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How can Dietary Formulation and Management Prevent SARA?

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Presentation Outline

Ruminal Acidosis – What is it?

Defining SARA

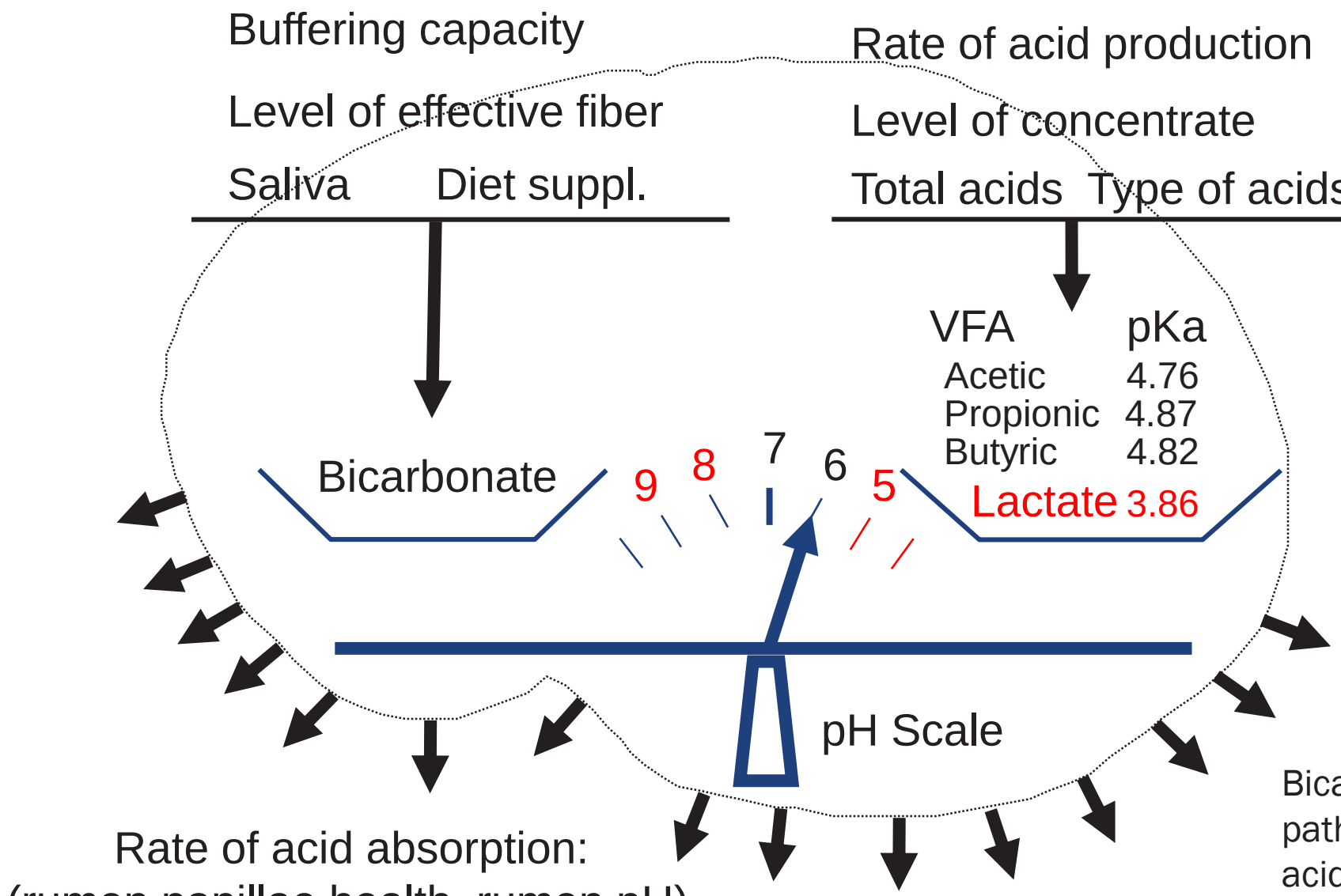
Dietary Starch vs. Fiber

Non-dietary Contributions

Summary Recommendations

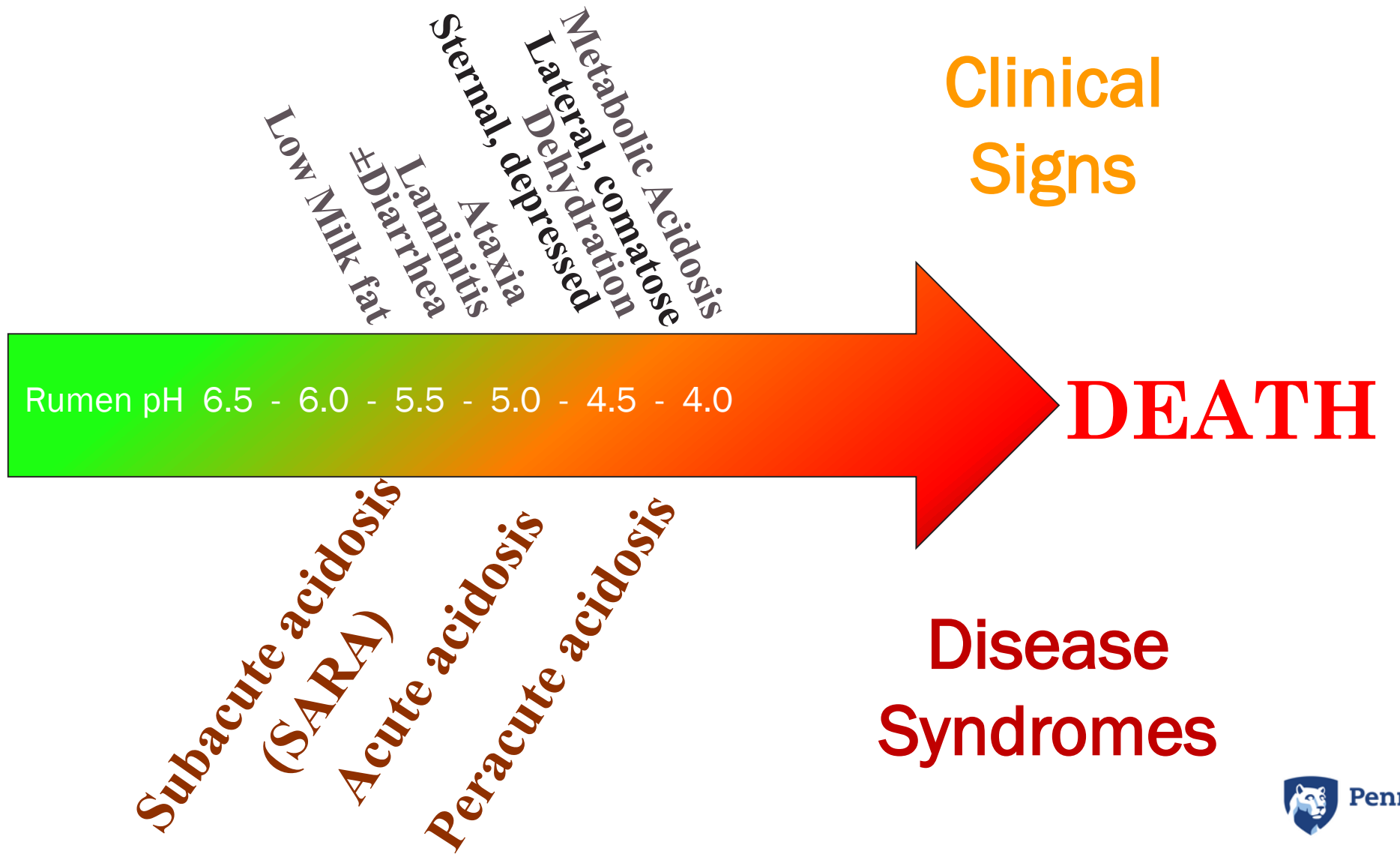
What is Ruminal Acidosis?

- Ruminal acidosis is a pathologic accumulation of acid in the rumen as a result of:
  - Excessive fermentable carbohydrate intake (acid production)
  - Inadequate or overwhelmed buffering system
- Results in a drop in ruminal pH that will adversely affect microbial populations altering fermentation patterns
  - Reduced cellulolytic activity (< pH 6.0)
  - Reduced proteolytic activity
  - Reduce lactate utilizer microbes



Bicarb-independent pathways tend to minimize acidosis – genetic or dietary? *(Penner et al., 2009)*

Rumen pH Continuum



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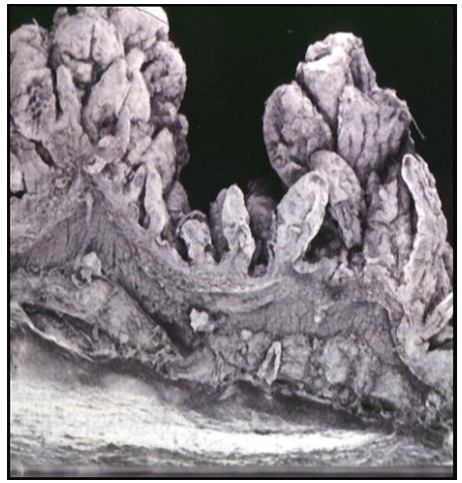
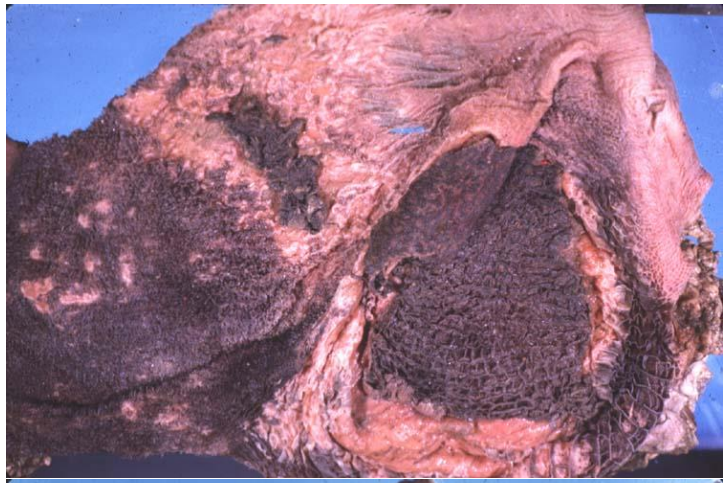
Acidosis Disease Consequences

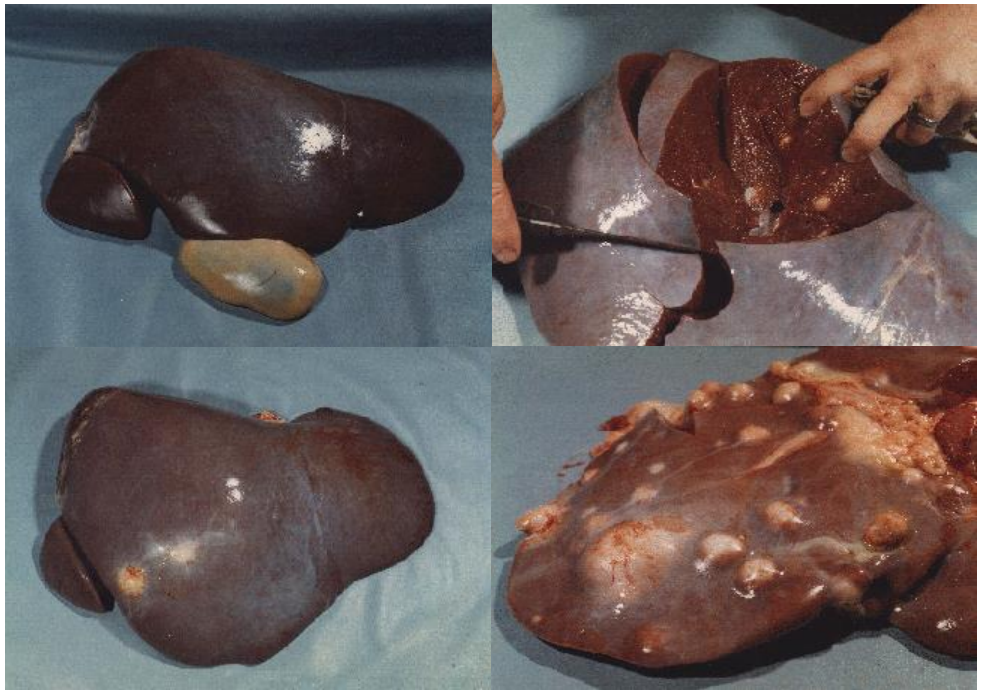
Normal

Abnormal





Rumen wall ulcers, mucosal scaring, mycotic ruminitis, reduced VFA absorption

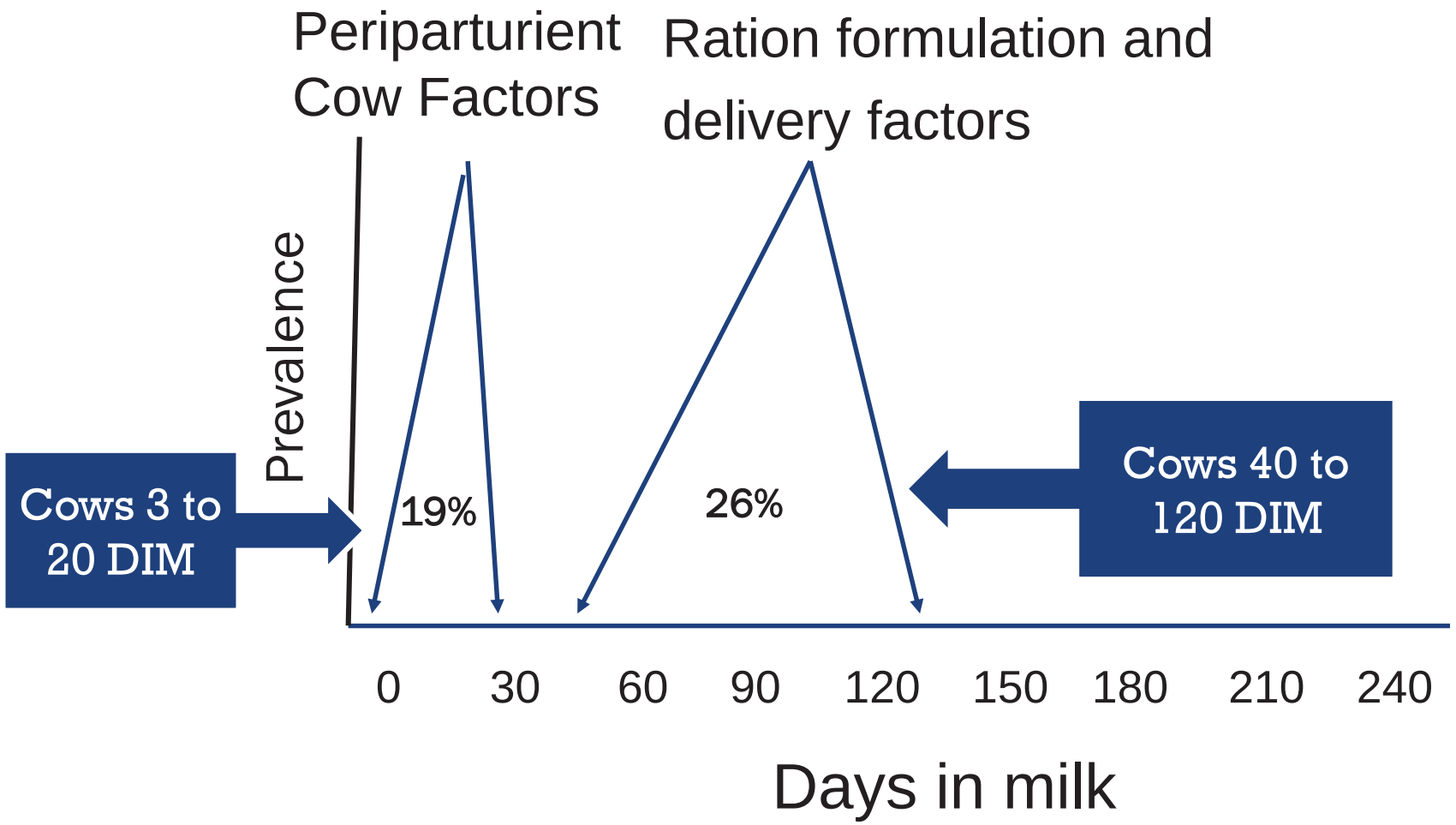


Bacterial translocation across the rumen wall seeding the liver, inducing abscess formation

Subacute Ruminal Acidosis (SARA)

- More insidious to chronic in nature
  - Rumen pH between 6.0 – 5.5 (varies with studies)
  - Related more to total time below threshold pH
- Clinical signs
  - Cyclic intake, “slug feeding” behavior, pica (eating soil/bedding)
  - Variable manure scores, ± Diarrhea
  - Altered rumen function/fermentation
  - Milk fat depression, response to buffers
  - Body condition, weight loss
  - Secondary epistaxis, pneumonia, lameness (?)

Groups at Risk for SARA



Oetzel, 2014

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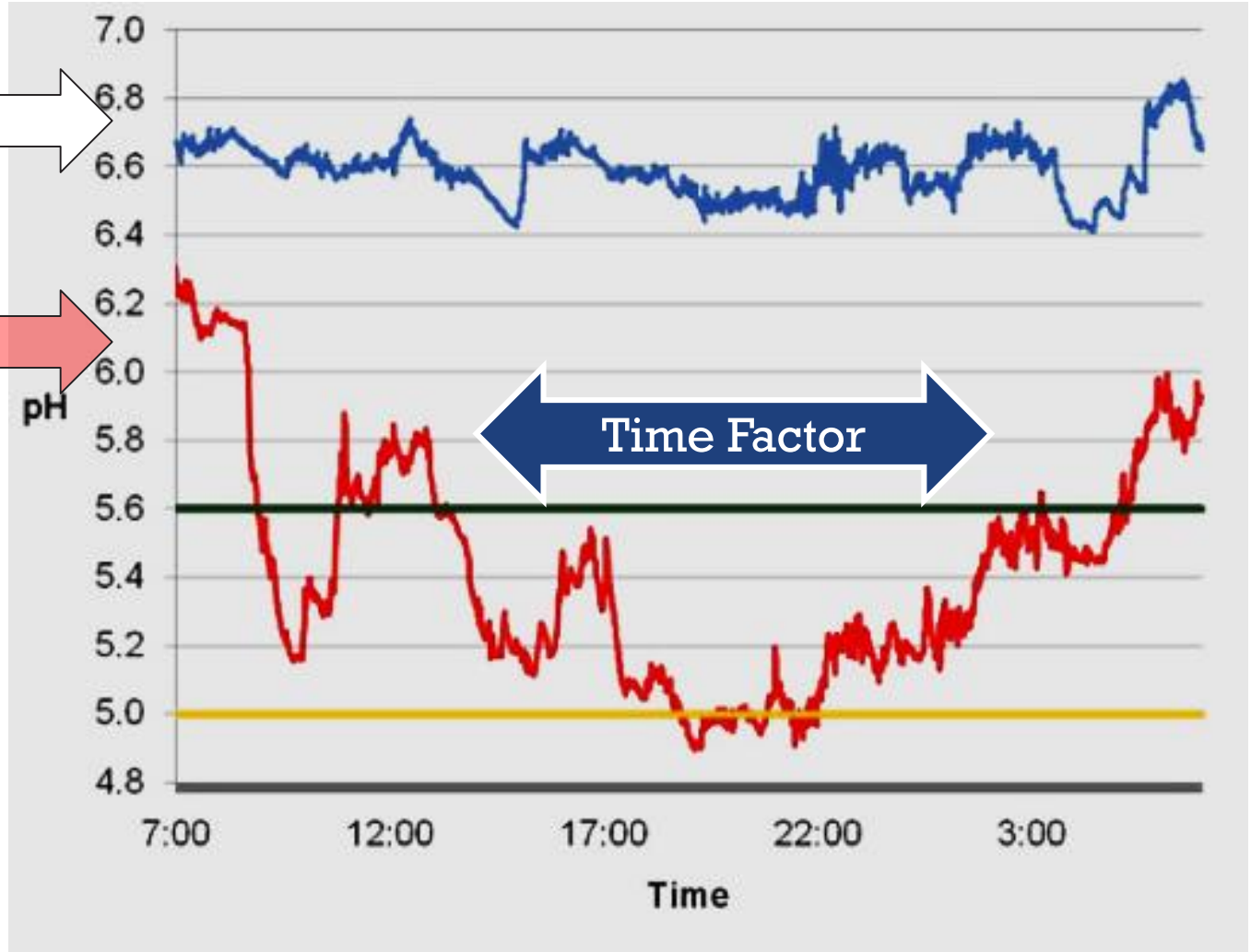
SARA – Rumen pH

High Forage Diet

High Grain Diet



SARA Threshold

Clinical Acidosis

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SARA Induction Study

		Control	SARA
Diet	TMR[1], %	100	75
	Grain pellet[2], %	0	25
	$NaHCO_3$, g/d	100	0
	Forage:Concen-trate ratio	70:30	60:40
Days of Tx		5	5
# of cows		4	4
Methods	pH measured every second and averaged per minute		

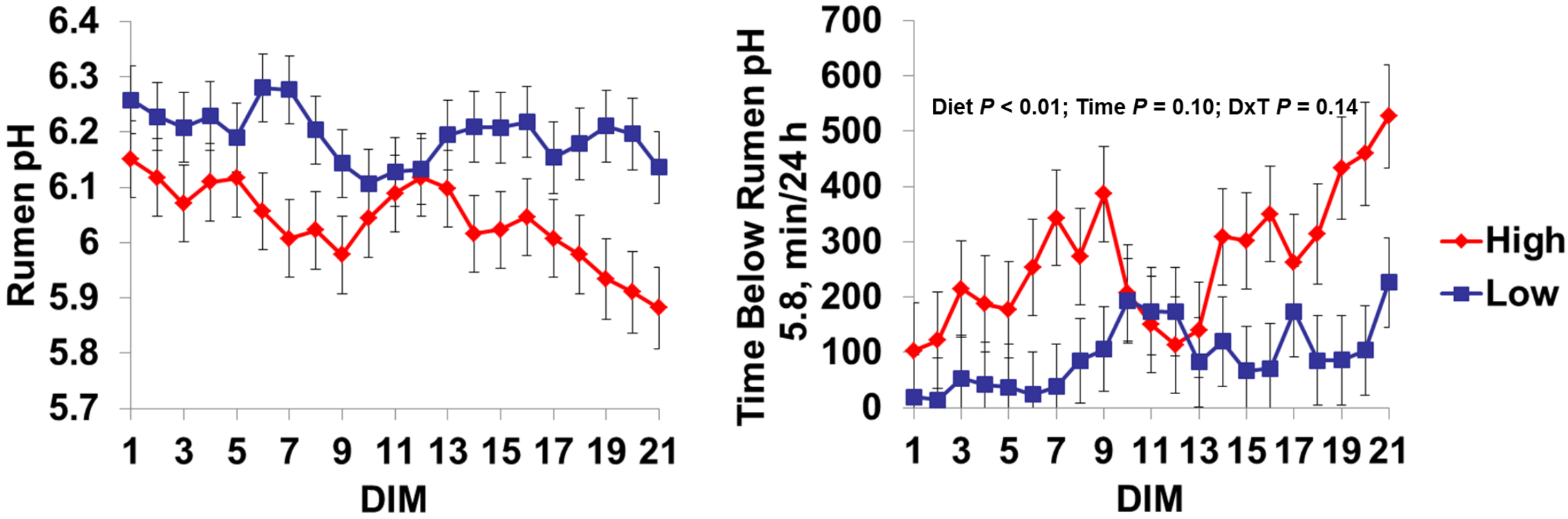
[1]TMR: corn silage 18.1%, mixed haylage 22.3%, mixed hay 6.6%, High moisture corn 28.4%, protein and supplement mix 24.7%

[2]1/2 ground wheat and 1/2 ground barley for 5 days

Measure	Parameter	Control	SARA	P
Rumen	Rumen pH	6.36	5.72	.05
	Time below 6.0, h/d	2.6	15.6	.05
	Time below 5.6, h/d	0.26	9.9	.05
48 hr In Vitro	Corn silage	56.1	44.8	.05
NDF degradability	Grass hay	51.3	36.9	.05
	Legume hay	49.0	35.8	.05
Production	DMI, kg/d	17.8	11.4	.05
	Milk, kg/d	31.1	31.5	NS
	Milk fat, %	3.43	3.03	NS
	Milk protein, %	3.11	3.03	NS

Krajcarski-Hunt, et al., JDS 2002

Rumen pH and time below pH 5.8 for cows fed high and low starch fresh diets



Lower starch diet (21% starch, 37% NDF)
Higher starch diet (27% starch, 32% NDF)

Williams et al., 2015. J. Dairy Sci. 98(Suppl. 1):741-742.

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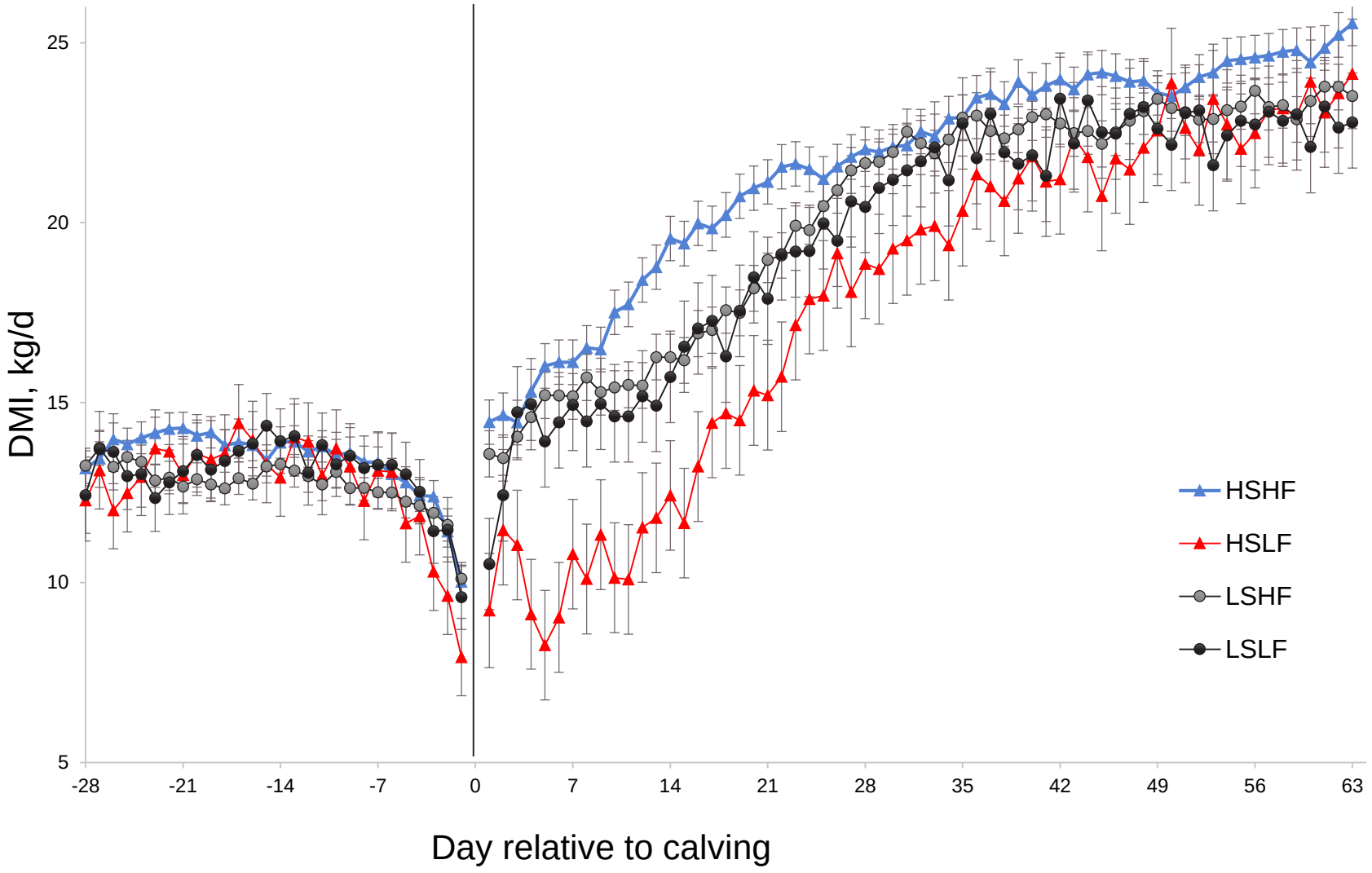

Dietary Starch – Fiber Interaction

HS: 26.2-28.3%
LS: 21-22%
HF: 34.3-36.9%
LF: 26.4-31.5%

McCarthy et al., 2015. Proceedings Cornell Nutrition Conference

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The Dietary Balancing Act of Rumen pH

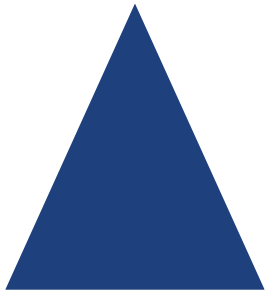
Physically Effective fiber

Chewing →

Buffer Production

Rumen Fermentable Carbohydrates

Acid production



Environment

Feeding Management

Dietary Formulation

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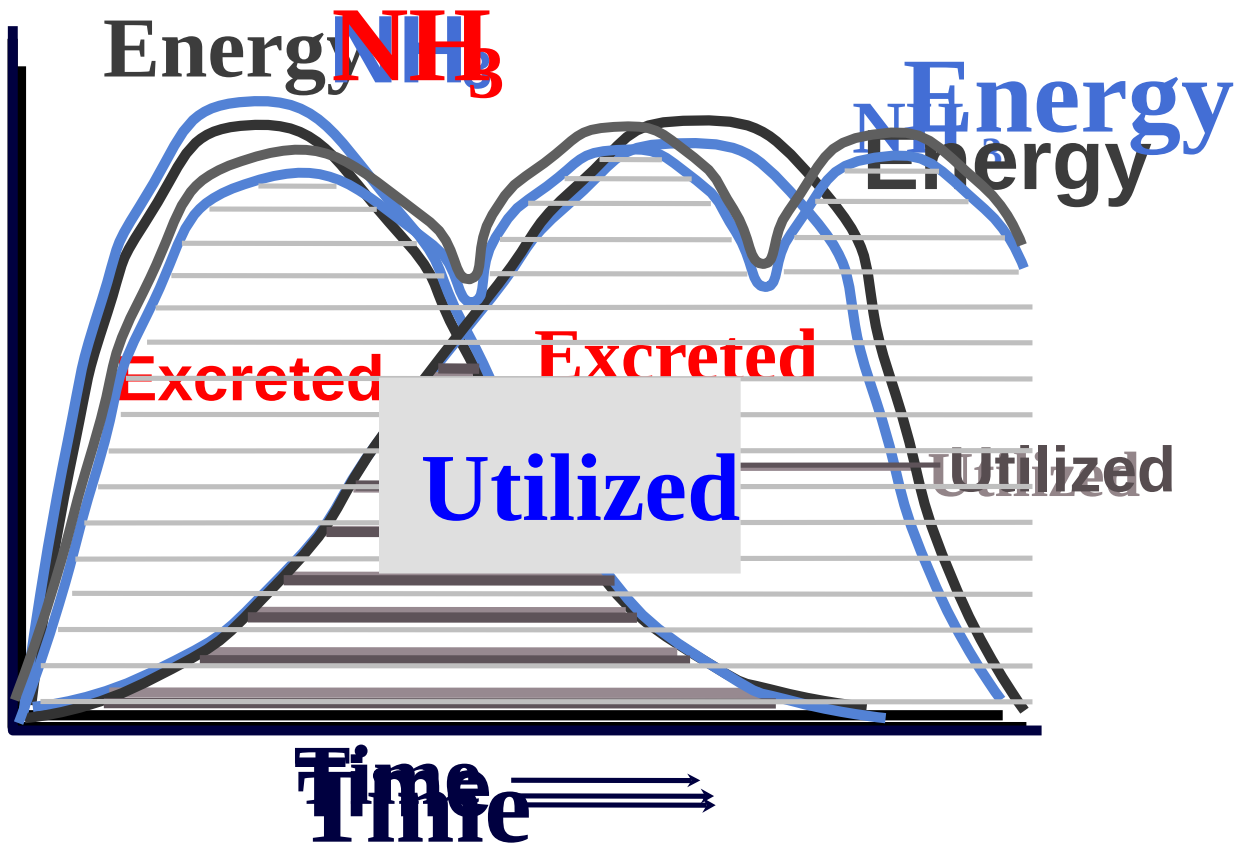
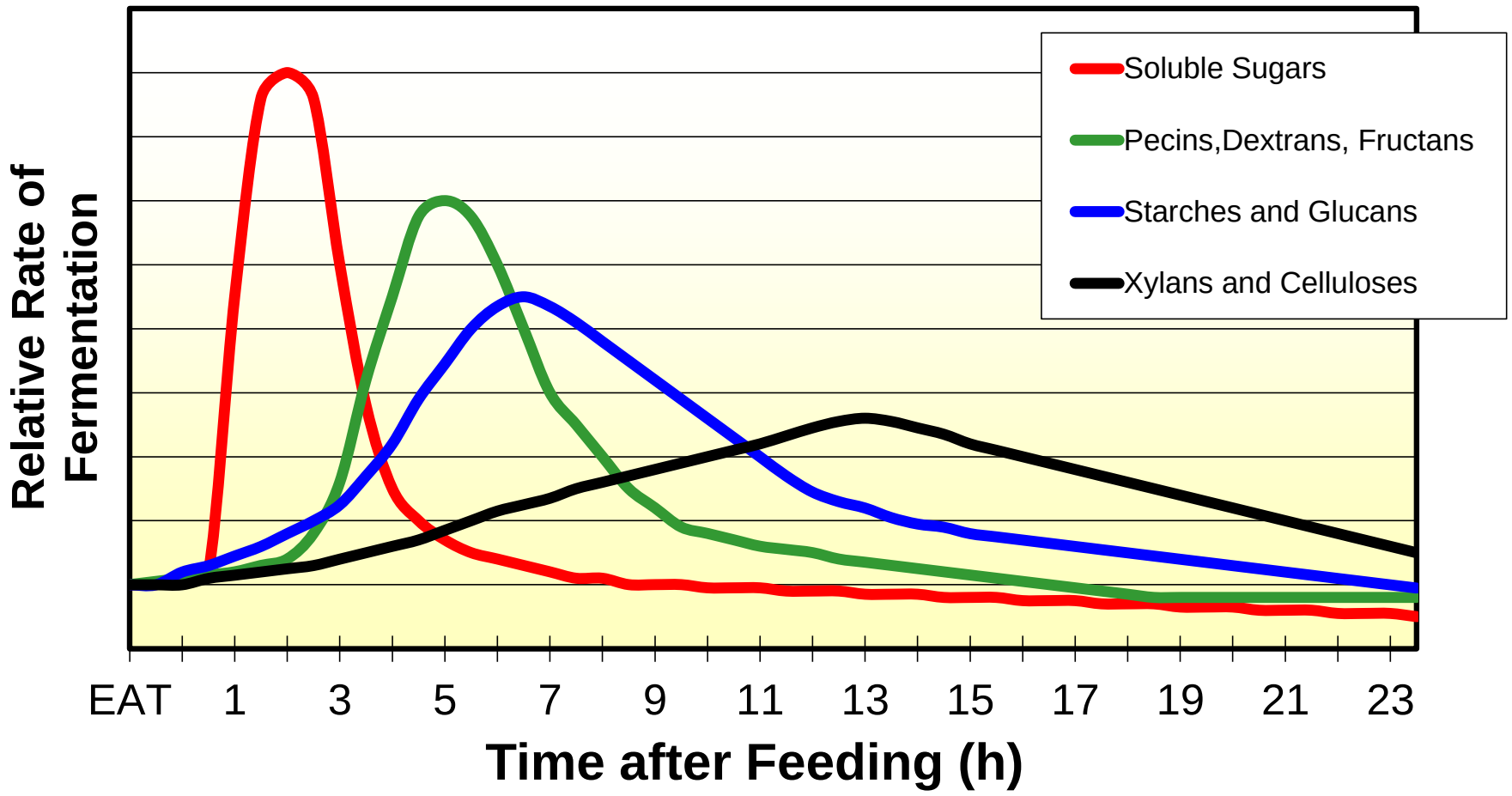
Goals for Formulating Carbohydrates in Diets

- Provide low-fill, highly fermentable diets
- Maintain adequate ruminal pH
- Consistent fermentation over time



Ruminal Feed Carbohydrate Fermentation Profile



Adapted from Johnson, R.R., 1976

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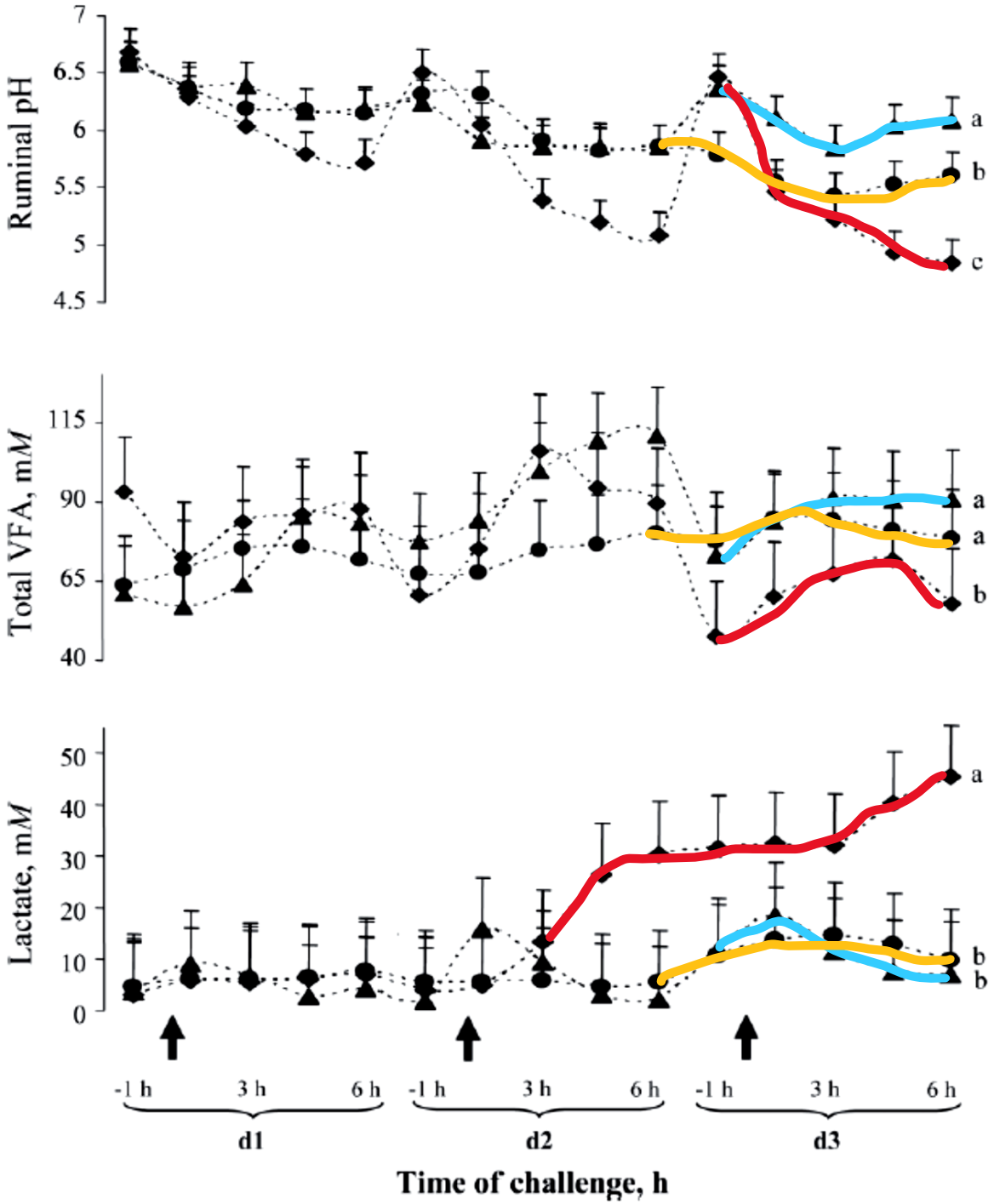

Effect of Grain Source

- Basal diet was grassland hay and wheat-based concentrate with 3% molasses in 4:1 ratio
- Sheep dosed with wheat (♦), corn (●), or beet pulp (▲) at 1.2% of body weight through rumen fistula
- Wheat induced lactic acidosis
- Corn induced SARA
- Beet pulp maintained rumen pH within normal limits

Lettat et al., J Anim Sci 2010

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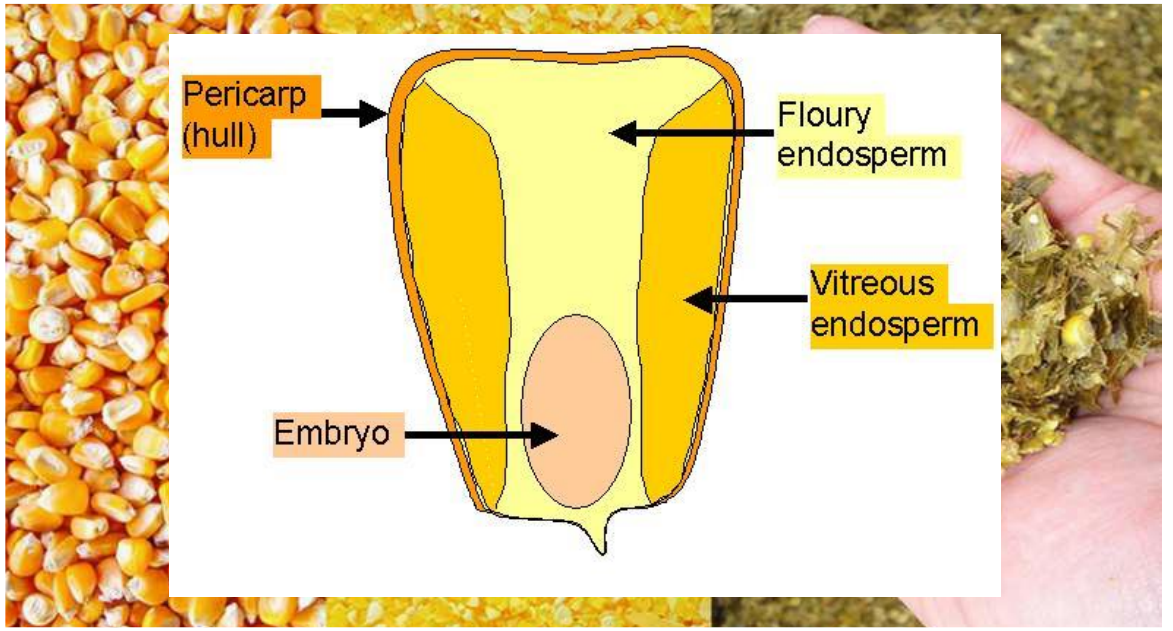
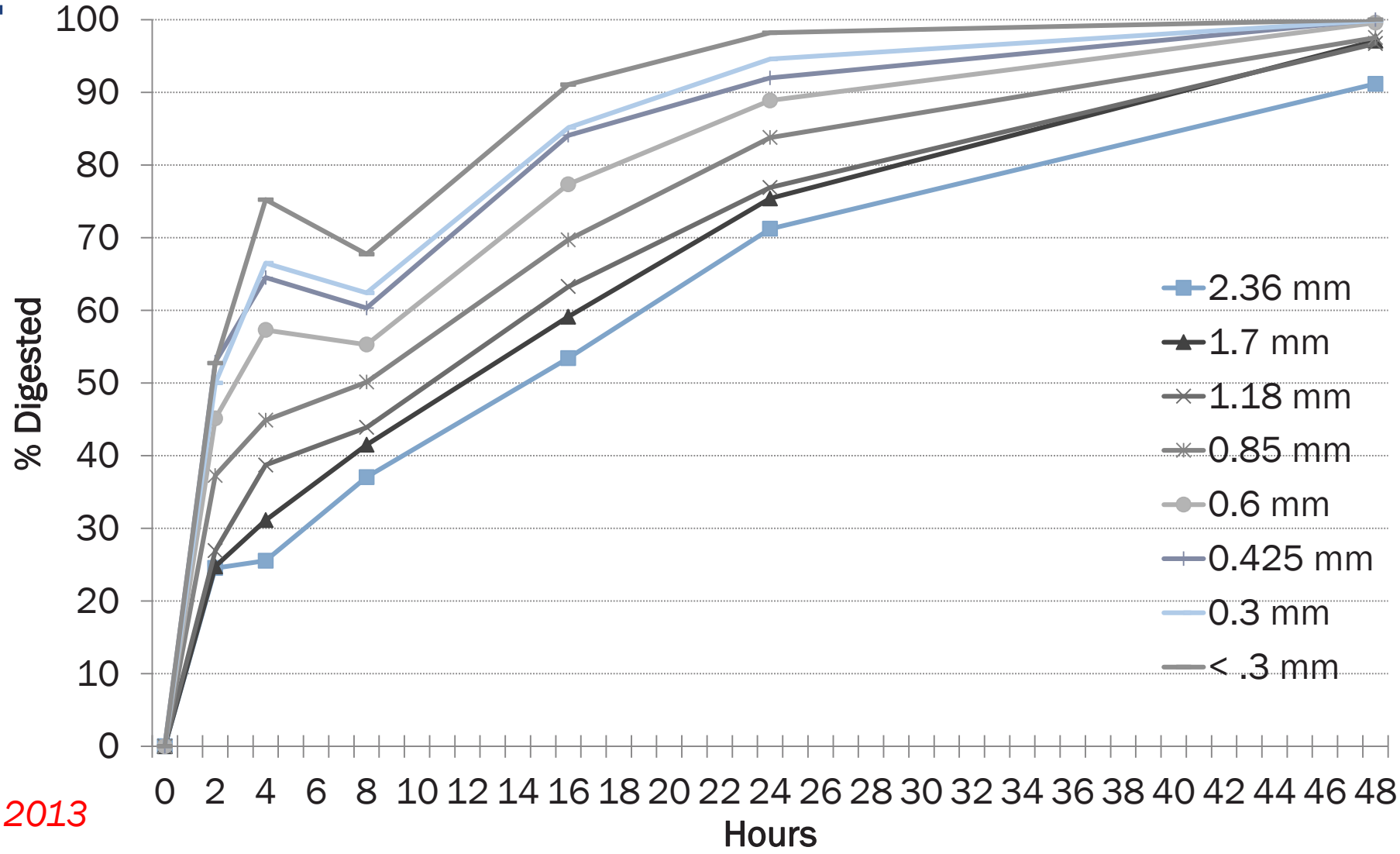
Factors affecting ruminal starch digestibility

- Type of grain: wheat>>barley>>oats>>corn
- DM of grain – moisture increases fermentability
- Ensiling / ensiling time
- Fineness of grind / flake density
- Endosperm type
- Fermentable starch intake
- Rumen consistency (passage)
- Dry matter intake (passage)



Starch Digestion by Particle Size Over Time



CVAS, 2013

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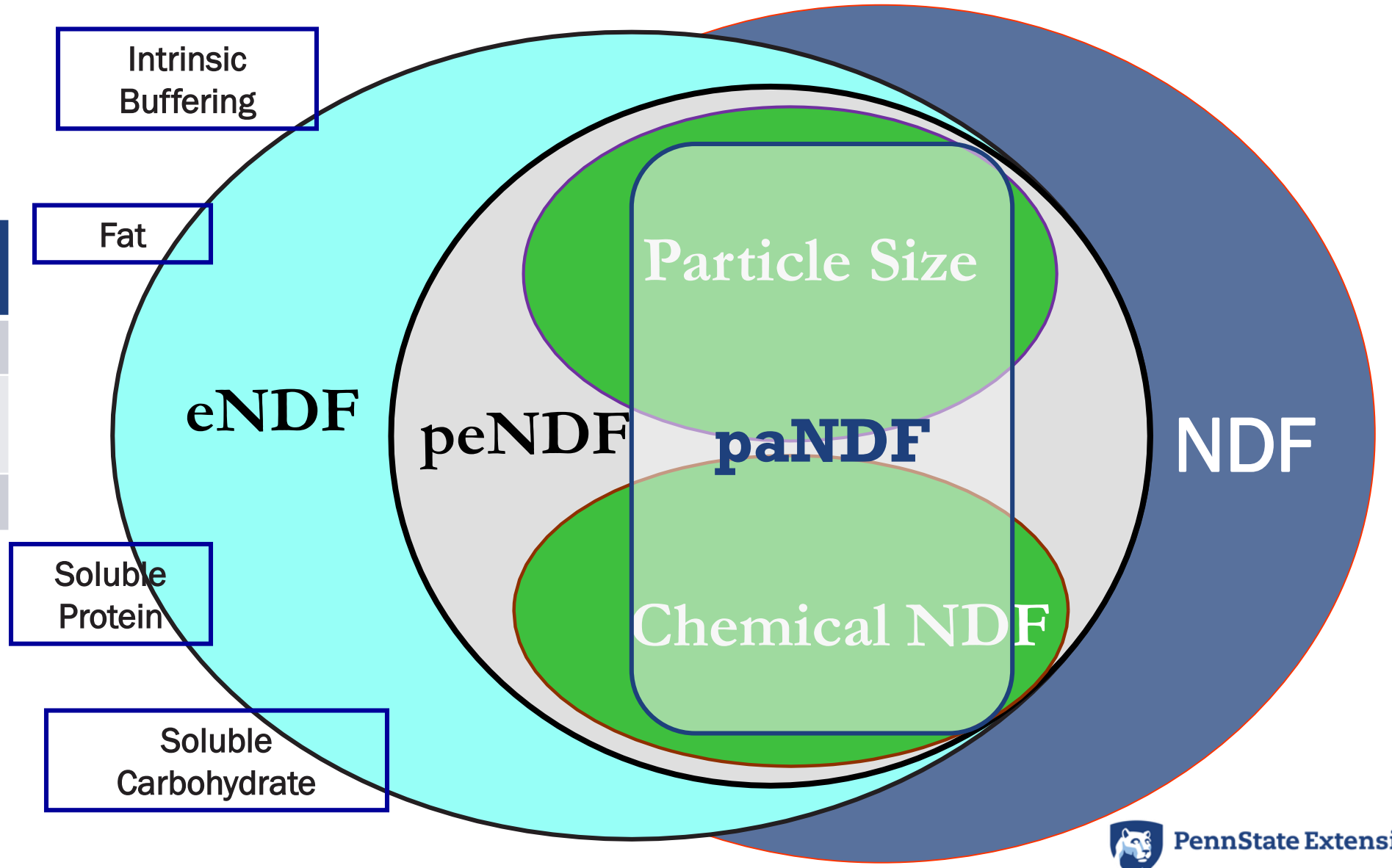
Defining Dietary Fiber

NDF Fraction	Response
eNDF	Milk fat %
peNDF	Chewing activity
paNDF	Rumen health



Ration Formulation for Dietary Fiber

- Balance rations to meet total NDF, peNDF (~21% DM) requirement
- Forage fiber intake: 1% BW, 75% of NDF
- If poor quality fiber, substitute fast fiber sources
  - Citrus pulp, beet pulp, soy hulls, wheat midds
- If lack of peNDF then use small amounts of
  - Grass hay, whole cottonseed, straw
- If good quality fiber formulate toward maximum peNDF and NDF capacity, watching DMI and animal performance carefully

Measuring pef Factor on Farm

Screen	Pore Size in (mm)	Particle Size in (mm)
Upper Sieve	**0.75 (19.1)**	**> 0.75 (> 19.1)**
Middle Sieve	**0.31 (7.9)**	**0.31 to 0.75 (7.9 to 19.1)**
Lower Sieve[1]	**0.16 (4)**	**0.16 to 0.31 (4.0 to 7.0)**
Lower Sieve[2]	**0.05 (1.18)**	**0.07 to 0.31 (1.8 to 7.9)**
Bottom Pan	**None**	**(< 4.0[1] or 1.8[2])**

[1]Newest lower sieve in 2013 model
[2]Previous lower sieve in 2002 model

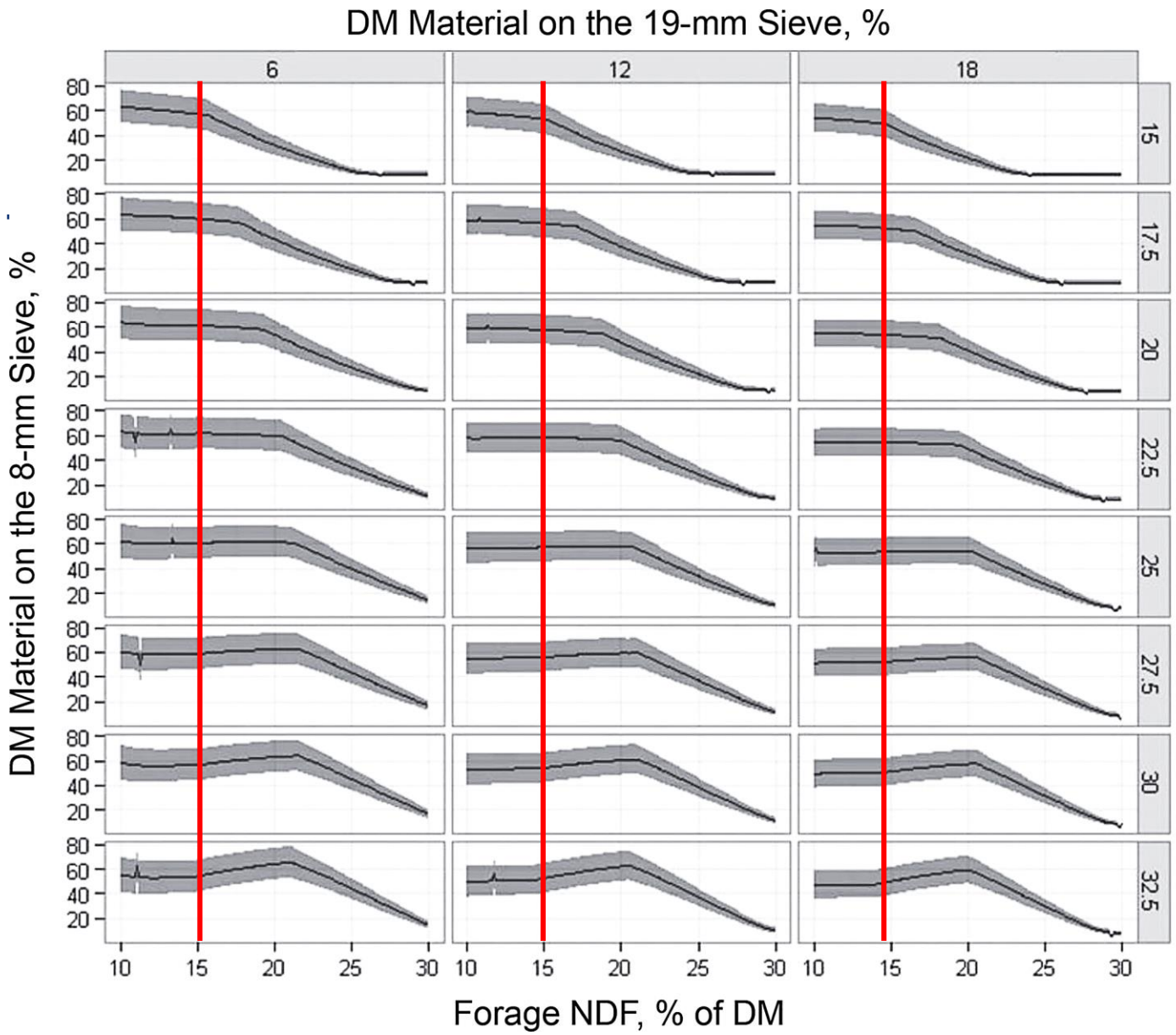
The Penn State Particle Separator (PSPS) has been used to evaluate “effective” fiber in forages or a TMR. This process is not the same as defined by Mertens as the material is wet and moves horizontally relative to the sieves.

Recent work with the PSPS has developed a new third sieve (4 mm pore) that when used in combination with the 19.1 and 7.9 mm sieves can accurately predict the “physical effectiveness” of fiber in the forage. This is the pef factor to multiply by NDF content to determine peNDF.

Physically Adjusted NDF (paNDF)

- Newest method of assessing role of fiber in ruminant diet
  - Interaction with starch content
  - Addresses fiber fragility (ADF:NDF ratio)
- Purpose is to estimate diet fiber adequacy to maintain ruminal conditions (good fiber digestion)
  - Use of particle size measures with PSPS (19 and 7.9 mm sieves)
  - Modeling process looking at many different dietary parameters
  - Addresses both physical and chemical factors
  - peNDF assumes NDF is uniformly distributed overall all particles irrespective of size

White et al., JDS 2017a.b



Effects of Starch

Modeling process addressing dietary starch, amount of material retained on the 19-mm sieve (DM) and forage NDF content and predicted amount of material (DM) needed to be retained on the 8-mm sieve to maintain rumen pH above 6.1.

White et al., JDS 2017b

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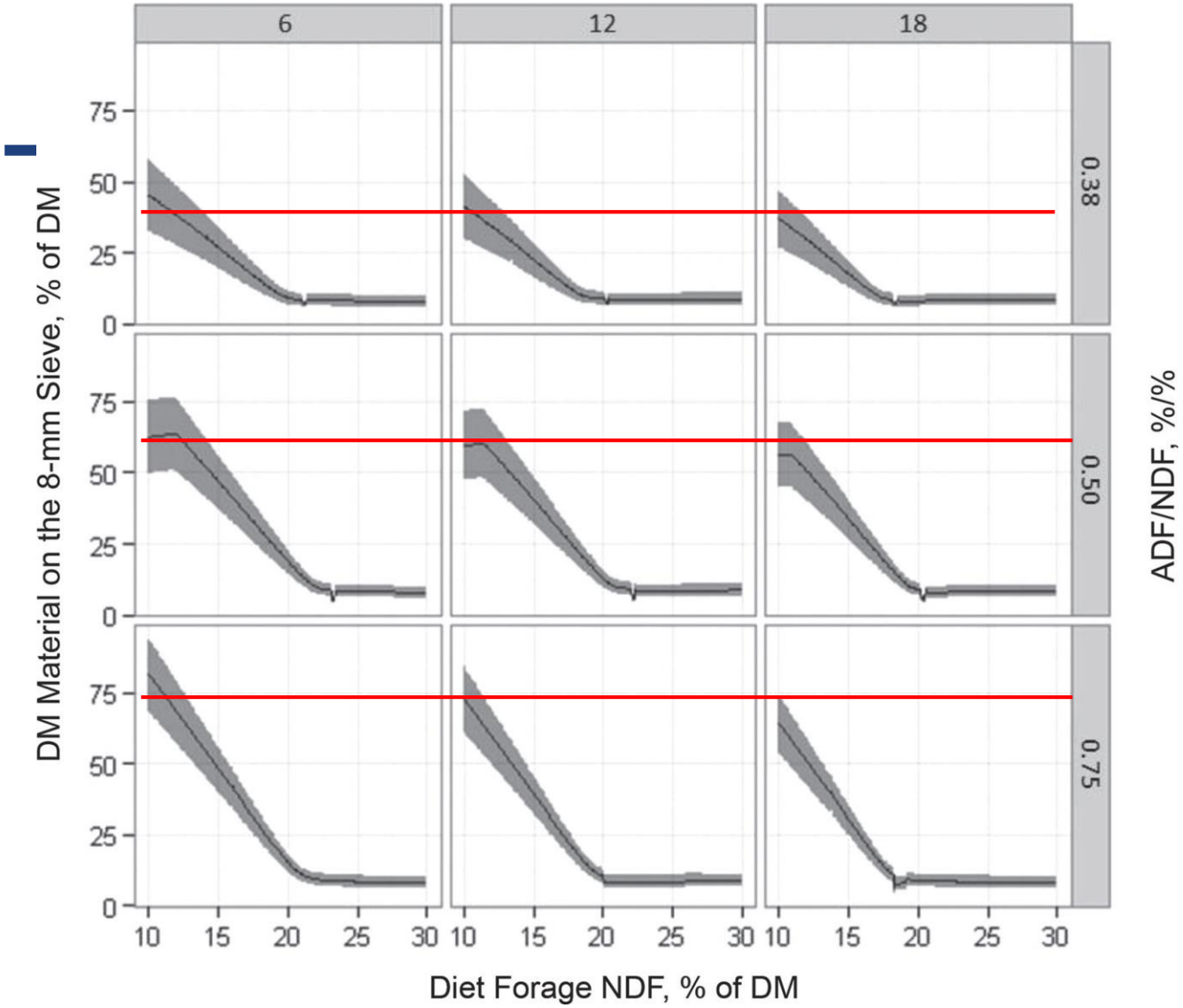
Effects of Forage Fragility



White et al., JDS 2017b

Forage fragility is defined as the rate at which plant tissues within a feed particle are further fragmented into small particles. Ratio of ADF:NDF can be used as an indirect measure of forage fragility.

Legumes have higher ADF:NDF ratio and are more fragile than grasses. Legumes are more easily fragmented and thus less likely to stimulate rumination and salivary buffer production.

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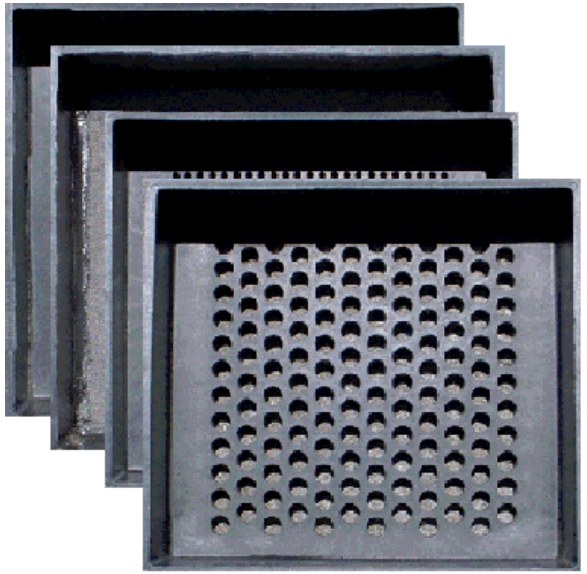
Physically Adjusted NDF (paNDF)

Inputs:

- Diet characteristics, % of dry matter
  - Forage NDF, total forage, wet forage
  - Cottonseed: whole, hulls, meal
  - NDF, ADF, CP, starch
- Body weight
- Penn State Particle Separator (PSPS)
  - % of TMR DM on 19 mm sieve (1.18 optional)
- Output predictions:
  - Recommended % of TMR DM on 8 mm sieve
  - Minutes per day of rumination



MUNCH, an effective fiber calculator for dairy cows

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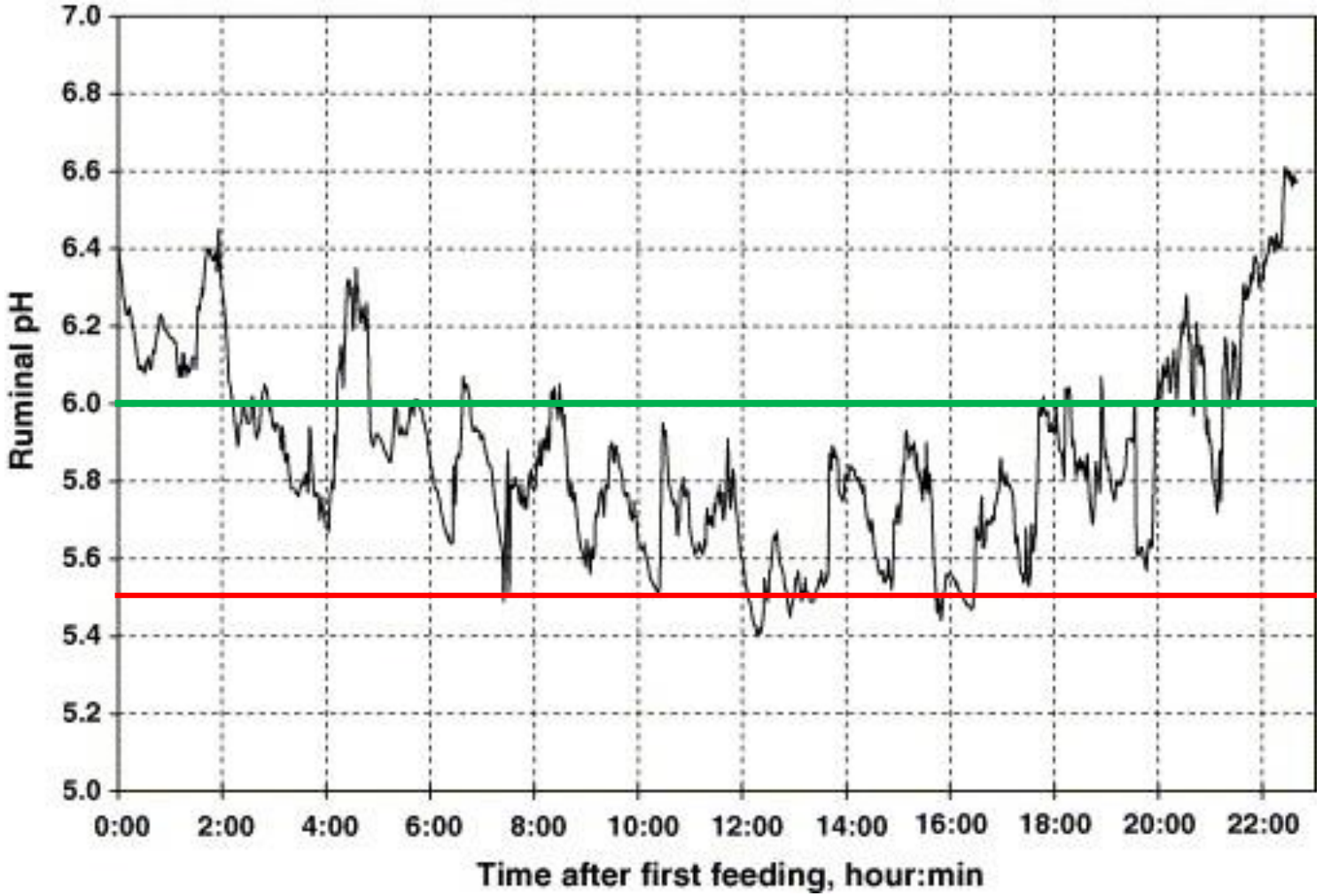
Non-Nutritional Factors



- Feed sorting
- Not pushing up feed
- Too small particle size
- Over mixing TMR
- Inadequate bunk space
- Empty bunks for > 3 hrs

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TMR Particle Size Variation

- Over filling mixer wagon
- Under mixing
- Under processing of hay
- Dull blades and worn kicker plates
- Improper loading of liquids
- Improper ingredient loading sequence
- Low inclusion products not mixed

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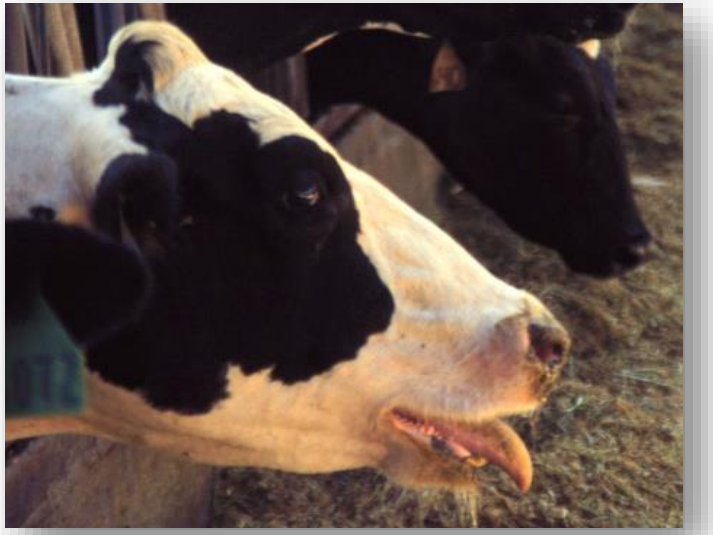
Heat Stress: Feed Intake/Digestion

- Increases rumen retention time: greater fermentability of feeds
- Reduced rumen contractions
- Reduced rumen buffering
  - Saliva losses
  - Decreased rumination
- Increased feed sorting
- Increased feed refusals
- Reduced dry matter intake



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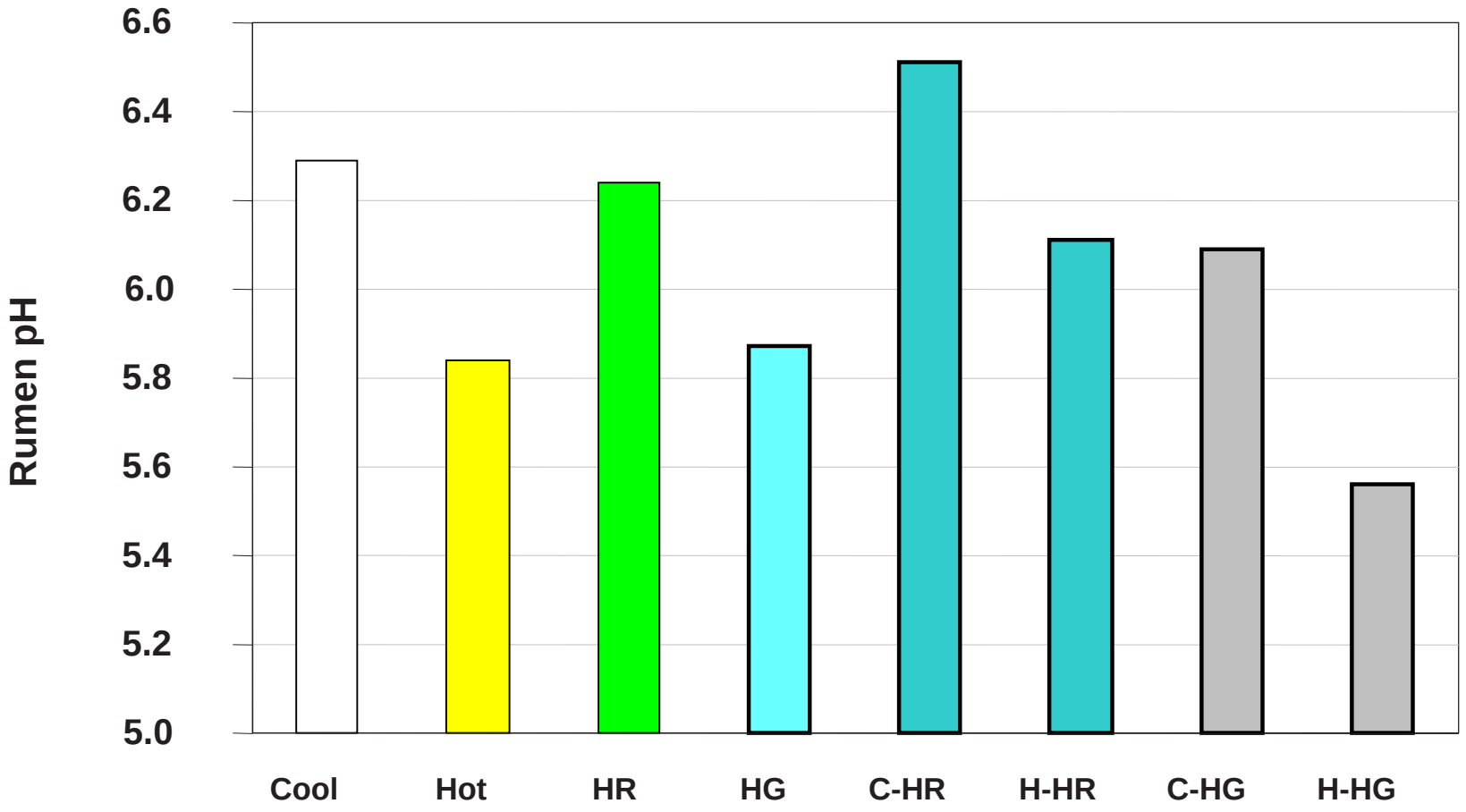
Ruminal pH Response to Heat Stress



Cool = 18.3C (65F),

Hot = 29.4C (85F)

HR = high roughage,

HG = high grain

Mishra, et al. 1970

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Acidosis Prevention

- Diet formulation
  - Fiber content, % forage, peNDF, paNDF
  - Starch content, degradability
- Method of feeding – conventional vs. TMR
- Gradual adaptation to high starch diets (?)
- Dietary buffers – bicarbonate, magnesium oxide
- Rumen modifiers – ionophores, yeast

Basic Recommendations

Minimum fNDF	Minimum Total NDF	Maximum Starch
19	25	30
18	27	28
17	29	26
16	31	24
15	33	22

NRC, 2001

Forage NDF, % of diet DM

17% ← → 28%

<< Higher dry matter intake
Faster ruminal clearance rate of forage NDF >>
Finely chopped forages >>
Higher diet starch, lower NFFS concentrations >>
Higher diet starch degradability >>
<< Supplemental buffers
Grain fed separately, infrequently >>
Limited feed bunk space, slug feeding >>
Greater daily variation in diet composition >>

M. Allen, 2014

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Dietary Starch Recommendations

Group	Starch Content, %DM	Fermentable Starch, % Starch 7-hr	Fermentable Starch, %DM
Close-up Dry Cows	16 – 18	80	12.8 – 14.4
Early Lactation	25 – 27	74	18.5 – 20.0
Peak Lactation	26 – 28	83	21.6 – 23.2
Mid-Lactation	24 – 26	78	18.7 – 20.3
Late Lactation	23 – 25	76	17.5 – 19.0

Sniffen and Ward, 2014

Carbohydrate Guidelines for Early Lactation Cow

Nutrient	kg/day	% DM	Min, % DM	Max, % DM
DM	24.5			
Total NDF	7.4	30	28	34
Fermentable NDF	2.6	10.5	10.5	12
Sugar	1.2	5	4	8
Starch	6.1	25	21	27
Fermentable starch	5.1	21	15	22
Soluble fiber	1.5	6	4	8
Ferm. soluble fiber	1.2	5	3	7
NFC (no silage acids)	8.7	36	29	43

Sniffen and Hoover, 2004

Predicted TMR Particle Distribution

TMR Composition, % DM basis				Maintenance of pH 6.0 % TMR on 19-mm Sieve			Maintenance of pH 6.1 % TMR on 19-mm Sieve		
				3	9	15	3	9	15
Forage	Starch	NDF	fNDF	Minimum % on 8-mm sieve			Minimum % on 8-mm sieve		
40	30	28	19	26	17	14	53	42	33
40	25	30	17	32	23	17	50	40	31
40	20	33	14	30	21	15	39	29	21
50	30	28	22	12	10	10	23	14	12
50	25	30	18	24	15	12	46	36	27
50	20	33	17				32	22	16
60	30	28	22				51	41	31
60	25	30	22				38	28	19

NASEM, Dairy Cattle Nutrient Requirements 2021 Table 5-2

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Summary Considerations

Risk of SARA[1]	Increased	Marginal	Low
NDF[2]	25	28 – 32	35
Forage NDF	16	20 – 25	27
peNDF[3]	18	21 – 23	25
Ruminal pH[4]	< 5.6	5.8 – 32	> 6.4
NFC[5]	45	42 – 35	30
NSC[6]	35	32 – 28	25

Forage considerations				
Dietary Adjustments	longer	←	Forage particle size	→ shorter
	slower	←	Rate of fiber digestion	→ faster
Concentrate considerations				
	slower	←	Ruminal starch digestiblity	→ faster
	more	←	High fiber byproducts[7]	→ less
	more	←	Buffers	→ less
Management and environmental considerations				
Environmental Adjustments	minimal	←	Heat stress, stall and bunk over-crowding	→ severe
	excellent	←	stall comfort	→ poor
	TMR fed	←	feeding system	→ grain fed
	consistently accurate	←	forage DM	→ infrequently variable accuracy
	entire height or face of silo	←	silage obtained for a load of feed	→ regions within the silo

Stone, JDS 2004

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Key Points

- SARA is a common problem in intensively managed confinement and grazing dairy herds
- Two groups of cows at special risk are fresh cows and high intake cows associated with peak milk yield
- Dietary prevention is based on appropriate balancing of fermentable carbohydrate load and physically effective fiber to maintain rumen health (ie., pH)
- A cow's response to dietary composition is influenced by many interactive factors preventing well-defined dietary recommendations
- Feeding management and environmental factors further influence the cow's response to a given diet

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Thank You for Your Attention!

Questions?

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