Managing metabolism and immune function of transition cows

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Transition period goals

- High milk production
- Maintain/minimize loss of BCS
- Low incidence of metabolic disorders
- Minimize loss of immunocompetence
- Control/decrease days to first ovulation and maintain/enhance fertility
- Low stillborn rate and healthy calves

- Our high performing dairies achieve ALL of these

We've learned and implemented a lot in the last 10 to 15 years

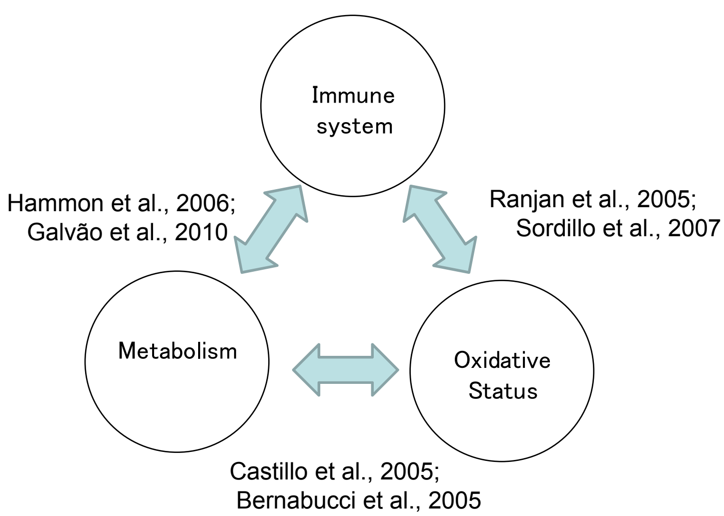
- Nutritional strategies
  - DCAD diets
  - Controlled energy diets
  - Increasing MP supply prepartum and balancing AA
  - Fresh cow diets?
- Importance of nonnutritional factors
  - Stocking density
  - Grouping strategies/moves
  - Segregating cows and heifers during transition period
  - Heat abatement
- Enhanced on-farm monitoring (hyperketonemia)
- Yet still much opportunity out there!!

Shift in mindset from the transition cow as a disease opportunity to the transition cow as a production and reproduction opportunity!!!

Physiological changes during the transition period and early lactation in dairy cows

- Tremendously increased nutrient and energy demands to support milk production regulated by homeorhetic adaptations (Bauman and Currie, 1980; Bell, 1995)
- Period of reduced immunological capacity during the periparturient period (Goff and Horst, 1997)
- Increased production of reactive oxygen species during the periparturient period (Sordillo and Aiken, 2009)

These systems are not independent of one another



** "Delicate balance" ** important within and among these systems

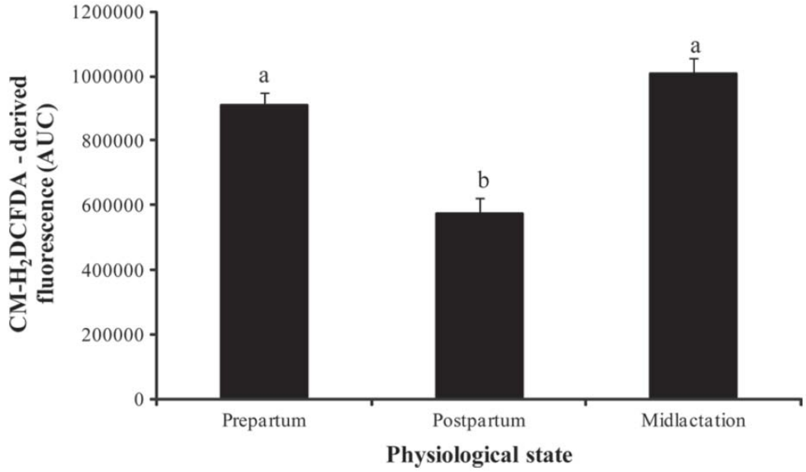
- Homeorhetic adaptations in energy metabolism that are important for the onset of copious milk production result in negative EB; however, excessive NEB is problematic
  - Bell, 1995; Ospina et al., 2010a,b,c
- Immune system must maintain balance between sufficient activity needed to eliminate the insult yet control the response to avoid bystander damage to host tissues
  - Sordillo et al., 2009
- Production of reactive oxygen species (ROS) critical for immunocompetence yet production of ROS in excess of antioxidant defense mechanisms results in oxidative stress
  - Spears and Weiss, 2008

** Sordillo et al., 2009

Periparturient immunosuppression

- Decreased sensitivity and responsiveness of immune system that makes the cow more susceptible to infection
  - ~3 weeks either side of calving
    - Mallard et al., 1998
- Leukocytes functionally compromised and hyporesponsive to pathogens; however, cytokine secretion hyperresponds when activated
  - Sordillo et al. 1995

Effect of stage of lactation on bovine neutrophil total ROS production

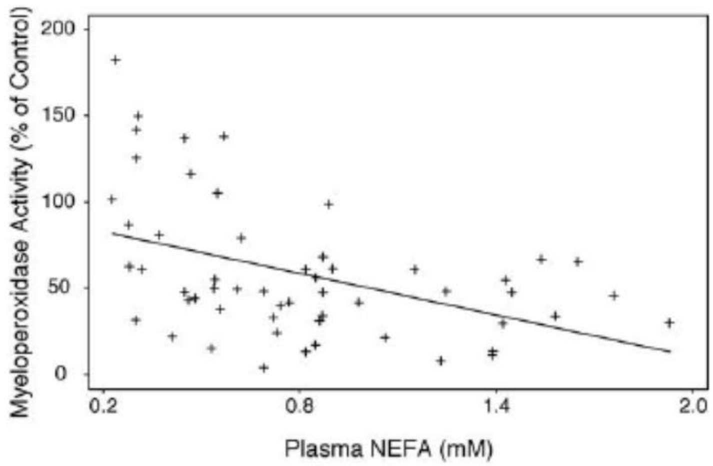


Revelo and Waldron, 2010

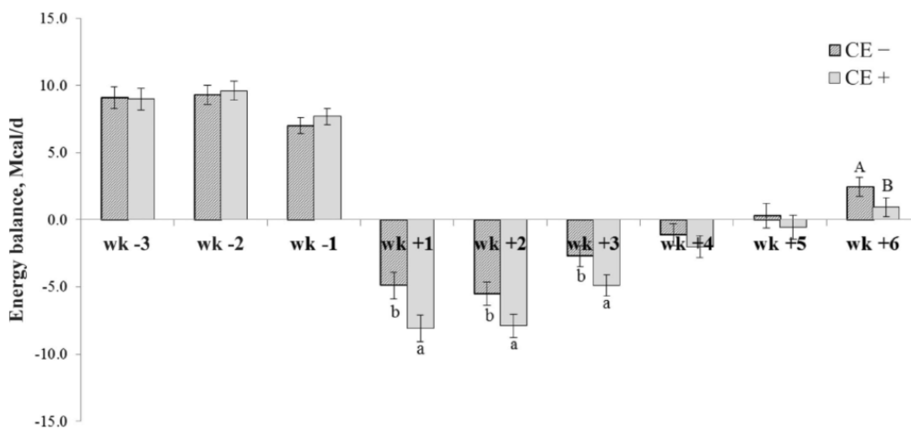
Interactions of nutrition and metabolism with immune function

- Energy metabolism
- Specific metabolites
  - NEFA
  - Ketone bodies
- Protein/AA
- Calcium
- Vitamin E and Se
- Other trace elements

Plasma NEFA and PMN Function

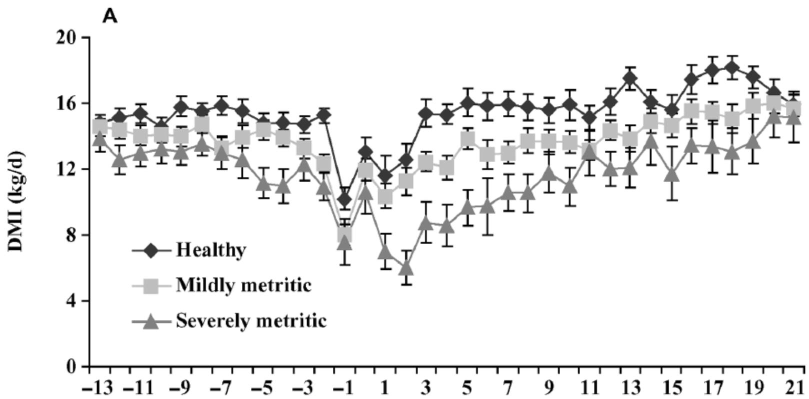


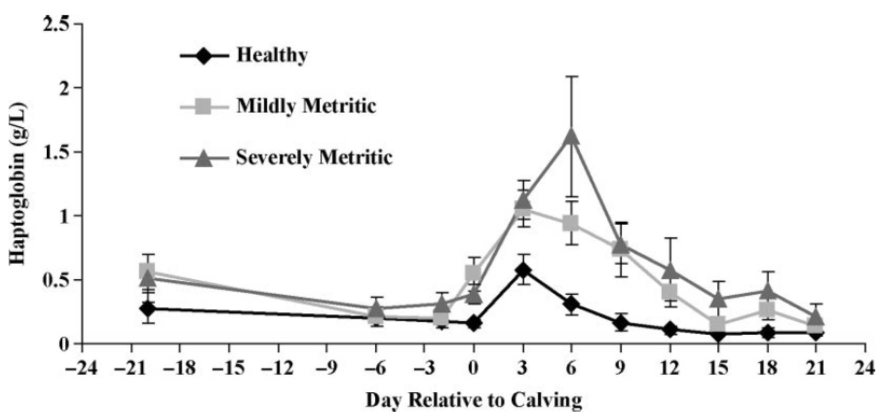
(Hammon et al., 2006)



Cows that go on to develop cytological endometritis (CE) are in more negative energy balance during the first three weeks postcalving. From Yasui et al., 2014.

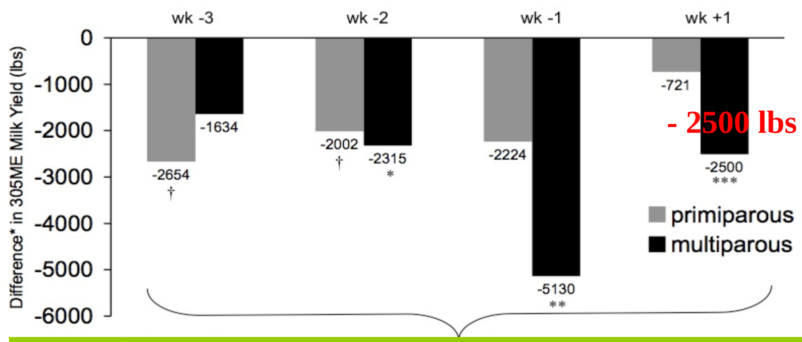
Dry matter intake for cows that developed metritis in early lactation. From Huzzey et al., 2007.





Mean (±SE) haptoglobin concentration of healthy (n = 23), mildly metritic (n = 32), and severely metritic (n = 12) cows during the period around calving (From Huzzey et al., 2009)

Haptoglobin & Subsequent Milk Yield (~60 DIM)

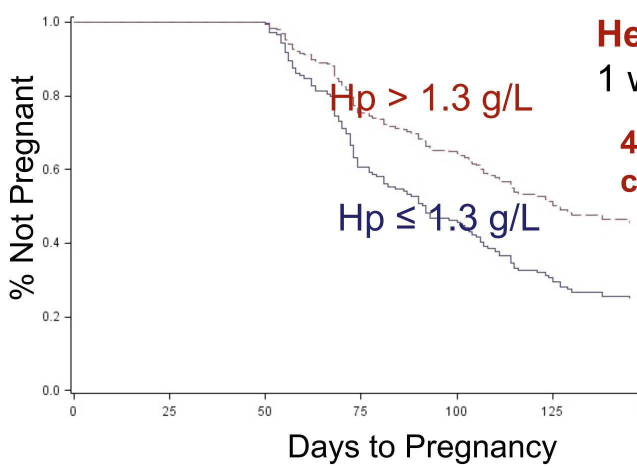


Cutpoint: >1.1 g/L

% Cows Above Cutpoint	wk -3	wk -2	wk -1	wk +1
Primiparous	4.9	7.7	6.0	39.0
Multiparous	3.0	4.8	3.0	27.4

Huzzey et al., 2012. J. Dairy Sci. 95(E. Suppl. 1):705.

Haptoglobin and Reproduction



Heifers sampled
1 wk **after** calving

42% lower rate of conception (*P* = 0.02)

- Heifers > 0.4 g/L Pre-partum - 41% lower rate of conception (*P* = 0.05)
- Among Cows Hp not associated with reproductive performance

Huzzey et al., 2012. J. Dairy Sci. 95(E. Suppl. 1):705.

Key components of transition cow management

- Nutritional management
  - Tight control of macrominerals in diet fed to cows as they approach calving
  - Controlling energy intakes both in far-off and close-up groups
  - Ensure cows consume diet as formulated for maximum intake
    - Feeding management is critical
    - Minimize sorting
  - Focus on ration fermentability during the fresh period
- Nonnutritional management
  - Minimize stressors and potential impact on physiology and variation in DMI
- Put cow- and herd-level monitoring systems in place to help identify need for management changes

Major strategies for application of DCAD for close-up dry cows

- Focus on feeding low K (and Na) forages and feeds to close-up dry cows
  - *Calculated DCAD ~ +10 mEq/100 g of DM*
  - *Urine pH ~ 8.3 to 8.5*
- Feeding low K forages along with partial use of anionic supplement in close-up ration or one-group dry cow ration
  - *Calculated DCAD ~ 0 mEq/100 g of DM*
  - *Urine pH ~ 7.5*
- Feeding low K forages along with full use of anionic supplement in close-up ration or one-group dry cow ration
  - *Calculated DCAD ~ -10 to -15 mEq/100 g of DM*
  - *Urine pH ~ 5.5 to 6.0 – need to monitor weekly and adjust DCAD supplementation if out of range*
- Need to also supplement Mg (dietary target ~ 0.45%) during close-up
- Recommend supplementing Ca (0.9 to 1.0% if low K only; 1.4 to 1.5% if full anionic diet)

U.S. trends in last 6 to 8 years

- Largely abandoned "steam up" concept advocated by 2001 Dairy NRC
- Controlled energy strategies for dry cows during both far-off and close-up periods (Drackley, 2007)
  - 0.59 to 0.62 Mcal/lb (1.30 to 1.36 Mcal/kg of NEL)
  - 12 to 16% starch
  - 40 to 50% forage NDF
- Appropriate for multiparous cows
- Too low energy/too bulky for primiparous cows?
- MP supply?? (RUP supplementation even more important)
- Diets need to deliver 15 to 18 Mcal/d of NEL (110 to 120% of ME requirements) during both far-off and close-up dry periods

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Potential management/facility related stressors for transition cows

- Overcrowding (increased stocking density)
- Commingling of cows and heifers
- Excessive number of pen moves (group changes)
- Heat stress
- Overall cow comfort/hygiene

Stressors for transition cows

- Decrease dry matter intake and milk
- Increase body fat mobilization and wasting of muscle tissue
- Divert nutrients from milk to stress response/immune system

- Potential mechanism
  - Release of pro-inflammatory cytokines (TNFα, IL-1β, IL-6) and stress hormones (glucocorticoids, epinephrine, cortisol)

Drackley et al., 2005

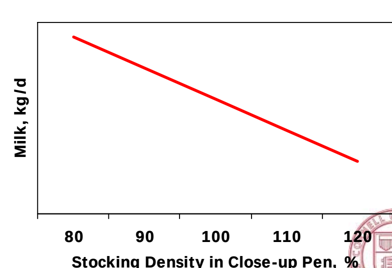
Stocking density

- Most attention by far
- Current recommendations (e.g., 0.75 m of feedbunk space per cow; 80% of headlocks) based upon observational work rather than randomized trials
- Observational studies have limited ability to determine optimal stocking density and relationships with other factors

Crowding in Close-up Pen Decreases Milk Production

- Primiparous and multiparous cows grouped together
  - 1600 cow facility, 2-row pens
- Primiparous cows
  - 2.95 kg/d increase in milk (1st 83 DIM) when stocked at 80 vs. 120% of stalls

- For each 10% increase in close-up stocking density above 80%, there was a 0.73 kg/d decrease in milk!



Cook et al., 2004

Commingling primiparous and multiparous cows

- Even fewer data than for stocking density
- Ospina et al. (2009) results suggest major opportunity in NE herds
  - Elevated NEFA in 45% of heifers sampled prepartum
- Higher responses of cortisol to ACTH challenge in primiparous compared to multiparous cows following introduction to a commingled environment
  - Gonzalez et al., 2003

Feeding Behavior of Heifers vs. Cows

Activity	Heifers	Cows
Prepartum total daily feeding time, min/d	213	187
Prepartum meal duration, min/d	27.2	24.2
Prepartum feeding rate, g DM/min	66.6	95.1
Postpartum feeding rate, g DM/min	78.8	106.7

Heifers need more time for access to feed; eat more slowly than cows

DeGroot and French, 2004

Crowding in Close-up Pen Decreases Milk Production (in some cows)

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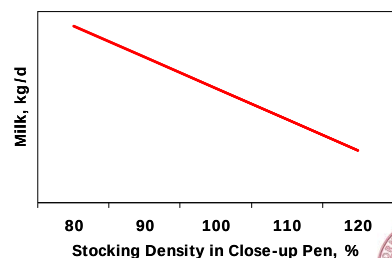

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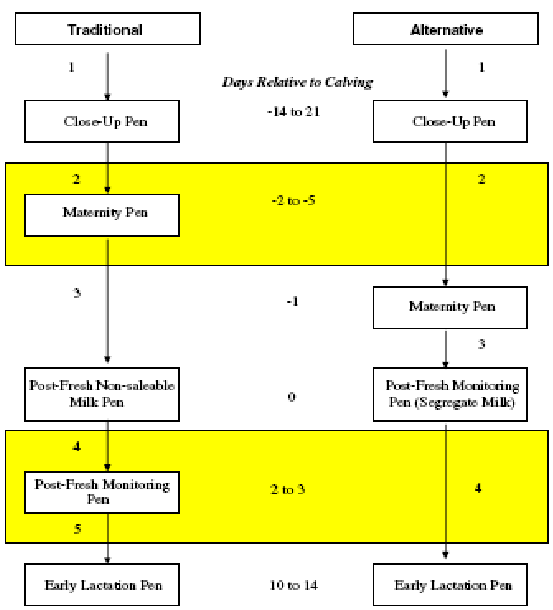


Streamline approaches to grouping management of transition cows (Cook and Nordlund, 2004)

Time Spent in Maternity Pen

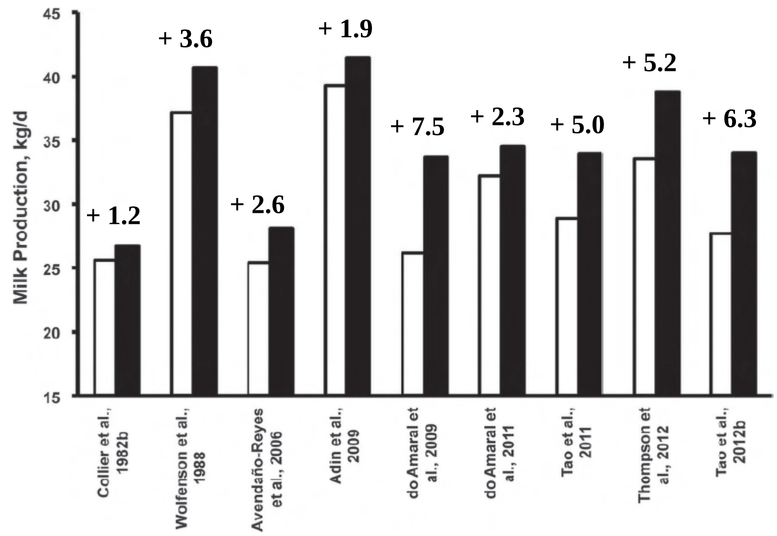
	<3 d	≥ 3 d	Δ
Herd 1 (4.5 d in pen)			
Calvings	112	182	
Culled by 60 d, %	3.6	9.3	2.6x
Herd 2 (5.9 d in pen)			
Calvings	34	129	
Culled by 85 d, %	2.9	9.3	3.1x
Subclinical ketosis, %	6.9	16.0	2.3x
Displaced abomasum, %	2.9	5.4	1.9x

Oetzel, 2003

Heat stress abatement during dry period

- Israeli study on evaporative cooling during entire dry period (Wolfenstein et al., 1988)
  - 24 C at 0700 h and 31 C at 1400 h
  - Cooled cows
    - Rectal temperatures 0.5 C lower than controls
    - Milk yield increased 3.6 kg/d during first 150 d
- Avendano-Reyes et al. (2006)
  - Study 1 – soaking cows without fans not effective in cooling
  - Study 2 – evaporative cooling for entire dry period increased milk yield (+ 2.5 kg/d) and milk fat (2.97 vs. 3.27%)

Cooling during the entire dry period increases subsequent milk production (differences in kg/d above bars)



Tao and Dahl. 2013. J. Dairy Sci 96 :4079–4093

Heat stress during the prepartum period decreases calf birth weight

Heat-stressed	Control	% reduction	Reference
36.6*	39.7	8	Collier et al. (1982b)
40.6*	43.2	8	Wolfsen et al. (1988)
33.7†	37.9	11	Avendano-Reyes et al. (2006)
40.8*	43.6	6	Adim et al. (2009)
31.0*	44.0	30	Do Amara et al. (2009)
39.5*	44.5	11	Do Amara et al. (2011)
41.6*	46.5	11	Tao et al. (2011)
36.5*	42.5	14	Tao et al. (2012b)

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Types of monitoring

- Cow-level
  - Seeking to make a diagnosis/treatment decision on an individual animal
- Herd-level
  - Periodic (e.g., weekly) evaluation of a representative sample of cows in a sampling window of interest
  - Using as a barometer of the herd
  - Large epidemiological studies involving many herds have given us the ability to make inferences relative to associations of analytes with herd-level outcomes

Challenges with assessing herd-level metabolism and stress biology-related opportunities in transition cows

- Most of dairy industry works on averages
- Challenges related to energy/grouping mgt/nonnutritional factors cause increases in ***variation*** in DMI/performance/metabolism
  - Almost impossible to detect some of these on farms
- Potential tools for use in monitoring variation in transition cow management
  - Calcium (getting renewed attention)
  - NEFA (best marker for negative energy balance)
  - BHBA ("gold standard" blood ketone)
  - Haptoglobin (acute-phase response/systemic inflammation)
  - Fecal cortisol metabolites? (likely research tool rather than herd use)
  - Urine pH – (feeding management in herds feeding DCAD diets)
  - Rumination monitors? – other electronic monitoring?
  - Variation in early lactation milk yield / Transition Cow Index (TCI)

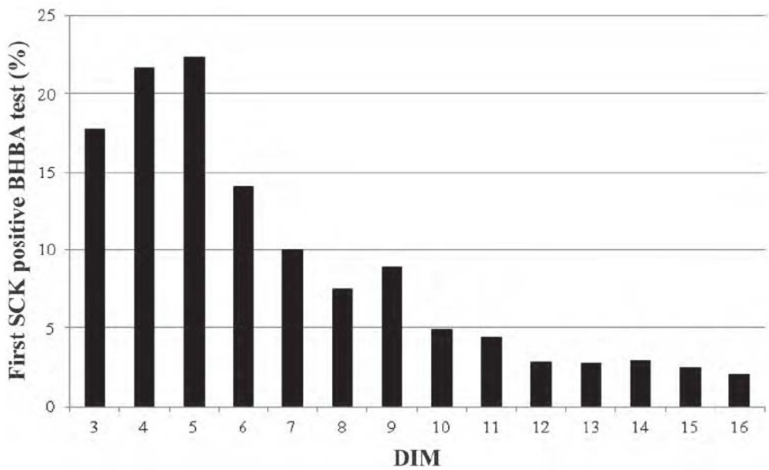
Herd-level impacts of elevated NEFA/BHB

Metabolite level	**Herd Alarm**	**Associated with:**
PRE-Partum NEFA ≥ 0.3 mEq/L	15%	+3.6% Disease incidence -1.2% Pregnancy rate - 529 lbs ME305 milk (both heifers and cows)
POST-Partum NEFA ≥ 0.6[a] - 0.7[b] mEq/L	15%	+1.7% Disease incidence[b] - 0.9% Pregnancy rate[a] Heifers: -640 lbs, Cows: **-** 1,272 lbs
BHB ≥ 10[a]-12[b*] mg/dL	15% *20%	+1.8% Disease incidence[b] -0.8% Pregnancy rate[b] Heifers: **-**1,179 lbs*, Cows: **-** 732 lbs[a]

***15% of 15 = 2-3 animals**

Ospina et al., 2010

Histogram of incidence of subclinical ketosis (SCK) in 1,717 Holstein dairy cows undergoing repeated testing for ketosis from 3 to 16 DIM. A positive test was defined as a blood BHBA concentration of 1.2 to 2.9 mmol/L



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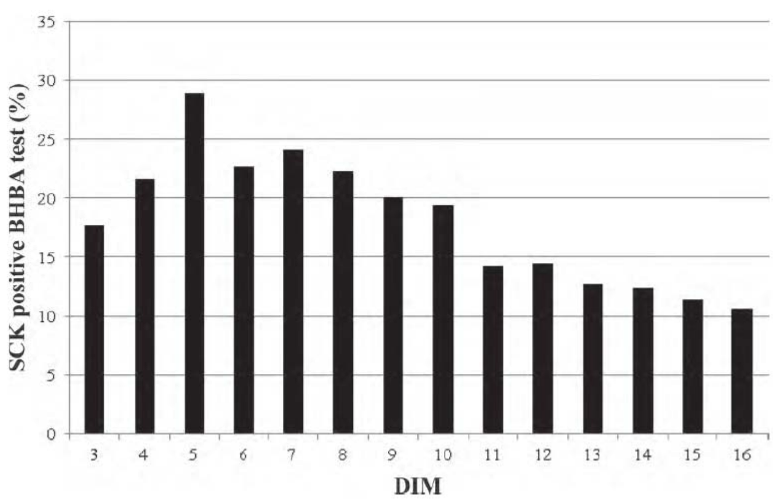

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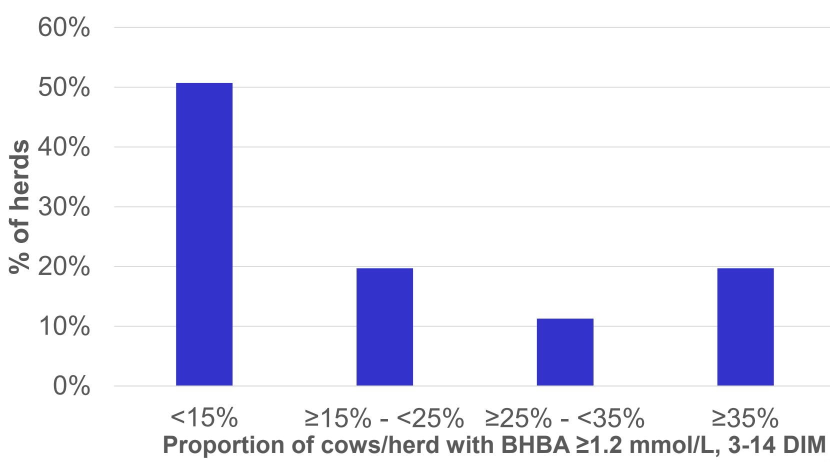
Approach for monitoring energy-related analytes in transition cows

- Sample size:
  - 15 to 20 cows
- Cows to sample
  - Pre-partum: 14 to 2 days before calving (NEFA only)
  - Post-partum: 3 to 14 DIM (NEFA and/or BHBA)
- Sample to take
  - Serum (red top tubes)
  - Don't shake, keep cool
  - Milk (ketones only)
- What to do with sample?
  - BHBA: Lab or Precision Xtra Meter (blood) or ketotest or infrared (milk)
  - NEFA: Lab
- What to do with results
  - Interpret % above cut-point
  - More than 15% above cut-point indicates herd-level problem

Prevalence of hyperketonemia between 3 and 14 DIM on 71 commercial dairy farms



Lawton et al., 2015 JAM

Top ten things to do for healthy and productive transition cows

- Manage macromineral nutrition/DCAD of dry cows, especially in the last 2 to 3 weeks before calving
- Control energy intake in both far-off and close-up cows – not too little, not too much
- Make sure supplying enough metabolizable protein before calving
- Get the feeding management right, every day
- Clean and comfortable housing and fresh water
- Manage social interactions/hierarchy
- Manage cold stress and heat stress
- High quality forage and fermentable diets for fresh cows
- Strategically use feed additives/nutritional tools
- Implement cow- and herd-level monitoring programs

THE OHIO STATE UNIVERSITY
COLLEGE OF VETERINARY MEDICINE

COW COMFORT DURING TRANSITION

Katy Proudfoot, PhD

What is cow comfort?

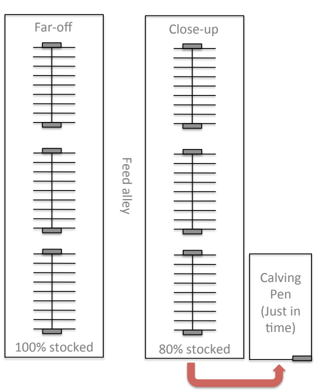
Farm Examples

- Focus on housing and movement of animals
- Assume producers have taken steps to resolve potential nutrition/genetic causes of problems

FARM A

Specific problem: 12% stillbirth rate

FARM A



Where to start?

- **Challenges with 'just-in-time'**
- Poor training
- Multiple daily regrouping in calving pen

Labor in dairy cows

✓Calf moves into position
✓Cervix begins to dilate

✓Calf moves through birth canal

✓Placenta is released

Stage I | Stage II | Stage III

Stage I

Labor in Dairy Cows

✓Calf moves into position
✓Cervix begins to dilate

Stage I | Stage II | Stage III

✓Restless behavior
✓Off feed
✓Engorged, leaky udder
✓Raised tail
✓Relaxed pelvic ligaments

Stage II

Labor in Dairy Cows

✓Calf moves through birth canal

Stage I | Stage II | Stage III

✓Abdominal contractions
✓Mucous or amniotic sac
✓Visible calf legs
✓Lying down

|— 20-70 min —|

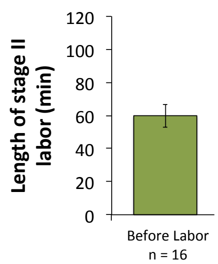
Schuenemann et al., 2011

When should cows be moved?

Stage I | Stage II | Stage III

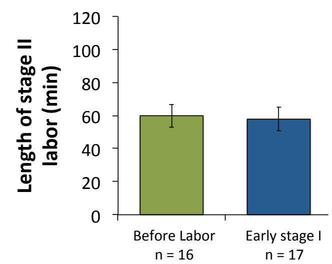
↑ Before Labor
↑ Early Stage I
↑ Late Stage I

Length of stage II labor



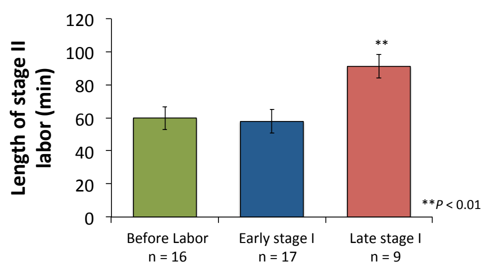
Proudfoot et al., 2013. J. Dairy Sci.

Length of stage II labor



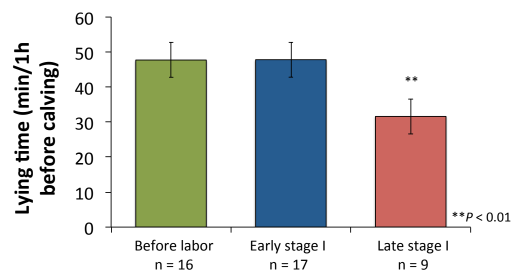
Proudfoot et al., 2013. J. Dairy Sci.

Cows moved later had the longest stage II labor



Proudfoot et al., 2013. J. Dairy Sci.

Lying time before calving



Proudfoot et al., 2013. J. Dairy Sci.

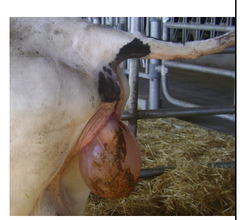
Where to start?

- Challenges with 'just-in-time'
- **Poor training**
- Multiple daily regrouping in calving pen

Does training help?

Personnel (n = 47) from 12 Ohio dairies given 2 h of training and 1 h of demonstration:

- ✓ Behavioral signs of calving
- ✓ Signs of dystocia
- ✓ Good hygiene practices
- ✓ Record-keeping
- ✓ When to call for help
- ✓ Newborn care

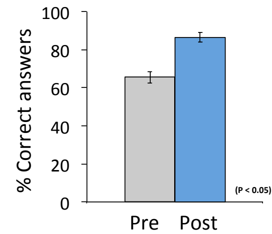


Schuenemann et al., 2011, 2013

Does training help?


Schuenemann et al., 2011, 2013

Training improves knowledge and reduces stillbirths



Schuenemann et al., 2011, 2013

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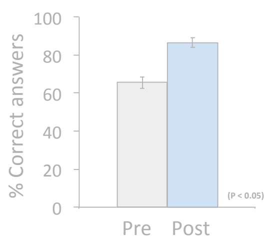
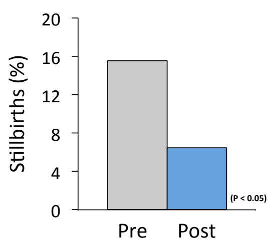
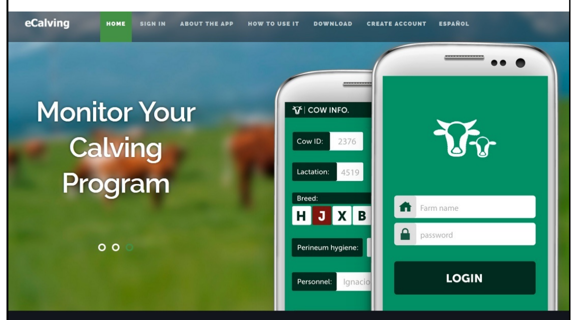




Schuenemann et al., 2011, 2013

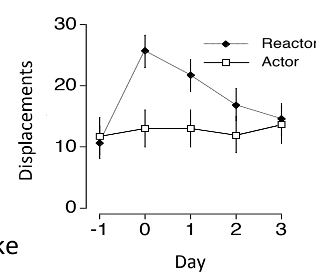
www.ecalving.com



Where to start?

- Challenges with 'just-in-time'
- Poor training
- **Multiple daily regrouping in calving pen**

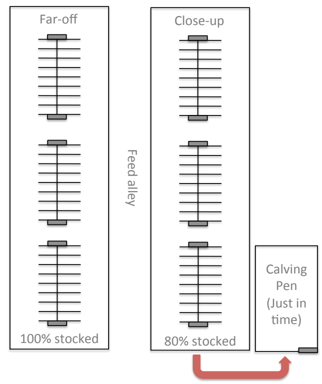
Effect of regrouping



↓ 9% feed intake
3.7 kg milk

von Keyserlingk et al. 2008. J. Dairy Sci., Schirmann et al., 2012

FARM A

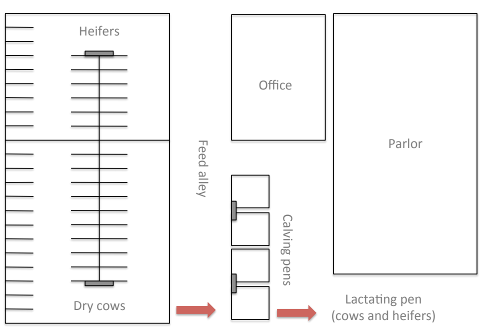


FARM B

Specific problems:

1. Lameness after calving
2. Dystocia and metritis

FARM B

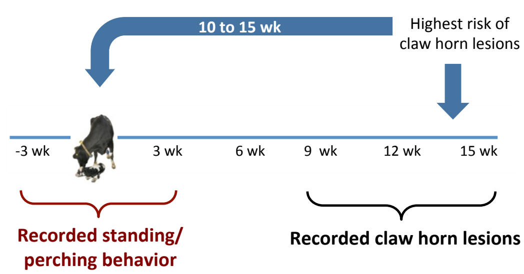


Where to start?

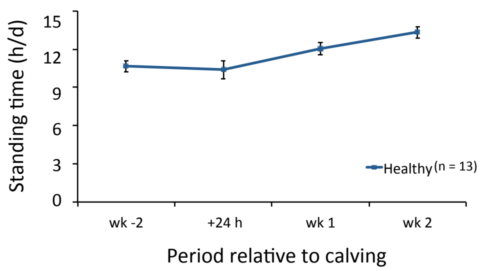
1. Comfort of close-up pens

2. Seclusion in calving pen

Is perching a problem?

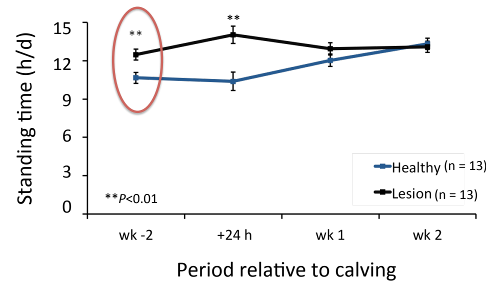


Standing time of healthy cows



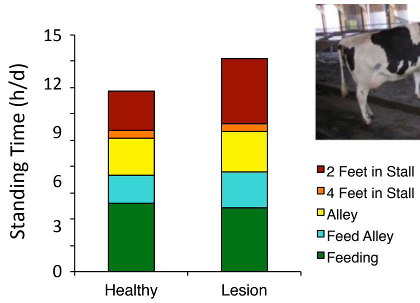
Proudfoot et al., 2010. J. Dairy Sci.

Standing time of cows with lesions



Proudfoot et al., 2010. J. Dairy Sci.

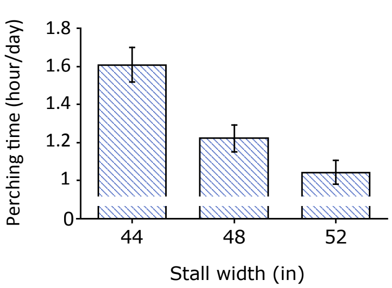
Where were they standing?



Proudfoot et al., 2010. J. Dairy Sci.

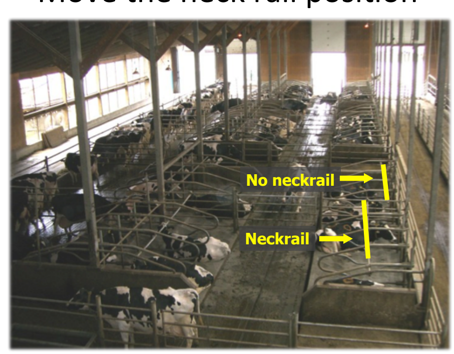
How do you reduce perching?

Widen stalls

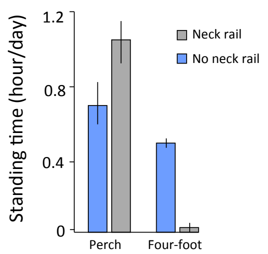


Tucker et al., 2004, J. Dairy Sci. 87: 1208-1216

Move the neck rail position



Neckrail position



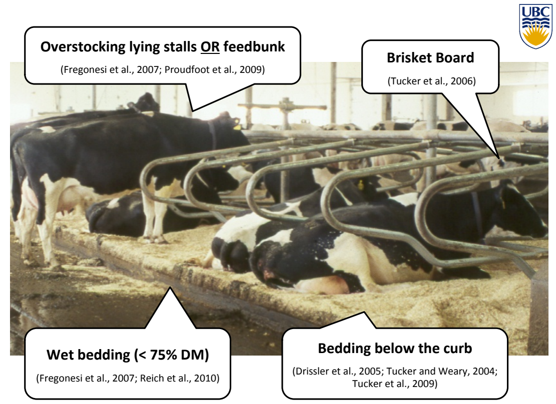
Bernardi et al., 2009. J. Dairy Sci.

Removing the neck rail reduces lameness

New cases	Neck rail	No neck rail	*P*
Lameness	11	2	0.01
Mastitis	0	0	N.S.
SCC>100,000 cells/ml	2	1	N.S.

Bernardi et al., 2009

What else increases standing time?



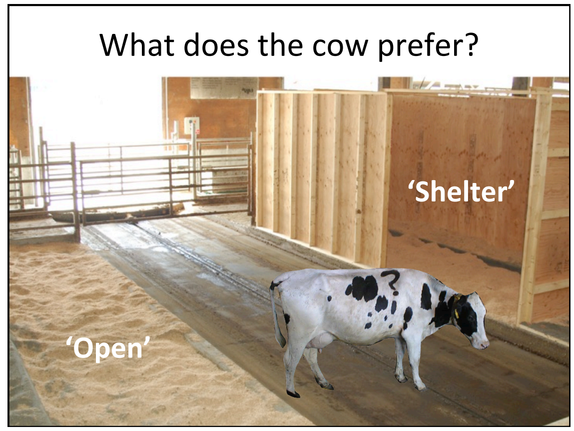
What else reduces risk of lameness?

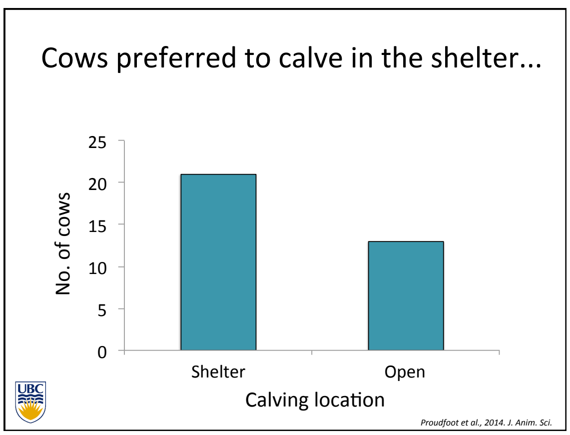
Access to pasture sometime during the dry period
= 50% fewer lame cows

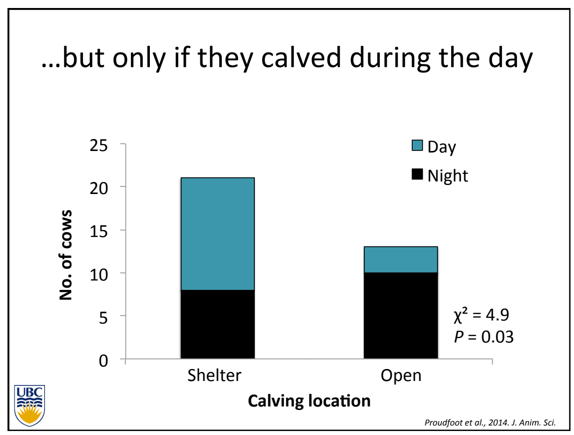
Chapinal et al. 2013, J. Dairy Sci. 96: 318-328

Where to start?

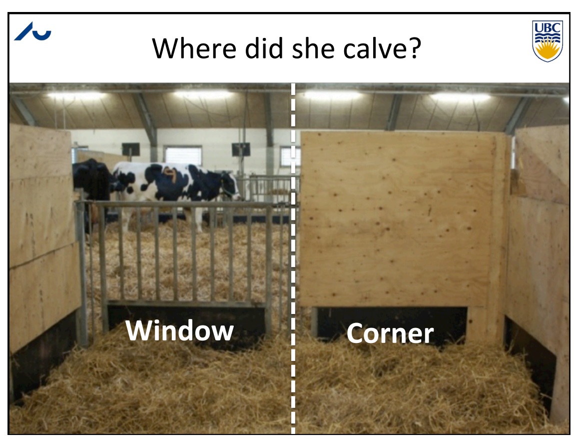
1. Comfort of lying stalls in close-up pens
2. **Seclusion in calving pen**


What does the cow prefer?
'Shelter'
'Open'
?

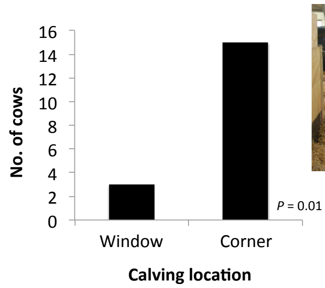

Cows preferred to calve in the shelter...
No. of cows
25
20
15
10
5
0
Shelter
Open
Calving location
Proudfoot et al., 2014. J. Anim. Sci.


...but only if they calved during the day
Day
Night
No. of cows
25
20
15
10
5
0
Shelter
Open
Calving location
$\chi^2 = 4.9$
$P = 0.03$
Proudfoot et al., 2014. J. Anim. Sci.


Can this be practical?


Where did she calve?
Window
Corner

Cows preferred the corner



Proudfoot et al., 2014, J. Dairy Sci.

FARM B

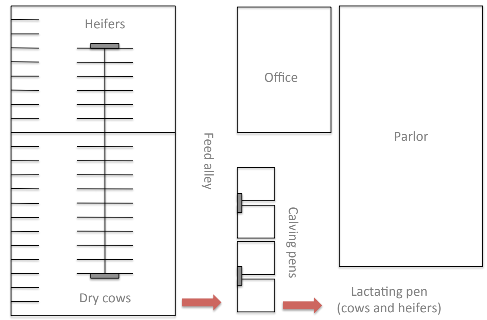


Photo courtesy of Dr. Ken Nordlund, University of Wisconsin-Madison

Summary

- Training staff to recognize the signs of calving and dystocia can reduce the risk of stillbirths
- Cows prefer quiet, secluded areas to calve, and disturbance can delay labor
- Improving cow comfort in the dry pens is essential for preventing lameness after calving

Thank You!

Projects conducted at OSU were supported by NCR-SARE Professional Development Program (ENC10-120).

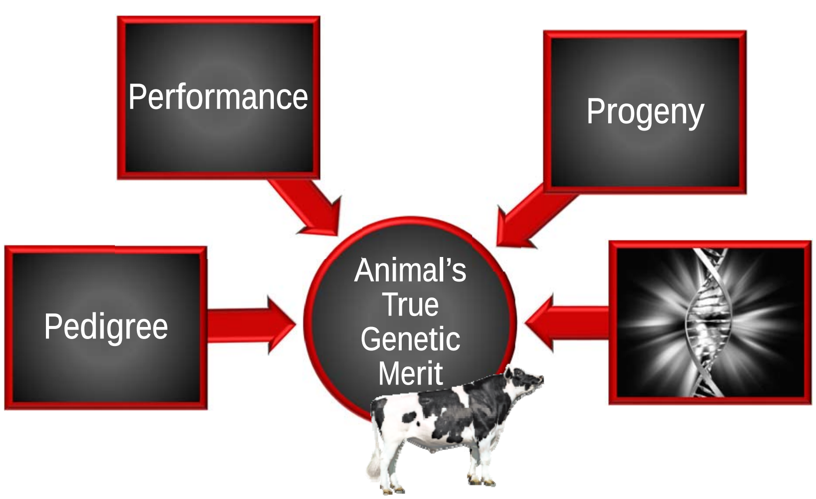
Funding for the UBC Animal Welfare Program provided by the Natural Sciences and Engineering Council, Dairy Farmers of Canada, BC Dairy Foundation, Pfizer, Westgen, Beef Industry Development Council, British Columbia Milk Producers, Alberta Milk and many others listed at www.landfood.ubc.ca/animalwelfare/

Projects conducted in Denmark were supported by the Danish Ministry of Food, Agriculture and Fisheries for funding (2009-2012).

Breeding for Milk Protein

Chuck Sattler

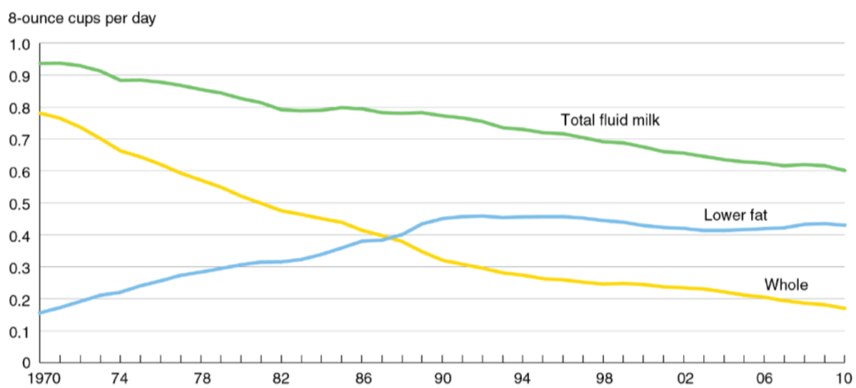
Turning Data into Genetic Information



Popular Traits Used for A.I. Sire Selection

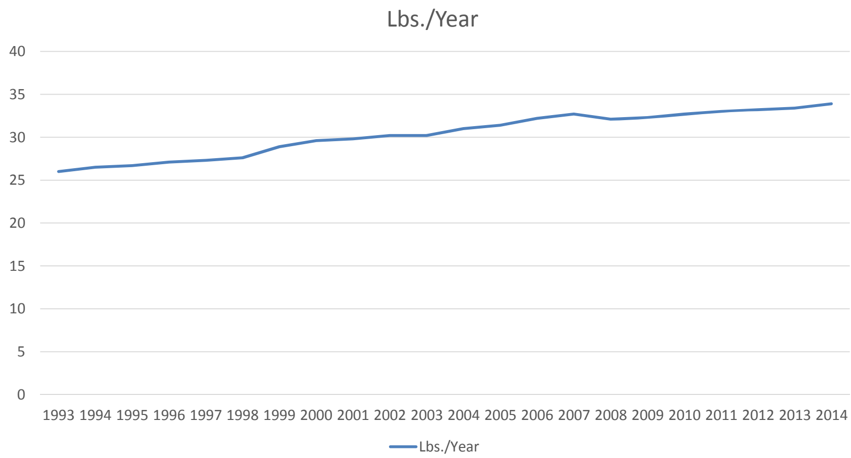
- Milk
- Udders
- Calving Ease
- Semen fertility

Figure 1
Per capita, daily fluid milk consumption declining



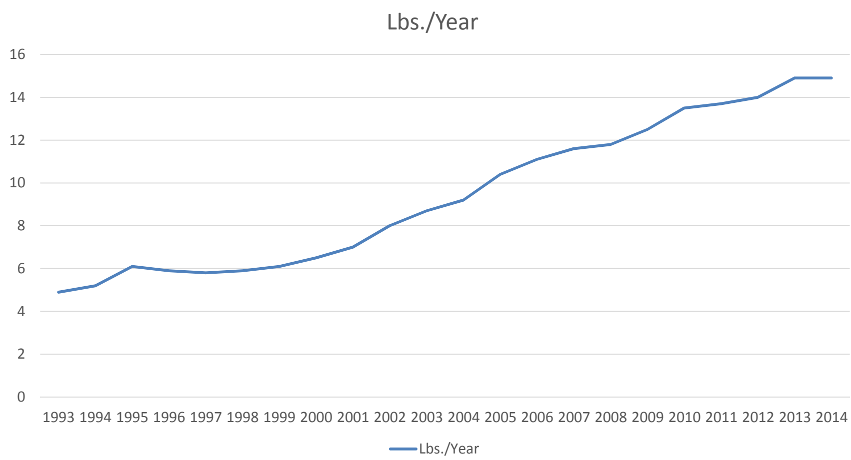
Notes: *Whole* milk has a fat content of at least 3.25 percent. *Lower fat* milk includes products with less milk fat than whole like 2-percent, 1-percent, and skim milk.
Source: Loss-Adjusted Food Availability, USDA-ERS (2013a).

US Per Capita Consumption of Cheese



Source: USDA-NASS

US Per Capita Consumption of Yogurt



Source: USDA-NASS

Heritability Values for Dairy Traits

Trait	Heritability
Milk	30%
Fat Percent	58%
Fat Yield	30%
Protein Percent	51%
Protein Yield	30%
Udders	25%
Somatic Cell Score	10%
Productive Life	8%
Calving Ease	8%
Daughter Pregnancy Rate	1.5%

Variance of Production Traits

Trait	Mean (lbs.)	Genetic SD (lbs.)	Coefficient of Variation
Milk Yield	26,995	672	2.5%
Fat Yield	1,006	25	2.5%
Protein Yield	822	18	2.2%

Source: CDCB, Dec. 2014

Genetic Correlation Between Traits

Trait	P%	Milk	Fat	F%	Udders	DPR	SCS	PL	CA$
Protein Yield	-0.12	0.83	0.59	-0.21	-0.14	-0.18	0.04	0.13	0.22
Protein %		-0.47	-0.40	0.59			0.01		
Milk Yield			0.43	-0.40	-0.10	-0.23	0.02	0.10	0.19
Fat Yield				0.35	-0.07	-0.15	-0.09	0.15	0.13
Fat %							-0.06		
Udders						0.09	-0.23	0.18	0.10
Dtr Preg Rate (DPR)							-0.27	0.64	0.35
Som Cell Score (SCS)								-0.45	-0.14
Productive Life (PL)									0.40

Source: CDCB, Dec. 2014
Welper and Freeman, JDS 75:1342-1348

Sire Selection Approaches

- Single-trait selection
- Independent Culling Levels
- Selection Indexes

Comparing Different Selection Approaches

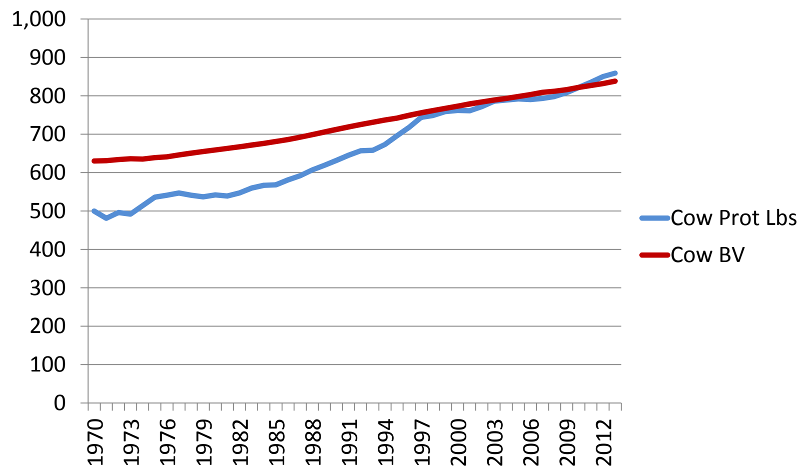
(Avg. of top-50 AI Sires)

Selection Criteria	Prot	Milk	Fat	P%	Udders	DPR	SCS	PL	CA$
Protein Yield	+51	+1549	+49	+.01	+0.65	-0.5	3.00	+2.3	11.1
Protein %	+20	-165	+28	+.09	+0.51	+0.8	2.93	+1.3	10.0
Milk Yield	+47	+1720	+41	-.02	+0.64	-0.3	2.96	+3.1	10.2
≥+.5DPR, ≤2.9 SCS	+37	+1023	+36	+.02	+0.66	+2.0	2.77	+4.3	22.2
TPI	+39	+1112	+52	+.02	+1.23	+1.9	2.83	+5.0	26.0
NM$	+37	+1036	+55	+.02	+0.85	+2.0	2.82	+5.6	28.3
CM$	+37	+973	+55	+.03	+0.89	+2.0	2.81	+5.5	28.3

Comparison of Indexes

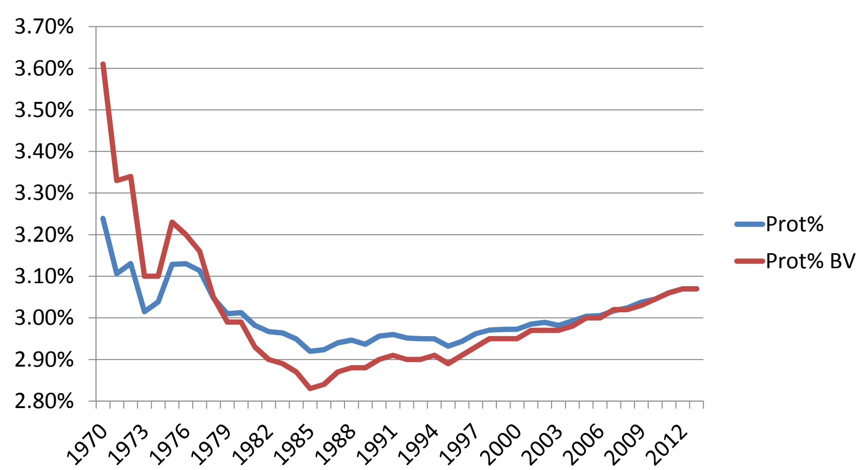
Trait	NM$		CM$		TPI	
Milk	- 1%		- 9%		- 0.5%	
Fat	22%	43%	19%	52%	17%	45.5%
Protein	20%		24%		28%	
Final Score					8%	
Udd. Comp.	8%	11%	6%	8%	11%	25%
F&L Comp.	3%		2%		6%	
Prod. Lf.	19%		16%		7%	
Som. Cell Score	- 7%		- 7%		- 5%	
Dtr. Fertility	10%	46%	8%	40%	13%	29.5%
Calving Ability	- 5%		- 5%		- 3%	
Body Comp.	- 5%		- 4%		- 0.5%	
Dairy Form					- 1%	

U.S. Holstein Actual and Genetic Trend for Protein Yield

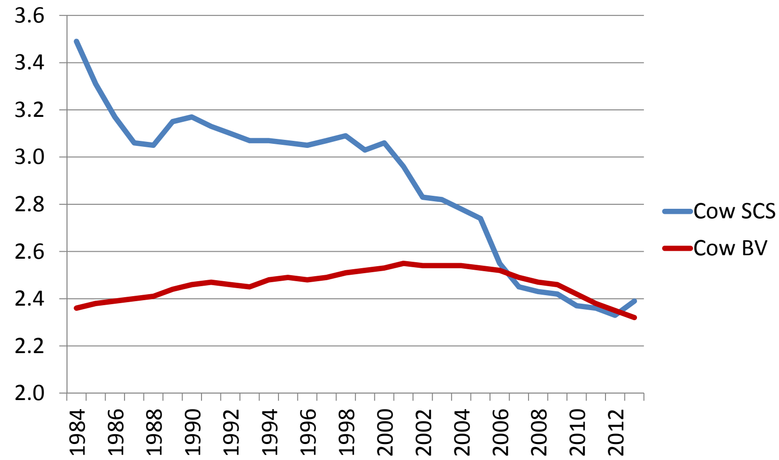


USDA, CDCB Aug. 2015

U.S. Holstein Genetic and Phenotypic Trend for Protein %

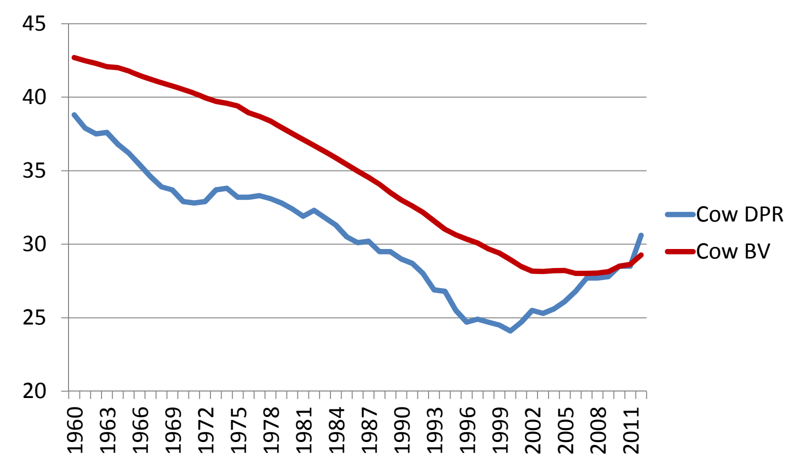


U.S. Holstein Actual and Genetic Trend for SCS



USDA, CDCB Aug. 2015

U.S. Holstein Actual and Genetic Trend for DPR



USDA, CDCB Aug. 2015

Kappa Casein

- Important protein for cheese making.
- A and B variants have been identified.
- B variant is preferred:
  - Milk with B variant forms firmer curd.
  - Milk with B variant coagulates faster.

Beta Lactoglobulin

- Whey protein.
- A and B variants have been identified.
- B variant is preferred:
  - Cows with the B variant produce similar total levels of protein but a smaller percentage of whey protein and a higher percentage of casein.

A2 Milk

- Beta casein makes up about 30% of the protein in cow's milk.
- A1 and A2 are the most common variants.
- When humans digest A1 milk we produce metabolites that may cause "problems".
- Fluid milk not containing A1 beta casein is now being marketed in the west.
- Some people may have fewer digestive problems when consuming A2 milk.

Take Home Points

- Protein is a valuable milk component.
- Selecting for increased protein yield should be a part of all breeding programs.
- Replace selecting for PTA Milk with PTA Protein or CFP in your selection program.
- Use a selection index – it's the most effective way to make simultaneous progress in several traits.

Thank You!

Email: csattler@selectsires.com
Website: www.selectsires.com

Feeding Smarter Not Harder: Finding Lost Milk in the Feeding Program

Dr. Will Seymour, Ph.D., PAS, Dipl. ACAN

Ruminant Technical Manager
Novus International, St. Charles, MO

SMART GOALS

The concept of S.M.A.R.T. goals (Specific, Measurable, Attainable, Relevant, Timely) has application when working with dairy clients. Time spent up front discussing and defining specific goals for the nutrition program is time well spent. It can help set realistic expectations and focus efforts where there is the greatest likelihood of a successful outcome (more profitable dairy business). Furthermore this process helps the dairy nutritionist learn more about the inner workings of a given dairy and help correct management issues that might otherwise undermine the success of the nutrition program. Working together to set smart goals sets a positive tone with a new customer/client, helping to build a long term relationship.

LOST MILK

Lost milk is a reference to the concept of marginal milk: additional milk that could potentially be produced by a dairy herd at the same fixed costs as current milk production. Marginal milk may be "found" in many places. Feeding management is often a good hunting ground for lost milk. The individual dairy cow in group housing may or may not be getting adequate nutrients at the right times of day to reach her lactation potential. Nutrient intake of an individual cow will be affected by how well the ration has been prepared, delivered, pushed back up and cleaned up. Water availability can be a limiting factor, especially during hot weather. The magic wand does not exist to instantly correct all the potential bottlenecks in nutrient delivery to the herd, but setting SMART goals and following up on these with key personnel can remove some of the barriers and realize greater herd productivity and profitability. Cow comfort and logistics are critically important co-factors with feeding management. The cow time budget can be distorted by uncomfortable stalls, too much time away for milking, poor air quality and a number of other factors that can be assessed on commercial dairies.

FEEDING MANAGEMENT

Achieving a consistent, balanced flow of nutrients to the mammary gland is essential for cows to reach their productive potential. Meeting this goal is a challenge, especially in loose housing systems. Accurate feed manufacturing and delivery is essential and has been thoroughly reviewed (Oelberg, 2015). Errors and inconsistencies in feed composition or quality will certainly reduce milk yield and feed efficiency. Dr. Mike Brouk of Kansas State University has estimated that deviations from the ration batch schedule can cost \$0.12 to \$0.20 per cow per day due to reduced herd performance and increased feed waste.

Feed intake can be a limiting factor to milk and milk component yield in group housing. A total mixed ration is formulated and fed to a pen of cattle based on the average cow, or the average cow plus a lead factor. Some cows will be underfed and some overfed compared to nutrient requirements. Feed intake of individual cows may be limited by several factors, first of which is the availability of feed and access to the feeding space. Dairy farms striving to increase "feed efficiency" may in fact be limiting herd productivity by underfeeding a significant proportion of cows relative to their nutrient requirements or more importantly, their potential to respond to a greater supply of nutrients with higher milk yields. The majority of free stall dairies should feed for a 3 to 5 percent refusal to ensure that the herd reaches its potential. Empty feed bunks during daylight hours are a strong indication that feed intake is being limited for a significant proportion of cows in the group. Timing of feed push-ups is also crucial.

A study of 22 commercial free stall dairies in Ontario, Canada (Sova et al., 2013) revealed some interesting relationships between feeding management and milk production. Herds were closely monitored for seven consecutive days during both the summer and winter months and complete statistical analysis of the data performed. Increased feeding frequency (1X vs. 2X per day) was associated with an increase of 3.1 lbs of dry matter intake and 4.4 lbs more milk production, which would produce a net economic return of 2:1. This was despite the fact that on average the dairies had 21 inches of bunk space per cow, a 100% stocking density and fed for 3.5% feed refusals.

Water supply and access is another opportunity area on many farms. In the Guelph study (Sova et al., 2013) each additional 1 inch of linear water space was associated with 2.0 lbs more milk production. Herds in this study had an average of 2.8 inches of water space per cow. Typical recommendations are for 3.5 inches of water space per cow. As an example, adding 1 inch of water space for a group of 120 cows would require the addition of a 10-foot water trough. If the trough cost $2500 (~ $21 per cow) and cows produced 2 lbs more milk @ $0.17 per pound, it would take 2 months to pay off this investment.

NUTRITIONAL STRATEGIES: OPTIMIZING TRACE MINERAL NUTRITION

There is no shortage of nutritional strategies available to help optimize herd health and performance. Trace mineral nutrition is one area that we will examine in this presentation. Zinc, copper, and manganese are required in the body for a large number of physiological functions. In its 2001 publication the National Research Council (NRC) committee adopted a net absorption model for assessing and meeting trace mineral requirements of dairy cattle. It was acknowledged data on trace mineral absorption in dairy cattle is limited and difficult to obtain but that it makes more biological sense to express trace mineral requirements and allowances as quantities of absorbed mineral rather than as gross concentrations of minerals the diet. This approach has led a greater emphasis on the absorption and bioavailability of trace mineral sources, in particular in cases where trace elements are chemically bound or exist in a stable complex with organic molecules. These products are often referred to by the general term “organic trace minerals” (OTM). The American Association of Feed Control Officials (AAFCO) in cooperation with the FDA has established specific categories and definitions for different organic trace mineral product forms. This regulatory approach was taken in an effort to provide some standards for OTM products as well as to verify the product’s safety, composition, manufacturing processes and nutritional availability.

Organic trace mineral sources are typically used to supply a portion of supplemental trace minerals. Reasons for doing so include potential improvements in reproduction, immune function, udder health, hoof health, and a reduction in infectious disease (Overton and Yasui, 2014). The mechanism by which OTM can effect these improvements in ruminants is twofold: (1) the trace elements in organic form are shielded from antagonists such as free iron, sulfate, molybdenum, clay compounds, and fiber that would otherwise bind and reduce the bioavailability of the trace element and (2) the organically bound or complexed trace elements are more effectively delivered to absorption sites in the small intestine. This leads to greater net absorption of trace minerals fed as OTM and greater bioavailability (utilization) by the cow for essential biochemical processes in the body (Richards, 2010).

RECENT STUDIES ON TRACE MINERAL STATUS, LAMENESS, AND HOOF HEALTH

(1) Zhao et al. (2015a) explored relationships between lameness, trace mineral and antioxidant status, and inflammation in forty Holstein cows over a 60-day period in a commercial dairy herd. Cows were selected based on gait score (1 to 5 scale; Sprecher et al., 1997) and categorized as either healthy (score < 3) or lame (score 3 or greater) with 20 cows per group. Lame cows had significantly lower concentrations of trace minerals in serum, hair sample, and hoof horn compared to healthy cows. Serum superoxide dismutase (SOD), an antioxidant enzyme requiring zinc, copper, or manganese as a co-factor was reduced in lame cows. Hoof hardness and resilience were also lower in lame cows. Serum markers of joint inflammation (cartilage degradation) were significantly higher in lame cows.

(2) The same researchers then conducted a controlled university study (Zhao et al., 2015b). Forty eight Holstein cows in early to mid-lactation were assigned to one of two diet treatments based on parity, milk production, and gait score such that each treatment group (n = 24) consisted of 12 healthy (score < 3) and 12 lame (score 3 or greater) cows. Dietary treatments were the addition of 50 ppm zinc, 12 ppm copper, and 20 ppm manganese to the same basal diet, supplemented as either inorganic mineral salts or methionine-hydroxy chelates and were fed for a total of 180 days. Samples of blood, hair, and hoof horn were taken at day 0, 90, and 180 of the study and hoof hardness of the solar horn tested using a Shore Durometer. At day 90 cows received a vaccination for three strains of foot and mouth disease (FMD). Additional blood samples were taken to assess the response to vaccination. Cows were milked three times daily. Milk production and dry matter intake was recorded every 10 days and milk sampled for analysis of fat, protein, lactose and SNF.

Results: Supplementing zinc, copper, and manganese in methionine-hydroxy chelated form significantly increased serum SOD and metallothionine in both healthy and lame cows. In addition cows fed the chelated trace minerals had increased response to FMD vaccination and a reduction in serum markers for inflammation. Hoof hardness was increased in cows fed chelated trace minerals by day 180 with a trend for improvement by day 90. Results suggested that using a more bioavailable source of trace minerals improved hoof quality and helped reverse the inflammatory effects of lameness observed in the previous study.

SUMMARY

Feeding smarter not harder starts with setting specific, measurable, and attainable goals for the nutrition program. Secondly feeding management needs to be addressed in terms of manufacturing, delivery, and actual consumption of the diet (including water). Thirdly novel product forms can be assessed as sources of essential nutrients to support overall cow health and performance. Using this three-phase approach can lead to improvements in herd performance and profitability.

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Zhao, X. J., Z. P. Li, J. H. Wang, X. M. Xing, Z. Y. Wang, L. Wang, and Z. H. Wang. 2015b. Effects of chelated Zn/Cu/Mn on redox status, immune responses and hoof health in lactating Holstein cows. J. Vet. Sci. June (Epub ahead of paper).

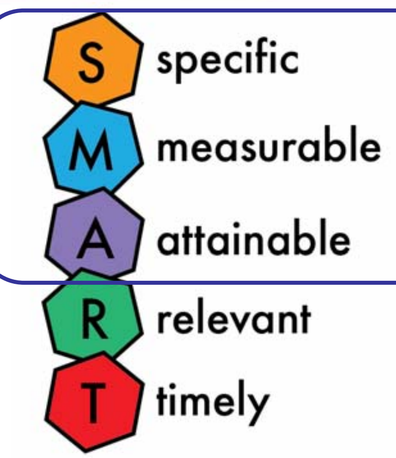
Feed Smarter Not Harder
Finding Lost Milk in the Feeding Program

Dr. Will Seymour, PAS, Dipl. ACAN,
Ruminant Technical Manager, Novus International

NOVUS

1

S.M.A.R.T Goals



G. Doran, 1981

NOVUS

2

We Must Set Goals

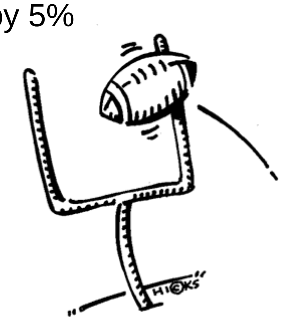
- Feeding with a goal
  - To maintain the business
  - To show improvement in herd performance/health
  - To improve IOFC

NOVUS

3

Set Smart Goals

- Feeding with a specific, measureable goal
  - To increase milk component yield by 1/4 lb /cow/day
  - To reduce fresh cow treatments by 10%
  - To reduce involuntary culling by 5%



NOVUS

4

Goal: Take $10/ton Out of Feed Cost

- Feeding rate of mix (?): 10 lb/cow/day

  Save: $10/ton x 10/2000 = $.05 per cow/day
- What if we lose 1 point in fat test?
  - 70 lbs milk
  - 3.7 vs. 3.6% fat test

  Lose .07 lbs fat @ $2.75 per pound

  Lose $.19/cow/day - $.05 saved = (-$.14/cow/d)

NOVUS 5

The High Cost of Cutting Feed Costs

Effects[1]	Time Frame	Response	Cost $/Cow/ Day
Short Term	~1 month	Decreased fat/protein yields	$.15 - $.30
Medium Term	2 to 4 months	Sick cows, higher SCC	$.10 - $.35
Long Term	5 to 9 months	Reproduction, hoof health	$.10 - $.35

[1]Loss of 1-2 points fat or protein; increase of 5-10 cows treated; 5-10 open cows; 5-10 lame cows/100 calvings (Hutjens, 2015)

NOVUS 6

What is Marginal (Lost) Milk?

Milk Yield	70 lbs/cow/day	75 lbs/cow/day	
Milk Income, $/cow/day	$11.90	$12.75	+ $.85
Maintenance Feed Cost, $/cow/day	$2.00	$2.00	
Marginal Feed Cost, $/cow/day	$4.67	$5.00	($.33)
Total Feed Cost, $/cow/day	$6.67	$7.00	
IOFC, $/cow/day	$5.23	$5.75	+ $.52

$17/CWT milk; $.133/lb DM;
50 lb DMI; 15 lb DM = Maintenance

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The Power of Marginal Milk

- 1 lb of marginal milk is worth $.10 per cow/day in additional net income

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The Search for Marginal (Lost) Milk

- Feeding management
- Cow Health, Reproduction

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Feeding Management Goals

- Achieve a consistent, balanced flow of nutrients to the mammary gland.
- Allow each cow to reach her production potential.
- Manufacture and feed the TMR accurately and consistently.

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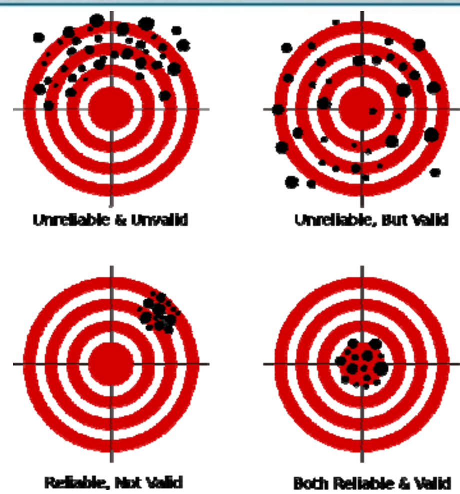
On-Farm Feed Manufacturing

Dr. Mike Brouk, Kansas State University

- $0.15 to $0.22 per cow per day lost due to deviations from batch formula.
- TMR tracking devices
- Accuracy of feeding equipment
- SOP for feeders



$26 vs $16 CWT?

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Feeding Variations on CA Dairies

Feeding sequence

Dropping order by pen - variation along the week

Seq	Wed	Thr	Fri	Sat	Sun	Mon
1	5 - 7	13 - 5 - 14	14 - 15	5 - 7	15	5 - 7
2	14 - 5 - 13	14 - 15	13 - 5 - 14	13 - 5 - 14	5 - 7	13 - 5
3	14 - 15	5 - 7	7 - 5	14 - 15	13 - 5	14
4	_	_	_	_	14	15

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Trillo et al., 2015, ADSA/ASAS Ann. Mtg. M304

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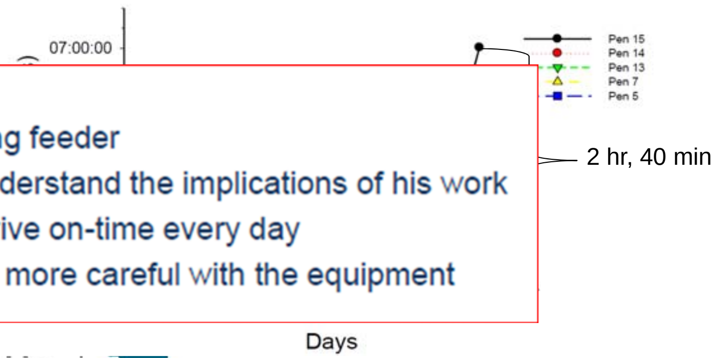
Feeding Variations on CA Dairies

First drop: delivery time



Dairy 2

- Training feeder
  - Understand the implications of his work
  - Arrive on-time every day
  - Be more careful with the equipment

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Trillo et al., 2015, ADSA/ASAS Ann. Mtg. M304

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Ration Software is a Tool

95 lbs; 3.6% F; 3.0% TP
80 DIM; Lact 2; 1500 lb

	Solution A, lb DM	Solution B, lb DM	Cost, $/ton
Corn Silage, Pr.	25.6	25.6	50
Alfalfa Hay (25/35)	5.0	5.0	245
Alfalfa Hay (17/46)	5.0	5.0	200
WBG	4.0	4.0	35
Corn, fine	3.0	3.0	150
Corn, flaked	5.5	5.9	170
SBM 47.5	2.4	2.0	341
WCS, lint	3.0	3.0	305
DDG, ethanol	3.0	3.0	145
Canola, expeller	1.7	1.7	260
Total	58.2 ($5.59/d)	58.2 ($5.56/d)	

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Cow Eating or Lying Down Ruminating

Feeding Management
22 Commercial Free-Stall Herds

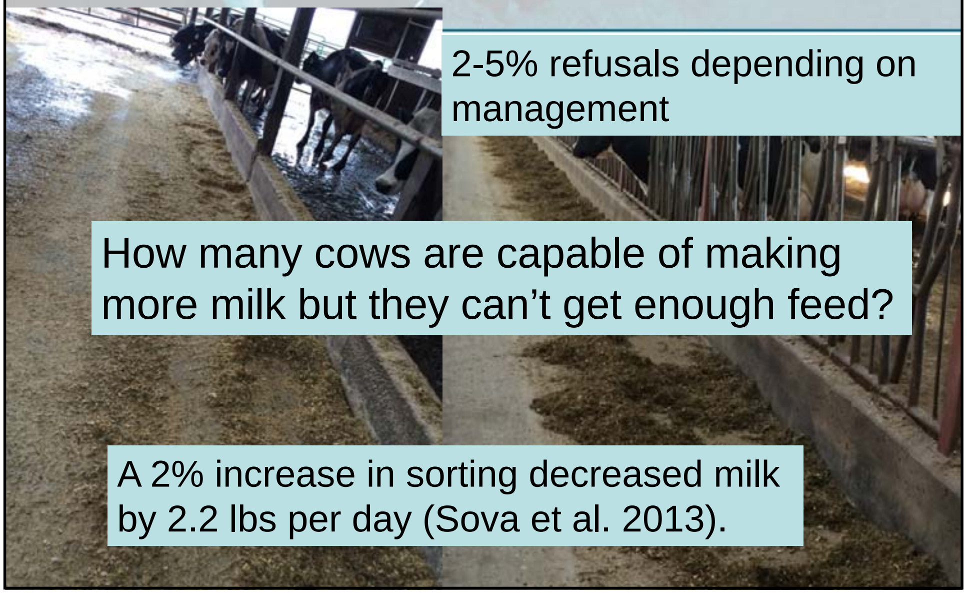
- Feeding Frequency: 2X vs 1X
  - + 3.1 lbs dry matter intake
  - + 4.4 lbs test day milk

Net $ Return: 2:1

21 inches bunk space (14-39 inch range)
100% stocking density (71-117%)
3.5% refusals (0.9 – 9.3%)

Sova, 2013, Univ. Guelph

Feed Availability and Edibility



2-5% refusals depending on management

How many cows are capable of making more milk but they can't get enough feed?

A 2% increase in sorting decreased milk by 2.2 lbs per day (Sova et al. 2013).

Timing of Feed Push Ups

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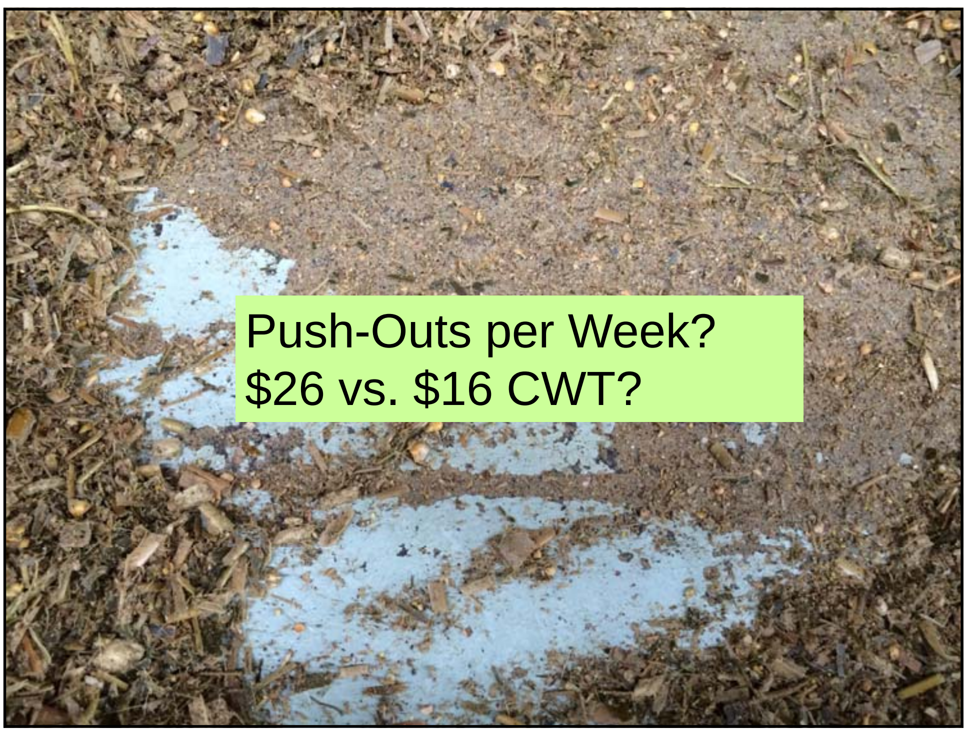
Push feed within 1 hour of feeding



Push-Outs per Week?
$26 vs. $16 CWT?

Clean Water

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Water Access

1 inch additional linear water space = + 2.0 lbs of milk/cow/day

Sova, 2013; Univ. Guelph Study
Avg. water space: 2.8 inch/cow
(1.5-4.6 inch/cow)

Benchmark Region	% of dairies in benchmark with < 3.5 in/cow
California	50%
Midwest	90%
Northeast	87%
Open Lot	50%
Canada	87%

Novus C.O.W.S. benchmark data

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Water Access, Cross-Overs

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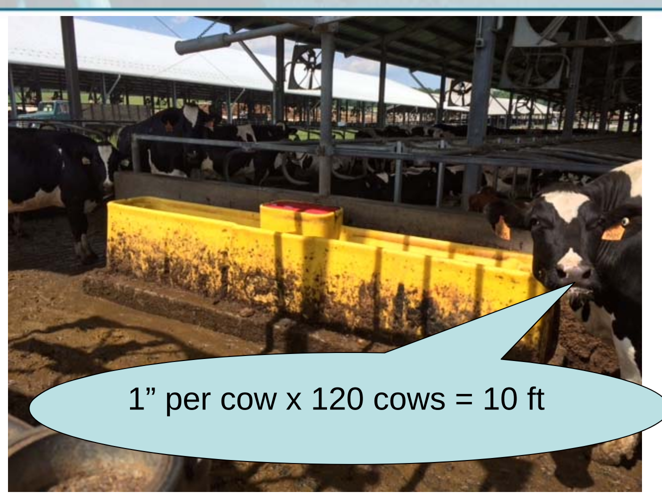
Water Linear Space



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Do Specific Nutrients Affect …….?

- Immune Function?
- Hoof Health?
- Reproduction?

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Why Use Organic Trace Minerals?
(Dr. Tom Overton)

- Improved reproductive performance
- Decreased lameness/improved foot health
- Decreased disease incidence
- Reduced somatic cell count

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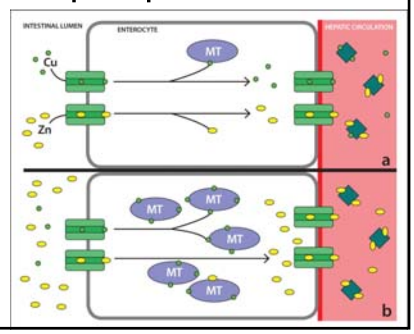
How Would OTM Improve Performance?

- Greater rumen stability
  - Shielded from antagonists (SO_4, Mo, Fe, soil)
- Greater intestinal absorption
  - Access to specific metal transport proteins



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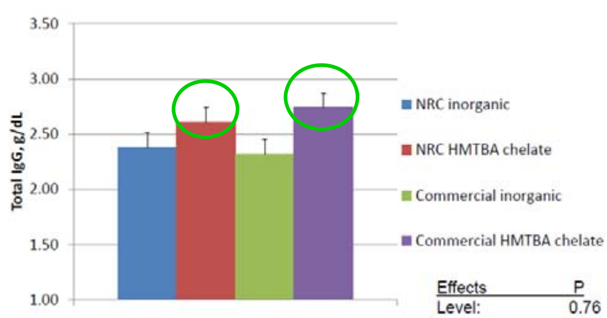
Improved Immune Function

Plasma Total IgG (overall period)



Effects	P
Level:	0.76
Source:	0.01
Level x source:	0.43

Yasui et al., 2009. J. Dairy Sci. 92(E. Suppl. 1):562.

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Hoof Health

Paint brush sole haemorrhages and white line disease.

Lamintic rings – these are the result of an outbreak of acute laminitis approximately two months previously.

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Hoof Health

Biol Trace Elem Res (2015) 164:43–49
DOI 10.1007/s12011-014-0207-1

Oxidative Stress and Imbalance of Mineral Metabolism Contribute to Lameness in Dairy Cows

Xue-Jun Zhao • Xin-Yu Wang • Jun-Hong Wang •
Zhen-Yong Wang • Lin Wang • Zhong-Hua Wang

- 60 day study
- Commercial dairy
- 20 healthy, 20 lame cows

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Trace Mineral and Oxidative Status in Lame vs. Healthy Cows

	Healthy Cows	Lame Cows	P value
SOD (U/mL)	55.0	50.8	0.05
MDA (nmol/ml)	5.4	6.4	0.02
Hoof Zn,(mg/kg)	58.8	54.6	0.04
Hoof Cu,(mg/kg)	9.73	7.48	0.04
Hoof Hardness[1]	30.2	27.7	0.009
CTX II (ng/ml)	104.1	112.9	0.08
COMP (ng/ml)	60.0	68.2	0.04

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[1]Shore Durometer, N/mm^2 Zhao et al., 2015. 31

Effect of chelated Zn/Cu/Mn on redox state, immune response and hoof health

- 180 day study, 48 multiparous Holstein cows
  - 24 per treatment; 12 healthy and 12 lame cows
- Control: 50 ppm Zn, 12 ppm Cu, 20 ppm Mn added as sulfate salts
- Treatment: 50 ppm Zn, 12 ppm Cu, 20 ppm Mn added as metal HMTBa chelates (Mintrex).
- Serum, hair and hoof samples collected 0, 90 and 180 days
- Milk yield and composition

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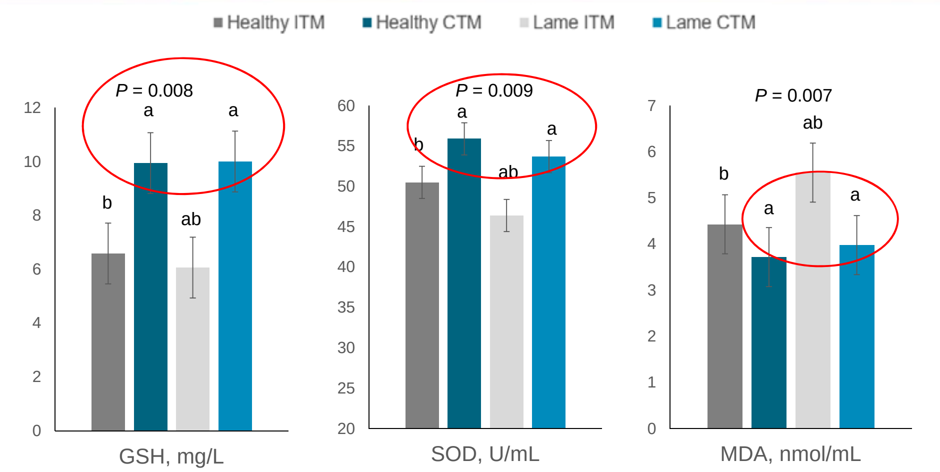
Zhao et al., 2015 32

Effect of TM Source on Antioxidant Status of Dairy Cows



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Zhao et al., 2015

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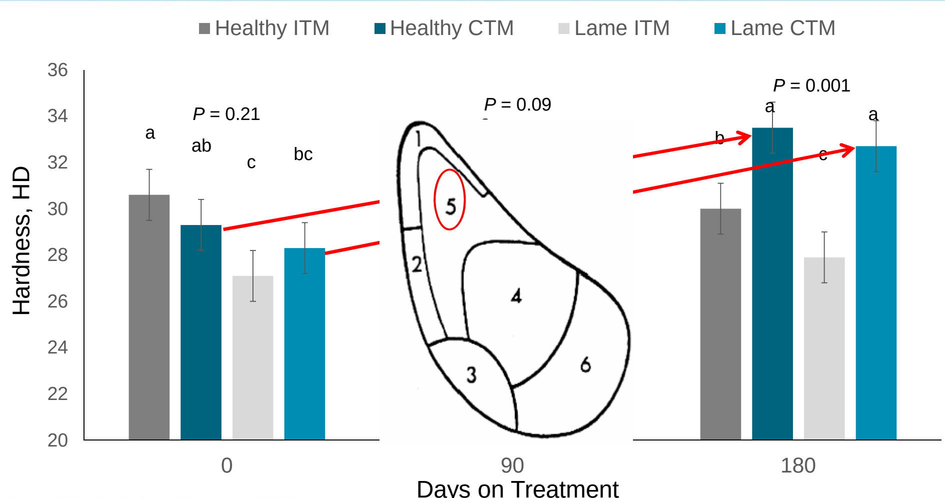
Effect of TM Source on Hoof Hardness (Shore Durometer)



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Zhao et al., 2015

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Effects of CTM on Gait Score[1]

Day 180	Lame Cows, Sulfates	Lame Cows, CTM
Gait Score <3	1	5
Gait Score 3 or greater	11	7

[1]Initial gait score was 3 or greater for all cows in these groups at Day 0 of the study

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Value of Feeding Organic Trace Minerals

- Organic trace minerals are used to improve trace mineral bioavailability to the cow.
- Higher bioavailability is reflected in improved immune function, antioxidant status, hoof health.
- These improvements add value: healthier cows, improved reproduction and reduced culling.

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Feeding Smarter Not Harder

1. Set S.M.A.R.T. goals
2. Evaluate and address feeding management issues (find lost milk)
3. Know what you are feeding and why

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Thank You

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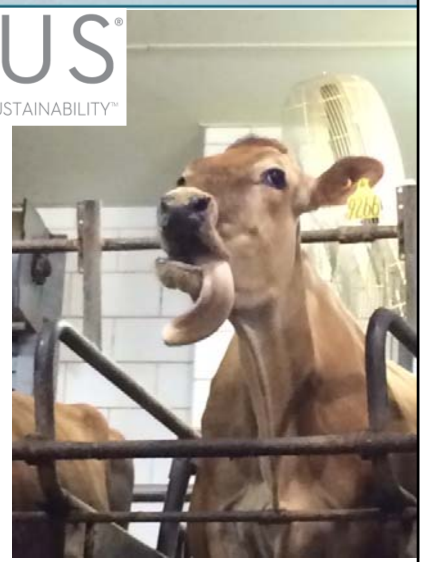

Basic Concepts and Practical Application of Vitamin and Trace Mineral Nutrition in Dairy Cows

The Concept of an Essential Nutrient: An essential nutrient is one that (1) plays a unique role(s) in metabolism and in maintaining normal physiological functions and (2) cannot be synthesized by the body at all, or not in sufficient quantities to meet physiological requirements, and therefore must be obtained either from the diet or from synthesis by gut microbes. The roles of essential nutrients are often confused with those of drugs. For example, if a person has Type II diabetes their physician may prescribe one of several medications to help lower blood glucose. The popular concept is that for Problem A you select one of several remedies; "they all do the same thing." This is NOT the concept of an essential nutrient. Essential nutrients do in some cases have overlapping functions, in the same way that engineers design airplanes to have overlapping systems, so that in the event of a failure of one system, another system can partially compensate. That does not mean that the first system can be replaced by the second. In some cases, and under less than ideal circumstances, one essential nutrient may partially spare another, as in the case with vitamin E and selenium. However these two nutrients play distinct roles in cellular metabolism and cannot completely replace each other. Biotin and zinc are both essential for the production of healthy, functional keratinized tissues like skin, hoof horn, and the rumen epithelium. The functions of zinc and biotin are completely distinct, they cannot spare each other to any significant extent, and in fact the best results may be obtained when they are supplemented together.

The Concept of Limiting Nutrients: The concept of a limiting nutrient is basic to the field of nutrition. For any given dietary situation a single essential nutrient may be limiting, or multiple essential nutrients may be co-limiting. Limitation simply means that the supply of a given nutrient to a given tissue or organ is limiting the function or output of that organ or body system. For example vitamin A is required to form the visual pigment in the eyes that allow us to see. If the supply of vitamin A is limiting (deficient) the production of visual pigment will be reduced to the point where vision is impaired. The first sign of this deficiency is night blindness, due to the loss of visual pigment in the rod cells of the retina. A nutrient may also be locally limiting, as in the case of certain nutrients required by the hoof tissue. In this case a reduction of blood flow to the extremity can create a local deficiency of essential nutrients that can in turn reduce the quality of hoof horn and increase the incidence of hoof lesions and lameness.

The Concept of Bioavailability: Nutrient bioavailability broadly refers to the proportion of a nutrient that is absorbed from the diet and used for normal physiological functions.

Essential Trace Nutrients for Dairy Cattle:

Dairy cattle require the same vitamins and trace elements as humans and other mammals. However the rumen microbial fermentation supplies a significant amount of water soluble vitamins to the host (cow). In some cases additional supplementation is beneficial, although some water soluble vitamins are degraded to a significant extent by rumen microbes. Fat soluble vitamins A, D, and E are derived naturally from beta-carotene (vitamin A), sunlight (vitamin D), and naturally occurring vitamin E. Fresh forages are rich in beta carotene and vitamin E activity, however the levels decline with maturity of the forage and during storage. Due to the small quantities required and potential losses in the rumen vitamin A and D are typically supplied in the form of a stabilized, spray-dried beadlet. Vitamin E is more rumen stable than vitamin A and D and is often provided dispersed on fine silica. It is important that vitamin and trace mineral product forms flow freely and disperse completely in feed mixes.

Trace elements required by dairy cattle are found in feeds, soil, and water, as are several potential antagonists of trace element absorption (iron, sulfur, molybdenum, clays, and fiber). Antagonists may reduce the net absorption of both endogenous and supplemental trace minerals in the diet. For this reason a "safety factor" is often used when formulating dairy rations. Absorption of trace elements can be understood based on their chemistry. Absorption of the positively charged trace elements: zinc, copper, manganese, and iron are generally regulated at the gut level, while the negatively charged elements iodine and selenium are regulated primarily through urinary excretion. Antagonisms can occur among the positively charged trace elements at the site of absorption (small intestine). There can be differences in gut absorption of iodine and selenium due to chemical forms (inorganic vs. organic). Cobalt is a special case in that it is only required as component of vitamin B_{12}, the largest and most complex of the vitamins. In ruminants vitamin B_{12} is synthesized by rumen bacteria, so cobalt bioavailability is related to how well rumen microbes are able to incorporate a given form of cobalt into vitamin B_{12}. High grain diets and subclinical acidosis may interfere with this synthesis.

<u>Steps in Vitamin and Trace Mineral Formulation:</u>

1. <u>Assessment:</u> Step one is to assess the animals, their requirements and their nutrient status and determine the optimum level of supplementation. The animal type, age, stage, and level of production will determine the NRC requirements. Visual assessment of the cattle and an oral history of animal health and production from the herd manager can be used for a gross assessment of trace nutrient status, i.e. are there ongoing health or reproductive problems? Is production (growth or milk yield) up to expectations? Forage analysis and sometimes water analysis is used to infer the presence of antagonists (high iron, sulfates, chlorides, molybdenum, ash) that may make it wise to add an additional safety factor(s) to the diet formulation.
2. <u>Formulation:</u> In this the animal description (age, body weight, stage and level of production etc.) is input into a ration formulation system. Dry matter intake will be estimated by the formulation program. Dry matter intake is a crucial input value and the most difficult to assess for a specific group of animals. Vitamin requirements are usually expressed in quantity per day (i.e. International Units, grams or milligrams per cow per day). Trace mineral requirements however have been expressed largely as diet concentration (percent or parts per million). Experts in the field of trace mineral nutrition are strongly recommending that trace minerals be expressed as quantity (milligrams) of absorbable trace mineral per cow per day in formulation. This reiterates the importance of dry matter intake (for instance in close-up dry cow and fresh cow diets) as well as net absorption (bioavailability) of the trace minerals in the ration. Safety factors (addition of trace nutrients above base requirements) are used in most dairy rations and are based on the judgment of the nutritionist and responses of the animals.
3. <u>Re-Assessment:</u> Vitamins and trace minerals are required by and affect multiple body systems such as the immune system, reproductive system, circulatory system, liver, and tissue metabolism. Many of the effects of dietary vitamins and trace minerals are long term and so an

appropriate amount of time must be allowed to correctly assess the effects of a change in vitamin or trace mineral supplementation on dairy cattle or any livestock. Effects on immunity might be observable within 30 to 60 days, for example in terms of clinical mastitis or other infectious disease, especially around the time of calving. Changes in reproduction or hoof health will take considerably longer, 3 to 6 months. Beyond 6 months other seasonal and management factors make it more difficult to assess responses to a change in micronutrient supplementation.

An Example of Micronutrient Formulation in a Dairy Ration

1. Assessment: We have been asked to formulate a ration for a mixed group of Holstein cows containing both first-calf heifers and older cows. Body weight is estimated at 1450 pounds on average. Days in milk ranges from one week fresh to ~200 days in milk. Based on calving history most cows are between 30 and 150 days milk (estimated average 90 days in milk). Milk yield average is 85 lbs for this group and 70 lbs for the herd overall with a 3.6% fat test and 3.0% protein. Somatic cell count averages 300,000 but has been up and down in recent months. Fresh cows are generally getting off to a good start although clinical mastitis and metritis have been higher than in previous years, including some heifers. Pregnancy rate has slipped during recent months with lower first service conception rates.

   Forages consist of corn silage (50#), 1st cutting alfalfa-grass haylage (12.5#), and 2nd cutting grass silage (10.5#). The remainder of the ration consists of wet distiller's grains (20#) and a grain mix (corn, soybean meal, canola meal, soy hulls, wheat midds, minerals, and vitamins). Current ration formulation is based on 50 lbs dry matter intake. Forage analysis indicates that soil contamination may be an issue in the hay crop silages (ash 10 to 12% DM, iron 400 ppm). Well water supply is ample. Water has not been analyzed for quality.

2. Discussion with herd management: Although we have been asked to formulate the lactation ration we need to ask some questions about the dry cow and heifer programs to assess that trace mineral and vitamin supplementation and general nutritional needs are being met. Recent data from diagnostic lab field investigations indicate first-calf heifers may calve with marginal trace mineral status due to low or marginal supplementation during the late rearing period. If our discussion leads us to question the trace mineral or vitamin status of cows at calving we may need to increase supplementation to dry cows/springing heifers or in the lactation ration. The primary concern appears to be udder health/mastitis/SCC which could be due several non-nutritional factors that should be explored (cleanliness, milking procedure, dry cow treatment). Reduced conception rates may well be secondary to mastitis, although it may also indicate marginal trace nutrient status in early lactation.
3. Formulation:
   a. A first step will be to obtain as sound an estimate of actual dry matter intake as possible and an idea of how much this varies day to day, week to week. This will require learning about feed mixing and ration delivery on the farm, how amounts fed are adjusted and whether dry matters are being measured on wet feeds and adjusted for in the batch

mix. We may need to ask that refusals be weighed back and that will require us learning about the feeder daily schedules to determine if this is feasible. This sounds like a lot of work but learning more about feeding practices gives us a much better chance of a successful outcome. Trace minerals and vitamins are required in very small quantities so it is important to ensure that these micronutrients are fed as accurately as possible over time.

b. Next we should review the trace mineral content of forages and byproduct feeds. These are the most variable sources of trace minerals. Ash content of forages should be included to account for soil contamination. The presence of antagonists such as sulfur (>0.4%), iron (>400 ppm), molybdenum (>2.0 ppm) should be assessed. Duplicate (and independent) samples of forages and byproducts are recommended for trace mineral analysis. It may be a good idea to take water samples for quality analysis.

c. Based on knowledge of the makeup of the group and estimated dry matter intake we can next formulate a ration. Cow data (parity, body weight, milk yield) will be used by most ration programs to predict dry matter intake and nutrient requirements. A lead factor should be applied either to the level of milk production (upward) or predicted dry matter intake (downward) to compensate for cows less than 50 days in milk in the pen. One standard deviation has been determined to be a good guideline for milk yield, but we rarely know the average and standard deviation for milk yield by pen. Therefore it becomes a judgment call whether to set milk production at 10 to 15 pounds above the pen average. This should be reviewed regularly as the average milk yield and days in milk of the pen changes over time.

d. The last step would be to establish a safety factor for vitamin and trace mineral requirements and to select sources of these micronutrients.
    i. Forage trace mineral and ash content
    ii. Presence of antagonists in water
    iii. Other mitigating circumstances such as health challenges, mycotoxins in feed, large variation of cow age, stage of lactation, production level within pen.

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Practical Aspects of Vitamin and Trace Mineral Fortification

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Vitamins and Trace Minerals

TABLE 1
The trace element nutrients

Definitely Essential
Iron
Zinc
Copper
Manganese
Iodine
Selenium
Molybdenum
Cobalt*
Chromium
Possibly Essential
Silicon
Nickel
Vanadium
Lithium
Tin
Arsenic
Beneficial
Fluorine

* Cobalt's essential role is as a component of vitamin B_{12}.

TABLE 2
The vitamins

Fat Soluble
Vitamin A
Vitamin D
Vitamin E
Vitamin K
Water Soluble
Thiamin
Riboflavin
Niacin
Vitamin B_6 (pyridoxine)
Biotin
Pantothenic acid
Folic acid
Vitamin B_{12} (cobalamin)
Vitamin C (ascorbic acid)

Burk and Solomons, 1985

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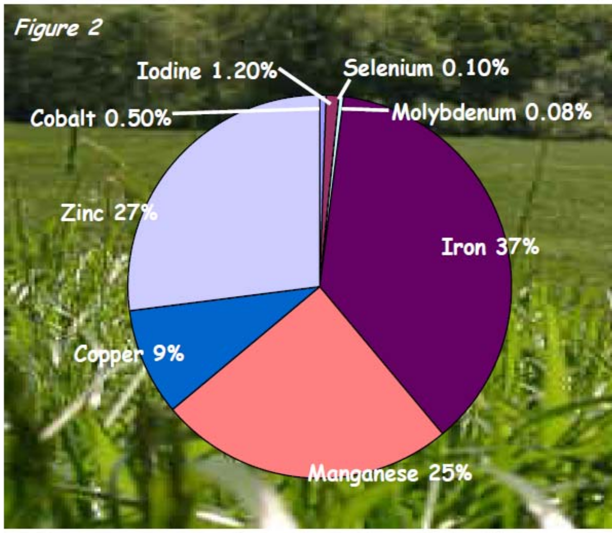
Relative requirements of trace minerals in cattle diets (D. Atherton; Thomson and Joseph, LTD)



ROLE:

- FERTILITY
  Mn, Cu, I, Se
- HEALTH
  Se, Cu, Zn, Mn, Co, I
- FEET & TEAT
  Zn, Se
- ENERGY
  Fe, Cu, Co, I
- GROWTH
  Zn, Se, Co, Cu

Physiological Functions of Trace Minerals

- Immune system
  - Antioxidant enzymes SOD and GSH reductase are essential for function of white blood cells (Zn, Cu, Mn, Se)
- Tissue integrity, epithelial barriers
  - Zinc, copper, manganese
  - Skin, hoof, teat canal, rumen epithelia, intestine
- Energy metabolism
  - Pancreatic function, insulin stability and sensitivity
  - Zinc, manganese, selenium

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Functions of the Vitamins (Bill Weiss, Ohio State)

	General function
Fat-soluble vitamins	
Vitamin A	Gene regulation, immunity, vision
Vitamin D	Ca and P metabolism, gene regulation
Vitamin E	Antioxidant
Vitamin K	Blood clotting
Water-soluble vitamins	
Biotin	Carbohydrate, fat, and protein metabolism
Choline	Fat metabolism and transport
Folacin (folic acid)	Nucleic and amino acid metabolism
Niacin	Energy metabolism
Pantothenic acid	Carbohydrate and fat metabolism
Riboflavin	Energy metabolism
Thiamin	Carbohydrate and protein metabolism
Pyridoxine (vitamin B6)	Amino acid metabolism
Vitamin B12	Nucleic and amino acid metabolism
Vitamin C	Antioxidant, amino acid metabolism

Vitamins and Trace Minerals

- Vitamins are organic compounds
- Trace minerals are inorganic elements
- They often work together
  - Zinc and Vitamin A
  - Biotin, Manganese and Choline
  - Selenium and Vitamin E

Vitamin Supplies

- Green pasture is a good source of vitamin A (beta-carotene) and vitamin E.
- Vitamin levels in forage decline with maturity and storage.
- Except for green pasture and prime hay the vitamin content of base feeds/forages is not considered.

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Vitamin Supplies and Storage

- Fat soluble vitamins are unstable to oxidation
  Vitamin A > Vitamin D > Vitamin E
- Commercial forms are stabilized
  - Spray-dried, cross-linked beadlets with antioxidant
  - Vitamin E oil adsorbed on fine silica
- Fat soluble vitamins are stored in the body
  - Vitamin A > Vitamin D > Vitamin E

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Vitamin Supplies and Storage

- Water soluble B-vitamins vary in stability
  - Vitamin C is the least stable
- Water soluble vitamins are not stored in the body
  - Exception is Vitamin B_{12}
  - Unlike fat soluble vitamins, B-vitamins are ~ non-toxic
- Rumen synthesis/degradation of B-vitamins is a major factor and only partly understood.
  - Biotin, thiamine escape rumen in significant amounts

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Practical Levels of Vitamin Fortification[1]

Vitamin	Supplemental, per cow per day	Rationale	Toxic Threshold
Vitamin A, IU	125,000-150,000	Immunity	500,000 (?)
Vitamin D, IU	30,000-40,000	Ca metabolism, immunity	50,000
Vitamin E, IU	500-3000	Udder health	50,000 (?)
Biotin, mg	20	Hoof health	Not a concern
Niacin, grams	6-12	Fat metabolism	Not a concern
Choline, grams	15	Liver function	Not likely
Beta-carotene, mg	300-600	Reproduction	Check status

[1]Various sources including the author, DSM Nutritional Products and Dr. Bill Weiss.

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Practical Levels of Vitamin Fortification Notes[1]

Vitamin	Notes
Vitamin A	150,000 vs 75,000: better immune function (Yan et al., 2014)
Vitamin E	Dry period 1,000 IU; Transition 2-3,000; Lactation 500-750 IU
Niacin	Needs rumen protection due to variable stability
Choline	Needs rumen protection
Beta carotene	Cows with low plasma status are target; 600 mg/d transition

Other B-vitamins (folic acid, B_{12}, B_6 thiamine, pantothenic acid) may be beneficial but more data is needed to make recommendations for routine supplementation.

[1]Various sources including the author, DSM Nutritional Products and Dr. Bill Weiss.

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Fun With Trace Mineral Fortification

- Trace minerals are chemically stable inorganic elements
- But they are subject to antagonisms
- Levels in feeds and forages vary
- Bioavailability varies among forms
- *NRC 2001 requirements are based on absorbed trace minerals, not total trace minerals in diet*

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Soils Affect Trace Minerals in Forages

- Acid soil (pH < 5.5-5.8) increases plant uptake of copper, zinc, manganese, iron and cobalt.
- Alkaline soil (pH > 7.2-7.5) decreases copper, zinc, manganese, iron and cobalt but increases molybdenum uptake.
- Correct pH range for forage growth moderates trace mineral levels.

Forage Sampling and Analysis[1]

- Sampling error is the greatest enemy
- The second sample does more to reduce uncertainty than any of the subsequent samples
- "Sample twice, formulate once."

[1]Weiss et al., Ohio State; Kohn, Univ. Maryland

Number of Silage Samples Analyzed
Dairy One Lab Data; 2014-15 Forage Year

	Corn Silage	MML Silage	MMG Silage
October '14	480	262	411
November '14	620	238	405
December '14	617	213	385
January '15	440	182	351
February '15	266	115	188
March '15	331	180	270
Total	2754	1190	2010

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N.Y. Silage Samples Analyzed for Trace Minerals, Dairy One Lab, 2014-15 Forage Year

	Corn Silage	MML Silage	MMG Silage
October '14	19	13	12
November '14	25	12	34
December '14	24	14	15
January '15	10	5	17
February '15	13	8	9
March '15	14	9	6
Total	105	61	93
Percentage of all samples	3.8%	5.1%	4.6%

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Ash: Soil Contamination Issues

- Wasted space in ration
  50 lbs DMI x .01 = 0.5 lb dry matter
- Antagonists
  – Iron, clay, molybdenum
- Skewing of trace mineral values
- Iron and titanium are markers
  – Titanium not absorbed by plants

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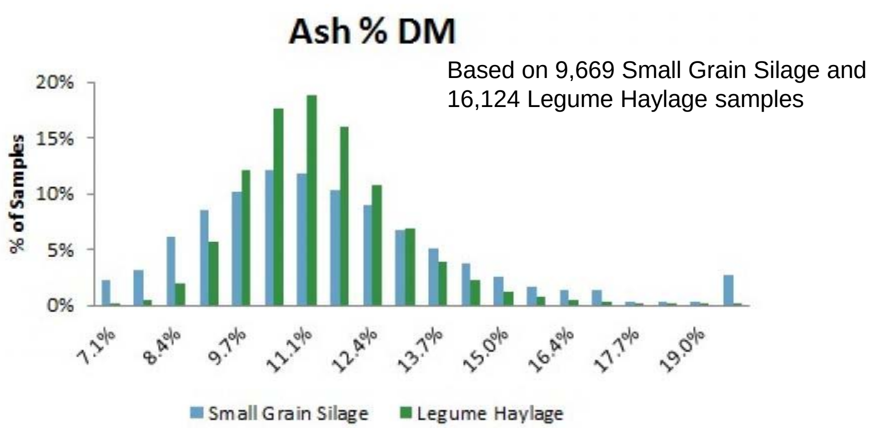
Ash contamination an issue in hay crop and small grain silages



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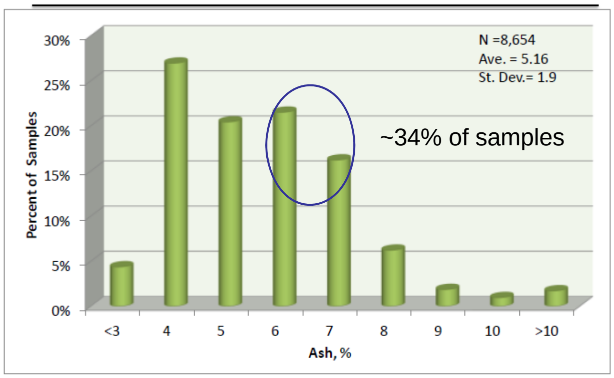
Undersander, Univ. Wisconsin

Ash Content of Corn Silages

Distribution of Ash in Corn Silage, CVAS 2010-2011



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R. Ward, CVAS

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Ash Values in NY Silages, 2014-2015

Ash (n=5,954)	October	November	December	January	February	March
Corn Silage, avg.	3.81	3.92	3.74	3.64	3.61	3.73
Corn Silage, SD	0.87	1.11	0.86	0.87	1.44	0.78
MML Silage, avg.	10.72	10.8	10.56	10.34	10.16	10.63
MML Silage, SD	1.44	1.78	1.64	1.53	1.36	1.47
MMG Silage, avg.	9.21	9.06	9.05	8.88	8.74	9.31
MMG Silage, SD	1.65	1.63	1.53	1.48	1.58	1.68

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Iron Values in NY Silages, 2014-2015

Iron (n=259)	October	November	December	January	February	March
Corn Silage, avg.	125.4	89.9	105.8	97.6	112.7	102
Corn Silage, SD	62.3	36	55.8	51.5	51	98.5
MML Silage, avg.	316.4	565.5	408.9	517	445.3	277.8
MML Silage, SD	216.1	469	240.1	450	280.5	128.6
MMG Silage, avg.	464.3	268.3	400	353.7	281.4	272.7
MMG Silage, SD	695	144.7	446	299.9	267.2	92.3

Fe, ppm[1]	Low	Medium	High
Corn Silage	133	234	555
MML Silage	265	423	1,155
MMG Silage	219	355	850

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[1] Soil contamination; Knapp et al., 2015

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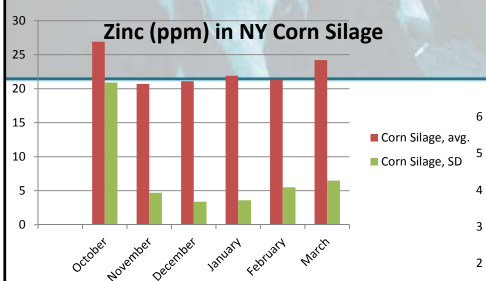
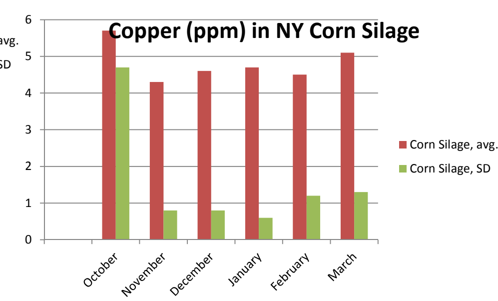
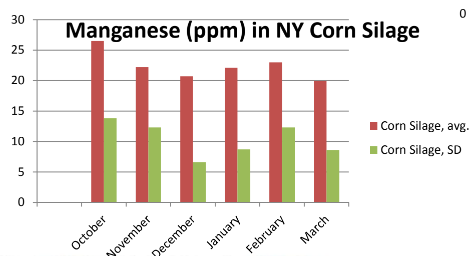
Trace minerals, corn silage, by sample month







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Dairy One Lab, 2014-2015

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Copper Values in NY Silages, 2014-2015

Copper (n=259)	October	November	December	January	February	March
Corn Silage, avg.	5.7	4.3	4.6	4.7	4.5	5.1
Corn Silage, SD	4.7	0.8	0.8	0.6	1.2	1.3
MML Silage, avg.	10.3	9.5	8.6	9.9	9.3	11.3
MML Silage, SD	1.6	2	1.4	1.4	2	6.9
MMG Silage, avg.	9.7	8.8	8.3	8.5	7.3	10.3
MMG Silage, SD	2.1	1.9	1.9	2	2.2	1.7

Corn silage 4.0 ppm
MML silage 9.0 ppm
MMG silage 8.0 ppm

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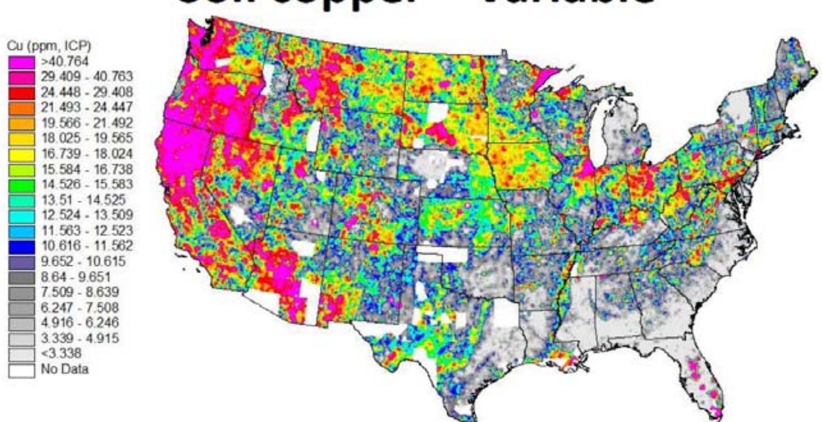
Soil Copper Levels Vary

Soil copper = Variable



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Zinc Values in NY Silages, 2014-2015

Zinc (n=259)	October	November	December	January	February	March
Corn Silage, avg.	26.9	20.7	21.1	21.9	21.3	24.2
Corn Silage, SD	20.9	4.7	3.4	3.6	5.5	6.5
MML Silage, avg.	27.4	24.4	27.2	26.5	26.1	47.3
MML Silage, SD	4.6	3.8	3.6	3.6	4.2	20
MMG Silage, avg.	31.4	30.6	27.3	30	33.3	27.2
MMG Silage, SD	9.6	5.4	5	5	11.8	4.3

Corn silage 18 ppm
MML silage 25 ppm
MMG silage 27 ppm

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Manganese Values in NY Silages, 2014-2015

Manganese (n=259)	October	November	December	January	February	March
Corn Silage, avg.	26.5	22.2	20.7	22.1	23	19.9
Corn Silage, SD	13.8	12.3	6.6	8.7	12.3	8.6
MML Silage, avg.	48.8	43.1	52.5	42.2	57.1	64.5
MML Silage, SD	9.1	15.4	25.5	25.5	20.6	54.3
MMG Silage, avg.	73.5	96.4	77.3	86.8	92.1	80.1
MMG Silage, SD	36.5	37.5	30.8	74.4	66.8	40.9

Corn silage 18
MML silage 38
MMG silage 60?

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Effect of Diet Sulfur and Molybdenum on Total Diet Copper (ppm) Needed to Meet Requirement[1]

	Dietary Sulfur (S) Concentration, Percent of DM		
Diet Mo, ppm	0.25	0.35	0.45
1	12.6 ppm	15.5 ppm	18.9 ppm
2	13.6 ppm	17.1 ppm	22.0 ppm

[1] Requirement of 12 mg/day absorbable copper for 1,500 lb cow; 77 lb/d milk; pregnant, gaining 1.1 lb/day; 50 lb/d DMI; (NRC, 2001)

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Notes on Molybdenum/Sulfur/Iron Antagonism

- Both molybdenum (Mo) and sulfur can act independently to reduce copper absorption
  - Molybdates are absorbed and bind copper in tissues
  - Sulfur can form sulfides of copper (low absorption)
- Excess iron promotes the sulfur/molybdenum antagonism on copper
  - Soy hulls, DDG, M&B meal, blood meal, some water
- High sulfur in DDG, CGF, some water sources

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Antagonists

Antagonist/Excess	Minerals Affected	Possible symptoms
Iron (Fe) >400-500 ppm	Cu, Zn, Mn, Se	Silent heats, poor conception, high SCC, reduced intake
Molybdenum/Sulfur >0.4% S, >2-5 ppm Mo	Cu, Se	Irregular cycles, poor heats and conception, high SCC

Notes

1. Iron is a pro-oxidant, excess stresses antioxidant defenses of the body.
2. Sulfur and molybdenum levels vary over time as feeds and forages change.
3. Recent Iowa State study: high S (.68 vs .24%) reduced Cu, Mn and Zn retention (Pogge et al., 2014, J. Anim. Sci. 92:2182-91).

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Water

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Water Quality[1]

Table 1. General guidelines for levels of nutrients in water

Item	Level	Item	Level
Calcium, ppm	< 100	pH	6 to 8.5
Chloride, ppm	< 100	Potassium, ppm	< 20
Copper, ppm	< 0.2	Sodium, ppm	< 50
Iron*, ppm	< 0.2	Sulfur, ppm	< 50
Magnesium, ppm	< 50	Sulfate, ppm	< 125
Manganese, ppm	< 0.05	TDS, ppm	< 960
Nitrate-N, ppm	< 20	Zinc, ppm	< 5

Hardness >300?

*When analyzed using total recoverable iron, cows may tolerate higher levels of iron in water.

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[1]Dairy One Lab, Ithaca, NY; Beede, Michigan State

Survey of water on Virginia Dairy Farms

Table 1 Water quality parameters for milk house water on Virginia dairy farms

Farm	TDS, mg/L	Hardness[1]	pH	Fe[1], mg/L	Cu[1], mg/L	Mn[1], mg/L
1	252	290	7.41	0.02	0.004	0.003
2	263	1	7.62	ND[2]	0.025	ND
3	295	281	7.92	ND	0.012	0.008
4	325	351	7.73	ND	0.01	ND
5	98	67	6.54	0.46	0.20	0.027
6	59	37	5.88	0.004	0.51	0.003
7	30	25	6.63	ND	0.01	ND
8	64	47	6.48	0.06	0.009	0.046
9	85	53	7.31	ND	0.014	0.0003
10	131	93	6.68	0.01	0.005	0.033
11	167	215	7.96	ND	ND	0.0004
12	84	65	6.24	ND	0.013	0.23
13	142	210	8.13	0.04	0.41	0.04

[1]Hardness reported in mg/L as $CaCO_3$; Fe = iron; Cu = copper; Mn = manganese.
[2]ND = not detected; method detection levels were: 0.004 mg/L Fe; 0.0001 mg/L Cu;

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Mann et al., 2012

Water Quality[1]

Signs of poor water intake and quality in lactating dairy cows:

- Depressed immune function - increased somatic cell count
- Increased reproductive failure - conception failure, early embryonic death, or abortions
- Increased off-feed events and erratic eating patterns

Symptoms of water-quality issues in dairy cows are:

- Health or performance issues
- Digestive upsets or scours in replacements
- Deteriorating health status of newly arrived heifers or dry cows

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[1]Dairy One Lab, Ithaca, NY; Beede, Michigan State 33

Water Quality[1]

- Sample water correctly
  - http://www.msu.edu/~beede
  - Take 2 independent samples
- Red Flags

  Iron (Fe) greater than 0.3 ppm

  (sulfate + chloride) > 250-500 ppm

  Positive coliform/E.coli test, nitrates

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[1]Dairy One Lab, Ithaca, NY; Beede, Michigan State 34

Practical Fortification Guidelines

- Be aware of multiple sources of variation
  - Variation in forage and feed trace minerals
  - Variation among cows in a pen
  - Uncertainty of actual variation among cows in pen
  - Variation (errors) in TMR preparation
  - Uncertainty in model predictions of requirements and absorption coefficients

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Trace minerals in base feed ingredients

- Should not ignore
- Source of both absorbable trace minerals and antagonists
  - Can be both an insurance policy and a liability
- Variation needs to be dealt with
  - Could discount values by ½ standard deviation
  - But to do that we need to have a realistic average and standard deviation for the forages being fed

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Other Issues

- Most nutritionists are working with a standard vitamin-mineral pack
- A regional/seasonal profile of forage trace minerals?
- Profile trace minerals in regional forage base and compare to NRC requirement levels
- Formulate add-pack based on this profile

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Considerations

- Cu, Zn, Mn levels in base feed ingredients
- Iron levels on hay crop silages
- Molybdenum and sulfur levels
- Copper accumulation in dairy cows
- Dry cows, heifers
- Water quality issues?
- Parasitism

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Dairy-Vitamin/Mineral Status

- Copper Excess (63%) Deficient (7%)
- Selenium Excess (69%) Deficient (6%)
- Manganese Low (45%)
- Zinc Low-deficient (26%)
- Vitamin E Deficiency
- Vitamin A Deficiency

Jeffery O. Hall, D.V.M., Ph.D., D.A.B.V.T.

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Keratinized Tissues

- Skin, hoof horn, rumen epithelium, teat canal keratin
  - First line of defense and protection
- Vitamins and trace minerals are essential
  - Zinc, copper, manganese
  - Biotin, Vitamin A

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Response Times to Changes in Vitamin and Trace Mineral Nutrition

- Infectious disease (mastitis,metritis): 30-90 days
  - depends on numbers of cows calving, new cases
- Hoof health: 60-180 days
  - turnover rates of skin < sole horn < hoof wall
- Reproduction: 60-180 days
  - how many cows are cycling? Being bred?

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Trace Mineral Formulation Problem[1]

	Required, Absorbed	Base diet TM levels	Absorbed from Base Diet	Deficit of absorbed TM	Added 1X ppm from sulfates
Copper	12 mg/d	6 ppm	6 mg/d	6 mg/d	5 ppm
Zinc	250 mg/d	25 ppm	118 mg/d	132 mg/d	28 ppm
Manganese	10 mg/d	30 ppm	5 mg/d	5 mg/d	18 ppm

23.5 kg DMI; 77 milk/day; 680 kg BWT
AC in base diet: Cu .04, Zn .15, Mn .0075
AC in TM sulfates: Cu .05, Zn .20, Mn .012

Approach adapted from Bill Weiss, Proc. Tri-State Nutrition Conf. 2015

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Trace Mineral Formulation Problem[1]

	Added 1X sulfates, ppm	Base diet TM levels	Total Diet Levels @ 1X	Add 2X Safety Factor	Total Diet with 2X Safety
Copper	5 ppm	6 ppm	11 ppm	10 ppm	16 ppm
Zinc	28 ppm	25 ppm	53 ppm	56 ppm	81 ppm
Manganese	18 ppm	30 ppm	48 ppm	36 ppm	66 ppm

23.5 kg DMI; 77 milk/day; 680 kg BWT
AC in base diet: Cu .04, Zn .15, Mn .0075
AC in TM sulfates: Cu .05, Zn .20, Mn .012

Approach adapted from Bill Weiss, Proc. Tri-State Nutrition Conf. 2015

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Other Trace Minerals

Mineral	Level (Added)	Comments
Cobalt	0.5 ppm	Adequate B_{12}
Iodine	1.0 ppm	Thyroid
Selenium	0.3 ppm	Legal limit
Chromium	0.5 ppm	Legal limit

Notes:

1. Negatively charged elements (Se, Iodine) are primarily regulated via urinary excretion rather than intestinal absorption.
2. Excess levels of selenium and iodine interfere with each other's metabolism
3. Chromium is not officially required but data supports its importance

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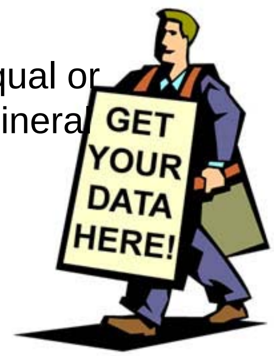
Organic Trace Minerals

- Combination of a trace element and an organic compound forming a stable bond or complex
  - In principle should have higher bioavailability
  - Bioavailability is both absorption and utilization for biochemical processes in the body
- In theory can feed less metal, get equal or greater amount of absorbed trace mineral

  More confidence = less overage



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Final Thoughts

- We should be thinking in terms of absorbed, not total trace minerals required (mg/cow/day)
  - Metabolizable trace mineral requirements
- Most ration models/programs have the 2001 NRC absorbed trace mineral requirements
- Need to consider animal requirements, status, feed variations and antagonists

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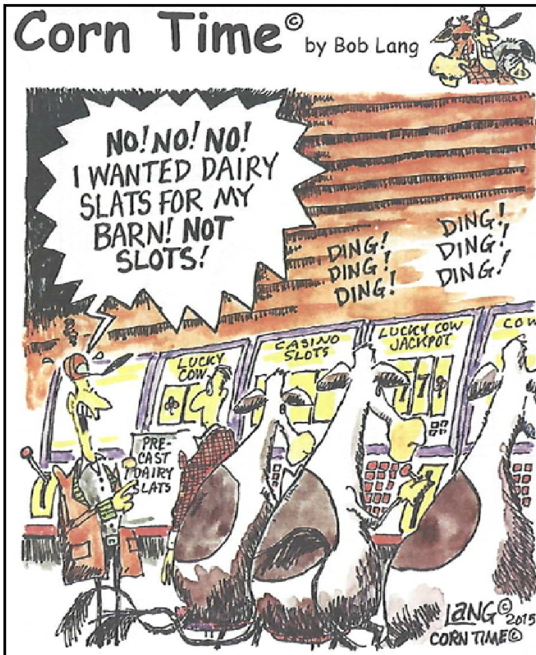

THANK YOU!

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What's new with corn silage?

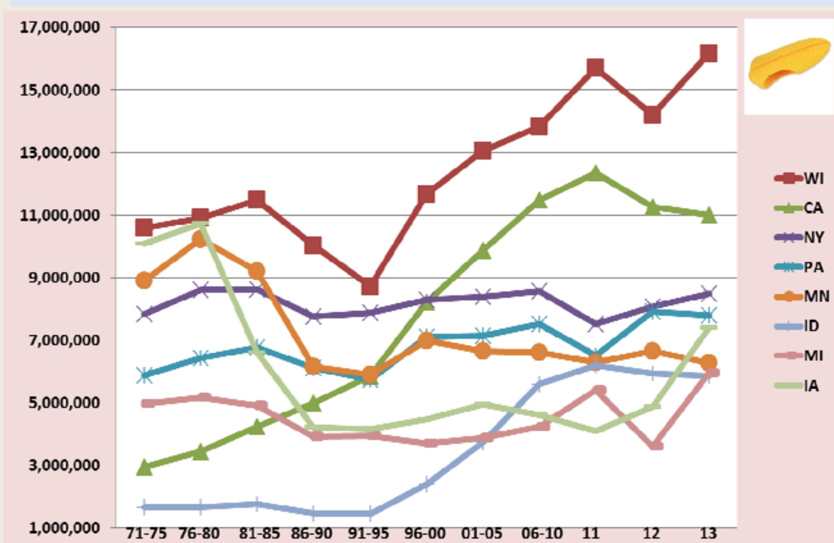
Randy Shaver and Luiz Ferraretto
Dairy Science Department

THE UNIVERSITY of WISCONSIN MADISON

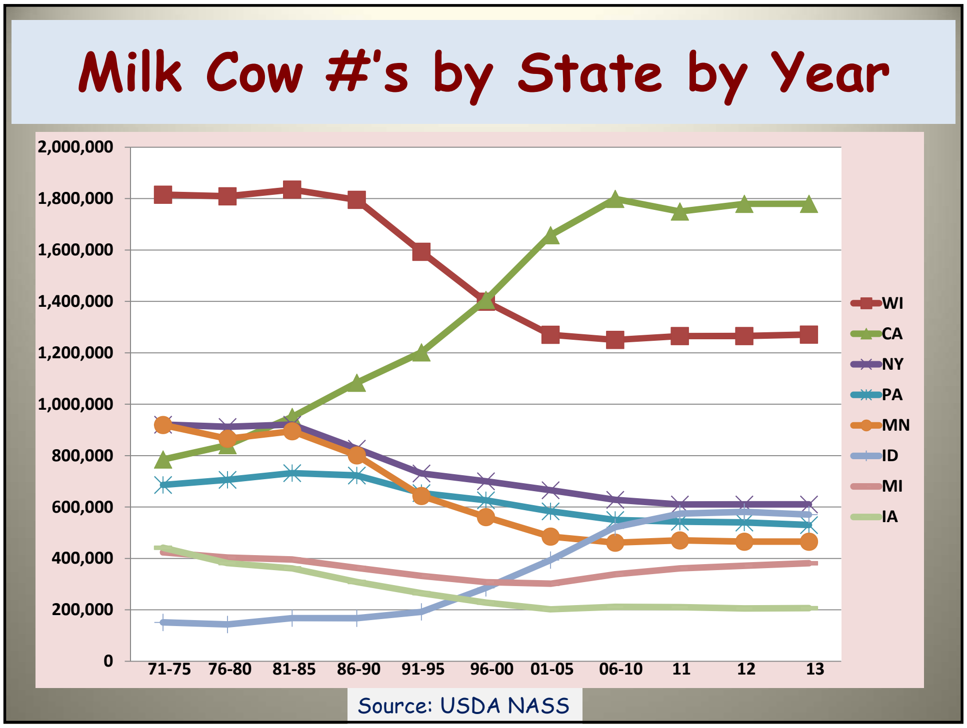
UW Extension

DEPARTMENT OF DAIRY SCIENCE
University of Wisconsin-Madison

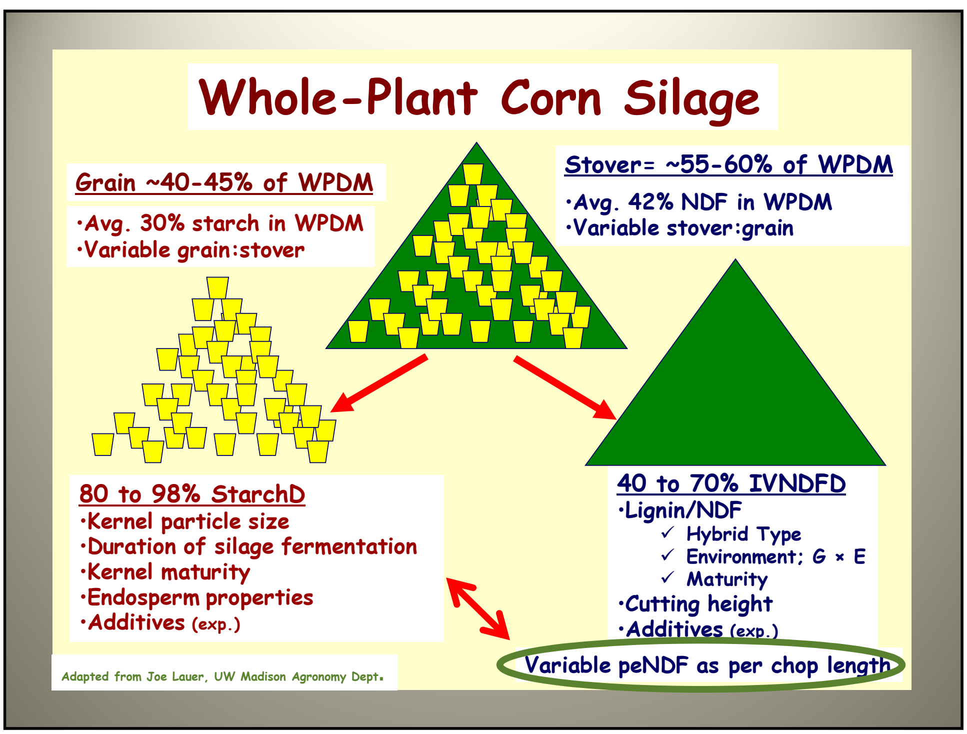
Corn Silage Tons by State by Year



Source: USDA NASS



Milk Cow #'s by State by Year
2,000,000
1,800,000
1,600,000
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
71-75
76-80
81-85
86-90
91-95
96-00
01-05
06-10
11
12
13
WI
CA
NY
PA
MN
ID
MI
IA
Source: USDA NASS



Whole-Plant Corn Silage
Grain ~40-45% of WPDM
•Avg. 30% starch in WPDM
•Variable grain:stover
Stover= ~55-60% of WPDM
•Avg. 42% NDF in WPDM
•Variable stover:grain
80 to 98% StarchD
•Kernel particle size
•Duration of silage fermentation
•Kernel maturity
•Endosperm properties
•Additives (exp.)
40 to 70% IVNDFD
•Lignin/NDF
✓ Hybrid Type
✓ Environment; G × E
✓ Maturity
•Cutting height
•Additives (exp.)
Variable peNDF as per chop length
Adapted from Joe Lauer, UW Madison Agronomy Dept.

J. Dairy Sci. 98:2662–2675
http://dx.doi.org/10.3168/jds.2014-9045

Effects of whole-plant corn silage hybrid type on intake, digestion, ruminal fermentation, and lactation performance by dairy cows through a meta-analysis

L. F. Ferraretto and R. D. Shaver[1]
Department of Dairy Science, University of Wisconsin, Madison 53706

- 162 treatments means (48 articles)
- 1995 and 2014
- Hybrids comparison

Categories

- Stalk characteristics
- Grain characteristics
- Genetically-modified hybrids

Hybrids differing in stalk characteristics

- Brown midrib (BMR) n = 30
- Conventional, dual-purpose, isogenic or low to normal fiber digestibility (CONS) n = 48
- High-fiber digestibility (HFD) n = 9
- Leafy (LFY) n = 11

Nutrient composition of stalk hybrids

Item	BMR	CONS	HFD	LFY	SEM	P-value
DM, % as fed	33.7	34.5	35.1	33.2	0.9	0.45
CP, %DM	8.0	7.8	8.1	8.0	0.2	0.20
NDF, %DM	42.3	42.6	45.0	42.3	0.8	0.09
Lignin, %DM	2.0[b]	2.8[a]	2.9[a]	2.6[a]	0.2	0.001
Starch, %DM	28.7[ab]	30.1[a]	26.7[b]	30.0[ab]	1.1	0.02

Lactation performance with stalk hybrids

Item	CONS	BMR	HFD	LFY	SEM	*P*-value
DMI, kg/d	24.0^{b}	24.9^{a}	24.6^{a}	23.7^{b}	0.4	0.001
Milk, kg/d	37.2^{c}	38.7^{a}	38.2^{ab}	37.3^{bc}	0.8	0.001
Fat, %	3.63^{a}	3.52^{b}	3.63^{ab}	3.67^{a}	0.06	0.01
MUN, mg/dL	15.0^{a}	14.0^{b}	15.1^{ab}	15.2^{a}	0.6	0.02
NDFD	42.3^{b}	44.8^{a}	47.1^{a}	41.7^{b}	1.8	0.001
TTSD	92.7^{b}	91.3^{c}	90.5^{c}	94.9^{a}	1.1	0.01

J. Dairy Sci. 98:395–405
http://dx.doi.org/10.3168/jds.2014-8232

Effect of corn silage hybrids differing in starch and neutral detergent fiber digestibility on lactation performance and total-tract nutrient digestibility by dairy cows

L. F. Ferraretto,* A. C. Fonseca,* C. J. Sniffen,† A. Formigoni,‡ and R. D. Shaver*[1]
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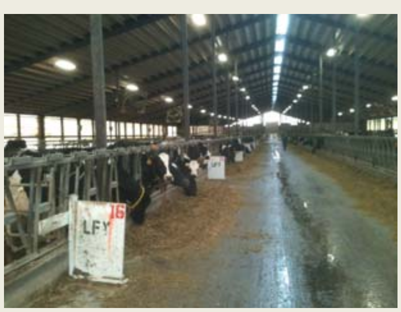
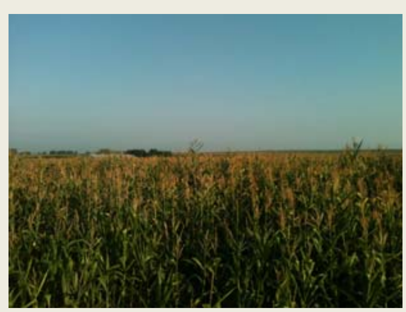




Feeding Trial Design

- 10/18/12 – 2/6/13; UW – Arlington Dairy
- 12 pens with 8 cows each; 96 cows (105 ± 31 DIM, 717 ± 19 kg BW at trial initiation)
- Cows stratified by milk yield & DIM, assigned to pens, and pens randomly assigned to 1 of 2 treatments
  - BMR
  - FL-LFY
- 2-week adjustment period with all pens fed UW herd diet with a non-experimental hybrid silage
- 14-week treatment period with all cows fed their assigned treatment TMR
- At week 8 diets were reformulated to contain similar lignin content

Nutrient composition at feedout

	BMR	FL-LFY
DM, % as fed	37.7% ± 2.5	36.0% ± 3.2
CP, % DM	8.7% ± 0.2	8.7% ± 0.3
Starch, % DM	30.6% ± 1.3	32.2% ± 1.2
ivStarchD, %starch	69.9% ± 3.2	75.6% ± 2.3
NDF, % DM	38.2% ± 0.9	36.0% ± 1.6
ivNDFD, %NDF	67.9% ± 0.8	57.2% ± 1.7
Lignin, %DM	2.3% ± 0.3	2.8% ± 0.2
uNDF, %DM	6.9% ± 0.7	9.4% ± 0.3

Lactation performance

	BMR	FL-LFY	SE	*P* <
DMI, kg/d	28.1	26.4	0.4	0.01
Milk, kg/d	49.0	46.8	0.8	0.05
Kg Milk/kg DMI	1.75	1.76	0.04	0.82
Fat, %	3.83	4.05	0.07	0.01
Fat, kg/d	1.84	1.84	0.04	0.89
Protein, %	3.27	3.27	0.08	0.98
Protein, kg/d	1.57	1.48	0.03	0.03
Lactose, %	4.87	4.81	0.03	0.06
Lactose, kg/d	2.35	2.19	0.05	0.01
MUN, mg/dL	15.6	16.8	0.3	0.001

Total tract nutrient digestibility

% of Nutrient Intake

	BMR	FL-LFY	SE	*P* <
DM	60.7	62.8	0.8	0.03
OM	62.8	65.0	0.7	0.02
NDF	40.4	39.7	1.9	0.73
Starch	93.3	98.0	0.7	0.001

J. Dairy Sci. TBC:1–13
http://dx.doi.org/10.3168/jds.2015-9511

JDS9511

Effect of ensiling time and exogenous protease addition to whole-plant corn silage of various hybrids, maturities, and chop lengths on nitrogen fractions and ruminal in vitro starch digestibility

L. F. Ferraretto,* P. M. Crump,† and R. D. Shaver*[1]
*Department of Dairy Science, and
†Department of Computing and Biometry, University of Wisconsin, Madison 53706

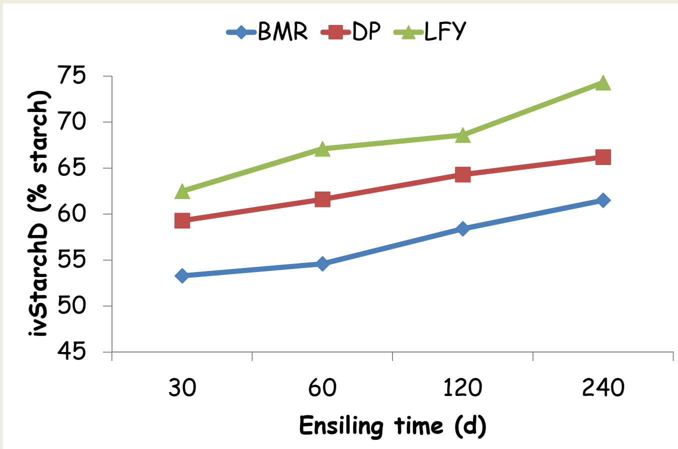
In Press

Treatments and Objectives

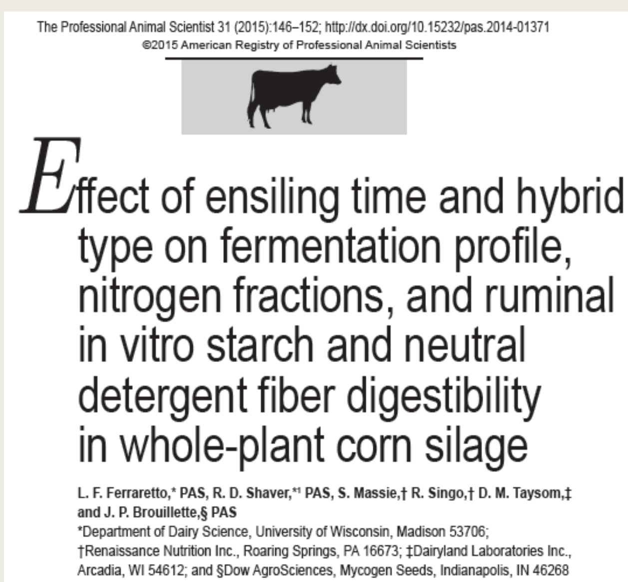
- BMR, DP, and LFY-FL
- 2/3 milk line, 7 d later
- 0.65-cm, 1.95-cm
- Protease vs. control
- 0, 30, 60, 120 or 240 d of ensiling

- Objective was to evaluate the effects of ensiling time and protease in WPCS of varied hybrids, maturities and particle size

Hybrid type × ensiling time



Time effect ($P < 0.001$)
Hybrid effect ($P = 0.02$)
Hybrid×Time ($P > 0.10$)



The Professional Animal Scientist 31 (2015):146–152; http://dx.doi.org/10.15232/pas.2014-01371

Effect of ensiling time and hybrid type on fermentation profile, nitrogen fractions, and ruminal in vitro starch and neutral detergent fiber digestibility in whole-plant corn silage

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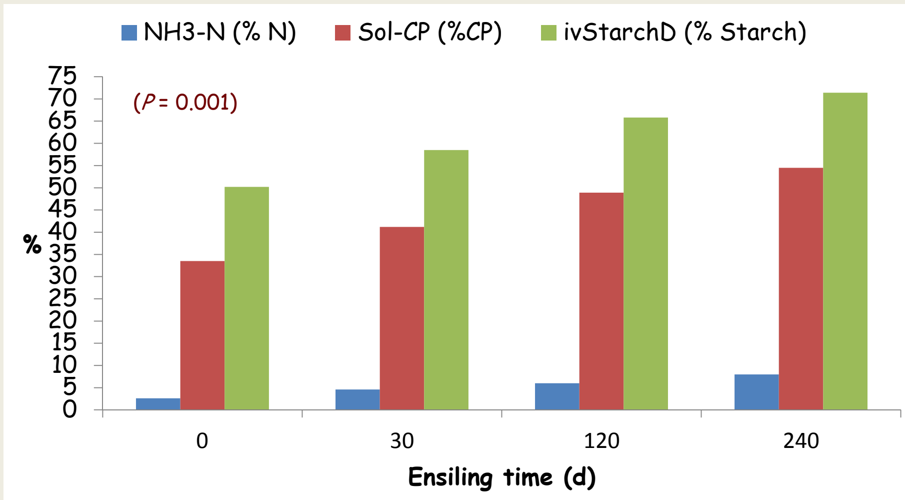
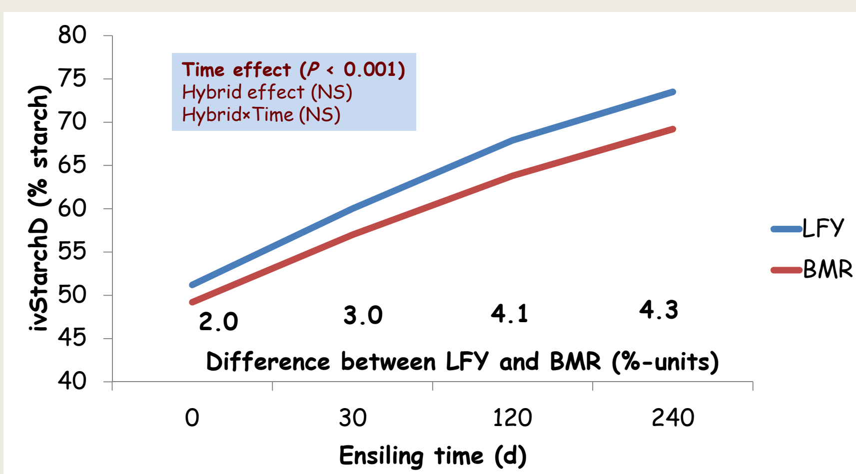
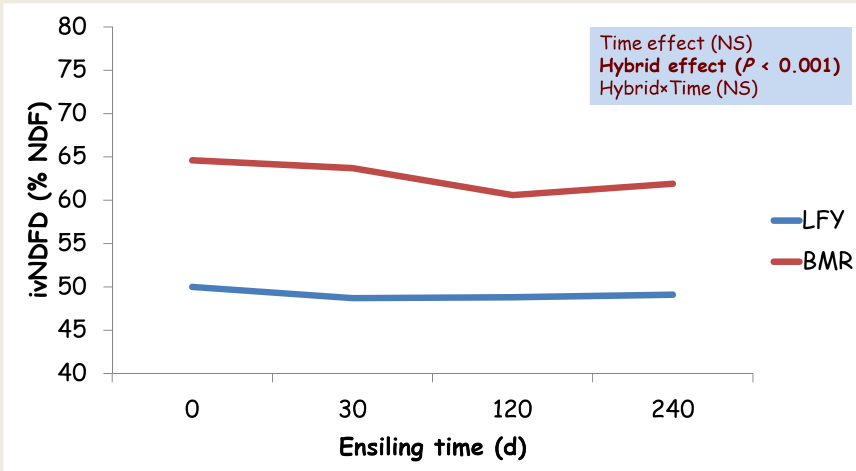
Ensiling time effect



Hybrid type × ensiling time



Hybrid type × ensiling time



Shredlage

Shredlage

http://www.shredlage.com/

New Processing Alternatives

- Novel intermeshing disk processors

- Processors with greater roll speed differential
    - Unsure of TLOC & MPL or comparability of fiber shredding

J. Dairy Sci. 98:5642–5652
http://dx.doi.org/10.3168/jds.2015-9543

Brown midrib corn shredlage in diets for high-producing dairy cows

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DEPARTMENT OF DAIRY SCIENCE University of Wisconsin-Madison

UW Madison Shredlage® Trials

	Trial 1	Trial 2
Hybrid	Dual Purpose	Brown Midrib
Crop Year	2011	2013
Harvest DM	34% ± 2	38% ± 4
Ensiling	Silo Bags	Silo Bags
Months in Storage Before Feeding	1	4

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UW Madison Shredlage® Trials

	Trial 1		Trial 2	
	Control	SHRD	Control	SHRD
TLOC, mm	19	30	19	26
WI-OS MPL, mm	10.4	11.2	10.0	11.4
% PSU Top	6%	32%	7%	18%
% PSU Top 2	82%	73%	75%	73%

Kernel Processing Score

Mertens, USDFRC

- Ro-Tap Shaker
  - 9 sieves (0.6 thru 19 mm) and pan
  - Analyze for starch on 4.75 mm & > sieves

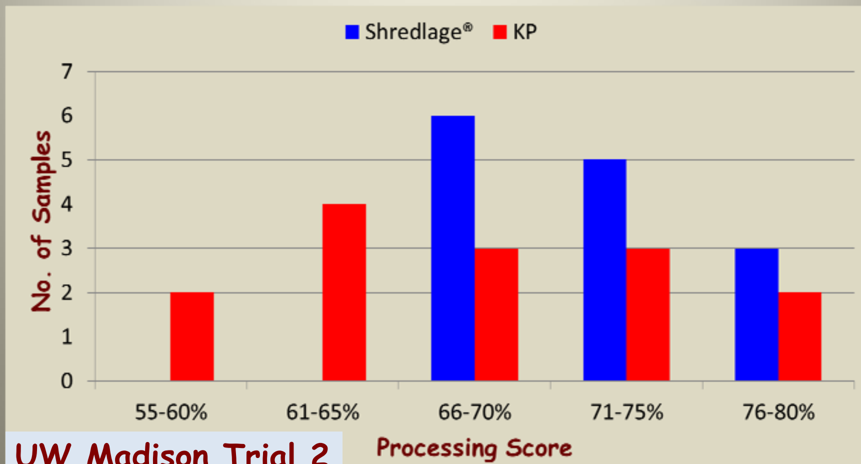
% of starch passing 4.75 mm sieve	KPS
>70%	Excellent
70% to 50%	Adequate
< 50%	Poor

UW Madison Shredlage® Trials

	Trial 1		Trial 2	
	Control	SHRD	Control	SHRD
Roll gap, mm	2 - 3	2.5	2	2
Roll Speed Differential	≈20%	≈30%	≈40%	30%-40%
Processing Score	60% ± 4	75% ± 3	68% ± 7	72% ± 4

Kernel Processing Score

Samples obtained weekly during feed-out from the silo bags



UW Madison Trial 2

UW Madison Shredlage® Trials

% of Diet DM	Trial 1	Trial 2
Forage	60%	55%
Corn Silage	50%	45%
Forage NDF	23%	24%
Starch	25%	29%
CP	17%	16%

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UW Madison Shredlage® Trials

	Trial 1	Trial 2
DIM at trial start	116 d ± 36	81 d ± 8
Trial Duration, weeks	10	16
Trial Average Control Milk, lb/cow/day	94	110

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UW Madison Shredlage® Trials

	Shredlage Response	
	Trial 1	Trial 2
DMI	no	no
Milk Yield	avg. +2 lb	avg. +2.5 lb
Feed Efficiency	no	no
Milk Composition	no	no
Milk Component Yields	yes	yes

UW Madison Shredlage® Trials

	Shredlage Response	
	Trial 1	Trial 2
Body Condition Score	no	no
Body Weight Change	no	no
Rumination Activity	---	no

UW Madison Trial 2

Rumination Activity

	KP	KPH	SHRD	*P* <
Minutes/day	503	499	504	0.88

UW Madison Shredlage® Trials

	Shredlage Response	
	Trial 1	Trial 2
Total Tract Diet StarchD	yes	yes
Ruminal Silage StarchD	yes	yes
Total Tract Diet NDFD	yes	no
Ruminal Silage NDFD	no?	no

New York Shredlage Trials

- Larry Chase – Cornell Univ. unpublished
  - No response
- Sally Flis – Dairy One unpublished field trial
  - Similar milk response as UW trials

2014 Farm Survey

Gustavo Salvati, Randy Shaver, Matt Lippert, Eric Ronk, & Chris Wacek-Driver

- Farm Sampling April - June 2014
  - 76 Samples from 69 Farms (WI, MN, IL)
    - 46/76 Claas SPFH with Shredlage® processor
    - 5/76 Loren Cut® rolls
    - 72/76 bunkers/piles; 4/76 silo bags
    - Hybrids
      - 31/76 Dual-Purpose
      - 19/76 Silage-Specific
      - 11/76 BMR
      - 11/76 Combination
    - Silage inoculant used 58/67 farms

2014 Farm Survey

Results

All farms	# of Milking Cows	Milk			
		lb/day	Fat%	Protein%	MUN mg%
Average	840	87	3.8	3.2	10.1
Std. Dev.	655	10	0.4	0.2	1.6
Max	3500	109	5.6	3.9	15.4
Min	66	52	3.3	2.9	6.0

2014 Farm Survey
Results

Verbal TLOC		Verbal Roll Gap	
	n		n
>26 mm	10	>2.5 mm	2
26 mm	33	2.5 mm	10
22 mm	22	2.0 mm	30
19 mm	4	1.5 mm	11
<19 mm	1	1.0 mm	7
		<1.0 mm	3

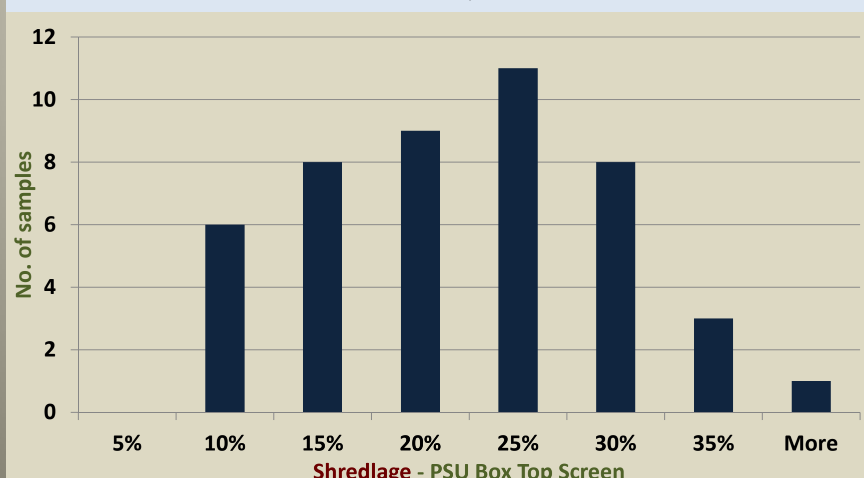
2014 Farm Survey
Results

Samples	n	% on Top Screen of PSU Box	Processing Score % Starch thru 4.75 mm Sieve
All	76	17.9%	66.4%
Shredlage	46	19.6%	67.3%
Loren-Cut Rolls	5	14.7%	66.0%
Conv. Processor	6	16.1%	62.2%
JD Conv. 32%	5	12.3%	65.1%
Horning Rolls 32%	2	6.3%	69.8%
Kooima Disc	5	14.6%	65.8%
Uncertain	7	20.7%	64.7%

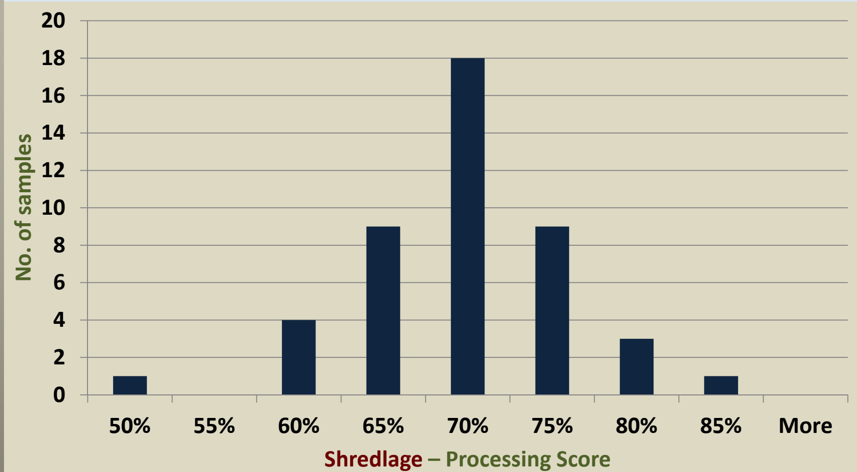
2014 Farm Survey
Results

Shredlage (n=46)	% on Top Screen of PSU Box	WI OS Particle Separator MPL (mm)	Processing Score % Starch thru 4.75 mm Sieve
Average	19.6%	11.9	67.3%
Std. Dev.	7.8%	1.4	5.9%
Max	39.9%	14.8	82.7%
Min	7.2%	9.0	49.5%

2014 Farm Survey
Results



2014 Farm Survey
Results



2014 Farm Survey
Results

% forage in diet DM	% of 63 farms
Increased	22.2%
Same	68.3%
Reduced	9.5%

2014 Farm Survey
Results

% corn silage in diet DM	% of 64 farms
Increased	46.9%
Same	50.0%
Reduced	3.1%

2014 Farm Survey
Results

Use Hay or Straw	% of 65 farms
Yes	53.8%
No	46.2%

2014 Farm Survey
Results

Hay or straw reduced	% of 35 farms
Yes	40.0%
No	60.0%

2014 Farm Survey
Results

Feed sorting	% of 67 farms
Increased	14.9%
Reduced	14.9%
No Change	67.2%
Unsure	3.0%

Kernel Processing Score

Mertens, USDFRC

- Ro-Tap Shaker
  - 9 sieves (0.6 thru 19 mm) and pan
  - Analyze for starch on 4.75 mm & > sieves

% of starch passing <u>4.75 mm sieve</u>	<u>KPS</u>
>70%	Excellent
70% to 50%	Adequate
< 50%	Poor

Industry Makes Advances in Corn Silage Processing

(CVAS Data, 2006 to 2014)

Crop Year	Number	Average	Percent Optimum	Percent Poor
2006	97	52.8	8.2	43.3
2007	272	52.3	9.2	37.9
2008	250	54.6	5.2	34.8
2009	244	51.1	6.1	48.0
2010	373	51.4	5.9	43.4
2011	726	55.5	12.3	33.1
2012	871	60.8	14.8	19.9
2013	2658	64.6	36.0	12.9
2014	322	61.8	24.2	9.0

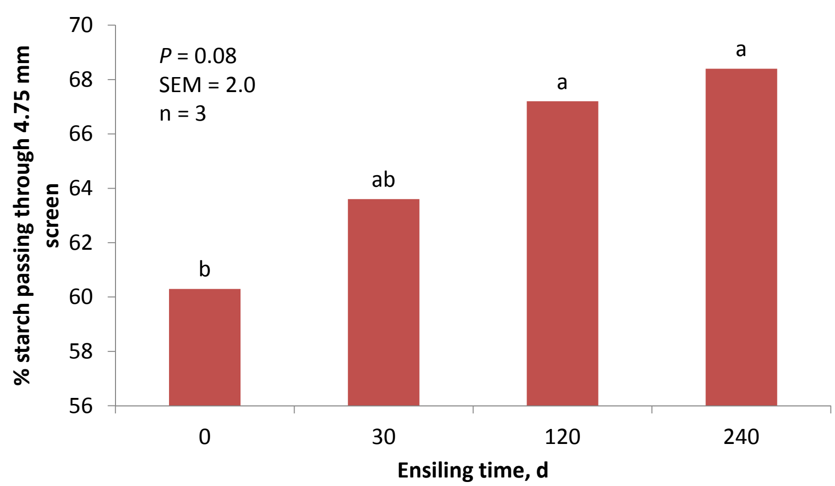
Adapted from slide provided by Ralph Ward of CVAS

Kernel Processing Score

	n	Unfermented	n	Fermented	SE	P <
% Starch Passing 4.75 mm Sieve	12	50.2%	12[1]	60.1%	3.1	0.01
	14	49.4% ± 11.4	28[2]	70.0% ± 5.0	---	---
	10	49.3% ± 15.5	20[3]	67.8% ± 3.3	---	---

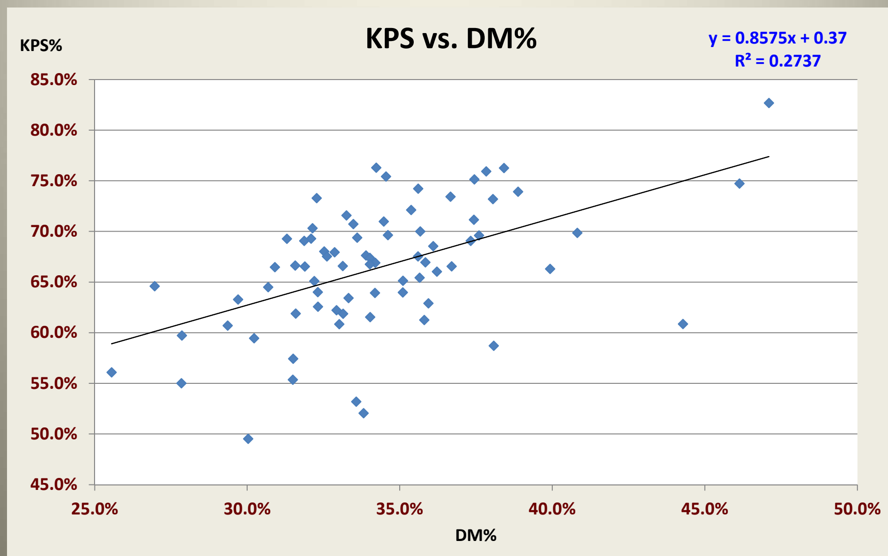
[1]30 days in vacuum sealed experimental mini silos
[2]90 to 210 days in farm level silo bags
[3]30 to 120 days in farm level silo bags

Kernel Processing Score



vacuum sealed experimental mini silos

Kernel Processing Score



GRAIN/STOVER SEPARATION

- **A sub-sample of 1 kg as fed of each sample was used to separate grain and stover fractions through the hydrodynamic separation procedure (Savoie et al., 2004)**
- **All samples were dried at 60°C for 48 h in a forced-air oven prior to immersion in water**

Focus on Forage

Wisconsin TEAM Forage

Making Sure Your Kernel Processor Is Doing Its Job

by Kevin J. Shinners and Brian J. Holmes

www.uwex.edu/ces/crops/uwforage/KernelProcessing-FOF.pdf

***Figure 1*.** Chopped whole-plant corn placed into water.

***Figure 2*.** Gently agitating material to help the kernels sink to the bottom of the container.

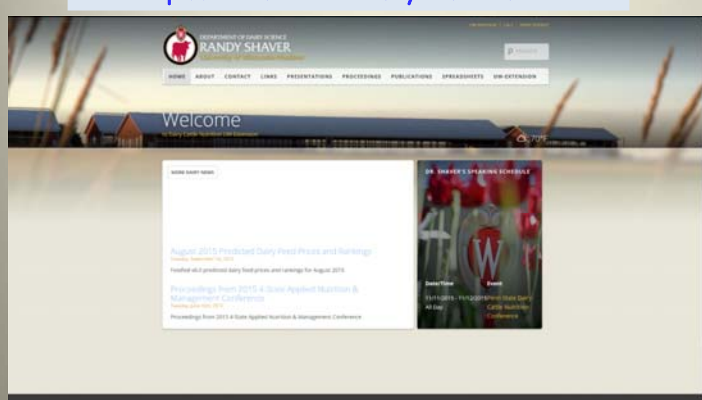
***Figure 3*.** Skimming and removing the floating stover.

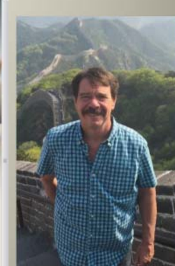
***Figure 4*.** Carefully draining the water so only the kernels remain in the container.

Figure 6. Separated kernels showing three levels of kernel processing. Only the material on the right could be considered adequately processed.

Visit UW Extension
Dairy Cattle Nutrition Website

http://www.shaverlab.dysci.wisc.edu/





UW Extension

THE UNIVERSITY of WISCONSIN MADISON

DEPARTMENT OF DAIRY SCIENCE
University of Wisconsin-Madison

Making Sense of Starch by NDF Interactions

Luiz Ferraretto and Randy Shaver

Department of Dairy Science
University of Wisconsin-Madison

INTRODUCTION

Associative effects of feeds, nutrients, diets, and dry matter intake (DMI) influence the digestibility of nutrients in vivo. However, associative effects are largely ignored with commercial-lab in vitro or in situ digestibility measurements.

Presented in Table 1 are the findings of a survey, performed by the authors, of websites and sample reports from 4 major dairy feed testing labs in the USA for analyses related to starch and NDF digestibilities. Dairy nutritionists have a seemingly endless stream of assays, and calculations from these assays, available for characterizing feed ingredients and diets. The inclusion of biological assays, e.g. digestibility in rumen fluid, to go along with chemical assays, e.g. NDF, lignin, starch, etc., in the commercial feed analysis system has been a major step forward for the industry to characterize feed ingredients and diets according to their nutritive value.

However, when attempting to interpret and translate to the farm from the myriad of assays and calculations listed in Table 1, the inherent flaws of rumen in vitro and in situ measurements relative to in vivo digestibility results should be kept in mind. A partial list is as follows:

- Measurements relative to ingredient and nutrient composition and physical form of diet fed to donor or incubation cows (Cone et al., 1989; Mertens et al., 1996) rather than client farms where results will be used, e.g. effects of variable diet starch content and source on ruminal amylase activity and in vivo starch digestibility; effects on in vivo fiber digestibility of fluctuations in ruminal pH via production, buffering, absorption and passage of volatile fatty acids; effects of variation in rumen degradable protein on in vivo fiber and starch digestibility; etc.
- Measurements relative to DMI of donor or incubation cows rather than client farms with highly variable milk yield and hence DMI levels. Determination of digestion rates (k_d) allows this discrepancy to be partly corrected for by using rate of passage (k_p) assumptions. However, DMI may influence rumen pH (Shaver et al., 1986) and hence k_d; this effect would not be accounted for with kp assumptions in the $k_d/(k_d+k_p)$ calculations of digestibility.
- Fine grinding of incubation samples, to pass through a 1- to 2-mm screen, results in measurement of maximal rates and extents of NDF digestibility, while grinding incubation samples to pass through a 4- to 6-mm screen may mask the effects of test feed particle size on starch digestibility.
- Ruminal in vitro and in situ techniques ignore post-ruminal starch and NDF digestion. The proportion

Table 1. Survey of websites and sample reports from 4 major dairy feed testing labs in the USA for analyses related to starch and NDF digestibilities.

NDF; NDF_{OM}; Lignin; uNDF (Lignin × 2.4)
Starch; Prolamin; Ammonia; Particle Size; UW Feed Grain Evaluation; Processing Score
TMR-D; Rumen in vitro total tract NDFD (Combs-ivttNDFD)
Traditional (Goering – Van Soest) NDFD; Standardized (Combs – Goeser) NDFD
NDF k_d calculated from 24, 30, 48, 120-h NDFD (Combs – Goeser)
NDF k_d Mertens; NDF k_d Van Amburgh
24-h NDFD; calculated B_2/B_3 kd
30, 120, 240-h NDFD – forages; 12, 72, 120-h NDFD – byproducts
4, 8, 12, 24, 48, 72, 120, 240-h NDFD lag, pools & rates
120-h uNDF; 240-h uNDF
3-h, 7-h Rumen in vitro or in situ starch digestibility (ivRSD); k_d
Fecal Starch; Dietary Total Tract Starch Digestibility (TTSD)
Fermentrics™ (gas production system)
Calibrate™

of starch digested post-ruminally can be significant (Ferraretto et al., 2013).

Therefore, for the most part, the assays or calculations from these assays listed in Table 1 should be viewed as relative index values for comparison among feeds/diets or over time within feeds/diets, rather than as predictors of in vivo digestibility results. The obvious exceptions include: 1) determination of fecal starch concentrations to estimate in vivo total tract starch digestibility (TTSD) for diets (Fredin et al., 2014; Owens et al., 2015), and 2) determination of concentrations of fecal and diet undigested NDF (uNDF at 120 to 288 h) along with the nutrients of interest, in both fecal and diet samples, to determine in vivo total tract nutrient digestibility for diets (Schalla et al., 2012; Krizsan and Huhtanen, 2013). It is noted, however, that these results provide no information about site of digestion and pertain only to the diet fed rather than specific feed ingredients included within the diet.

In a field study of 32 high-producing commercial dairy herds in the Upper Midwest, Powel-Smith et al. (2015) used lignin and uNDF (240 h) as indigestible markers to determine in vivo TTSD and total tract NDF digestibility (TTNDFD) for diets. Measurements of ruminal in vitro starch digestibility (ivSD; 7 h) were unrelated ($R^2 = 0.00$) to TTSD. For TTNDFD, measurements of ruminal in vitro NDF digestibility (ivNDFD; 24 h) and uNDF were poorly ($R^2 = 0.13$ and 0.21, respectively) related.

Lopes et al. (2015), using in vivo TTNDF data from 21 treatment diets in 7 lactating dairy cow feeding trials conducted at the University of Wisconsin, evaluated uNDF (240 h) and the Combs rumen in vitro estimate of total tract NDF digestibility (ivttNDFD). Diet uNDF (240 h) was negatively related ($R^2 = 0.40$) to TTNDFD; each 1%-unit increase in uNDF (240 h) was associated with a 0.96%-unit decrease in TTNDFD. Mean values, however, were 15%-units greater for uNDF-predicted TTNDFD compared to the observed TTNDFD. The ivttNDFD calculations included diet uNDF (240 h), potentially-digestible NDF and NDF k_d determined using the in vitro procedure of Goeser and Combs (2009), assumed k_p, and assumed hindgut NDF digestion. The R^2 for the relationship between ivttNDFD and TTNDFD was 0.68 and mean values differed by only 1%-unit, showing promise for this approach.

The remainder of this paper will focus primarily on review and discussion of the effects of starch by NDF interactions and DMI on in vivo starch and NDF digestibilities.

CORN SILAGE

Substantially (10 to 15%-units) greater ivNDFD for brown midrib 3 mutation (bm_3) whole-plant corn silage (WPCS) hybrids associated with reduced lignin content compared to conventional hybrids is well established (Jung and Lauer, 2011; Jung et al., 2011). However, greater ivNDFD for bm_3 hybrids has sometimes, but not always, translated into greater in vivo NDF digestibility (Oba and Allen, 1999; Tine et al., 2001; Jung et al., 2011; Ferraretto and Shaver, 2015). Variable TTNDFD response to feeding bm_3 WPCS is influenced by the DMI response to the greater ivNDFD (Oba and Allen, 1999; Tine et al., 2001), while WPCS type (bm_3 versus near-isogenic or conventional WPCS hybrids) by dietary forage-NDF (Oba and Allen, 2000; Qiu et al., 2003), starch (Oba and Allen, 2000) and CP (Weiss and Wyatt, 2006) concentration or supplemental corn grain endosperm type (Taylor and Allen, 2005) interactions were undetected.

With approximately 10%-units greater ivNDFD for bm_3 compared to near-isogenic or conventional WPCS hybrids, DMI and TTNDFD responses were, respectively, 2.1 kg/d per cow and 1.8%-units (Oba and Allen, 1999), 0.8 to 1.4 kg/d per cow and non-significant (Oba and Allen, 2000), and 0.9 kg/d per cow and 2.5%-units (meta-analysis by Ferraretto and Shaver, 2015). Furthermore, Oba and Allen (1999) observed a negative linear relationship between DMI and TTNDFD responses for bm_3 WPCS, which was likely related to a faster passage rate through the rumen associated with greater DMI (NRC, 2001), with the regression indicating a zero TTNDFD response at a 3 kg/d per cow DMI response.

Tine et al. (2001) fed bm_3 WPCS TMR ad libitum or restricted to the DMI of the TMR containing near-isogenic WPCS to lactating dairy cows, while dry cows were fed bm_3 and near-isogenic WPCS TMR at maintenance intake levels. For dry cows, TTNDFD was 10%-units greater for the bm_3 diet, while for the lactating cows TTNDFD was 9%-units or 7%-units greater, respectively, for restricted-fed or ad libitum-fed cows compared to near-isogenic WPCS control diets. Averaged across treatments, TTNDFD was 67% in dry cows and 54% in lactating cows. Results from this study show a negative relationship between DMI and TTNDFD and TTNDFD response to bm_3 WPCS. While diet net energy for lactation (NE_L) concentrations were unaffected by treatment ($P > 0.10$), numerically diet NE_L content was 9% greater in dry cows, but only 2% greater in lactating cows, for bm_3 compared to near-isogenic WPCS diets. In Tine et al. (2001), DMI and milk yield were 2.4 and 3.1 kg/d per cow, respectively, greater for cows fed bm_3 WPCS compared to cows fed near-isogenic WPCS.

It is evident that the milk yield response to greater ivNDFD in bm_3 WPCS derives primarily through increases in DMI. Based on this research, the MILK2006 update of the MILK2000 WPCS hybrid evaluation model included discounts for estimating the NE_L content of WPCS from predicted increases in DMI in response to greater ivNDFD, so that increases in estimated milk per ton in relationship to greater ivNDFD derive primarily through increases in DMI (Shaver, 2006; Shaver and Lauer, 2006). Prediction of DMI by NRC (2001), however, is not influenced by diet composition or forage ivNDFD.

From a meta-analysis, Ferraretto and Shaver (2015) reported 7%-unit and 2%-unit reductions in vivo for ruminal (RSD) and total tract (TTSD) starch digestibility, respectively, in bm_3 compared to near-isogenic or conventional WPCS hybrids. Compared to leafy hybrids, TTSD was 5%-units lower for bm_3 WPCS hybrids. Reduced starch digestibility for bm_3 WPCS hybrids could be due to greater kernel vitreousness (Fish, 2010; Glenn, 2013) and/or faster passage rate through the digestive tract associated with increased DMI (NRC, 2001; Ferraretto et al., 2013). Ferraretto et al. (2015a) reported 5%-units greater TTSD for lactating dairy cows fed an experimental floury-leafy WPCS hybrid compared to cows fed a bm_3 WPCS hybrid that appeared related to reduced kernel vitreousness and greater WPCS ruminal ivSD (7 h) and in situ (12 h) starch digestibility for the floury-leafy hybrid. However, ivNDFD (30 h), DMI and milk yield were 11%-units, 1.7 kg/d per cow and 2.2 kg/d per cow, respectively, greater for the bm_3 WPCS treatment. In agreement with previously discussed trials, TTNDFD was similar for the 2 diets despite the large ivNDFD difference between the WPCS treatments. Greater ivNDFD, DMI and milk yield for a bm_3 WPCS hybrid compared to an experimental floury-leafy WPCS hybrid has also been reported by Morrison et al. (2014).

These results underscore the importance of ivNDFD for WPCS hybrid selection from the standpoint of DMI and milk yield responses, and when attempting to incorporate parameters associated with greater starch digestibility into new WPCS hybrids. For example, improving starch digestibility of bm_3 hybrids through genetics appears to be a logical WPCS hybrid development strategy.

Ferraretto and Shaver (2012a), from a meta-analysis of WPCS trials with lactating dairy cows, reported the following: processing (1- to 3-mm roll gap) increased diet TTSD compared to 4- to 8-mm processed and unprocessed WPCS; processing increased TTSD for diets containing WPCS with 32 to 40% DM; processing increased diet TTSD when length of chop was set for 0.93 to 2.86 cm. Ferraretto and Shaver (2012b) and Vanderwerff et al. (2015) reported greater TTSD in lactating dairy cows fed Shredlage™ compared to conventional-processed WPCS. Clearly, physical form of WPCS affects starch digestibility. Grinding incubation samples for in vitro or in situ analysis through a common screen (e.g. 4- or 6-mm) may mask differences in particle size among WPCS that impact starch digestibility. Furthermore, incorporating measures of starch digestibility into WPCS hybrid selection is difficult because starch digestibility increases over time in storage (Ferraretto et al., 2015b).

DIETARY STARCH AND FORAGE NDF

Presented in Figure 1 (meta-analysis by Ferraretto et al., 2013) is the effect of dietary starch concentration on fiber digestibility. Increased dietary starch concentration reduced ruminal NDFD in vivo (P = 0.01) and TTNDFD (P = 0.001). The digestibility of dietary NDF decreased

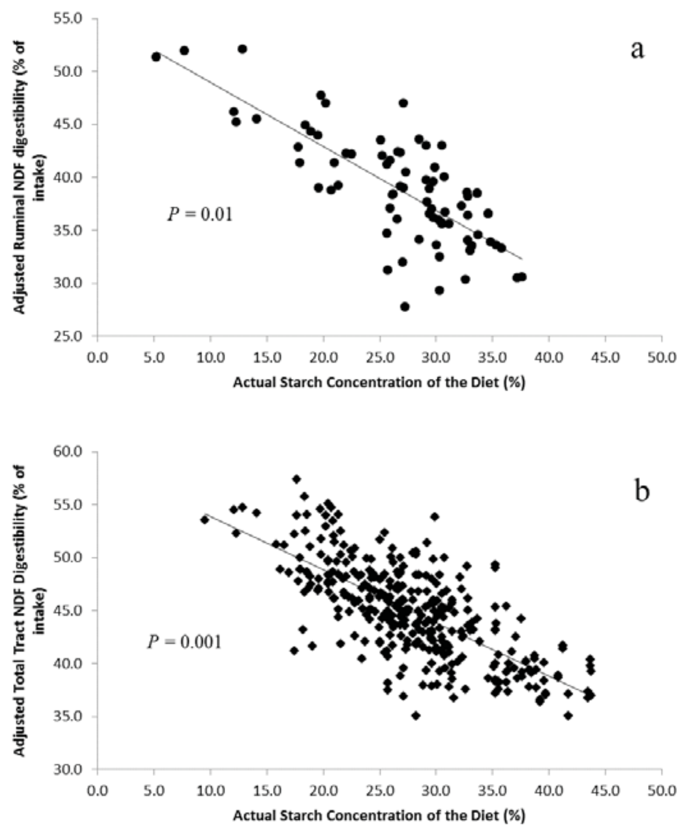


Figure 1. Effect of starch concentration of the diet on ruminal and total-tract digestibility of diet NDF adjusted for the random effect of trial. Ruminal digestibility data (Panel a) predicted from equation: y = 54.9746 + (-0.605 × starch concentration) + (0.063 ± 3.524); n = 70, RMSE = 3.55. Total-tract digestibility diet (Panel b) predicted from equation: y = 58.2843 + (-0.4817 × starch concentration) + (0.059 ± 3.191); n = 320, RMSE = 3.20. Ferraretto et al., 2013.

0.61%-units ruminally and 0.48%-units total-tract per %-unit increase in dietary starch content. Decreased fiber digestibility may be partially explained by a decrease in rumen pH as a consequence of greater amounts of starch (kg/d) being digested in the rumen as starch intake increases. Low rumen pH is known to affect microbial growth and bacterial adherence and thereby fiber digestion. Also, the inherently high fiber digestibility of non-forage fibrous by-products used to partially replace corn grain in reduced-starch diets may be partly responsible.

Weiss (2014; unpublished from 28th ADSA Discover Conf. in Starch for Ruminants) used the slope of Ferraretto et al. (2013) in Figure 1, or 0.5%-unit change in TTNDF for each 1%-unit change in dietary starch content, to calculate effects on dietary energy values. In the Weiss (2014) example, a 5%-unit increase in dietary starch content (e.g. 30% vs. 25%) reduced TTNDF 2.5%-units (46.5% to 44.0%), which resulted in a 5.3% increase in diet NEL content compared to a 6.5% increase had TTNDFD not been adversely affected by increased dietary starch content. Greater TTSD (>90%) than TTNDFD (<50%) tempers the negative impact on diet NEL content of reduced TTNDFD with greater dietary starch concentrations.

Effects of dietary forage NDF (FNDF) concentration on nutrient digestibilities were reported in the meta-analysis of Ferraretto et al. (2013). Fiber digestibility was unaffected by FNDF concentration in the diet either ruminally or total-tract. Similar results were reported by Zebeli et al. (2006). Furthermore, starch digestibility decreased only 0.17%-units per %-unit increase in dietary FNDF total-tract ($P = 0.05$), but not ruminally (Ferraretto et al., 2013). Thus, if dietary starch and total NDF concentrations are held constant, the primary effect of dietary FNDF was on DMI ($P = 0.04$) with a 0.17 kg/d per cow decrease in DMI per 1%-unit increase in dietary FNDF (Ferraretto et al., 2013). For example, a 3%-unit increase in dietary FNDF (25% vs. 22%, DM basis) would result in a 0.51 kg/d per cow decrease in DMI.

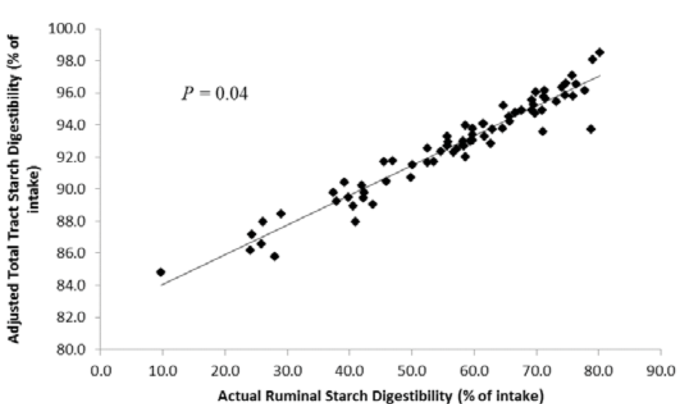


Figure 2. Relationship between ruminal and total-tract starch digestibility adjusted for the random effect of trial. Prediction equation: y = 82.224 + (0.185 × ruminal) + (-0.002 ± 0.772); n = 72, RMSE = 0.78. Ferraretto et al., 2013.

SITE OF STARCH DIGESTION

Relationships between ruminal, post-ruminal and total-tract starch digestibilities from the meta-analysis by Ferraretto et al. (2013) are presented in Figures 2 and 3. The RSD and TTSD were related positively ($P = 0.04$; Figure 2), with an increase of 0.19%-units total-tract per %-unit increase ruminally. Post-ruminal starch digestibility measured as percentage of flow to the duodenum was positively related to TTSD ($P = 0.001$; Figure 3). In feedstuffs with a high proportion of rumen-digested starch, e.g. corn silage or high-moisture corn, in vitro or in situ measurement of starch digestibility may be a useful predictor of TTSD if particle size differences among test feeds were not masked by grinding of the incubation samples to a similar particle size.

CONCLUSIONS

Generally, lab analyses related to starch and NDF digestibilities should be viewed as relative index values for comparison among feeds/diets or over time within feeds/diets, rather than as predictors of in vivo digestibility.

The milk yield response to greater ivNDFD in bm_3 WPCS derives primarily through greater DMI rather than diet TTNDFD or NE_L content. Reduced RSD and TTSD in bm_3 compared to near-isogenic or conventional WPCS hybrids suggests potential for genetic improvement of bm_3 hybrids with a more floury-type endosperm.

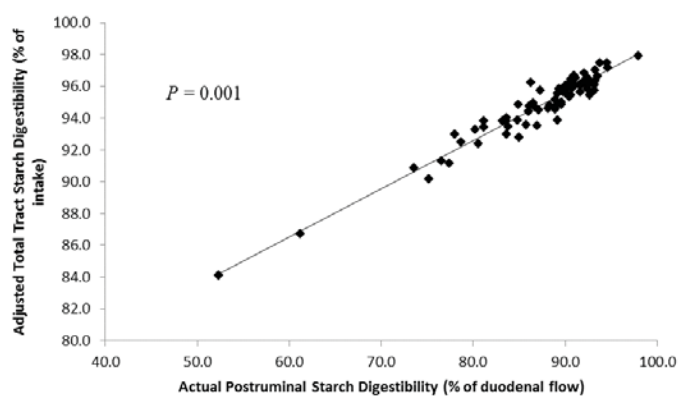


Figure 3. Relationship between postruminal starch digestibility as a percentage of duodenal flow and total-tract starch digestibility adjusted for the random effect of trial. Prediction equation: y = 68.287 + (0.304 × postruminal % of flow) + (0.013 ± 0.574); n = 72, RMSE = 0.58. Ferraretto et al., 2013.

Grinding incubation samples for in vitro or in situ analysis may mask differences in particle size among WPCS that impact starch digestibility, and incorporating measures of starch digestibility into WPCS hybrid selection is difficult because of ensiling effects on starch digestibility.

Increased concentrations of dietary starch decrease fiber digestibility. The negative effect, however, on calculated diet NE_L content is not large, and thus still favors higher starch diets. Comparisons among sites of starch digestion indicate that greater ruminal starch digestibility increases starch digestibility in the total tract. However, the proportion of starch digested post-ruminally can be high for some feedstuffs and diets, which would go undetected by rumen in vitro or in situ starch digestibility measurements.

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A Perspective on NDF & Starch Digestibility Measures

Randy Shaver & Luiz Ferraretto
Dairy Science Department

THE UNIVERSITY of WISCONSIN MADISON

UW Extension

DEPARTMENT OF DAIRY SCIENCE
University of Wisconsin-Madison

In Vitro

In Situ

Gas Production

In Vivo

Wisconsin Holstein sets 72,170 milk production record
2010: Tom & Gin Kestell & Sons, Waldo, WI

Ever-Green-View My 1326-ET
(EX-92 EX-MS)
4-05 365d 3x 72,168 3.9 2787 3.2 2286

WI AgSource DHIA Top 100

		RHA (lb)			
Stat	Cow #	Milk	Fat	Protein	Cheese
Average	486	31,297	1,154	961	3,150
Std. Deviation	500	1,622	90	57	203
Min	20	30,141	981	857	2,733
Max	3490	41,364	1,677	1,288	4,395

Sept. 2015

111 Herds >30,000 lb RHA which represents 2.5% of herds on test there

+30 WI Herds >30,000 lb RHA at NorthStar DHI

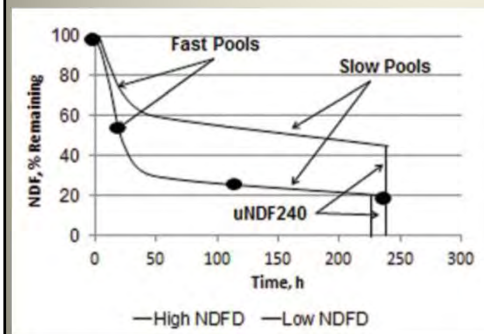
- **Associative effects of feeds, nutrients, diets and DMI influence the digestibility of nutrients in vivo**
  - **Associative effects are largely ignored with in vitro or in situ digestibility measurements**

Survey of websites and reports of 4 major US dairy feed labs for analyses related to starch and NDF digestibilities
NDF; NDF_{OM}; Lignin; uNDF (Lignin × 2.4)
Starch; Prolamin; Ammonia; Particle Size; UW Feed Grain Evaluation; Corn Silage Processing Score
TMR-D; Rumen in vitro total tract NDFD (Combs-ivttNDFD)
Traditional (Goering – Van Soest) NDFD; Standardized (Combs – Goeser) NDFD
NDF k_d calculated from 24, 30, 48, 120-h NDFD (Combs – Goeser)
NDF k_d Mertens, MIR; NDF k_d Van Amburgh
24-h NDFD; calculated B_2/B_3 kd
30, 120, 240-h NDFD – forages; 12, 72, 120-h NDFD – byproducts
4, 8, 12, 24, 48, 72, 120, 240-h NDFD lag, pools & rates
120-h uNDF; 240-h uNDF
3-h, 7-h Rumen in vitro or in situ starch digestibility (ivRSD); k_d
Fecal Starch; Dietary Total Tract Starch Digestibility (TTSD)
Fermentrics™ (gas production system)
Calibrate™
Jones Index; (NDFd30 + starch)/NDFu30

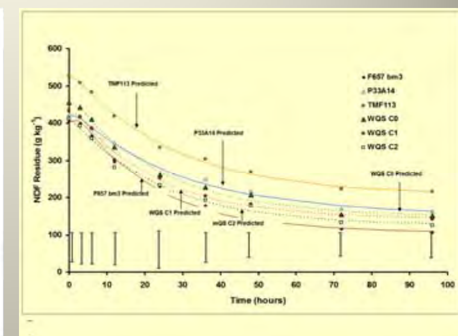
Partial list of inherent flaws of rumen in vitro & in situ digestibility measures relative to in vivo

- Donor/incubation cow diet ingredient/nutrient content & physical form versus client farm(s)
  - e.g. Diet starch% & source affects amylase & cellulase activities; Rumen pH & fluctuation; RDP; etc.
- Ditto for DMI
  - $k_d/(k_d+k_p)$
  - k_p assumed; disagreement over use of k_p of DM or nutrient and determination methods for k_p (markers or fill/flux)
  - DMI & diet influence rumen pH and hence k_d
- Fine grinding of incubation samples
  - 1-2 mm screen for ivNDFD
    - Results in maximal rates and extents of NDF digestibility
  - 4-6 mm for ivStarchD
    - Masks particle size effects on starch digestibility
- Ignores post-ruminal NDF and starch digestion

A bit more on digestion kinetics



Grant, Proc. 2015 4-State Nutr. & Mgmt. Conf., Dubuque, IA



Jim Coors, UW Madison, Ben Justen's Thesis

For the most part, ruminal in vitro and in situ NDF digestibility measurements, should be viewed as relative index values for comparison among feeds/diets or over time within feeds/diets, rather than as predictors of in vivo digestibility

J. Dairy Sci. 98:6361–6380
http://dx.doi.org/10.3168/jds.2015-9378

The Cornell Net Carbohydrate and Protein System: Updates to the model and evaluation of version 6.5

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J. Dairy Sci. 98:6340–6360
http://dx.doi.org/10.3168/jds.2015-9379

Updating the Cornell Net Carbohydrate and Protein System feed library and analyzing model sensitivity to feed inputs

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In Vitro

In Situ

In Vivo

J. Dairy Sci. 98:2596–2602
http://dx.doi.org/10.3168/jds.2014-8665

Validation of an approach to predict total-tract fiber digestibility using a standardized in vitro technique for different diets fed to high-producing dairy cows

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Department of Dairy Science, University of Wisconsin, Madison 53706

How is TTNDFD determined?

Forage sample

Standardized iv NDFD (24, 30, 48h)
and iNDF

Rate of fiber digestion (kd)
Potentially digestible NDF (pdNDF)

Rumen and
hindgut digestion

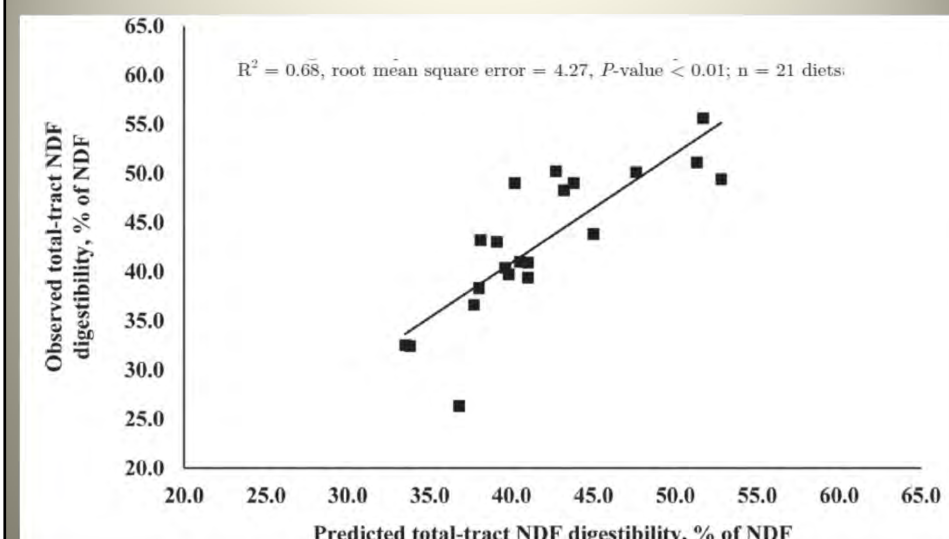
Rate of fiber passage, (kp)

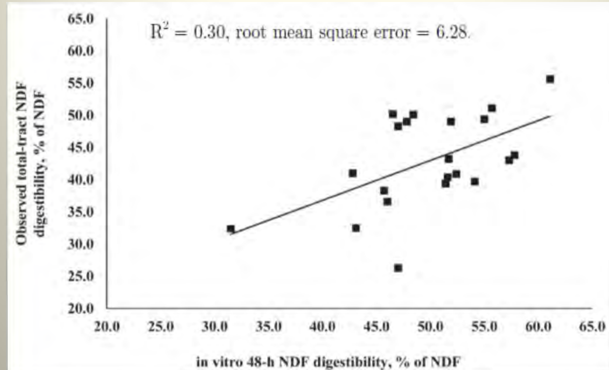
TTNDFD
(total tract NDF Digestibility)

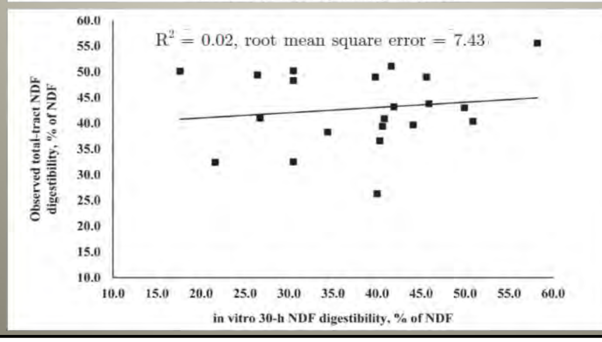
Table 2. Differences between observed and predicted total-tract NDF digestibility using different parameters

Item	Difference	SD[1]	*P*-value
TTNDFD in vivo – TTNDFD in vitro[2]	1.09	4.21	0.24
TTNDFD in vivo – 30-h NDFD[3]	4.87	11.6	0.07
TTNDFD in vivo – 48-h NDFD[3]	−6.93	6.60	<0.01
TTNDFD in vivo – iNDF[4]	14.5	11.0	<0.01

[1]SD = standard deviation of the means.
[2]TTNDFD = predicted total-tract NDF digestibility using TTNDFD test.
[3]In vitro incubation for 30 and 48 h to measure NDF digestibility (NDFD).
[4]iNDF = indigestible NDF measured from 240-h in vitro rumen fluid incubation.







J. Dairy Sci. 97:1862–1871
http://dx.doi.org/10.3168/jds.2013-7395

Fecal starch as an indicator of total-tract starch digestibility by lactating dairy cows

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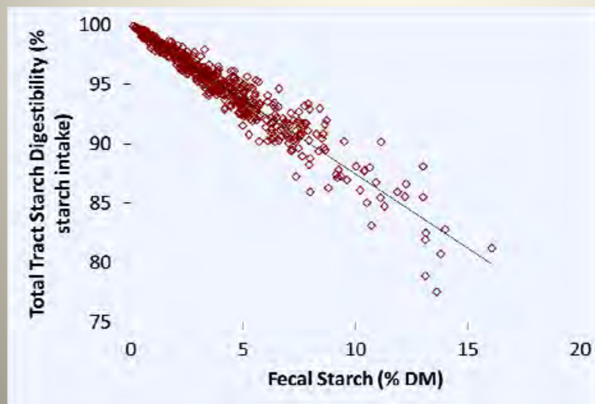


P < 0.001

R^2 = 0.94

564 samples

TTSD % = 100.0% - (1.25 X fecal starch %)

Fredin et al., 2014, JDS

Utility of On-Farm Fecal Starch?

- Can be used to predict total tract starch digestibility from available equation or using uNDF
  - Monitor specific group over time
  - Reflects total diet, not specific feedstuffs!
  - Gives no indication of site of digestion
  - If <3% starch in feces no need to investigate feeds to improve starch digestion
  - If >3% should evaluate specific starchy feedstuffs

StarchD & NDFD Field Study

Powel-Smith et al., 2015, JAM abstr.

- 32 Upper Midwest dairy herds
- uNDF (240 h) used as internal marker to determine in vivo total-tract starch & NDF digestibility in high pens
- 7-h ivStarchD and 24-h ivNDFD measured on corn silage, corn grain & TMR
- 7-h ivStarchD unrelated (R^2=0) to in vivo total-tract starch digestibility
- 24-h ivNDFD poorly related (R^2=0.13) to and over-estimated in vivo total-tract NDF digestibility

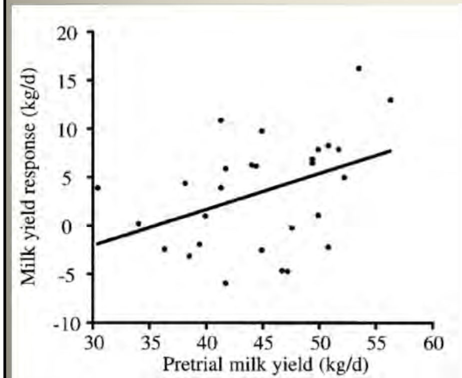
ivNDFD vs. DMI, FCM & FE

	High – Low ivNDFD Forage			
	4%-units		10%-units	
	- - Response (lb/cow/day) - -			
Review Papers	DMI	FCM	DMI	FCM
Oba & Allen, JDS, 1999	1.6	2.2	4.0	5.5
Jung et al., MN Nutr. Conf., 2004	1.1	1.2	2.6	3.1
Ferraretto & Shaver, JDS, 2013	0.7	1.2	1.8	3.1
Average	1.1	1.5	2.8	3.9

Tabular data calculated from reported responses per %-unit difference in ivNDFD

Feed efficiency seldom improved statistically

Response to ivNDFD vs. Level of Production



Effects of Brown Midrib 3 Mutation in Corn Silage on Dry Matter Intake and Productivity of High Yielding Dairy Cows

1999 J Dairy Sci 82:135–142

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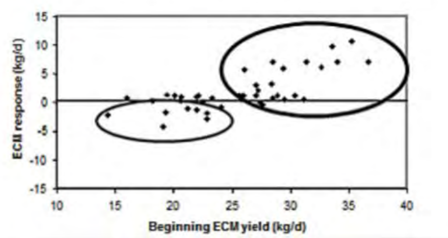
Figure 1. Difference in energy-corrected milk (ECM) response for cows fed high versus low NDF digestibility corn silage hybrids as it varies with milk production level (Ivan et al., 2004). Circles indicate that higher producing cows respond positively to higher NDF digestibility whereas lower producing cows do not respond, or respond negatively, to higher corn silage NDF digestibility.



Grant, Proc. 2015 4-State Nutr. & Mgmt. Conf., Dubuque, IA

Effects of Brown Midrib 3 Mutation in Corn Silage on Dry Matter Intake and Productivity of High Yielding Dairy Cows

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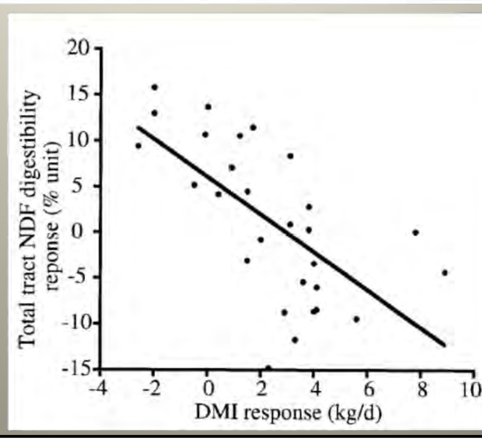
TABLE 1. Nutrient composition of corn silage used to formulate experimental diets.

	Before study[1]		During study[2]	
	bm3[3]	Control	*bm3*[3]	Control
DM, %	30.2	33.5	31.7	32.6
NDF, % of DM	42.0	40.4	38.3	40.1
ADF, % of DM	21.1	21.0	19.9	21.2
Lignin, % of DM	1.7	2.5	1.7	2.5
NDFD,[4] %	45.3	36.8	49.1	39.4
CP, % of DM	8.7	8.4	9.7	9.5
Ash, % of DM	4.2	3.8	4.5	4.0
Starch, % of DM	ND[5]	ND	33.1	33.3

TABLE 6. Least squares means, standard errors, and significance of effects of corn silage hybrids on apparent total tract digestibility.

	Treatment			
	bm3[1]	Control	SE	*P*
	(%)			
DM	61.8	61.0	0.4	0.18
OM	63.2	62.6	0.4	0.22
NDF	33.1	30.9	0.6	0.02
ADF	34.9	31.8	0.6	<0.001
Starch	81.1	83.1	1.1	0.17
CP	67.0	67.4	0.5	0.61



Effects of Brown Midrib 3 Mutation in Corn Silage on Dry Matter Intake and Productivity of High Yielding Dairy Cows

1999 J Dairy Sci 82:135–142

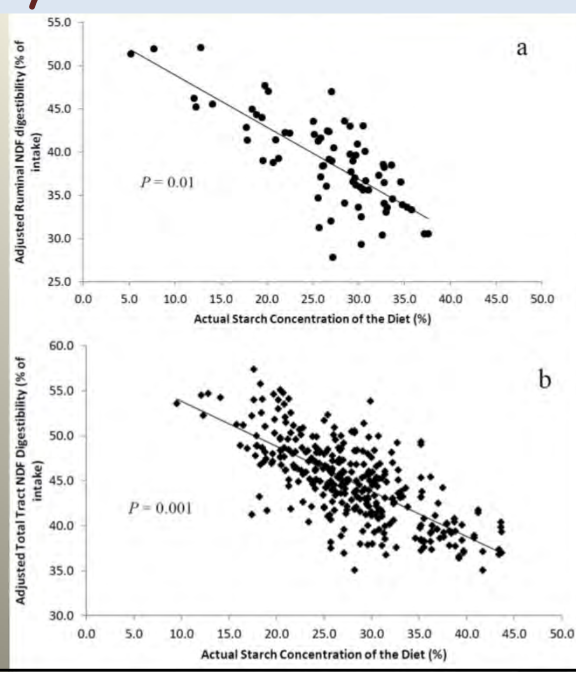
M. OBA and M. S. ALLEN[1]

Energy content of bm_3 corn silage

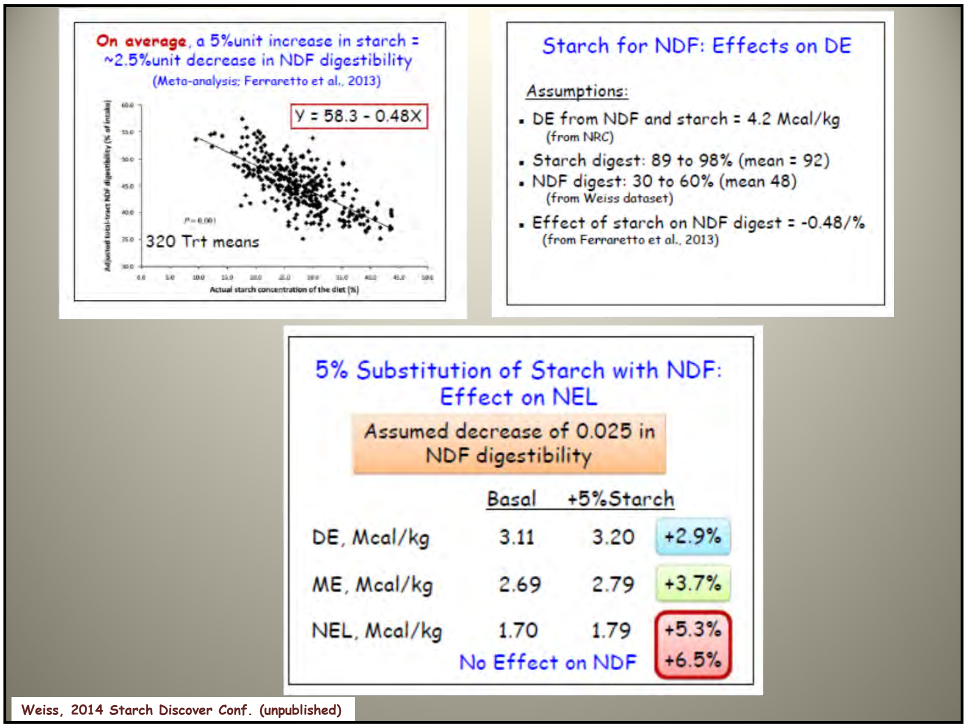
Tine et al., 2001, JDS

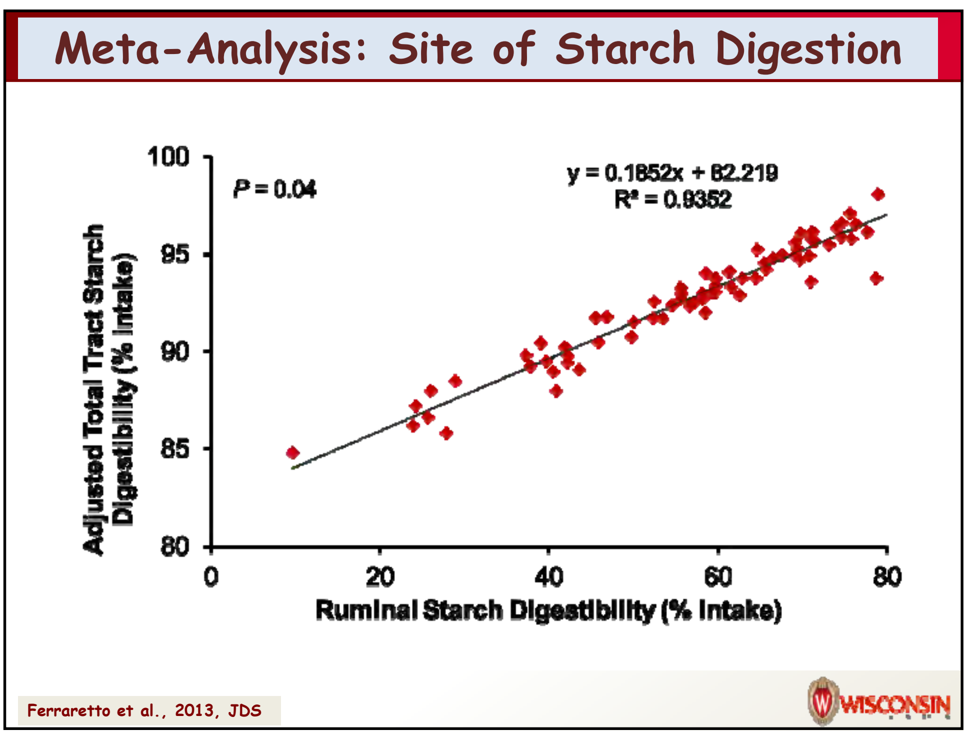
Item	Lactating 4x Maintenance		Dry Maintenance	
	Isogenic	bm_3	Isogenic	bm_3
TDN, %	---	---	72.1[b]	74.8[a]
DE, Mcal/kg	3.10	3.12	3.20[b]	3.32[a]
ME, Mcal/kg	2.58	2.68	2.62[b]	2.77[a]
NE_L, Mcal/kg	1.43	1.49	1.42	1.54

Meta-Analysis: Diet Starch% vs. NDFD

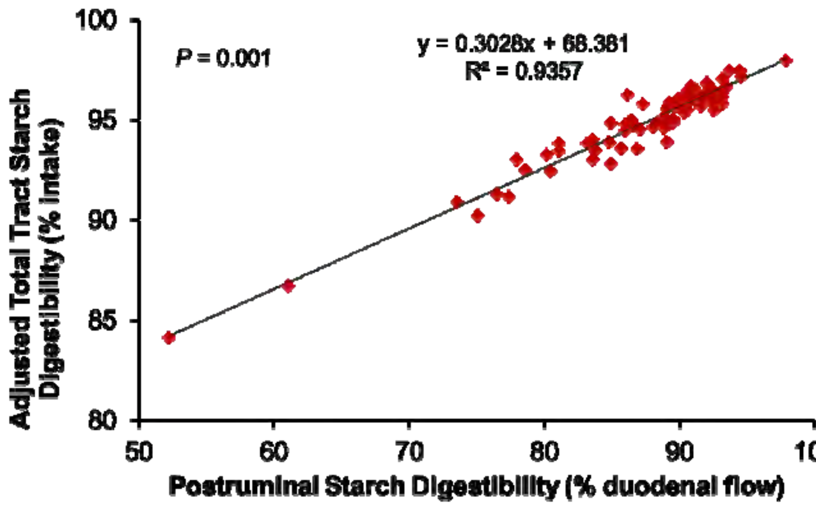


Ferraretto et al., JDS, 2013


On average, a 5%unit increase in starch = ~2.5%unit decrease in NDF digestibility
(Meta-analysis; Ferraretto et al., 2013)
Y = 58.3 - 0.48X
320 Trt means
Starch for NDF: Effects on DE
Assumptions:
• DE from NDF and starch = 4.2 Mcal/kg (from NRC)
• Starch digest: 89 to 98% (mean = 92)
• NDF digest: 30 to 60% (mean 48) (from Weiss dataset)
• Effect of starch on NDF digest = -0.48/% (from Ferraretto et al., 2013)
5% Substitution of Starch with NDF: Effect on NEL
Assumed decrease of 0.025 in NDF digestibility
Basal +5%Starch
DE, Mcal/kg 3.11 3.20 +2.9%
ME, Mcal/kg 2.69 2.79 +3.7%
NEL, Mcal/kg 1.70 1.79 +5.3%
No Effect on NDF +6.5%
Weiss, 2014 Starch Discover Conf. (unpublished)


Meta-Analysis: Site of Starch Digestion
P = 0.04
y = 0.1852x + 82.219
R² = 0.9352
Adjusted Total Tract Starch Digestibility (% Intake)
Ruminal Starch Digestibility (% Intake)
100
95
90
85
80
0
20
40
60
80
Ferraretto et al., 2013, JDS
WISCONSIN

Meta-Analysis: Site of Starch Digestion



Ferraretto et al., 2013, JDS

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Meta-Analysis: Supplemental Fats & NDFD

	ΔttNDFd/1%FA		
Type of Fat Supplement	N	Δ (%-unit)	P-value
C12/C14	6	-2.73[b]	<0.0001
Oil	11	-0.28[a]	0.42
Animal - Vegetable Fat	7	-0.26[a]	0.62
Tallow	25	-0.24[a]	0.49
Hydrogenated Fat	12	-0.19[a]	0.63
C16	8	0.17[a]	0.69
Calcium Salts Other	5	0.71[a]	0.10
Calcium Salts Palm	10	0.99[a]	0.02

	ΔDMI/1%FA		
Type of Fat Supplement	N	Δ (lb/d)	P-value
C12/C14	6	-2.18[bc]	<0.0001
Oil	11	-0.51[ab]	0.11
Animal - Vegetable Fat	7	-0.40[abc]	0.38
Tallow	25	-0.59[abc]	0.07
Hydrogenated Fat	12	+0.59[a]	0.13
C16	8	-0.44[abc]	0.24
Calcium Salts Other	5	-0.97[bc]	0.01
Calcium Salts Palm	10	-1.28[bc]	0.001

Background

-Multiple reviews state that there are negative effects of fat on fiber digestibility (Jenkins, 1992; Palmquist and Jenkins, 1980)

-Much of the original research was done in sheep (Devendra and Lewis, 1974)

-*In vitro* literature shows negative effects of unsaturated fatty acids on bacteria (Maia et al, 2007)

-Calcium salts seem to have lesser negative effects than other fat supplements (Palmquist and Jenkins, 1980)

-Quantitation of this effect from summarized, published *in vivo* studies using lactating dairy cattle is lacking.

Conclusions

-C12/C14 fatty acids or fat sources have significant negative effects on ttNDFd and DMI.

-Long chain dietary fats do not have large negative effects on ttNDFd when fed at levels typically found in dairy cow diets (~3%).

-Calcium salts (palm oil and other oils) increase ttNDFd and decrease DMI relative to lower fat diets.

-ΔDMI and ΔttNDFd are unrelated thus change in passage rate is an unlikely mechanism for increased ttNDFd.

Weld & Armentano, JAM, 2015

Summary & Conclusions

- There are associative effects on in vivo digestibility that go undetected with in vitro/in situ measures
- There are inherent flaws with in vitro/in situ measures relative to in vivo
- Nutrition models drive required analyses

Summary & Conclusions

- ivNDFD measures mostly unrelated to in vivo NDFD
- Milk yield response to greater ivNDFD derives mainly thru greater DMI
  - Logically DMI response to NDF/ivNDFD or uNDF should be included in intake prediction equations
- For diagnostics, fecal starch, uNDF to estimate in vivo digestibilities, & the Combs in vitro-TTNDF model look promising

Summary & Conclusions

- Greater diet starch content reduces fiber digestibility in vivo
  - The negative effect on diet NE_L is not large though and still favors higher starch diets
- Greater ruminal starch digestion related to greater total tract starch digestibility
  - Post-ruminal starch digestion can be high for some feeds & diet situations
    - Undetected by current in vitro/in situ StarchD measures
  - Sample grinding likely masks important particle size effects on in vitro/in situ StarchD measures

Visit UW Extension
Dairy Cattle Nutrition Website

http://www.shaverlab.dysci.wisc.edu/

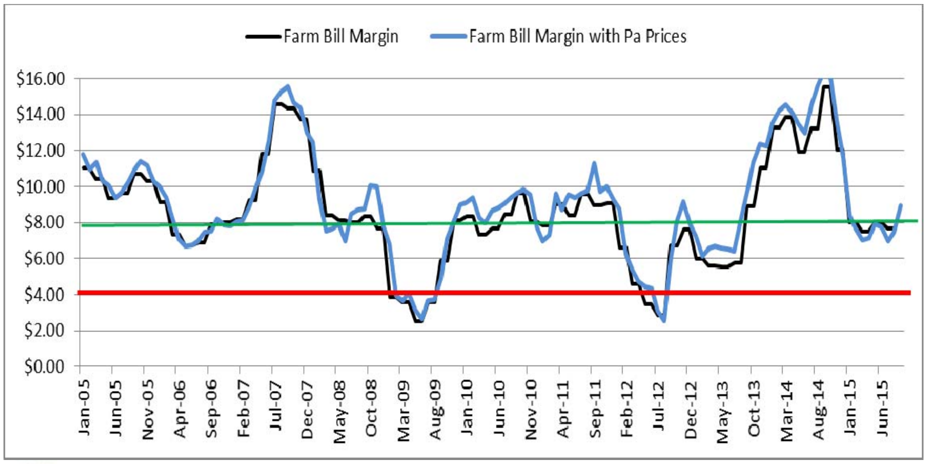
Pa Nutrition Conference

Alan Zepp
Center for Dairy Excellence
Risk Management Program Manager

Agenda

- Margin Review
- MPP & LGM-Dairy
- LGM-Dairy History and Performance
- Marketing Plan
- Discussion

PA & US MPP Margins



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Margin?????

Milk Price (All Milk Price) (Class III)

\- **Corn** (NASS monthly report) (CME)

\- **Soy Bean Meal**

(Central Illinois –Feed Outlook) (CME)

\- **Alfalfa Hay** (NASS monthly report)

= **Margin**

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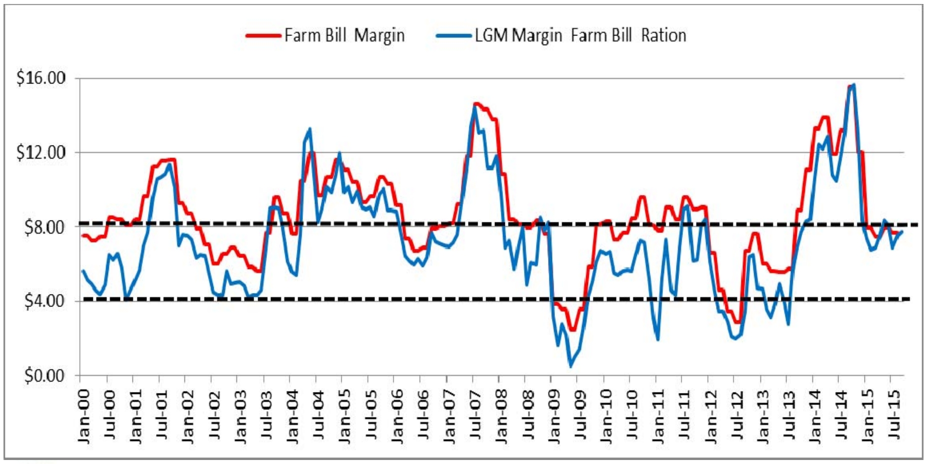
Margins



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MPP & LGM-Dairy

- "Dairy operations enrolling in the new program cannot participate in the Livestock Gross Margin dairy insurance program."
- Farms with policies providing coverage in any 2016 month are excluded from MPP participation.

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LGM-Dairy Sales

	Policies Sold	Policies Indemnified	Units Earning Premium	Units Indemnified	% Policies Indemnified	% Units Indemnified
2009	45	34	68	53	75.6%	77.9%
2010	153	56	221	80	36.6%	36.2%
2011	1412	24	1738	31	1.7%	1.8%
2012	1769	124	943	125	7.0%	13.3%
2013	1697	221	1235	242	13.0%	19.6%
2014	1621	123	1309	214	7.6%	16.3%
2015	2105	307	1781	460	14.6%	25.8%
2016	1682	0	362	0		0.0%

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LGM-Dairy Coverage

	Quantity of Milk (Cwt)	Quantity/ policy	Liabilities ($)	Total Prem ($)	Subsidy ($)	Indemity / cwt	Indemnity ($)
2009	401,680	8,760	$4,715,858	$287,201	$0	$1.79	$718,035
2010	1,872,499	20,901	$24,914,997	$781,589	$0	$0.15	$280,566
2011	46,172,815	51,052	$769,644,504	$25,012,757	$10,735,652	$0.00	$64,738
2012	40,474,408	41,584	$703,999,855	$19,143,689	$8,861,771	$0.03	$1,395,079
2013	34,178,852	56,796	$664,077,985	$16,873,156	$7,656,348	$0.08	$2,666,303
2014	27,740,876	55,234	$546,398,697	$11,592,590	$4,967,240	$0.13	$3,653,307
2015	48,737,639	51,840	$889,332,341	$22,337,591	$10,177,578	$0.23	$11,080,402
2016	9,185,274	25,043	$148,656,200	$3,156,307	$1,419,497	$0.00	$0

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State Breakdown

		Policies Sold	Policies Earning Prem	Policies Indemnified	Units Earning Premium	Units Indemnified	% policies indemnified	Quantity	Cwt / policy	Liabilities ($)	Total Prem ($)	Indemity / cwt	Indemnity ($)
2009	MN	3	3	3	6	5	100%	33960	11320	$376,262	$17,241	$0.81	$27,350
2009	NY	1	0	0	0	0	0%	0	0	$0	$0		$0
2009	PA	5	4	3	5	3	60%	26250	5250	$349,018	$18,967	$2.44	$63,998
2009	WI	12	12	10	30	23	83%	104877	8740	$1,200,630	$97,254	$2.08	$218,579
2010	MN	8	7	5	20	9	63%	107157	13395	$1,408,451	$66,030	$0.47	$50,643
2010	NY	3	2	2	3	3	67%	1500	500	$20,196	$788	$0.25	$373
2010	PA	44	37	14	51	16	32%	163470	3715	$2,225,208	$74,726	$0.33	$54,440
2010	WI	53	52	25	103	40	47%	504328	9516	$6,691,603	$271,920	$0.25	$124,871
2011	CA	40	38	2	53	2	5%	4380941	109524	$73,627,704	$2,444,664	$0.00	$1,101
2011	ID	28	27	0	41	0	0%	1404675	50167	$22,132,484	$628,475	$0.00	$0
2011	MN	166	117	3	164	4	2%	2268438	13665	$38,150,455	$1,341,608	$0.01	$22,258
2011	NY	86	80	0	105	0	0%	3259367	37900	$55,354,776	$1,949,749	$0.00	$0
2011	PA	133	117	7	232	10	5%	2268013	17053	$37,529,545	$1,375,587	$0.01	$26,550
2011	TX	7	5	0	6	0	0%	176000	25143	$2,869,660	$99,002	$0.00	$0
2011	WI	421	355	7	499	10	2%	9238286	21944	$153,875,001	$5,010,527	$0.00	$4,420
2012	CA	54	48	12	48	12	22%	6413274	118764	$111,499,097	$2,961,235	$0.04	$227,296
2012	ID	11	11	5	11	5	45%	809195	73563	$14,047,625	$437,522	$0.26	$210,021
2012	MN	290	143	19	150	19	7%	4374776	15085	$76,071,849	$2,086,569	$0.02	$90,428
2012	NY	53	39	6	40	6	11%	2374993	44811	$41,285,721	$1,106,333	$0.03	$62,240
2012	PA	172	125	23	138	24	13%	2916868	16959	$50,743,028	$1,455,841	$0.08	$221,210
2012	TX	7	2	1	2	1	14%	220000	31429	$3,833,200	$88,526	$0.01	$1,291
2012	WI	668	233	27	242	27	4%	7943724	11892	$138,255,091	$3,745,966	$0.02	$139,515

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State Breakdown

		Policies Sold	Policies Earning Prem	Policies Indemnified	Units Earning Premium	Units Indemnified	% policies indemnified	Quantity	Cwt / policy	Liabilities ($)	Total Prem ($)	Indemity / cwt	Indemnity ($)
2013	CA	39	32	14	60	18	36%	4,387,886	112,510	$86,047,453	$2,221,788	$0.13	$553,692
2013	ID	8	8	4	8	4	50%	978,200	122,275	$19,818,828	$506,367	$0.39	$385,087
2013	MN	323	138	41	264	47	13%	4,237,123	13,118	$83,080,746	$2,359,386	$0.05	$207,005
2013	NY	46	34	9	67	9	20%	2,180,891	47,411	$41,206,741	$1,017,148	$0.05	$99,238
2013	PA	92	27	12	56	16	13%	707,046	7,685	$13,702,431	$352,352	$0.10	$70,001
2013	TX	5	2	0	2	0	0%	290,000	58,000	$5,898,600	$134,578	$0.00	$0
2013	WI	742	267	84	486	85	11%	10,979,539	14,797	$213,098,474	$5,174,025	$0.04	$424,033
2014	CA	36	26	1	35	1	3%	3,011,671	83,658	$58,023,160	$1,238,675	$0.01	$29,262
2014	ID	3	3	0	5	0	0%	285,000	95,000	$5,213,776	$160,887	$0.00	$0
2014	MN	306	78	13	210	24	4%	2,238,045	7,314	$44,404,728	$1,064,034	$0.13	$292,276
2014	NY	49	40	14	103	26	29%	3,479,290	71,006	$69,580,419	$1,443,015	$0.21	$745,677
2014	PA	92	32	11	80	17	12%	894,174	9,719	$17,708,341	$418,099	$0.16	$143,624
2014	TX	2	1	0	1	0	0%	40,000	20,000	$863,200	$17,644	$0.00	$0
2014	WI	743	183	38	512	71	5%	7,299,171	9,824	$142,851,968	$2,809,078	$0.10	$739,905
2015	CA	42	33	12	37	13	29%	3,630,786	86,447	$65,505,408	$1,386,733	$0.35	$1,255,783
2015	ID	7	7	5	10	7	71%	475,600	67,943	$9,769,442	$268,306	$1.38	$656,408
2015	MN	377	87	45	182	60	12%	4,222,564	11,200	$83,116,257	$1,801,830	$0.45	$1,904,846
2015	NY	118	113	35	244	56	30%	11,191,535	94,844	$206,157,921	$5,819,340	$0.16	$1,845,125
2015	PA	126	81	27	148	42	21%	2,728,352	21,654	$49,712,517	$1,325,071	$0.20	$553,597
2015	TX	3	2	1	5	2	33%	145,500	48,500	$2,748,785	$66,034	$0.46	$66,277
2015	WI	860	189	80	483	116	9%	7,468,361	8,684	$127,916,984	$3,316,549	$0.14	$1,072,263
2016	CA	14	5	0	8	0	0%	634,270	45,305	$10,220,843	$155,881	$0.00	$0
2016	ID	1	1	0	1	0	0%	90,000	90,000	$1,485,900	$20,207	$0.00	$0
2016	MN	391	33	0	58	0	0%	1,663,850	4,255	$27,146,853	$412,190	$0.00	$0
2016	NY	24	20	0	35	0	0%	983,650	40,985	$16,039,155	$432,154	$0.00	$0
2016	PA	76	18	0	33	0	0%	609,995	8,026	$9,642,575	$203,084	$0.00	$0
2016	TX	1	0	0	0	0	0%	0	0	$0	$0		$0
2016	WI	773	64	0	118	0	0%	2,042,115	2,642	$32,880,436	$761,856	$0.00	$0

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LGM-Dairy Scenarios

Results of example 10 month policies from January 2002 to October 2014

	Maximum Feed				**Default Feed**				**Minimum Feed**			
	$0.00 deductible		$1.50 deductible		$0.00 deductible		$1.50 deductible		$0.00 deductible		$1.50 Deductible	
	Premium	Indemnity	Premium	Indemnity	Premium	Indemnity	Premium	Indemnity	Premium	Indemnity	Premium	Indemnity
Cost/ Benefit Ratio		1.1		1.2		1.2		2.9		1.3		3.9
Per cwt	$0.66	$0.71	$0.14	$0.17	$0.55	$0.69	$0.08	$0.23	$0.54	$0.72	$0.07	$0.28

Default Feed Scenarios

			$1.50 deductible				$1.50 deductible				$1.50 deductible	
	Purchase months		Purchase Months		Purchase Months		Purchase Months		Purchase 10 Months		Purchase 10 Months	
	4, 5, & 6	33% each	4, 5, & 6	33% each	7,8,9,&10	25% each	7,8,9,&10	25% each	10% each month		10% each month	
	$291,350	$254,144	$88,589	$89,930	$326,697	$280,550	$115,900	$109,057	$240,456	$211,200	$56,732	$57,241
Cost/ Benefit Ratio		1.1		2.0		1.0		1.9		1.1		2.0
Per cwt	$0.67	$0.71	$0.12	$0.25	$0.76	$0.80	$0.16	$0.31	$0.56	$0.60	$0.08	$0.16

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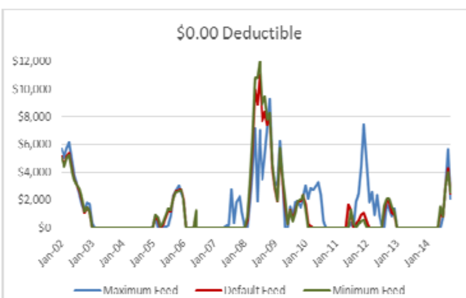
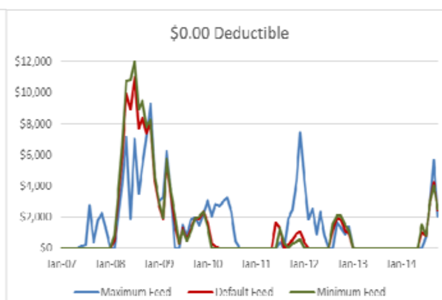
LGM Feed Scenario Histories





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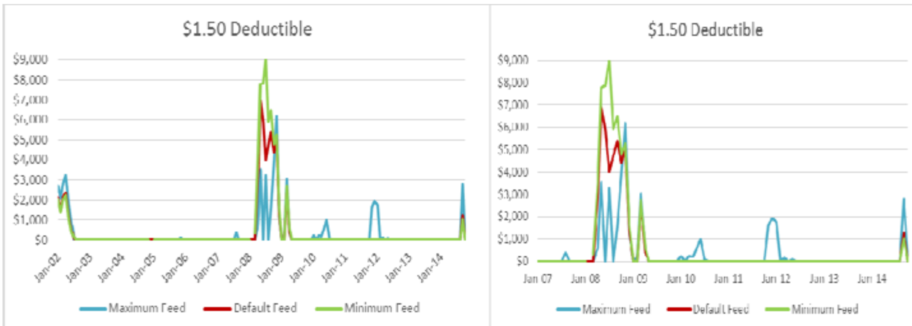
LGM Feed Scenarios



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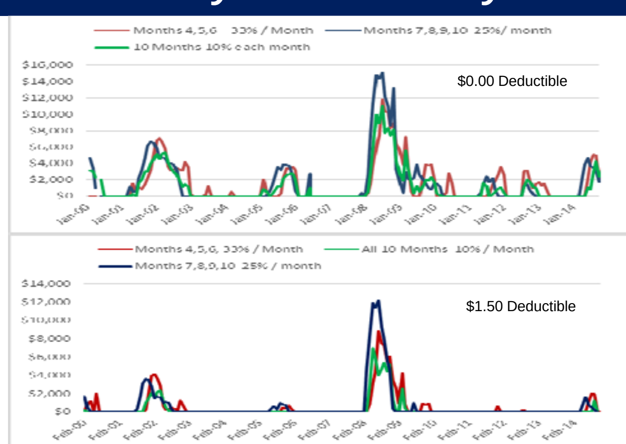
LGM-Dairy Indemnity History



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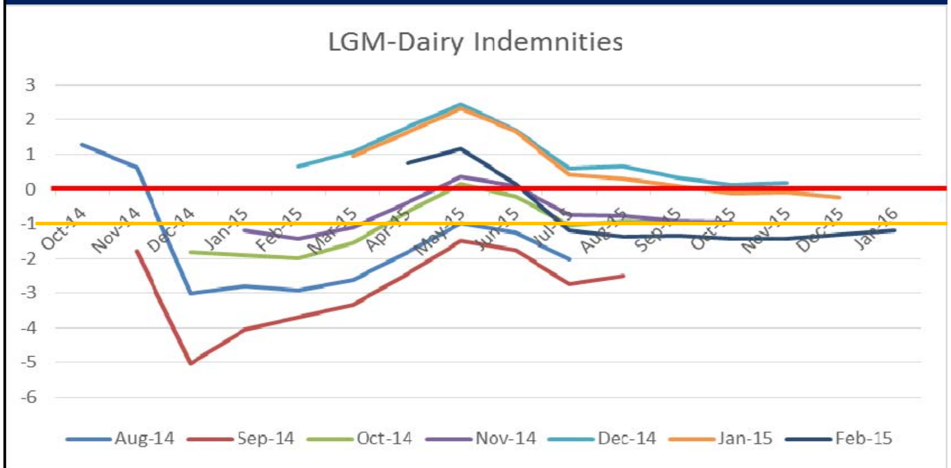
MPP Feed $0.00 Deductible



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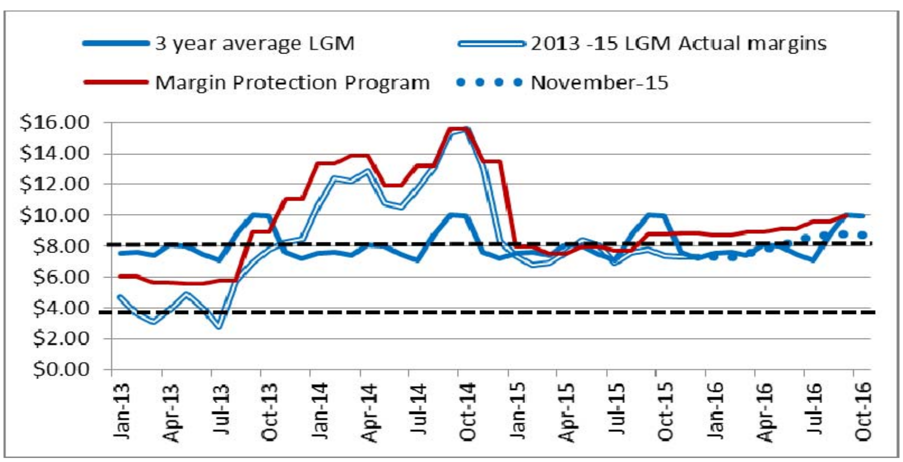
Margins



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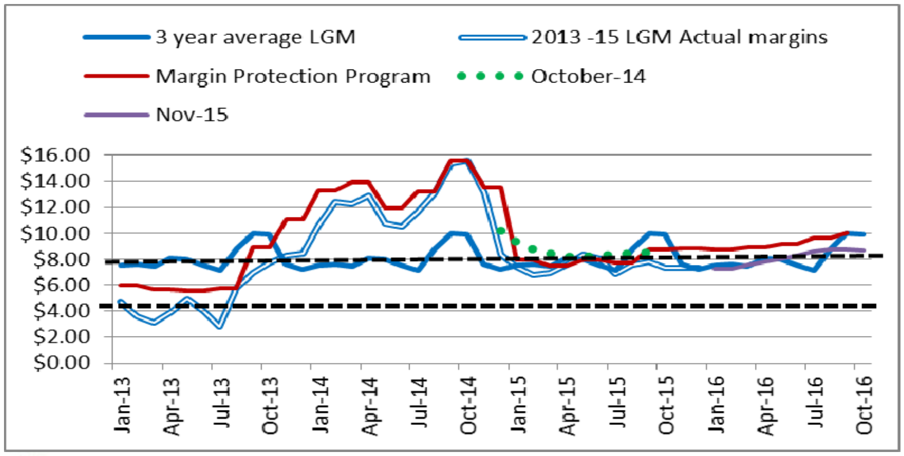
October 2014 Margins



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Marketing Plan

pennsylvania DEPARTMENT OF AGRICULTURE

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USDA United States Department of Agriculture Risk Management Agency

		MPP	LGM Dairy		Class III				Margin Protection Program				LGM coverage		Coopertive Sales		Brokerage Sales	
Month	Cost to produce 100 lbs of Milk	5 Year Monthly Average Margin Protection Program	5 year Average LGM margin (Farm Bill Ration)	Current LGM-Dairy Expected Margins (Farm bill ration)	Current Class III Price	5 year Average Class III closing price	Basis	Class III Target Price	Monthly milk production in lbs	Production base	% of prodiction base covered	Coverage level $4.00-$8.00	cwt	Margin	cwt	Price	cwt	Price
October		$10.41	$8.64		$15.49	$19.61	$3.21											
November		$10.20	$8.24		$15.46	$19.21	$3.41											
December		$8.95	$6.60	$7.47	$15.51	$17.58	$3.38											
January		$8.36	$6.15	$7.44	$15.48	$17.19	$4.31											
February		$8.34	$6.51	$7.56	$15.66	$17.81	$3.52											
March		$8.36	$6.61	$7.74	$15.89	$18.18	$3.27											
April		$7.89	$6.48	$7.81	$15.93	$18.05	$3.28											
May		$7.39	$6.26	$7.86	$16.08	$17.82	$3.56											
June		$7.58	$6.31	$8.15	$16.48	$18.19	$3.08											
July		$7.48	$6.44	$8.41	$16.71	$18.64	$2.83											
August		$8.18	$7.53	$8.59	$16.85	$19.14	$2.46											
September		$9.48	$7.94	$8.61	$16.88	$19.30	$3.10											
Average		$8.55	$6.98	$7.96	$16.04	$18.39	$3.28											

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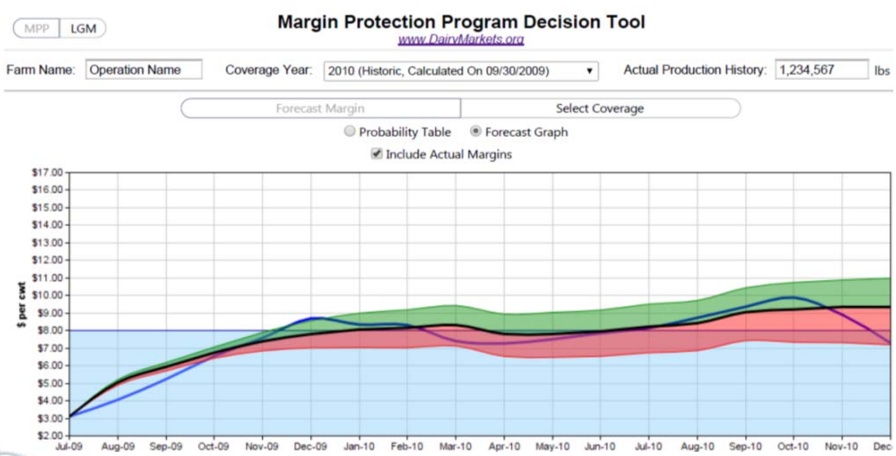
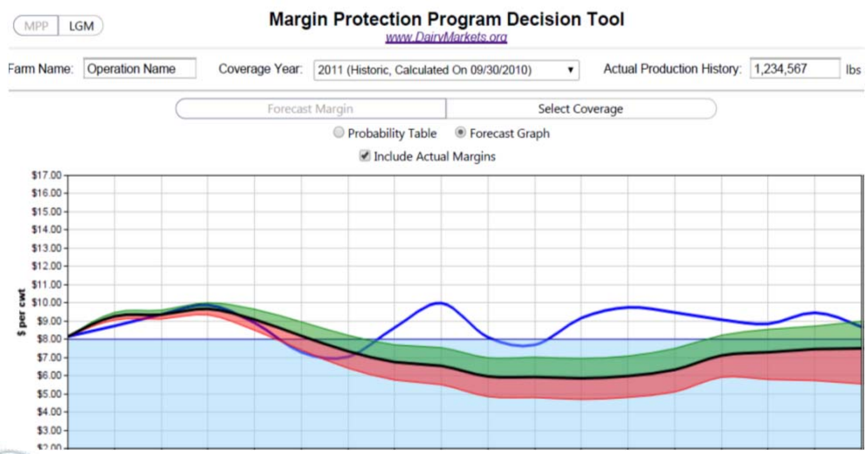
Thank You !

717-346-0849
www. centerfordairyexcellence.org
717-420-7448

2010



2011



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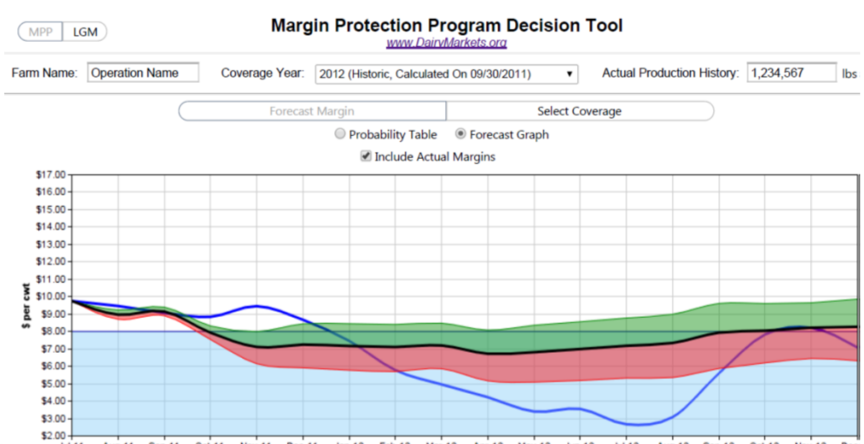
2012



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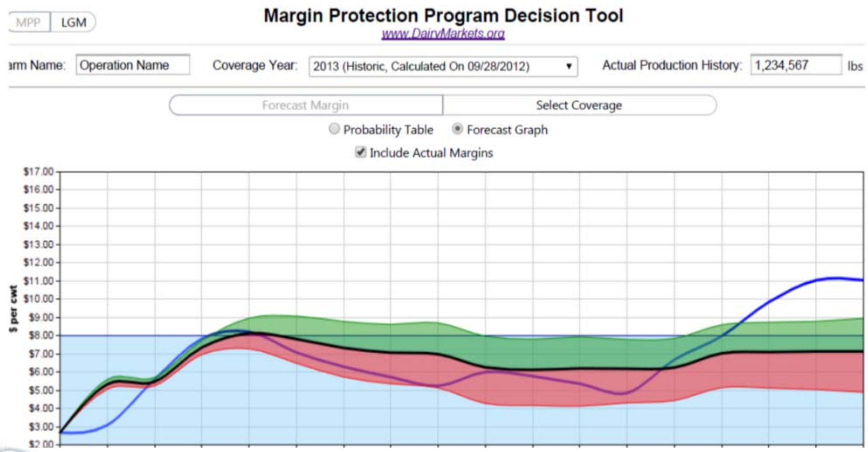
2013



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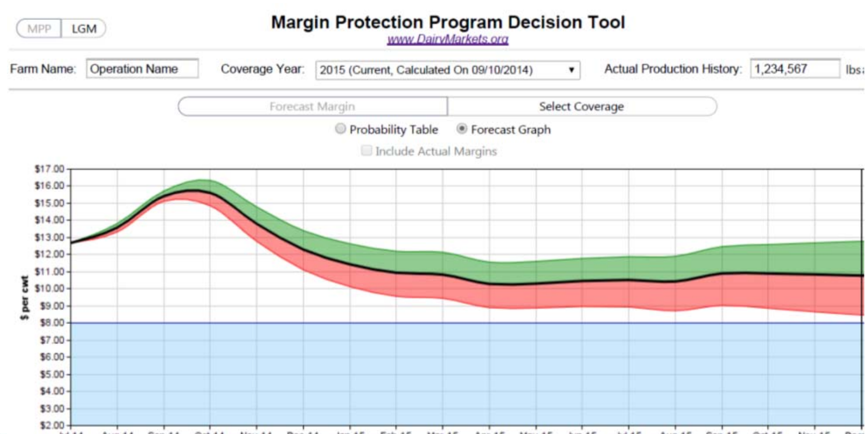
2015



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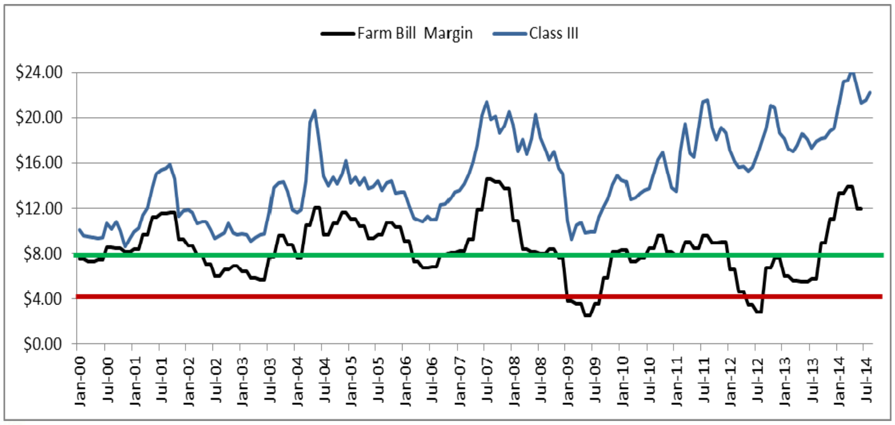
Why?



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2015 MPP Enrollment

- 48% of US Dairy Farms
  - 80 % of milk
- 30% of PA Dairy farms
  - 50% of milk
- $4.00 Margin
  - US- 44% enrolled farms - 58% enrolled milk
  - PA-42% enrolled farms - 47% enrolled milk
- $6.50 Margin
  - US- 26% enrolled farms - 13% enrolled milk
  - PA- 26% enrolled farms - 24% enrolled milk

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Milk Price & Margins

Month	All Milk Price	Margin
November-07	$21.90	$14.23
August-11	$22.10	$9.46
November-12	$22.10	$8.21
December-13	$22.00	$11.04
May-01	$15.50	$10.84
March-04	$15.50	$9.16
September-04	$15.50	$10.52
March-05	$15.50	$10.61
October-05	$15.50	$10.90
December-08	$15.50	$7.04
June-10	$15.40	$7.85
May-12	$16.20	$3.40

CENTER FOR DairyEXCELLENCE