

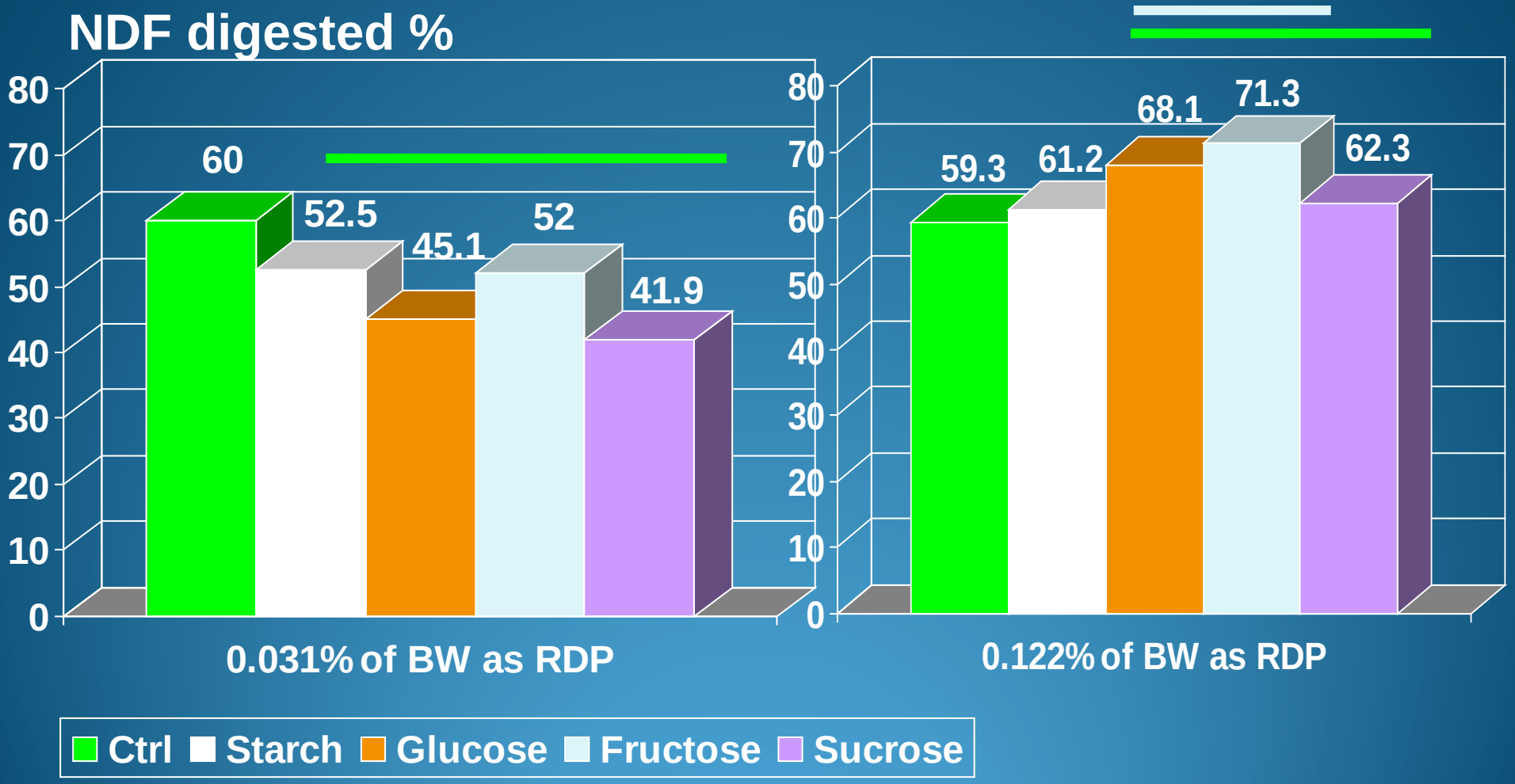
- Make more microbes
- Faster fermentation >> more lactic acid
- Greater ruminal digestion



Sugars vs Starch?

Counotte and Prins, 1981
Branco et al., 1999

NFC & RDP and NDF Digestibility



NFC at 0.3% of BW

Heldt et al., 1999
Piwonka and Firkins, 1996

Effect on Milk Fat

Biohydrogenation

- Some glucose-utilizing microbes biohydrogenate fat
- *Trans*-10 isomer of C18:1 associated with milk fat depression

	Low sugar	High Sugar
DM Intake,lb	37.9	40.3
Rumen pH	6.06	6.21
Butyrate, mol%	12.2	12.8
Milk, lb	73.4	75.8
Fat lb/%	2.98 / 4.21	3.17 / 4.27
C18:1 trans % of milk fatty acids	3.14	2.72

In the first 4 weeks of lactation, substituted 4.7% sucrose for cracked corn grain. Barley silage, alfalfa hay. ~20% CP, 50% forage, 33-34% NDF, 20.6 and 18.5% starch.

McKain et al., 2010
Penner and Oba, 2009

Effect on Milk Fat

Butyrate

- More butyrate from sugars than starch
- Increase milk fat?
- Butyrate = 30% of the fatty acids in the *sn*-3 position on milk triglycerides

Molar % of Butyrate	Starch/Ctrl	Sucrose/Lactose
Strobel & Russell, 1986	8.2	9.5
DeFrain et al., 2004	13.9	16.3
Charbonneau et al., 2006	8.2	11.4
Hall et al., 2010	9.5	12

Rook and Balch, 1961
Rook et al., 1965
Jensen, 2002

Sucrose vs. Starch

	Sucrose:Starch (% Diet DM)			
	0:7.5	2.5:5.0	5.0:2.5	7.5:0
DM intake[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
Milk/DMI[L]	1.60	1.58	1.54	1.52
MN/IN[L]	0.31	0.29	0.29	0.30
FPCM/DMI	1.64	1.63	1.66	1.64

L P=<0.05, L P < 0.10

Alfalfa Silage: 40.0%, Corn Silage: 20.0%, HMSC: 20.5%

Broderick et al., 2002

Whey Permeate vs. Starch

	Ctrl	Gr. Corn	GC+St	GC+W
DM intake[T]	50.0	53.6	53.8	56.7
Milk, lb[T]	75.0	82.4	82.9	78.9
Fat, lb[%]	2.82	2.89	2.82	3.02
Protein, lb[T]	2.38	2.72	2.72	2.59
Rumen pH	6.50	6.41	6.41	6.51
NEL Milk/DMI%	67.75	70.38	67.88	70.13
MN/IN%[T]	24.8	27.9	28.4	24.9

T *P*=<0.05,

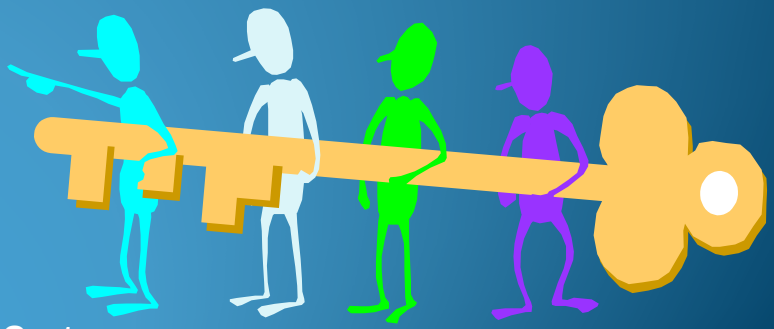
Alfalfa Silage: 45%, Gr. Corn: 35-47%, WP or St: 11%

Charbonneau et al. 2006

How much sugar can we feed?

Taking This To The Farm

- All sugars are not the same: lactose vs…
- Protein affects how microbes handle it
- Protein production: sugars vs. starch
- May increase fat test… but when?
- Less negative effect on rumen pH
- Not “fast starch”



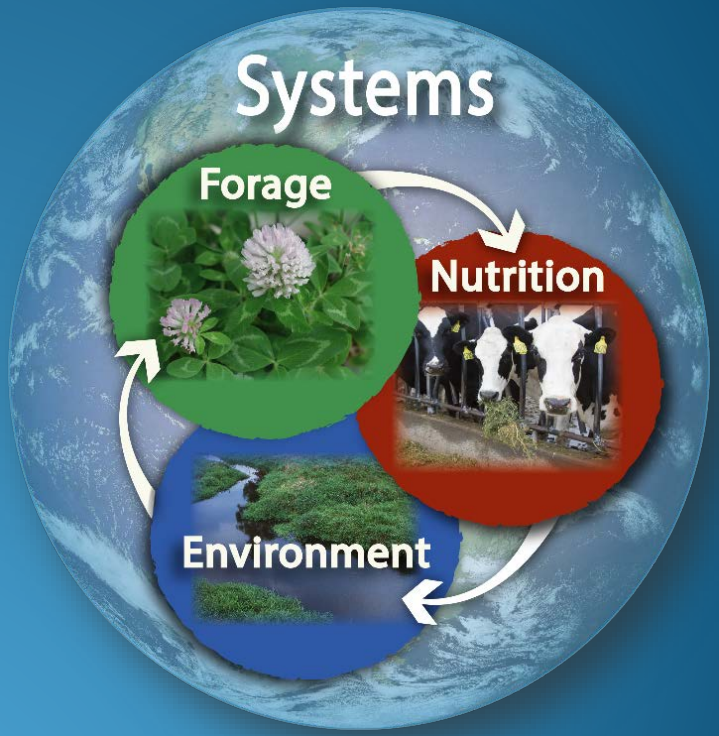
Questions……

- How much of what sugars can we feed?
- What's optimal in what rations?
- How do sugar and fat feeding interact?
- How does sugar affect fat test?
- Feeding RDP & sugars?
- Sugars are in feeds….

USDA

United States Department of Agriculture

Questions?



U. S. Dairy Forage Research Center

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