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Upcoming Conference Dates

June 12-13, 2019
June 10-11, 2020

Strategies To Capture Your Herd's Potential

Roger Scaletti, PhD
Technical Support Mineral Management
Alltech, Inc.
rscaletti@alltech.com

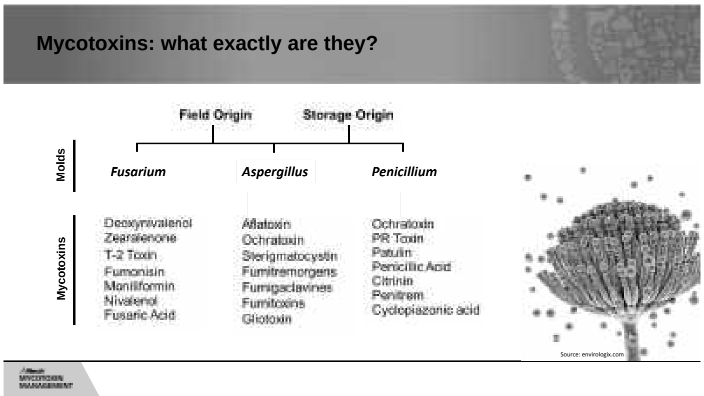
Peer reviewed research has demonstrated advantages to dairy cows when only supplementing with organic trace minerals (BIOPLEX® and SEL-PLEX®). Kinal et al. (2007) showed greater ($P < 0.05$) milk over the first two months of lactation when using only BIOPLEX minerals to supply Zn, Mn and Cu (600 mg, 400 mg, 120 mg, respectively) compared to cows supplemented with inorganic mineral sources or cows supplemented with half of the trace minerals from BIOPLEX and half from inorganic sources. Additionally, the total replacement cows produced more milk ($P < 0.05$) over the first 100 days of lactation than cows supplemented with inorganic minerals. Somatic cell count was also lower ($P < 0.05$) in cows supplemented with BIOPLEX minerals compared to cows supplemented with inorganic minerals. Cope et al. (2009) showed increased milk production ($P < 0.05$) when BIOPLEX Zn was supplemented at 600 mg/cow/day compared to the same amount of zinc from an inorganic source. Scaletti and Harmon (2012) showed decreased ($P < 0.05$) bacteria count in milk and increased milk production ($P <0.05$) in response to an intramammary challenge with E. coli when cows were supplemented with BIOPLEX Cu (200 mg/cow/day) compared to the same amount of Cu from copper sulfate.

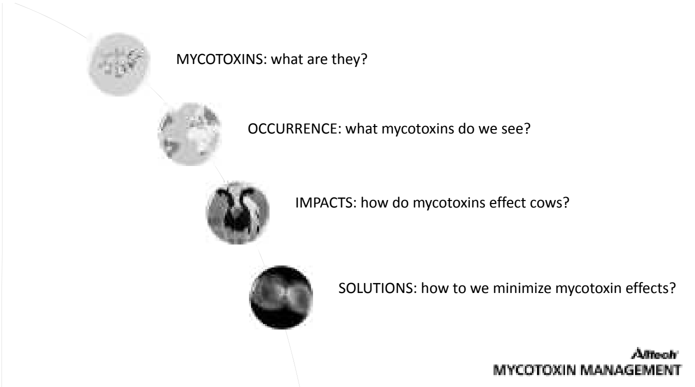
Pino and Heinrichs (2016) compared total replacement of trace minerals (Zn, Mn, Cu, Co and Se) with BIOPLEX and SEL-PLEX® to diets supplemented with inorganic sources. Total replacement diets (with some minerals fed at lower levels compared to the inorganic mineral treatment) resulted in greater ($P = 0.08$) total VFA production and greater ($P =0.03$) total butyrate production. These differences could be explained by the higher bioavailability of the BIOPLEX and SEL-PLEX treatment and accelerated replication of the rumen microorganisms. This research also confirms that there is not a rumen requirement for inorganic minerals, as the BIOPLEX and SEL-PLEX treatment contained no inorganic minerals and had improved rumen function as measured by increased total VFA production and increased butyrate production.

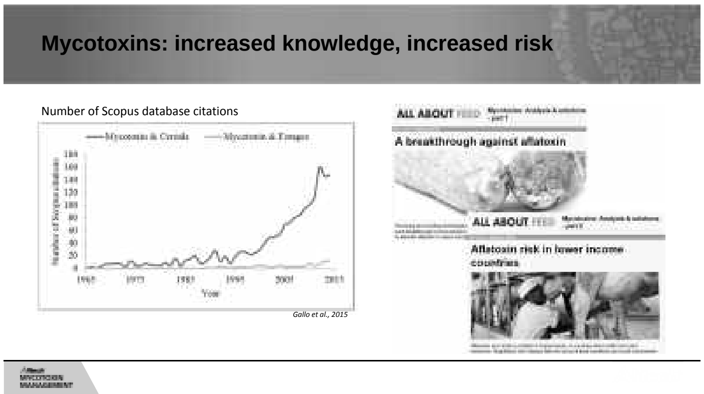
Effect of mineral supplementation beginning in the dry cow program on calf health and then future heifer development was investigated. Gelsinger et al. (2016) found that supplementing BIOPLEX and SEL-PLEX compared to inorganic minerals to the dry cow or to the calf after birth could improve overall health score. BIOPLEX and SEL-PLEX feeding to the dry cow was the only way to decrease haptoglobin in calves. Pino et al. (2018) continued supplementing calves from Gelsinger et al. (2016) with BIOPLEX and SEL-PLEX through the heifer development period and into their first lactation. BIOPLEX and SEL-PLEX supplementation to the dry cow resulted in their heifers calving 26.5 days earlier ($P = 0.05$) compared to heifers born to dry cows supplemented with inorganic minerals. BIOPLEX and SEL-PLEX supplementation to the heifer tended to lower ($P = 0.07$) age at calving by 22 days. After freshening heifers supplemented with BIOPLEX and SEL-PLEX produced 170 kg more milk ($P = 0.05$) in the first 100 days of lactation.

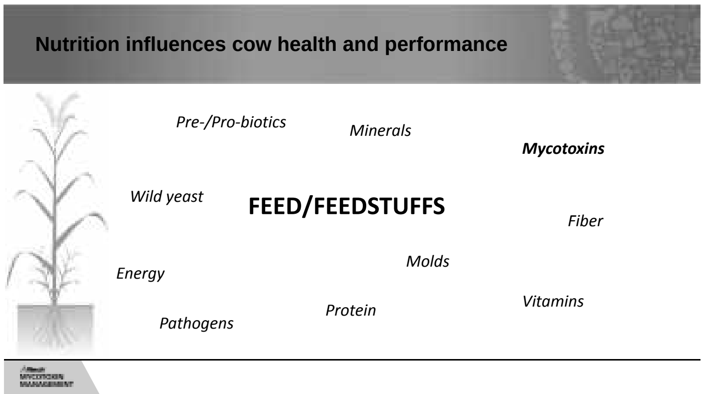
Mycotoxin Impact on Lifetime Performance from Fetus Through Freshening

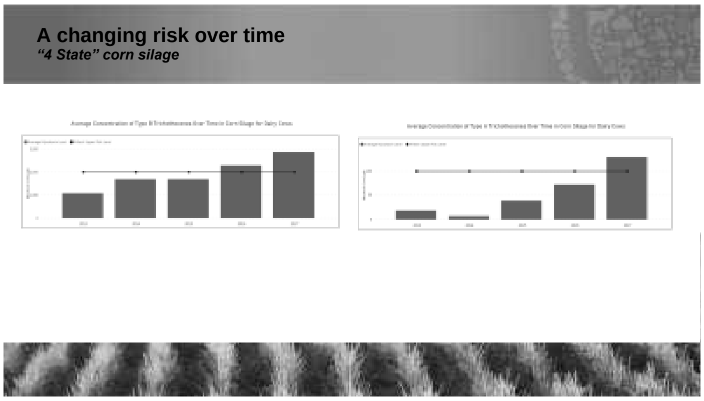
Dr. Alexandra Weaver
53 Clark Falls Rd, Orrington, ME 04474
aweaver@alltech.com











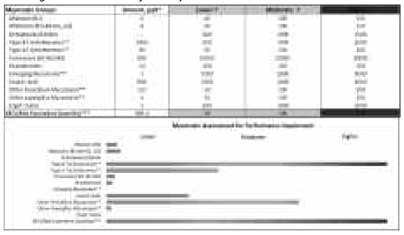
Why Increased Focus on Mycotoxins?

- Global issue/trading
- Increased monitoring/technology
- Changing agriculture practices
- Variable weather
- Food safety/regulations
- Mycotoxin interactions

Client

Mycotoxins levels pose a risk to cows
Ex. "4 State" corn silage

Average risk assessment for dairy cows



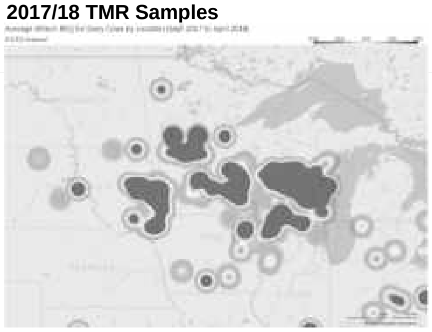
Mycotoxin analysis conducted by:

Results: Sept 1, 2017 to April 10, 2018

Methods of mycotoxin analysis
Alltech 37+: cutting edge technology

- **High technology UPLC-MS/MS**
- **37+ mycotoxins, simultaneous analysis**
  - DON-3-Glucose
  - Fusaric Acid
  - Storage: Penicillium and Aspergillus
  - Citrinin
  - Emerging mycotoxins
  - New ergot toxins to be added Q2 2018
- **Broad Spectrum of Feed Materials**
  - Grains, plant proteins, silages/forages
  - Finished feeds
- **Published method**
- **Globally accredited**
- **In depth reports**
- **Global database/ "big data"**
  - +21,000 samples

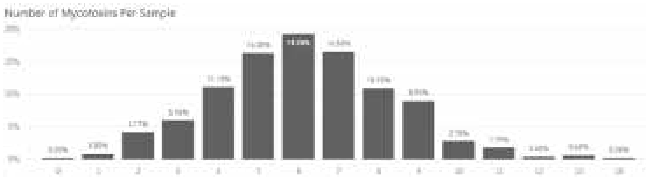
2017/18 TMR Samples



Mycotoxin analysis conducted by:

USA TMR, Sept 1, 2017 to April 10, 2018

Mycotoxins rarely found in isolation…



USA TMR, Sept 1, 2017 to April 10, 2018
Analyzed by Alltech 37+

Phase 1. Challenges during the peripartum period

Even in a good environment, immunity can present road blocks for the cow

Mycotoxins levels pose a risk to cows
Ex. "4 State" corn silage

33% aflatoxin B1

1 OR MORE IN **100%** of samples

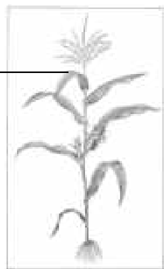
AVERAGE OF **5.6** mycotoxins

93% fusaric acid

30% type A trichothecenes

96% type B trichothecenes

63% fumonisins



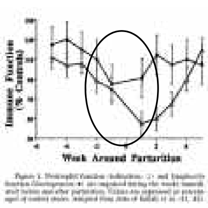
Number of Samples: 106

Mycotoxin analysis conducted by:

Results: Sept 1, 2017 to April 10, 2018

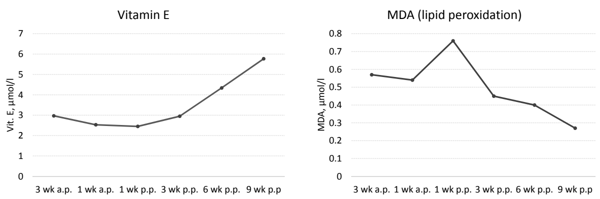
Changes during the peripartum period

Immune Function Pre & Post Calving



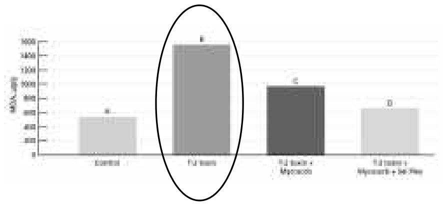
Detilleux et al., 1995; Goff and Horst, 1997

Changes during the peripartum period

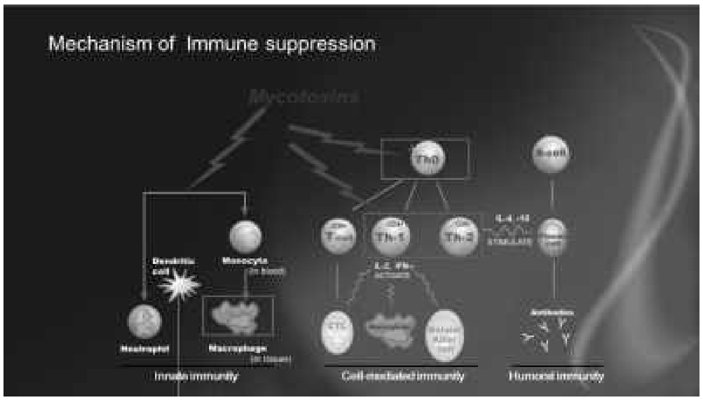


Konvicna et al., 2015

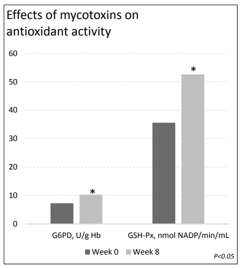
An increase in oxidative stress levels in liver during mycotoxin challenge

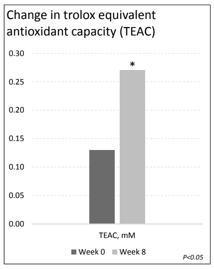


Dvorska et al. 2007.



Influence of mycotoxins on oxidative stress





*When **mycotoxins** consumed...*

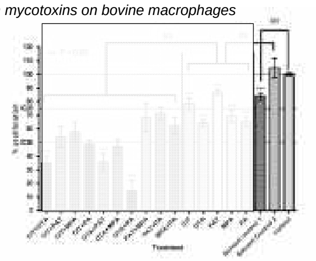
antioxidant activity lowered, *therefore cows may have* ***increased oxidative stress***

Mycotoxins:
-Higher *Penicillium* mycotoxins
-Higher *Aspergillus* mycotoxins
-Higher ZEA (91-240 ppb)
-Low/moderate DON (205 - 761 ppb)
Yeast cell wall material (Alltech) added for 8 weeks

(Santos and Fink-Gremmels, 2014)

Influence of mycotoxins on immunity

Influence of penicillium mycotoxins on bovine macrophages



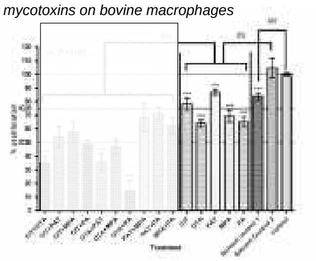
(Oh et al., 2012)

Phase 2. Mycotoxins impact growth and health of calves

Alltech
MYCOTOXIN MANAGEMENT

Influence of mycotoxins on immunity

Influence of penicillium mycotoxins on bovine macrophages



Additive effect:
CIT + OTA
CIT + PAT

Synergistic effect:
OTA + PA
(over 80% of cell proliferation inhibited)

(Oh et al., 2012)

A decrease in colostrum and milk

Calves must receive ample amounts of high quality, clean colostrum

Ergot alkaloids are shown to reduce the prolactin surge on the day of parturition and for at least 1 day following
- Prolactin peak reduced by 43%
- Prolactin restriction decreases colostrum and milk production

Aflatoxins shown to reduce colostrum production
- Inflammation of mammary gland

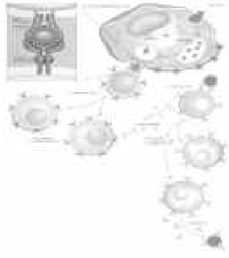
Deoxynivalenol shown to reduce milk production

(Bernard et al., 1993; Hafez et al 1985)

22

Calves undergo a stress

- Weaning stress
- Diet changes
- Gut irritation
- Immune challenges
- Diseases
- Environment



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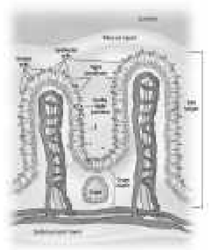
Phase 3. Mycotoxin impact on heifers could alter the future of the farm

Intestinal system a component of calf health

Mycotoxins alter intestinal structure/function

- Intestinal damage, lesions, haemorrhage
- Increase in intestinal permeability
- Reduced mucus production
- Altered gut level immunity
- Change in nutrient digestion
- Diarrhea

Improved gut health early offers protection against mycotoxins



Antonissen et al., 2014; Bojkovski and Relic, 2012; Hussein and Brasel, 2001; Weaver et al., 2014

The cost of mycotoxins

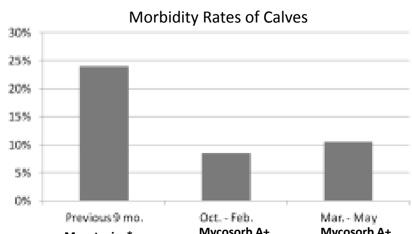
Researchers have speculated that dairy replacement heifers could potentially **lose up to 25% of their full genetic potential** of milk production

- Disease in early life
- Feed challenges from mycotoxins

Client

Courtesy of Dr. Fink-Gremmels, University of Utrecht of the Netherlands

Mycotoxins may increase health costs



*High fumonisisn + moderate type A trichothecenes)

25

Heifers: the future of the farm

Whether maintaining or expanding herd size, *disease management* should be a focus

- Enteritis (*E. coli* & *Salmonella*)
- Pneumonia
- Challenges from molds and mycotoxins

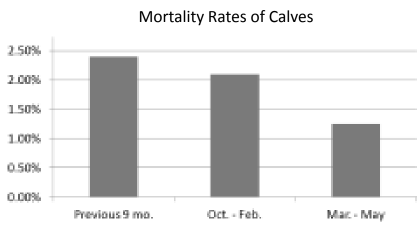
Disease occurrence could…

- Alter growth performance
- Delay onset to puberty
- Impact organ and immune systems
- Alter long term reproduction and milk production
- Increase death loss

Client

Courtesy of Dr. Fink-Gremmels, University of Utrecht of the Netherlands

Mycotoxins may increase health costs



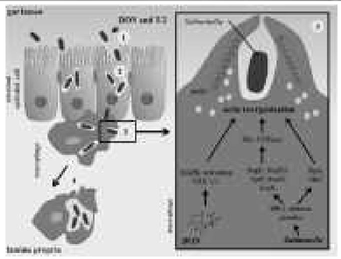
*High fumonisisn + moderate type A trichothecenes)

26

Mycotoxins impact disease resistance at the gut level

Salmonella Infection

Addition of DON + T2 increases the passage of *Salmonella* across the gut epithelium as well as promote update by macrophages



Antonissen et al., 2014

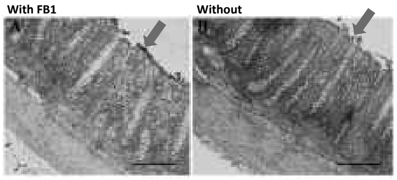
Mycotoxins observed may impact swine

Fumonisins alter gut pathogen virulence

(*p* <0.05)

Fumonisin…

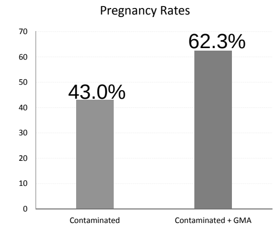
Exposure to FB_1 at 5 to 8 ppm can be a predisposing factor to infectious disease such as E. Coli.



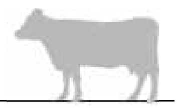
In situ visualization of bacteria in colon tissue by immunohistochemistry following inoculation with *E. coli* strain 28CNal. Bacteria, were found in aggregates closely associated with the colon surface epithelium and in the serosa. Increased colonization detected with FB1.

(Oswald et al., 2003)

Impact on reproductive performance

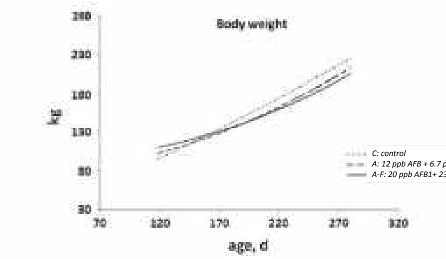


- Mastitis occurrence/treatment also lowered when the feed additive included



Hulik and Zeman, 2014

Growth curves for dairy heifers with or without mycotoxin challenge



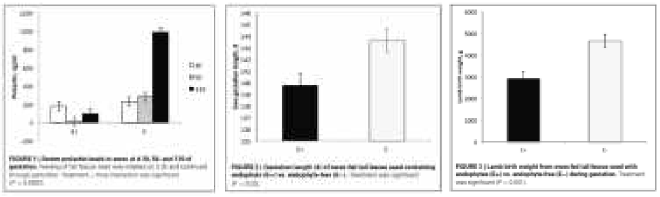
36 Friesian heifers (18 to 21 weeks old), 24 week long trial

Abeni et al., 2014

Mycotoxins impact gestation

Ergot toxins impact on reproduction *(800 µg/kg DM ergovaline+ergovalinine)*

- Ewes fed from day 35 gestation to parturition (Duckette et al., 2014)



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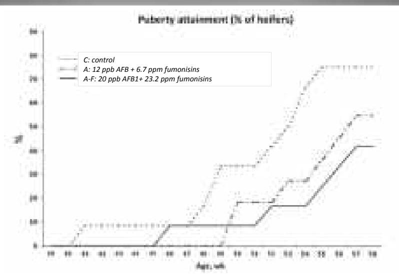
Puberty attainment for dairy heifers with or without mycotoxin challenge



36 Friesian heifers (18 to 21 weeks old), 24 week long trial

Abeni et al., 2014

Phase 4.

Mycotoxin challenges limiting reproductive efficiency

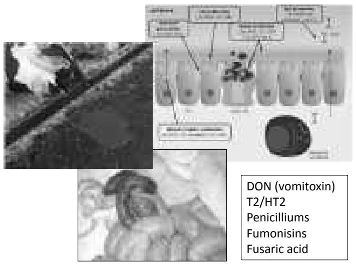
Influence of mycotoxins on GIT structure and function

Rumen and gut health is important for optimal cow performance

Healthy Cows = High Production

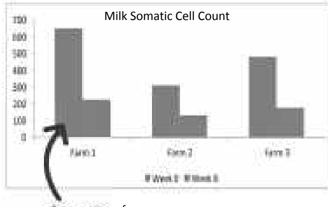
Influence of mycotoxins on GIT structure and function

Digestive disorders
- Rumen disfunction
- Damage, lesions, haemorrhage
- Change in nutrient digestion
- Inconsistent manure quality
- May impact microbial functions
- Reduced feed intake



Antonissen et al., 2014
Hussein and Brasel, 2001

Impact on milk quality



*When cows consumed **mycotoxins**…*

***somatic cell count** was an average of 62% higher*

Mycotoxins:
-Higher *Penicillium* mycotoxins
-Higher *Aspergillus* mycotoxins
-Higher ZEA (91-240 ppb)
-Low/moderate DON (205 - 761 ppb)
Yeast cell wall material (Alltech) added for 8 weeks

(Santos and Fink-Gremmels, 2014)

Influence of mycotoxins on rumen health

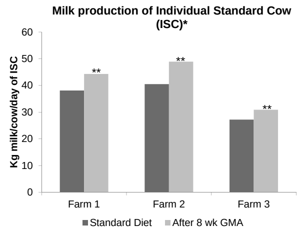
Effect of DON on ruminal protein synthesis

Duodenal Flow of:	Control	DON 3.1 ppm
Crude Protein, g/day	1180	↓950
Microbial Protein, g/day	862	↓680
Metabolizable Protein, g/day*	1091	↓871

***20% less MP**

(Danike et al., 2005 J Animal Physiol. and Animal Nutrition 89:303-315)

Impact on milk production



*ISC: normalizes milk production to days in milk.

Consumption of **mycotoxins**

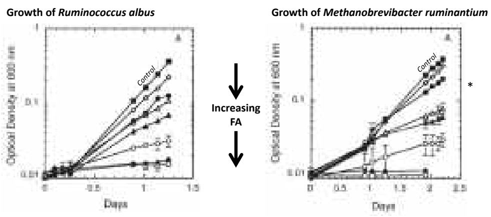
suppressed milk production by an average of **6.1 kg/cow/day (13.2 lb)**

Mycotoxins:
-Higher *Penicillium* mycotoxins
-Higher *Aspergillus* mycotoxins
-Higher ZEA (91-240 ppb)
-Low/moderate DON (205 - 761 ppb)
Yeast cell wall material (Alltech) added for 8 weeks

(Santos and Fink-Gremmels, 2014)

Influence of mycotoxins on rumen health

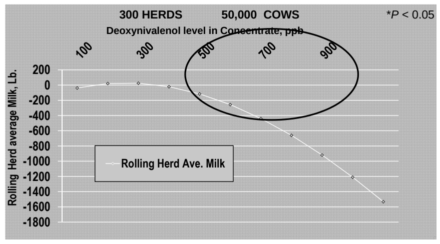
Increasing amounts of fusaric acid (FA) reduce microbial growth of beneficial organisms for the rumen.



(Moy et al., 2000)

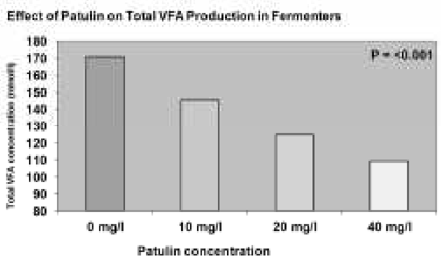
Mycotoxins at lower levels impact production

Relationship of deoxynivalenol to change in rolling herd average milk



(Whitlow et al. 1991. North Carolina State University, 1982-1983)

Influence of mycotoxins on rumen health



Change in total VFA concluded to be a related to a decrease in rumen bacterial populations

(Tapia et al., 2005)

What could mycotoxins cost your herd in milk production loss?*

Mycotoxins can have many effects on cows. Loss in milk production is one response causing lower profitability. Mycotoxins can also impact reproductive performance and immunity, increasing the loss in overall profitability.

Alltech 37+® analysis with average REQ = 407 (Sept 2017 to April, 2018) at 50% inclusion (REQ = 204). The REQ represents the "risk equivalent quantity," or the total toxicity of multiple mycotoxins on animal performance. These estimates were generated by the Alltech PROTECT Calculator™, and may differ from that observed on-farm.

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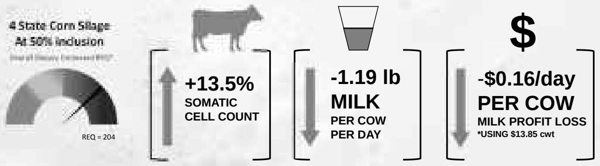


*Based on the mycotoxin levels from IL, IA, MN and WI corn silage samples from Alltech 37+® analysis with average REQ = 407 (Sept 2017 to April, 2018) at 50% inclusion (REQ = 204). The REQ represents the "risk equivalent quantity," or the total toxicity of multiple mycotoxins on animal performance. These estimates were generated by the Alltech PROTECT Calculator™, and may differ from that observed on-farm.

Alltech

Key message

Mycotoxins are a common contaminant that play a key role in the health of the entire herd

Alltech
MYCOTOXIN MANAGEMENT

19 points for preventing, decontaminating and minimizing the toxicity of molds/mycotoxins

Jouany, 2007

1. Crop rotation
2. Tillage method
3. Soil fertilizers
4. Planting date
5. Plant breeding
6. Chemical control
7. Biological control
8. Insect control
9. Weed control
10. Farming method (organic vs conventional)
11. Physiological stage of the plant
12. Mycotoxin analysis
13. Combine harvester settings
14. Humidity level before and during harvest
15. Storage quality/duration
16. Physical treatment of contaminated grains
17. Chemical treatments of grains
18. Biological treatment of grains
19. Adsorbents

Summary: the cost of mycotoxins

Mycotoxins impact health, immunity and performance of calves, growing and breeding heifers, and cows

- Suppress immune response and increase the susceptibility and severity to other disease challenges
  - Enteritis (*Salmonella* and *E. coli*)
  - Respiratory diseases (bovine respiratory diseases)
  - Reduce vaccine titer response and vaccination protection
  - Increased morbidity/mortality
    - Increases health costs

Client

Courtesy of Dr. Fink-Gremmels, University of Utrecht of the Netherlands

MYCOTOXIN MANAGEMENT

Managing mycotoxins

to lower risk

1. Analysis: identifying risk
2. Agronomy/field management
3. Bunk density and proper face management
4. Inclusion rates of feedstuffs
5. Nutritional technologies

Alltech
MYCOTOXIN MANAGEMENT

Summary: the cost of mycotoxins

Mycotoxins impact health, immunity and performance of calves, growing and breeding heifers, and cows

- Delay onset of puberty due to changes in calves/growing heifers typical growth patterns
  - Longer time to first service and first conception
- Metabolic instability and reduced performance characteristics
  - Milk production
  - Udder health

Client

Courtesy of Dr. Fink-Gremmels, University of Utrecht of the Netherlands

MYCOTOXIN MANAGEMENT

Why Increased Focus on Mycotoxins?

- Global issue/trading
- Increased monitoring/technology
- Changing agriculture practices
- Variable weather
- Food safety/regulations
- Mycotoxin interactions

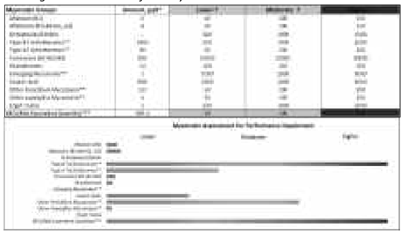
Client

MYCOTOXIN MANAGEMENT

Mycotoxins levels pose a risk to cows

Ex. "4 State" corn silage

Average risk assessment for dairy cows



MYCOTOXIN MANAGEMENT

Mycotoxin analysis conducted by: Alltech 37+

Results: Sept 1, 2017 to April 10, 2018

Methods of mycotoxin analysis

Alltech 37+: cutting edge technology

- **High technology UPLC-MS/MS**
- **37+ mycotoxins, simultaneous analysis**
  - **DON-3-Glucose**
  - **Fusaric Acid**
  - **Storage: Penicillium and Aspergillus**
  - **Citrinin**
  - **Emerging mycotoxins**
  - **New ergot toxins to be added Q2 2018**
- **Broad Spectrum of Feed Materials**
  - **Grains, plant proteins, silages/forages**
  - **Finished feeds**
- **Published method**
- **Globally accredited**
- **In depth reports**
- **Global database/ "big data"**
  - **+21,000 samples**

MYCOTOXIN MANAGEMENT

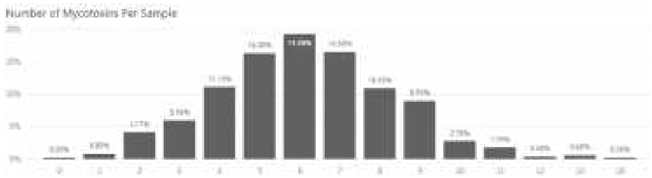
2017/18 TMR Samples

MYCOTOXIN MANAGEMENT

Mycotoxin analysis conducted by: Alltech 37+

USA TMR, Sept 1, 2017 to April 10, 2018

Mycotoxins rarely found in isolation…



MYCOTOXIN MANAGEMENT

USA TMR, Sept 1, 2017 to April 10, 2018
Analyzed by Alltech 37+

Phase 1. Challenges during the peripartum period

Even in a good environment, immunity can present road blocks for the cow

MYCOTOXIN MANAGEMENT

Mycotoxins levels pose a risk to cows

Ex. "4 State" corn silage

33% aflatoxin B1

1 OR MORE IN **100%** of samples

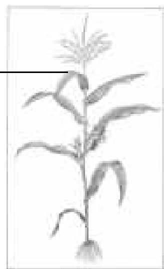
AVERAGE OF **5.6** mycotoxins

93% fusaric acid

30% type A trichothecenes

96% type B trichothecenes

63% fumonisins



Number of Samples: 106

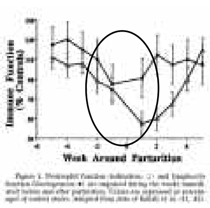
MYCOTOXIN MANAGEMENT

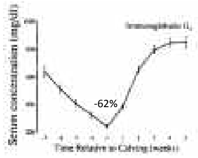
Mycotoxin analysis conducted by: Alltech 37+

Results: Sept 1, 2017 to April 10, 2018

Changes during the peripartum period

Immune Function Pre & Post Calving





Detilleux et al., 1995; Goff and Horst, 1997

MYCOTOXIN MANAGEMENT

The 5 C's of Calf Management

Dr. Sam Leadley
Calf & Heifer Management Specialist
Attica Veterinary Associates
smleadley@yahoo.com www.atticacows.com

The 5 C's of Calf Management

Four-State Dairy Nutrition and Management Conference

June 13-14, 2018

The 5 C's of Calf Management

- Dr. Shelia McGuirk
- Univ. Wisc. School of Vet. Med.
- " Managing the Young Calf – Keep it Simple"
- A simple alliteration to help us remember

Why do I need 5 C's?

- Colostrum, Cleanliness, Comfort, Calories, Consistency
- Short! 5 words fit on the back of your business card
- Alliteration/memory – "Seven ships sailed silently."

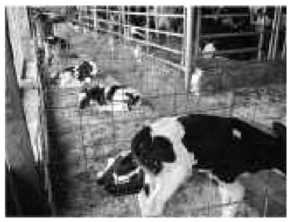
Keep it Simple - Colostrum

- 1. Quickly – sooner is always better
- 2. Quality – higher concentrations of IgG's always better
- 3. Quantity – meet the 200g IgG's threshold
- 4. Quantify – follow up with blood testing
- 5. sQueaky clean – teat-to-mouth cleanliness, confirmed by laboratory cultures

Keep it Simple - Cleanliness

Calving Pen

Newborn Pen



Keep it Simple - Cleanliness

Individual Pens

Group Housing

Keep it Simple - Cleanliness

Supply of clean air, draft free

Supply of clean air, draft free

Keep it Simple - Cleanliness

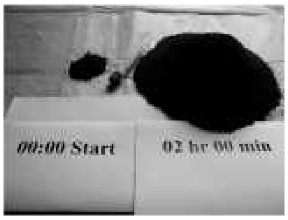
Equipment Cleaning Protocol
[click <u>HERE</u> for protocol]

Equipment Cleaning Protocol
http://atticacows.com/library/newsletters/WashMilkContProtocolR1815.pdf

Keep it Simple - Cleanliness

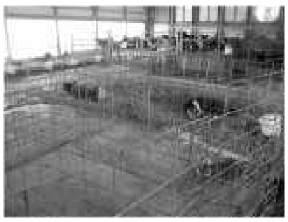
Coliforms in Colostrum

1,000cfu/ml to 64,000cfu/ml in 2 hours



Keep it Simple - Comfort

Heat Loss – <u>Conduction</u> - Insulation

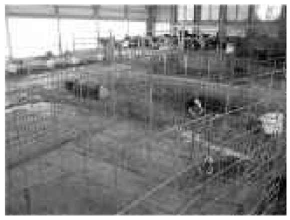


Heat Loss – <u>Convection</u> - Nesting

Keep it Simple - Comfort

Heat Loss – Dry
Knee-Drop Test

Using Calf Coats/Blankets

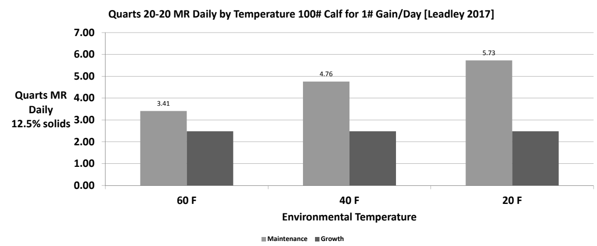


Keep it Simple - Calories

Colostrum – 1.6 X calories compared to whole milk

Transition milk – 1.2 – 1.5X calories compared to whole milk

Keep it Simple - Calories



Keep it Simple - Calories

- **"But, every time I try feeding more milk my calves have scours!"**
- **Ten-Point Check list on best management practices**
- **Click <u>HERE</u> for checklist**
- **Enter this URL http://atticacows.com/library/newsletters/FeedingMoreMilkwithoutScoursR1845.pdf**

Keep it Simple - Calories

Calf Starter Grain Consumption Summer

Lbs. Eaten	Energy-Limited Gain @ **60F**
2	**Wt. Loss**
3	0.7lbs
4	1.3lbs
5	1.8lbs

[180 lb. heifer calf, calf starter = 18% c.p. , DE(Mcal/kg)=3.69]

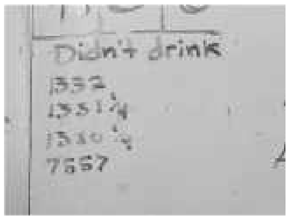
Calf Starter Grain Consumption Winter

Lbs. Eaten	Energy-Limited Gain @ **20F**
2	**Wt. Loss**
3	**Wt. Loss**
4	0.3lbs
5	1.0lbs

[180 lb. heifer calf, calf starter = 18% c.p. , DE(Mcal/kg)=3.69]

Keep it Simple - Consistency

Person-to-Person Communication

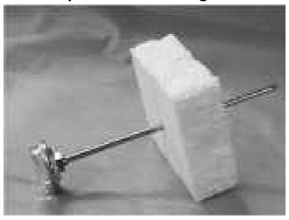


Same Persons take care Same Calves

Keep it Simple - Consistency

Milk Temperature – Start Right

Milk Temperature – Feed Right



Keep it Simple – 5 C's

- Colostrum
- Cleanliness
- Comfort
- Calories
- Consistency

Keep it Simple - Consistency

Volume of Milk Fed – Everyone on the same page

Volume of Milk Fed – Guessing vs. Metering

Dr. Sam Leadley
Attica Veterinary Associates, P.C.

- Specializing in dairy calf rearing since 1988.
- ***Calving Ease*** monthly letter for calf rearers via Internet. Send e-mail with subscribe in subject to smleadley@yahoo.com
- Website is **calffacts.com**
- E-mail smleadley@yahoo.com
- Blog, Google title **Calves with Sam**

Keep it Simple - Consistency

Solids & Composition – Test

Solids & Composition - Weigh

Fine Tuning Your Diary for Greater Efficiency and Profits

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Alltech On-Farm Assistance

Alltech offers on-farm services and audits to evaluate and improve various aspects of a dairy. The main goal is to help dairy producers remain profitable by maintaining a clean, comfortable environment for employees, farm visitors and most importantly, the cows.

Biosecurity Protocols

Following on-farm biosecurity protocols is essential for ag consultants. Biosecurity is the first step to preventing and managing disease on any farm. Infectious diseases could strike at any time; therefore, it is important to have a biosecurity plan in place. As dairy professionals, we must promote biosecurity both through ourselves and proper care of the tools we use. Biosecurity is our collective responsibility.

Animal Care

Today's consumer takes an intense interest in the foods they eat and serve their families. It's up to the FARMERS to show them they are committed to producing quality food and properly caring for their livestock. Alltech provides on-farm support and tools for dairy producers as they continue to earn the trust of the consumer.

Cow Comfort

Milk quality starts with providing a clean, dry, comfortable environment for the cows. During a cow comfort audit, the facility is assessed for meeting the behavioral and safety needs of the cow. In addition, the cow themselves are evaluated for signs of injury, lameness, or behavioral abnormalities.

Milking Procedures

The milking routine is another important part of our audit. There is a lot of milk won or lost in the milking parlor with inconsistent milking routines. We will observe the milking technicians and review written milking protocols to look at ways to improve cow throughput. When necessary, current milking routines are modified to improve cow throughput and milk quality. End of milking reports, flow rates, and unit on times are also evaluated.

Development of an Assay to Predict Intestinal Nitrogen Indigestibility and Application of the Assay in High Producing Lactating Cattle: One Step Closer to Feeding a Cow like a Pig?

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Cornell University
Corresponding author: mev1@cornell.edu

Summary

1. An up-dated method to estimate intestinal nitrogen indigestibility of feeds for ruminants was developed from a combination of current methods and then refined to reduce particle and N loss.
2. The assay is comprised of a 16 hr in-vitro incubation in rumen fluid and buffer and then a 24 hr in-vitro incubation in a specific intestinal enzyme cocktail in a shaking water bath.
3. The assay was developed primarily for non-forage feeds and represents a departure from the detergent system used to fractionate most feeds.
4. For most feeds the results from the assay differ significantly from acid detergent insoluble protein demonstrating differences between feed chemistry versus the bio-assay.
5. To investigate the accuracy and precision of the assay predictions, a study was conducted with high producing lactating cattle to evaluate the sensitivity to differences in predicted indigestibility o two different blood meal products.
6. In the cattle study milk yield and overall performance of lactating dairy cattle was reduced in cattle fed the lower digestibility protein source and the difference in the amount of available N supplied was 32 grams, less than 5% of total N intake.

Introduction

Current cattle diet formulation models rely on library estimates of intestinal digestibility of proteins and carbohydrates to predict metabolizable energy (ME) and protein (MP) supply (NRC, 2001; Fox et al., 2004; Tylutki et al., 2008). As models become more accurate and precise in the prediction of nutrient supply and evaluation of requirements and nutrient balance, greater scrutiny will be placed on inputs currently relegated to static library values. Although CP is not a functional dietary nutrient for cattle, many diets are still formulated on this metric, creating confusion due to inadequate information provided by the value, especially with regard to MP supply and amino acid availability. As diets are formulated to be closer to MP requirements and rumen ammonia balance, they will, under most circumstances, be lower in CP, thus, accurate estimates of intestinal digestibility (ID) of protein and amino acids are increasingly important to ensure an adequate supply of those nutrients. Application of outdated feed library values to all feeding conditions can lead to under- and over-estimations of MP and amino acid supply, resulting in variation from expected production. This paper describes the re-development of an in-vitro intestinal digestion (IVID) assay for protein containing feeds used in ruminant nutrition, including intact commercially available feeds designed to resist rumen degradation. The methods used were developed to provide adequate sample size, minimize sample loss, and to allow for standardization of enzyme activity and concentration. The assay contains positive and negative controls to evaluate standardization among and within laboratories.

The feed library of the Dairy NRC (National Research Council, 2001) and the Cornell Net Carbohydrate and Protein System (CNCPS) (Tylutki et al., 2008; Higgs et al., 2015) has static values for intestinal protein digestibility values for various protein fractions, and acid detergent insoluble protein (ADIP) is used to define the unavailable protein. The committee that developed the 2001 Dairy NRC adjusted available MP from feed by assigning a digestibility of 5% to the ADIP fraction based on data indicating that some amino acids could be liberated and absorbed from this fraction (NRC, 2001). The results from the assay described in this paper can be compared to both the ADIP and the adjusted ADIP value from the NRC calculation as an unavailable protein fraction.

Further, current cattle diet formulation models rely on library estimates of intestinal digestibility of proteins and carbohydrates to predict metabolizable energy (ME) and protein (MP) supply (NRC, 2001; Fox et al., 2004; Tylutki et al., 2008). As models become more accurate and precise in the prediction of nutrient supply and nutrient balance, there is a greater need to evaluate and be able to adapt the inputs currently used as static library values. Although CP is not a functional dietary nutrient for cattle, many diets are still formulated on this metric, creating confusion due to inadequate information provided by the value, especially with regard to MP supply and amino acid availability. As diets are formulated closer to the MP requirements of cattle and subsequently lower in CP, accurate estimates of intestinal digestibility (ID) or indigestibility of protein and amino acids are increasingly important to ensure an adequate supply of those nutrients. Use of outdated feed library values to all feeding conditions can lead to under- and overestimations of MP and amino acid supply, resulting in variation from expected production.

Since the inception of the Cornell Net Carbohydrate and Protein System (Fox et al., 2004; Tylutki et al., 2008), the detergent system of fractionation has been applied to both the carbohydrate and protein components of feeds (Sniffen et al., 1992). More recent work suggests this approach, especially for feeds not containing NDF, might not be appropriate to accurately characterize how protein is partitioned and digests in the rumen and post-ruminally. Several approaches have been developed to predict the intestinal digestibility of protein in feeds and are a departure from the detergent system of feed chemical composition (Calsamiglia and Stern, 1995; Gargallo et al., 2006; Ross et al., 2013). The N assay was developed to predict N indigestibility, and will be briefly described in that manner throughout the paper. The cattle study described in this paper was conducted by formulating two different diets in high producing cattle using two different blood meals with different predicted intestinal protein indigestibility to test the accuracy and precision of both the assay (Ross et al., 2013) and our ability to apply those values in the CNCPS for diet formulation.

Assay Development Considerations

The following discussion points are provided to highlight potential problems or concerns with current methods and to provide evidence for the need to develop alternative approaches.

Use of bags:

- Created a microbial barrier to feed access and microbial attachment which artificially prolongs the lag phase of digestion.
- Demonstrated loss of highly soluble components of feeds from the bag prior to digestion and loss of particles as digestion progresses. Measured losses of up to 30% of the initial sample prior to any analyses have been reported.

Use of enzymes:

- Profiles and activities are not properly described and characterized.
- The digestive process of the ruminant is a continuous flow of digesta with continuous secretion of enzymes and digestive juices (Hill, 1965).

Abomasal digestion:

- Pepsin, an endopeptidase, hydrolyzes approximately 15-20 % of dietary protein to AA and small peptides (Kutchai, 1998). Bovine pepsin has approximately ~60-70 % of the activity of porcine pepsin with hemoglobin as substrate (Lang and Kassell, 1971). Porcine pepsin is generally used in the first step of IV intestinal digestion assays to measure ruminant intestinal digestion (Calsamiglia and Stern, 1995; Gargallo et al., 2006).
- One mg of porcine pepsin contains 200 to 625 units with pH between 1.5 and 2.5, for optimum pepsin activity.
- Lysozymes which aid in digestion of microbes are also secreted in the digestive tract. Bovine digestive lysozyme has a lower optimum pH than chicken lysozyme (7.65 vs. 10.7, respectively) with a pH optimum 5, not 7, making it resistant to pepsin hydrolysis. Furthermore, bovine lysozymes lyse gram-negative and gram-positive bacteria, while chicken lysozyme acts only on gram positive bacteria (Dobson et al., 1984; Protection of plants against plant pathogens: http://www.patentstorm.us/patents/5422108/description.html; accessed Nov 1, 2010). However, bovine digestive lysozyme is commercially unavailable.

Small intestine digestion:

- Species differences exist in the activities of proteases in the pancreas. In rats, trypsin activity represents ~80 % while in ruminants it represents only 15 % and chymotrypsin makes up 43 % (Keller et al., 1958).
- The calculated activities of trypsin and chymotrypsin in intestinal contents from 5 month old calves (Gorrill et al., 1968) were 19.48 and 15.9 U/ml, respectively using p-toluene-sulfonyl-L-arginine methyl ester (TAME) and benzoyl-L- tyrosine-ethyl ester (BTEE), as substrates.
- In sheep, the activities of trypsin, chymotrypsin and carboxypeptidase A increased from the pylorous to 7 m beyond with maximum specific activities of 24, 150, and 35 µM of respective substrates (benzoyl-L-arginine-ethyl ester (BAEE), acetyl- L- tyrosine-ethyl ester (ATEE), hippuryl-DL-phenyl-lactic acid) per minute per ml digesta, and then decreased (Ben-Ghedalia et al.,1974).
- Sklan and Halevy (1985) found maximal activities of pancreatic enzymes in the proximal segments of the ovine SI at 1 m distal to the pylorous and then relatively constant ratios of enzyme levels

(trypsin, chymotrypsin, elastase, carboxypeptidases A & B) to cerium-141, an unabsorbed reference, of 0.065, 0.053, 0.015, 0.05 and 0.045, respectively, 1.5 to 9 m distal to the pylorous. No other in vivo activities for bovine pancreatic proteolytic enzymes were measured.
- Units of enzyme activity are dependent upon substrate (a protein or ester) hydrolyzed in addition to the wavelength used. Among the studies reviewed, this data varies considerably and is not standardized.
- The current three step assays (Calsamiglia and Stern, 1995; Gargallo et al., 2006; Borucki Castro et al., 2007; Boucher et al., 2009a,b,c) use 3 g of pancreatin per L after an IV abomasal digestion with 1 g L-1 of porcine pepsin in 0.1 N HCl N at pH 1.9 or 2. However, the pancreatin concentration in the assay of Calsamiglia and Stern (1995) was 1.69 mg ml-1 based on the conditions described for the assay as published.
- Pancreatin always contains amylase and lipase but over time the proteolytic enzyme has changed from trypsin to many enzymes, including trypsin, ribonuclease and protease (specifications for P7545; (www.sigmaaldrich.com/catalog/product/sigma/p7545?lang=en. accessed, Nov 10, 2010) and specific units of enzymatic activity are not provided.
- Further, lipase activity is essentially nonexistent in bovine pancreatic juice (Keller, 1958) but is high in saliva. Calsamiglia and Stern (1995) attributed the increase in digestion of their proteins over those obtained using the multi-enzyme system of Hsu et al. (1977) to the presence of amylase and lipase in pancreatin.
- Bovine bile salts were added to the enzyme system to improve the emulsification of samples, especially those containing fat.

Thus, the enzymes used in the assay for the abomasal and intestinal digestion step and their respective activities were based on the data described and were adopted and run in parallel with pancreatin.

Assay Methods Evaluated

A description of the assay development follows in a sequential manner with statements about sources of variation and decisions made to optimize the assay while minimizing or eliminating irrelevant sample loss.

General procedures:

- Unless specified otherwise, all analyses were conducted on duplicate samples.
- Dry matter was determined at 105ºC in a forced-air oven overnight.
- Nitrogen (N) content of original feeds and residues was measured by block digestion and steam distillation with automatic titration (Application Note, AN300; AOAC Official method 2001.11; Foss, 2003; Tecator Digestor 20 and Kjeltec 2300 Analyzer, Foss Analytical AB, Höganäs, Sweden; AOAC 2001.11).

Exposure to rumen microbes:

This step in the assay was evaluated in three stages to evaluate variation and sample loss.

- Three bag materials with different pore sizes (15 µm, mesh; 25 µm, fiber (Ankom) and 50 µm, in situ (Ankom)) were evaluated for in vitro intestinal digestion following in vitro vs. in situ fermentation (Ross, et al., 2010). After many attempts at developing conditions that minimized loss of material prior to assay or during the assay, it was difficult to distinguish digestion from bag loss, thus the use of any bags was abandoned.

From this point forward 16-h fermentation was performed via IV methods in Erlenmeyer flasks.

- Plastic centrifuge tubes were evaluated as a fermentation vessel and found to be unfavorable for rumen bacterial growth and sample size had to be reduced to work appropriately in 50 mL tubes.
- Glass Erlenmeyer flasks provided the greatest digestibility values, and had lower variability and superior repeatability compared to plastic centrifuge tubes. For this reason, flasks were chosen as the vessel for the fermentation step. Commercial protein sources (0.5 g) were included in their unground form, while forages, byproducts and non-commercial protein sources were ground through a 2 mm screen in a Wiley Mill (Thomas Scientific, Swedesboro, NJ).

Enzymatic hydrolysis

- Pepsin: Porcine pepsin used but added at 60 % of previous methods in pH 2 HCl (~0.013 M) to contain ~282 U ml-1 in flask.
- Intestinal (ID) enzymes: Initially, enzymes and activities described by Ben-Ghedalia et al. (1974) were used in the enzyme mix until carboxypeptidase A became unavailable. Different combinations of elastase and carboxypeptidase Y in addition to trypsin and chymotrypsin were then evaluated for intestinal digestion. Amylase and lipase were added along with trypsin and chymotrypsin (50 and 4; 24 and 20 U ml-1, respectively) which yielded digestion approximately similar to levels observed with carboxypepetidases A & B. Pancreatin at a level similar to Calsamiglia and Stern (1995; 1.72 mg ml-1, difference due to ini-

tial dilution so maintained throughout) was also analyzed concurrently with the mixture of individual enzymes. Bovine bile salts were also added to ensure adequate emulsification of fat to provide realistic digestibility of fat encapsulated proteins.
- Assay termination for both IV fermentation and enzymatic digestion was accomplished by quantitative filtration under vacuum though 9 cm glass microfiber filter (pore size of 1.5 µm; Whatman 934-AH; GE Healthcare Bio-Sciences Corp., Piscataway, NY) using hot (not boiling) water to transfer. Hot water was necessary to help dissolve away viscous residues from the in vitro step.

Discussion

Use of positive and negative controls to evaluate IV and intestinal digestibility:

Positive and negative controls for both fermentation and intestinal digestibility steps were included. To evaluate the fermentation phase, NDF digestion of corn silage ND residue sample was run concurrently. A heat damaged blood meal with near zero ruminal and intestinal digestibility was included throughout as a negative control. A feed with similar digestibility as samples, i.e., a soy product or blood meal, was also included. A blood meal with known high intestinal digestibility was included as a positive control for the ID assay.

Comparison of modified TSP with Cornell assay

Digestibility of two blood meals (from Boucher et al., 2011) were evaluated using the new method with the enzyme mix and pancreatin (Table 1) and compared with the modified TSP. Rumen N digestibility of BM4 was 18 % higher using bags but 6 % lower for BM5. The implication from this comparison is that material was solubilized or lost from the bag prior to being analyzed which provided higher rumen degradability in the TSP. Total N digestibility for BM5 was similar between both procedures and the enzyme mix and pancreatin. However pancreatin digestion of BM4 in the modified TSP was lower than either ID digestion using the Cornell procedure - using the Cornell method, BM4 had higher intestinal digestion.

Comparison of intestinal digestion with the acid detergent insoluble protein

Within the current structure of many contemporary nutrition models, acid detergent insoluble nitrogen (ADIN) represents the unavailable N component of feed (NRC, 2001; Tylutki et al., 2008) however, the NRC for Dairy Cattle (2001) provides for 5% digestibility of the ADIN fraction. The implication is that the ADIN fraction is not completely unavailable to the animal. Accordingly, the ID assay as outlined was utilized to ascertain whether ADIN is indigestible (Table 2). The ADIN of solvent extracted soybean meal and Soy1 were very similar to undigested feed N following IV fermentation, abomasal and intestinal digestion with either the enzyme mix or pancreatin; however, the ADIN of heat damaged blood meal was roughly 2 % while undegraded N from both intestinal digestion treatments was 95 %. Undegraded N of corn silage following digestion and after correction for microbial contamination was roughly 3 times higher than ADIN content.

This approach for determining the unavailable N from feeds departs from the traditional detergent partitioning system established by Van Soest and others, and implementation within nutrition models like the CNCPS will create a fraction that crosses the fractions described by detergent chemistry and has a different behavior. We believe this to be more appropriate approach for describing available protein for cattle. For forages, a longer in vitro step might be necessary to make the assay relevant for estimating protein availability since forage particle retention is usually great than 16-18 hr and closer to 30 hr so more work needs to be conducted to fully evaluate the assay for those feeds.

Dairy Cattle Evaluation Study

Treatments, Animals and Experimental Design

Treatments were established from a quantity of two blood meals secured through the marketplace that would allow an inclusion level of approximately 1 kg per head per day for the entire experimental period. The two blood meals were analyzed for unavailable N (uN) prior to the start of the study using the in-vitro assay described by Ross et al. (2013). Briefly, 0.5g of sample are placed into a 125ml Erlenmeyer flask. 40ml of rumen buffer and 10ml of rumen fluid are added to each flask. Flasks are incubated in a water bath at 39°C for 16h under continuous CO_2. Samples are then acidified with 3M HCL to bring the pH down to 2. Samples are incubated on a shaking bath for one hour after the addition of 2ml of pepsin and pH 2 HCl. Samples are then neutralized with 2ml of 2M NaOH to stop the pepsin reaction. An enzyme mix containing trypsin, chymotrypsin, lipase and amylase is added to the flask and incubated for 24h in the shaking bath at 39°C. Samples are then filtered with a 1.5 µm glass filter and boiling water. Nitrogen content of the residue is determined by Kjeldahl and expressed as a % of total N in the sample. The blood meals are characterized by their predicted intestinal N indigestibility (INID) since that is the outcome of the assay. The predicted uN of the low (LOW treatment) INID blood meal was 9%, whereas that of the other treatment (HIGH) was 33.8%. Thus, the two dietary treatments were established by inclusion of these blood meals in two different diets on an iso-N basis. The rest of the diets were formulated to be identical. The low uN blood meal was 15.04% N and the higher uN blood meal was 14.6% N, thus at approximately 1 kg inclusion level, the maximum difference in intestinal N availability was 38.5g N. The composition of the two diets fed to cattle is in Table 1.

Due to potential changes in milk yield in both treatments due to stage of lactation, the protein content of both diets was adjusted down at approximately 5 weeks of treatment by reducing the canola meal inclusion level by 50% to be more consistent with the ME allowable milk and to maintain the N supply to a level the cattle should remain sensitive to the treatment differences in N availability created by the inclusion of the two different blood meals.

Ninety-six multiparous cows (726 ± 14.2 kg BW; 147 ± 64 DIM) and thirty-two primiparous cows (607 kg ± 29.5kg BW; 97 ± 20 DIM) were distributed by DIM and BW into 8 pens of 16 cows (12 multiparous and 4 primiparous). Pens were stratified into four levels of milk production, and each stratum randomly allocated to treatments. Diets were formulated using Cornell Net Carbohydrate and Protein System (CNCPS v6.1; Van Amburgh et al., 2013) using the chemical composition of the ingredients used in the experimental diets (Table 3).

The lactation trial consisted of a two week adaptation period, one week covariate period and 9 week experimental period, between March 30 and June 21, 2014 at Cornell University Ruminant Center (Harford, NY). All cows were fed the LOW uN diet during adaptation and covariate periods. Cows were housed in pens under a four row barn design with one bed and more than one headlock per cow and free access to water. All cows received rBST (Posilac, Elanco Animal Health, Indianapolis, IN) on a 14 day schedule throughout the length of the trial.

Cattle were fed once per day for approximately 5% refusal and milked 3 times per day at 6:00, 14:00 and 22:00 and data from all milkings was recorded using Alpro herd management system (DeLaval International AB, SG). Individual milk samples were collected weekly during three consecutive milkings, and preserved with 2-bromo-2-nitropane-1, 3-diol at 4°C until analyzed. Milk yield was expressed as 3.5% energy corrected milk (ECM) according to the equation of Tyrell and Reid (1965): ECM (kg) = (12.82 * kg fat) + (7.13 * kg protein) + (0.0323 * kg milk).

Cattle were weighed once per week using a walk scale XR3000 (Tru-test, TX) after the morning milking. Further, BCS on a scale of 1 to 5 was determined every two weeks by the same two evaluators. An average of the two evaluators was used for calculation of the mean BCS.

Results and Discussion

Animal Performance

Overall DMI and N intake for the treatments were similar and milk yield was significantly different for cattle fed the two treatments (Table 4). Milk yield was 1.6 kg/d lower for cattle fed the HIGH uN diet and energy corrected milk (ECM) was 1.9 kg/d lower on the same diet. Further, cattle fed the HIGH uN diet had significantly lower MUN levels that cattle fed the LOW uN diet (Table 2). From this information, it is apparent that the cattle fed the different blood meals had significantly different MP supply, consistent with the predicted values from the uN assay. The predicted difference described earlier (38.5 g N) is equal to approximately 240 g MP, about the amount required to produce 5 kg of milk under the conditions of this study.

However, the observed difference on an ECM basis was 1.9 kg, thus the difference between the absolute levels measured in the assay and the observed ECM yield are either due to differences in digestibility within the cow, the amount of the blood meal arriving at the small intestine or the amount of nutrients partitioned to body reserves, or a combination of all of those factors. Although the change in BW and BCS were not significant, the changes are still biologically relevant given the partitioning of nutrients to reserves and away from milk.

To evaluate the outcome of the study, CNCPS v6.55 (Van Amburgh et al., 2015) with the updated feed library rates and pool sizes was used to evaluate the predictions. The chemical composition of the feeds used in the study was inputted into the model. To evaluate the assay within the structure of the model and against the study data, the blood meal values for the uN and ADIN were the only values changed. For the two blood meals, the uN values were inputted in place of the ADIN value, and intestinal digestibility left at zero. Further, the intestinal digestibility of the NDIN value were set to 100% although after being analyzed for aNDFom, the blood meals do not contain any ND residue, so that pool is zero. With this approach, all of the protein in blood meals is in the A2, B1 and C fractions.

The current intestinal digestibility of the NDIN fraction for all feeds is 80% and it appears that the assay of Ross et al. captures that portion of the indigestible protein, therefore by difference; the remaining fractions should be set at 100% digestibility. Thus, with continued testing and implementation of the uN assay for all feeds, the NDIN fraction ID will be set to 100% because it appears that in NDF containing feeds, the uN assay spans both the ADIN and NDIN fractions.

For the cattle inputs, the expected BW change based on the target growth approach was used and the BCS change was also inputted over the period of the study (9 wks), thus this accounted for the distribution of nutrients to other productive uses and not just milk output. With all of the inputs accounted for, the prediction of ME and MP allowable milk with the uN assay information is in Table 5.

In the CNCPS evaluation (Table 5), it is apparent that the feed chemistry described through the detergent system is not appropriate to allow the model to predict the most limiting nutrient in this comparison using blood meal as the treatment. When the uN data are used to describe the chemistry of the blood meals, the model provides an acceptable and realistic prediction of the most limiting nutrient. It is also important to recognize that an accurate and complete description of the animal characteristics was important to make this evaluation and in the absence of that information, the model would predict over 4 kg of MP allowable milk difference. The sensitivity of the model predictions to complete and accurate animal characterization cannot be overstated and helps explain why literature data to evaluate any model rarely allows for robust predictions of most limiting nutrients due the lack of complete information.

In summary, the uN assay appears to provide protein indigestibility predictions that are consistent with cattle responses and serves as a platform for modifying the approach to predict protein digestibility within the CNCPS and will improve the model's ability to identify the most limiting nutrient. The data also demonstrate we are ready to move beyond the detergent system of fractionation for protein and move to a system that fractionates proteins based on solubility and indigestibility. This approach should allow us to develop a prediction model to more effectively estimate rates of protein degradation because we now have what appears to be a more robust method to predict the indigestible protein pool, consistent with the approach for NDF (Raffrenato et al., 2009) and this fraction is important for accurate calculations of the rate of digestion of the available protein.

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Table 1. Comparison of the percent N digested in two blood meals using the modified three step procedure (from Boucher et al., 2011) with Cornell procedure.

	Modified TSP*		Cornell		
	Rumen	Pancreatin	Rumen	Enzyme Mix	Pancreatin
	----% N digested----		-------% N digested-------------		
BM4	19.9	89	1.0	96.6	97.1
BM5	42.3	94	48.7	97.4	97.0

*Boucher

Table 2. Comparison of percent feed N and acid detergent insoluble N versus undigested feed N after 16-h IV ruminal fermentation followed by 1-h abomasal digestion with pepsin in HCl and 24-h intestinal digestion using either a mix of trypsin, chymotrypsin, amylase and lipase or pancreatin (n=2).

	Feed N % DM	ADIN % N	% Undigested Feed N Enzyme Mix*	Pancreatin
Anchovy meal	11.50	1.3	25.5	20.1
Bakery waste	1.80	3.3	20.6	23.6
Blood meal 1	16.20	4.7	22.9[a]	8.0[b]
Blood meal 285	16.89	1.1	0.0	na
Blood meal 300	16.20	7.5	4.6	na
Blood meal 350	15.13	0.9	23.6	na
Blood meal 800	16.50	1.8	2.8	na
Canola 1	6.50	6.3	16.2	12.5
Canola 2	6.60	5.8	14.0	14.0
Citrus pulp	1.04	15.8	55.0	45.4
Corn germ	4.27	11.2	18.5	9.4
Corn gluten	3.13	16.9	28.7	18.9
Corn gluten feed	3.08	11.2	20.7	16.2
Distillers grains 1	4.90	13.1	11.7	9.5
Distillers grains 2	6.40	32.7	27.9[a]	13.6[b]
Solv. extract. soybean meal	7.60	6.7	7.8	7.6
Soy product 1	7.70	6.5	9.0	4.3
Soy product 2	7.30	7.9	11.1[a]	6.6[b]
Wheat midds	3.30	3.1	9.3	7.2
Heat damaged blood meal	16.10	1.8	95.0	95.0

[abc]Means with different superscripts in same row differ ($P < 0.05$) using Duncans Multiple Range test. Not all samples were statistically evaluated for this manuscript. NA – not available.

Table 3. The ingredient content and chemical composition of two diets containing blood meals with Low and High indigestible intestinal N digestibility.

	Treatment	
Ingredient, % DM	LOW uN	HIGH uN
Alfalfa haylage	11.5	11.5
BMR corn silage	49.3	49.3
Bakery	1.8	1.8
Blood meal High	3.7	---
Blood meal Low	---	4.0
Canola meal	3.0	3.0
Corn grain	16.1	16.1
Energy Booster 100	1.8	1.8
Molasses	1.8	1.8
Smartamine M	0.1	0.1
Sodium bicarbonate	0.6	0.5
Soybean hulls	4.6	4.5
Urea	0.2	0.2
Wheat midds	4.6	4.5
Min/vit mix	1.0	1.0
Chemical composition		
DM, % as fed	50.0	50.5
CP, % DM	15.2	15.2
NDF, % DM	31.9	32.3
ADF, % DM	21.3	20.5
Ether extract, % DM	4.3	3.9
Starch, % DM	30.4	31.2
Sugar, % DM	3.6	3.3
Ca, % DM	0.65	0.60
P, % DM	0.43	0.43
ME[1], Mcal/kg DM	1.8	1.7
Lys:Met[1], % MP	3.21	3.19

[1]CNCPS predicted

Table 4. Effect of N availability on intake, milk production, milk composition and body weight gain of dairy cows fed diets with low and high unavailable N

	Treatment			
Item[1]	LOW uN	HIGH uN	SEM	P-value
DMI, kg	27.4	27.1	0.61	0.75
N Intake, kg DM	671.1	664.4	14.8	0.77
Milk production				
Milk, kg	42.0	40.4	0.31	<0.01
ECM, kg	41.9	40.0	0.32	<0.01
Fat, kg	1.51	1.42	0.02	<0.01
Protein, kg	1.26	1.23	0.01	0.03
Milk composition				
Fat, %	3.6	3.5	0.03	<0.03
Protein, %	3.03	3.06	0.02	0.20
Lactose, %	4.90	4.86	0.02	0.18
MUN, mg/dl	9.4	8.0	0.18	<0.01
SCC (log1000/ml)	3.9	4.0	0.05	0.13
BW and BCS				
BWinitial, kg	684.1	692.1	10.1	0.58
BWchange, kg	34.7	29.7	2.25	0.12
BCSchange, (1-5)	0.20	0.16	0.03	0.29
Efficiency				
Feed efficiency[2]	1.56	1.50	0.03	0.34
Milk N efficiency[3]	30.0	29.7	0.70	0.76

[2] calculated as kg milk / kg DMI
[3] calculated as milk N/N intake*100

Table 5. The actual and energy corrected milk and the metabolizable energy (ME) and protein (MP) allowable milk for both treatments predicted by the CNCPS using the assay data of Ross et al., (2013) to estimate intestinal digestibility of blood meal, or using the original fractionation approach using acid detergent insoluble nitrogen as the unavailable fraction

	Treatment	
Item	LOW uN	HIGH uN
Actual milk, kg	42.0	40.4
Energy corrected milk, kg	41.9	40.0
Using uN assay inputs		
ME allowable milk, kg	45.0	46.0
MP allowable milk, kg	42.6	39.3
Using NDIN and ADIN		
MP allowable milk, kg	44.9	44.6

Low Lignin Forages:
BMR corn and reduced-lignin alfalfa

Ev Thomas
Oak Point Agronomics, Hammond, NY

Low lignin forages:

BMR corn and reduced-lignin alfalfa

Ev Thomas

Oak Point Agronomics, Hammond, NY

1

2

Increased focus on forage quality

- In recent years two developments have brought increased focus to the topic of forage quality.
- Reduced-lignin alfalfa varieties were developed using both conventional plant breeding and genetic engineering.
- And Dupont-Pioneer started selling BMR corn hybrids, considerably expanding BMR's market exposure.

BMR Corn Silage

4

An inconvenient truth

- BMR corn yields less than conventional corn.
- It always has, ever since the first Cargill BMR hybrid.
- Maybe it always will.
- BMR yields have increased, but so have conventional corn hybrid yields.
- No university trial data showing that BMR yield is "catching up" to conventional corn yields.

5

2017 Penn State silage trials
Average of 3 sites, 110-115 RM

Hybrids	DM.%	Yield, T/A @ 35% DM	Lignin, %	Starch, %	30-hr NDFd % (range)	240-hr uNDF,%
BMR 4 entries	32.1	18.3	2.4	31.9	64.5 (62-68)	22.1
Conv. 44 entries	32.2	21.9	3.0	36.1	53.8 (51-57)	33.6

- Conventional hybrids had 20% higher yield than BMR.
- Note modest range in NDF-d among 44 conventional hybrids.
- The best conventional hybrid for NDF-d was 5% points lower than the worst Mycogen BMR hybrid for NDF-d.

6

Experience from 15 years of growing BMR corn

- BMR hates "dry feet". Avoid thin, droughty soils. Plant on your best corn ground, expect 10-15% yield drag.
- BMR ain't pretty. If you care what "the boys in the coffee shop" say, plant the guard rows to a leafy hybrid and plant the rest of the field to BMR.
- BMR has less lignin, often will bend but not break during summer storms, then recover quickly.
- Don't let BMR mature past about 35% DM.

BMR gene:
BM-1, BM-3
…or is it all BS?

8

2015 Penn State Corn Hybrid Trials

4 Mycogen and 2 Pioneer 110-116 RM hybrids

	DM %	T/A @ 35% DM	Starch %	Lignin %	24-hr NDF-d %	Milk/T	Milk/A
Myco.	35.8	18.7	31.3	2.8	58.4	3405	22527
Pioneer	37.7	18.6	33.4	2.6	53.4	3428	22546
*Conv.	38.9	24.1	37.0	3.1	48.7	3180	27144

***BMR average of 4 sites, conventional hybrids average of 3 sites. Conventional hybrid NDF-d via NIR, BMR NDF-d via wet chemistry**. **Conventional hybrids: 29% higher yield.**

9

Data Drought

- Universities test the hybrids that seed companies enter in their silage hybrid trials.
- No BMR hybrids are entered in most state university corn silage hybrid trials, and only one or two in others, with the notable exception of Penn State.
- **Result**: Very limited data comparing the performance of BMR hybrids, and virtually no data on standability of any hybrids harvested for silage.

10

BMR is just different

- BMR cell walls are more fragile. May need to chop BMR at more than 19-20 mm to get enough physically effective fiber.
- Cows need a certain amount of chewing for optimum rumen function.
- Therefore, feed a high % of forage when feeding BMR, and if necessary supplement with less digestible, lower fragility forages: straw or late-cut grass.

11

Weird BMR stuff from Miner Institute

- Several chewing studies compared BMR vs. conventional corn silage. Cows ate more BMR corn silage and ruminated fewer minutes per pound of NDF consumed.
- Cows on the BMR ration spent 5-10 fewer minutes eating per pound of NDF consumed.
- That adds up to significantly less time at the feed bunk--30 minutes less/day in one study. Important if bunk space is limited by high stocking rates?

12

BMR milk response is rate-dependent

- BMR should be at least 20% of **total ration** DMI. Optimum: 30% or more.
- 55 lbs. DMI = at least 11 lbs. of BMR DM.
- Half the rows planted to BMR & half to a conventional hybrid = ~55% conventional CS and ~45% BMR “silo blend” because of BMR yield drag.
- Therefore to get 11 lbs. of BMR DM from that “silo blend” you’d have to feed over 70 lbs. of corn silage/cow.

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Therefore…

- Either plant BMR or don't plant BMR, but <u>don't</u> mix BMR and conventional hybrids in the field.
- Store BMR corn silage in a separate silo, give priority to the cows that will most benefit from it: Transition cows, high group cows. Breakeven ~60 lbs./cow.
- Limited inventory of BMR? Feed during the heat of summer. Better to feed 11+ lbs. BMR DM/cow during hot, humid weather than to try to stretch limited supplies over the entire year.

Foliar fungicides for BMR corn

- **Photo: Greg Roth, Pennsylvania, 2012. Northern Corn Leaf Blight.**
- **Mycogen BMR hybrids were most affected but Pioneer BMRs were also blighted.**
- **Many Pennsylvania farmers apply fungicides on their BMR corn—but only on BMR.**

15

Focus on what's important

- BMR corn is so different (yield, digestibility, stress resistance) that it acts like it's a unique species: *Zea mays vs. Zea bmr.*
- Fed at the right rate to the right cows, BMR should result in a 3-5 lb. milk response. (Metanalysis 3.1 lb.)
- 3 lbs. of milk will pay for a 20% yield drag.
- BMR has its challenges, but it puts milk in the tank.

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Reduced-lignin alfalfa

- Two main types of reduced alfalfa on the market: HarvXtra (GMO) and Hi-Gest (non-GMO).
- All HarvXtra varieties are glyphosate tolerant (Roundup Ready).
- Both types are lower in lignin and higher in NDF-d vs. conventional varieties. Hi-Gest has similar % change in lignin and NDF-d, while HarvXtra has twice the % change in lignin as in NDF-d.

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Potential advantages of clear-seeded reduced lignin alfalfa

- Allows farmers to delay harvest by 7 -10 days (to 10% bloom) *while maintaining high forage quality.*
- Delayed harvest may reduce the number of cuts per year. Result: increased yield and possibly longer stand life.
- Longer stand life due to less field traffic and better root carbohydrate recovery between harvests. Higher yields in last 1-2 years of stand.

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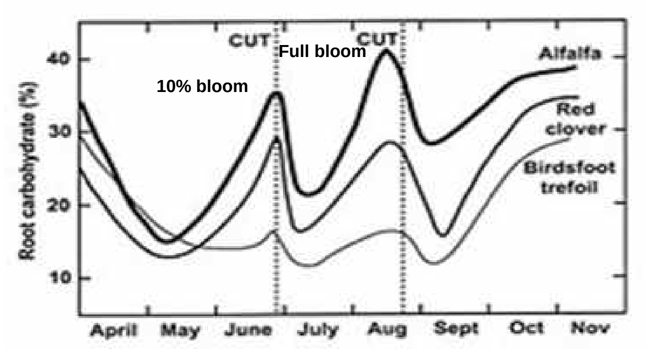
Alfalfa harvest management

1962 Cornell University recommendation



1962 N.Y. average milk/cow: 8500 lbs.

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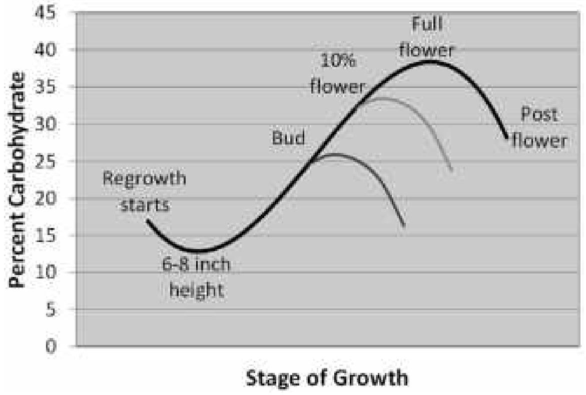
Root carbohydrate levels



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An accumulation of insults

- Repeated harvests at the bud stage, especially if followed by a fall harvest, may deplete alfalfa stands. Not just a root carbohydrate issue: Harvest also affects rhizobial nodules and root hairs.
- "Winter damage to alfalfa is an accumulation of insults." Jerry Cherney, Cornell University forage agronomist.
- With a 3+ cut schedule, every plant in the field is run over at least once by something heavy, often resulting in crown damage.

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No manure

3 day delay

7 day delay

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Fewer harvests = Healthier, higher-yielding alfalfa

University of Wisconsin: Over four years, 15-20% higher yield with **3** vs. **4** cuts of a *conventional* alfalfa variety .

1. Impact of less field traffic. Heavy equipment damages crowns, opening them up to diseases and desiccation. More trips = more crown damage.
2. Harvesting at bud stage never allows the alfalfa to fully recover root carbohydrates. *Neither does delaying harvest by 7-10 days,* but closer to ideal.

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Reduced lignin questions

- Lodging problems due to less lignin? Plant breeders, farmers and university trials all say no.
- Problems if late summer cuts of reduced-lignin alfalfa are harvested at the bud stage? Penn State trials @ 28-day harvest interval: 3rd cut = 30% NDF, 4th cut = 25% NDF. (Dairy One average: 45% NDF) "Cow candy?" Maybe not!
- Will farmers pay the higher cost of reduced-lignin alfalfa seed? What if the farmer doesn't need the $140 Roundup Ready trait in HarvXtra?

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Harvesting 1st cut reduced-lignin alfalfa at bud vs. 10% bloom

- 7-10 day delay in first cut harvest means more time to harvest other first cut forage, complete corn planting and other spring fieldwork.
- Wide windrows are a must when delaying 1st cut harvest to 10% bloom because this increases yield by about ½ ton of DM/acre.
- Bud stage harvest allows for seeding alfalfa-grass, which has higher yield and higher milk production potential than clear alfalfa. Also allows for unexpected harvest delays due to weather, breakdowns, etc.

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Reduced lignin alfalfa + grass: An ideal match?

- One drawback of alfalfa-grass is that (especially in first cut) the grass usually matures ahead of the alfalfa.
- But meadow fescue + reduced-lignin alfalfa harvested in the bud stage can result in excellent forage quality.
- Bud stage harvest doesn't result in a change in a farmer's normal schedule, assuming he normally harvests alfalfa in the bud stage.

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Working reduced-lignin alfalfa into a forage system

- Seed a portion of the alfalfa acreage to reduced-lignin alfalfa or alfalfa. *Choose your best alfalfa land*.
- Harvest any alfalfa-grass fields first, conventional alfalfa next, then reduced-lignin alfalfa.
- Objective: Uniformly high forage quality from the first field harvested to the last. Extends the ideal harvest window.

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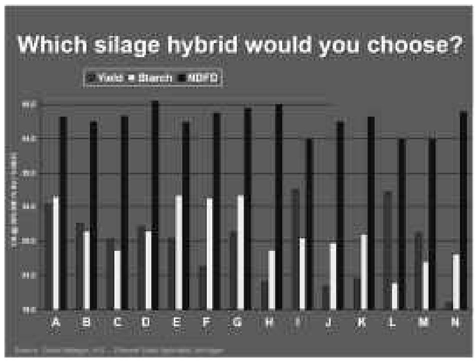
Goals and risk management

- Reduced-lignin alfalfa harvested at 10% bloom doesn't allow plants to fully accumulate carbohydrates—less stress, but still there.
- However, the goal of dairy forage management is the production of forages that will meet the quality needs of high producing cows.
- Risk can be managed, but some risk is unavoidable.

Making Low-Lignin Highly Digestible Forages Work on the Dairy

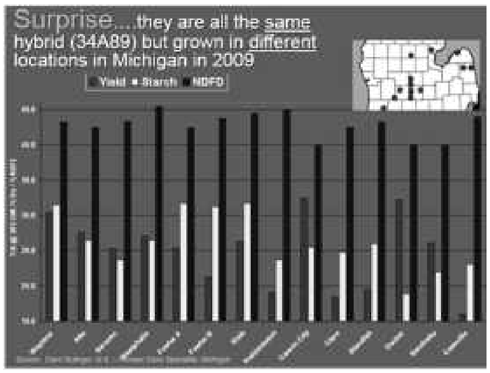
Jim Barmore and Brian Forrest
GPS Dairy Consulting
Maple Ridge Dairy, WI
jimbarmore@gpsdairy.com

Understanding the Impact of Growing Season Environments



Cow Comfort + Quality Forage + DIM = Milk

Understanding the Impact of Growing Season Environments



Combs

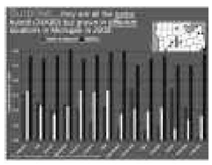
Optimizing Forage Quality



Harvest	Harvest management ✓ Moisture ✓ Maturity ✓ Chop length ✓ Processing	DM NDF Particle size Kernel processing
Ensiling	Ensiling success ✓ Packing ✓ Covering	pH Silage acids (VFA) Ammonia
Feedout	Stability ✓ Control 'shrink' ✓ No	Aerobic stability Ash

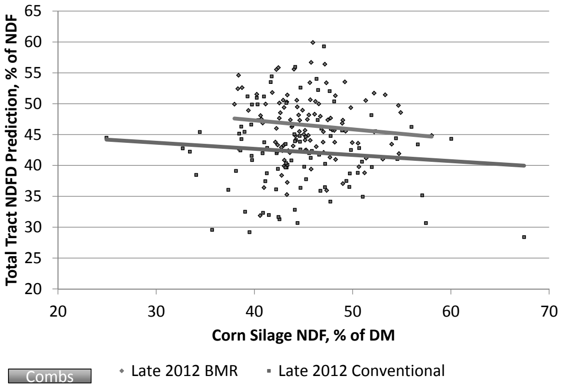
Averages vs. Outliers Thinking

Understanding the Impact of Growing Season Environments

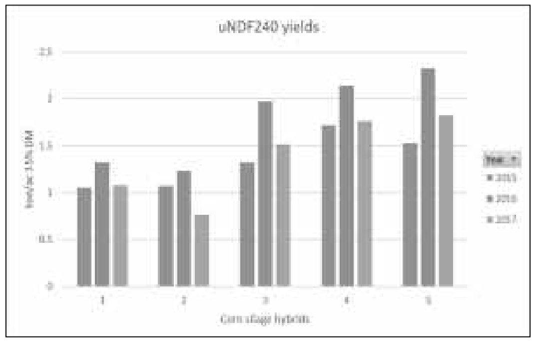


- Weather likely accounts for 2/3 or more of the NDFd variation from year-to-year within the same hybrid or across fields the same growing year.
- Lower lignin forage varieties impact the direction, or quartile, of expected NDFd and pdNDF, relative to other varieties, while weather largely drives the NDFd variation and actual NDFd from year-to-year and across different fields

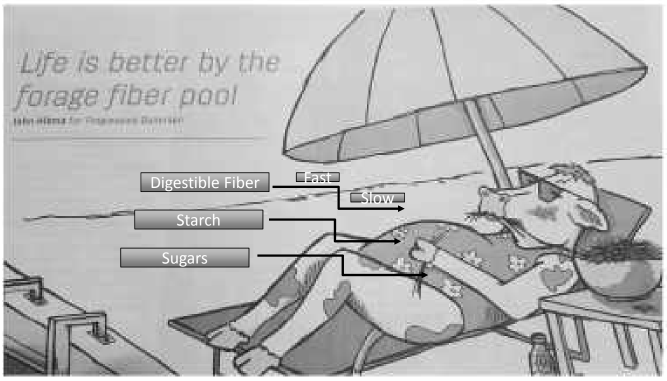
TTNDFD: BMR vs Conventional Corn Silage



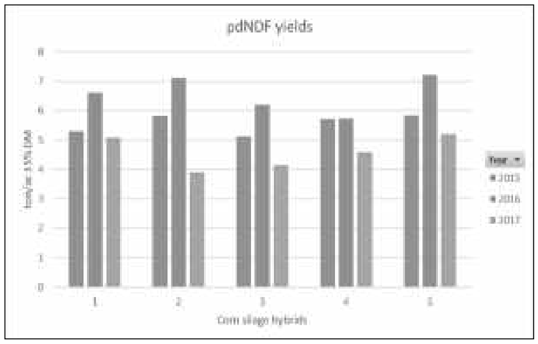
NNY corn hybrid study
uNDF240 yields



Grant, 2018

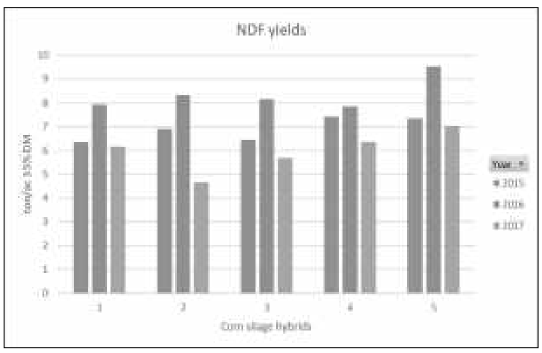


NNY corn hybrid study
pdNDF yields (forage "fuel" on the dairy)



Grant, 2018

NNY corn hybrid study
NDF yields

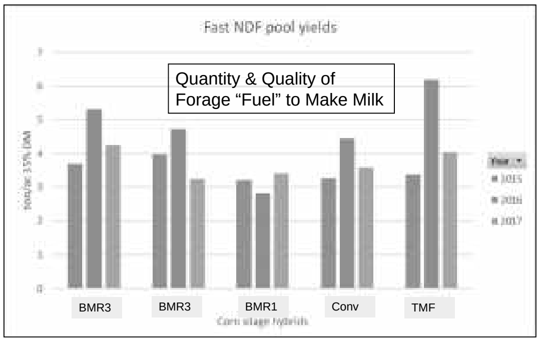


Grant, 2018

Table 1. Comparison of BMR and Non-BMR corn silages hybrids.

Trait	BM3	BM1	Non-BMR
Yield, ton/ac (35% DM)	20.5	20.9	21.0
NDF, % of DM	35.6	33.5	35.2
NDFd 30-h, %	62.3	58.7	54.0
uNDF240, % of DM	7.8	8.9	11.9
pdNDF, % of DM	27.9	24.6	23.4
NDF yield, ton/ac	7.3	7.0	7.4
pdNDF yield, ton/ac	5.7	5.1	4.9

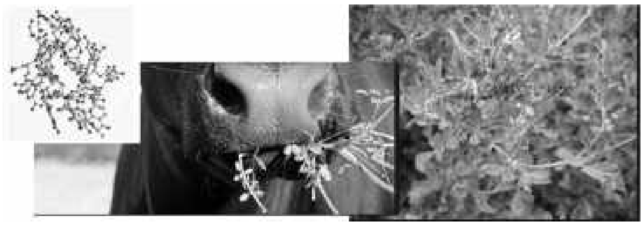
NNY corn hybrid study
Fast NDF yields



Grant, 2018

Reduced Lignin Alfalfa

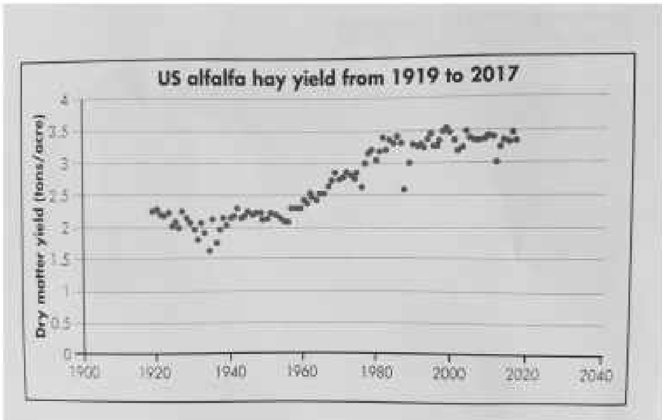
HiGest™ Alforex
HarvXtra™ Forage Genetics International



Combs, 2018

BMR Corn Silage

- Corn silage typically larger portion of ration than alfalfa
- pdNDF, starch, and sugar drive milk production – not just fiber
- Starch can vary considerably impacting the “% forage” in the ration (2017 harvest: 26 – 43% starch)
- Focus on DM Yield of RFOM/acre versus wet tons/acre
- Maximum forage should not be the goal of feeding low lignin forages
- ⇧Rumen turnover rate and driving production of lbs of solids and efficient production of ECM through higher feed intake is the key to ROI with lower lignin forages



BMR Corn Silage

Plant Health is key to NDFd and starch content

- Late emergence
- Nitrogen supply during ear fill
- Healthy stalks and leaves (fungal infection, frost)

Mahanna, Powel-Smith, 2018

Lower Lignin Alfalfa Varieties

- Focus on the financial implications and strategies of managing lower lignin forages over just the improved NDFd (soy hulls have high NDF that is very digestible)
- Target the RFQ and forage quality metrics which are key for a given dairy and put systems in place to achieve (not easy!)

Lower Lignin Alfalfa Varieties

- Wider harvest window option with similar quality
  – weather risk management
- Growing Days Expanded
  – greater tonnage per cutting, lower cost per ton of pdNDF?

- Reduced Cuttings – less field traffic & compaction, $/ton
- Improved forage quality on similar cutting intervals
- Conversion years create a challenge with cutting interval and quality differences
- Land management/conservation is part of forage mngt.
- Need to consider alfalfa –grass fields and the possible +/- of cutting intervals with mixed stands of grass + lower lignin alfalfa

Too Much High Quality Forage?

Function of –

1. Factors limiting cow performance (ex. Cow comfort, genetics, feeding)
2. Allocation and segregation of forage quality across livestock types (heifers, dry cows, late lactation, early lactation) is part of cost management and ROI of lower lignin forages.
3. Feeding management and consistency of feeding is key!
4. Balancing peNDF and fiber/CHO pools are both key
5. peNDF – the optimal forage length & % on PSPS boxes is evolving as forages and rations evolve (Cornell, UW-Madison, Penn St)
6. Nutrients and pools are not one of the same balancing rations
7. Corn silage starch ruminal availability & characterization is challenging

Frequent forage testing may be one of the best ROI and drivers of IOFC

What's Golden in Colostrum: Communication from the Dam to the Calf

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What's Golden in Colostrum:
Communication from the Dam to the Calf

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Herd Replacement Objectives

- Focus on return on investment – over their productive life
- Minimize non-completion (animals that are born and either never milk or finish a lactation)
- Optimize the productivity of the animal (manage them for their genetic potential starting at birth)

Overview of today's talk

- Introduction
- Effects of colostrum on growth and nutrient use
- Role of colostrum in gastrointestinal tract development
- Colostrum components and the immune system
- Colostrum components and changes in metabolism
- Summary

Snapshot Evaluation of the Potential Quality of The Replacement

- 1st Calf Heifers "Treated" as Calf/Heifer* ≤30%
  24 hrs. → 3 mos. ____, 4 mos. → fresh ____
- DOAs in first calf heifers ≤7%
  Male DOAs. ____, Female DOAs ____
- 1st Calf avg. peak ≥80% of Mature
  1st Calf lactation total yield ≥80% of Mature
- 1st Calf Culls ≤ 60 Days in Milk ≤5%
- 1st Calf ME's ≥Mature
- 1st Calf "Treated" in Lactation* ≤15%
- 85% retention (any herd) to 2nd lactation ≥85%
- Lower #1 reason for 1st lact. culls(continuous improvement)

Goal of The Replacement Program

The primary goal of all heifer programs is to raise the highest quality heifer that can maximize profits when the animal enters the lactating herd.

A quality heifer is an animal carrying no limitations – nothing that detracts from her ability to produce milk under the farm's management system.

Optimize profits by obtaining the highest quality heifer at the lowest possible cost usually in the least amount of time.

The lactation cycle and the opportunity to provide bioactive factors to the offspring

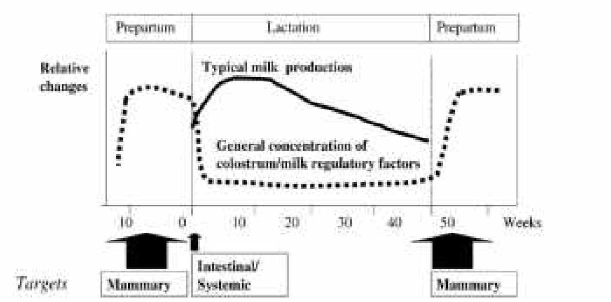


Fig. 1. Common pattern and target opportunity of regulatory/bioactive components in mammary secretions of dairy cows.

Blum and Baumrucker, 2002

Relatively new definition related to the topic of epigenetic programming in neonates:

•Lactocrine hypothesis (Bartol, Wiley and Bagnell, 2009)

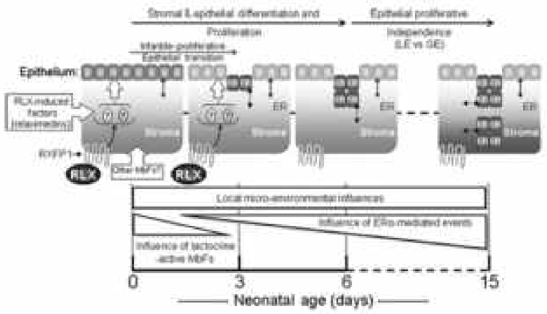
- maternal programming extended beyond the uterine environment through ingestion of milk-borne morphological factors - milk in this case can include colostrum
- In neonatal pigs, maternal relaxin from colostrum stimulates development and differentiation of the uterus (15 vs 30 ml colostrum)
- Mediates the expression of estrogen receptors – stimulates on differentiation of stroma and epithelial cells and then proliferation

Colostrum vs milk

Components	Units	Colostrum	Mature Milk
Gross Energy	MJ/L	6	2.8
Immunoglobulin G	g/L	81	<2
Lactoferrin	g/L	1.84	Undetectable
Insulin	µg/L	65	1
Glucagon	µg/L	0.16	0.001
Prolactin	µg/dL	280	15
Growth hormone	µg/dL	1.4	<1
IGF-1	µg/dL	310	<1
Leptin	µg/dL	30	4.4
TGF-α	µg/dL	210	<1
Cortisol	pg/ml	1,500-4,400	710
17βEstradiol	pg/ml	1,000-2000	10-20

Blum and Hammon, 2000, Bonnet et al., 2002; Blum and Baumrucker, 2008

Role of colostrum Relaxin in female piglets on expression of estrogen receptors and development



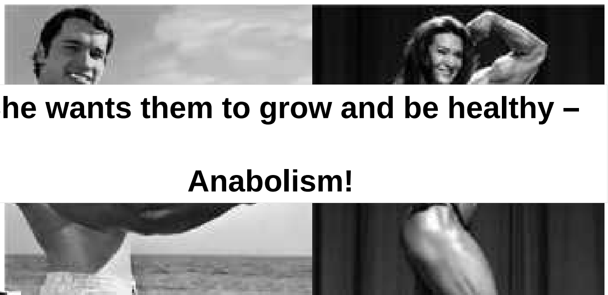
(Bartol, Wiley and Bagnell, 2008)

Composition of colostrum, transition milk and whole milk of Holstein cows

Parameter	Colostrum 1	Transition milk (milking postpartum) 2	3
Specific gravity	1.056	1.040	1.035
Total solids (%)	23.9	17.9	14.1
Fat (%)	6.7	5.4	3.9
Total protein (%)	14.0	8.4	5.1
Casein (%)	4.8	4.3	3.8
Albumin (%)	6.0	4.2	2.4
Immunoglobulins (%)	6.0	4.2	2.4
IgG (g/100 mL)	3.2	2.5	1.5
Lactose (%)	2.7	3.9	4.4
IGF-I (µg/L)	341	242	144
Insulin (µg/L)	65.9	34.8	15.8
Vitamin A (µg/100 mL)	295	190	113
Vitamin E (µg/g fat)	84	76	56

Foley and Otterby, 1978; Hammon et al. 2000

What Does Mom Want for Her Calf?



She wants them to grow and be healthy –

Anabolism!

With or without the steroids?

Importance of Colostrum Supply for the Neonate

- Colostrum provides immunoglobulins for establishing passive immunity
- Colostrum contains high amounts of nutrients, but also non-nutrient factors that support gut maturation
- Colostrum borne growth factors such as IGF-1 or hormones like insulin might act through specific receptors in the gut mucosa of the neonate to stimulate cell proliferation, cell differentiation, and protein synthesis
- Colostrum is a communication tool of the dam to direct calf development at the beginning of extra-uterine life

Inadequate Colostrum Intake Reduces Long Term Performance

Effects of Colostrum Ingestion on Lactational Performance, Prof. Anim. Scientist, 2005

Brown Swiss calves were fed 2 L or 4 L of colostrum and colostrum over another 6 to 8 feedings

	2 L	4 L
n	37	31
Daily gain, lb/d	1.76	2.2
Age at conception, mo	14.0	13.5
Survival through 2nd lact.	75.3	87.1
Milk yield through 2nd lact., lb	35,297	37,558

Effect of Colostrum level on Growth and Feed Efficiency

- Calves fed 4 L (+2L @12 hrs) or 2 L of pooled colostrum within one hour of birth
- Half of calves on each colostrum treatment assigned to "*ad libitum*" feeding regimen
- All calves are housed in a co-mingled pen and fed with an automatic feeder
- Daily intakes of milk replacer and weekly measures of body weight and hip heights
- Weekly blood samples

Soberon, 2011

Source of Colostrum Replacement Important for Feed Efficiency – observable over first 29 days of life

Calves fed colostrum or a serum derived colostrum replacement demonstrated differences in feed efficiency

- **no differences in IgG status**

Variable	Colostrum		Colostrum Replacement	
	N	P	N	P
Total DMI, lb	34.5	33.1	30.1	32.1
Milk replacer DMI, lb	23.5	24.3	21.6	24.1
Starter DMI, lb	10.9	8.7	8.5	8.2
Feed efficiency,(gain:feed)	0.43	0.36	0.22	0.26
	0.40		0.24	

Jones et al. JDS 2004

Effect of High (4+2 L) or Low (2L) Colostrum and Ad-lib (H) Milk Replacer Intake on Feed Efficiency and Feed Intake in Pre and Post-Weaned calves (Soberon Ph.D. diss., 2011)

Treatment	HH	LH	
	Mean	Mean	Std dev
n	34	26	
IgG concentration, mg/dl*	2,746^{a}	1,466^{c}	98
Birth wt, lb	97	92	2
Weaning wt, lb	172^{a}	159^{c}	4
ADG pre-weaning, lb	1.74^{a}	1.48^{c}	0.06

INADEQUATE COLOSTRUM INTAKE DECREASES GROWTH OF CALVES ON INTENSIFIED FEEDING PROGRAMS

Johan S. Osorio and James K. Drackley

Colostrum status impacts feed efficiency but varies by level of nutrient intake

Conventional: 1.25 lb/d, 22:20
Intensified: 1.75 lb/d 7 days, 2.5 lb/d to 42 days 28:20
23% CP starter

	Conventional		Intensified	
Ig status	Poor	Good	Poor	Good
n	21	20	17	25
Mean serum IgG, mg/dL	558^{a}	1,793^{b}	609^{a}	2,036^{b}
Average daily gain, lb/d	1.17^{a}	1.09^{a}	1.39^{b}	1.63^{c}

^{abc}means in same row with different letters are differ P<0.10

Effect of High (4+2 L) or Low (2 L) and Ad-lib (H) Milk Replacer Intake on Feed Efficiency and Feed Intake in Pre and Post-Weaned calves

Treatment	HH	LH	
	Mean	Mean	SD
ADG birth to 80 d, lb	1.72^{a}	1.45^{b}	0.07
Hip height gain, birth to 80 d, cm/d	0.214^{a}	0.184^{c}	0.008
Total milk replacer intake, lb DM^{1}*	97.8^{a}	90.1^{c}	2.4
Grain intake pre-weaning, lb^{1}*	4.8^{a}	4.6^{a}	3.3
ADG/DMI, pre-weaning^{2}*	0.60	0.67	0.042
ADG post-weaning^{3}, lb	2.4^{a}	1.76^{b}	0.13
DMI post-weaning^{3}, lb/d	6.4^{ab}	5.7^{c}	0.23

Colostrum components and gastrointestinal tract development

- Many studies have been conducted that demonstrate short term responses to hormones and growth factors found in colostrum
- General response is enhanced protein synthesis, increased enzyme expression, greater GIT development
- This development suggests:
  - The GIT is a stronger barrier to infection
  - Has more surface area for digestion and absorption
  - More capacity to digest more nutrients due to higher enzyme secretion

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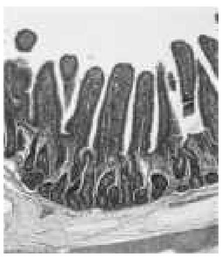
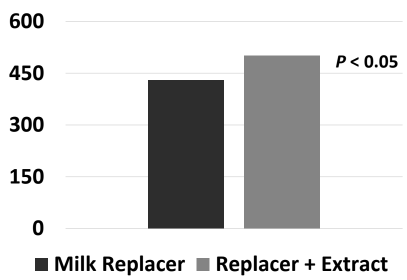
Feeding of a Colostrum Extract in Calves: Effects on Small Intestinal Villus Growth

Trait	Colostrum Extract	Colostrum 1st Milking
Gross energy, MJ/kg DM	19.7	24.9
Crude protein, g/kg DM	690	555
Immunoglobulin G, g/kg DM	44.2	159
Whey protein, g/kg DM	656	410
Crude fat, g/kg DM	3.2	265
N-free extracts, g/kg DM	173	104
Crude ash, g/kg DM	61.8	75
IGF-I, mg/kg DM	23	1.1
Insulin, µg/kg DM	365	67
Lactoferrin, g/kg DM	1.6	7.5

Roffler et al., 2003

Influence on Villus Height in Neonatal Calves

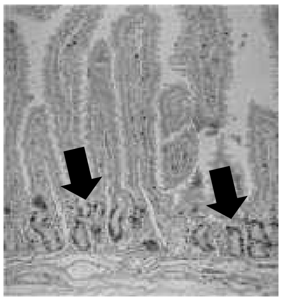


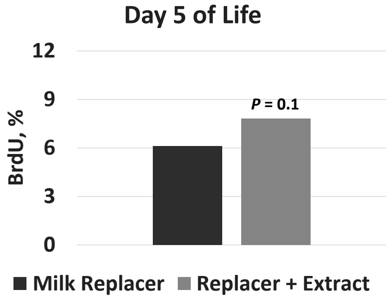


Roffler et al., 2003

21

Influence on Crypt Cell Proliferation in Neonatal Calves Milk replacer with and without a colostrum extract

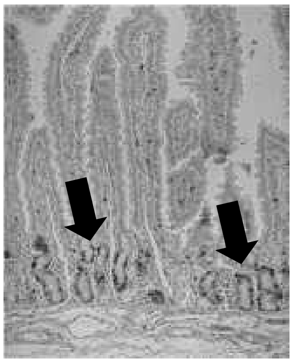


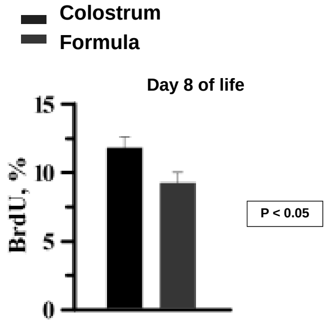


Roffler et al., 2003

22

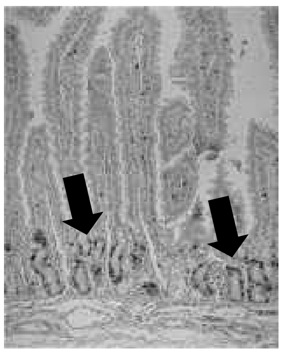
Colostrum versus Formula Feeding: Crypt Cell Proliferation in Neonatal Calves

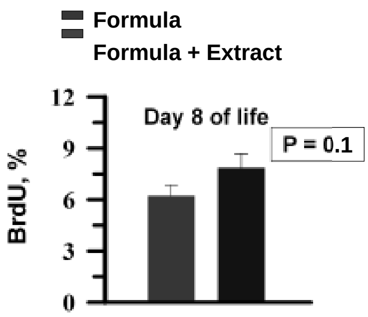




Blättler et al., 2001

Colostrum Extract Feeding: Crypt Cell Proliferation in Neonatal Calves



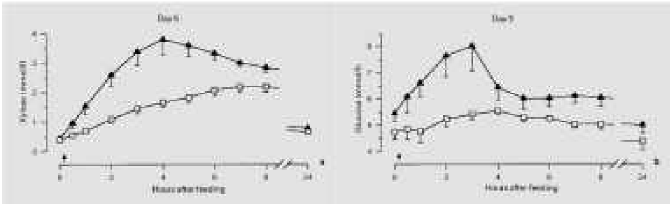


Blättler et al., 2001

Colostrum versus Formula Feeding:

Xylose Absorption in Neonatal Calves

Plasma Xylose *Plasma Glucose*



▲ *Colostrum*
☐ *Formula*

Rauprich et al., 2000

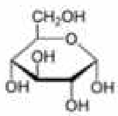
Composition of Colostrum and Formula

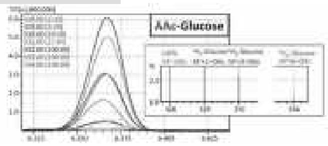
	Dry Matter g/kg	Ash g/kg FM	OM g/kg FM	Lactose g/kg DM	Crude Protein g/kg DM	Crude Fat g/kg DM	Crude Energy MJ/kg DM	IGF-I µg/l
Colostrum								
Day 1	239	10.7	228.2	200.9	523.2	194.6	22.1	373.4
Day 2	179	9.1	170.0	259.6	395.9	269.1	23.6	192.4
Day 3/4	151	8.1	143.2	341.0	296.8	292.8	23.3	85.6
Formula								
Day 1	240	20.9	219.0	200.9	514.0	173.4	22.5	n.m.
Day 2	179	12.9	165.7	259.8	409.3	246.4	23.8	n.m.
Day 3/4	153	10.5	142.6	338.3	338.3	246.2	23.5	n.m.

n. m. = not measureable

Steinhoff-Wagner et al., 2011

Colostrum Feeding and Glucose Uptake in Neonatal Calves



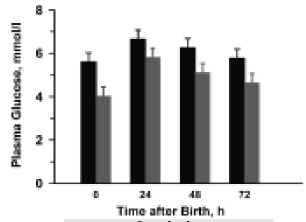


Steinhoff-Wagner et al., 2011

Plasma Glucose: Postnatal Concentrations and Changes after Feed Intake

■ *Colostrum*
■ *Formula*

Postnatal Concentrations before Feed Intake

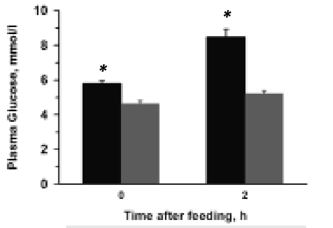


Statistics

Main Effects:

Diet	*P < 0.001*
Time	*P < 0.05*
Diet × Time	*P < 0.7*

Changes on Day 4 after Feed Intake



Statistics

Main Effects:

Diet	*P < 0.001*
Time	*P < 0.001*
Diet × Time	*P < 0.001*

****: Sig. Diet Effet at Time Point***

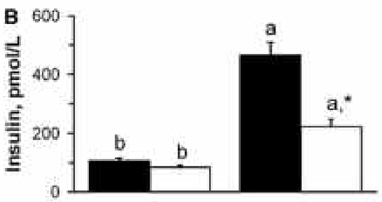
Steinhoff-Wagner et al., 2011

Effect of Colostrum Intake over 4 days on Glucose Metabolism and Energy Status

- 7 calves fed colostrum versus 7 calves fed milk-based formula 4 hrs on average after birth
  - Comparable in macronutrients
- Basal blood samples were drawn before morning feed and 2 hours after intake on day 1 to day 4
- Glucose absorption into blood using isotopes

Steinhoff-Wagner et al., 2011

Plasma Insulin Concentration of Calves Fed Colostrum or Colostrum like formula from Birth – Day 4 of Life

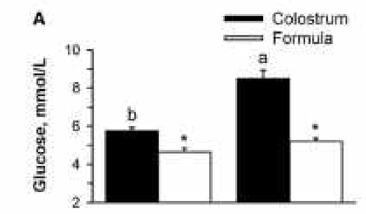


0 2
Time after feeding on day 4, hr

Dark bars are colostrum fed calves, white bars are control calves

Steinhoff-Wagner et al., 2011

Plasma Glucose Concentration of Calves Fed Colostrum or Milk Replacer from Birth – Day 4 of Life



0 2
Time after feeding on day 4,h

Dark bars are colostrum fed calves, white bars are control calves

Steinhoff-Wagner et al., 2010

Colostrum vs Milk Replacer for first 4 days of life - summary

Glucose uptake increased – similar nutrient supply
- Colostrum enhanced glucose uptake via insulin or enhanced enzyme activity in gut or simply maturation of gut

Plasma glucagon higher – better glucose status, indication of higher reserve capacity

Plasma protein levels higher – more protein available for growth, higher protein synthesis, less protein for glucose

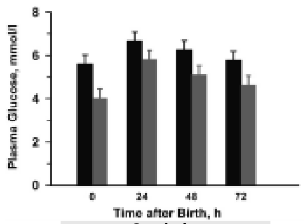
Plasma urea lower – less protein turnover and lower protein utilization for glucose production

Steinhoff-Wagner et al., 2011

Plasma Glucose: Postnatal Concentrations and Changes after Feed Intake

Colostrum
Formula

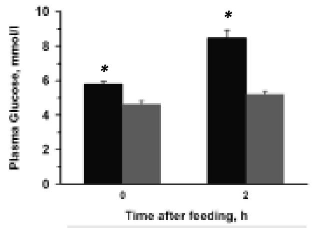
Postnatal Concentrations before Feed Intake



Statistics

Main Effects:	
Diet	***P < 0.001***
Time	***P < 0.05***
Diet × Time	***P < 0.7***

Changes on Day 4 after Feed Intake



Statistics

Main Effects:	
Diet	***P < 0.001***
Time	***P < 0.001***
Diet × Time	***P < 0.001***

****: Sig. Diet Effet at Time Point***

Steinhoff-Wagner et al., 2011

Effect of Insulin Supplementation of a Colostrum Supplement on Insulin Absorption and Glucose Uptake

•6 bulls and 6 heifers, were obtained from the Teaching and Research Dairy in Harford New York.

• Calves were dried, weighed, and received IV catheters before first feeding and a blood sample was taken immediately prior to first feeding

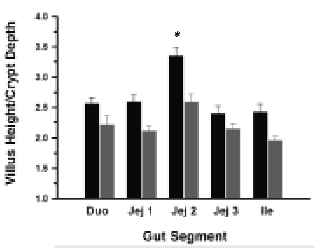
•Land O' Lakes Colostrum Replacer was used as colostrum, and calves were fed on average 1.25 hr after birth.

• 1000 IU of human insulin (Novolin) was added to the treatment group 1st feeding ***Lopez, unpubl. 2012***

Feeding Effects on Villus Maturation and Lactase Activity in Neonatal Calves

Colostrum
Formula

Villus Height/Crypt Depth Ratio

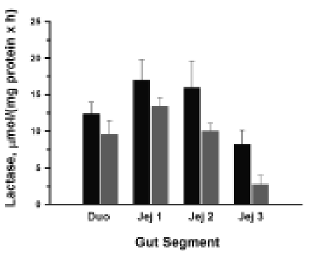


Statistics

Main Effects:	
Diet	***P < 0.001***
Segment	***P < 0.001***
Diet × Segment	***P < 0.16***

****: Sig. Diet Effet in Segment***

Lactase Activity



Statistics

Main Effects:	
Diet	***P < 0.06***
Segment	***P < 0.001***
Diet × Segment	***P < 0.7***

Steinhoff-Wagner et al., unpublished

Sampling

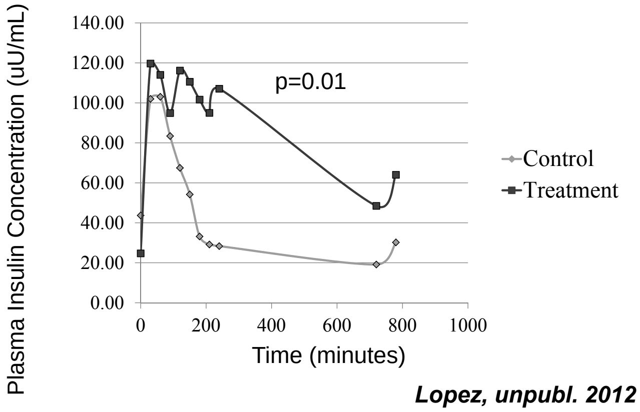
• Samples were obtained every 30 minutes for the first 4 hours from the catheter following first feeding

• Calves were fed their second feeding (colostrum replacer) 12 hours post first feeding

• Final samples were obtained immediately before and 1-hour after second feeding

Lopez, unpubl. 2012

Insulin Curves



Lopez, unpubl. 2012

Plasma Glucose and Insulin of Calves Provided Supraphysiologic levels of Insulin in a Colostrum Replacer

	Control	Treatment	S.E.	P
Insulin, uU/ml	56.75	85.45	7.99	0.01
Glucose, mg/dL	69.81	81.74	3.56	0.02

Lopez, unpubl. 2012

What happens to immune cells in colostrum?

- Data generated over the last 15 -20 years demonstrates that leukocytes and other immune related cells in colostrum are “trafficked” into circulation in the calf
- Does this have any impact on the activity of the neonatal immune system?
- Other implications for the calf?

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Immune cell transfer from colostrum to circulation

- Maternal leukocytes can be detected in calf circulation within 12 hr, peak at 24 hr and disappear by 48 hr. (Reber et al. 2008)
- Cells appear to be sequestered into tissues and lymph nodes after 48hr (Tuboly and Bernath, 2002; Williams, 1993).
- However, cells have been measured up to 5 wks after colostrum administration (Reber, et al. 2005)
- Long-term there appears to be greater cellular immunity in calves that received the whole colostrum compared to cell free colostrum (Reber et al. 2005; 2008)

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Immune cell transfer from colostrum to circulation

- Calves fed whole colostrum have greater cellular immunity as defined the activation markers CD25 and CD26 by 7 days after birth
- Also greater antigen presenting capacity on cell surfaces
- Calves fed whole colostrum have greater cellular immune responsiveness to vaccinations

Reber et al. 2008

Effect of maternal cells transferred with colostrum on cellular responses to pathogen antigens in neonatal calves

- Calves were fed whole colostrum, frozen colostrum, or cell-free colostrum within 4 hours after birth.
- Leukocytes were obtained from calves before feeding colostrum and 1, 2, 7, 14, 21, and 28 days after ingestion.
- Proliferative responses against bovine viral diarrhea virus (BVDV) and mycobacterial purified protein derivatives were evaluated.
- Dams received a vaccine containing inactivated BVDV, but were not vaccinated against mycobacterial antigens.

Donovan et al. 2007. Am J Vet Res. 68:778–782

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Effect of maternal cells transferred with colostrum on cellular responses to pathogen antigens in neonatal calves

- All calves had essentially no IgG in circulation at birth, but comparable and substantial concentrations by day 1.
- Calves that received whole colostrum had enhanced responses to BVDV antigen 1 and 2 days after ingestion of colostrum.
- Calves that received frozen colostrum or cell-free colostrum did not respond to BVDV.
- No difference in mycobacterium challenge in all treatments
- **Take home:** uptake of cells from colostrum enhance cellular immunity in calves by providing mature, programmed cells from the dam

Donovan et al. 2007. Am J Vet Res. 68:778–782

Thank you for your attention.

Take home for colostrum management

Colostrum feeding for 4 days….

First milking colostrum within 6 hr of birth – 4 qt for large breeds

First milking colostrum at 12 hr

Second milking colostrum for day 2

Third and fourth milking colostrum for days 3 and 4

Summary

- Mom is trying to send information to the calf via mammary secretions – some of our management approaches have short circuited this "information flow"
- Colostrum contains factors that impact intestinal development and nutrient supply independent of nutrient consumption
- Colostrum can positively impact pre and post weaning feed efficiency (from 12 to over 50%)
- The dam makes colostrum for more than one day, and this has additional impacts on calf development

Alfalfa and Alfalfa-Grass: Obstacles and Opportunities

Ev Thomas
Oak Point Agronomics
Hammond, NY

Alfalfa and alfalfa-grass: Obstacles and opportunities

Ev Thomas

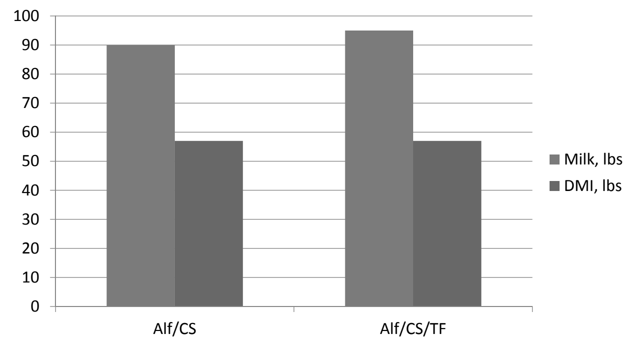
Rations: Alfalfa vs. alfalfa + grass

	% of total ration	
Feed	**Alfalfa /Corn silage**	**Alfalfa/Corn silage/Tall fescue**
Corn silage	26	17
Alfalfa silage	26	17
Tall fescue silage	0	17
High moisture corn	26	25
Protein/minerals	22	24

Different strokes for different folks

- Only about 10% of alfalfa in the U.S. is seeded with a forage grass.
- However, about 85% of alfalfa in N.Y. is seeded with a cool-season forage grass, and a similar % in New England and Eastern Canada.
- Tall fescue is used in 20-30% of alfalfa-grass seedings but meadow fescue may be a better choice—higher quality.

Milk production and dry matter intake



Why is the Northeast different?

1. More variable soils than the Midwest due in part to glacial activity. Within-field variability in drainage, pH, fertility, etc. favors alfalfa-grass.
2. Very cold winters affect alfalfa more than it does most grass species.
3. Tradition: Farmers in the Northeast have seeded alfalfa-grass for generations.

Grass is different

- Grass harvested at the boot stage has much higher digestibility than conventional alfalfa varieties harvested at the late bud stage.
- However, grass digestibility declines twice as fast. Therefore, timing is everything! "When you see the head, quality is dead."
- Big differences in heading date between grass species, and between varieties within <u>some</u> species.

Changing times

- Two factors have influenced grass species selection:

1. 1. An increased knowledge of (and focus on) grass fiber digestibility. Shift from timothy to reed canarygrass to tall fescue, recently to meadow fescue.
2. 2. More intensive management of alfalfa-grass stands: Some grass species (smooth bromegrass) don't tolerate today's 30-day harvest intervals.

Grass is boring

- Grasses are generally ignored by most major seed companies (Pioneer, DeKalb, Mycogen).
- Farmers often buy whatever grass seed is cheap, often whatever the dealer has in stock.
- Where alfalfa will do best, *perhaps* grow straight alfalfa. But where field conditions aren't ideal for alfalfa, consider alfalfa-grass.

Alfalfa grass ups and downs

Alfalfa-grass almost always yields more than straight alfalfa, seeding year and in established stands.

A major challenge is getting the right % of grass in the stand. Often this depends on the weather soon after seeding. More rain = more grass.

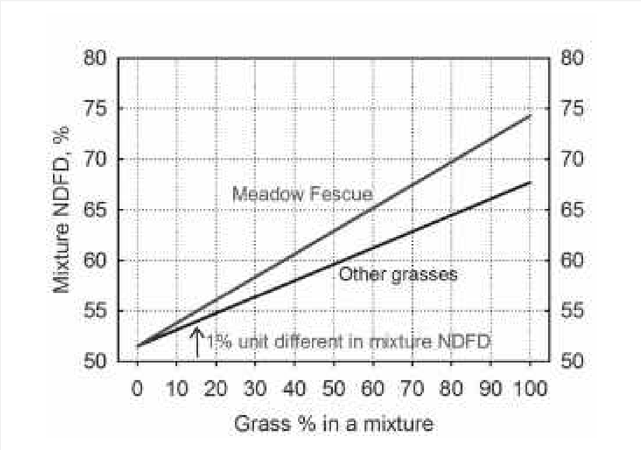
Recent Cornell research suggests that even 1 pound per acre of orchardgrass may be too much!

What's new? Meadow fescue

- Meadow fescue is the top choice for alfalfa-grass seedings.
- Cornell University research: 10% higher digestibility than any other forage grass at a wide range of maturity.
- Liherold, Pradel and BAR FPF32 all appear to be good varieties, Liherold isn't new but as good as any.

The real vs. the ideal

- The ideal alfalfa-grass stand is 2/3 alfalfa and 1/3 grass. Alfalfa provides N to the grass.
- However, may be better to start with a bit less than 1/3 grass as the stand ages the % grass will increase.
- The grass species is critical: As little as 10% meadow fescue in the stand is enough to make a significant quality difference.



An example from Miner Institute

- **Leased field, seeded to alfalfa-reed canarygrass. Alfalfa died, canarygrass grew very well.**
- **2008 Cornell University soil test K = 0!**
- **Confirmed to be close to zero by a second sample.**
- **Third cut grass, harvested a week before the soil sample was taken: Grass K = 2.65% = normal!**
- **Where did the grass find the potassium? It just did!**

Notable quotes from Jerry Cherney, Cornell University

- *"I have tried making the case that reduced -lignin alfalfa was really invented for alfalfa-grass people, but the alfalfa group outside of NY still does not know what alfalfa-grass is, they just have a puzzled look. "*
- *"Switching from a lower quality grass to a higher quality grass such as meadow fescue can impact forage quality as much as a switch from an average alfalfa to a higher quality reduced-lignin alfalfa."*

Therefore…

- Do not seed grass with alfalfa if soil test K is low or medium-low.
- The alfalfa may grow well at first…but only until the grass root system becomes well-established.
- Then the alfalfa will start to disappear, *even with the recommended K fertilizer application rates.*
- Increase soil test K to medium-high or high before seeding to alfalfa-grass.

Alfalfa vs. grass: There is a difference!

- Alfalfa tap roots reach deep into the soil profile, while grasses have dense, relatively shallow root systems.
- Grasses are much more efficient than alfalfa in nutrient uptake. This can be a plus or a minus.
- Grasses will thrive and accumulate ~2.5% K at soil potassium levels that are low enough to starve alfalfa to death.

Alfalfa and grass nutrition: There's a big difference

- Alfalfa stores nutrients in its taproot. Soon after mowing the stubble dies, regrowth is from crown buds.
- Grass stores nutrients in the bottom 3-4" of the above-ground portion of the plant, regrows from the cut stems.
- Mowing at 2" stubble height has no effect on alfalfa nutrient status, but reduces grass nutrient reserves.

Summary:

- => Huge differences in alfalfa seeding practices in the Northeastern U.S. and Eastern Canada vs. the rest of North America.
- => In cool-season areas alfalfa-grass yields more than alfalfa, and milk production is higher.
- => Choosing the right grass species and getting the right alfalfa-grass ratio are critical.
- => So is cutting height and maintaining adequate soil potassium levels, both during and after seeding.

Feeding Practices in Top U.S. Jersey Herds

Dr. Mike Hutjens
Dairy Extension Specialist
University of Illinois at Urbana-Champaign

Feeding Practices in Top U.S. Jersey Herds

Four State Dairy Conference
June 13, 2018

Dr. Mike Hutjens
Dairy Extension Specialist
University of Illinois at Urbana-Champaign

Experimental Design

- AJCA provided a list of 110 top cheese yield herds in the U.S. in 2015 along with e-mail addresses.
- We developed an on-line survey instrument to collect on-farm management information and tested by the graduate students, Jim, and me.
- In addition, we requested DHI data summary from Nov/Dec 2016, current forage test results, and current milking and dry cow rations (up to seven could be submitted).

A Need for Conducting the Field Study

- Jersey numbers continue to increase in the U.S. due to emphasis on milk components
- Crossbreeding with Jerseys can reduce inbreeding while improving fertility and health
- Jersey research data is limited as few Jersey herds exist at land grant colleges
- Most sponsored research is conducted with Holsteins

Timeline of the Field Study

- AJCA sent out an e-mail indicating that a survey would be sent out from the U of IL in early 2017.
- Electronic survey was sent out January, 2017.
- Data arrived for the next four months with one reminder from us (those not responding).
- In May, any “unusual” or missing data were requested and clarified from participating farms.

The Team

- AJCA and Research Foundation for names and funding
- Mike Hutjens—co-leader with name recognition
- Jim Baltz—co-leader, our IT specialist to design the survey instrument and dairy background
- Sarah Morrison—graduate student from Jersey herd in New England, provided statistical analysis
- Kristen Glossom—graduate student from North Caroline pasture based herd, provided statistical analysis

Phase One Article
Herd Summary Data

Herd Stats

	Ave	Max	Min	SD	n
Cows	593.2	6,545	24	1,259	32
Milk Yield	63.4	78.5	50.4	7.6	31
Fat %	5.14	6.72	4.10	0.48	31
Protein %	3.77	4.10	3.50	0.17	31
SCC	180.3	475	42.5	94	29
RHA-Milk	20,124	24,195	16,987	1,786	31
RHA-Fat	995	1271	831	101	31
RHA-Protein	738	875	634	66	31
Age at 1st Calving	23.3	25	21	1.08	24

Bunk Space

	Bunk space per cow				
	<15"	16-22"	23-29"	>30"	n
All	12%	31%	40%	17%	121
All Dry Cows	7%	30%	41%	22%	27
All Milking	19%	33%	38%	11%	64
Close Up		25%	50%	25%	16
Far Off	7%	33%	53%	7%	15
Fresh		33%	42%	25%	12
Heifers	33%	11%	33%	22%	9

	High Group Rations					Dry Cows Rations				
	Ave	Max	Min	SD	n	Ave	Max	Min	SD	n
DM	52.0	88.6	40.0	10.7	21	50.7	79.9	41.0	9.5	15
CP	17.1	18.3	16.0	0.6	22	14.5	16.5	12.1	1.3	16
Fat	4.7	6.4	2.7	1.0	20	3.2	4.2	2.0	0.6	13
ADF	18.5	21.6	14.6	1.7	18	28.2	35.4	19.3	5.0	12
NDF	28.9	34.9	25.0	2.2	22	41.3	49.1	31.4	5.2	16
Sugar	5.1	6.5	3.1	1.2	16	4.3	8.2	2.7	1.7	9
Starch	26.5	30.9	21.1	2.6	21	15.3	23.5	4.5	6.4	15
% Corn Silage	64.3	92.0	35.0	13.7	27	55.3	81.0	20.0	20.6	16
% Haylage	30.6	65.0	9.0	15.4	21	37.4	66.0	4.0	20.6	11
% Hay	20.5	51.0	3.0	16.8	15	34.4	73.0	8.0	18.9	14
% Straw	5.0	6.0	4.0	1.4	2	20.3	36.0	11.0	7.6	10

Housing

	Freestall	Tie Stall	Loose Housing	Corral / Open Lot / Pasture	Individual pens	n
All	66%	8%	20%	6%	1%	128
All Dry Cows	38%	6%	40%	15%	2%	48
All Milking	81%	10%	7%	1%		68
Close Up	17%		61%	17%	6%	18
Far Off	50%	6%	19%	25%		16
Fresh	92%		8%			12
Heifers	89%			11%		9

Corn Silage Test Results

	Ave	Max	Min	SD	n
DM	35.9	43.1	27.7	4.5	23
CP	8.1	10.1	6.9	0.7	23
ADF	23.3	28.6	16.0	3.1	23
NDF	38.1	45.0	29.3	3.9	22
uNDF-240	10.8	28.0	5.2	5.4	14
Starch	33.8	43.3	26.8	4.7	23

Cows per Stall

Group	Stalls per Cow	Max	Min	n
Far Off	1.39	2.00	1.00	11
Close Up	1.37	2.00	0.90	10
All Dry Cows	1.29	2.00	0.90	31
All	1.08	2.00	0.49	105
Fresh	1.03	1.35	0.49	12
All Milking	0.98	1.50	0.49	75
Heifer	0.95	1.35	0.78	8

Legume/Grass Forage Test Results

	Ave	Max	Min	SD	n
DM	58.1	91.4	30.6	23.2	22
CP	20.2	25.5	12.5	3.4	22
ADF	31.4	40.2	21.2	4.8	22
NDF	39.7	55.0	27.6	6.9	22
uNDF	15.7	20.4	5.7	4.4	10
RVQ/RFV	163.6	233.0	111.0	35.2	19

Additive Usage by Farms

	Product	n
96%	Buffer	25
89%	Rumensin/monensin	27
86%	Organic trace minerals	22
85%	Anionic product	27
79%	Yeast product	24
63%	Mycotoxin binder	24
52%	Choline (rumen protected)	21
52%	Biotin	23
48%	Cation product (heat stress)	21

	Product	n
38%	Probiotics/DFM	21
35%	Sodium bentonite	20
35%	Immune stimulation	23
29%	Enzymes	21
15%	Niacin	20
10%	Calcium propionate	20
5%	Essential oil compounds	20
5%	Propyl glycol	20
0%	Organic Acids	20

Close Up Additives

Product	Sum	Percent	n
Anionic product	23	85.2%	27
Rumensin/monensin	19	76.0%	25
Organic trace minerals	16	72.7%	22
Yeast product	16	66.7%	24
Biotin	10	43.5%	23
Choline (rumen protected)	8	38.1%	21
Mycotoxin binder	8	33.3%	24
Sodium bentonite	5	25.0%	20
Immune stimulation	5	21.7%	23
Cation product (heat stress)	3	14.3%	21
Enzymes	3	14.3%	21
Probiotics/DFM	3	14.3%	21
Buffer	3	12.0%	25
Niacin	2	10.0%	20
Calcium propionate	1	5.0%	20

Rumensin/Monensin Levels

mg/head/day	Close up	Far off	Fresh	High	Low
<200	15%	20%	5%	0%	10%
200 to 250	**40%**	**33%**	10%	14%	10%
250 to 300	25%	27%	**33%**	24%	**25%**
300 to 350	10%	13%	14%	19%	15%
350 to 400	10%	7%	10%	14%	15%
>400	0%	0%	29%	**29%**	**25%**
n	20	15	21	21	20

Far Off Additives

Product	Sum	Percent	n
Rumensin/monensin	14	56.0%	25
Organic trace minerals	11	50.0%	22
Anionic product	10	37.0%	27
Yeast product	8	33.3%	24
Mycotoxin binder	6	25.0%	24
Biotin	5	21.7%	23
Sodium bentonite	4	20.0%	20
Immune stimulation	4	17.4%	23
Buffer	3	12.0%	25
Cation product (heat stress)	2	9.5%	21
Choline (rumen protected)	2	9.5%	21
Enzymes	2	9.5%	21
Calcium propionate	1	5.0%	20
Niacin	1	5.0%	20
Probiotics/DFM	1	4.8%	21

Percent of herd on rBST (n=38)

Do NOT use	63.2%
< 30%	5.3%
30 to 50%	10.5%
> 50%	21.1%

Fresh Additives

Product	Sum	Percent	n
Buffer	22	88.0%	25
Rumensin/monensin	20	80.0%	25
Organic trace minerals	17	77.3%	22
Yeast product	15	62.5%	24
Mycotoxin binder	13	54.2%	24
Biotin	10	43.5%	23
Probiotics/DFM	7	33.3%	21
Sodium bentonite	6	30.0%	20
Cation product (heat stress)	6	28.6%	21
Choline (rumen protected)	6	28.6%	21
Immune stimulation	6	26.1%	23
Enzymes	5	23.8%	21
Calcium propionate	2	10.0%	20
Essential oil compounds	1	5.0%	20
Niacin	1	5.0%	20
Propyl glycol	1	5.0%	20
Anionic product	1	3.7%	27

Milking Frequency

2X	64.9%
3X	18.9%
Combination of 2x-3x	8.1%
Combination of 3x-4x	2.7%
Robot	5.4%

High Group Additives

Product	Sum	Percent	n
Buffer	24	96.0%	25
Organic trace minerals	18	81.8%	22
Rumensin/monensin	20	80.0%	25
Yeast product	16	66.7%	24
Mycotoxin binder	14	58.3%	24
Biotin	11	47.8%	23
Probiotics/DFM	8	38.1%	21
Sodium bentonite	7	35.0%	20
Immune stimulation	7	30.4%	23
Cation product (heat stress)	6	28.6%	21
Enzymes	6	28.6%	21
Choline (rumen protected)	3	14.3%	21
Calcium propionate	2	10.0%	20
Essential oil compounds	1	5.0%	20
Anionic product	1	3.7%	27

Type of TMR Mixer (n=38)

Horizontal	Reel	Tumble	Vertical
11%	11%	5%	74%

Number or augers/screws in your TMR mixer?

1	2	3	4
42%	45%	3%	11%

"On average, how times a year do you review and/or reformulate your ration?" (n=38)

4 or less (Quarterly)	5 to 8 (Bimonthly)	9 to 15 (Monthly)	16 to 30 (Biweekly)	>30 (Weekly or more)
9	6	13	6	4
24%	16%	34%	16%	11%

Number of times a day feed is pushed up? (n=38)

37%	5 to 12 times a day
34%	3 to 4 times a day
11%	We don't push up feed
11%	1 to 2 times a day
8%	>12 times a day

"On average, how times a year do you test your forages? " (n=37)

4 or less (Quarterly)	5 to 8 (Bimonthly)	9 to 15 (Monthly)	16 to 30 (Biweekly)	>30 (Weekly or more)
7	10	15	2	3
19%	27%	41%	5%	8%

Amount of Weigh Back Dry Matter as % of Daily DMI (n=38)

Feed to empty bunk	Weigh Back			
	1 to 2%	2 to 3%	4 to 5%	>5%
16%	34%	26%	18%	5%

When do you check the moisture content of your TMR? (n=38)

Never check moisture content of TMR	6	16%
Every 3 months or more	3	8%
Monthly	9	24%
Weekly	6	16%
Daily	3	8%
Nutritionist checks	10	26%
After heavy rains	2	5%
Only when there is a problem	7	18%
Other	2	5%

Where does the weigh back go? (n=34)

32% Heifers
24% Discarded
18% Remix in lower group ration
12% Dry cows
9% Steers
6% Remix in current ration

Frequency of Feeding? (n=38)

1X	2X	3X	>3X
42%	53%	5%	0%

Forage Storage

	Bags	Bunkers	Piles	Silo	Wrapped bales	Silage inoculant	n
Corn Silage	41%	52%	14%	21%		52%	29
Corn Silage (BMR)	56%	50%	13%	25%		56%	16
Grass Silage	26%	32%	5%	16%	32%	42%	19
Legume Silage	42%	33%	4%	21%	21%	42%	24
Small Grain Silage	63%	19%	13%	13%	6%	56%	16
Sorghum Silage	71%	14%	14%		14%	71%	7

How do you handle a majority of your hay? (n=7)

53%	Big square bales
25%	Balage
14%	Round bales
8%	Conventional small square bales

University of Illinois at Urbana-Champaign

How do you determine when the cow(s) are ready to move to another group? (n=26)

54%	Days in milk
31%	Cows general appearance
31%	Other
23%	Whenever there is a group of cows to move
19%	Milk production
8%	Feed intake
4%	Body temperature
4%	Rumination activity

University of Illinois at Urbana-Champaign

Do you use a hay preservative/inoculant when baling?

37%	Yes (47%)
42%	No (53%)
21%	We do not bale hay

Do you require a hay preservative/inoculant when purchasing hay?

11%	Yes (16%)
55%	No (84%)
34%	We don't purchase hay

University of Illinois at Urbana-Champaign

Do you have a fresh cow group? (n=38)

Yes 47%
No 53%

How days are fresh cows kept in the fresh group? (n=17)

Average: 30.7
Max: 100
Min: 10
SD: 24.1

University of Illinois at Urbana-Champaign

Health Issues: % Incidents

	Ave	Max	Min	SD	n
Milk fever	5.6	25	1	6.40	37
Ketosis	5.9	30	1	6.46	36
Displaced abomasum	1.8	5	0.005	1.36	30
Retained placenta	3.3	10	0.05	2.47	34
Metritis	3.8	15.3	0.05	3.80	35

University of Illinois at Urbana-Champaign

Phase Two Article Statistical Analysis

University of Illinois at Urbana-Champaign

Are you using calcium boluses?

37%	Use as needed
32%	Use only on 2+ lactation cows
24%	Do NOT use
8%	Use on all cows

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Effect of production level

- Farms that responded n = 38
- Farms with RHA milk < 19,800 lbs classified as LOW (n = 15)
- Farms with RHA milk > 19,800 lbs classified as HIGH (n = 16)

- Evaluated the effect of production level on different production parameters, diets, forages, management, and health on Jersey farms.

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Low (<19,800 lbs) vs. High (>19,800 lbs) Production Level

	Production level			
	Low	High	SE	*P* value
n	15	16		
Milk Yield, lbs	58.6	67.9	1.6	<0.001
Fat, %	5.23	5.05	0.12	0.31
Protein, %	3.78	3.76	0.04	0.73
SCC	197.7	164.1	25.2	0.35
RHA milk, lbs	18,640	21,515	270	<0.001
RHA Fat, lbs	932.1	1053.2	21.1	<0.001
RHA Protein, lbs	687.2	785.0	11.6	<0.001
Age at 1st calving, months	23.1	23.4	0.32	0.58

Take Home Messages: Level of Milk

- Higher protein dry cow ration with less hay in high herds
- Lower ADF and NDF corn silage in high herds (bmr silage)
- Less metritis in high herds
- Trend with lower SCC and more 3x milking in high herds

Conclusion: Differences were minor

Effect of BST use

- Farms that responded n = 38
  - Farms that did not use BST were classified as NO (n = 25)
  - Farms that did use BST were classified as YES (n = 13)
- Evaluated the effect of BST use on production parameters, diets, forages, management, and health on Jersey farms.

Effect of BST Use (Yes vs. No)

	BST			
	No	Yes	SE	*P* value
n	25	13		
Milk Yield, lbs	63.31	63.53	2.4	0.94
Fat, %	5.16	5.09	0.15	0.68
Protein, %	3.77	3.77	0.05	0.97
SCC	168.0	203.8	30	0.34
RHA milk, lbs	19929	20533	567	0.39
RHA Fat, lbs	989.1	1006	33	0.67
RHA Protein, lbs	733.5	746.4	21	0.62
Age at 1st calving, months	23.3	23.2	0.45	0.75

Take Home Message: Use of rBST

- Higher levels of fat fed, less ADF, and less hay (higher energy rations) in rBST herds
- Dry cow rations higher in ADF and NDF with less starch (may reflect high straw dry cow ration) in rBST herds
- Forages contain less uNDF in rBST herds (wish I had more data)
- Pushed up feed more frequently in rBST herds

Conclusions: More aggressive feeding and management

Effect of herd size

- Farms that responded n = 38
  - Farms that had a herd size < 200 cows were classified as small (n = 21)
  - Farms that had a herd size >200 cows were classified as YES (n = 13)
- Evaluated the effect of herd size on production parameters, diets, forages, management, and health on Jersey farms.

Small (<200 cows) vs Large (>200 cows)

	Herd Size			
	Small	Large	SE	*P* value
n	21	17		
Milk Yield, lbs	63.8	63.1	2.1	0.81
Fat, %	5.2	5.1	0.1	0.71
Protein, %	3.7	3.8	0.04	0.26
SCC	186.3	175.5	27	0.77
RHA milk, lbs	19,856	20,344	481	0.46
RHA Fat, lbs	981	1006	27	0.50
RHA Protein, lbs	722	751	18	0.23
Age at 1st calving, months	23.2	23.4	0.3	0.66

Take Home Message: Herd Size

- No differences in milk production
- No effect on rBST use
- Trend for more pushing up of feed in larger herds

Conclusion: Surprised to observe no differences

Effect of Percent of Herd as Jersey

- Farms that responded n = 38
  - Farms that had <100% of cows as Jersey were classified as <100% (n = 22)
  - Farms that had 100% of cows as Jersey were classified as 100% (n = 16)
- Evaluated the effect of % of herd as Jersey on production parameters, diets, forages, management, and health on Jersey farms.

<100% vs 100% Jerseys in Herd

	Percent Jersey			
	<100%	100%	SE	*P* value
n	22	16		
Milk Yield, lbs	64.2	62.5	2.0	0.52
Fat, %	5.08	5.20	0.12	0.49
Protein, %	3.73	3.82	0.04	0.13
SCC	152.3	214.9	25	0.08
RHA milk, lbs	20,126	20,122	469	0.99
RHA Fat, lbs	976.5	1014	23	0.31
RHA Protein, lbs	731.6	744.1	17	0.61
Age at 1st calving, months	23.3	23.3	0.4	0.98

Take Home Message: Mixed vs. Jersey

- More 3X milking occurred in mixed herds
- More weigh-back/feed refusal in mixed herds
- More ketosis and higher SCC in Jersey herds

Conclusion: Mixed herds may be more aggressive in feeding management and intake.

Limitations of the Study

- Could not collect the actual dry matter fed
- Multiple TMRs were difficult to interpret
- Could not trace which legume/grass forages were being fed in each group
- Close up rations had limited numbers
- A face-to-face data collection would be ideal, but is not possible with a $2500 grant.

Getting the Biggest Bang for Your Calf Recommendations!

Dr. Sam Leadley
Calf & Heifer Management Specialist
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Getting the Biggest Bang for Your Calf Recommendations!

Four-State Dairy Nutrition and Management Conference

June 13 & 14, 2018

Adding Value to Product/Service

- Compare performance to standards – national and/or farm-specific
- **Identify areas of risk for low performance – (1) calving area,** (2) colostrum management, (3) housing environment, (4) nutrition

  [Calf Risk Assessment Checklist – click HERE or go to this URL http://atticacows.com/library/newsletters/RiskAssessPreweanedCalvesChecklistR1899.pdf
- Suggest practical alternatives and solutions

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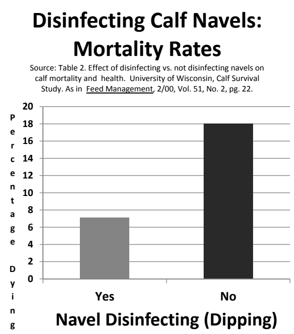
Calving Area
This is Where it Starts
NO MANURE MEALS!!!

Compare performance to standards – national and/or farm-specific

- **I. Mortality** Preweaned target rates is **less than 5%**
- **II. Morbidity**
- **Scours** preweaned target treatment rate **less than 25%**
- **Pneumonia** preweaned target treatment rate **less than 10 %**
- **III. Growth rate** double weight by 56 days

Next Step: Stop Navel Infections



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- Compare performance to standards – national and/or farm-specific
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[Calf Risk Assessment Checklist – click HERE or go to this URL http://atticacows.com/library/newsletters/RiskAssessPreweanedCalvesChecklistR1899.pdf

- Suggest practical alternatives and solutions

The Problem: Coliform bacteria in colostrum double every 20 minutes at cow's 102F

Feed Clean Colostrum

See www.calffacts.com, "Bacteria Quality Control: Collecting colostrum samples."

60cc Vial [$.25]– Sampling Protocol @www.calffacts.com

Pack of 5 Sample Vials + Sampling Protocol [$1.50]

Feed Clean Colostrum

Milk/Feed or Chill to 60F within 30 minutes

Ice bath for chilling colostrum

Ice in colostrum to chill

Feed Clean Colostrum

- **45 percent samples had more than 100,000 cfu/ml bacteria.**
- **Culturing is the only way to monitor this.**
- **Vet Lab will speciate and quantify (NOT a milk plant)**

- Morrill, K.M. "Nationwide evaluation of quality and composition of colostrum on dairy farms in US" JDS 95:3997-4005 July 2012
- See www.calffacts.com, "Bacteria Quality Control: Collecting colostrum samples."

Feed Clean Colostrum
Use an Effective Cleaning Protocol

- **1. Rinse with warm water.**
- **2. Wash with hot chlorinated detergent solution by BRUSHING all surfaces.**
- **3. Rinse with warm acid solution**
- **4. Dry.**

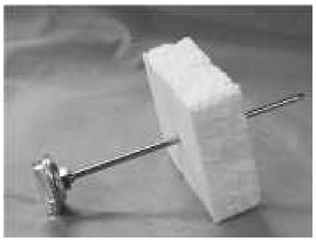
Source: click HERE or use this URL http://atticacows.com/library/newsletters/WashMilkContProtocolR1815.pdf

Feed Clean Colostrum

Instant Read Pocket Thermometer <$6

Monitor wash water temp.

Just read the dial – wash water always above 120F



Works like a charm.

@$3

Right brush for cleaning the inside of this bottle. @$18-19

Error-Free ***<u>Bottle</u>*** Feeding of Colostrum

- **Starting clean by using good sanitation practices** [“Washing Milk Containers Checklist” www.calffacts.com]
- **Feeding it calf body temperature (103F)** [Beware of warm too long > bacteria counts]
- **Maintaining low stress conditions** [Find or make a corner, reward patience]
- **Monitoring drinking** [NO coughing and/or choking, always provide alternative nipple sizes]

It goes in both ends for a clean tube feeder @$3

Error-Free ***<u>Tube</u>*** Feeding of Colostrum

[“Colostrum: 4 Rules for Tube Feeding” at www.calffacts.com]

- **Starting clean by using good sanitation practices** [“Washing Milk Containers Checklist” www.calffacts.com]
- **Feeding it warm** [Beware of warm too long > bacteria counts]
- **Passing tube properly** [no colostrum in tube as it goes in and comes out, always feel for ball in esophagus]
- **Positioning her body correctly** [Always upright]
- **Monitoring rate of flow** [NO coughing and/or choking, limiting rate of flow to prevent back flow in esophagus]

Adding Value to Product/Service

- Compare performance to standards – national and/or farm-specific
- **Identify areas of risk for low performance –** (1) calving area, (2) colostrum management, (3) housing environment, **(4) nutrition**

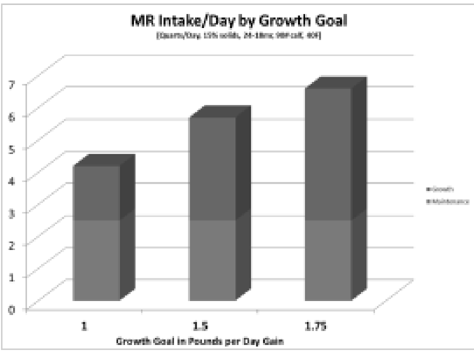
  [Calf Risk Assessment Checklist – click HERE or go to this URL http://atticacows.com/library/newsletters/RiskAssessPreweanedCalvesChecklistR1899.pdf
- Suggest practical alternatives and solutions

Feeding More Milk without Scours

- **Feed plenty of clean, high antibody colostrum ASAP after birth.**
- **Check for successful passive transfer rates.**
- **Feed climate-appropriate rates of milk to double birth weight in 60 days.**
- See www.calffacts.com, "Feed More Milk without Scours" for a 10-point checklist and a list of 5 key skills needed for successful intensive feeding.

Dry Matter Intake Drives Growth

Goal = Double Weight in 2 months



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- ***Calving Ease*** monthly letter for calf rearers via Internet. Send e-mail with subscribe in subject to smleadley@yahoo.com
- Website is **www.calffacts.com**.
- Blog, Google the title, **"Calves with Sam"**

But, Every time I Feed More Milk My Calves Have Scours!!!!!!!!!!!!

Feed More Milk without Scours

Cold weather arrives. You decide to feed more milk/milk replacer. Soon after making the change your treatable scours rate goes up too much to be acceptable.

What are the differences among farms that have this problem and those that feed milk/milk replacer at higher volumes without diarrhea issues among young calves?

The most common differences

Low Scours Rate	High Scours Rate
1. Milks fresh cows as soon as possible after calving, nearly all of them within 6 hours post-calving.	1. Milks fresh cows next regularly scheduled milking.
2. Checks colostrum quality and uses highest quality for first feeding.	2. Does not check colostrum quality.
3. Feeds colostrum as soon as possible after birth, always within first 4 hours.	3. Feeds colostrum at next regular calf feeding time.
4. Feed 3.5-4 quarts colostrum (large breeds)	4. Feeds 1.5-2 quarts of colostrum.
5. Checks colostrum cleanliness with regular culturing.	5. Does not check colostrum for bacteria content.
6. Checks for successful passive transfer of immunity on a regular basis.	6. Checks for successful passive transfer of immunity only if there is a "problem."
7. Cleans colostrum and milk handling equipment after every use following an accepted cleaning protocol that is written and posted.	7. Cleans colostrum and milk handling equipment as convenient with no regular protocol.
8. Checks milk or milk replacer cleanliness with regular culturing.	8. Does not check milk or milk replacer for bacteria content.
9. Feeds preweaned calves enough milk or milk replacer to support at least 1 pound a day gain all seasons of the year.	9. Feeds preweaned calves milk or milk replacer at a rate such that calves do not gain weight some seasons of the year.
10. Keeps calf housing clean.	10. Houses calves in a high bacteria environment.

How Realistic is it to try Feeding at a Higher Volume?

Following all the practices in the left-hand column above does not guarantee that none of your calves will have scours. In contrast, the chances for scours do go up as your practices look more and more like the ones in the right-hand column.

Feeding calves is always like walking a tight-rope. You are trying to maintain a balance. As you increase milk or milk replacer feeding volumes the chances of losing your balance go up. That is, the calves have diarrhea. This requires better management skills.

Key Skills:

- Be able to feed different volumes of milk to calves – not every calf receives the same amount. While there a few exceptions most calf feeding programs that feed more than the traditional 2 quarts twice daily increase volume as calves grow. Lots of folks mark individual or groups of pens to receive a specific amount per feeding.

- Be able to feed consistent volumes of milk. This means delivering each feeding within 1 cup of the intended volume. For example, when feeding 3 quarts at 1 feeding the actual amount delivered does not vary more than 2.75 to 3.25 quarts.

- Be able to deliver milk replacer mixed at the same concentration at every feeding. A significant step in achieving this consistency is having an accurate set of scales that are used all the time to measure milk replacer powder.

- Be able to deliver milk or milk replacer at the same temperature at every feeding. My goal is to achieve delivery temperatures in the range of 100-105 F. In cold weather conditions this may mean delivering liquid feeds in multiple batches.

- Be able to observe and diagnose scours in calves. Prompt diagnosis and treatment is always important. Equally important is watching a group of calves the first few days after their ration has been bumped up in volume.

  Many folks have observed that it is a good practice to temporarily drop back volume fed for a few days when a calf scours after a ration increase. My personal experience suggests that at least 1 out of 20 calves will experience what is often called “nutritional” scouring even when volume increases are as small as 0.5 quart per feeding.

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For Calves with Sam blog go to dairycalfcare.blogspot.com

Looking Back to Understand the Present: Monitoring the Transition Cow

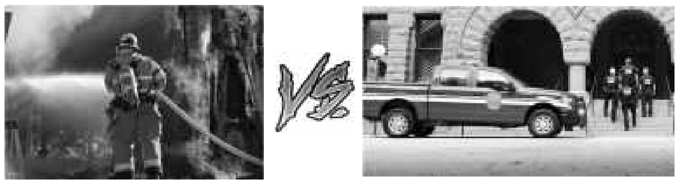
Luciano Caixeta DVM, PhD
Dubuque, IA

Looking back to understand the present: monitoring the transition cow

Luciano Caixeta DVM, PhD
Dubuque, IA
June 13th, 2018

UNIVERSITY OF MINNESOTA

Being *proactive* is better than being *reactive*.
What do we want to be?



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Monitoring is important to support management

- Detect unintended disruptions in performance under the existing management conditions
- Measure the impact of an implemented intervention or management change
- Help motivate management or employee behavioral change on the dairy
- Monitoring is intended to make sure that performance matches expectations.

Slide courtesy of Dr. Fetrow

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We are looking for monitors that:

1. Minimum delay between cause and effect (**lag**)
2. Use of historical data does not hide recent changes (**momentum**)
3. Summary does not conceal problem deviations (detects **variation**)
4. Information is not misleading (avoids **bias**)
5. Sensitively detects problems (**sensitive**)
6. Specifically identifies the problem (**specific**)

- Use the methods that are practical and most useful to address the problem(s) at hand

Slide courtesy of Dr. Fetrow

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Negative nutrient balance is a hallmark of the transition period

- Increased energy and mineral demands to support:
  - Fetal growth
  - Colostrum and milk production
- Changes in diet
- Delayed increase in DMI after calving

Transition Period			
Dry period: Far-off	Dry period: Close-up	Fresh	Early Lactation

-60 -21 0 ~ 7 30

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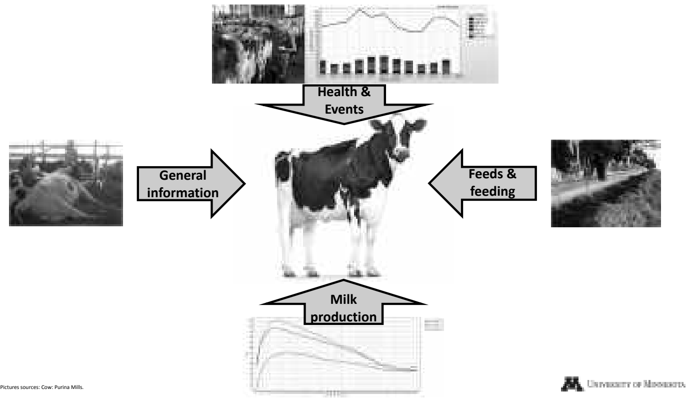


Pictures sources: Cow: Purina Mills.

Good management practices during the dry period can improve postpartum performance

- Control energy intake in far-off dry cows
- Minimize stress
- Avoid excessive weight variation
- Provide adequate and comfortable beds
- Management of calcium homeostasis (DCAD)
- Manage long dry days closely

Check list for monitoring factors associated with the occurrence of transition period diseases	
• **Assess cow comfort**	
○ Appropriate stocking density	○ Stall design
○ Bunk space	○ Comfortable and sanitary bedding material
○ Access to water	○ Heat abatement
• **Manage early lactation cows in "fresh cow pens"**	
• **Routine comprehensive total mixed ration audits**	
○ Particle length	○ Feeding routine
○ Consistency of the delivered diet	○ Bunk management
• **"Test-and-Treat" strategy to monitor hyperketonemia on fresh cows**	
• **Use of anionic salts during the dry period to minimize the occurrence of hypocalcemia and assess urine pH on close up cows**	
• **Use of automated health-monitoring systems for early diagnosis of diseases**	

Adapted from Caixeta et al., 2017

Strategies to improve calcium in fresh cows

Avoid overcrowding for dry and fresh cows

- Appropriate stocking density depending on breed and parity
  - Far-off dry cows: 100% SD
  - Close up dry cows: 80% to 100% SD
  - Fresh cows: 80% SD
- Access to water
- Comfortable and sanitary bedding
- Heat abatement
- Avoid prolonged standing times

Nutritional strategies are effective in reducing the incidence of clinical hypocalcemia

- Use of low DCAD diets leads to metabolic acidosis allowing full PTH response
- Low DCAD diets can lower feed intake
- Forage potassium can greatly influence diet DCAD

When using anionic salts we should monitor:

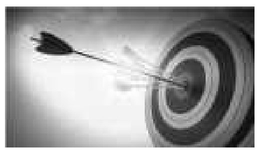
- Urine pH (GOAL: pH = 6.0 – 7.0)
- Feed intake

100% stocking density (headlocks) did not alter health parameters and culling in Jerseys

- Silva et al. (2014)
- SD80 vs SD100 – animals separated by parity
- 100% stocking density reduced lying time and increased displacement rate from the feedbunk
- Stocking density did not affect innate immune parameters, incidence of disease, BCS, milk production, and repro performance

Blanket supplementation of calcium is not the solution for all fresh cows

- Blanket supplementation of calcium does not:
  - Improve health status;
  - Decrease culling in early lactation;
  - Improve milk production;
  - Improve reproductive performance.
- Oral calcium supplementation is only beneficial to a groups of cows
  - Lack (or very few) benefits for blind treatment
  - **Not recommended** for primiparous cows
- TARGET: "older" high producing cows and lame cows



Strategy	Mean	95% range	SD
High mature-equivalent milk yield cows			
Net herd impact ($)	4,425	87 to 9,835	2,508
Net impact per dosed cow ($)	15	0 to 33	9
Return on investment	1.1	0.0 to 2.4	0.5
Lame cows			
Net herd impact ($)	5,812	1,614 to 11,403	2,523
Net impact per dosed cow ($)	89	27 to 159	34
Return on investment	6.5	2.0 to 11.4	2.4
High mature-equivalent milk yield cows and lame cows			
Net herd impact ($)	8,313	3,377 to 10,634	3,587
Net impact per dosed cow ($)	25	6 to 47	10
Return on investment	1.8	0.5 to 3.4	0.8
All cows			
Net herd impact ($)	3,605	3,377 to 10,634	3,587
Net impact per dosed cow ($)	5	5 to 16	5
Return on investment	0.3	0.4 to 1.2	0.4

McArt and Oetzel (2015)

Disease	Definition	Herd Alarm	Cost/case
Ketosis	Decreased appetite, elevated milk, urine, and blood ketones in the absence of other disease (BHBA > 1.2 mmol/L)	15%	$289
Fatty Liver	Accumulation of fat within the cow's liver without any pathognomonic signs. Only diagnosed by liver biopsy.	50%	TBD
Milk Fever	Calcium deficiency causing progressive neuromuscular dysfunction with flaccid paralysis, circulatory collapse, and depression of consciousness	5%	$246
LDA	Decreased appetite accompanied by a high-pitched tympanic resonance by percussion of the left abdominal wall.	3%	$700
Retained Placenta	Fetal membrane visible at vulva or in vagina or uterus by vaginal examination for more than 24h after parturition	5%	$232
Metritis	Abnormal cervical, vaginal, or uterine discharge.	10%	$218
Mastitis	Visually abnormal milk from one or more quarters with or without signs of inflammation of the udder.	3%	$376

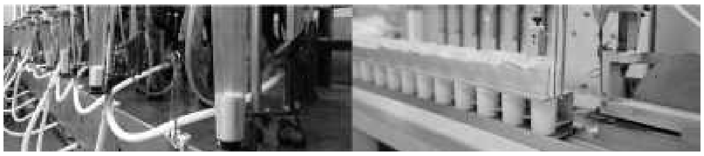
Adapted from: Melendez and Risco (2005), McArt et al. (2015), Liang et al. (2017), Caixeta et al. (unpublished)

Management of dry cows in essential for a successful transition to lactation

- How to monitor dry period?
  - ✓Check urine pH on a regular basis (weekly if possible)
  - ✓Keep track of pen counts
  - ✓Assess DMI and consistency of feed delivery
  - ✓Monitor days dry
  - ✓Make sure that cows have clean, comfortable, and sanitary beds

Fat-to-Protein ratio can be used as a herd level monitoring tool

- Good sensitivity (>80%) and specificity (70%)
- Goal should be < 40% of cows with 1st test F:P > 1.4
- Not a good test on the cow level



Monitoring Ketosis: Test-and-Treat Strategy

Estimate herd level prevalence by sampling approximately 20 cows between 3 and 14 DIM
Positive cows have BHB ≥ 1.2 mmol/L

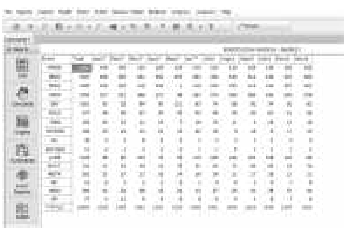
≤ 15% (3 out of 20) → **Monitor**: Monitor prevalence of hyperketonemia every other week.

> 15% to 40% (3 to 8 out of 20) → **Test and Treat**: Monitor incidence of elevated BHB. Sample all cows 3 to 9 DIM twice a week.

≥ 40% (≥ 9 out of 20) → **Treat all**: Give 300 mL of propylene glycol starting at 3 DIM for all cows. Recheck prevalence in 2 weeks.

Adapted from: Ospina et al. (2013)

Reliable and effective data recording systems are essential for monitoring transition cows



- Monitor and treat metabolic and infectious disease:
  - Hyperketonemia
  - Hypocalcemia
  - Metritis
  - Mastitis
  - Retained fetal membranes
  - Dystocia

KetoStix	N[a]	SCK[b]	CK[c]	Overall	Precision Xtra Results (mmol/L) Mean (SE)	Range
Negative	43	4 (9%)	0 (0%)	4 (9%)	0.6 (0.05)	0.2–1.6
Trace (5 mg/dL)	10	5 (50%)	4 (40%)	9 (90%)	1.8 (0.22)	1.0–3.4
Small (15 mg/dL)	5	4 (80%)	0 (0%)	4 (80%)	1.5 (0.17)	1.1–1.9
Moderate (40 mg/dL)	6	2 (33%)	4 (67%)	6 (100%)	2.5 (0.50)	1.2–4.3
Large (> 80 mg/dL)	10	2 (20%)	8 (80%)	10 (100%)	2.9 (0.39)	1.4–5.3

[a] N = number of cows.
[b] The threshold for SCK was blood BHB ≥ 1.2 to ≤ 2.9 mmol/L.
[c] The threshold for CK was blood BHB > 2.9 mmol/L.

Adapted from Galvão et al., 2012.

Automated health monitoring systems can identify cows suffering metabolic and digestive disorders

- Great number of options of sensors
- Health monitoring systems can identify cows with DAs, ketosis, metritis, and mastitis earlier than farm personnel
- HMS have a relatively lower sensitivity to identify cows with metritis and mastitis

- Opportunities and challenges when using HMS:
  - Earlier treatment of diseases and improvement of prevention programs
  - Challenging to make a treatment decisions when clinical signs are not present.

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Monitoring of fresh cows assists is a good tool to make sure that performance matches expectations

- How to monitor fresh cows?
  - ✓ Keep track of pen counts
  - ✓ Assess DMI and consistency of feed delivery
  - ✓ Monitor days fresh pen
  - ✓ Make sure that cows have clean, comfortable, and sanitary beds
  - ✓ Postpartum disease occurrence
  - ✓ Changes in BCS (less than $\leq$ 0.75 BCS)
  - ✓ Keep lock-up times under 45 minutes/day

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Management practice	Goal
Removal of old feed from bunk	Daily
Availability of feed	$\geq$ 23 hours/day
Feed push-up	Every 4 hours
Eating space	$\geq$ 60 cm/head (24 inches)
Water availability	$\geq$ 10 linear cm/head (4 inches)
Pre-partum dry matter intake	
Primiparous	$\geq$ 22 lbs/day
Multiparous	$\geq$ 26 lbs/day
Post-partum dry matter intake	
Primiparous	$\geq$ 34 lbs/day
Multiparous	$\geq$ 42 lbs/day
Social groupings	Separate parity groups

Adapted from Caixeta et al., 2017

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Take home message

- Transition period is challenging for animals and farmers
- Prevention >>>> Treatment
- Reliable and effective data recording system are paramount
- During transition period cows need to:
  - Have enough energy to avoid ketosis
  - Maintain normocalcemia
  - Have optimal cow comfort

University of Minnesota

Thank you!

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College of Veterinary Medicine, University of Minnesota, Driven to Discover

dairyKNOW

Feeding and Management Practices for Robotic Milking Success

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Introduction

Dairy producers install robotic milking system (RMS) for a variety of reasons, but surveys have shown that one of most common reasons relates to labor (flexibility maybe more than labor cost) and lifestyle or quality of life. de Jong et al. (2003) conducted a survey of North American dairy producers who had implemented RMS. They reported that for many smaller farms, using RMS improved flexibility of their schedule and reduced the physical intensity of labor, which was primarily provided by the family owning the farm. In fact, 84% of the producers surveyed mentioned having a more flexible work schedule as a reason for making the decision to install RMS. However, producers did not report a reduction in hours of work on the farm but they did have a reduction in physical labor, and decreased cost of hired labor was reported by 70% of farms. We found similar results in our survey of RMS dairy farms in Minnesota and Wisconsin. For larger farms, the challenge to find, train and retain high quality milking labor is causing them to consider RMS. RMS may also improve quality of life for the employees they hire. Larger farms are adopting RMS. These include TDI Farms in Michigan with 24 DeLaval (Tumba, Sweden) VMS units and Chilean Dairy, Fundo El Risquillo, milking 4,500 cows with 64 DeLaval VMS units (delaval.com). Other examples include Hemdale Farms in New York with 19 Lely (Maassluis, Netherlands) RMS and Corner's Pride in British Columbia with 30 Lely RMS (Lely.com). We are also beginning to see fully automated rotary robots installed in the upper Midwest.

One of the most important factors for success in RMS is how cows are fed. When we feed dairy cows, we aim to develop a low cost diet that meets the nutritional requirements of cows while optimizing milk production and cow health. In most conventional confinement herds, we accomplished this by feeding a totally mixed ration (TMR) where all ingredients are mixed together and delivered to the cows. For box RMS herds, a partial mixed ration (PMR) containing all the forage and some of the concentrate is offered in the feed bunk. Additional concentrate is fed through the RMS milking station. This amount is determined by the management and varies according to the cow's stage of lactation, lactation number and milk production. This appears on the surface to be a simple concept, but achieving the optimal combination of nutrients from the PMR and the concentrate pellet is not necessarily an easy task and it takes some trial and error in some instances.

Enticing Cows to Visit the Milking Station

Prescott et al. (1998) demonstrated that a palatable feed offered in the RMS milking station is the main motivating factor for cows to visit the RMS. The interaction between cow behavior, activity, feed consumption, health and milk production is complicated (Rodenburg, 2011). Cow's attendance to the milking station is not only dependent on the PMR delivered in the feed bunk and concentrate pellets offered in the RMS, but also on feeding management, cow comfort, cow health, and social interactions among cows. A poor performing RMS can cause frustration for both the farmer and their nutritionist.

We asked nutritionists to rank five feeding factors they thought were keys to RMS feeding success: PMR energy content, PMR starch content, consistent mixing of the PMR, consistent delivery and push-up of PMR, and palatability of the pellet. Nutritionists working with these dairies indicated that palatability of the pellet and consistent PMR mixing were the two biggest feeding factors contributing to RMS success. These results agree with comments made by dairy producers on our visits and existing research. Rodenburg and Wheeler (2002) showed that in a free flow RMS, feeding a high quality pellet (hard pellet with few fines made from palatable ingredients) increased the number of voluntary milkings from 1.7 to 2.1/cow per day compared with feeding a low quality pellet. We observed that at start-up of a new RMS, nutritionists and farmers focused on developing a pellet formula that encouraged milking station visits. Once they had a pellet that worked well, other factors became more important. Many producers commented that even minor changes in the PMR moisture, consistency of the mix (i.e., long hay that is difficult to process to a consistent length), and changes in forage quality affected visits. Visits may drop if forage moisture changes and rations are not adjusted promptly. The drop in visits will result in a decrease in milk production and an increase in the number of fetch cows. The increase in fetch cows may disrupt other cow behaviors, resulting in even greater decreases in visits and milk production, leading to a downward spiral that creates much frustration for the producer. These complicated interactions between feeding management, voluntary visits and milk production can be challenging.

Guided Flow Versus Free Flow

Free flow cow traffic (cows have unrestricted access to the feeding area, resting area, and AMS unit) was associated with greater milk yield per cow per day (Tremblay et al., 2016) compared to guided flow (cows must visit areas of the barn in sequence, such as from resting area to the AMS unit to the feeding area, using a combination of pre-selection and one-way gates); their study included only Lely RMS farms. On another study, guided flow was associated with increased number of milkings per day and reduced number of cows being overdue for milking and needing to be fetched (Bach et al., 2009).

There are two types of guided flow traffic - milk first and feed first. In the milk first system, cows leaving the resting area must pass through a pre-selection gate that determines if she is eligible for milking. If she meets the requirement to be milked she is guided to a commitment pen that contains the RMS unit. If she is not eligible for milking she is allowed to enter the feeding area and can only enter the resting area through a one-way gate. In the feed first system, cow traffic is the reversal of the milk first system. After eating the PMR, cows enter a selection gate that determines if she is eligible for milking. The gate either guides her to the commitment pen for milking or to the resting area.

Farmer comments and our observations indicate that the milk first system is superior with the US style of dairying where economics demand high production. Our observation is that in feed first systems cows fill up on PMR and tend to stand in the feed alley or commitment pen chewing their cud without entering the selection gate or visiting the RMS. Feed first systems work best in farms where the PMR is very low in energy and there is a drive for cows to consume the concentrate in the milking station (Rodriguez, 2013).

Free flow feeding strategies

Our survey indicated that amount of pellets offered through the milking station averaged 11.2 lbs/cow per day and ranged from 2 to 25 lbs/cow per day. In free flow herds the PMR was balanced for milk production levels of 10 to 30 lbs less than the herd's bulk tank average production.

Lead feeding is generally used in early lactation. To 14 to 28 days in milk, cows are fed for 75 to 90 lb/day of milk. From 14 to 28 days in milk through peak lactation, cows continue to be fed nutrients that support 75 to 90 lb/day of milk or for actual milk production, whichever is higher. After this time, the feed delivery changes to feed cows for actual milk production and regaining body condition. Some farms with very high producing late lactation cows close to dry-off develop a feed table for late lactation cows that decreases RMS station feed so cows drop in production before dry off. One challenge of free flow systems is that late lactation cows can become fetch cows. A field survey in 2002 showed that as energy of the PMR increased, the number of late lactation fetch cows increased (Figure 1). The key to preventing this is to have an excellent reproductive program that maintains high milk production through the end of lactation.

Guided flow systems

Feed first and milk first guided flow RMS employ different feeding strategies. Feed first systems use a feeding strategy that is very similar to free flow milking systems and will not be discussed further.

Our survey indicated that dairy producers using a milk first guided flow system have a different feeding philosophy than free flow. The amount of feed offered in the milking station is minimal and only used to entice cows to attend the milking station. A higher percentage of the cow's feed intake is delivered through the PMR. One main reason farmers install guided flow RMS is the desire to feed less of the more expensive pelleted feed in the milking station. Farmers with milk first guided flow systems were feeding from 2 to 12 lb of pellets/cow per day. The average amount fed across all herds was approximately 8 lb/cow per day. Commonly, 1.3 to 3 lb of pellets was fed at every milking visit. Because earlier lactation, higher producing cows are guided to the milking station more frequently, they receive more RMS pelleted concentrate.

Research on guided flow systems consistently show a decrease in the number of cows that require fetching. Older research shows that that the number of daily PMR meal events are lower in guided flow (6.6) compared to free flow (10.1) systems (Bach, 2009). However, observations from 18 more recently designed guided flow systems indicate they are able to achieve high numbers of gate passes (9.3) from the resting area to the feeding area (Peissig, personal communication)

The PMR in guided flow systems included in our survey tended to be slightly higher in energy (0.015 Mcal/b) and lower in NDF (2.1%) than the PMR in free flow systems. For guided flow herds the PMR was balanced for 9 to 20 lbs less than the average of the herd. This difference should probably be expected between the two systems. High energy density of the PMR in free flow barns may lead to decreased milking, whereas in guided flow systems selection gates help guide cows to the RMS.

Other Feeding Considerations

Pellet composition and feeding

Pellets that are made from high quality, palatable ingredients and with a very hard sheer force promote increased visits and more rapid feed consumption. Milking station pellets should be designed to complement the farms' forages and other ingredients in the PMR. For example, if the PMR is high in corn silage and thus high in starch, a pellet with highly digestible NDF from by-products should be considered to minimize the risk of sub-acute ruminal acidosis.

Halachmi et al. (2006) found that both pellets high in starch (high inclusion of ground barley, corn, sorghum, and wheat bran) and pellets high in digestible neutral detergent fiber (high inclusion of soy hulls, corn gluten feed, and soybean meal) could be used successfully to attract cows to the RMS. The two pellets resulted in similar daily milk visits, milk yield, and fat-corrected milk yield. However, concentrate allowance was kept low. Miron et al. (2004) reported a difference in milk components with a higher concentrate allowance - concentrates high in starch resulted in greater milk protein percent whereas concentrates high in digestible fiber resulted in greater milk fat percent. However, results of these studies may indicate that palatability can be maintained even when significant changes are made to the ingredient composition of the pelleted concentrate.

However, it does not appear that offering more concentrate will necessarily increase visits to the milking station. An observational study (Bach et al., 2007) showed that increasing the amount of pellets offered in the milking station from 6.6 lbs/cow per day to 17.6 lbs/cow per day increased the frequency of visits from 2.4 to 2.7 milkings per day for cows not being fetched. However, increasing the feed offered in the milking station did not decrease the number of fetch cows. Something other than the amount of concentrate offered such as lameness, or fear was affecting the number of fetch cows. Bach (2007) also showed that for every 1 lb increase in robot pellet consumed, the PMR intake decreased by 1.14 lbs. More recent research in a guided flow system showed dry matter intake averaged 5.9 lbs lower for cows fed 11 lbs of robot feed compared to 1.1 lbs (Hare et al, 2018).

Precision feeding

One potential advantage of RMS is the opportunity to feed each cow closer to her nutrient requirements by providing nutrients through a combination of the PMR and milking station pellet. Even though RMS allow for feeding more than one concentrate feed in the milking station, many producers in our survey only used one feed. Our observations indicate that producers are more recently using more than one feed to better target cows' nutrient requirements. Feeding a combination of concentrates in the milking station at different proportions and amounts according to milk yield, body weight, stage of lactation, and potentially milk components may maximize returns from RMS (Bach and Cabrera, 2017). These authors suggested that concentrate meal sizes should be limited to about 3 lb or less per visit so that cows consume all the feed that is allocated to them at each visit (Bach and Cabrera, 2017).

There are other benefits of precision feeding. Feeding cows more closely to their nutrient requirement will result in a more consistent body condition. High producing cows are fed the higher energy that they need to sustain high production while not overfeeding late lactation cows.

PMR automated feeding systems

Several manufacturers are promoting PMR automated feeding systems and speculate they will improve performance of the RMS. Belle et al. (2012) compared 20 free flow RMS, nine feeding the PMR with a conventional mixer and 11 using an automated PMR feeding system. There was no difference in number of milkings per cow (2.6 each). Refused visits to the RMS were 20.8% higher for the automated feeding barns (2.5 vs 2.0). Although this was not statistically different because of the large variation between farms, the authors suggested this meant that t the automated feeding stimulated higher cow activity. No milk production data were reported. However, more research is needed, especially in a US farming context.

Fresh cow management

Most RMS facilities do not have a separate fresh/early lactation group. Suggestions to consider that may increase the likelihood that all cows have a successful transition and high production include:

1. Use of multiple feeds through the milking station which allows the producer to use feed additives specifically targeted to fresh cows. As mentioned earlier, this will allow more precise targeting of nutrients to meet the cow's needs.
2. Special observation and monitoring of fresh cows. Fresh cows that are not feeling well may continue to consume all the milking station pellet but decrease intake of the PMR. This can potentially lead to sub-acute rumen acidosis, digestive upsets, and increase the risk for other diseases.
3. Rumination and activity on all fresh cows should be observed daily. The RMS software (depending on the system) creates a daily list of cows that are not meeting rumination and activity goals compared to herd mates. If these metrics are deteriorating, producers need to intervene rapidly and consider making adjustments to the milking station feed offered.
4. It is important to have a high quality PMR to encourage intake at the feed bunk.
5. Achieving frequent visits by cows in early lactation should be a priority. Research in conventional systems has shown that high milking frequency in early lactation increases milk production throughout lactation.

   Our research from 32 free flow showed that multiparous cows milking frequency increased rapidly after calving and averaged over three visits per cow per day by the second week in lactation. However, primiparous cows milking frequencies increased much more slowly, did not reach 2.5 visits until the third week of lactation, and did not peak until 4 to 5 months after calving (Figure 2). Farmers that design systems that allow them to pre-train heifers to the robot before calving report that milking frequencies in early lactation are higher and the number of days to train heifers to visit on their own is decreased.

Feeding consistency

Cows in all systems like consistency. This is even more important in a RMS. Farms that achieve consistently high production have the following attributes:

1. Consistent PMR dry matter
2. Consistent mixing and delivery of the PMR
3. Consistent feed push ups
4. Consistent and frequent cow fetching
5. Consistently high visits by fresh cows
6. Highly palatable PMR
7. Highly palatable, consistent, high quality, milking station feed

Factors affecting RMS productivity

Milk production per robot is one factor affecting profitability of RMS systems. Our research on 32 farms with free flow systems showed that herds using automatic feed pushers had higher milk production per robot (4581 lbs) as compared to herds that did manual feed push-ups (4178 lbs) (Siewert et al, 2018). Factors associated with increased milk per robot included average robot milkings day, milking speed, cows per robot and the amount of robot feed offered. Factors associated with lower milk per robot included higher residual feed and the number of failed and refused visits to the robot (Siewert et al., 2018). Residual feed is the concentrate feed/cow programmed by the feed tables but not offered because the total time in the milking stall was less than the time required to feed this amount at the preset feed delivery rate.

Similar to milk per robot, factors associated with more daily milk per cow included higher successful milking visits per cow per day, faster milking speed and increased robot feed offered. Lower milk production per cow was associated with higher residual feed, failed visits and refused visits per cow (Siewert et al., 2018).

Feed Cost

One concern is that feed cost will be higher with RMS compared to conventional milking systems because of the pellets fed through the milking station. Matt Haan (2017) recently compared the feed costs of 8 RMS farms with 46 conventional farms (Figure 3). Feed cost was very similar between the two systems. University of Minnesota Finbin data (2017) comparing RMS farms to conventional farms show similar results with average feed cost per day of $6.00 for RMS and $6.35 for conventional herds and feed cost per cwt of $8.83 for RMS and $9.79 for conventional.

Conclusions

The rapid growth on the number of farms using RMS in the US is expected to continue. The complexity of balancing the ration in the PMR and feed offered in the milking station can be a challenging task for nutritionists. Based on research, nutritionist surveys and farmer comments, the most important factors affecting feeding success include a high quality, palatable pellet and excellent feeding management. Research shows that feeding pellets are better than a meal and that a very hard pellet made from highly palatable ingredients will minimize fetch cows. Focus on maximizing visits and health of early lactation cows. It is important to work with herd managers to educate them on the importance of feed management and to balance energy in the PMR with pellets fed through the milking station to optimize visits and minimize the number of fetch cows.

Acknowledgements

We would like to thank the RMS specialists from Lely and DeLaval and their local dealers for their valuable input and help with RMS data collection. A special thanks to all of the cooperating nutritionists for sharing information with us and the many RMS users that allowed us to visit their farms and collect data and provided their valuable insight into their successes and challenges.

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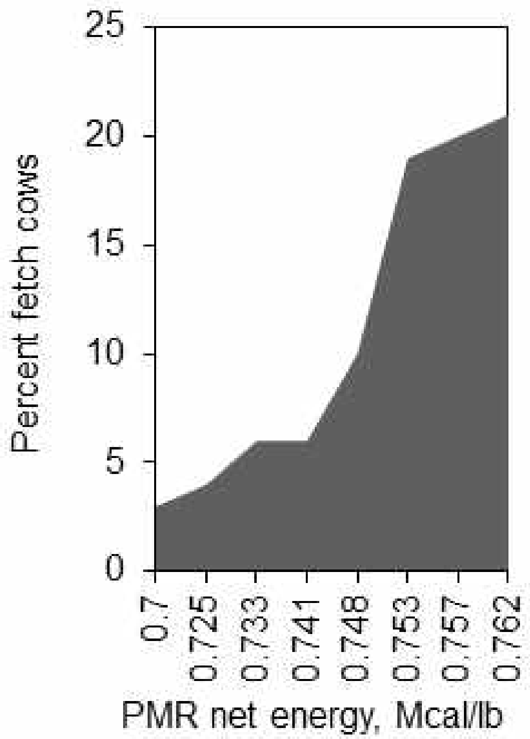
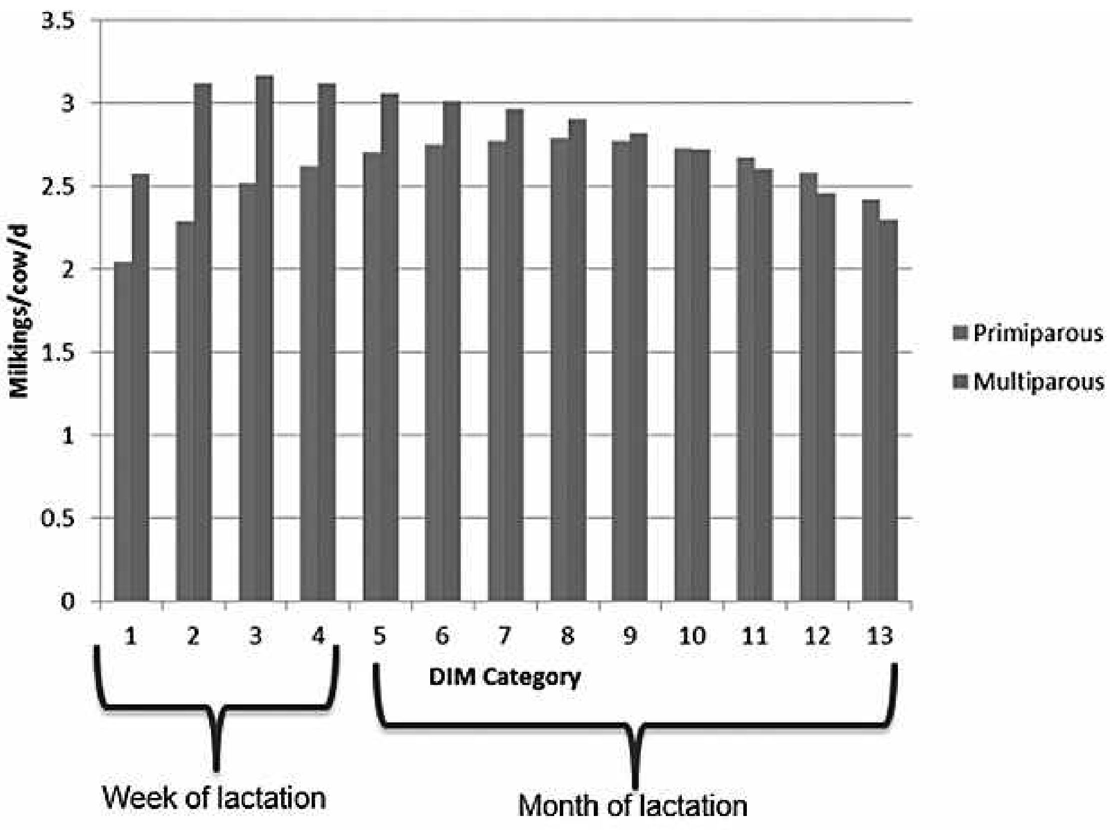
Figure 1. Percent of fetch cows vs. PMR net energy content[1]



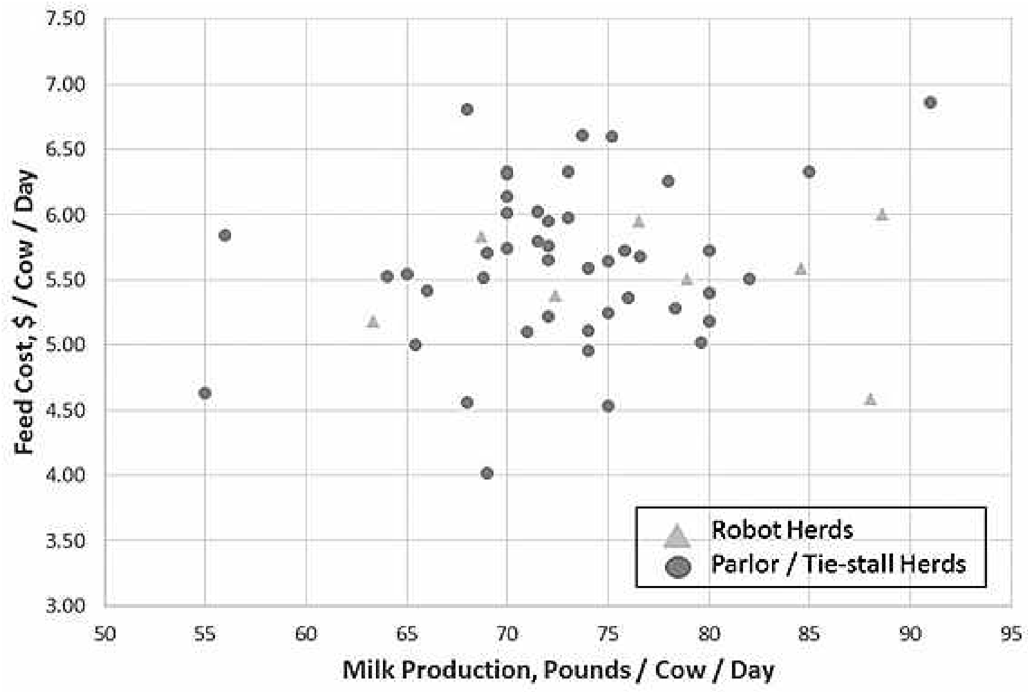
[1]Rodenburg and Wheeler, 2002

Figure 2. Milking frequency of box RMS cows by stage of lacation[1].



[1]Siewert et al., unpublished results.

Figure 3. Comparison of feed cost between RMS and conventional herds[1]



[1]Haan, 2017

Management Practices of Iowa Robotic Milking System-2017

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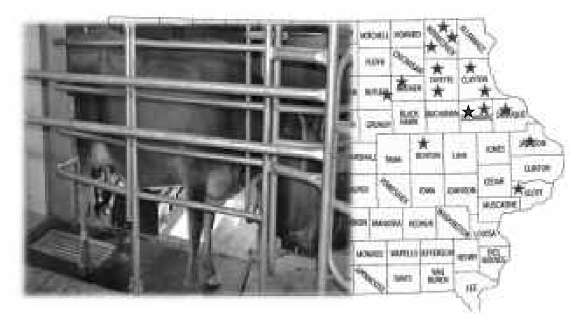

IOWA STATE UNIVERSITY
Extension and Outreach

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Milk Production and Quality Changes

- 10-17% increase
  - Lesser increase with retrofits verses new housing
    - Before: 70#
    - After: 82#

- **Percent Fat**
  - Before: 3.88
  - After: 4.07
- **Percent Protein**
  - Before: 3.16
  - After: 3.26
- **Somatic Cell Count**
  - Before: 223,000
  - After: 183,000

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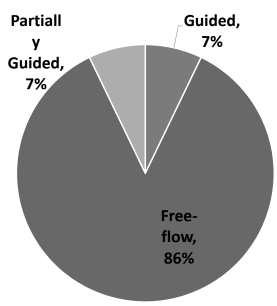
AMS Layout



- 15 farms with 41 robots
  - 1-6 robots per farm
  - (Lely, Delaval, Galaxy)
  - Average: 60 cows per robot (range 48-75)
  - Average Herd Size: 201 cows
- **Cows per employee** (1 FTE = 3000 hrs.)
  - Before installation (n= 12):
    - Average 46 (30-70 range)
  - After installation (n=14):
    - Average 79 (37-140)

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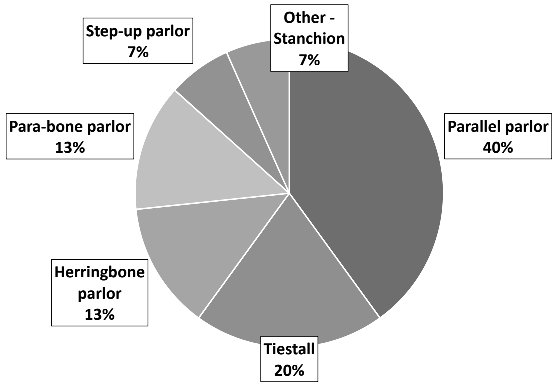
n=15

How were Cows milked prior to AMS?



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n=15

Number of Milking Cows and Groups

- **Number of cows per pen** (n=17)
  - Range: 50-150 cows
- **Number of milking groups:**
  - 1 group: 4 farms
  - 2 groups – 10 farms
    - 2 year old-Mature
    - High-Low group
  - 3 groups: 1 farm
    - By breed (H/J/Ho-J)
- **Dry cow groups:**
  - 1 group: 7 farms
  - 2 groups: 7 farms (faroff/prefresh)
  - 4 groups: 1 farm (far off/close-up/prefresh/post fresh)

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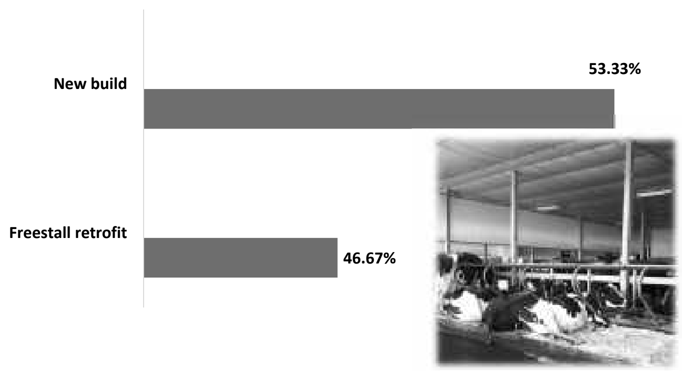
AMS Installation



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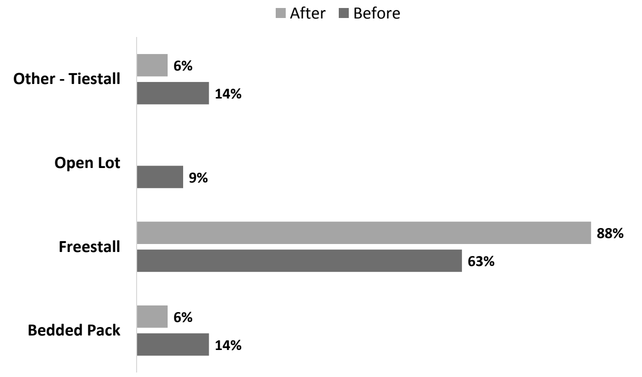
n=15

Dairy Housing Before and After



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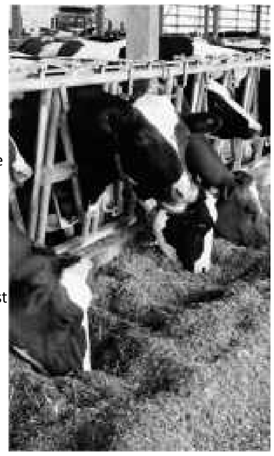
Before, n=21
After, n=16

Feed Management



- Pellet -variations included protein and flavored pellet (n=13)
- Nutrient dense grain mix –
  - whole roasted soybeans, ground and cracked corn, distillers, gluten, molasses, Megalac, salt, fat source
- Roasted beans
- Propylene glycol (n=2)
- **Types of feed tried and no longer using:**
  - Type of grain mix - cows weren't getting right amount of nutrition
  - Grain mix - ground finer - cows couldn't eat it as fast
  - 22% protein pellet - okay but not as good fat and protein
  - Fat in the pellet
  - Gluten pellets
  - Cottonseed/protein mix-didn't work well in robot feeding system

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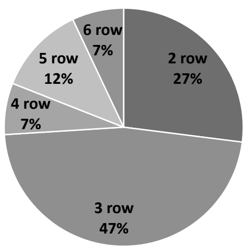
Freestalls per Pen and Feeding Space

Freestalls per pen
Average = 3 rows



Average feeding space 22.9 inches

Range 12-54 inches (n=28)

Heifers/Close-up/Fresh Cows – higher end of the range

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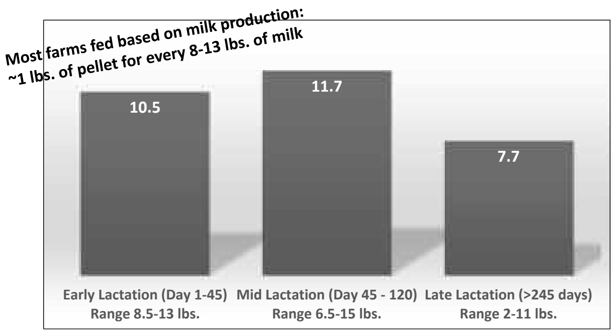
n=15

Average Pounds of Pellet Fed



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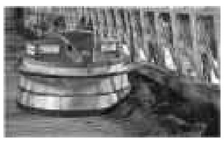
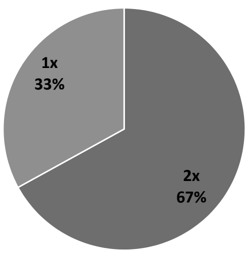
Early, n=14
Mid, n=14
Late, n=15

Frequency of Feeding





Feed Pushing-Frequency	No. Farms	Method
12+ times/day	7 farms	Automatic/Manual
4-6 times/day	5 farms	Manual
As Needed	1 farm	Manual
None	2 farms	Bunks

67% of farms say feed push-up frequency affects robot visits

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n=15

Feeding Management

- **Pellet cost per ton** (n=13)
  - Average: $314/ton
  - Range: $220-$640
- **% forage in the PMR** (n=12)
  - Average: 64%
  - Range: 56-76%
- **Top Three Feeding Factors that affect visits:**
  1. **Pellet Nutrition**
     - Quality
     - Taste
     - Amount fed
  2. **PMR Nutrition**
     - Consistency
     - Ratio/Energy balance
  3. **Cow movement and behavior**

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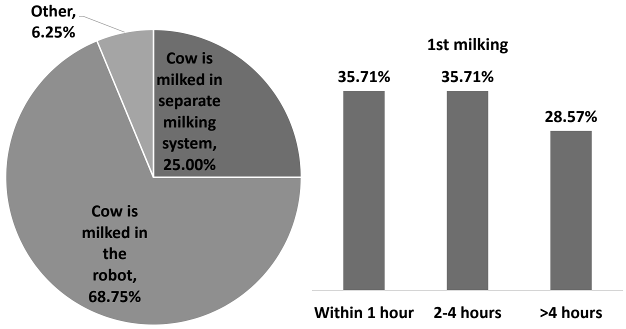
Fresh Cow Management=16



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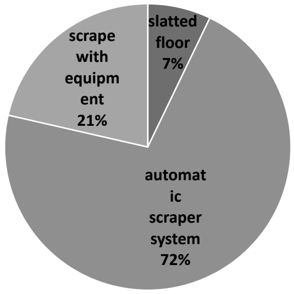
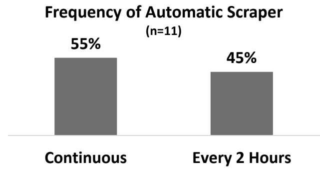
Location, n=16
Time, n=14

Manure Handling



- Manually Scraping (n=5)
  - 2x/day
  - 1 farm slatted floor 2x/week



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n=14

Fresh Cow Management

- Pellet Management (n=8)
  - Transition to pellets over a period of time (~3 weeks 5-16 pounds)
- Propylene glycol first 18 days with a pump feeder in robot (n=1)
- Administer Calcium boluses (n=3)

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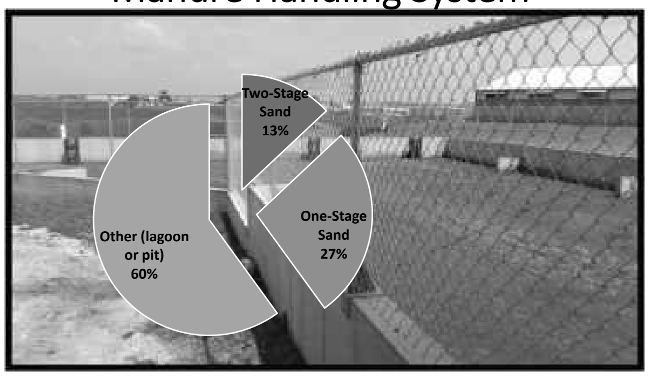
Manure Handling System



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n=15

Nutrient Content-Pellet and PMR

- **Pellet Nutrient Content**
  - Crude Protein, % DM (n=8)
    - Avg. = 22%
    - Range (16 – 26%)
  - NDF, % DM (n=5)
    - Avg. = 17
    - Range (8 – 26)
- **Partial Mixed Ration Nutrient Content** (n=5)
  - NDF, % DM
    - Avg. = 30%
    - Range (29-32%)
  - NEL, % DM
    - Avg. = .75
    - Range (.74 - .76)
  - Crude Protein, % DM
    - Avg. = 16%
    - Range (14.5 – 17%)

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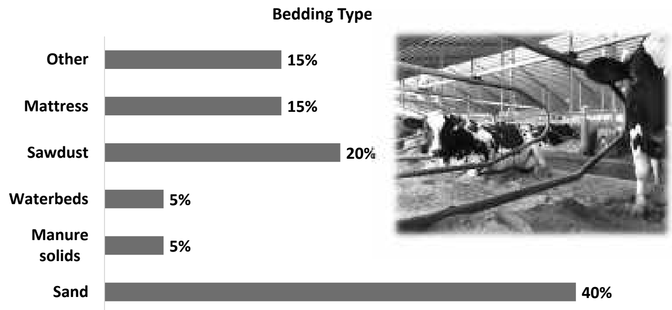
Bedding Management



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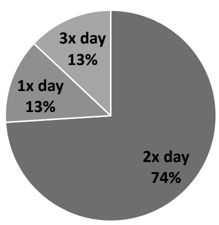
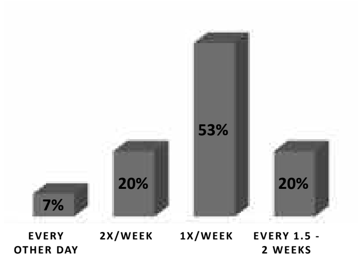
n=20

Bedding Management





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n=15

Change in Reasons for Culling?

- **Yes** (n=10)
  - More selective culling (butterfat, attitude, milking speed, teat placement, deep udders, low production)
- **No** (n=4)
  - If cows don't work in robot, they are milked in parlor

- **Percent culled for udder conformation** (n=13)
  - Avg. 3.33% (range 0-12.5%)*
- **Percent not adjusted to robot** (n=14)
  - Avg. <1% (range 0-4%)*
- **Additional reasons**
  - Milking speed (n=4)
  - Feet and legs
  - Better records

**farms with multiple herds move cows to non-robot herd*

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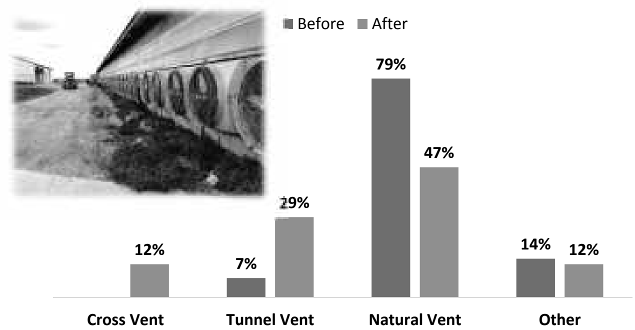
Ventilation System



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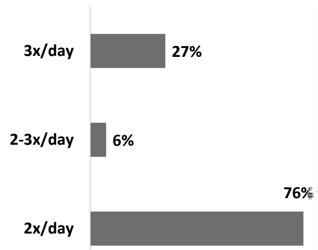
n=17

Number of Fetches per Day



- Average number of cows fetched
  - 5 cows/robot/time (range 2-10)*

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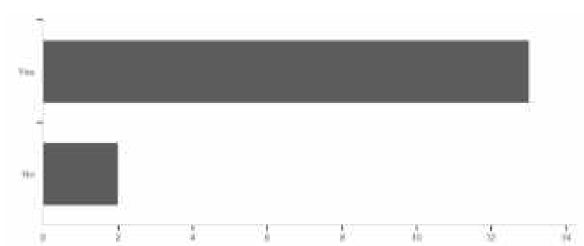
n=15

*total fetch cows/number of robots per farm = average number of cows fetched

Use of long-day lighting (16 hours light/8 hours of dark)



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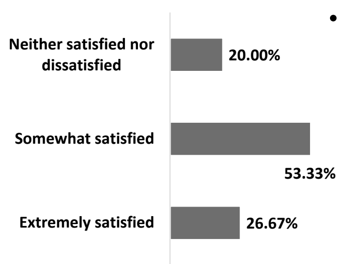
n=15

Satisfaction with Conductivity to Manage Milk Quality



- Location of cow treatment
  - In the robot (n=7)
  - Chute/headlock/ outside robot area (n=5)
  - In the stall (n=2)
  - Parlor (n=2)
  - Do not treat – just separate clinical (n=1)

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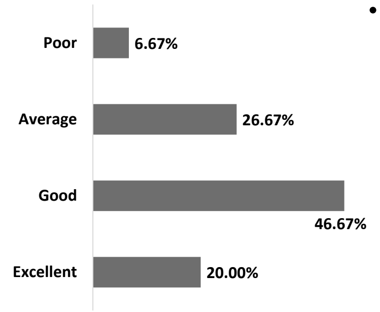
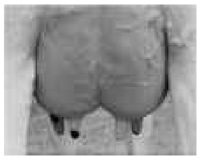
n=15

Farm Perspective of Postdipping Coverage



- This is a little better than expected, tend to see less coverage on farms when observing.



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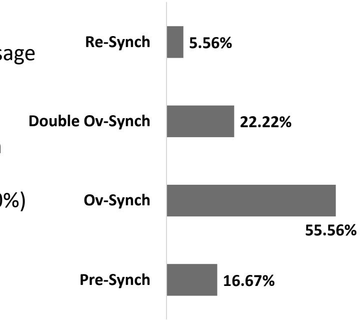
n=15

Usage of Synchronization Programs

- Same to moderately lower usage as compared to before
- % of cows enrolled in a synch program (n=8)
  - Average: 13% (range 2-40%)



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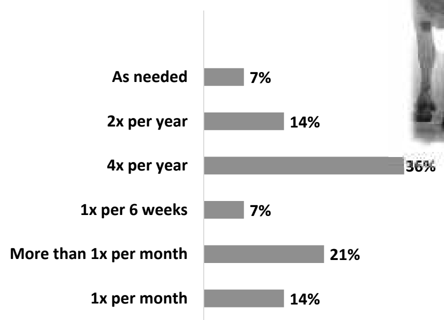
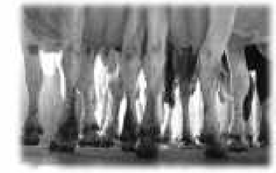
Hoof Trimming Frequency





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n=14

Reproduction

	Avg Services per Conception	Conception Rate %	Days to First service*
Before Robot	Average = 2.5 range = 1.6-3.2 n = 10 farms (1 bull bred – no pre)	Average = 33.5% range = 10-80% n = 11 farms	Average = 71.6 range = 30-105 n = 11 farms
After Robot	Average = 2.1 range = 1-3 n = 11 farms	Average = 35.1% range = 12-80% n = 12 farms	Average = 71.2 range = 30-140 n = 11 farms

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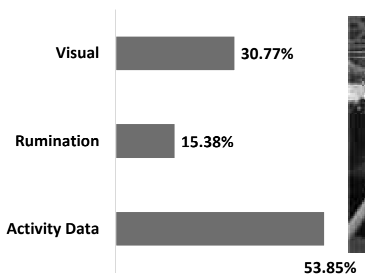
*genetics/recip cows have longer Days to First Service

Heat Detection Monitoring Tools



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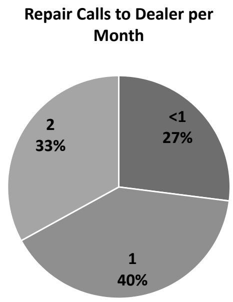
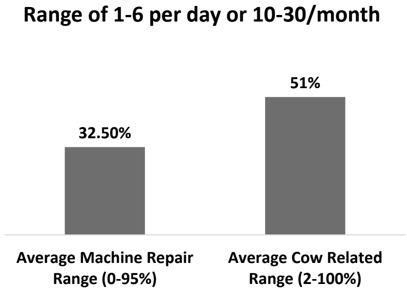
n=26

Robot Calls





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n=15

Repairs and Supplies

	Max	Min	Average
Annual Avg. Cost Per Robot – Repair Cost	$16,500	$3,000	$7508.15
Annual Avg. Cost Per Robot – Milk House Supplies	$4,312	$486.75	$1,749.43
Annual Avg. Cost Per Robot – Teat Dip Before	$5,000	$800.00	$1,691.67
Annual Avg. Cost Per Robot – Teat Dip After	$5431.00	$500.00	$1,919.45

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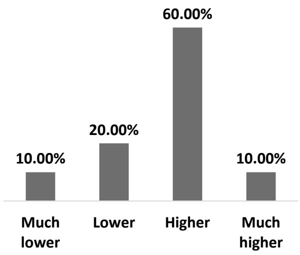
Evaluating Feeding Financials

- Don't let shrink eat your profits.
- If you do not have feeding software now is the time to invest.
- Don't underestimate what a farm scale can do for you.
- Invest in a time/person to keep information up to date.

Impact of Bedding Choice on Maintenance and Repair Cost



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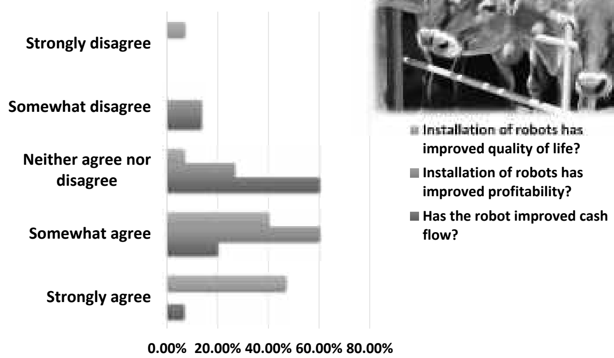
n=10

Farm Perspectives



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Farm Perspectives

- **Main reasons for installing AMS:**
  - **Labor Availability**
  - Labor Flexibility
  - Quality of Life
  - Other reasons:
    - Next generation
    - Education
    - milk production
    - cow management
    - modernize facilities
- **Key factors for robot success:**
  - **Daily and routine maintenance**
  - Nutrition
  - Cows – Healthy/Barn Flow
  - Utilizing Records/Data

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100% agreed the robot has been a….

- Good financial investment
  - Improved cow health/labor efficiency; increased milk production
- Good personal investment
  - Labor flexibility
- Good management investment
  - Taking better care of the cows with data (rumination, activity, monitoring)
- Overall good investment

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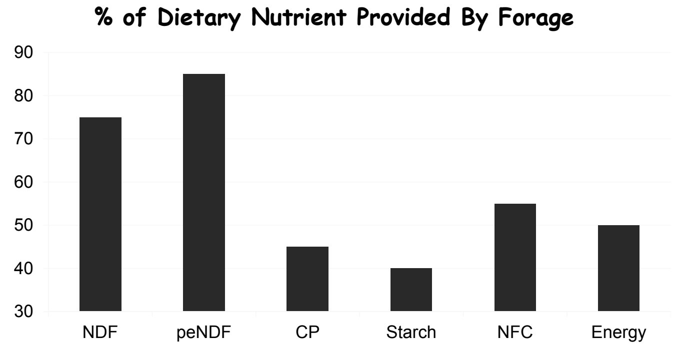
Producing More Milk with more High-Quality Forages

Randy Shaver, Ph.D., PAS, ACAN
Dairy Science Department
University of Wisconsin-Madison

Producing more milk with more high-quality forages

Randy Shaver, Ph.D., PAS, ACAN
Dairy Science Department

Calculated from Ration Survey of WI Herds at ≥30,000 lb Milk per Cow



Production Efficiency

- 2017 average for 23-major states exceeded 23,000 lb milk per cow (USDA-NASS)
- For WI as of March 2018, 8% of dairy herds on DHIA test exceeded 30,000 lb milk per cow with 5 AgSource herds >37,000 lb milk per cow (R.D. Shaver survey)
- Projected that average for USA to exceed 30,000 lb milk cow within 20 years (J.H. Britt, 2016)

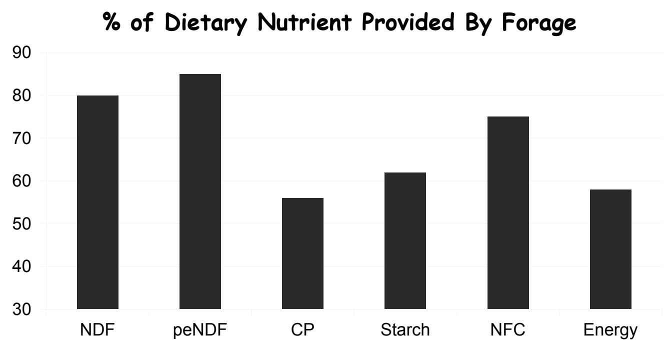
Milk from Forage

- Calculated from ration survey of WI herd producing 44,000 lb milk per cow (R.D. Shaver)
  - 60% or 84 lb per cow/d

Milk from Forage

- Calculated from ration surveys of selected WI herds producing ≥30,000 lb milk per cow (R.D. Shaver)
  - Averaged 63% or approximately 60 lb per cow/d

Calculated from Ration Survey of WI Herd at 44,000 lb Milk per Cow



Practical forage-NDF range in high-group TMR

24% forage-NDF

- High Quality Forages
- Large Forage Supply
- Forages Favorably Priced

i.e. 60% Forage @ 40% NDF; 70% Forage @ 34% NDF

16% forage-NDF

- Limited Forage Supply
- Heavy use of High-Fiber Byproducts
- Forages Expensive
- Moderate/Low Quality Forages

i.e. 35% Forage @ 46% NDF

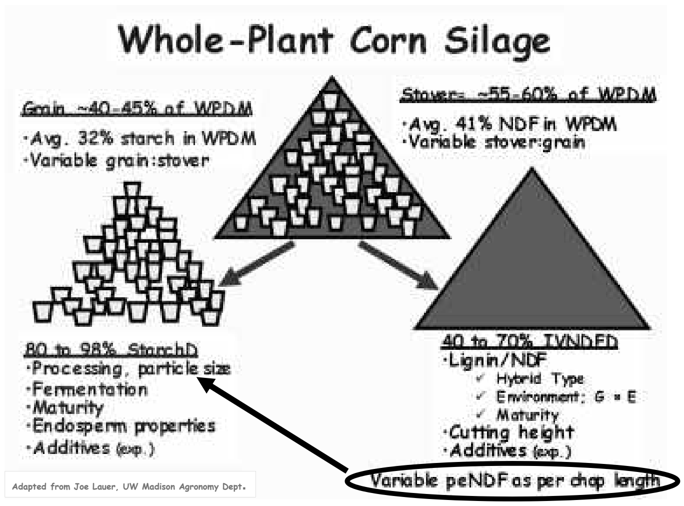
Nutritional Constraints

24% forage-NDF

- NDF, ivNDFD
- Fill Limitation of DMI
- Reduced Milk Yield

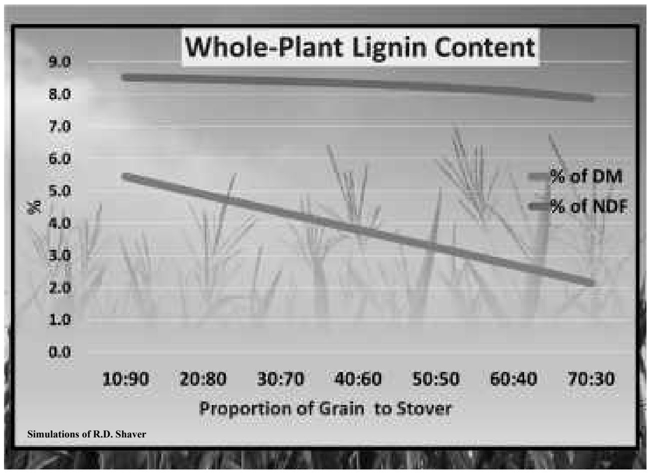
16% forage-NDF

- peNDF
- Milk Fat Depression
- Cow Health



Corn Silage Quality Indicators for High-Producing Dairy Herds

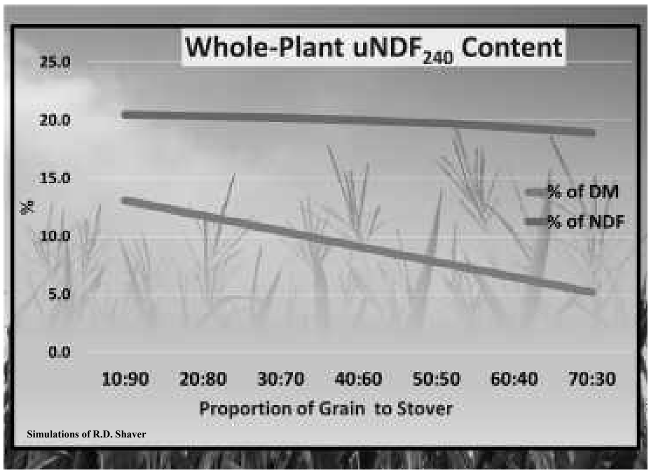
Parameter	Indicates Better Quality	Primary Reason
NDF	↓	↓ Rumen Fill Limitation of DMI
Lignin	↓	
$uNDF_{240}$	↓	Potential for production response or feeding of higher-forage diets
$NDFD_{30}$	↑	
Starch	↑	↑ Energy Density Potential for production response or feeding less corn grain
Milk per ton	↑	Quality Index for Ranking

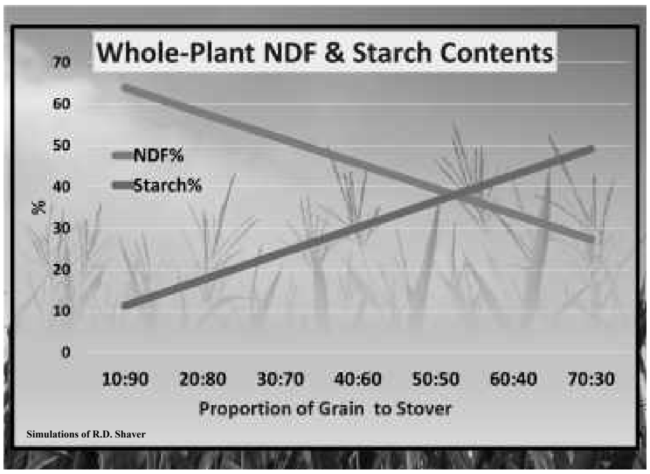


Corn Silage Quality Indicators for High-Producing Dairy Herds

Parameter	Indicates Better Quality	n	Average ± 1 STDEV
NDF (% DM)	↓	384,715	41 - 36
Lignin (% DM)	↓	344,134	3.3 - 2.6
$uNDF_{240}$ (% DM) (% NDF)	↓	81,418	11 - 9 27 - 24
$NDFD_{30}$ (% NDF)	↑	170,634	54 - 60
Starch (% DM)	↑	347,759	32 - 39
Milk per ton (lb)	↑	136,056	3320 - 3683

Summary of combined multi-year, multi-lab (CVAS, DairyOne, RRL, DLL) data





Corn Silage Harvesting

- **Conventional Processors**
  - 17-22 mm TLOC
  - ≈20% Roll speed differential
  - 1-2 mm Roll Gap
- **Contemporary Processors**
  - 17-26 mm TLOC
  - 40-50% Roll speed differential
  - 1-3 mm Roll Gap
  - Alternative processor type
    - Cross-grooved rolls
    - Intermeshing discs

Longer TLOC Corn Silage

- **Ferraretto et al. (2012, PAS); Vanderwerff et al. (2015, JDS)**
  - 30 mm TLOC or 26 mm TLOC, respectively, vs. 19 mm TLOC
  - 30-40% Roll speed differential
  - >70% KPS
  - % on PSU top screen increased 3-4 fold, however, % on PSU top-2 screens similar
  - Milkfat content & rumination activity unaffected by TLOC

Haycrop Silage Quality Indicators for High-Producing Dairy Herds

Parameter	Indicates Better Quality	Primary Reason
NDF	⬇	⬇ Rumen Fill Limitation of DMI
Lignin	⬇	
$uNDF_{240}$	⬇	Potential for production response or feeding of higher-forage diets
$NDFD_{30}$	⬆	
NFC (includes soluble fiber)	⬆ ⬆	⬆ Energy Density Potential for production response or feeding less corn grain
CP	⬆	⬇ Supplemental Protein
Ash	Minimal Soil Contamination	⬆ Energy Density
RFV; RFQ	⬆	Quality Index for Ranking

<u>Shaver et al., 1988, JDS</u> – Masticated bolus particle size and DM content similar for cows fed chopped (10 mm MPS) dry hay compared to cows fed long dry hay with only a 13% increase in eating time for cows fed long hay

From R.D. Shaver article in Hay & Forage Grower (November, 2017)

Comparison of feed particle and bolus length

Feed sample	Feed	Masticated bolus
	Mean particle length (mm)	
Ryegrass hay		
Long form	–	10.3
Cut at 50 mm length	42.2	9.9
Chopped and retained on 19 mm screen[1]	43.5	10.7
Chopped and retained on 8 mm screen[1]	25.1	10.8
Chopped and retained on 1.18 mm screen[1]	9.7	8.1
Grass silage	13.8	11.8
Corn silage	12.0	11.2
TMR	13.1	12.5

Source: Schadt and co-workers, J. Dairy Science, 2012.
[1]Penn State Particle Separator (PSPS) screens.

Legume Silage Quality Indicators for High-Producing Dairy Herds

Parameter	Indicates Better Quality	n	Average ± 1 STDEV
NDF (% DM)	⬇	111,310	42 - 37
Lignin (% DM)	⬇	100,029	7 - 5
$uNDF_{240}$ (% NDF)	⬇	25,541	45 - 36
$NDFD_{30}$ (% NDF)	⬆	61,568	46 - 57
NFC (% DM)	⬆	94,337	26 - 30
CP (% DM)	⬆	112,423	21 - 24
Ash (% DM)	Minimal Soil	100,888	<13
RFV	⬆	100,831	141 - 167
RFQ	⬆	51,453	155 - 179

Summary of combined multi-year, multi-lab (CVAS, DairyOne, RRL, DLL) data

Grass/MMG Silage Quality Indicators for High-Producing Dairy Herds

Parameter	Indicates Better Quality	n	Average ± 1 STDEV
NDF (% DM)	⬇	85,213	55 - 48
Lignin (% DM)	⬇	76,222	6 - 4
$uNDF_{240}$ (% NDF)	⬇	15,972	33 - 24
$NDFD_{30}$ (% NDF)	⬆	34,833	54 - 62
NFC (% DM)	⬆	80,008	20 - 25
CP (% DM)	⬆	85,889	15 - 18
Ash (% DM)	Minimal Soil	76,530	<10
RFV	⬆	79,702	112 - 136
RFQ	⬆	24,541	135 - 167

Summary of combined multi-year, multi-lab (CVAS, DairyOne, RRL, DLL) data

Forage Use on 1000-Cow Dairy

	Forage Needs @ 15% Shrink Tons DM	Acres Needed @ 6 ton DM avg. yield
Daily	15	2.5
Weekly	105	18
Monthly	450	75
Annually	5,475	915

2012 US Milk Production by Herd Size

Feb.-2013

Herd Size	% Dairies	% Cows	% Milk
2000+	1.5%	32.6%	34.7%
1,000-1,999	1.8%	14.0%	15.9%
500-999	3.1%	11.9%	12.4%
200-499	7.5%	12.5%	12.6%
Total ≥ 500	6.4%	58.5%	63.0%

Forage Use on 1000-Cow Dairy

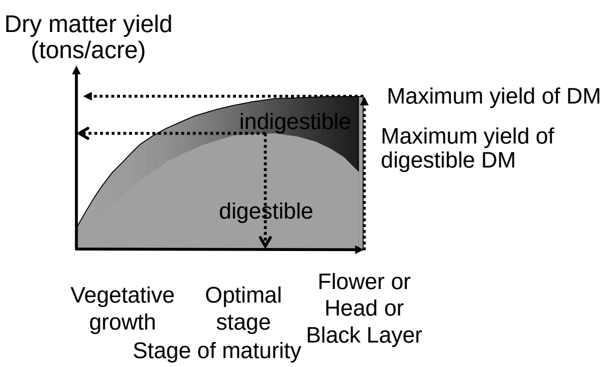
	Extra Acres Needed
10% Yield Drag	+100
10%-units more forage in Lactation Diet DM	+144
Both	+260

Total Feed Use on 1000-Cow Dairy

	TMR Fed[a] (tons DM)
Daily	24
Weekly	168
Monthly	720
Annually	8,760
	Approx. Annual $ Value
	$2,000,000
Approx. Milk $ Value	$4,000,000

[a]Assumes 3% feed bunk refusals

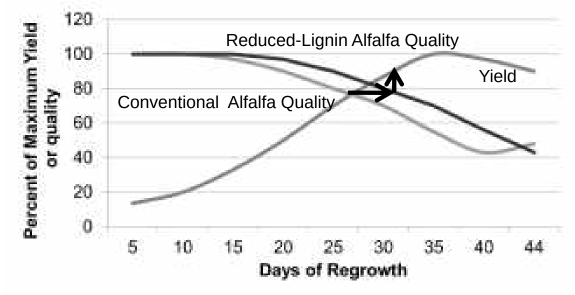
Forage yield - quality vs. quantity



JW-Madison

Department of Dairy Science

Yield and Quality Curve of Alfalfa



Slide courtesy of Dave Combs, UW Madison

Dry Matter Loss for Forage Harvest and Ensiling

	Dry Matter Loss Range (%)	Dry Matter Loss Normal (%)
Mowing/Conditioning Haylage	1-4	2
Respiration Haylage	1-7	4
Rain (Haylage only)	0-50	varies
Raking Haylage	1-20	5
Merging Haylage	1-3	1
Chopping Haylage	1-8	3
Chopping Whole Plant Corn	0-1	0.5
Storage Filling	2-6	---
Ensiling, Storage & Feedout (bunker)	10-16	12
Haylage Total	17-64	
Whole Plant Corn Total	12-23	

Slide courtesy of Brian Holmes, UW Madison

Wisconsin Team Forage

UW Extension

Winter Annuals

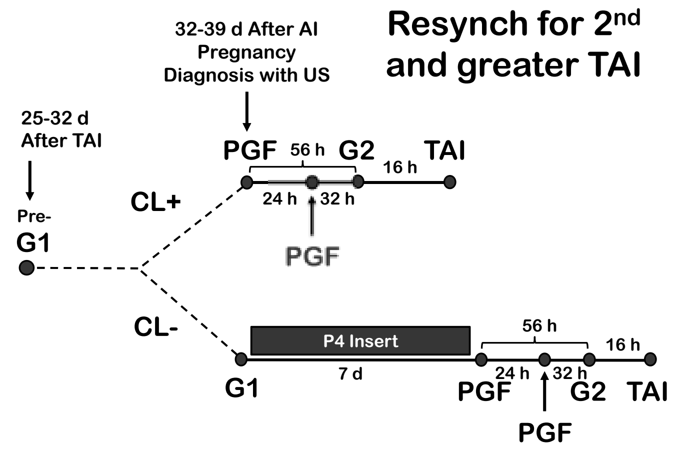
- **Cover Crop?**
- **Forage Inventory Contributor?**
  - Replacement Heifers
  - Dry Cows (K, DCAD issue?)
  - Lactation Rations
- **Agronomic Challenges**

Dry Matter Losses From Different Levels of Silo Management

Losses From	Excellent	Average	Poor
Respiration	< 1%	< 2%	> 5-10%
Fermentation	< 3%	3-5%	10-15%
Seepage	0%	< 1%	>5%
Storage (aerobic)	3-5%	5-6%	>10-30%
Total	8-10%	11-15%	20-40%

Slide courtesy of Brian Holmes, UW Madison

Feeding reduced-lignin alfalfa <u>with</u> BMR corn silage


Resynch for 2nd and greater TAI
32-39 d After AI
Pregnancy
Diagnosis with US
25-32 d
After TAI
Pre-
G1
CL+
PGF
56 h
G2
16 h
TAI
24 h
32 h
PGF
CL-
P4 Insert
G1
7 d
PGF
56 h
24 h
32 h
G2
16 h
TAI
PGF


DEPARTMENT OF
DAIRY SCIENCE
University of Wisconsin-Madison

Wrap your Head around Today's Fiber Digestion Metrics: Working to Better Understand Feeds on Farm and Build Better Diets

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Adjunct - Asst. Prof, University of Wisconsin – Madison

What's the aim today with fiber in dairy diets?

Carbohydrate impact upon animal and ruminant nutrition is not a new focal point for nutritionists. Hall and Mertens (2017) recently reviewed 100 years of carbohydrate research relative to ruminant nutrition. Fiber, defined as Neutral Detergent Fiber (NDF; Goering and Van Soest, 1970) in dairy nutrition, contributes two major facets of dairy diets. It is important for both physical and energetic aspects, but energetically fiber provides the least energy per pound of all nutrients in the total mixed ration (TMR). The balance of the diet is then more readily digestible carbohydrates (primarily sugar and starch), protein and fatty acid. It's important to simultaneously consider both fiber's physically effective and energetic attributes, and at times these are inter-related.

Physical attributes

With dairy diets, we typically feed adequate fiber to maintain sound rumen function and metabolism. There is often a perception of rampant clinical acidosis or sub-acute rumen acidosis (SARA). However, my belief, founded upon working with many consulting nutritionists across the US and reviewing diets, is that very few formulated diets today are responsible for clinical symptoms. Rather, management factors such as feed delivery timing or feed mixing are often the contributing factors toward rumen health and SARA.

To date, there is not a readily accepted "standard" in quantifying the aNDF percentage that is physically effective (peNDF, % of aNDF or DM). Prof Mertens' work suggested the 1.18 mm size was ideal, yet other work from Penn State and others suggested the 4 mm size may be more accurate in determining effectiveness. Both 1.18 and 4 mm sieves are now incorporated within the Penn State particle size separator and the aNDF percentage greater than these sizes can be readily determined (Heinrichs, 2013). Of note, the NRC (2001) held back from making recommendations for fiber effectiveness. Rather, the National Research Council committee provided recommendations for forage NDF, % of DM, at varying fiber to starch ratios.

Fragility (i.e. alfalfa fiber being more fragile than grass fiber; Allen, 2000) is another concept contributing to fiber's effectiveness that warrants further exploration but is vaguely understood and characterized today.

Prior to discussing the energy side of fiber, the detergent fiber complex warrants discussion as considerable confusion exists yet today within the industry. **Figure 1** demonstrates the concept of various fiber fractions, each nested within aNDF. Forage analysis laboratories sequentially rinse (like a laundry machine) feed samples with neutral, mildly acidic and then strongly acidic solutions to wash away feed components and ultimately determine the fractions outlined in Figure 1. Each is determined by relating the remaining sample weight to original mass after sequential rinses or burning in an often (ash).

Energetic attributes

Starch and fiber contain the same calorie content per pound, around 4 calories per gram. Both starch and fiber (cellulose) are generally chains of glucose bonded together. Yet as nutritionists, we understand the energy available to the cow varies greatly between these two nutrients. The enormous difference in energy available is due both the type of glucose-glucose bond (alpha- vs beta- bond configurations) as well as lignin and cell wall cross linking that further zippers cellulose into a less digestible complex. In 2014, I surveyed several meta-analyses and summarized fiber and starch digestion data from more recent published lactating cow feeding studies. Total-tract fiber digestion in lactating cows averages about 40 to 50% (Table 1) whereas total-tract starch digestion averages over 90% (Goeser, 2014). Further, commercial dairy cow-level digestion (apparent digestion, % of

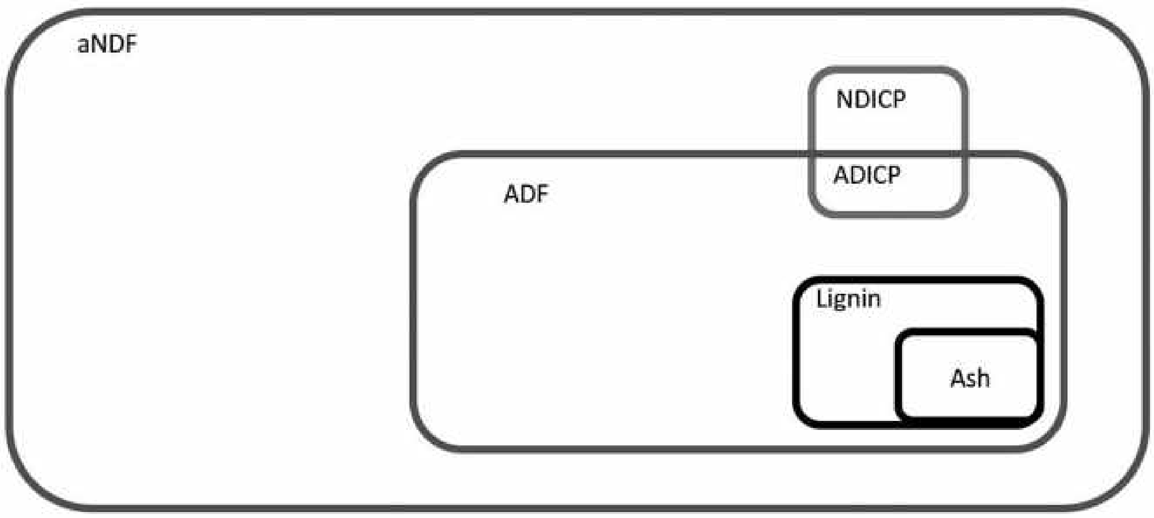

Figure 1: The fiber nesting doll. The acid detergent fiber (ADF), neutral and acid detergent insoluble crude protein (NDICP, ADICP), lignin and some ash are nested within aNDF. Image Adapted from the March 10, 2018 Hoard's Dairyman article, "Dairy nutrition's tribal language: speaking fiber."

nutrient) appear similar to published research (Figure 3). In the 2014 summary, my aim was to revisit laboratory fiber and starch digestion measures relative to real, in vivo data and recognized that 30h in vitro NDF digestion values often over-estimate cow level digestion thus questioned the utility.

Since the 2014 survey and time, the industry has better embraced the notion that single time point fiber digestion measures (i.e. NDFD30) are inadequate to describe complex rumen nutrient digestion. In conjunction with this better recognition, forage analyses laboratories have advanced multi-time point rumen fiber digestion predictions by near infrared reflectance (NIR) spectroscopy.

To merge the two points together and bring functional nutrition decision making tools to the field, two practical nutrition models have come online in the US:

1. Cornell Net Carbohydrate and Protein System v6.5 (Van Amburgh et al., 2015)
2. Total Tract NDF Digestibility (Combs, 2013)

Another multi-time point analytic tool warrants recognition, Fermentrics^{TM} (www.fermentrics.com, accessed online; Johnston, personal communication), which was developed using methodology and concepts described by Pell and Schofield (1993). Gas production is intriguing as these models allow one to consider thousands of data measures over time. However, the model fiber and starch digestion rates are determined via gas production curve peeling and not direct fiber quantification.

Each of these tools incorporate digestible nutrient pool sizes and nutrient digestion rates into compartmental models to predict fiber digestibility within the rumen or total-tract. To better understand both nutrient digestible pool size and digestion rate consider the following analogy and story.

uNDF and NDFD meaning and relationship

Similar to how the detergent fiber parameters can be depicted with a nesting doll analogy, uNDF30 and uNDF240 (% of DM or NDF) can be better understood relative to aNDF with a picture (Figure 2). Within the laboratory, the sample (and it's fiber) is digested for a time period and then it's washed with neutral detergent to determine the amount of fiber that's left. This ends up being a gram divided by gram type equation and NDF digested at time = x ($NDFD_x$, % of NDF) is then calculated by: (aNDF – $uNDF_{x)}$ / aNDF x 100. Alternatively, the amount of fiber left after 30 or 240 hours may be a better lignified fiber indicator, thus comparing uNDF (% of DM) has become another measure we evaluation. In this case, the uNDF is looked at as a % of the original sample. Just like is the case with aNDF.

Building a camp fire within the rumen: kindling and a bundle of fire wood.

Continuing with the analogies, rumen fiber (or any other nutrient) digestion can be more simply under-

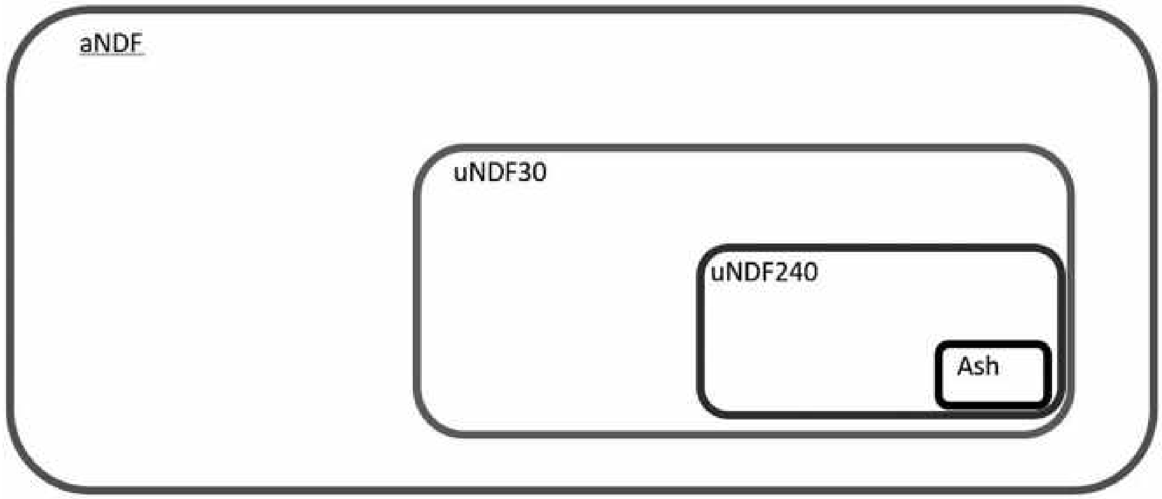

Figure 2: The undigested fiber nesting doll. Each uNDF30 and uNDF240 are nested within aNDF (% of DM).

stood by comparing to our experience with building a campfire. Both the wood pile size and moisture (i.e. dry vs wet wood) contribute the heat we feel through the night from the fire pit. Similarly, digestible fiber pool size (akin to the wood pile size) and fiber digestion rate (akin to wood moisture) must be accounted for to accurately predict rumen fiber digestion across different diets and intake levels. The same forage consumed in a high cow or dry cow TMR will actually be digested differently due to passage rate (i.e. rumen retention time). The only way this can be accurately predicted is by combining digestible fiber pool size and digestion rate in a model that also includes a passage rate. Reason being, fiber leaves the rumen in two ways; digestion or passage. Both the CNCPS and TTNDFD models combine passage rate (kp, % hr^{-1}) with potentially digestible fiber pool and digestion rate (aNDFom k_d, % hr^{-1}) in the following equation:

Rumen NDF digestion (% of aNDFom) = potentially digestible fiber pool x fiber [kd / (kd + kp)], where:

- pdNDF, % of aNDFom = NDFD240om = (aNDFom – uNDF240om)/aNDFom x 100
- fiber k_d, % pdNDF hr^{-1} = non-linear model determined using multi-time point NDFD (i.e. 24, 30, 48 or 30, 120, 240)

Fiber digestion term dictionary

- aNDF = NDF determined with amylase in the neutral detergent solution
- aNDFom = aNDF corrected for ash
- uNDF = undigested aNDF following a discrete digestion time (i.e. 30 or 240 h)
- iNDF = indigestible aNDF, theoretical value determined only by nonlinear modelling
- uNDFom = undigested fiber corrected for ash
- NDFD = Digested aNDF, expressed as a percent of aNDF
- pdNDF = potentially digestible NDF
- NDF k_d = fiber digestion rate

Semantics

Often, "k_d rate" has been used to describe fiber or starch digestion rates. Like how Prof. Mertens helped the industry's understanding of uNDF (undigested NDF at time = x) vs iNDF (indigestible NDF at time = infinity), I'll attempt to help us understand rate coefficient terminology; "k_d rate" is grammatically incorrect as the "k" is defined as the rate coefficient and the "d" is defined as digestion. Hence, "k_d rate" is redundant and akin to stating, "Digestion rate rate".

Helping growers manager toward better feed and margins

While uNDF and digestion rate are related to one another, they both can theoretically be improved.

Reduced lignin forages have lesser uNDF levels and correspondingly greater digestible NDF pools. This does not mean though that reduced lignin forage fiber digests faster, it just means there is more fiber to digestion similar to how a large bundle of wood offers more energy than does a small bundle.

Reducing uNDF in feeds can be achieved in two ways; 1) diluting the uNDF with more digestible nutrients such as starch, protein or sugar or 2) managing to lessen the uNDF in relation to total aNDF. The second strategy is the route that brown midrib corn mutants lessen uNDF and theoretically how reduced or low-lignin alfalfa varieties improve quality. Exceptional grain yields or leaf to stem ratio is the strategy 1 path to lessening uNDF, however with crops bred for grain yield the uNDF may be.

Going forward, Prof Combs' (personal communication) has suggested that digestion rate may be heritable, which could then lead to advances in fiber digestion speed along with decreasing uNDF and increasing digestible NDF pool size.

In the field, harvesting alfalfa and grass crops earlier should result in both lesser uNDF and faster digestion rates. Cross linking within cell walls develops as plants mature and will be related to bacterial cellulose access, thus decreasing both digestion speed and extent as maturity advances. Cut first crop each year at 22 to 24" PEAQ (Hintz and Albrecht, 1993). Do not assume 28 day cutting intervals result in dairy quality forage, I suggest walking fields approximately 17 days after the prior cutting and monitoring plant maturity every 3 to 5 days with scissor clipping.

Managing what the dairy has provided us with the camp fire in mind.

Balancing diets with 30 or 48 h NDFD could not be considered "old school" as the days of using a single NDFD measure to formulate are behind us. Given better information available from labs, I now recommend considering both pdNDF and aNDF k_d in formulation to accurately formulate with the same forage at different intake levels and passage rates. The aNDF k_d should not be used by itself under any circumstances as it depends upon the uNDF level. However, uNDF values have utility as "new lignin" measures.

I suggest monitoring uNDF30 and 240 levels (% of DM) in diets on a herd by herd basis. To my knowledge, there is not an industry accepted or published benchmark for a certain uNDF level that will limit intakes, however within a herd these metrics can prove valuable to help formulate forage inclusion rates when switching forage sources. Further, uNDF level could be used within diet projections to evaluate potential income over feed costs within partial budgets. I've appreciated also learning from Dr. Sam Fessenden recently (AMTS technical services) to use uNDF (g CHO-C) as a tool to consider when forecasting an intake response due to lesser uNDF content in feeds. Sam has suggested that diet projections can be compared by using different forages at similar dry matter intakes but further by also comparing the diet scenarios and maintaining CHO-C relatively constant between diets.

On farm, consider using Prof Combs' TTNDFD as a forage analysis level tool to make decisions and allocate feeds. Many consultants have had success coaching their clients to focus on TTNDFD as a "new RFQ on steroids" in better projecting forage quality.

Speak a different language on farm

Lastly, try and change the language you speak on farm as the terms discussed in this paper are difficult to convey to those not skilled in the art. Rather than speak of uNDF or NDFD or NDF k_d, speak in terms of total fiber in the diet, pounds of fiber digested by the cow or the amount of fiber that washes out the back end in manure. For example, at 55 pounds dry matter intake and 28% aNDFom, this approximates to 15 pounds of fiber cows consume each day in the TMR. If diet digestibility is recognized to be only 40% whereas the goal is 50%, talk about the 15 pounds being digested at both 40 and 50% results in 6 versus 7.5 pounds of fiber digested. The 40 versus 50% may seem vague, but when we're talking about 1.5 pounds of digestible nutrient at hand it may spur change. This 1.5 pounds of digestible nutrient could correspond to 3 pounds of milk or more!

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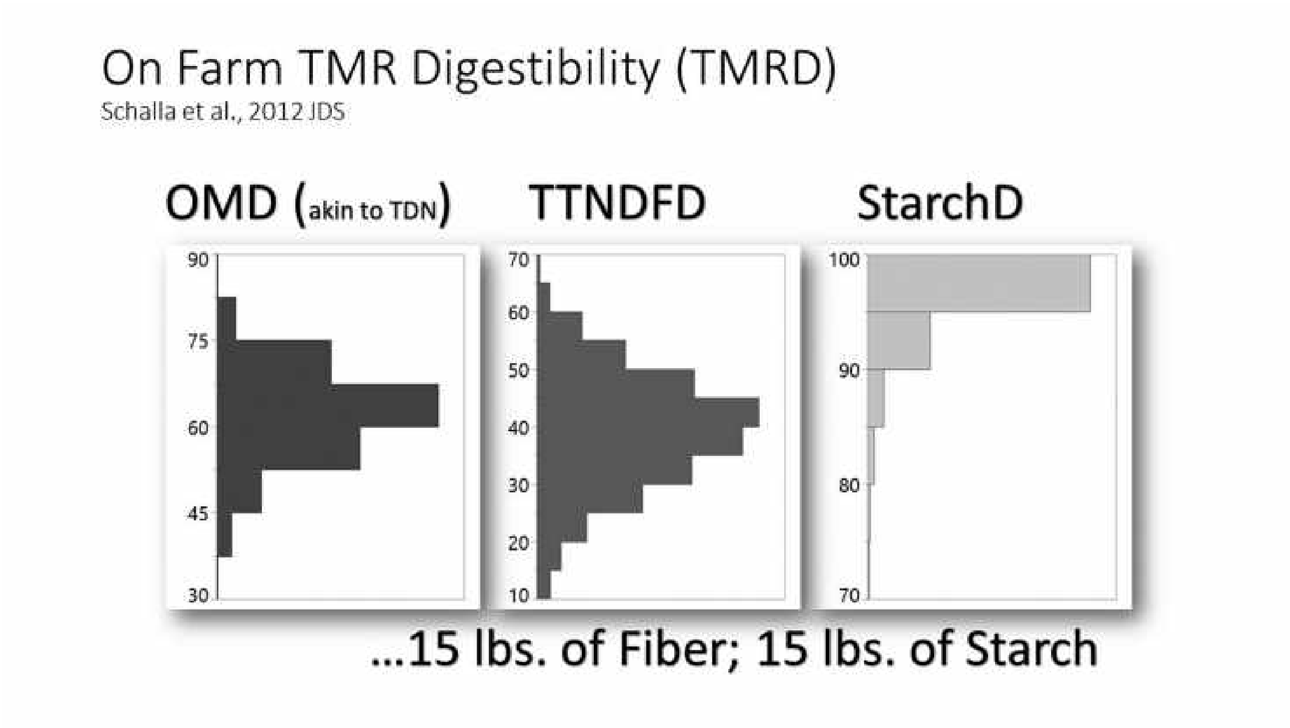
Table 1: Rumen and total-tract fiber digestibility measures for lactating dairy cattle in published research. Table adapted from Goeser (2014).

Description	Digestion Site	Author(s)	Treatment means	Digestion Coefficient, %	SD
Mixed TMRs	Rumen	Firkins et al. (2001)	121	43.5	11.3
Mixed TMRs	Rumen	Hannigan et al. (2013)	152	42.8	12.8
Corn silage based TMRs	Rumen	Ferraretto and Shaver (2012)	39	41.9	NA
TMRs containing barley based grain	Rumen	Ferraretto et al. (2013)	30	39.4	NA
TMRs containing corn based grain	Rumen	Ferraretto et al. (2013)	82	39.3	NA
n or Weighted means	**Rumen**		**424**	**42.0**	**12.0**
Alfalfa and Grass Forage based TMRs	Total Tract	Goeser (2008)	75	47.4	8.0
Corn and Sorghum Forage based TMRs	Total Tract	Goeser and Combs (unpublished)	85	42.7	10.5
Mixed TMRs	Total Tract	Firkins et al. (2001)	75	48.0	10.9
Mixed TMRs	Total Tract	Hannigan et al. (2013)	137	49.2	10.7
TMRs	Total Tract	Krizsan et al. (2010)	172	59.7	12.8
Corn silage based TMRs	Total Tract	Ferraretto and Shaver (2012)	105	44.7	NA
TMRs containing barley based grain	Total Tract	Ferraretto et al. (2013)	62	47.2	NA
TMRs containing corn based grain	Total Tract	Ferraretto et al. (2013)	335	45.6	NA
n or Weighted means	**Total Tract**		**1046**	**48.5**	**10.7**

Figure 3: Apparent total-tract fiber digestibility measures for commercial dairies in the Midwestern US (Rock River Laboratory, Inc; unpublished data since 2015). Commercial measures performed using methods described by Schalla et al. (2012). Organic matter digestibility (% OM), total tract NDF digestibility (TTNDFD; % of NDF) and total tract starch digestibility (StarchD; % of starch) histograms.



Impact of Individual and Combinations of Supplemental Fatty Acids on Dairy Cow Performance and Metabolism

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Introduction

Recently, the effects of individual fatty acids (FA) on digestibility, metabolism, and production responses of dairy cows has received renewed attention. The addition of supplemental FA sources to diets is a common practice in dairy nutrition to increase dietary energy density and to support milk production. The ability to understand and model FA, the effects of individual FA, and different FA supplements on production parameters has direct impact on dairy industry recommendations and the usefulness of FA supplementation strategies. In fresh cows, the high metabolic demand of lactation and reduced DMI during the immediate postpartum period result in a state of negative energy balance. Approaches to increasing energy intake of postpartum cows include increasing starch content of the diet and supplementing FA to increase the energy density of the diet. However, feeding high starch diets that promote greater ruminal propionate production during early lactation could be hypophagic and therefore further reduce DMI and increase the risk of ruminal acidosis and displaced abomasum (Allen and Piantoni, 2013). Regarding supplemental FA, some authors suggest that caution should be exercised when using dietary FA to increase the caloric density of diets in early lactation dairy cows, since a high lipid load may affect the endocrine system, feed intake, and increases the risk for metabolic disorders (Kuhla et al., 2016). However, just as we recognize that not all protein sources are the same it is important to remember that not all FA or FA supplements are the same. We will briefly review the biological processes and quantitative changes during the metabolism of FA, the digestibility of these FA, and their overall impact on performance. Our emphasis in the current paper is on recent research supplementing palmitic (C16:0), stearic (C18:0), oleic (cis-9 C18:1), omega-3, and omega-6 acids on feed intake, nutrient digestibility, milk production and milk composition, health, and reproduction.

C16:0, C18:0, and Cis-9 C18:1 Effects on FA Digestibility

Our recent FA digestibility research has utilized and focused on C16:0, C18:0, cis-9 C18:1. Of particular importance, Boerman et al. (2017) fed increasing levels of a C18:0-enriched supplement (93% C18:0) to mid-lactation dairy cows and observed no positive effect on production responses, which was likely associated with the pronounced decrease in total FA digestibility as FA intake increased (Figure 1A). Similarly, Rico et al. (2017) fed increasing levels of a C16:0-enriched supplement (87% C16:0) to mid-lactation dairy cows and even though a positive effect was observed on production response up to 1.5% diet DM, a decrease in total FA digestibility with increasing FA intake was observed (Figure 1B). However, considering that the range in FA intake was similar across both studies, the decrease in total FA digestibility was more pronounced when there was increased intake/rumen outflow of C18:0 rather than C16:0. This is supported by our meta-analysis, in which a negative relationship between the total flow and digestibility of FA was observed, with the decrease in total FA digestibility driven by the digestibility of C18:0 because of the negative relationship between duodenal flow and digestibility of C18:0 (Boerman et al., 2015). The exact mechanisms for these differences in digestibility are not understood; however, potential causes include the lower solubility of C18:0 compared to C16:0, which would be more dependent of emulsification for absorption (Drackey, 2000). Additionally, results have shown that cis-9 C18:1 has greater digestibility than C16:0 and C18:0 (Boerman et al., 2015). Freeman (1969) examined the amphiphilic properties of polar lipid solutes and found that cis-9 C18:1 had a positive effect on the micellar solubility of C18:0. To further understand what factors influence FA digestibility, we utilized a random regression model to analyze available individual cow data from 5 studies that fed a C16:0-enriched supplement to dairy cows. We observed that total FA digestibility was negatively impacted by total FA intake, but

[1] Paper previously presented at the Western Canadian Dairy Seminar [Advances in Dairy Technology (2018) Volume 30: 133-144].

positively influenced by the intake of cis-9 C18:1 (unpublished results). Finally, we recently evaluated the effects of varying the ratio of dietary C16:0, C18:0, and cis-9 C18:1 in basal diets containing soyhulls or whole cottonseed on FA digestibility. We observed that feeding a supplement containing C16:0 and cis-9 C18:1 increased FA digestibility compared with a supplement containing C16:0, a mixture C16:0 and C18:0, and a non-fat control diet. The supplement containing a mixture C16:0 and C18:0 reduced 16-, 18-carbon, and total FA digestibility compared with the other treatments (de Souza et al., 2018). This is displayed in Figure 2 by using a Lucas test to estimate the apparent digestibility of the supplemental FA blends. The slopes (i.e., digestibility of the supplemental FA blends) in soyhulls based diets were 0.64, 0.55 and 0.75 and in cottonseed diets were 0.70, 0.56 and 0.81 for supplements containing C16:0, a mixture C16:0 and C18:0, and a mixture of C16:0 and cis-9 C18:1, respectively. This supports the concept that a combination of 16-carbon and unsaturated 18-carbon FA may improve FA digestibility, but reasons for this need to be determined.

In fresh cows, there is scarce information about the effects of supplemental FA on FA digestibility. We recently conducted a study to evaluate the effects of timing of C16:0 supplementation on performance of early lactation dairy cows (de Souza and Lock, 2017b). We observed a treatment by time interaction for C16:0 supplementation during the fresh period (1 – 24 DIM); although C16:0 reduced total FA digestibility compared with control, the magnitude of difference reduced over time (Figure 3). Interestingly, we also observed an interaction between time of supplementation and C16:0 supplementation during the peak period (25 – 67 DIM), due to C16:0 only reducing FA digestibility in cows that received the control diet in the fresh period. This may suggest an adaptive mechanism in the intestine when C16:0 is fed long-term. Understanding the mechanisms responsible for this effect deserves future attention, as does the impact of other supplemental FA during early postpartum on FA digestibility and nutrient digestibility.

Effect of Fatty Acids on NDF Digestibility

Changes in intake and digestibility of other nutrients, such as NDF, due to FA supplementation may affect positively or negatively the digestible energy value of any FA supplement. Weld and Armentano (2017) performed a meta-analysis to evaluate the effects of FA supplementation on DMI and NDF digestibility of dairy cows. Supplementation of supplements high in medium chain FA (12 and 14-carbons) decreased both DMI and NDF digestibility. Addition of vegetable oil decreased NDF digestibility by 2.1 percentage units, but did not affect DMI. Also, feeding saturated prilled supplements (combinations of C16:0 and C18:0) did not affect DMI, but increased NDF digestibility by 0.22 percentage units. Overall, the authors concluded that the addition of a fat supplement, in which the FA are 16-carbon or greater in length, has minimal effects on NDF digestibility, but the effect of C16:0-enriched supplements were not evaluated.

We recently utilized a random regression model to analyze available individual cow data from 6 studies that fed C16:0-enriched supplements to dairy cows (de Souza et al., 2016). We observed that NDF digestibility was positively impacted by total C16:0 intake (Figure 4A) and DMI was not affected. This suggests that that the increase in NDF digestibility when C16:0-enriched supplements are fed to dairy cows is not explained through a decrease in DMI. Additionally, when comparing combinations of C16:0, C18:0, and cis-9 C18:1 in supplemental fat, we observed that feeding supplements containing C16:0 or C16:0 and cis-9 C18:1 increased NDF digestibility compared with a supplement containing C16:0 and C18:0 (de Souza et al., 2018).

With early lactation cows, Piantoni et al. (2015b) fed a saturated fat supplement (~ 40% C16:0 and 40% C18:0) and observed that fat supplementation increased NDF digestibility by 3.9% units in the low forage diet (20% fNDF), but had no effect in the high forage diet (26% fNDF). In our recent study that evaluated the effects of timing of C16:0 supplementation (PA) on performance of early lactation dairy cows (de Souza and Lock, 2017b), we observed that C16:0 supplementation consistently increased NDF digestibility ~ 5% units over the 10 weeks of treatment compared with control (Figure 4B).

Effects of C16:0, C18:0, and Cis-9 C18:1 on Production Responses

We have recently carried out a series of studies examining the effect of individual saturated FA on production and metabolic responses of lactating cows. Piantoni et al. (2015a) reported that C18:0 increased DMI and yields of milk and milk components, with increases more evident in cows with higher milk yields, but the response occurred only in one of the two periods of the crossover design. Reasons why only higher yielding cows responded more positively to C18:0 supplementation and only in one period remains to be determined. Additionally, in a recent dose response study with mid lactation cows, feeding a C18:0-enriched supplement (93% C18:0) increased DMI but had no effect on the yields of milk or milk components when compared to a non-FA supplemented control diet, which was probably associated with the decrease in FA digestibility (Figure 1A, Boerman et al., 2017). Our results, and those of others, indicate that C16:0 supplementation has the potential to increase yields of ECM and milk fat as well as the conversion of feed to milk, independent of production level when it was included in the diet for soyhulls or C18:0 (Piantoni et al., 2013; Rico et al., 2014). We recently utilized a random regression model to analyze available individual cow data from 10 studies that fed C16:0-enriched supplements to post peak dairy cows (de Souza et al., 2016). We observed that energy partitioning toward milk was increased linearly with C16:0 intake, as a result of a linear increase in milk fat yield and ECM with increasing intake of C16:0.

When we compared combinations of C16:0, C18:0, and cis-9 C18:1 in FA supplements, a supplement containing more C16:0 increased energy partitioning toward milk due to the greater milk fat yield response compared with the other treatments (de Souza et al., 2018). In contrast, a FA supplement containing C16:0 and cis-9 C18:1 increased energy allocated to body reserves compared with other treatments. The FA supplement containing a combination of C16:0 and C18:0 reduced nutrient digestibility, which most likely explains the lower production responses observed compared with the other treatments. Interestingly, in a follow up study we compared different ratios of C16:0 and cis-9 C18:1 in FA supplements fed to post-peak cows, and observed that supplements with more C16:0 favored energy partitioning to milk in cows producing less than 45 kg/d, while supplements with more cis-9 C18:1 favored energy partitioning to milk in cows producing great than 60 kg/d (de Souza and Lock, 2017a). Also, regardless of production level, supplements with more cis-9 C18:1 increased BW change. This may suggest that C16:0 and cis-9 C18:1 are able to alter energy partitioning between the mammary gland and adipose tissue, which may allow for different FA supplements to be fed in specific situations according to the metabolic priority and needs of dairy cows. Further research is needed to confirm these results in cows at different stages of lactation or other physiological conditions.

In early lactation cows, Beam and Butler (1998) fed a saturated FA supplement (~ 40% C16:0 and 40% C18:0) and observed that FA supplementation decreased DMI and did not affect yields of milk and ECM in the first 4 weeks after calving. Piantoni et al. (2015b) fed a similar saturated FA supplement (~ 40% C16:0 and 40% C18:0) and observed that FA supplementation during the immediate postpartum (1-29 DIM) favored energy partitioning to body reserves rather than milk yield, especially in the lower forage diet. The high forage diet with supplemental FA increased DMI and tended to decrease BCS loss compared with the same diet without FA supplementation. Also, regardless of forage level, feeding supplemental FA increased DMI, decreased BCS loss, but tended to decrease milk yield. When cows were fed a common diet during the carryover period, the low forage diet with FA supplementation fed during the immediate postpartum continued to decrease milk yield and maintained higher BCS compared with the other treatments. On the other hand, Weiss and Pinos-Rodriguez (2009) fed a similar saturated FA supplement (~ 40% C16:0 and 40% C18:0) to early-lactation cows (21 to 126 DIM) and observed that when high-forage diets were supplemented with FA, the increased NEL intake went toward body energy reserves as measured by higher BCS with no change in milk yield. However, when low-forage diets were supplemented with FA, milk yield increased (2.6 kg/d) with no change in BCS.

In a recent study, we evaluated the effects of timing of C16:0 supplementation on performance of early lactation dairy cows (de Souza and Lock, 2017b). During the fresh period (1-24 DIM), we did not observe treatment differences for DMI or milk yield (Figure 5A), but compared with control, C16:0 increased the yield of ECM by 4.70 kg/d consistently over time (Figure 5B). However, C16:0 reduced body weight by 21 kg (Figure 5C), and body condition score by 0.09 units and tended to increase body weight loss by 0.76 kg/d compared with CON. Feeding C16:0 during the peak period (25 to 67 DIM) increased the yield of milk by 3.45 kg/d, ECM yield by 4.60 kg/d, and tended to reduce body weight by 10 kg compared with control (Figure 5).

Interestingly, Greco et al. (2015) observed that decreasing the ratio of omega-6 to omega-3 FA in the diet of lactating dairy cows while maintaining similar dietary concentrations of total FA improved productive performance in early lactation. A dietary omega-6 to omega-3 ratio of approximately 4:1 increased DMI and production of milk and milk components compared with a 6:1 ratio. Approximately 1.3 kg of milk response could not be accounted for by differences in nutrient intake, which suggests that reducing the dietary FA ratio from 6:1 to 4:1 can influence nutrient partitioning to favor an increased proportion of the total net energy consumed allocated to milk synthesis. Further studies focusing on altering ratio of dietary FA are warrant, especially in early lactation cows.

Conclusion

The addition of supplemental FA to diets is a common practice in dairy nutrition to increase dietary energy density and to support milk production. Although in general FA supplementation has been shown to increase milk yield, milk fat yield, and improve reproduction performance, great variation has been reported in production performance for different FA supplements, and indeed the same supplement across different diets and studies. Results are contradictory about the benefits of FA supplementation to early lactation dairy cows. We propose that this is a result of differences in FA profile of supplements used and the time at which FA supplementation starts. Further work is required to characterize the sources of variation in response to FA supplementation. Just as we recognize that not all protein sources are the same it is important to remember that not all FA sources and FA supplements are the same. The key is to know what FA are present in the supplement, particularly FA chain length and their degree of unsaturation. Once this information is known it is important to consider the possible effects of these FA on DMI, rumen metabolism, small intestine digestibility, milk component synthesis in the mammary gland, energy partitioning between the mammary gland and other tissues, body condition, and their effects on immune and reproductive function. The extent of these simultaneous changes along with the goal of the nutritional strategy employed will ultimately determine the overall effect of the FA supplementation, and the associated decision regarding their inclusion in diets for lactating dairy cows.

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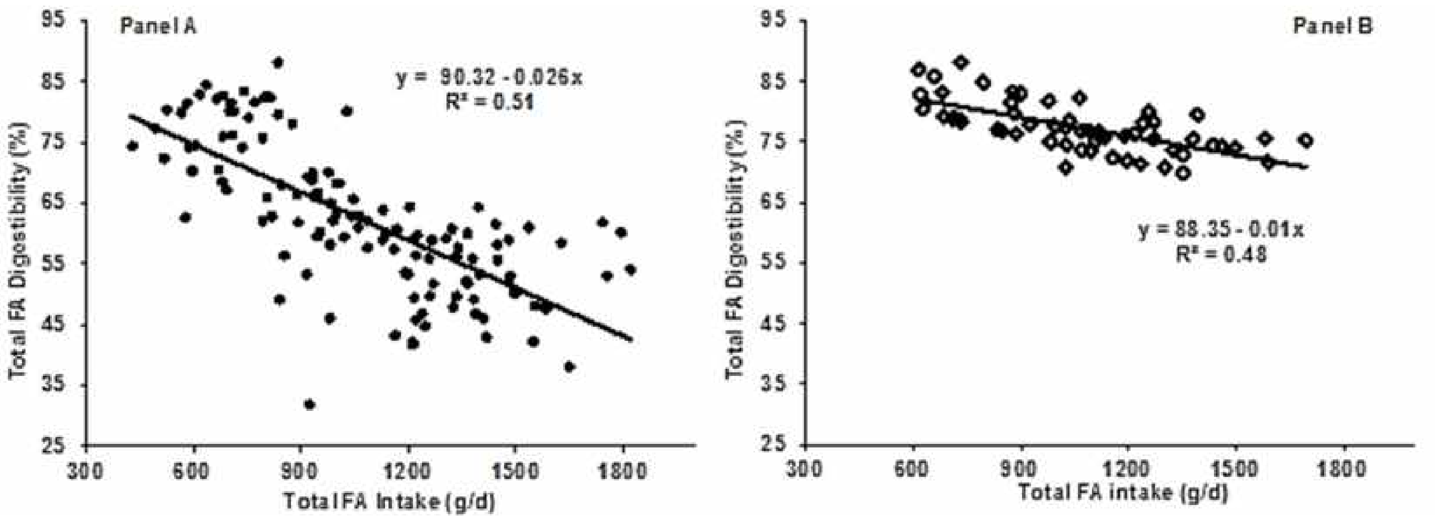

Figure 1. Relationship between total FA intake and apparent total-tract FA digestibility of dairy cows supplemented with either a C18:0-enriched supplement (Panel A) or a C16:0-enriched supplement (Panel B). Results in Panel A utilized 32 mid-lactation cows receiving diets with increasing levels (0 to 2.3% dry matter) of a C18:0-enriched supplement (93% C18:0) in a 4 X 4 Latin square design with 21-d periods (Boerman et al., 2017). Results in Panel B utilized 16 mid-lactation cows receiving diets with increasing levels (0 to 2.25% dry matter) of a C16:0-enriched supplement (87% C16:0) in a 4 X 4 Latin square design with 14-d periods (Rico et al., 2017).

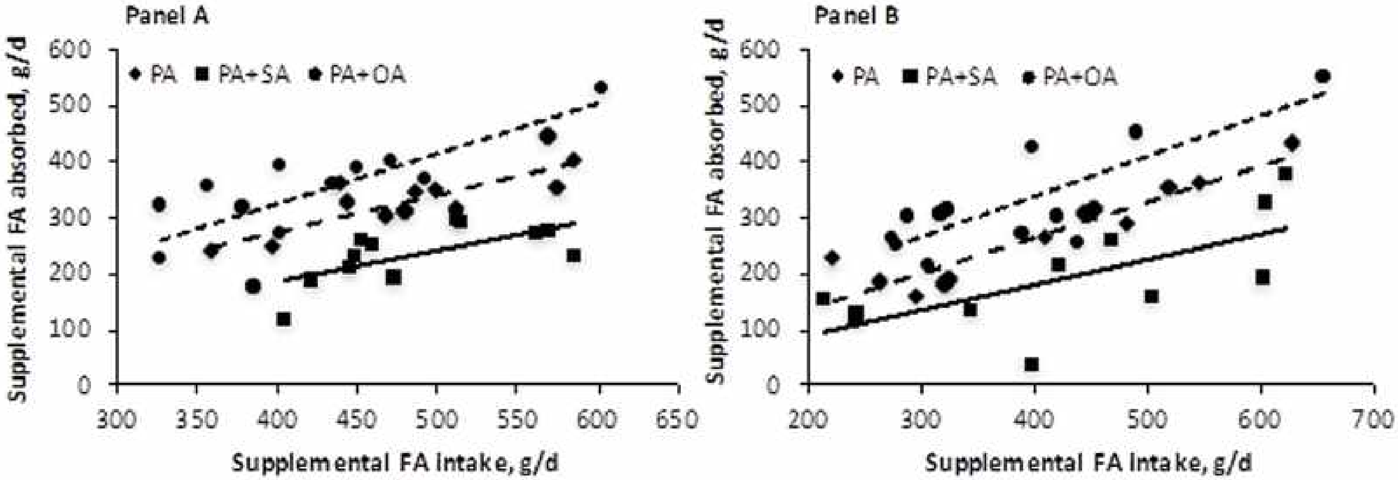

Figure 2. Lucas test to estimate total FA digestibility of supplemental FA treatments when cows received either a soyhulls basal diet (Panel A) or a cottonseed basal diet (Panel B). PA long-dashed line (1.5% of FA supplement blend to provide ~ 80% of C16:0); PA+SA solid line (1.5% of FA supplement blend to provide ~ 40% of C16:0 + 40% of C18:0); and PA+OA short-dashed line (1.5% of FA supplement blend to provide ~ 45% of C16:0 + 35% of C18:1 cis-9). Digestibility of supplemental FA was estimated by regressing intake of supplemental FA on intake of digestible supplemental FA. The mean intakes of FA and digestible FA when cows were fed the control diet were subtracted from the actual intakes of total FA and digestible FA for each observation. From de Souza et al. (2018).

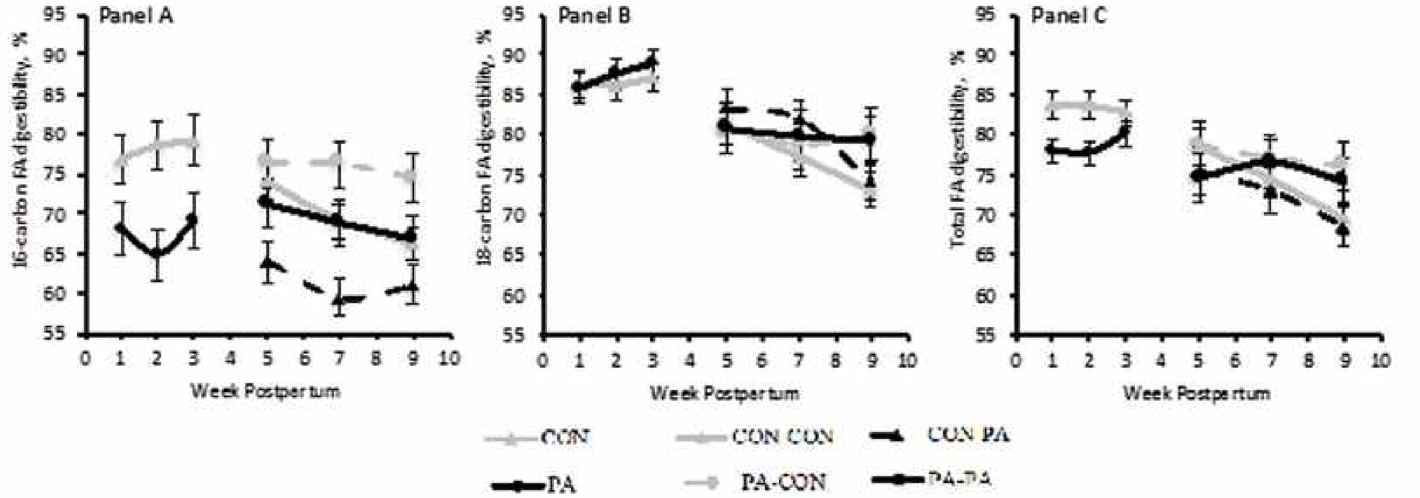

Figure 3. The effects of C16:0-enriched supplementation for early lactation cows on digestibility of 16-carbon (Panel A), 18-carbon (Panel B), and total FA (Panel C). Results utilized 52 early-lactation cows receiving the following diets: no supplemental fat (CON) or a C16:0 supplemented diet (PA) that was fed either from calving (1 to 24 DIM; fresh period FR) or from 25 to 67 DIM (peak period). From de Souza and Lock (2017b).

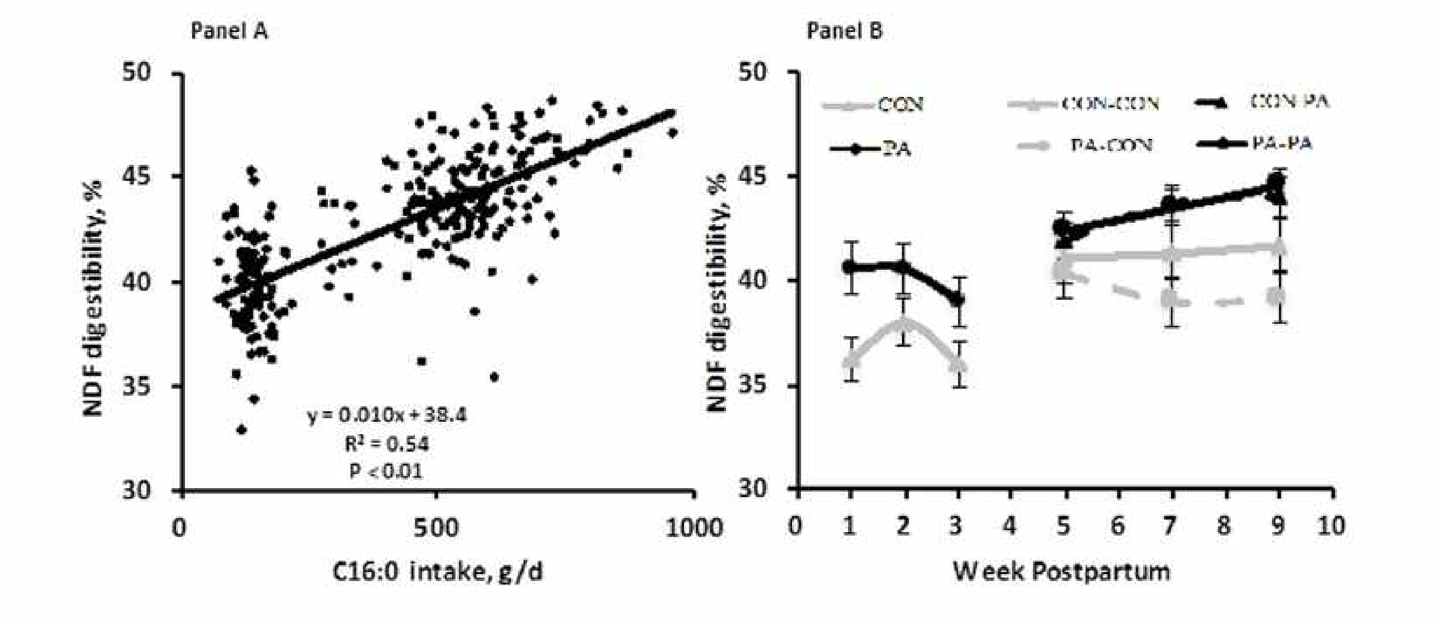

Figure 4. Panel A: Relationship between C16:0 intake and NDF digestibility of dairy cows fed C16:0-enriched FA supplements. Panel B: The effects of C16:0-enriched supplementation in early lactation cows on NDF digestibility. Results in Panel A represent a combined data set evaluated using a random regression model from 6 studies feeding C16:0-enriched supplements on NDF digestibility of post-peak cows (de Souza et al., 2016). Results in Panel B utilized 52 early-lactation cows receiving the following diets: no supplemental fat (CON) or a C16:0 supplemented diet (PA) that was fed either from calving (1 to 24 DIM; fresh period) or from 25 to 67 DIM (peak period). From de Souza and Lock (2017b).

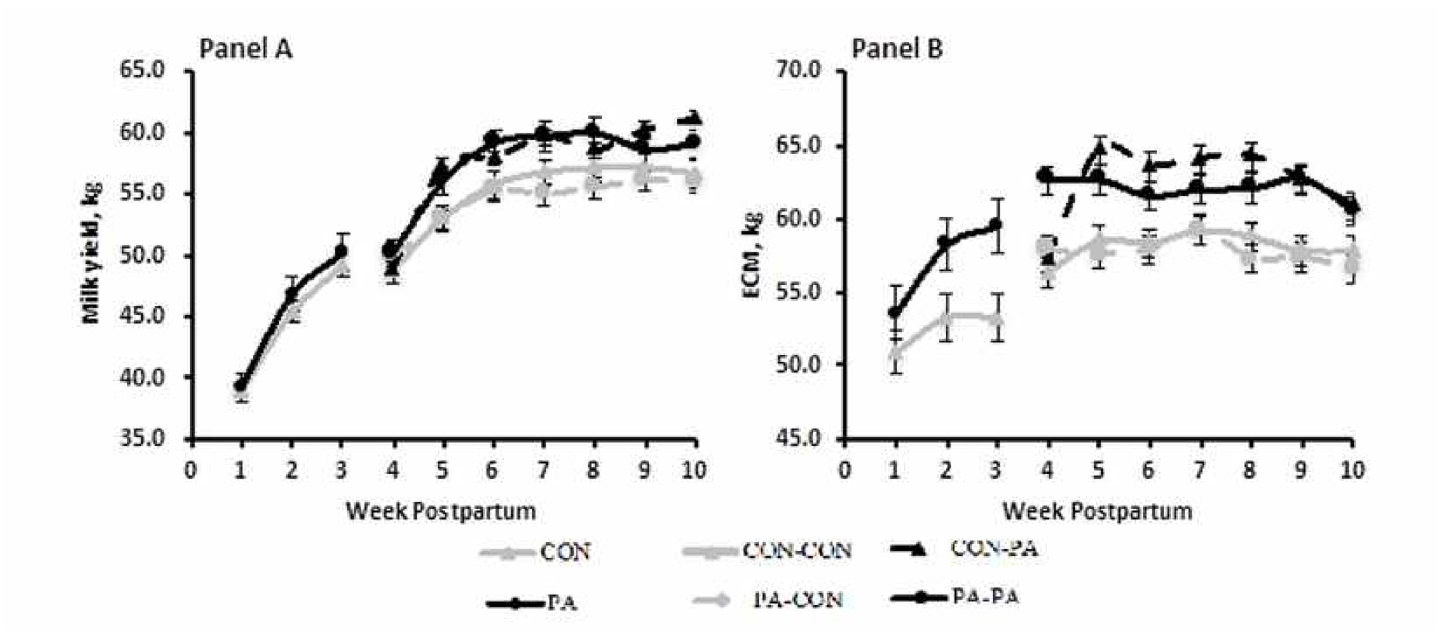

Figure 5. The effects of C16:0-enriched supplementation in early lactation cows on the yield of milk (Panel A) and ECM (Panel B). Results from 52 early-lactation cows receiving the following diets: no supplemental fat (CON) or a C16:0 supplemented diet (PA) that was fed either from calving (1 to 24 DIM; fresh period FR) or from 25 to 67 DIM (peak period). From de Souza and Lock (2017b).

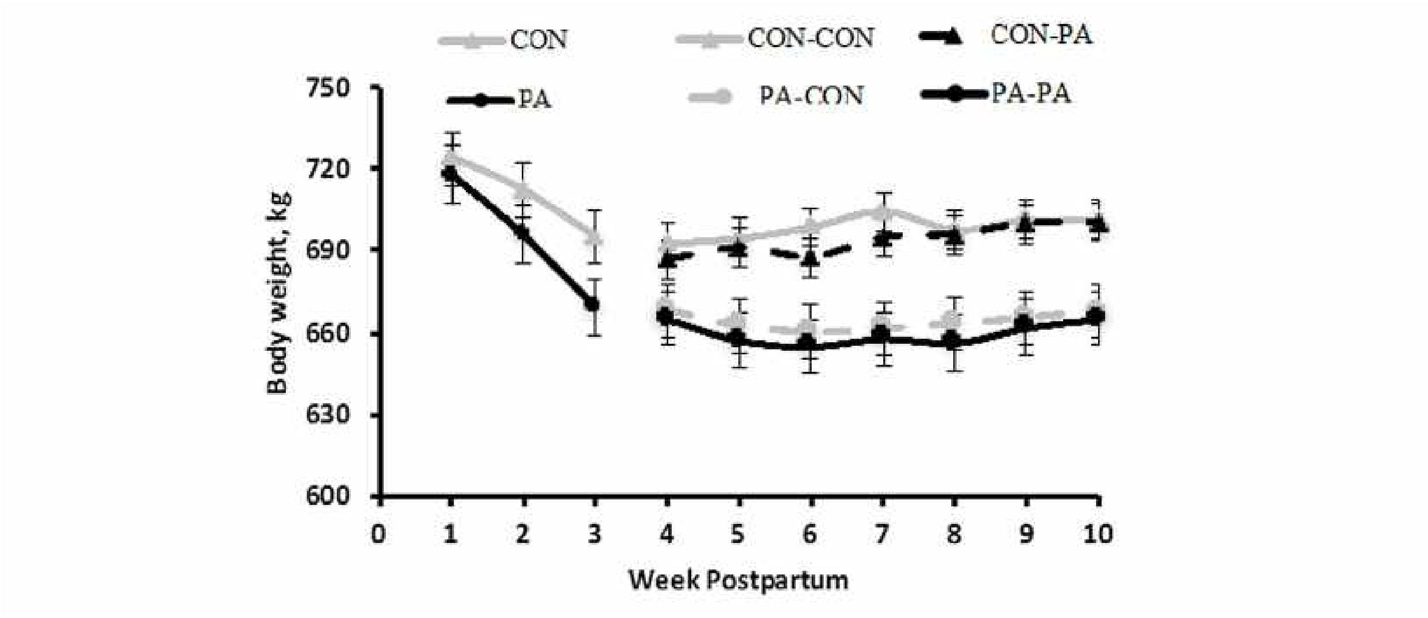

Figure 6. The effects of C16:0-enriched supplementation in early lactation cows on body weight. Results from 52 early-lactation cows receiving the following diets: no supplemental fat (CON) or a C16:0 supplemented diet (PA) that was fed either from calving (1 to 24 DIM; fresh period) or from 25 to 67 DIM (peak period). From de Souza and Lock (2017b).

Corn Genetic Applications Improve Silage Starch Digestibility in Dairy Cows

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Corn genetic applications to improve silage starch digestibility in dairy cows

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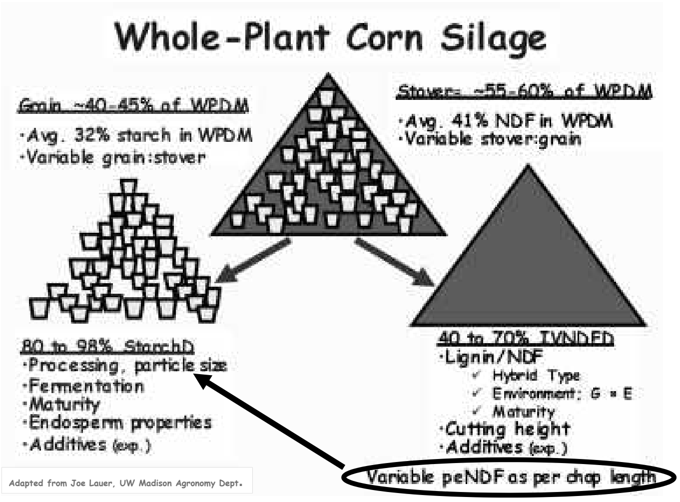
Dairy Science Department

Corn Silage StarchD

- **Genetic or transgenic modifications studied**
  - **Comparisons of Flint, Dent, Reduced-Vitreousness Dent, Floury, Opaque, Waxy Endosperm in Conventional Hybrids** (numerous citations but few feeding trials)
  - **Floury-Leafy Hybrid** (Ferraretto et al., 2015, JDS; Morrison et al., 2014, JDS abstr)
  - **Floury-BMR Hybrid** (Morrison et al., 2016 JDS abstr)
  - **α-Amylase expressed in kernel** (Hu et al., 2010, JDS; trials in progress)



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

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

Corn Silage StarchD

- **Hybrid selection for kernel endosperm properties to improve StarchD very slow to evolve**
- **Genetic effects on StarchD tempered in corn silage**
  - **Harvest should be completed pre-blacklayer**
  - **Kernel processed during harvest**
  - **Prolonged silo storage increases StarchD**
- **No standardized agreed upon method for assessing differences in StarchD among samples**
  - **Test Sample/Assay Sample particle size & drying challenging confounders**
  - **Ruminal vs. post-ruminal starch digestion**
- **StarchD has not been incorporated into university-extension hybrid performance trials**
- **Altering kernel endosperm properties in WPCS mainly experimental & cannot ignore potential changes in Starch (NDF) %, NDFD or agronomics**

Categories

- **Stalk characteristics**
- **Kernel characteristics**
- **Genetically-modified hybrids**

Kernel characteristics

- High-oil hybrids depressed milk fat content and yield and milk protein content
- Otherwise minimal effects on lactation performance

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

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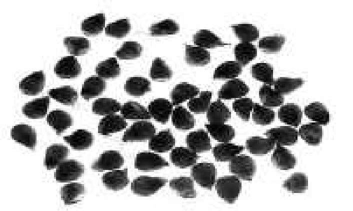


30% Floury

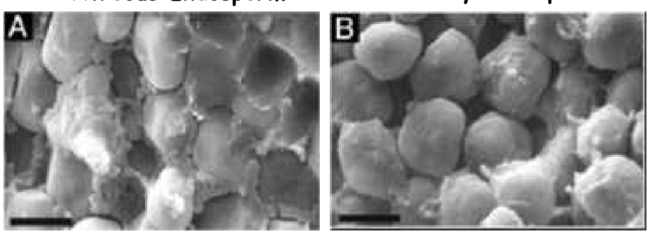
90% Floury

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

The Starch-Protein Matrix

Vitreous Endosperm — Floury Endosperm



Scanning electron microscopy of starch granules in corn: A) starch granules heavily imbedded in prolamin-protein matrix, B) starch granules in opaque corn endosperm with less extensive encapsulation by prolamin-proteins (Gibbon et. al., 2003).

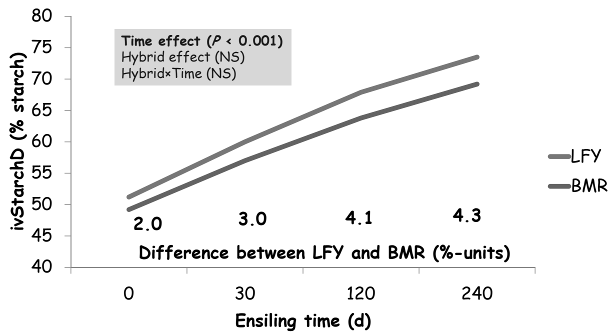
Nutrient composition at feedout

	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

Hybrid type × ensiling time



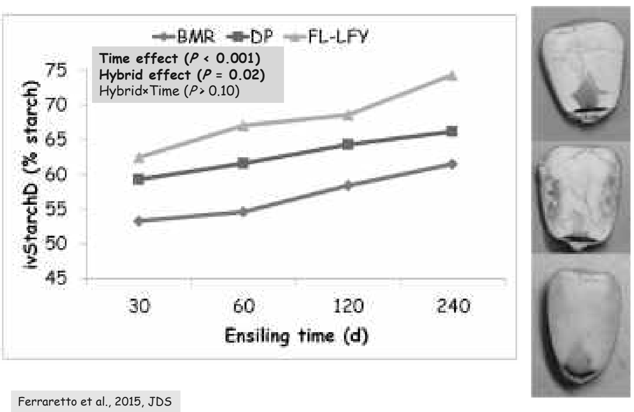
Ferraretto et al., 2015, PAS

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

Hybrid type × ensiling time vs StarchD



Ferraretto et al., 2015, JDS

Floury BMR

Grant et al., 2017, CNC

	CCS[1] (TMF2R447)	bm_3[1] (F2F498)	EXP bm_3[1] (FBDAS3)
DM, % as fed	32	29	31
NDF, % DM	43	41	40
30-h ivNDFD[2], % NDF	43	56	57
Starch, % DM	30	30	32
7-h ivStarchD, % Starch	81	80	80

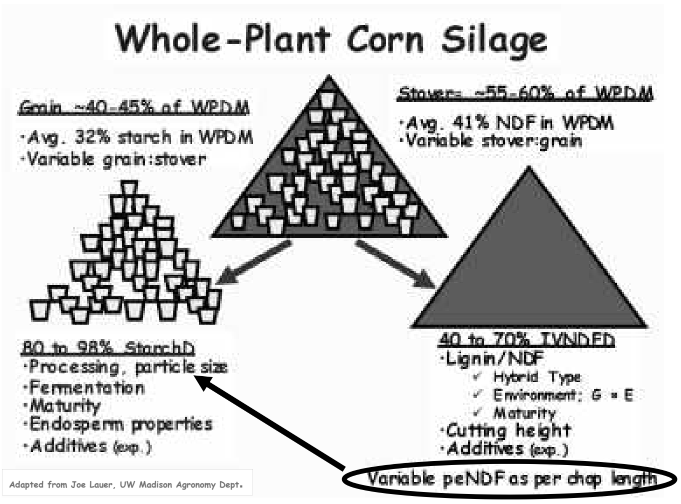
[1]Fed in TMR containing 49% corn silage and 6% haycrop silage (DM basis) in 5x replicated 3 × 3 Latin Square design with 28d periods
[2]Calculated from 30-h uNDFom results provided in the paper

Floury BMR

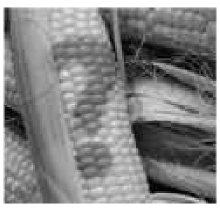
Grant et al., 2017, CNC

	CCS[1]Starch (TMF2R447)	bm_3[1] (F2F498)	EXP bm_3[1] (FBDAS3)
DMI, lb/d	59^{b}	62^{a}	61^{ab}
Milk, lb/d	96^{b}	104^{a}	106^{a}
Fat, %	4.00^{a}	3.85^{b}	3.87^{b}
ECM, lb/d	104^{b}	111^{a}	114^{a}
ECM/DMI	1.76^{b}	1.79^{b}	1.87^{a}
MNE, %	35^{c}	38^{b}	40^{a}
Total Tract Digestiblity, %			
OM	74	75	74
NDF	58	58	58
Starch	99	99	99

[1]Fed in TMR containing 49% corn silage and 6% haycrop silage (DM basis) in 5x replicated 3 × 3 Latin Square design with 28d periods



Questions?



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UW Extension

Nutrition Aspects During the Transition Period in Dairy Cows

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Take Home Message

- Nutritional strategies and feeding management during precalving and post-calving periods impact health, productivity and fertility of high-producing dairy cows.
- Formulating diets to meet requirements of the cows but avoid over-consumption of energy may improve outcomes of the transition period and lead to improved fertility.
- Management to improve cow comfort and ensure good intake of the ration is pivotal for success.
- Rumen-protected methionine and lysine added to the diet of Holstein cows during the transition period and early lactation improves the survival rate of preimplantation embryos.
- Impacts of the transition program should be evaluated in a holistic way that considers disease occurrence, productivity, and fertility.

Introduction

During the transition period from late gestation through early lactation, the dairy cow undergoes tremendous metabolic adaptations (Bell, 1995). The endocrine changes during the transition period are necessary to prepare the dairy cow for parturition and lactogenesis. As peak milk yield increases, the transition period for dairy cows becomes much more challenging with most infectious diseases and metabolic disorders occurring during this time (Drackley, 1999; Grummer, 1995). Decreased dry matter intake (DMI) during late gestation influences metabolism leading to fat mobilization from adipose tissue and glycogen from liver.

Nutrient demand for milk synthesis is increased in early lactation; if no compensatory intake of nutrients is achieved to cope with the requirement, reproductive functions (i.e., synthesis and secretion of hormones, follicle ovulation, and embryo development) may be depressed. Milk production increases faster than energy intake in the first 4 to 6 weeks after calving, and thus high yielding cows will experience negative energy balance (NEB). Nutritional strategies and feeding management during pre-calving and post-calving periods impact health, productivity and fertility of high producing dairy cows. Formulating diets to meet requirements of the cows but avoid over-consumption of energy may improve outcomes of the transition period and lead to improved fertility. Management to improve cow comfort and ensure good intake of the ration is pivotal for success. Impacts of the transition program should be evaluated in a holistic way that considers disease occurrence, productivity and fertility.

Studies over the last 2 decades clearly established the link between nutrition and fertility in ruminants (Robinson et al., 2006; Wiltbank et al., 2006; Grummer et al., 2010; Santos et al., 2010; Cardoso et al., 2013; Drackley and Cardoso, 2014). Dietary changes can cause an immediate and rapid alteration in a range of humoral factors that can alter endocrine and metabolic signaling pathways crucial for reproductive function (Boland et al., 2001; Diskin et al., 2003).

Strategies have been used to improve the reproductive performance of dairy cows through alteration of nutritional status (Santos et al., 2008; Santos et al., 2001). In other species, dietary supplementation with specific AA (e.g., arginine, glutamine, leucine, glycine, and methionine) had beneficial effects on embryonic and fetal survival and growth through regulation of key signaling and metabolic pathways (Del Curto et al., 2013; Wang et al., 2012). Methionine and lysine are the most limiting AA in lactating cows (NRC, 2001), but supplementation of diets with crystalline methionine and lysine has been excluded because free methionine and lysine are quickly and almost totally degraded by the microorganisms in the rumen (NRC, 2001).

Reproduction, Nutrition, and Health

A widespread assumption is that fertility of modern dairy cows is decreasing, particularly for Holstein-Friesen genetics, at least in part because of unintended consequences of continued selection for high milk production. This assumption has been challenged recently (LeBlanc, 2010; Bello et al., 2012). There is a wide distribution of reproductive success both within and among herds. For example, within five California herds encompassing 6,396 cows, cows in the lowest quartile for milk yield in the first 90 days postpartum (32.1 kg/day) were less likely to have resumed estrous cycles by 65 days postpartum than cows in quartiles two (39.1 kg/day), three (43.6 kg/day) or four (50.0 kg/day); milk production did not affect risk for pregnancy (Santos et al., 2009). Changes in management systems and inadequacies in management may be more limiting for fertility of modern dairy cows than their genetics per se.

Dairy cows are susceptible to production disorders and diseases during the peripartal period and early lactation, including milk fever, ketosis, fatty liver, retained placenta, displaced abomasum, metritis, mastitis, and lameness (Mulligan et al., 2006; Ingvartsen and Moyes, 2013; Roche et al., 2013). There is little evidence that milk yield per se contributes to greater disease occurrence. However, peak disease incidence (shortly after parturition) corresponds with the time of greatest NEB, the peak in blood concentrations of nonesterified fatty acids (NEFA), and the greatest acceleration of milk yield (Ingvartsen et al., 2003). Peak milk yield occurs several weeks later. Disorders associated with postpartum NEB also are related to impaired reproductive performance, including fatty liver (Rukkwamsuk et al., 1999; Jorritsma et al., 2003) and ketosis (Walsh et al., 2007; McArt et al., 2012). Cows that lost >1 body condition score (BCS) unit (1-5 scale) had greater incidence of metritis, retained placenta, and metabolic disorders (displaced abomasum, milk fever, ketosis) as well as a longer interval to first breeding than cows that lost <1 BCS unit during the transition (Kim and Suh, 2003).

Indicators of NEB are highly correlated with lost milk production, increased disease and decreased fertility (Ospina et al., 2010; Chapinal et al., 2012). However, the extent to which NEB is causative for peripartal health problems rather than just a correlated phenomenon must be examined critically (Roche et al., 2013). For example, in transition cows inflammatory responses may decrease DMI, cause alterations in metabolism, and predispose cows to greater NEB or increased disease (Bertoni et al., 2008; Graugnard et al., 2012 and 2013; Ingvartsen and Moyes, 2013). Inducing a degree of calculated NEB in midlactation cows similar to what periparturient cows often encounter does not result in marked increases in ketogenesis or other processes associated with peripartal disease (Moyes et al., 2009). Nevertheless, early postpartal increases in NEFA and decreases in glucose concentrations were strongly associated with pregnancy at first insemination in a timed artificial insemination (TAI) program (Garverick et al., 2013). Although concentrations of NEFA and glucose were not different between cows that ovulated or did not before TAI, probability of pregnancy decreased with greater NEFA and increased with greater glucose concentrations at day 3 postpartum (Garverick et al., 2013). In support of these findings, early occurrence of subclinical ketosis is more likely to decrease milk yield and compromise fertility. McArt et al. (2012) reported that cows with subclinical ketosis detected between 3-7 days after calving were 0.7 times as likely to conceive to first service and 4.5 times more likely to be removed from the herd within the first 30 days in milk compared with cows that developed ketosis at 8 days or later.

Cows that successfully adapt to lactation (Jorritsma et al., 2003) and can avoid metabolic (Ingvartsen et al., 2003) or physiological imbalance (Ingvartsen and Moyes, 2013) are able to support both high milk production and successful reproduction while remaining healthy. Decreased fertility in the face of increasing milk production may be attributable to greater severity of postpartal NEB resulting from inadequate transition management or increased rates of disease. Competition for nutrients between the divergent outcomes of early lactation and subsequent pregnancy will delay reproductive function. Because NEB interrupts reproduction in most species, including humans, inappropriate nutritional management may predispose cows to both metabolic disturbances and impaired reproduction. Cows must make "metabolic decisions" about where to direct scarce resources, and in early lactation nutrients will be directed to milk production rather than to the next pregnancy (Friggens, 2003).

Different nutritional strategies have been proposed to improve reproduction of the dairy cow with no detrimental effect on lactation performance. Feeding high quality forages, controlled-energy (CE) diets, or adding supplemental fat to diets are some of the most common ways to improve energy intake in cows (Cardoso et al., 2013; Drackley and Cardoso, 2014; Mann et al., 2015). Reproduction of dairy cattle may be benefited by maximizing DMI during the transition period, minimizing the incidence of periparturient problems (Cardoso et al., 2013; Drackley and Cardoso, 2014).

Some AA are limiting for optimal milk production as evidenced by an increase in milk yield, percentage of milk protein, and milk protein yield after supplementation with specific, rumen-protected amino acids. The first three limiting amino acids for milk production are considered to be Methionine, Lysine (NRC, 2001). There is evidence that methionine availability alters the follicular dynamics of the first dominant follicle (Acosta et al., 2017), the transcriptome of bovine preimplantation embryos in vivo (Penagaricano et al., 2013) and its contents (Acosta et al., 2016).

Prepartum Dietary Considerations

Controlling energy intake during the dry period to near calculated requirements leads to better transition success (Grum et al., 1996; Dann et al., 2005 and 2006; Douglas et al., 2006; Janovick et al., 2011; Graugnard et al., 2012 and 2013; Ji et al., 2012). Research drew from earlier reports that limiting nutrient intakes to requirements of the cows was preferable to over-consumption of energy (e.g., Kunz et al., 1985). Cows fed even moderate-energy diets (1.50 – 1.60 Mcal NEL/kg DM) will easily consume 40 – 80% more NEL than required during both far-off and close-up periods (Dann et al., 2005 and 2006; Douglas et al., 2006; Janovick and Drackley, 2010). Cows in these studies were all less than 3.5 BCS (1-5 scale) at dry-off, and were fed individually TMR based on corn silage, alfalfa silage, and alfalfa hay with some concentrate supplementation. We have no evidence that the extra energy and nutrient intake was beneficial in any way. More importantly, our data indicate that allowing cows to over-consume energy even to this degree may predispose them to health problems during the transition period if they face stressors or challenges that limit DMI (Cardoso et al., 2013).

Prolonged over-consumption of energy during the dry period can decrease post-calving DMI (Douglas et al., 2006; Dann et al., 2006; Janovick and Drackley, 2010). Over-consuming energy results in negative responses of metabolic indicators, such as higher NEFA and betahydroxybutirate (BHB) in blood and more triacylglycerol (TAG) in the liver after calving (Douglas et al., 2006; Janovick et al., 2011). Alterations in cellular and gene-level responses in liver (Loor et al., 2006 and 2007) and adipose tissue (Ji et al., 2012) potentially explain many of the changes at cow level. Over-consumption of energy during the close-up period increases the enzymatic "machinery" in adipose tissue for TAG mobilization after calving, with transcriptional changes leading to decreased lipogenesis, increased lipolysis and decreased ability of insulin to inhibit lipolysis (Ji et al., 2012). Controlling energy intake during the dry period also improved neutrophil function postpartum (Graugnard et al., 2012) and so may lead to better immune function.

Allowing dry cows to consume more energy than required, even if cows do not become noticeably over-conditioned, results in responses that would be typical of overly fat cows. Because energy that cows consume in excess of their requirements must either be dissipated as heat or stored as fat, we speculated that the excess is accumulated preferentially in internal adipose tissue depots in some cows. Moderate over-consumption energy by non-lactating cows for 57 days led to greater deposition of fat in abdominal adipose tissues (omental, mesenteric, and perirenal) than in cows fed a high-bulk diet to control energy intake to near requirements (Drackley et al., 2014). The NEFA and signaling molecules released by visceral adipose tissues travel directly to the liver, which may cause fatty liver, subclinical ketosis and secondary problems with liver function.

Data from our studies support field observations that controlled-energy dry cow programs decrease health problems (Beever, 2006). Other research groups (Rukkwamsuk et al., 1998; Holcomb et al., 2001; Holtenius et al., 2003; Vickers et al., 2013) have reached similar conclusions about controlling energy intake during the dry period, although not all studies have shown benefits (Winkleman et al., 2008). Application of these principles can be through controlled limit-feeding of moderate energy diets or ad libitum feeding of high-bulk, low-energy rations (Janovick and Drackley, 2010; Janovick et al., 2011; Ji et al., 2012) as proposed by others (Beever, 2006).

Nutritionally complete diets must be fed and that the TMR must be processed appropriately so that cows do not sort the bulkier ingredients (Janovick and Drackley, 2010). Feeding bulky forage separately from a partial TMR or improper forage processing will lead to variable intake among cows, with some consuming too much energy and some too little. Underfeeding relative to requirements, where nutrient balance also is likely limiting, leads to increased incidence of retained placenta and metritis (Mulligan et al., 2006). Merely adding a quantity of straw to a diet is not the key principle; rather, the diet must be formulated to limit the intake of energy (approximately 1.3 Mcal NEL/kg DM, to limit intake to about 15 Mcal/day for typical Holstein cows) but meet the requirements for protein, minerals and vitamins. Reports of increased transition health problems or poor reproductive success (Whitaker et al., 1993) with "low energy" dry cow diets must be examined carefully to discern whether nutrient intakes were adequate.

Fresh Cow (Postpartum) Dietary Considerations

Less is known about diet formulation for the immediate postpartum period to optimize transition success and subsequent reproduction. Increased research is needed in this area. Proper dietary formulation during the dry period or close-up period will maintain or enable rumen adaptation to higher grain diets after calving. Failure to do so may compromise early lactation productivity. For example, Silva-del-Rio et al. (2010) attempted to duplicate the dietary strategy of Dann et al. (2006) by feeding either a low-energy far-off diet for 5 weeks followed by a higher-energy diet for the last 3 weeks before parturition, or by feeding the higher-energy diet for the entire 8-week dry period. They found that cows fed the higher-energy diet for only 3 weeks before parturition produced less milk than cows fed the diet for 8 weeks (43.8 vs. 48.5 kg/day). However, the far-off dry period diet contained 55.1% alfalfa silage and 38.5% wheat straw but no corn silage. In comparison the higher-energy dry period diet and the early lactation diet both contained 35% corn silage. Ruminal adaptation likely was insufficient for cows fed the higher energy diet for only 3 weeks.

A major area of concern in the fresh cow period is sudden increase in dietary energy density leading to subacute ruminal acidosis (SARA), which can decrease DMI and digestibility of nutrients (Mulligan and Doherty, 2008). Adequate physical form of the diet, derived either from ingredients or mixing strategy, must be present to stimulate ruminal activity and chewing behavior (Zabeli and Metzler-Zabeli, 2012), although good methods to quantify "adequacy" remain elusive. Dietary starch content and fermentability likely interact with forage characteristics and ration physical form. Dann and Nelson (2011) compared three dietary starch contents (primarily from corn starch) in the fresh cow period for cows fed a CE-type ration in the dry period. Milk production was greatest when starch content was moderate (23.2% of DM) or low (21.0% of DM) in the fresh cow diet compared with high (25.5% of DM). If SARA decreases DMI and nutrient availability to the cow, NEFA mobilization and increased ketogenesis may follow. In addition, rapid starch fermentation in the presence of NEFA mobilization leads to bursts of propionate reaching the liver, which may decrease feeding activity and DMI according the hepatic oxidation theory (Allen et al., 2009). A moderate starch content (ca. 23-25% of DM) with starch of moderate fermentability (for example, ground dry corn rather than high-moisture corn or ground barley) along with adequate effective forage fiber may be the best strategy for fresh cows. Recent research also has demonstrated that high grain diets can lead to greater numbers of gram-negative bacteria such as E. coli with resulting increases in endotoxin present in the rumen, which may decrease barrier function and inflammatory responses in the cow (Zebeli and Metzler-Zebeli, 2012).

Supplemental fats have been widely investigated as a way to increase dietary energy intake and improve reproduction (Thatcher et al., 2011). A novel strategy to use polyunsaturated fatty acid (PUFA) supplements to improve reproduction has been reported (Silvestre et al., 2011). Cows fed calcium salts of safflower oil from 30 days before to 30 days after calving, followed by calcium salts of fish oil to 160 days postpartum, had greater pregnancy rates and higher milk production. The mechanism is believed to be provision of greater amounts of linoleic acid (omega-6 PUFA) until early postpartum, which improves uterine health, followed by greater amounts of omega-3 PUFA from fish oil to decrease early embryonic loss (Thatcher et al., 2011). The effects of turbulent transitions on reproduction are established early postpartum, likely during the first 10 days to 2 weeks postpartum (Butler, 2003; McArt et al., 2012; Garverick et al., 2013). By 8 weeks postpartum, >95% of cows should be at or above energy balance (Sutter and Beever, 2000). Use of targeted prepartum and postpartum strategies may minimize health problems and lessen NEB, and thereby improve subsequent fertility.

Body Condition Score

The role of excessive BCS in contributing to transition problems and impaired subsequent reproduction is well established and has been discussed by many authors (Drackley et al., 2005; Garnsworthy et al., 2008; Roche et al., 2013). Cows with excessive body lipid reserves mobilize more of that lipid around calving, have poorer appetites and DMI before and after calving, have impaired immune function, have increased indicators of inflammation in blood and may be more subjected to oxidative stress (Contreras and Sordillo, 2011). What constitutes "excessive" BCS relative to the cow's biological target remains controversial. Garnsworthy (2007) argued that the average optimal BCS has decreased over time with increased genetic selection for milk yield, perhaps related to correlated changes in body protein metabolism. Recommendations for optimal BCS at calving have trended downward over the last two decades, and in the author's opinion a score of about 3.0 (1-5 scale) represents a good goal at present. Adjustment of average BCS should be a longstanding project and should not be undertaken during the dry period.

Cows fed high-energy (1.58 Mcal NEL/kg DM) diets during the last 4 weeks before calving lost more BCS in the first 6 weeks postpartum than those fed controlled energy (1.32 Mcal NEL/kg DM) diets (−0.43 and −0.30, respectively) (Cardoso et al., 2013). The effect of BCS change on cow's fertility is clear. Carvalho et al. (2014) showed that cows that either gained or maintained BCS from calving to 21 days after calving had higher (38.2 and 83.5%, respectively) pregnancy per AI at 40 days than cows that lost BCS (25.1%) during that same period. Previously, Santos et al. (2009) had shown that cows that had > 1.0 BCS unit change from calving to AI at approximately 70 days postpartum had lower pregnancy per AI (28%)

than cows that lost < 1.0 BCS unit change (37.3%) or did not have a BCS change (41.6%). In a grazing system, researchers from New Zealand suggested that BCS at calving should be targeted at 2.75-3.0, to optimize production, while reducing liver lipid accumulation and the negative effects of inflammation on liver function (Roche et al., 2013; Akbar et al., 2015).

The Importance of Amino Acids

Some AA are limiting for optimal milk production as evidenced by an increase in milk yield, percentage of milk protein, and milk protein yield after supplementation with specific, rumen-protected amino acids. The first three limiting amino acids for milk production are considered to be Methionine, Lysine (NRC, 2001), and Histidine (Hutannen, 2002). In addition, many amino acids can have positive effects on physiological processes that are independent of their effects on synthesis of proteins (Wu, 2013). Fertilization and the first few days of embryo development occur in the oviduct. By about 5 days after estrus the embryo arrives in the uterine horn. The embryo reaches the blastocyst stage by 6 to 7 days after estrus. The embryo hatches from the zona pellucida by about Day 9 after estrus and then elongates on Days 14-19. The elongating embryo secretes the protein interferon-tau that is essential for rescue of the corpus luteum and continuation of the pregnancy. By Day 25-28 the embryo attaches to the caruncles of the uterus and begins to establish a vascular relationship with the dam through the placenta. During all the time prior to embryo attachment, the embryo is free-floating and is dependent upon uterine secretions for energy and the building blocks for development, including amino acids. Thus, it is critical to understand the changes in amino acid concentrations in the uterus that accompany these different stages of embryo development.

The lipid profile of oocytes and early embryo can be influenced by the environment of the cow. Our group ran a trial with the objective to determine the effect of supplementing rumen-protected methionine on DNA methylation and lipid accumulation in preimplantation embryos of dairy cows Acosta et al. (2016). Lactating Holsteins entering their 2nd or greater lactation were randomly assigned to two treatments from 30 ± 2 DIM to 72 ± 2 DIM; Control (CON; n = 5, fed a basal diet with a 3.4:1 Lys:Met) and Methionine (MET; n = 5, fed the basal diet plus Smartamine M to a 2.9:1 Lys:Met). Embryos were flushed 6.5 d after artificial insemination. Embryos with stage of development 4 or greater were used for analysis. For lipids, fluorescence intensity of Nile Red staining was compared against a negative control embryo (subtraction of background). A total of 37 embryos were harvested from cows (MET = 16; CON = 21). Cows receiving MET had greater lipid accumulation (7.3 arbitrary units) when compared with cows receiving CON (3.7 arbitrary units). There were no treatment effects on number of cells or stage of development. In conclusion, cows supplemented with methionine produced embryos with higher lipid concentration when compared to CON which could potentially serve as an important source of energy for the early developing embryo.

The requirements for complete development of bovine embryos have not yet been determined. Current culture conditions allow development of bovine embryos to the blastocyst stage (day 7-8) and even allow hatching of a percentage of embryos (day 9), however conditions have not been developed in vitro that allow elongation of embryos. The methionine requirements for cultured pre-implantation bovine embryos (day 7-8) was determined in studies from University of Florida (Bonilla et al., 2010). There was a surprisingly low methionine requirement (7 μM) for development of embryos to the blastocyst stage by Day 7, however development to the advanced blastocyst stage by day 7 appeared to be optimized at around 21 μM (Bonilla et al., 2010). Thus, the results of these studies indicated that development of morphologically normal bovine embryos did not require elevated methionine concentrations (>21 μM), at least during the first week after fertilization. Stella (2017) reported the plasma concentration of cows fed RPM or not (CON). It seems that cows, when fed RPM, have plasma methionine concentration greater than 20 μM.

Researchers at the Univ. of Wisconsin (Toledo et al., 2015) conducted a trial with a total of 309 cows (138 primiparous and 171 multiparous) that were blocked by parity and randomly assigned to two treatments; 1) CON: Cows fed a ration formulated to deliver 2500 g of MP with 6.9% Lys (% MP) and 1.9 Met (% MP) and 2) RPM: Cows fed a ration formulated to deliver 2500 g of MP with 6.9% Lys % MP) and 2.3 & Met (% MP). Cows were randomly assigned to three pens with head-locks and fed a single basal TMR twice daily. From 28 to 128 DIM, after the AM milking, cows were head-locked for 30 minutes and the TMR of CON and RPM cows were individually top dressed with 50 g of DDG or 50 g of a mix of DDG (29 g) and Smartamine M(21 g) respectively. Following a double ovsynch protocol, cows were inseminated and pregnancy checked at 28 (plasma Pregnancy Specific Protein-B concentration), and at 32, 47 and 61 d (ultrasound). Individual milk samples were taken once a month and analyzed for composition. There were no statistical differences in milk production, but RPM cows had a higher milk protein concentration. Cows fed the methionine enriched diet had a lower pregnancy loss from 21 to 61 after AI (16.7 % RPM cows vs. 10.0% from CON cows). Pregnancy losses between days 28 and 61 were not different in the primiparous cows (12.8% CON and 14.6% RPM), however, pregnancy losses between treatments were significant for the multiparous cows (19.6% CON vs. 6.1% RPM; Toledo et al., 2015).

Perhaps the most detrimental impact of NEB on reproductive performance is delayed return to cyclicity (Jorritsma et al., 2003). The dominant follicle (DF) growth and estradiol (E2) production are key factors for a successful conception, and their impairment can be attributed to reduced luteinizing hormone (LH) pulses (Grainger et al., 1982) as well as decreased circulating insulin and IGF-I concentrations (Komaragiri and Erdman, 1997; Canfield and Butler, 1990). Furthermore, immune function is also suppressed along the periparturient period (Butler 2003; Kehrli et al., 1999), NEB, and fatty liver syndrome demonstrated to impair peripheral blood neutrophil function (Zerbe et al., 2000; Hammon et al., 2006). Acosta et al. (2017) reported that methionine and choline supplementation induced a down regulation of pro-inflammatory genes, possibly indicating lower inflammatory processes in follicular cells of the first DF postpartum. Also, supplementing methionine, during the transition period increased 3β-Hydroxysteroid dehydrogenase (3β -HSD) expression in the follicular cells of the first DF postpartum. It is important to highlight that higher methionine concentrations in the follicular fluid of supplemented cows can potentially affect oocyte quality. The understanding on how this finding may affect reproductive performance in commercial farms needs to be further investigated. Batistel et al. (2017) reported that that studies with non-ruminant species argue for the potential relevance of the maternal methionine supply during late gestation in enhancing utero-placental uptake and transport of nutrients. The authors hypothesized that the greater newborn body weight from cows fed RPM compared to control (42 vs. 44 kg) could have been a direct response to the greater nutrient supply from the feed intake response induced by methionine, the fact that certain AAs and glucose are known to induce mTOR signaling to different degrees is highly suggestive of ‘‘nutrientspecific’’ mechanistic responses.

Conclusions

Formulation and delivery of appropriate diets that limit total energy intake to requirements but also provide proper intakes of all other nutrients before calving can help lessen the extent of NEB after calving. Effects of such diets on indicators of metabolic health are generally positive, suggesting the potential to lessen effects of periparturient disease on fertility. Supplementation of cows with rumen-protected methionine during the final stages of follicular development and early embryo development, until Day 7 after breeding, lead to lipid accumulation changes in the embryos and resulted in differences in gene expression in the embryo.

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Supplementing Fatty Acids to Fresh Cows: Which Ones, When, and How Much?

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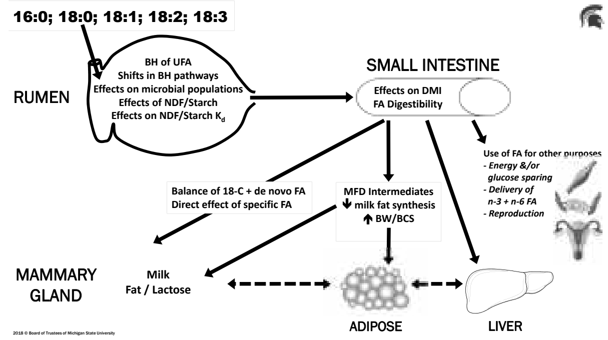


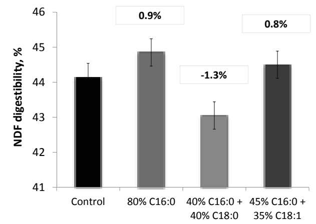
Supplementing Fatty Acids to Fresh Cows: Which Ones, When, and How Much?

Adam L. Lock & Jonas de Souza
Department of Animal Science
Michigan State University

4-State Dairy Nutrition and Management Conference
Grand River Center
Dubuque, Iowa
June 13-14, 2018

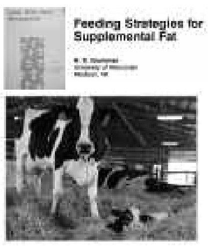
Effect of Altering the FA Profile of Supplemental Fats on Apparent Total Tract NDF Digestibility

- Supplement blends fed at 1.5% DM
- Blends of 3 commercially available FA supplements:
  - C16:0-enriched free FA supplement
  - C16:0 and C18:0 free FA supplement
  - Ca-salt palm FA
- Blended in different ratios to alter content of C16:0, C18:0, and C18:1
- 24 cows in a 4 x 4 Latin square with 21 d periods



de Souza et al. 2018. J. Dairy Sci. 101:172–185

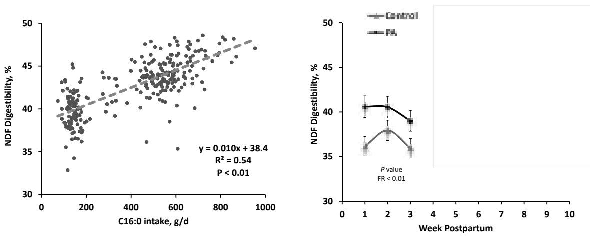
Fatty Acid Supplementation to Early Lactation Cows?



- When Should Fat Feeding Begin?
  - Ideally, fat probably should be left out of the diet immediately postpartum
  - Numerous trials have indicated that there was little benefit from feeding fat during the first 5 to 7 wk postpartum
  - The lack of early lactation response seems to be related to depression in feed intake which offsets any advantage that may be gained by increasing energy density of the diet

Grummer. 1992. Large Dairy Herd Management, 2nd Edition

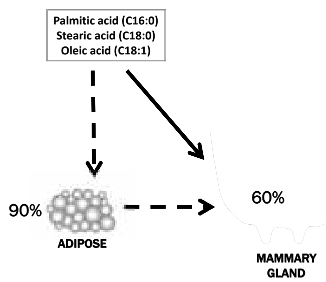
Effect of C16:0 Intake on ttNDFd



de Souza & Lock (ADSA Abstract, 2016)

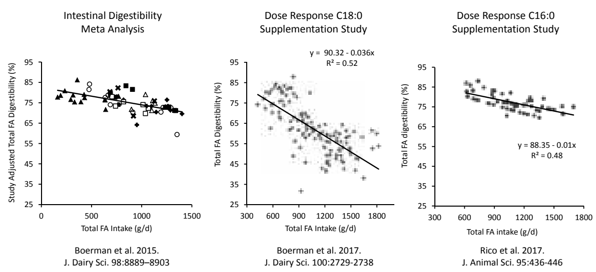
de Souza & Lock (ADSA Abstract, 2017)

Recent Focus on Palmitic, Stearic, and Oleic Acids



- C18:0, under typical feeding situations, is the predominant FA available for absorption by the dairy cow (due to BH)
- Represent the majority of FA in milk fat and adipose tissue
- Predominant FA in the 3 main categories of dietary FA supplements

Apparent Intestinal Digestibility of Fatty Acids



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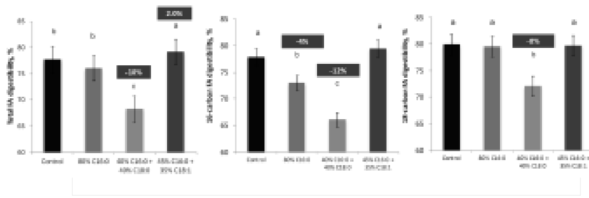
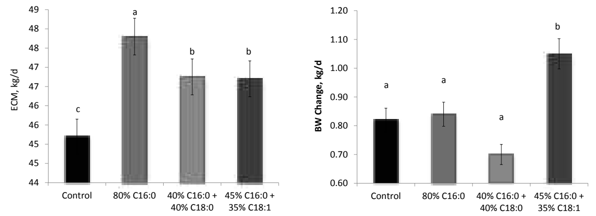
Effect of Altering the FA Profile of Supplemental Fats on Apparent Total Tract FA Digestibility



All *P value for* FA treatment = 0.01

de Souza et al. 2018. J. Dairy Sci. 101:172–185

Effect of Altering the FA Profile of Supplemental Fats on ECM and BW

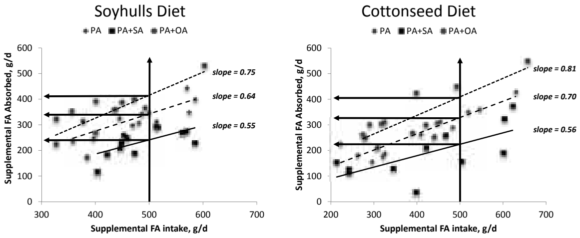


P value
FA treatment = 0.01

P value
FA treatment = 0.01

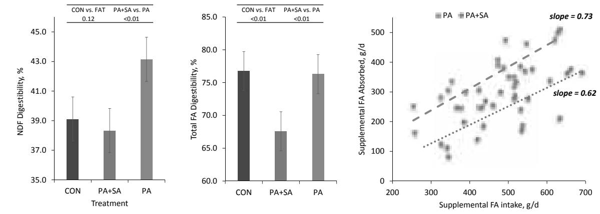
de Souza et al. 2018. J. Dairy Sci. 101:172–185

Effect of Supplement Profile: FA Intake vs. FA Absorbed



de Souza et al. 2018. J. Dairy Sci. 101:172–185

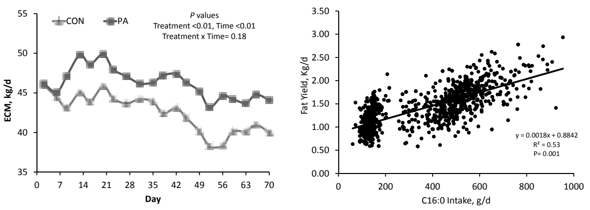
Long Term Effects of Commercially-Available C16:0 and C16:0 + C18:0 Supplements on Digestibility and Production Responses



- 3X3 incomplete Latin Square study with two 5 wk periods
- CON: Control diet (no supplemental fat)
- PA+SA: Control supplemented with 1.5% DM C16:0 and C18:0 FA supplement (Energy Booster 100)
- PA: Control supplemented with 1.5% DM C16:0 FA supplement (Fusion)

Western, de Souza, & Lock (Unpublished)

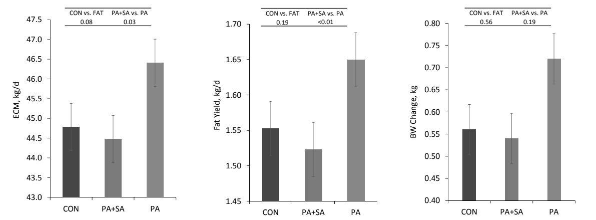
Effect of C16:0 Intake on Fat and Energy-Corrected Milk Yields



de Souza & Lock. 2018.
J. Dairy Sci. (in press)

de Souza & Lock
(ADSA Abstract, 2016)

Long Term Effects of Commercially-Available C16:0 and C16:0 + C18:0 Supplements on Digestibility and Production Responses



- 3X3 incomplete Latin Square study with two 5 wk periods
- CON: Control diet (no supplemental fat)
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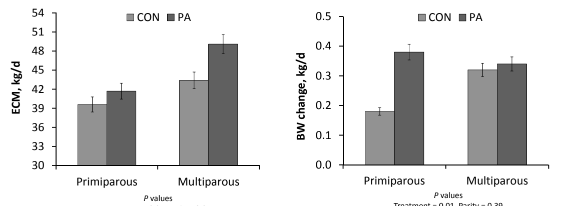
- PA: Control supplemented with 1.5% DM C16:0 FA supplement (Fusion)

Western, de Souza, & Lock (Unpublished)

Treatment by Parity Interactions



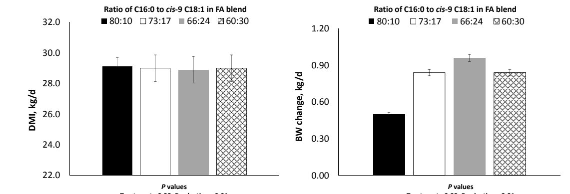
P values
Treatment <0.01, Parity <0.01
Treatment x Parity = 0.04

P values
Treatment = 0.01, Parity = 0.39
Treatment x Parity = 0.09

- ECM increased to a greater extent in multiparous (2.1 vs. 5.7 kg)
- BW increased in primiparous but not multiparous

de Souza & Lock. 2018. J. Dairy Sci. (in press)

Effect of Altering the Palmitic to Oleic Ratio of Supplemental Fats on DMI and BW



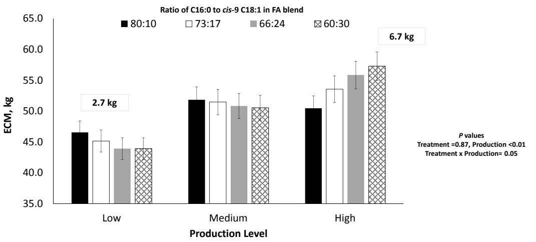
P values
Treatment =0.98, Production <0.01
Treatment x Production= 0.89

P values
Treatment =0.09, Production <0.01
Treatment x Production= 0.74

- 36 cows in an incomplete 4 x 4 Latin square with 35 d periods
- Supplements fed at 1.5% DM
- Blends made using combinations of commercially available C16:0-enriched and Ca-salts palm oil supplements

de Souza & Lock. ADSA Abstract 2017

Treatment X Production Level Interactions

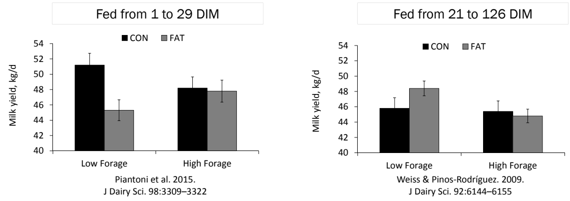


- 36 cows in an incomplete 4 x 4 Latin square with 35 d periods
- Supplements fed at 1.5% DM
- Blends made using combinations of commercially available C16:0-enriched and Ca-salts palm oil supplements

de Souza & Lock. ADSA Abstract 2017

Effect of a C16:0 + C18:0 Supplement in Early Lactation

- Inconsistent response to fat supplementation in early lactation may be associated with the the time at which fat supplementation starts

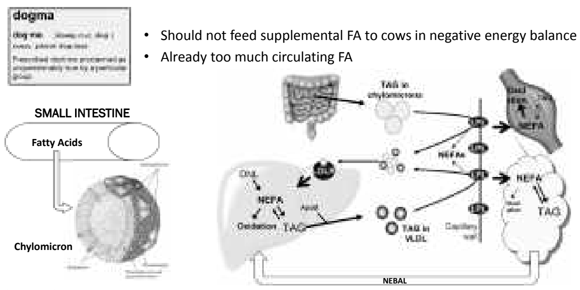


Piantoni et al. 2015. J Dairy Sci. 98:3309–3322

Weiss & Pinos-Rodríguez. 2009. J Dairy Sci. 92:6144–6155

Fatty Acid Supplementation to Early Lactation Cows?

- Should not feed supplemental FA to cows in negative energy balance
- Already too much circulating FA



C16:0 Supplementation to Early Lactation Cows?

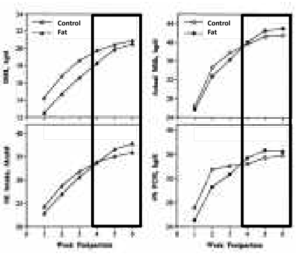
- C16:0 responses have only been evaluated in post peak cows
- Concern regarding:
  - Negative energy balance
  - Reduced DMI of cows in early lactation
  - Increased risk of metabolic disorders

Fresh period (1 to 24 DIM)	Peak period (25 to 67 DIM)
CON (n = 26)	CON (n = 13)
	PA (n = 13)
PA (n = 26)	CON (n = 13)
	PA (n = 13)

- PA fed at 1.5% DM
- 52 multiparous Holstein cows
- Block design; assigned by parity, 305ME, and BCS

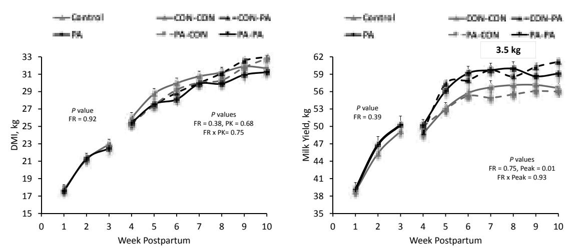
Effect of a C16:0 + C18:0 Supplement in Early Lactation

- Prilled C16:0 and C18:0 supplement fed during first 6 wk of lactation (2.3% DM)
- DMI lower in cows supplemented with fat during the first 4 wk of lactation
- Energy intake and predicted energy balance similar between diets
- Treatment X time interactions around ~ 4 wk



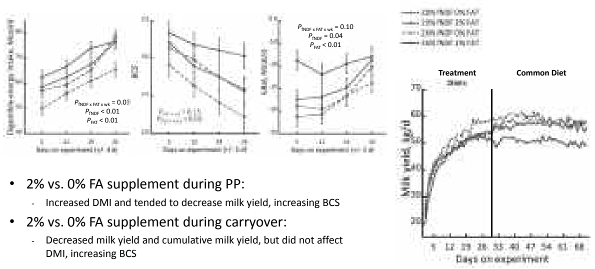
Beam & Butler 1998. J. Dairy Sci. 81:121–131

Effect of C16:0 Intake on DMI and Milk Yield



de Souza & Lock (ADSA Abstract, 2017)

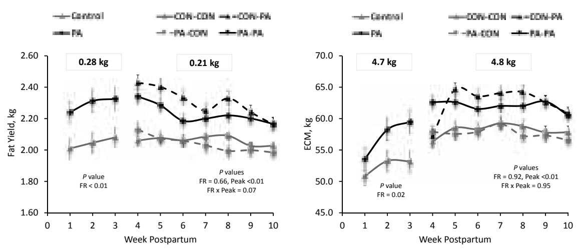
Effect of a C16:0 + C18:0 Supplement in Early Lactation



- 2% vs. 0% FA supplement during PP:
  - Increased DMI and tended to decrease milk yield, increasing BCS
- 2% vs. 0% FA supplement during carryover:
  - Decreased milk yield and cumulative milk yield, but did not affect DMI, increasing BCS

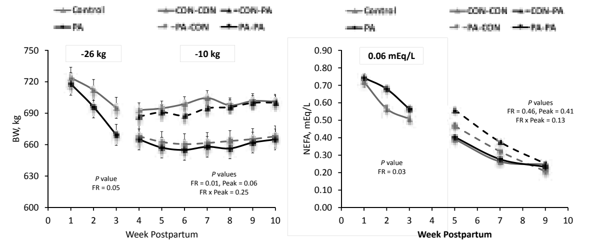
Piantoni et al. 2015. J Dairy Sci. 98:3309–3322; Piantoni et al. 2015. J Dairy Sci. 98:3323–3334

Effect of C16:0 Intake on Yield of Fat and ECM



de Souza & Lock (ADSA Abstract, 2017)

Effect of C16:0 Intake on Body Weight and NEFA



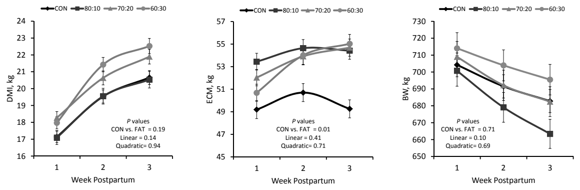
de Souza & Lock (ADSA Abstract, 2017)

Caloric vs. Non-Caloric Effects of Fatty Acids?

- Effect of specific fatty acids:
  - Yield of milk and milk components
  - Maintenance of body condition
  - Nutrient digestion
  - Nutrient partitioning
  - Reproduction
  - Health

FA profile of a fat supplement most likely the first factor in determining the response to it

Effect of Altering the Palmitic to Oleic Acid Ratio of Supplemental Fats to Fresh Cows



- CON: Control diet (no supplemental fat)
- FA supplement blends fed at 1.5% DM
- Supplemental fat blends fed from calving for first 3 wk of lactation

de Souza, St-Pierre, & Lock (Unpublished)

Previous results are contradictory about the benefits of FA supplementation to early lactation dairy cows; we suggest this is due to differences in FA profile of supplements used, inclusion rates, and the time at which FA supplementation started

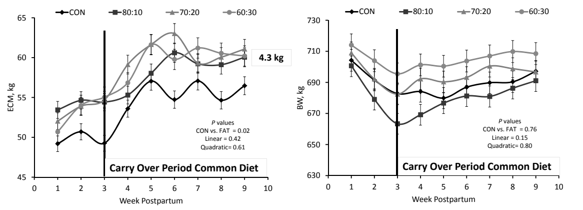
Use of supplemental FA in the fresh period should be considered; new research suggests that FA supplementation increases performance in fresh cows

Important to consider possible effects of FA in the rumen (BH/MFD/NDFd), in the small intestine (DMI/digestibility), in the mammary gland (increased incorporation/substitution), and energy partitioning between tissues

Profile of supplemental FA key in determining production responses and energy partitioning

1) **C16:0 drives increases in milk fat yield and ECM partially due to a decrease in BW**
2) **C16:0 and C18:1 drives increases in milk yield and ECM without changing BW loss compared to non-supplemental diet**
3) **Feeding FA supplements in the fresh period has carryover effects on early lactation**

Effect of Altering the Palmitic to Oleic Acid Ratio of Supplemental Fats to Fresh Cows



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de Souza, St-Pierre, & Lock (Unpublished)

Acknowledgements

M-AAA Michigan Alliance for Animal Agriculture

PERDUE AgriBusiness

NutriLinx

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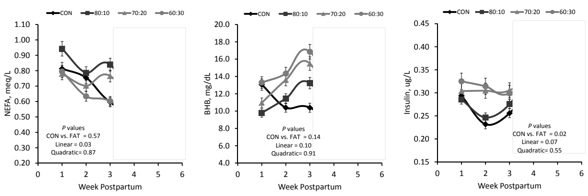
VITA PLUS

VOLAC WILMAR

Animal Nutrition

Effect of Altering the Palmitic to Oleic Acid Ratio of Supplemental Fats to Fresh Cows



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- Supplemental fat blends fed from calving for first 3 wk of lactation

de Souza, St-Pierre, & Lock (Unpublished)

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MICHIGAN STATE UNIVERSITY Extension

http://dairynutrition.msu.edu
https://www.facebook.com/MSUDairyNutritionProgram

Effect of Manipulating Progesterone Before Timed AI on Double Ovulation and Twinning Rates in High-Producing Holstein Cows

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Professor of Dairy Science
University of Wisconsin
Department of Dairy Science

Effect of manipulating progesterone before timed AI on double ovulation and twinning rates in high-producing Holstein cows

Paul M. Fricke, Ph.D.
Professor of Dairy Science

DEPARTMENT OF DAIRY SCIENCE
University of Wisconsin-Madison

J. Dairy Sci. 90:1255–1264
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An Observational Analysis of Twin Births, Calf Sex Ratio, and Calf Mortality in Holstein Dairy Cattle

N. Silva del Río,* S. Stewart,† P. Rapnicki,† Y. M. Chang,* and P. M. Fricke*[1]
*Department of Dairy Science, University of Wisconsin, Madison 53706
†Department of Veterinary Population Medicine, University of Minnesota, St. Paul 55108

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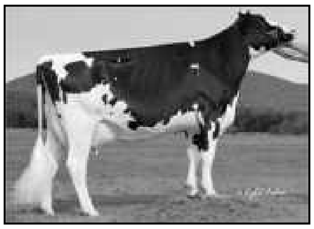
Negative Impacts of Twinning



- Increased average days open and services per conception during the subsequent lactation
- Increased risk for retained placenta, dystocia, metritis displaced abomasum, and ketosis
- Increased risk of culling

- Abortion, stillbirth,neonatal calf mortality, and reduced birth weight are greater for calves born as twins than calves born as singletons
- Reduced gestation length
- Increased incidence of dystocia

Data set description

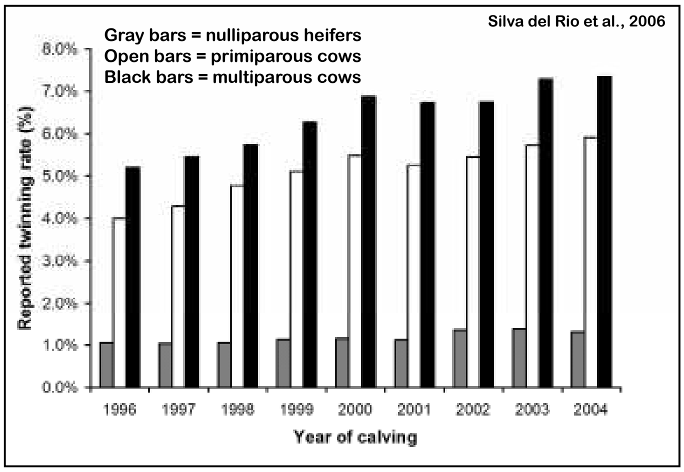
Calving records	Herds	Cows
2,318,601	4,123	1,088,926

85% of herds had <100 calving events per year
Range = 11 to 1,877

Twin calvings:

96,222

4.1% twining rate



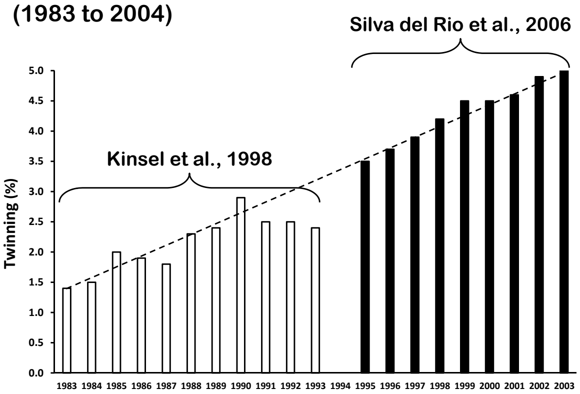
Frequency of monozygotic (MZ) twinning determined empirically or estimated mathematically

Silva Del Rio et al., 2006; Theriogenology 66:1292

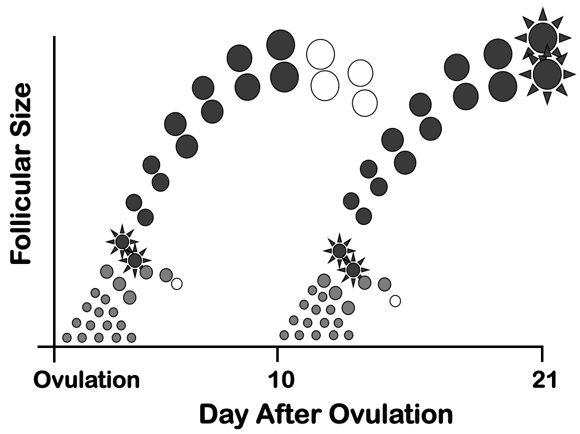
		Empirical		Mathematical
Classification		DZ	MZ	MZ
	n	% (n)	% (n)	%
MM twins	29	86 (25)	3 (1)	-
FF twins	38	97 (37)	14 (4)	-
All same-sex	67	93 (62)	8 (5)	39.5
Opposite-sex	40	100 (40)	-	-
All twins	**107**	**95** (102)	**5** (5)	**24.7**

Twining by time in Holsteins

(1983 to 2004)



Codominance & Double Ovulation



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Theriogenology
ELSEVIER
Theriogenology 66 (2006) 1292–1299
www.journals.elsevierhealth.com/periodicals/the

Observed frequency of monozygotic twinning in Holstein dairy cattle

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[b] Department of Animal Sciences, University of Wisconsin, Madison 53706, USA

Received 27 January 2006; accepted 6 April 2006

Ear biopsies were collected from **107** sets of Holstein twins from 6 Wisconsin dairies.

40 MF twins; **29 MM** twins; **38 FF** twins

DNA from ear biopsies from the **67** same-sex twins was PCR amplified for 5 polymorphic microsatellite DNA markers.

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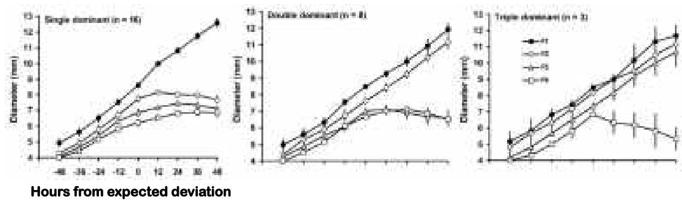
University of Wisconsin-Madison

BIOLOGY OF REPRODUCTION 72, 788–795 (2005)
Published online before print 03 November 2004.
DOI 10.1095/biolreprod.104.035493

Reproductive Hormones and Follicular Growth During Development of One or Multiple Dominant Follicles in Cattle[1]

Hernando Lopez,[3] Roberto Sartori,[2,3] and Milo C. Wiltbank[2,3,4]

Department of Dairy Science[3] and Endocrinology-Reproductive Physiology Program,[4] University of Wisconsin, Madison, Wisconsin 53706
Embrapa Genetic Resources and Biotechnology,[5] Brasilia, DF 70770-900, Brazil



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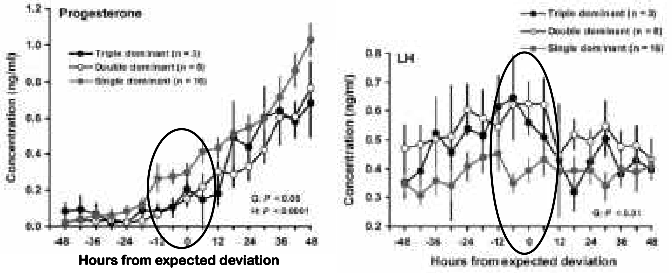
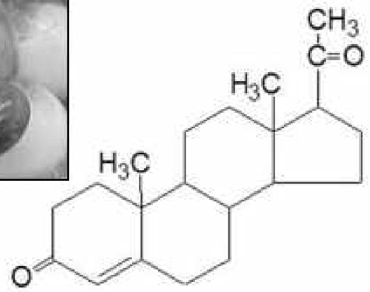
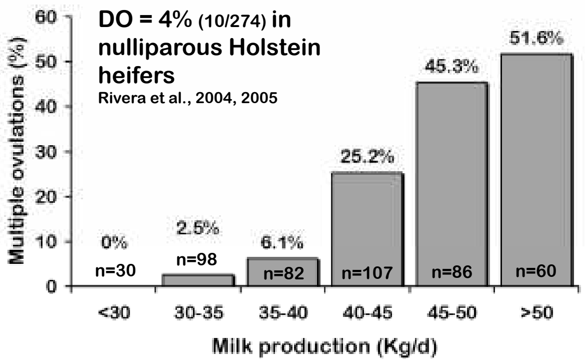


Manipulation of Progesterone



Effect of Milk production on Multiple Ovlation Rate
Lopez et al., J. Dairy Sci. 88:2783; 2005



J. Dairy Sci. 99:6780–6792
http://dx.doi.org/10.3168/jds.2016-11229
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Effect of manipulating progesterone before timed artificial insemination on reproductive and endocrine parameters in seasonal-calving, pasture-based Holstein-Friesian cows

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*Department of Dairy Science, University of Wisconsin-Madison, Madison 53706
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‡Animal Research Department, Animal and Grassland Research and Innovation Centre, Teagasc, Moorepark, Fermoy, County Cork, Ireland
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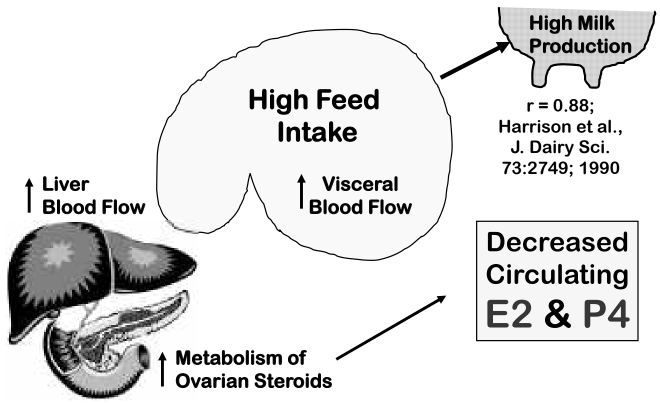
#School of Veterinary Medicine, University College Dublin, Belfield, Dublin 4, Ireland

Hepatic Steroid Metabolism
Milo Wiltbank, UW-Madison



Objective:

To manipulate cows into a high vs. a low progesterone environment during growth of the preovulatory follicle.

Hypotheses:

Compared to cows with high progesterone, cows with low progesterone during growth of the ovulatory follicle will:

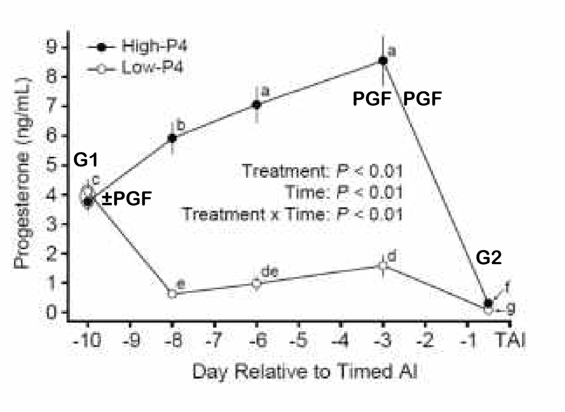
- **Ovulate larger follicles**
- **Have more progesterone after AI**
- **Have increased pregnancy loss and decreased fertility**

Synchronization rate and characteristics of cows enrolled in the experiment

	Treatment*	
Item	Low P4	High P4
Cows enrolled (n)	30	30
Synchronization rate (%)	90 (27/30)	93 (28/30)
Primiparous cows (%)	33 (9/27)	32 (9/28)
Lactation no. (mean ± SEM)	2.8 ± 0.3	2.8 ± 0.3
BCS (mean ± SEM)	2.71 ± 0.02	2.74 ± 0.01
Milk (kg/d), week of TAI	24.7 ± 1.2	24.9 ± 0.9
DIM at Timed AI (mean ± SEM)	88.5 ± 3.1	89.1 ± 2.9

*Items did not differ between treatments

Effect of treatment on progesterone during the synchronization protocol



High Progesterone
n = 30

Sun	Mon	Tue	Wed	Thu	Fri	Sat
					GnRH	
					PGF	
	GnRH					
	GnRH			High Progesterone		
	PGF	PGF	GnRH	TAI		

Effect of treatment on follicle diameter at G2 and CL volume 15 d after TAI

	Treatment		
Item	High P4	Low P4	
Estrus before TAI	No	No	Yes
n	28	16	11
F1 diameter at G2 (mm)	15.6^{a} ± 0.4	16.7^{ab} ± 0.5	17.1^{b} ± 0.4
CL volume 15 d after TAI (mm^3)	9,632^{a} ± 810	9,531^{a} ± 750	12,203^{b} ± 1,383

Low Progesterone
n = 30

Sun	Mon	Tue	Wed	Thu	Fri	Sat
					GnRH	
					PGF	
	GnRH					
	GnRH	PGF		Low Progesterone		
	PGF	PGF	GnRH	TAI		

Effect of treatment on pregnancies per AI (P/AI) and pregnancy loss

	Treatment		
Item	Low P4	High P4	P-value
P/AI, % (no./no.)			
29 d after TAI (PAG test)	70 (19/27)	64 (18/28)	0.63
39 d after TAI (ultrasound)	63 (17/27)	61 (17/28)	0.87
60 d after TAI (ultrasound)	63 (17/27)	61 (17/28)	0.87
Pregnancy loss % (no./no.)			
29 to 39 d	11 (2/19)	6 (1/18)	-
39 to 60 d	0 (0/17)	0 (0/17)	-

Effect of manipulating progesterone before timed AI on double ovulation and twinning rates in high producing dairy cows

P.D. Carvalho, V.G. Santos,
H.P. Fricke, A. M. Niles,
L.L. Hernandez and P.M. Fricke

DEPARTMENT OF DAIRY SCIENCE
University of Wisconsin-Madison

Characteristics of cows enrolled in the experiment

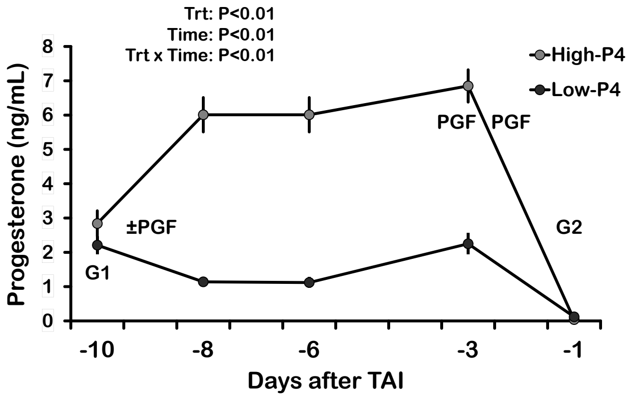
	Treatment	
Item	High P4	Low P4
Cows enrolled (n)	40	40
Lactation (mean ± SEM)	2.85 ± 0.20	2.90 ± 0.20
Body Condition Score (mean ± SEM)	2.76 ± 0.04	2.75 ± 0.04
ECM (kg/day, mean ± SEM)	50.5 ± 1.1	50.7 ± 1.2

High Progesterone

n = 40

Sun	Mon	Tue	Wed	Thu	Fri	Sat
					GnRH	
					PGF	
	GnRH					
	GnRH		2 new CIDR Inserts			
	PGF	PGF	GnRH	TAI		

Effect of treatment on Progesterone before AI



Low Progesterone

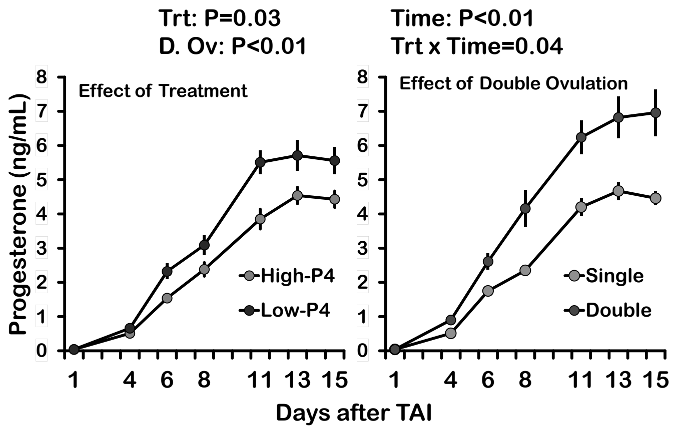
n = 40

Sun	Mon	Tue	Wed	Thu	Fri	Sat
					GnRH	
					PGF	
	GnRH					
	GnRH	PGF	1 used CIDR insert			
	PGF	PGF	GnRH	TAI		

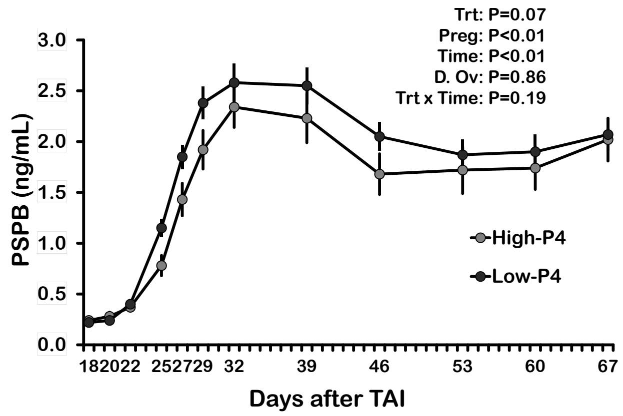
Effect of treatment on no. CL at PGF, follicle size at G2, double ovulation, and CL volume 7d after TAI

	Treatment		
Item	High P4	Low P4	P-value
No. CL at PGF (mean ± SEM)	1.90 ± 0.08	1.20 ± 0.09	<0.01
No. Follicles at G2 (mean ± SEM)	1.15 ± 0.06	1.35 ± 0.08	0.01
Follicle size at G2 (mean ± SEM)	14.8 ± 0.32	16.4 ± 0.54	<0.01
Double Ovulations (%, no/no)	10.0 (4/40)	32.5 (13/40)	<0.01
CL volume 7d after AI (cm3, mean ± SEM)	5.55 ± 0.34	8.13 ± 0.64	<0.01

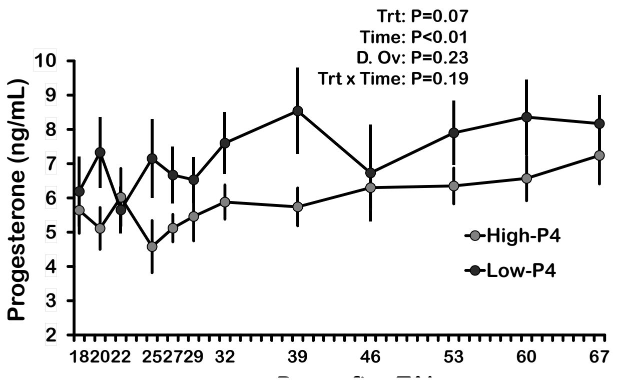
Effect of treatment and Double Ovulation on P4 After AI (D1 to D15)



Effect of treatment on PSPB

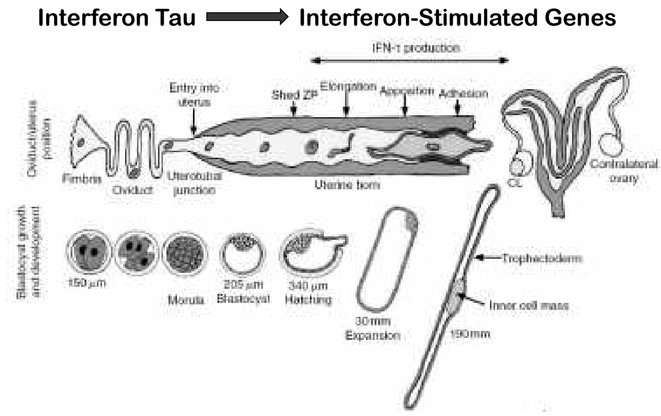


Effect of treatment on P4 After AI



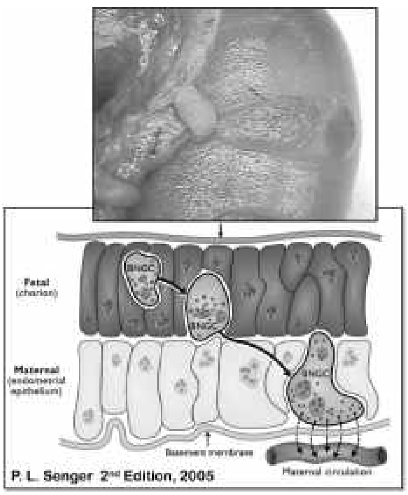
Critical events during early pregnancy

Spencer et al., 2007; Compliments of Dr. Troy Ott

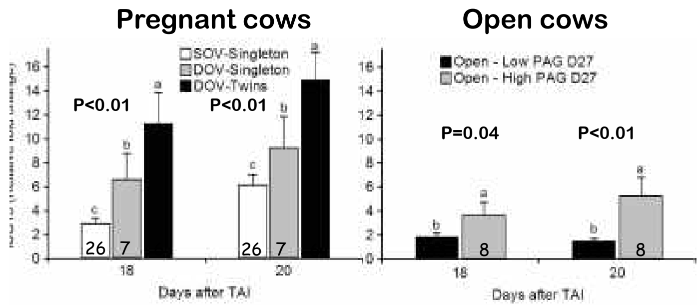


PAGs

- PAGs belong to a large family of >20 glycoproteins expressed during pregnancy
- Inactive aspartic proteinases
- Function of PSPB and PAGs during pregnancy is unclear



Effect of Double ovulation and pregnancy status on ISG15



Effect of treatment

Item	Treatment: High P4	Low P4	P- Value
P/AI 32 d, % (no)	45 (40)	53 (40)	0.97
Twins at 32 d, % (no)	0 (18)	29 (21)	<0.01
P/AI 39 d, % (no)	40 (40)	45 (40)	0.90
P/AI 46 d, % (no)	38 (40)	40 (40)	0.99
P/AI 53 d, % (no)	38 (40)	40 (40)	0.99
P/AI 60 d, % (no)	35 (40)	40 (40)	0.83
P/AI 67 d, % (no)	35 (40)	40 (40)	0.83
Loss, % (no)	22 (18)	24 (21)	0.49

Embryo viability, pregnancy loss, and single embryo reduction

Silva del Rio et al., 2009; Theriogenology 71:1462-1471.

Item	Pregnancy type: Single	Twin
Cows with embryos at 1st exam (n)	518	98
Cows with non-viable embryos at 1st exam, % (n)	4 (19)	-
Cows with viable embryos at 1st exam (n)	499	98
Cows with pregnancy loss by 2nd exam, % (n)	5 (23)	13 (13)
Cows with twins undergoing single reduction, % (n)	-	11 (11)
Cows maintaining pregnancy by 2nd exam, % (n)	92 (476)	76 (74)

1st exam: 25-40 d after AI; 2nd exam: 48-82 d after AI.

Effect of Double Ovulation

Item	Ovulation: Single	Double	P-value
P/AI 32 d, % (no)	41 (63)	77 (17)	0.02
Twins at 32 d, % (no)	0 (26)	46 (13)	<0.01
P/AI 39 d, % (no)	37 (63)	65 (17)	0.05
P/AI 46 d, % (no)	37 (63)	47 (17)	0.45
P/AI 53 d, % (no)	37 (63)	47 (17)	0.45
P/AI 60 d, % (no)	35 (63)	47 (17)	0.42
P/AI 67 d, % (no)	35 (63)	47 (17)	0.42
P Loss, % (no)	15 (26)	39 (13)	0.11

Reproductive Events Before Day 90 of Gestation in Cows With Twin Fetuses

Lopez-Gatius and Hunter, 2004; Theriogenology 63:118-125.

	Bilateral	Uni-Right	Uni-Left	Total
	n (%)			
No. of cows	86 (41)	74 (35)	51 (24)	211
Preg Loss	7 (8)	24 (32)	20 (39)	51 (24)
Single EED[1]	8 (9)	16 (22)	11 (22)	35 (17)
Reduction[2]	6 (75)	4 (25)	3 (27)	13 (37)

[1]Presence of one dead of the two embryos.

[2]Embryo reduction without compromising embryo maintenance as a % of total cows with single embryo death.

Incidence, location of ovulation, and conception rate of single and double ovulating cows

Fricke and Wiltbank, 1999; Theriogenology 52:1133-1143.

Response	Incidence	Location		CR (%)
		Left	Right	
Single Ovulation	85.9% (171/199)	43.3%[a] (74/171)	56.7%[b] (97/171)	45.2%[y] (75/166)
		Ipsilateral	Contralateral	
Double Ovulation	14.1% (28/199)	53.6% (15/28)	46.4% (13/28)	64.0%[z] (16/25)

[a,b]Proportions tended to differ (p=0.08)

[y,z]Proportions tended to differ (p<0.08)

Conclusions:

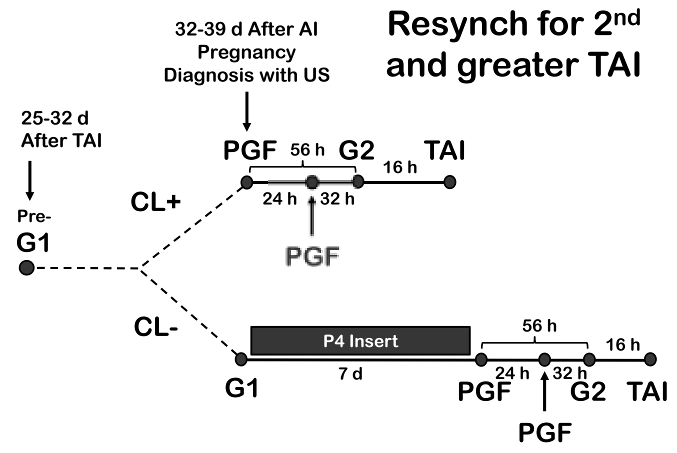
Decreasing P4 concentrations before AI resulted in:

- Larger ovulatory follicles
- More double ovulation.
- Greater P4 concentrations after AI
- Greater PSPB concentrations

Cows with double ovulation had:

- Greater P4 concentrations after AI
- Greater ISG15.
- More twin pregnancies
- Greater pregnancy loss

Based on PSPB concentrations and relative ISG, early pregnancy loss (before D32) occurred in at least 20% of cows diagnosed open on D32


Resynch for 2nd and greater TAI
32-39 d After AI Pregnancy Diagnosis with US
25-32 d After TAI
Pre-G1
CL+
PGF
56 h
G2
16 h
TAI
24 h
32 h
PGF
CL-
P4 Insert
G1
7 d
PGF
56 h
24 h
32 h
G2
16 h
TAI
PGF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University of Wisconsin-Madison

Utilizing a Novel Dairy Heat Stress Model Using Electric Blankets (EHB) to Evaluate Summer Nutritional Strategies

M. Al-Qaisi, L. H. Baumgard, and L. L. Timms
Iowa State University
http://www.extension.iastate.edu/dairyteam/

4 State Dairy Conference

Utilizing a novel dairy heat stress model using electric blankets (EHB) to evaluate summer nutritional strategies



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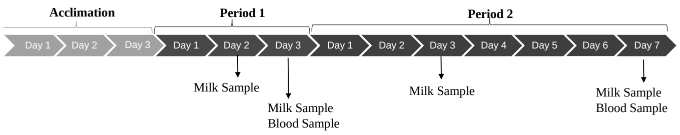
Extension and Outreach
Healthy People. Environments. Economies.

M. Al-Qaisi, L. H. Baumgard, and L. L. Timms
http://www.extension.iastate.edu/dairyteam/

Materials and Methods

- 8 lactating Holstein cows (133 ± 3 DIM; 709 ± 31 kg BW; parity 2.6 ± 0.3)
- Two experimental periods:
  - Period 1 (3 d)
    - Baseline data collection
    - Thermoneutral (TN) conditions
  - Period 2 (7 d)
    - Electric heat blanket (EHB)



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Introduction

- **Heat stress (HS)** is an annual environmental issue which negatively affects physiological and production parameters.
- Heat stress occurs when environmental conditions create a heat load that exceeds the upper limit of the thermoneutral zone
- Dairy cows are more susceptible to HS than most farm animals.
- Traditionally, environmental chambers have been required to design and conduct well-controlled HS studies.
- However, due to construction and operation costs, many institutions lack such facilities and/or resources.

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Materials and Methods

- EHB consisted of 12 infrared heating pads as a heat source (Thermotex Therapy Systems Ltd. Calgary, AB, Canada)
- The blanket was powered by a 110 volt electrical cord that connected to the EHB at the withers
- March 1- April 19, 2016
  - Ambient temperature ranges between 7.5-22

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Initial Objective

➢ **Explore the efficacy of utilizing an electric heat blanket (EHB) as an alternative and cost effective method to study HS and to determine whether EHB-induced hyperthermia affects production parameters similar to natural HS.**

➢ 2^0 Monitor behavioral changes via an ear tag based behavior monitor system (Cow Manager ®)

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Electric Heat Blanket (EHB)


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Materials and Methods

- Cows individually fed TMR (ad libitum) once daily (0800 h) and orts were measured daily before the a.m. feeding.
- Cows were milked twice daily and milk recorded at each milking.
- Milk samples collected on d 2 and 3 (P1) and on d 3 and 7 (P2).
  - Milk samples were analyzed for:

    *Fat * Protein * Lactose
    * Total Solids * Solids Non-fat * Milk Urea Nitrogen
- During P1 and P2, rectal temperature (Tr), skin temperature (Ts), respiration rate (RR), heart rate (HR) obtained 2X/day: 6 am/pm
- Blood samples collected d 3 (P1) and d 7 (P2): Analyzed for:
  * Glucose * NEFA

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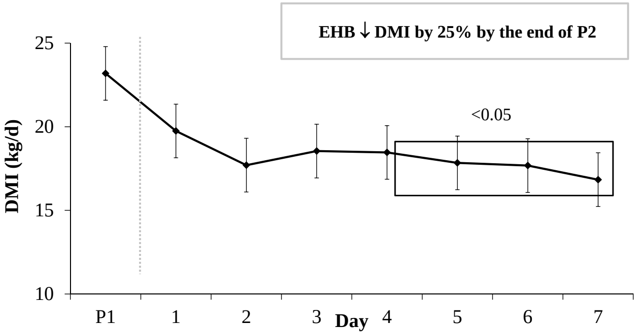
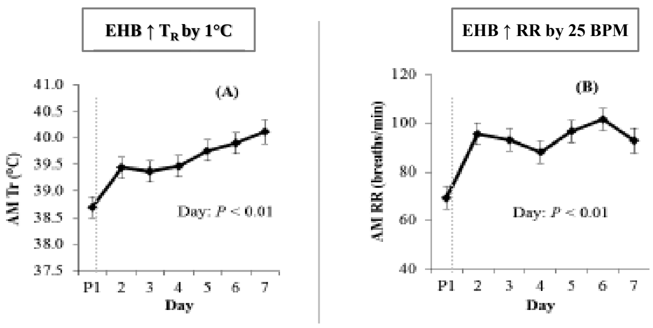
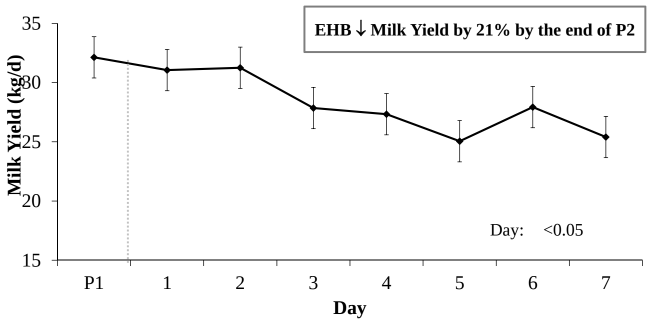
Effect of EHB on DMI



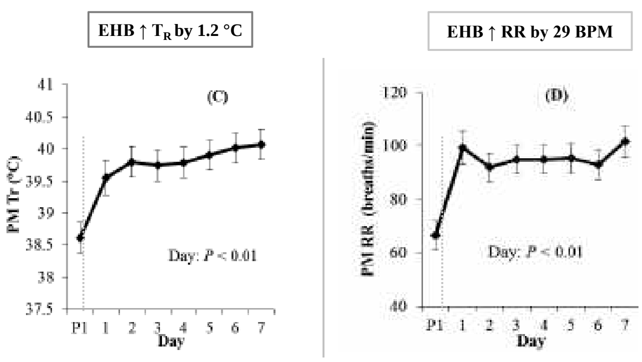
Effects of EHB on AM T_R and RR



Effects of EHB on Milk Yield



Effects of EHB on PM T_R and RR



Effect of EHB on production and metabolism variables

	Periods			
Parameter	Period 1	Period 2	SEM	-value
Milk components				
Fat, %	3.91	4.04	0.2	0.66
Protein, %	3.03	2.90	0.05	0.07
Lactose, %	4.80	4.81	0.02	0.89
Total solids, %	12.7	12.6	0.2	0.95
SCC, × 1000	91	106	24	0.66
MUN, mg/dL	12.8	17.0	0.6	<0.01
Glucose, mg/dL	73.3	69.4	1.9	0.17
NEFA, µEq/L	145	225	31	0.09

COW MANAGER BEHAVIOR TAGS !!

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BEHAVIOR PERIODS

P0: 1 week before trial barn

P1: day 5-7 in trial barn (accl.)

P2: Blanket (EHB) week

P3: 1-3 d post trial (farm barn)

P4: 5-7 d post trial (farm barn)

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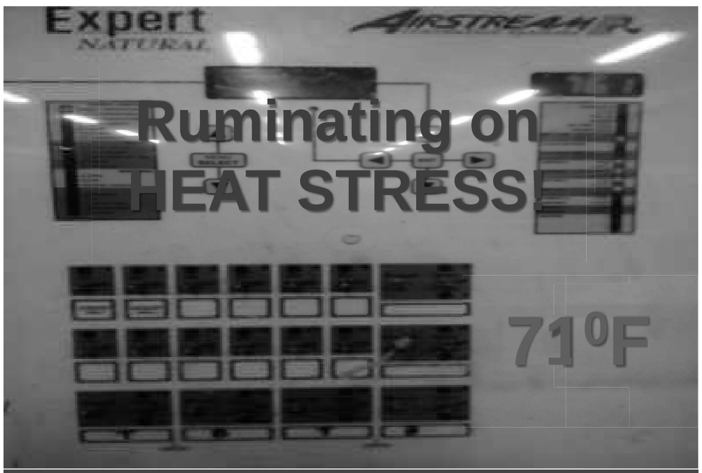

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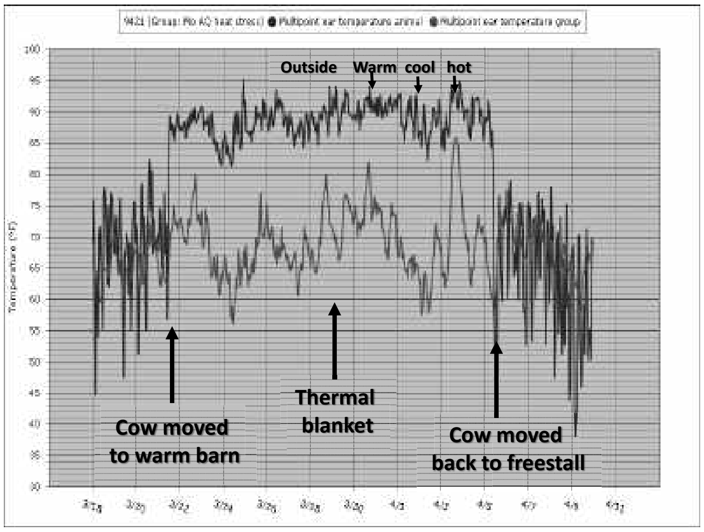

Validation of EHB Using Pair Fed Model

- 27 lactating Holstein cows (19 EHB; 8 pair fed)
- The trial included 2 experimental periods (P):
  - **P1** (4 d), all cows fed ad libitum and housed in thermoneutral (TN) conditions (baseline values).
  - **P2** (4 d), 19 cows fitted with an EHB and fed adlib
    8 TN cows pair fed to match EHB cow DMI
- Housing, feeding, milking, and sampling similar to initial EHB trial.
- Additional analyses: blood gases & chemistry, insulin

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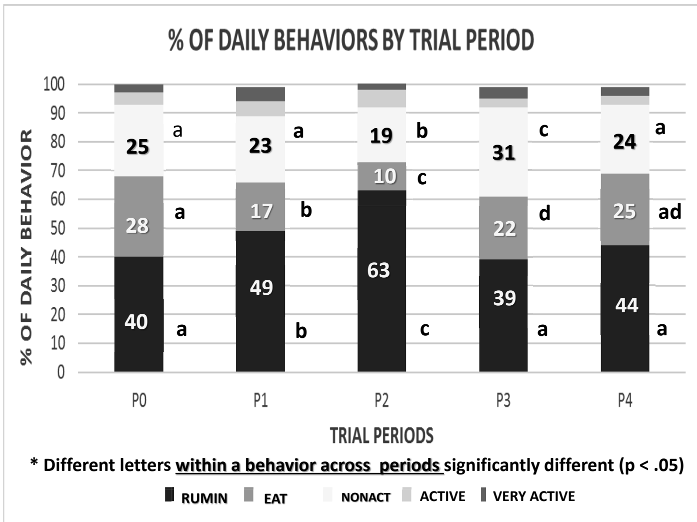
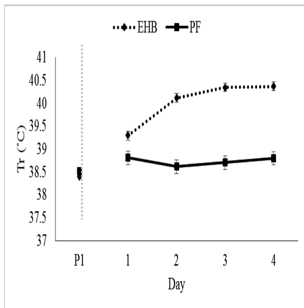
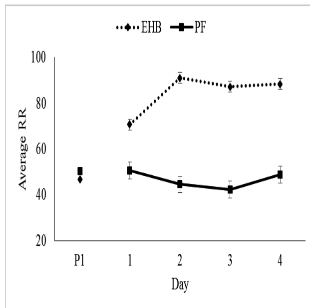


Effects of EHB vs Pair Fed on T_R and RR

EHB ↑ T_R by 1.3 °C

EHB ↑ RR by > 2X BPM





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Conclusions

- Employing the EHB increased the body temperature indices (Tr and RR) and negatively affected feed intake and production parameters.
- **Thus, utilizing the EHB is an unconventional but relatively low-cost (while scientifically valuable) research technique to model HS in lactating dairy cows.**
- Importantly, the EHB is likely not a good technique to study products whose mode of action are to facilitate heat dissipation via radiation, convection as the blanket markedly interferes with normal routes of heat loss.
- However, if experimental objectives are to study the biological consequences of HS or to test products whose activity is either within the gastrointestinal tract or via modifying metabolism then the EHB is a feasible research strategy.
- Behavioral tools may be excellent system for monitoring heat stress, including early onset! (especially if system can discern panting from rumination!! (algorithms)

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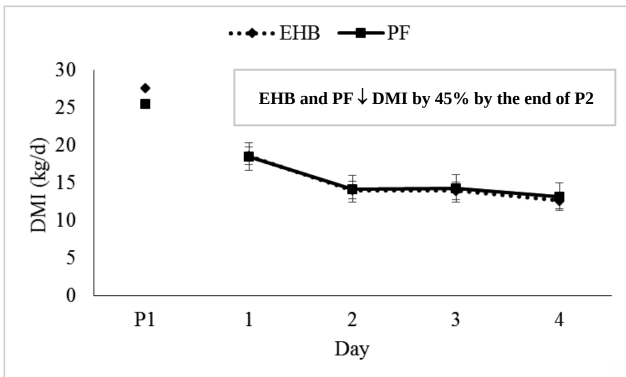
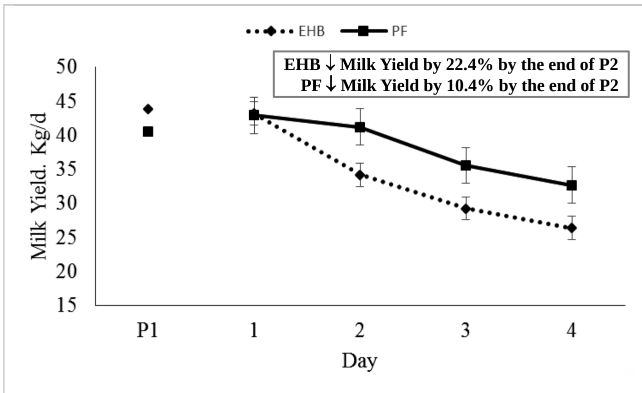
Effects of EHB vs Pair Fed on DMI



Effects of EHB vs Pair Fed on Milk Yield



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Other results: EHB vs Pair Fed

- Increased rectal, vaginal, skin temps (1.3^{0}C, 1.4^{0}C, 1.1^{0}C (p <.01))
- Increased respiration and heart rates (> 2X and 15 bpm (p <.01))
- MUN increased 20.4% (p < .01)
- Decreased total blood CO^2, partial CO^2, HCO^3, base excess levels (15, 13, 15, and 78% respectively (p <.01))
- Increased hematocrit and hemoglobin by 9% (dehydration) (p < .01)
- NEFA increased in PF cows only!
- No differences in glucose but increased insulin (9%; p = .07)

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Conclusions

- **Employing the EHB model:**
  - ✓ **Increased body temperature indices**
  - ✓ **Altered metabolism**
  - ✓ **Reduced productivity (DMI & Milk Yield)**
    - ❖ **Reduced DMI only accounts for 50% MY↓**
- **Similar to climate controlled chamber studies!!**

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Effects of re-hydration therapy on EHB heat stressed lactating cows

- 19 lactating Holstein cows (all EHB; 2 dietary treatments)
- The trial included 2 experimental periods (P):
  - **P1** (4 d), all cows fed ad libitum and housed in thermoneutral (TN) conditions (baseline values).
  - **P2** (4 d), all cows fitted with an EHB and fed adlib 10 cows topdressed 1X/d (113 g) w/ EOEC*
    * EOEC: electrolyte, osmolyte, energetic compounds
    * Bovine BlueLite® Pellets, TechMix LLC

❖ Housing, feeding, milking, sampling similar to previous EHB.

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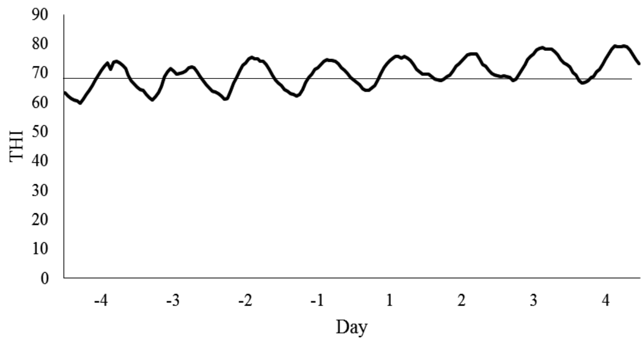
Temperature humidity index (THI)



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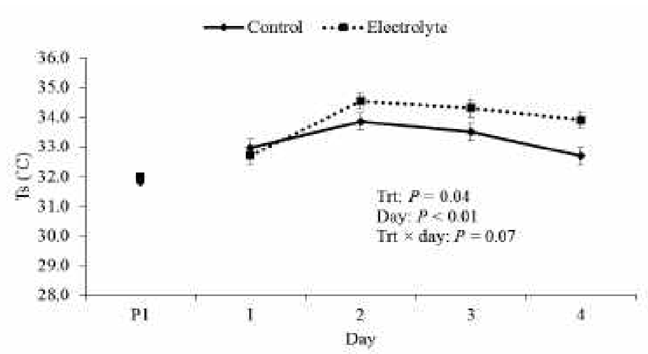
Effects of EOEC vs skin temperature



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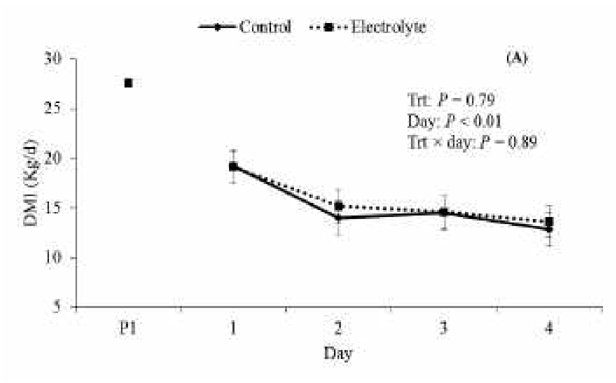
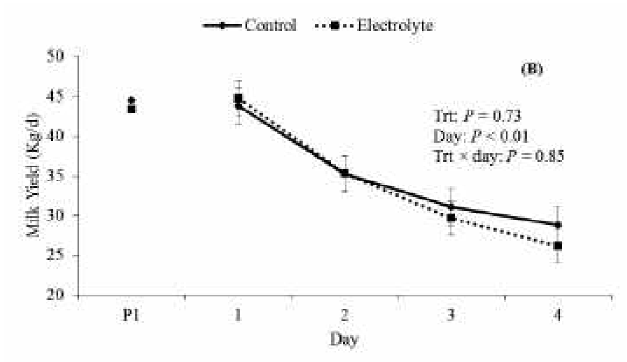
Effects of EOEC on DMI



Conclusions

- ➢ **Employing the EHB model:**
  - ✓ **Increased body temperature indices**
  - ✓ **Altered metabolism**
  - ✓ **Reduced productivity (DMI & Milk Yield)**
- ➢ **EOEC (dietary) supplementation**
  - ✓ **Increased skin temperature indices**
  - ✓ **Altered metabolism (glucose, insulin, NEFA)**
  - ✓ **No effects on DMI, Milk Yield / components)**
  - ✓ **No effects on most other parameters.**
  - ✓ **How long to supplement to see effects?**

Effects of EOEC on Milk Yield



Overall Summary

- ➢ **EHB model: EXCELLENT HS MODEL!**
  - ✓ **Increased body temperature indices**
  - ✓ **Altered metabolism**
  - ✓ **Reduced productivity (DMI & Milk Yield)**
  - ✓ **Similar to natural HS & envir. chamber models**
- ➢ **EHB model: Nutritional studies!**
  - ✓ **Very sensitive to short term effects if there**
  - ✓ **How long to implement strategy for response**
- ➢ **EHB model: Future studies!**
  - ✓ **Yeast products! Other products/strategies? Uof IL**

Other results: EHB and / or EOEC (diet)

- ➢ EHB ↑↑↑ rectal, vaginal, skin temps (1.6^{0}C, 1.5^{0}C, 1.7^{0}C (p <.01))
- ➢ EHB ↑↑ respiration and heart rates (> 2X and 11 bpm (p <.01))
- ➢ EHB ↓↓↓ DMI (45%) and milk production (38% d 4) (p < .01)
- ➢ EHB ↑↑ MUN 34%
- ➢ No EHB / dietary effects on all other milk components
- ➢ No dietary effects on temps and rates except Skin Temperature ↑↑
  - ✓ Possibly suggests ↑↑ heat dissipation, likely via ↑ sweating
- ➢ EOEC: ↑↑↑ glucose (5%, p =.07) and insulin (1.95X, p < .01)
- ➢ EOEC: ↓↓ NEFA (20%, p = .06) in period 2.
- ➢ No dietary effects in most other parameters.

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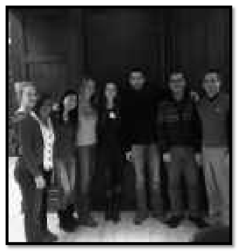
Acknowledgments

- **Baumgard Lab**
- **Ramirez Lab**
- **Appunhamy Lab**
- **Timms Lab**
- **Samantha Lei**
- **ISU Dairy Farm**
- **Undergraduate Assistants**



Integrating Cover Crops and Livestock to Improve Farm Profitability

Brad Heins and Hannah Phillips
West Central Research and Outreach Center
University of Minnesota, Morris, Minnesota

Integrating Cover Crops and Livestock to Improve Farm Profitability

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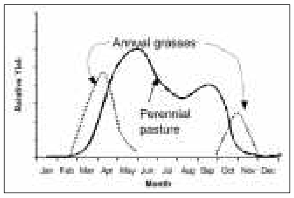
[1]University of Minnesota West Central Research and Outreach Center, Morris, MN
[2]Iowa State University, Ames, IA

Small grain winter cover crops

- **Grow in cool temperatures**
- **Improve soil health**
  - **Reduce leaching and erosion** (Dabney et al., 2001)
  - **Fit into soil building plan** (USDA-NOP, 2017)
- **Other uses**
  - **Typically, stored feed**
  - **May extend grazing season**



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Why Cover Crops?

- **Provide crop diversity**
- **Improve soil fertility**
- **Nutrient cycling**
- **Keep soil covered over winter**
- **Integration of livestock on cropland**
- **Provide early season forage for grazing livestock**

Background on the study

- **Locations**
  - **University of Minnesota** (Morris)
  - **Iowa State University** (Greenfield)
  - **Rodale Institute** (Kutztown, PA)
- **Objectives**
  - **Biological outcomes of crop and livestock integration**
    - Evaluate soil health, forage/crop production, pest/beneficial insects
    - Grazed vs. ungrazed
    - Legume vs. corn rotations

Socioeconomic

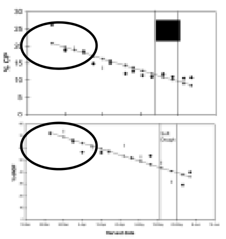
Animal nutrition and food safety/health of beef
Forage quality
Meat quality – carcass, consumer
Health of beef – fatty acids, amino acids
Food safety – microbial contaminants

Extension and outreach

Grazing small grains

- **Concerns for forage quality**
  - **Rapidly decrease in:**
    - **Crude protein (CP)**
    - **Neutral detergent fiber digestibility (dNDF)**
- **Higher quality in early spring** (Moyer and Coffey, 2000)
  - **Lower plant maturity**
  - **Grazing**

CP and dNDF of winter wheat at different harvest dates



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Crop/Pasture Rotation

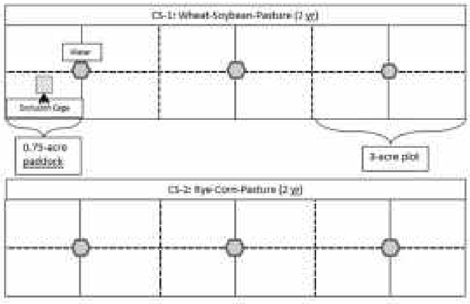
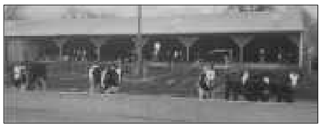


Figure1. Experimental design showing the 2 crop sequence treatments (rotations) replicated three times. Each 3-acre plot is sub-divided into four 0.75-acre paddocks during the grazing phases of the study.

Grazing dairy steers

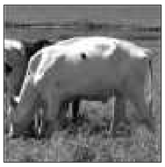
- **Born spring 2015 and group housed (6 replicated breed groups)**
  - **6 L of organic milk daily and starter grain *ad lib.***
- **Weaned at 10 w and over-wintered with organic TMR**
- **Remained in their respective replicated breed group**

Loose confinement barn



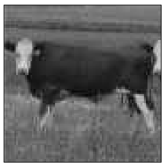
Breed groups

HOL (n = 10)



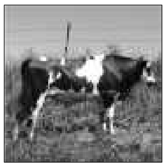
Comprised of:
- **Holstein**

MVH (n = 10)



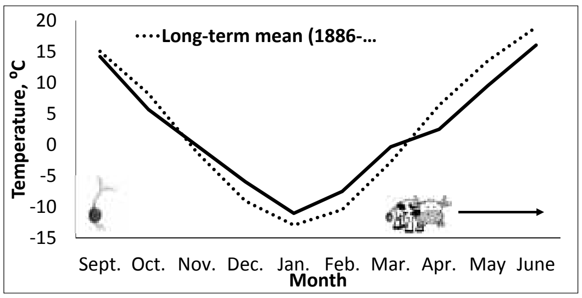
Comprised of:
- **Montbéliarde**
- **Viking Red**
- **Holstein**

NJV (n = 10)



Comprised of:
- **Normande**
- **Jersey**
- **Viking Red**

Monthly temperature over the growing season



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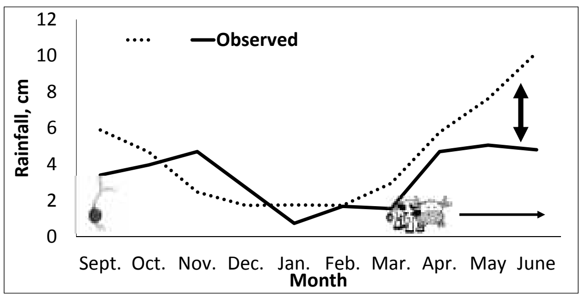
Monthly rainfall over the growing season



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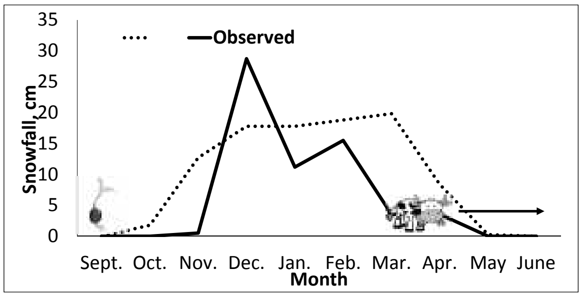
Monthly snowfall over the growing season



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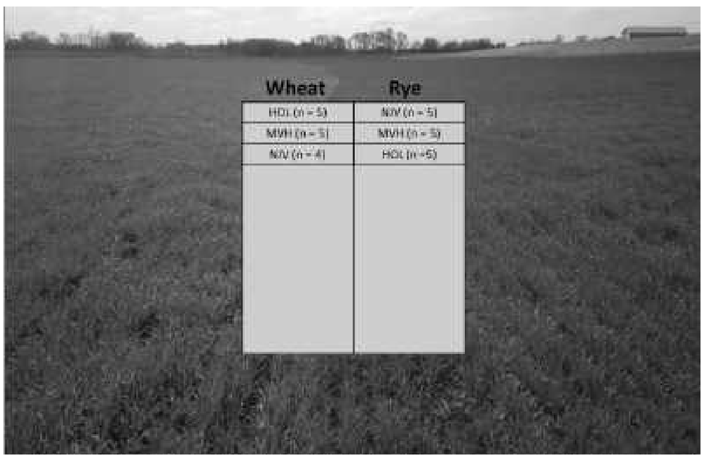
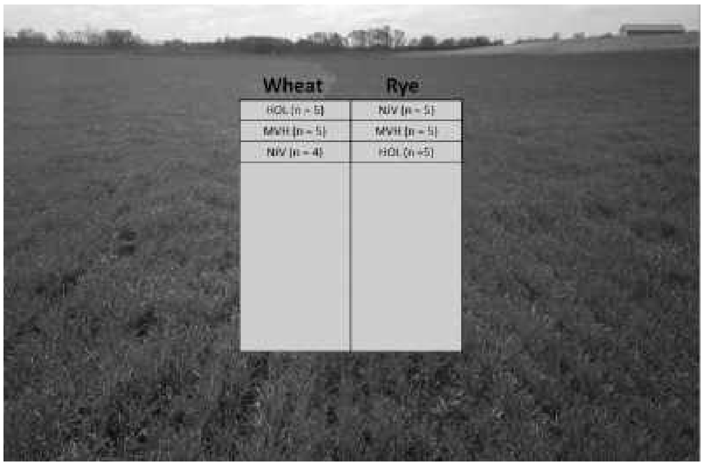
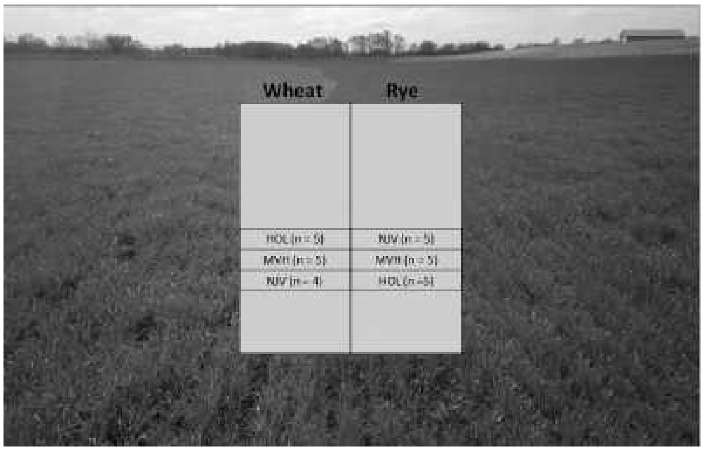
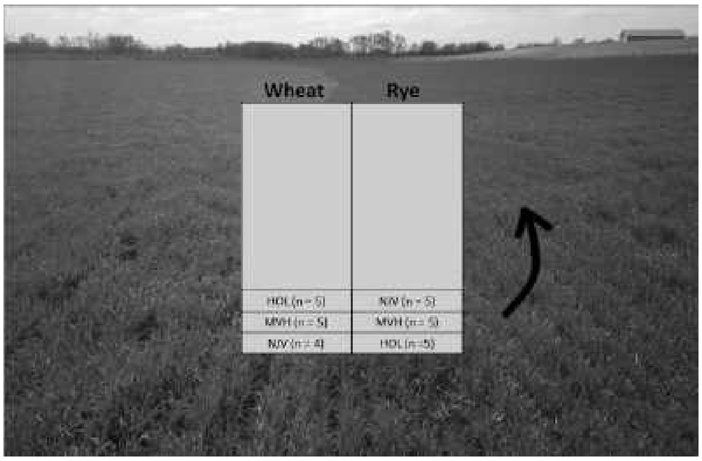


Wheat	Rye
HOL (n = 5)	NJV (n = 5)
MVH (n = 5)	MVH (n = 5)
NJV (n = 4)	HOL (n = 5)



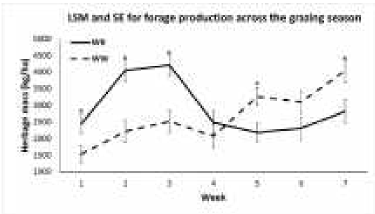


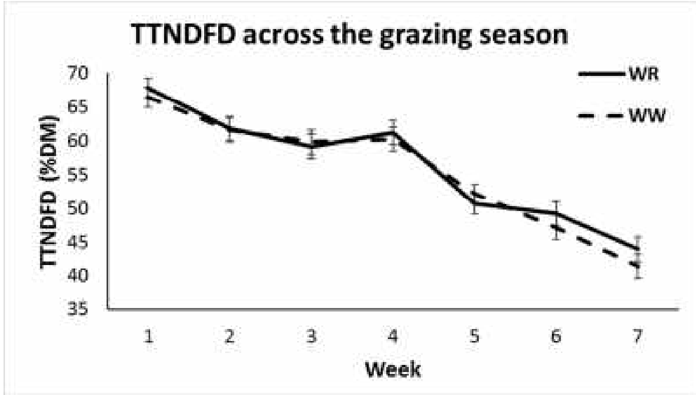



Stopped grazing June 13 2016 when seed head formed

Herbage Mass of grasses

Variable	Winter rye	Winter wheat	P-value
Herbage mass (kg/ha)	2,925	2,674	0.28



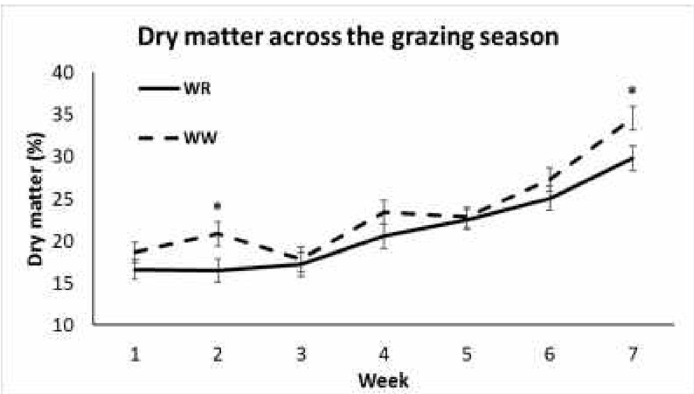


Forage quality of grasses

Variable	Winter rye	Winter wheat	P-value
Dry matter (%)	21.2	23.6	0.01
Crude protein, %DM	17.6	19.0	0.03
Lignin,%	2.72	2.55	0.25
NDF, %DM	48.0	45.1	0.01
TTNDFD, %DM	56.2	55.5	0.99
NE_g, Mcal/kg	0.44	0.44	0.32
Ne_l , Mcal/kg	0.69	0.69	0.50
RFQ	177.3	178.2	0.85

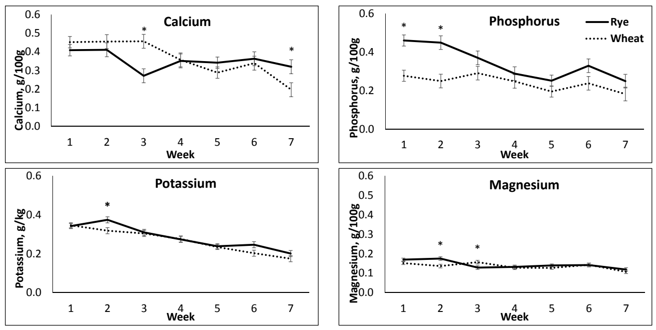
Mineral quality of grasses

Variable	Winter rye	Winter wheat	P-value
	---- %DM ----		
Calcium	0.35	0.36	NS
Phosphorous	0.34	0.24	0.01
Potassium	2.84	2.65	0.05
Magnesium	0.14	0.14	NS



* = means within week are different between forages

Mineral compositions across the grazing season



* Means within a week are different at $P < 0.05$.

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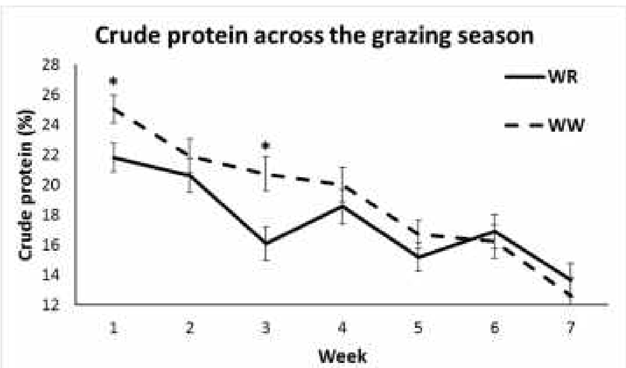


* = means within week are different between forages

Carcass quality - cover crops

Measurement	Winter rye	Winter wheat	SE[1]
Live wt, kg	470.2	471.1	3.5
Hot carcass wt, kg	225.0	230.4	4.4
Dressing, %	47.8	49.0	0.94
Marbling score[2]	1.9	2.1	0.16
Back fat, cm	0.27	0.30	0.04
Ribeye area, cm[2]	50.3	48.2	3.1
Yield grade	1.9	1.9	0.09

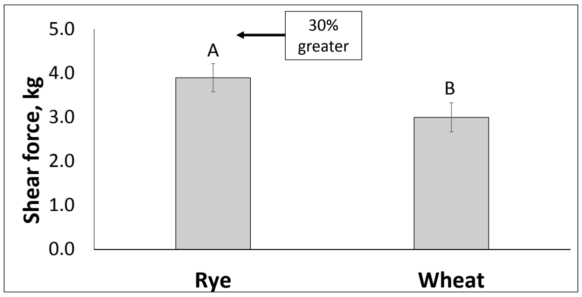
[a,b] Means within a row without a common letter are different at $P < 0.05$.
[1] Standard errors are the same for cover crops.
[2] Slightly abundant = 5; moderate = 4; small = 3; slight = 2; traces = 1.

Likeness of steaks - cover crops

Sensory attribute[1]	Winter rye	Winter wheat	SE[2]
Overall	66.7[b]	72.0[a]	1.4
Flavor	66.5[b]	70.3[a]	1.5
Texture	66.1[b]	74.3[a]	1.4

[a,b] Means within a row without a common letter are different at $P < 0.05$.
[1] 0 = greatest imaginable disliking; 120 = greatest imaginable liking
[2] Standard errors are the same for cover crops.

Effect of cover crop on shear force



A,B Means without common letters are different at $P < 0.10$.

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Intensity of steaks - cover crops

Sensory attribute[1]	Winter rye	Winter wheat	SE[2]
Toughness	8.9[a]	7.3[b]	0.3
Juiciness	8.0[b]	9.2[a]	0.3
Off-flavor	5.6[a]	4.8[b]	0.4

[a,b] Means within a row without a common letter are different at $P < 0.05$.
[1] 0 = none ; 20 = extremely intense
[2] Standard errors were the same for cover crops.

Fatty acids - cover crops

	Winter rye		Winter wheat	
Fat	LSM	SE	LSM	SE
	--------- *% weight in fat sample* ---------			
Saturated	44.3	0.83	42.6	0.86
cis-monounsaturated	47.7	0.91	49.6	0.94
cis-polyunsaturated	3.67	0.11	3.65	0.11
trans	4.26	0.19	4.16	0.19
Omega-3	0.54	0.02	0.56	0.02
Omega-6	3.04	0.10	3.02	0.10
Omega-6/3 ratio	5.76	0.19	5.41	0.20

Means within a row are not different ($P > 0.05$).

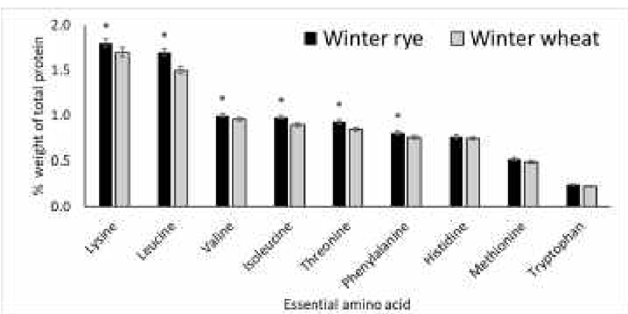
Rye Ungrazed Economics

Total Costs	$305.45	$71.19	$376.64
Returns over variable cost		$405.81	
Returns over total cost		$100.36	
Return to Land, Labor, and Management		$379.72	
Return to Land and Management		$370.36	
Return to Management		$100.36	

Rye Grazed Economics

Total Costs	$290.96	$62.27	$353.23
Returns over variable cost		$153.73	
Returns over total cost		($137.23)	
Return to Land, Labor, and Management		$142.13	
Return to Land and Management		$132.77	
Return to Management		($137.23)	

Amino acids - cover crops



*** Means within a column are different at *P* < 0.05.**

Profitability per head

Income	Price	Unit	Quantity	Unit	Total
Steer sales	[illegible]	per lb	[illegible]	lbs	[illegible]
Variable Costs	Price	Unit	Quantity	Unit	
Feeder Cost	[illegible]	per lb	[illegible]	lbs	$585.45
Interest	[illegible]		[illegible]	months	[illegible]
Feed Costs					
Alfalfa hay	[illegible]	per ton	[illegible]	ton	[illegible]
Supplement & minerals	[illegible]	per lb	[illegible]	lbs	[illegible]
Corn silage	[illegible]	per ton	[illegible]	ton	[illegible]
Pasture grazing	[illegible]	[illegible]	[illegible]	AUM	[illegible]
Crop grazing	[illegible]	[illegible]	[illegible]	AUM	[illegible]
Total Feed Costs					[illegible]
Veterinary and health					[illegible]
Machinery and equipment					[illegible]
Marketing and miscellaneous					[illegible]
Interest on variable costs	[illegible]		[illegible]	months	[illegible]
Labor	[illegible]	per hour	[illegible]	hours	[illegible]
Death loss	[illegible]				[illegible]
Total Variable Costs					[illegible]
Income over Variable Costs					[illegible]
Fixed Costs					
Machinery, equipment, housing					[illegible]
Total All Costs					[illegible]
Income over All Costs					[illegible]
Breakeven selling price for variable costs					[illegible] per lb
Breakeven selling price for all costs					[illegible] per lb

Conclusions

- Herbage mass was similar for winter wheat and winter rye
- Crude protein was greater for winter wheat compared to winter rye
- Similar TTNDFD for all grasses
- Grazing producers may incorporate winter wheat and winter rye to provide adequate forage in grazing systems without sacrificing forage quality

Conclusions

- No differences in fatty acids for winter rye and winter wheat cover crops.
- Crossbred steers had 14% greater omega-3 and a 14% lower omega-6/3 ratio compared to Holstein steers.
- Overall, consumers preferred beef from steers finished on winter wheat compared to winter rye.
- Overall, consumers preferred beef from crossbred steers compared to Holstein steers.

Integrating Cover Crops and Livestock to Improve Farm Profitability

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West Central Research and Outreach Center
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It is well established that winter cover crops, when used in rotation with other crops, improve soil health. Cover crops are commonly used as a "green manure" or harvested for grain and straw; however, they could potentially be grazed with livestock in the early spring and summer. In addition, grazing is a low-input method to feed livestock which could improve soil health by adding fresh manure to the field or pastures. Farmers who want to improve soil health and utilize a low-input grazing system may benefit from integrating crops and livestock in their system. Integrating crops and livestock on a multi-function operation could have multiple benefits and the potential to improve the profitability of these kinds of operations.

Researchers at Iowa State University, the University of Minnesota, and Rodale Institute are in the third year of a four-year project, funded by the USDA Organic Research and Extension Initiative, to evaluate the production, environmental, and economic benefits of growing cash crops with forage crops for grazing, including small grains and hay crops for livestock feed. They are comparing two crop rotations—pasture-winter wheat-soybean-pasture and pasture-winter rye/hairy vetch-corn-pasture—and grazing dairy steers on the cover crops as a method of integrating livestock and organic cropping systems.

At the University of Minnesota West Central Research and Outreach Center's organic dairy in Morris, Minn., the dairy bull calves are: Holsteins; crossbreds comprised of Holstein (HOL), Montbéliarde, and Viking Red (MVH); and crossbreds comprised of Normande, Jersey, and Viking Red (NJV). Researchers there are grazing steers on a pasture divided in half for the two crop sequences (S1: Pasture-wheat-soybean, and S2: Pasture-rye/vetch-corn). These pastures are separated into 15 paddocks, with a non-grazed enclosure in each paddock. Winter wheat (WW) and winter rye (WR) forages were planted on Sept. 11, 2015, for grazing during spring 2016. During this spring, calves were randomly assigned to replicated groups (winter wheat or winter rye), but balanced by breed group to reduce potential breed bias. Twelve-month old dairy steers started grazing the wheat and rye pastures on April 25, 2016. Forage samples were collected when steers moved to new paddocks which was about every three days.

Winter rye (2,626 lbs DM/acre) had greater herbage mass compared to winter wheat (2,021 lbs DM/acre). Crude protein was very high in both the winter wheat and winter rye across the grazing season, which lasted until June 14, 2016 for these grasses. From early May through the end of the grazing season, the crude protein was lower than at the start of grazing; however, the steers were probably more efficient at utilizing the protein when it was lower compared to high protein levels observed during late April. Digestibility (see figure) of the winter wheat and rye also was very high. As the wheat and rye matured, the digestibility was lower; however, the dairy steers grazed each paddock and wheat and rye four times in a two-month period.

For cover crops, HOL and MVH steers did not differ in body weight between cover crops throughout the grazing season. However, NJV steers grazing WW tended to be heavier than NJV steers grazing WR throughout the grazing season. For average daily gain, breed groups did not differ throughout the grazing season. At harvest, MVH and HOL steers weighed more than NJV steers, and steers grazed on WW (483 kg) weighed more than steers grazed on WR (458 kg). Dressing percent, marbling score, back fat, ribeye area, and yield grade were not different between breeds or cover crops.

For cover crop differences, beef from steers grazing WW had higher flavor, texture, juiciness, and overall liking, and lower toughness and off-flavor compared to beef from steers grazing WR. For breeds, the NJV steaks had a higher texture liking and lower toughness compared to steaks from both MVH and HOL. Furthermore, NJV and MVH steaks had higher juiciness than HOL steaks. The NJV steaks had a higher overall and flavor liking than HOL steaks.

The omega-6 and 3 FA's were not different between steers that grazed WW compared to WR. From this study, cover crops did not influence omega-6 or 3 FA concentration in the fat of beef. The omega-3 FA concentration was higher in fat from MVH steers compared to HOL fat. The omega-6/3 ratio was higher in HOL back fat compared to NJV and MVH back fat. Although these steers were finished on a forage diet, they received grain during the pre and post weaning stages. This may have influenced the higher omega-6/3 ratio in this study than steers fed a no-grain diet throughout their lifetime.

In this study, the wheat and rye cover crops were ready to graze 3 weeks earlier than other perennial pastures on the farm. This study not only applies to grazing steers, but to grazing dairy cows as well. By grazing cover crops, we were able to start grazing 3 weeks earlier in the grazing season and graze the system 3 times through with about 16 days of rest between grazing periods. Grazing winter wheat and winter rye are both feasible to graze in the early spring and summer.

The integration of livestock in organic cropping systems is a prerequisite for long-term agricultural stability. We are studying methods to integrate crops and livestock to determine this model's effect on animal performance, crop productivity (including small grains for grazing), soil quality, food safety and social acceptance.

Costs of Raising Calves Using Individual or Automated Feeding

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Critical Control Points

- Calf Enterprise
  - Keeping heifers healthy
  - Minimize morbidity and mortality
  - Optimizing growth potential
  - Improving labor efficiency
  - Reducing time to first conception
  - Optimizing calving age
  - Minimize involuntary cull rates

Heifers… An Investment in the Future Dairy Herd

- Provide high quality replacements for improving genetic progress.
- Heifer raising is the second largest expenditure on the dairy farm.

The shift to group-housed feeding systems

- Increased labor efficiency
  - Shift from physical labor to management
  - Employee challenges
- Calf well-being
  - Socialization
  - Natural behaviors
  - Smoother transition from birth to post-weaning

Source: J. Bentley, Leave No Calf Behind Series: Considerations for Success of Automatic Calf Feeding Systems

Intuitive Cost of Production Analysis

Individual versus Automated

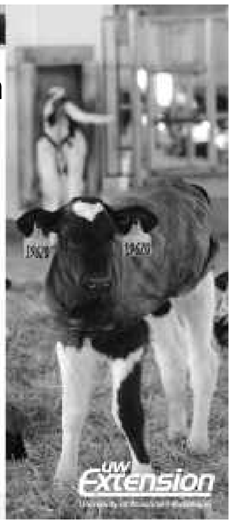
Our Farms

11 Traditional Calf Feeding Systems

15 Automated Calf Feeding Systems

Intuitive Cost of Production Analysis (ICPA)

- An analysis system that calculates producer-specific costs and labor efficiencies associated with raising dairy replacements
- Evaluates cost and labor efficiencies
- Provides an economic and labor efficiency benchmark for dairy herd replacements



Key Calf Assumptions

Item	
Calf Value	$200
Labor (paid and unpaid)	$13 per hour
Management (paid and unpaid)	$22 per hour
Interest rate	4.5%
Waste milk (non-saleable)	$8 per cwt (feed costs)
Whole milk (saleable)	$17 per cwt (market value)
Replacement Value of Calf Housing*	
Homemade calf hutch	$200
Purchased calf hutch	$400
Greenhouse barn	$10 per square foot
Post-frame calf building	$15.50 per square foot

**Provided by UW-Extension Dairy Engineering Specialist David Kammel, 2017*

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Historical Cost of Raising a Calf in WI

Birth to Time When Moved to Transition Housing

	1999	2007	2013	2017 Individual Housing	2017 Autofeeder
Total Cost	$160.26	$326.07	$363.69	$419.62	$431.19
Daily Cost	$2.68	$5.42	$5.51	$5.84	$6.35
Days on Feed (birth to moving)	59.70	61.36	68.60	70.32	67.85
Weaning Age					
Weeks	7.40	7.04	7.61	7.86	7.96
Days	51.80	49.28	53.27	55.02	55.72

Cost of Raising a Calf - Total

Birth to Time When Moved to Transition Housing

	Cost per Calf*	
	Traditional (n=11)	Automated (n=15)
Feed costs	$165.53	$202.00
Liquid	$111.95	$140.50
Starter	$53.26	$60.96
Paid Labor & Management	$116.52	$74.13
Other Variable Costs	$40.75	$47.76
Fixed Costs	$40.89	$77.69
Total Allocated Cost	$363.69	$401.58
Unpaid Labor/Management	$55.93	$29.61
Allocated Cost + Unpaid Labor/Mgmt	$419.62	$431.19

****Does not include calf value***

Liquid Feeding Costs

Milk replacer cost	$/lb powder	1.34
Pasteurized whole milk (includes pasteurizer cost)	$/lb solids or $/gallon	0.77

- Operations feeding higher milk amounts can reduce cost by using pasteurized whole milk
- Avg. cost of pasteurizer/lb solids = $0.05/lb solids
- Some farms used salable milk for feeding since not enough waste milk

Cost of Raising a Calf - Daily

Birth to Time When Moved to Transition Housing

	Cost per Calf*	
	Traditional (n=11)	Automated (n=15)
Feed costs	$2.35	$2.93
Liquid	$1.60	$2.08
Starter	$0.75	$0.84
Paid Labor & Management	$1.57	$1.18
Other Variable Costs	$0.59	$0.73
Fixed Costs	$0.58	$1.13
Total Allocated Cost	$5.09	$5.97
Unpaid Labor/Management	$0.75	$0.38
Allocated Cost + Unpaid Labor/Mgmt	$5.84	$6.35

****Does not include calf value***

Fixed Costs: Housing & Equipment

		Traditional	Automated
Housing	$/calf/day	0.39	0.80
Equipment	$/calf/day	0.19	0.33

- Automated facilities higher due to newer facilities
- All automated systems less than 10 years old
  - Many traditional systems over 20 years old
- New facilities had less depreciation
  - As facilities age, difference will likely lessen

Feeding Costs

		Traditional	Automated
Liquid feed	$/calf/day	$1.60	$2.08
Starter	$/calf/day	$0.75	$0.84
Milk Replacer cost	$/calf/day	$1.46	$2.56
Milk Replacer powder	lb/calf	79.7	134.4
Whole milk cost	$/calf/day	$1.18	$1.27
Whole milk solids (12.5%)	lb/calf	106.9	115.2
Balancer cost	$/calf/day	$0.30	$0.33
Balancer (if feeding whole milk)	lb/calf	11.8	15.5

Labor & Management

		Traditional	Automated
Labor (paid & unpaid)	$/calf/day	$1.99	$1.30
Management (paid & unpaid)	$/calf/day	$0.33	$0.26
Labor & Management Required	hours/calf	12.5	7.4
Labor Efficiency	calves/hour	7.8	11.6
	calves/day	62.7	93.2

Labor & Management

Iowa State University Calf Management Practices-Producer Survey

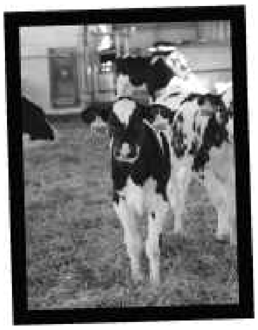
Labor Changes			
Task	Time		Range
Current Feeding Labor Time per day	8.0	min/calf	5-10 minutes
Anticipated Feeding labor Time per day	1.0	min/calf	1 minute
Current calf labor management per day	7.0	min/calf	4-9 minutes
Anticipated calf labor management per day	7.0	min/calf	4-9 minutes
Increased hours for record management	0.5	hrs/day	
Decreased hours for labor management	0.5	hrs/day	

Stay tuned…

- Health Management Survey by Tina Kohlman and Sarah Mills-Lloyd is close to completion

Labor & Management

Iowa State University Calf Management Practices-Producer Survey



- Minimal labor time saved
- Labor time more flexible
- Labor versus management
- Some reported average 1.5 hours per day reduced labor

Source: J. Bentley, Leave No Calf Behind Series: Considerations for Success of Automatic Calf Feeding Systems

Take home messages

- Autofeeder operations had higher liquid feeding costs
  - Use of whole milk helped control costs
- Paid and unpaid labor costs lower for autofeeder operations
  - Management costs similar
- Housing costs higher for autofeeder operations
  - Newer facilities; difference may lessen over time

The Canadian Canola Industry – Serving the US Dairy Industry

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The canola industry in Canada is growing at an exciting pace, fueled by the demand for quality end products, oil and meal. Countries around the world recognize the value of canola oil, as the vegetable oil with the least amount of saturated fat, and the meal as a quality protein source, and in fact the second most commonly traded protein source in the world.

Amongst all of the growth, both at home and abroad, one thing has stayed consistent. The USA remains one of the most valued markets for canola end products. The industry has a strong plan for growth, moving from the current production of 21 million metric tonnes in 2017 to 26 million metric tonnes by 2025. This means the potential for more availability of quality canola oil and meal coming off of the Canadian prairies.

When it comes to canola meal, the US dairy industry is the biggest buyer, and for good reason. Canadian canola meal has been consistently demonstrated as a superior protein source for lactating dairy cows. The canola industry along with Agriculture and Agri-Food Canada, has invested over a million dollars in US dairy scientists in an effort to uncover the true advantage seen when canola meal is fed. This research is helping US dairy nutritionists formulate rations with correct nutrient values, in order to maximize use of canola meal in formulation programs. This work ultimately reaches US dairy producers.

To learn more about canola meal, you can visit Canolamazing.com or connect with any of the following US dairy researchers: Dr. Kenneth Kalscheur, Dr. Peter Robinson, Dr. Antonio Faciola and Dr. Glen Broderick. The Canola Council of Canada looks forward to continuing to work on canola meal research to the benefit of the US dairy industry.

Canola Meal, a Proven Advantage in Various Diet Formulations

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Introduction

The past decade has given rise to a shift in the paradigm around feeding protein to dairy cattle. This can be attributed to a greater understanding of dairy cattle protein requirements, desire to reduce ration costs through increased efficiency, and reduction in the environmental impact of dairy cattle waste. The use of oilseed crop by-products as animal feed is an effective way to feed dairy cattle and supply required nutrients, specifically protein. While soybean meal has long been a staple in North American dairy rations, the popularity of canola meal inclusion is on the rise due to an increase in canola production, particularly in Canada. The increased availability of this quality animal feed has necessitated research efforts to evaluate its value in dairy production systems.

Canola is a variety of rapeseed. A member of the Brassica genus, it is bred to produce an edible oil fraction and protein feed suitable for livestock. Two endemic compounds to rapeseed, glucosinolates and erucic acid, negatively impact the use of oil and meal fractions for human or animal consumption via toxicity and decreased palatability (Tripathi and Mishra, 2007). It was not until the mid-1970's that Canadian plant breeders were able to develop cultivars low in these two compounds, increasing the use of canola products (Stefansson and Kondra, 1975). The nomenclature "canola", "double-low" rapeseed, or "double-zero" rapeseed is used to identify these improved varieties from their less desirable counterparts. Meal glucosinolate levels of <30 µmol/g and oil erucic acid levels of <2% are maintained to denote high quality rapeseed (Canola Council of Canada, 2015).

Nutrient composition

Canola meal has been shown to be a quality protein by-product when used as an animal feedstuff. Its position in the marketplace and use in dairy cow rations will be supported by evaluating the production response of cows fed canola meal compared directly to other protein by-products and how the nutrient fractions of canola meal behave in the dairy cow. In an evaluation of solvent-extracted canola meal from 11 different North American plants, crude protein ranges 40.6 to 43.7% of DM over a 4-year period (Table 1; Adewole et al., 2016). Soybean meal values range between 46.3 and 55.9% DM (Table 1; Dairy One, 2017). Canola has a considerably larger NDF fraction (Table 1; 27.4 to 30.9% of DM; Adewole et al., 2016), whereas soybean meal tends to fall within 7.8 to 19.2% NDF, % of DM (Table 1; Dairy One, 2017). The RUP fraction of canola ranged from 32.3 to 46.1% of CP, with a mean of 41.0% RUP, % of CP when evaluated *in situ* (Table 1; Jayasinghe et al., 2014). A comparison sample of solvent extracted soybean meal was tested and RUP fraction was 31.0% or CP (Table 1; Jayasinghe et al., 2014). When similar samples were evaluated in vitro the mean RUP was slightly higher approximately 44.0% RUP, % of total N compared to solvent extracted soybean meal with 34.9% RUP, % total N (Broderick et al., 2016). While a higher proportion of canola meal crude protein reaches the small intestine, the availability of this protein fraction is less than soybean meal. Intestinally digestible protein (IDP) ranged from 71.6% to 77.4% when evaluated using a modified 3-step *in situ/in vitro* procedure, whereas soybean meal was 94.5% IDP, % of RUP (Table 1; Jayasinghe et al., 2014). These values are similar to those determined by the National Research Council, 75% for canola meal and 93% for soybean meal (NRC, 2001).

Feeding studies

The majority of the feeding studies evaluating the inclusion of canola meal in dairy cow diets on production responses have been used in two published meta-analyses. In the 2011 meta-analysis, which included 292 treatment means from 122 peer-reviewed studies, DMI, milk yield, and energy-corrected milk were greater for canola meal-fed cows, compared to those fed soybean meal (Huhtanen et al., 2011). Dry matter intake, milk yield, and energy-corrected milk were greater for cows fed diets formulated with canola meal versus soybean meal. A second meta-analysis conducted by Martineau et al. (2013) compared the substitution of canola meal with various vegetable protein sources (soybean meal, corn gluten meal, cottonseed meal and distillers grains). Milk yield, 4% fat-corrected milk, milk protein yield, and dry matter intake increased as canola meal replaced all protein sources. When comparing canola meal directly with soybean meal, milk protein yield increased, however, 4% fat-corrected milk yield was not different. In a third meta-analysis evaluating the response of plasma amino acids and milk urea nitrogen (MUN) to changes in the protein sources in the diet, Martineau et al. (2014) found that essential amino acids were higher and MUN was lower when cows were fed canola meal compared to all other protein sources.

More recently, canola meal has been included in a variety of different diet formulations to evaluate whether it performs similarly to alternative protein sources. Several studies were conducted evaluating canola meal at two protein concentrations versus an alternative protein source. Broderick et al. (2015) evaluated the inclusion of canola meal compared to soybean meal formulated at 14.7 or 16.5% CP in the diets (on a DM basis). They found that replacing soybean meal with canola meal increased DMI 0.88 lb/d, increased milk yield 1.98 lb/d and true protein yield 0.66 lb/d. In addition, MUN and urinary nitrogen excretion were lower for cows fed canola meal compared to cows fed soybean meal consistent with findings from Martineau et al. (2014). In this study, CP concentration did not affect DMI, milk yield or true protein yield. Acharya et al. (2015) evaluated the inclusion of canola meal compared to distillers dried grains with solubles (DDGS) formulated at 14.3 or 16.3% CP in the diet (on a DM basis). They found that DMI, milk yield and true protein yield was the same regardless of protein source; however, MUN was lower for cows fed the canola meal compared to cows fed DDGS. In this study, cows fed the higher protein diet (16.3% CP) were higher in DMI, milk yield, and milk protein yield compared to cows fed the lower protein diet (14.3% CP). When replacing DDGS with canola meal at the same protein concentration, Mulrooney et al. (2009) found that DMI, milk production, and milk composition was similar regardless of the protein supplement. On the other hand, Swanepoel et al. (2014) found that cows fed a diet with a mixture of canola meal (67%) and DDGS (33%) out-performed diets formulated with canola meal or DDGS alone.

To evaluate the inclusion of canola meal across a range of different diet formulations, several experiments were conducted to determine how forage inclusion or changes in starch source or concentration may affect dairy cow performance when canola meal is included in the diets. Schuler et al. (2013) evaluated the optimum dietary forage concentration when using canola meal as the primary protein source. Forage (70% corn silage and 30% alfalfa haylage) was included in the diet at 42, 50, 58, and 66% of the diet (DM basis). Canola meal was included at a constant 11% of the diet (DM basis). As forage increased in the diet, DMI decreased linearly, while milk yield and energy-corrected milk remained the same across all 4 diets. As a result, feed efficiency (ECM/DMI) increased linearly as forage increased from 42 to 66% of the diet.

Two studies were conducted to investigate whether starch source or starch concentration would affect lactation performance in dairy cow diets formulated with canola meal. To evaluate whether starch source affects lactation performance, Jayasinghe et al. (2015) fed diets varying in proportions of ground corn and rolled barley. No differences in DMI, milk yield, or milk protein were found when starch source varied. To evaluate whether starch concentration and protein source affects lactation performance, Sanchez-Duarte et al. (2016) fed diets with two protein sources (canola meal and soybean meal) at two dietary starch concentrations (21 and 27%, DM basis). Cows fed the high starch diets formulated with canola meal performed similarly to cows fed the SBM diets, but had greater DMI and milk yield compared to cows fed the low starch diets formulated with canola meal. It was thought that increasing dietary starch concentration in diets with canola meal seem to improve protein utilization compared to cows fed lower dietary starch concentrations.

While studies conducted on dairy cows at and after post-peak milk production have demonstrated similar or slightly more milk production for cows fed canola meal compared to other protein sources, there has been very little research investigating the use of canola meal in early lactation dairy cows. To determine the impact of feeding canola meal in early lactation, Moore and Kalscheur (2016) conducted an experiment with 79 multiparous Holstein cows that received diets formulated to be high protein, 17.6% CP (% of DM) or low protein 15.4% CP (% of DM) provided by either canola or soybean meal. Cows were enrolled at calving and production was followed for 16 weeks of lactation. Cows fed canola meal out-performed those that received soybean meal, producing (mean ± SEM) 122.8 vs 112.9 ± 2.14 lb/d of milk, respectively. While cows fed canola meal diets tended to have a higher DMI compared to cows fed soybean meal diets (56.9 vs 55.1 ± 0.75 lb/d, respectively), this additional DMI was not fully responsible for the improvement performance. More research on transition and early lactation dairy cows is needed to further investigate how canola meal improves production.

Conclusions

While changes in market dictate when canola, soybean meal, or another protein source can be favorably incorporated into dairy cow diets, there are potential benefits for using canola meal as a protein source in the diets of lactating dairy cows. Mid-lactation dairy cows result in similar or slightly greater performance when canola meal is included in their diets, but there appears to be great potential of including canola meal in the diets of early lactation dairy cows. Canola meal is a proven protein source that can be formulated in a wide range of lactating dairy cow diets.

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Table 1. Canola versus soybean meal nutrient composition and digestibility				
	Canola meal		Soybean meal	
Item	**Mean**	**Range**	**Mean**	**Range**
Crude protein	41.7[a]	40.6 - 43.7[a]	51.1[b]	46.3 - 55.9[b]
Ether extract	3.5[a]	2.8 - 4.0[a]	4.38[b]	0.0 - 9.1[b]
Ash	7.5[a]	7.2 - 8.0[a]	7.3[b]	5.9 - 8.6[b]
NDF	29.4[a]	27.4 - 30.9[a]	13.5[b]	7.8 - 19.2[b]
RDP, % of CP	59.0[c]	53.9 - 67.7[c]	69.0[c]	-
RUP, % of CP	41.0[c]	32.3 - 46.1[c]	31.0[c]	-
IDP,[1] % of RUP	74.8[c]	71.6 - 77.4[c]	94.5[c]	-
[1]Intestinally digestible protein.				
[a]Adewole et al. (2016).				
[b]Dairy One (2017).				
[c]Jayasinghe et al. (2014).				

Canola Meal for Early Lactation Cows

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Introduction

Energy and protein demands in early lactation are great. Feed intake during the postpartum period does not provide the nutrient quantity necessary for the lactating animal and therefore, body reserve mobilization occurs (Drackley, 1999; Ji and Dann, 2013). It is common to raise the energy density of the early lactation diet to combat this problem. However, caution must be taken to ensure rumen health is not negatively impacted by this practice. Transition-related disorders can be exacerbated when this balance is not negotiated with care. Alternatively, increasing the protein concentration of the diet in early lactation has not shown to negatively impact the rumen environment. The dairy cow utilizes protein as an energy source and amino acids for the synthesis of milk lactose and protein, respectively. Increasing the quantity or the quality of the protein provided during this period can be a useful tool in managing the highly sensitive and important transition period. The focus on this period of lactation is imperative because it dictates the production potential for the lactation.

Amino acids

Feed protein serves to supply many tissues with essential amino acids for innumerable functions within the body. The first two limiting amino acids, lysine (Lys) and methionine (Met) are recommended for inclusion at a ratio of 3:1 to optimize metabolizable protein for milk production (NRC, 2001; Liu et al., 2013). The amino acid profile of canola meal has a ratio of Lys to Met at 3.01:1, whereas soybean meal has a ratio of 4.37:1 (NRC, 2001). Therefore, canola meal can be used to provide essential amino acids in a proportion needed by the cow with limited reliance on protein from other feedstuffs. The impact of providing adequate Lys and Met in early lactation can have dramatic effects on maximizing milk yield and components. Enriching diets with Lys and Met during the transition period (3 weeks pre-partum to 3 weeks postpartum) increased daily milk yield 1.50 lb/d and milk protein 0.18 lb/d throughout the first 16 weeks of lactation (Garthwaite et al., 1998; Grummer, 1995; Liu et al., 2013). This describes the importance of balancing for essential amino acids during the transition period and the responsiveness of the cow to varying concentrations or supplementation of amino acids.

Increase in early lactation milk yield

An experiment was conducted at the U.S. Dairy Forage Research Center in Prairie du Sac, WI. Four treatment diets were fed, beginning at parturition. A total of 79 multiparous Holstein cows received high protein (17.6% CP, % of DM) or low protein (15.4% CP, % of DM) diets. The main protein source was provided by either canola or soybean meal. The diets were formulated to reflect a typical Midwestern ration composition; 55.0% forage (39.6% corn silage, 15.4% alfalfa silage) and 45% concentrate mix on DM basis. Canola meal was included at 19.4% and 11.9% DM, whereas soybean meal was included at 14.5% and 8.9% DM. The study lasted 8 months and followed each animal through 16 weeks of lactation.

Replacing soybean meal with canola meal produced a significant increase in milk production in treatment animals; (mean ± SEM) 122.8 vs 112.9 ± 2.14 lb/d of milk, respectively (Moore and Kalscheur, 2016; Figure 1). There was not a commensurate increase in DMI to support the increase in production. Canola meal-fed cows tended to have higher DMI (56.9 vs 55.1 ± 0.74 lb/d; Moore and Kalscheur, 2016; Figure 2). This resulted in a trend for improved feed efficiency (ECM/DMI) in canola meal-fed cows compared those fed soybean meal (2.27 vs 2.16 ± 0.38; Moore and Kalscheur, 2016). Therefore, efficiency of nutrient utilization and body reserve turnover contributed to the additional energy required for greater milk yield. The source of CP did not affect milk fat, protein, lactose, or total solids concentration. Dietary CP concentration had an inverse relationship with the concentration of milk fat and total solids. As diet CP was reduced, milk fat and total solids percentage increased (4.09 vs 3.90 ± 0.07% fat and 12.8 vs 12.5 ± 0.95% total solids; Moore and Kalscheur, 2016). There are concerns to consider when feeding higher protein levels. While the animal is able to use the higher protein concentration to meet some energy and protein deficiencies, the amount of nitrogen excreted as waste also increases. This was reflected in greater milk urea N (MUN) from cows fed high protein diets than those fed low protein diets (12.6 vs 9.82 ± 0.22 mg/dL; Moore and Kalscheur, 2016). Milk urea N tended to be lower for cows fed canola meal compared to cows fed soybean meal (10.9 vs 11.4 ± 0.22 mg/dL) which is consistent with previous work (Martineau et al., 2014; Broderick et al., 2015). It should be noted that milk yield did not increase with additional dietary protein. This is indicative of a protein quality effect versus a quantity response. The additional protein in the diet did not produce a significant increase in milk yield. However, the quality of protein provided by canola meal induced a dramatic response during this early lactation period.

Conclusion

In this study, early lactation dairy cows fed diets formulated with canola meal tended to have greater DMI, produced more milk, and showed a greater efficiency of nitrogen utilization. These data suggest that fluid milk production and efficiency of nutrient conversion to milk can be improved in early lactation with the inclusion of canola meal in dairy rations. There are a vast number of systems within the biology of the cow that are affected by transition-related nutrition. The system is in a deficit at this time and therefore more responsive to the type of protein supplied. This study did not balance for amino acids, but rather replaced one protein source for the other on an isonitrogenous basis. Evaluating transition cow nutrition in this way was valuable in discerning the differences in the protein sources and the biological system.

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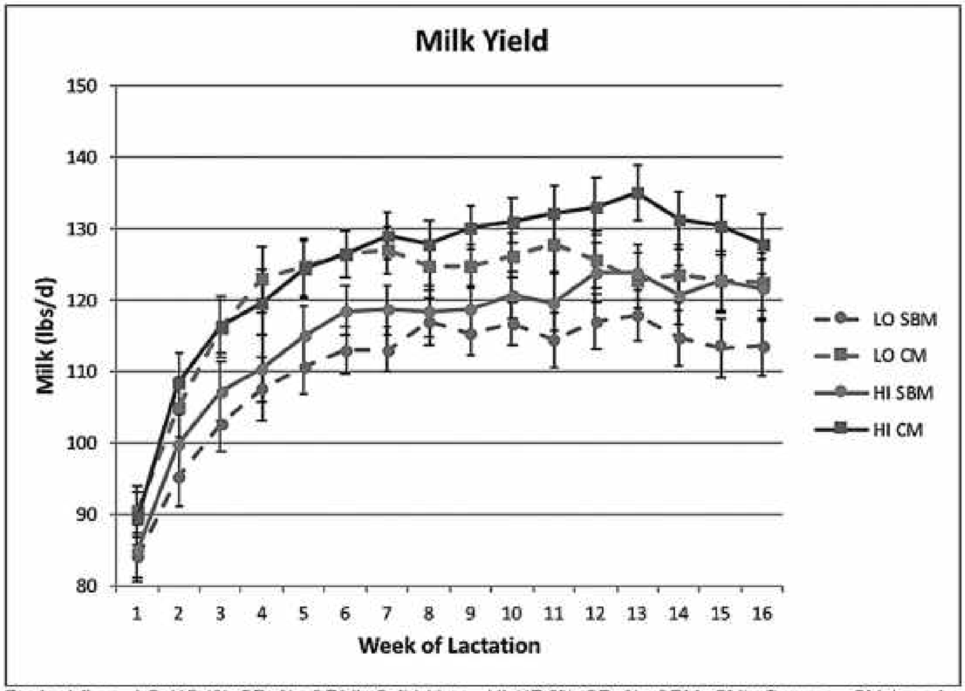
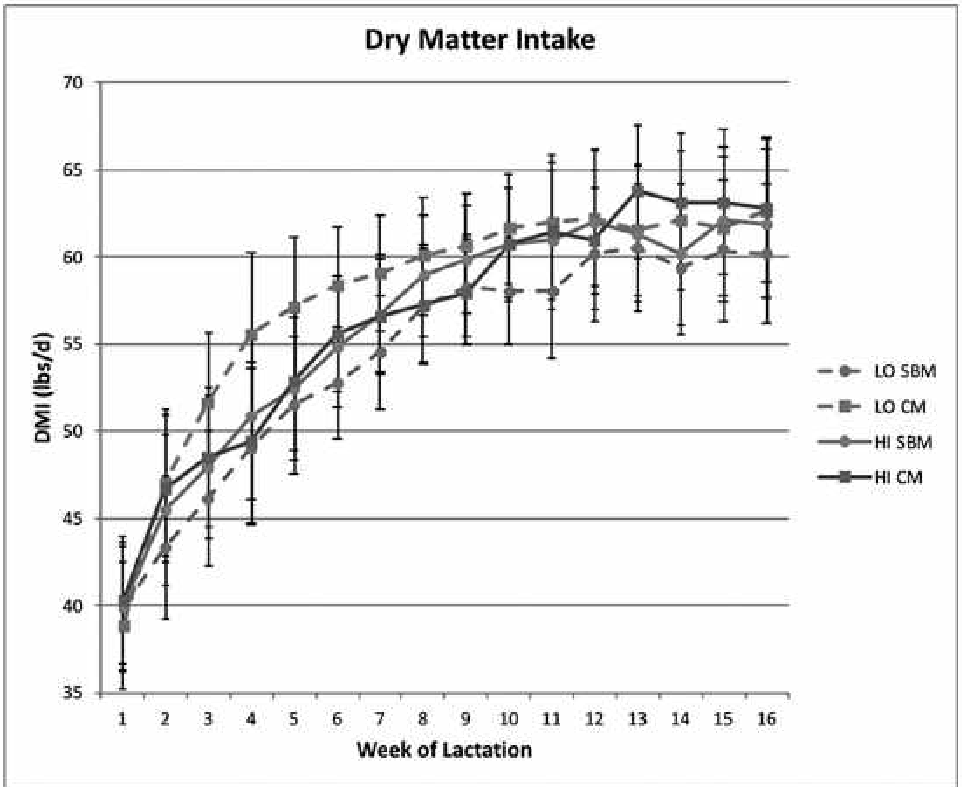
Figure 1. Milk yield by week of lactation



Dashed line = LO (15.4% CP, % of DM); Solid Line = HI (17.6% CP, % of DM; CM); Square = CM (canola meal); Circle = SBM (soybean meal).

Figure 2. Dry matter intake by week of lactation.



Dashed line = LO (15.4% CP, % of DM); Solid Line = HI (17.6% CP, % of DM; CM); Square = CM (canola meal); Circle = SBM (soybean meal).

Getting Canola Meal Values Right in Your Formulation

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Introduction

Feeding studies conducted at the U.S. Dairy Forage Research Center as well as elsewhere in the USA and Canada have repeatedly shown that dairy cows produce about 2 pounds more milk than would be expected from the formulation (Table 1 and Table 2). About 6 years ago, with the assistance of programs sponsored by Agriculture and Agri-Food Canada the Canola Council of Canada invested in numerous studies to determine the nutritional worth of canola meal for lactating dairy cows, and to provide updated nutrient values for this ingredient. The purpose of this extensive research was to provide fair and accurate feeding values for canola meal so that the ingredient can be used in diets with confidence of results. lso important to remember that the composition of drinking water is not only under natural influence but septic tanks, milk-house wastes and industrial drainage or drilling practices (Vidic et al., 2013) may also contribute to these composition problems. It is generally recommended that the water supply for cattle should be evaluated several times a year for coliforms, pH, minerals, nitrate and nitrites, and total bacteria. Expected levels and potential benchmarks of concerns for common water quality tests are given in Table 2.

Updated nutrient values for canola meal

Canola meal is a fairly new protein source. Developed in the 1970s from rapeseed meal, it had undergone continuous improvements, moving from a somewhat difficult to use protein to a premium product. Many existing databases rely on values from early studies, and these do not really relate to the meal at hand. The NRC (2001) publication Nutrient Requirements of Dairy Cattle, lists older values for expeller canola meal, and no values for solvent extracted meal. This key publication lacks representation of a feed ingredient that is predominantly available as solvent extracted canola meal. Furthermore, the methodologies used to assess nutritional values have likewise been improved as time passed. In situ disappearance of protein was the gold standard, and is now recognized as providing misleading values for rumen undegraded protein (RUP) and rumen degraded protein (RDP). Commercial laboratories currently provide an amazing selection of low cost assays to determine these values along with rates of digestion and digestibility.

The project to determine accurate feeding values was multifaceted. A survey was conducted that involved 12 canola processing facilities in Canada. Three samples of canola meal were obtained annually for 4 consecutive years. These samples were then analyzed by several laboratories. The complete set of samples was analyzed by Dr. Bogdan Slominski and his team at University of Manitoba (Adewole et al., 2016). This group of researchers tabulated proximate analyses as well as fiber sub-fractions, amino acids, and total tract digestibility in monogastric animals (Adewole et al., 2017a,b). The Manitoba group also assessed the presence of antinutritional factors. The complete sample set was furthermore analyzed by scientists at the U.S. Dairy Forage Research Center, under the guidance of Dr. Glen Broderick (Broderick et al., 2016). This laboratory used the Inhibitor Method (Colombini et al., 2011) to assess protein degradation in the rumen and determined digestibility of protein fractions. Protein and fiber digestion was determined in continuous culture at the University of Nevada under the supervision of Dr. Antonio Faciola. In addition, a portion of the samples were submitted to Dr. Debbie Ross, at Cornell University for evaluation of protein and amino acids using the Multi-Step Protein Evaluation System (Ross et al., 2013).

Results

The results of the analysis were eye-opening, and helpful in explaining the results found in past studies when canola meal was compared to other vegetable proteins. In a nutshell, the results showed that a high proportion of the protein in canola meal escaped fermentation in the rumen. In addition, the amino acid profile of the escape protein was found to be quite similar to the amino acid profile of rumen microbes, and well suited to efficient use for milk protein synthesis.

The meal contains a high proportion of lignin. However, this does not appear to interfere with fiber digestion, and the digestibility of the fiber fraction was determined to be considerably greater than in older tables. As a result the metabolizable energy value of the meal was determined to be greater as well.

An interesting observation on Table 1 and 2 is that the urea N is lower in diets that contain canola meal. The reason for this is because there is less rumen degraded protein, which ultimately gets absorbed and must be disposed by the cow. This also means that there is more RUP that can be efficiently used by the cow.

Why rule of thumb estimations are not reliable- and what can be done

Ingredient buyers must make decisions regarding ingredient procurement with the goal of remaining as competitive as possible. Purchasers have a variety of rules or systems for assessing the value of an ingredient. It is not unusual for purchasing departments in mills and on dairies to rely on an intuitive dollar value spread between various protein ingredients. For example, canola meal might only be considered when the price is $75 less than soybean meal. How do such methods compare to the actual feeding value of the ingredient?

Prices for vegetable proteins vary, and some ingredients may be better buys some years than other years. In the above example, if soybean meal is priced at $300/ton, then canola meal would appear on the radar screen when the price is $225 or below. Basically one would be assessing the value of canola meal at 75% of the value of soybean meal. However, with the price of soybean meal at $500/ton, canola meal would be purchased if the price were below $425. Canola meal would be worth 85% of the value of soybean meal. However, the nutritional worth to the cow does not change.

Another approach is to compare on the basis of protein content. Canola meal has 77% of the protein of high protein soybean meal so therefore the price should be 77% of the current price of soybean meal. However, most nutritionists do not formulate diets on the basis of crude protein, and the RDP and RUP are of greater importance. As Table 3 shows, canola meal provides as much RUP as soybean meal on a pound/pound basis. If this metric were used than the price paid for CM should be equal to that of SBM!

There are other differences as well. The RUP in canola meal provides 40% more methionine than soybean meal, but it also has 10% less lysine. If methionine is limiting, then canola meal might be a good choice, while perhaps not so if ingredients at hand are marginal in lysine.

Rule of thumb type valuations can either over or under value the comparative worth of canola meal or any other protein ingredient in feeding circumstances. It is possible to make a wrong choice and not buy canola meal, as well as make a wrong choice by buying canola meal, or any other protein being substituted. For more on the topic see the article "Comparison of feed proteins for dairy cows takes careful thought", in Feedstuffs, July 5th 2017 issue (Broderick et al., 2017).

Handy tools

To try and remove some of the guesswork when comparing protein ingredients, the Canola Council of Canada developed the Dairy Feed Calculator. This calculator assigns comparative values to feed proteins. Values are assigned based on costs for RUP, RDP, energy. This tool can be accessed at http://canolamazing.com/feed-calculator/. Use is not restricted to canola meal.

Another important tool is the Feed Val program developed by University of Wisconsin and maintained by Dr. Victor Cabrera (http://dairymgt.uwex.edu/tools.php#feeding). This program takes advantage of up to date nutrient values that have been determined for canola meal. There are other similar programs, but the user needs to be aware of the values that are being used in the matrix. Those that rely on NRC (2001) data for nutrient values will be out of date for many ingredients.

But probably the most important method of assessing the value of a protein is to evaluate it in a feed formulation program. Feed formulation programs assess the value in relationship to other ingredients available in each unique situation. For example, the value of more methionine in the RUP fraction may or may not be important, based on other ingredients available: grains, forages and byproducts. Or, methionine might be more valuable than predicted by other methods. The tools provide relative values based on a few nutrients. In actual fact, any nutrient can cause ingredients to gain or lose in importance in feed formulation.

Are your values up to date?

Every effort has been made to supply platforms with up-to date values. If there remain doubts about a particular platform, nutrient profiles can be compared to values found at canolamazing.com, where a spreadsheet is available for downloading. Should this be inadequate, either of the authors can be contacted for additional support.

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Table 1. Comparison of feeding results from the U.S. Dairy Forage Research Center (Faciola and Broderick, 2013)

	Canola Meal	Soybean Meal
Dry-matter intake, lbs.	52.4	51.7
Milk yield, lbs.	82.1	80.1
Fat Yield, lbs.	3.21	3.19
Protein yield, lbs.	2.46	2.42
Milk urea nitrogen, mg/dL	12.9	14.0

Table 2. Comparison of feeding results from the U.S. Dairy Forage Research Center (Broderick et al., 2015)

	Canola Meal	Soybean Meal
Dry-matter intake, lbs.	55.9	55.0
Milk yield, lbs.	89.4	87.4
Fat Yield, lbs.	3.56	3.47
Protein yield, lbs.	2.70	2.63
Milk urea nitrogen, mg/dL	10.4	11.5

Table 3. Comparison of rumen undegraded protein values for soybean meal and canola meal (canolamazing.com)

Variable	Soybean Meal	Canola Meal
Crude protein, %	48.0	37.0
Degraded (RDP), %	53.6	40.0
Not degraded (RUP), %	47.4	60.0
Not degraded (RUP), % of meal	22.8	22.2
Digestibility, %	93.0	85.0
Available RUP, % of meal	21.2	18.9

Table 4. Amino Acids in the RUP fraction of protein as compared to milk (canolamazing.com)

	Milk	Canola meal	Blood meal	Soybean meal	Corn Gluten meal
Methionine	2.5	2.1	0.8	1.5	2.0
Lysine	7.5	5.7	9.2	6.3	1.5

Evaluating Feeding Financials

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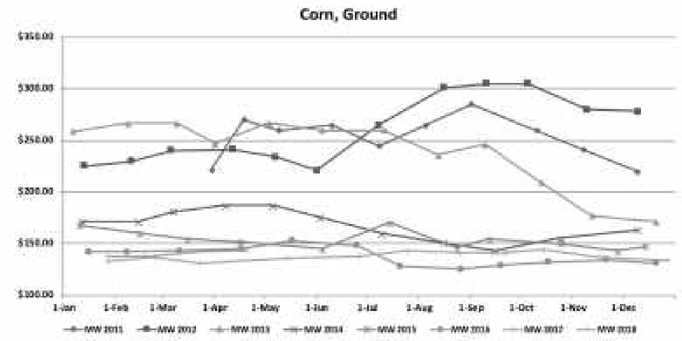
Market View

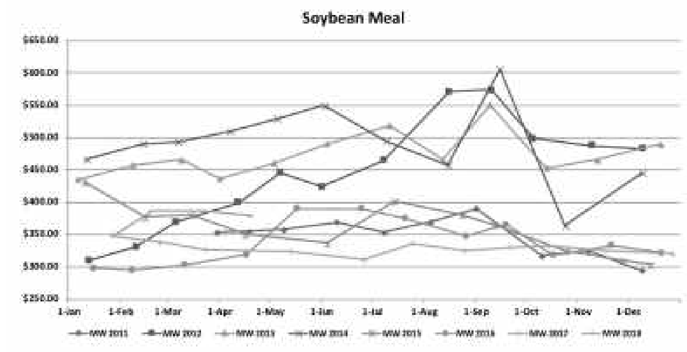
Evaluating Feeding Financials

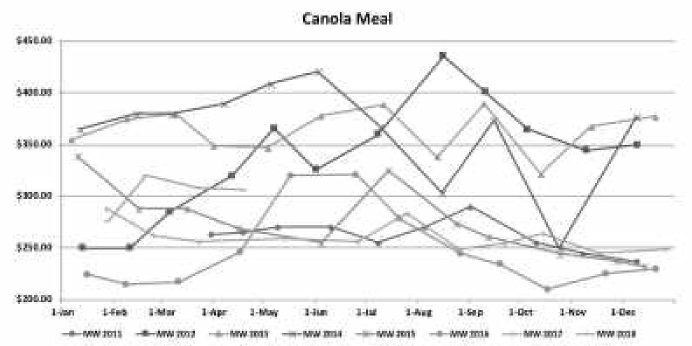
- **Feed costs are the highest expense on a P&L.**
  - Which measurements guide us to higher profit either through increased revenue or decrease cost or some combination?
  - Which measurements guide us to better decisions?
  - Are we monitoring and tracking the right information for daily, weekly, monthly and yearly decisions?
  - Which measurements guide us to higher feed efficiency?

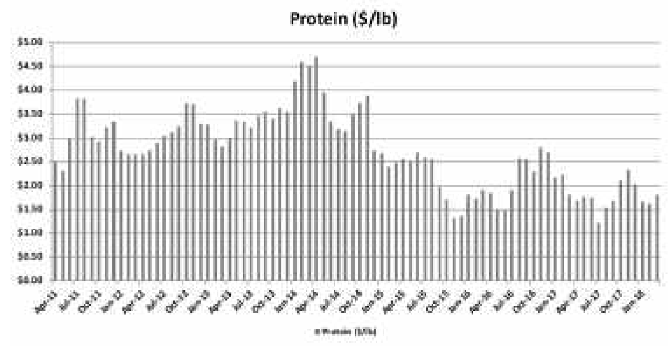


Feed Financial Terms

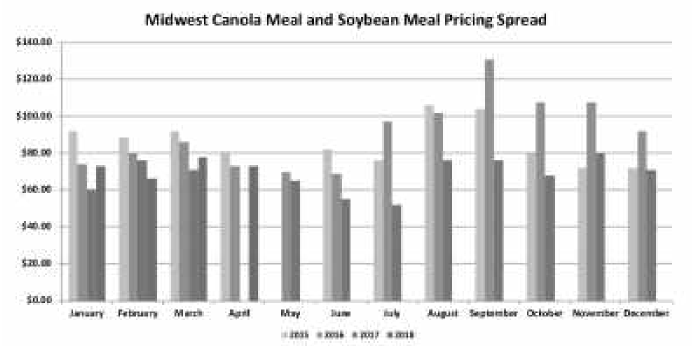
- **Feed costs** – per ton, per lb, per lb DM, per hd, per cwt, per ECM cwt, per FCM cwt, per MCM cwt, actual feed costs, static feed costs, How are forage costs being valued?
- **Milk** – lbs, cwt, components, FCM 3.5% or 4%, ECM 3.5% fat and 3.0% protein or 4% fat and 3.0% protein, lbs fat and protein, MCM or RCM
- **Milk Value** - $ per cwt, component values, PPD, basis, quality premiums, What drives the milk check?
- **Dry matter intake** – Are we tracking DMI? Do we have feeding software? Does DMI include weighback or not? Are DM's being adjusted on wet feeds routinely?
- **Inventory** – How much do we need? How do we monitor?
- **Shrink** – It is real! Where is it? Are we tracking? How are we tracking?

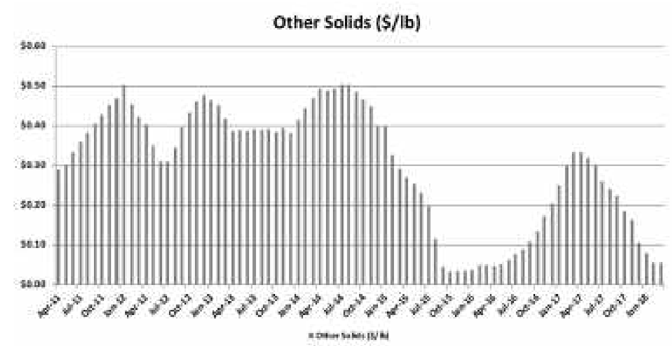






Milk Component Values (www.ams.usda.gov)





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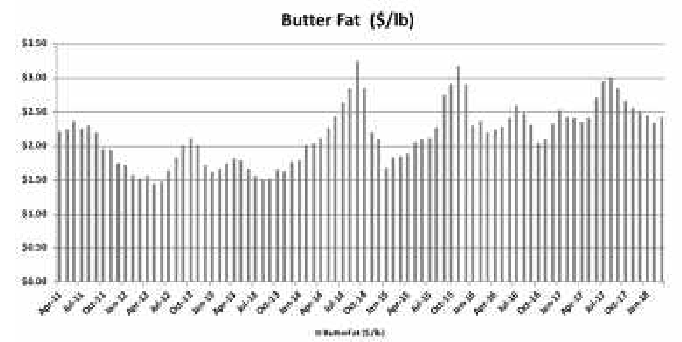

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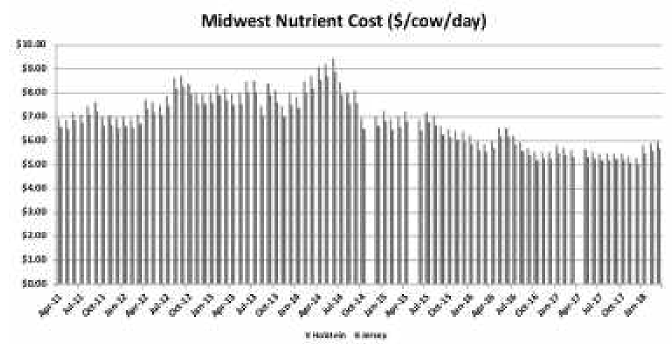
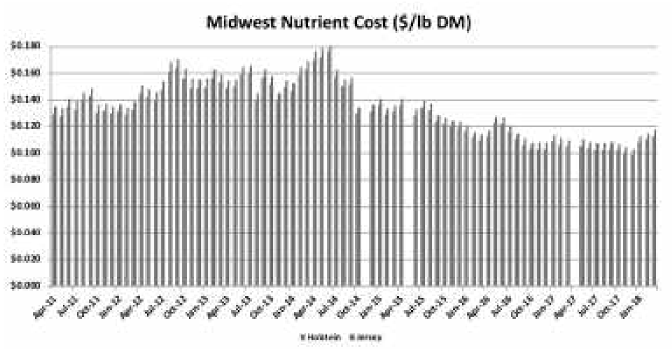
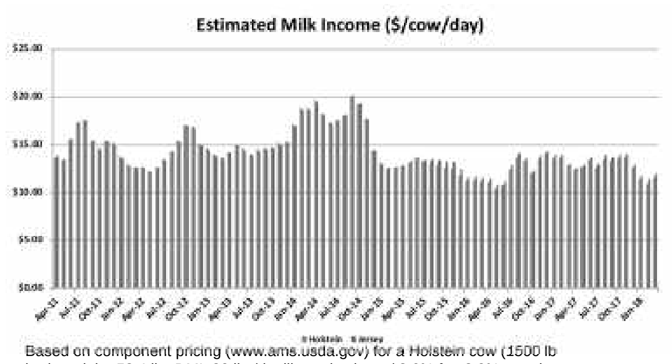


Nutrient Cost for a Holstein cow (1500 lb body weight, 53.4 lbs DMI, 80 lbs/d milk production w/ 3.6% fat, 3.0% protein, 5.7% other solids) and a Jersey cow (1200 lb body weight, 48.5 lbs DMI, 65 lbs/d milk production w/ 4.8% fat, 3.6% protein, 5.7% other solids) (St-Pierre, 2011, ADSA DC22-Milk Components).



Nutrient Cost for a Holstein cow (1500 lb body weight, 53.4 lbs DMI, 80 lbs/d milk production w/ 3.6% fat, 3.0% protein, 5.7% other solids) and a Jersey cow (1200 lb body weight, 48.5 lbs DMI, 65 lbs/d milk production w/ 4.8% fat, 3.6% protein, 5.7% other solids) (St-Pierre, 2011, ADSA DC22-Milk Components).

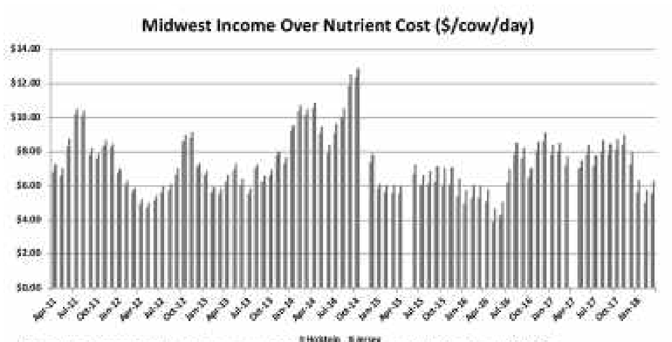
Farm view



Based on component pricing (www.ams.usda.gov) for a Holstein cow (1500 lb body weight, 53.4 lbs DMI, 80 lbs/d milk production w/ 3.6% fat, 3.0% protein, 5.7% other solids) and a Jersey cow (1200 lb body weight, 48.5 lbs DMI, 65 lbs/d milk production w/ 4.8% fat, 3.6% protein, 5.7% other solids) (St-Pierre, 2011, ADSA DC22-Milk Components).

Feed costs per cwt on P&L's

- Calculated by accrual usage of feed consumed (or fed) by milking and dry cows divided by cwts of milk shipped.
- Provides long term picture of how well the farm converted feed costs into saleable cwts.
- Takes into account mik cow numbers, milk level, prices paid for feeds, DMI, shrink, weighbacks, hospital cows, dry cow numbers, and dry period lengths.
- It is impacted by reproduction performance, DIM, cow comfort, milking frequency, facility design, as well as other factors.
- Biggest weakness is it ignores the value of milk. Both components and SCC. Comparing accross different component level herds would be misleading information.



Based on component pricing (www.ams.usda.gov) for a Holstein cow (1500 lb body weight, 53.4 lbs DMI, 80 lbs/d milk production w/ 3.6% fat, 3.0% protein, 5.7% other solids) and a Jersey cow (1200 lb body weight, 48.5 lbs DMI, 65 lbs/d milk production w/ 4.8% fat, 3.6% protein, 5.7% other solids) (St-Pierre, 2011, ADSA DC22-Milk Components).

Feed costs per "corrected"cwts on P&L's

- Corrected cwts trying to take into account differences in components of milk to help provide a better financial number.
- FCM – Fat Corrected Milk typically corrected to 3.5% milk fat. No correction for milk protein.
- ECM - Energy Corrected Milk typically corrected to 3.5% fat and 3.0% protein. Corrects for the energy of the milk but not value.
- MCM – Money Corrected Milk is corrected for a value for milk fat, milk protein, other solids, quality, hauling, and basis. Developed by Dr. Greg Bethard. A revenue-based measure.

Income over feed costs (IOFC)

- IOFC can been seen calculated on P&L's as milk income minus feed costs either as $, or per cwt, or per corrected cwt.
- A better reference of IOFC is the margin that is calculated as milk revenue per cow per day minus feed costs per cow per day.
- Feeding and management changes that increases IOFC would be good as long as the change does not impact cow health.
- IOFC is influenced by feed costs, milk price, DMI, milk lbs, and the value of the components and premiums.
- Most common margin used to measure feeding economics.

Feeding Efficiency

- Measures the relative ability of cows to turn feed nutrients into milk or milk components.
- Typcially calculated using a milk output metric divided by intake (DMI).
- Many milk output metrics are being used:
  - **Milk/DMI** - misleading and should not be used
  - **ECM/DM**I - more widely used
  - **FCM/DMI** - does not take into account protein.
  - **Total components/DMI**
  - **MCM/DMI** – takes into account value of milk output.
- Feed efficiency is one tool to use for monitoring herd performance but should never be used alone!

Component lbs

- Calculated by adding the lbs of fat and lbs of protein together per day.
- Easy calculation and has become an indicator for quick reference to performance.
- Component lbs has been used in conjunction of DMI to calculate a component efficiency metric.
- Component static revenue and static feed costs can be used to calculate Component IOFC.

MCM IOFC or Static IOFC

- Calculated by using a fixed price for feed, component prices, and other milk check assessment values that reflect market conditions.
- Calculation will reflect changes in cow performance taking into consideration feed costs, DMI, milk lbs, component value and component changes in milk.
- Results can be monitored daily and actions taken when appropriate.
- Analysis to recipe changes like additives can be monitored with better confidence to their benefits.
- Provides the best measure of dairy feeding economics.

Money Corrected Milk (MCM)

- Revenue based measure of cow productivity.
- Takes into consideration the economic value of components and milk check assesments.
- MCM is expressed back to lbs of milk per cow per day and typically uses 3.5% milk fat and 3.0% milk protein along with 5.70% other solids for basis.
- Results can be monitored daily and actions taken when appropriate.
- Analysis to recipe changes like additives can be monitored with better confidence to their benefits.

Calculations of Financial Performance

Milk, lbs	Fat %	Protein %	DMI	Feed $	$/hd/day	IOFC	ECM	MCM	Lbs fat & prot	3.5% FCM
95.0	3.68	3.10	60.0	$ 6.30	$ 17.60	$ 11.30	98.1	98.6	6.44	97.8
92.0	3.90	3.10	60.0	$ 6.30	$ 17.62	$ 11.32	97.7	98.8	6.44	98.0

Class III	$ 16.34
Fat $/lb	$ 2.85
Protein $/lb	$ 1.70
other Solids	$ 0.22
Basis - all other	$ 1.50
Cost per lb DM	$ 0.105

Calculations of Financial Performance

Milk, lbs	Fat %	Protein %	DMI	Feed $	$/hd/day	IOFC	ECM	MCM	Lbs fat & prot	3.5% FCM
95.0	3.68	3.10	60.0	$ 6.30	$ 17.50	$ 11.20	98.1	98.1	6.44	97.8
92.0	3.90	3.10	60.0	$ 6.30	$ 17.30	$ 11.00	97.7	97.0	6.44	98.0

Class III	$ 16.35
Fat $/lb	$ 1.75
Protein $/lb	$ 2.64
other Solids	$ 0.40
Basis - all other	$ 1.30
Cost per lb DM	$ 0.105

Calculations of Financial Performance

Milk, lbs	Fat %	Protein %	DMI	Feed $	$/hd/day	IOFC	ECM	MCM	Milk/DMI	ECM/DMI	MCM/DMI
91.0	3.78	3.11	62.0	$ 6.51	$ 17.13	$ 10.62	95.3	96.0	1.47	1.54	1.55
80.6	4.15	3.35	54.6	$ 5.73	$ 16.35	$ 10.62	90.0	91.7	1.48	1.65	1.68
65.0	5.05	3.90	46.0	$ 4.83	$ 15.46	$ 10.63	83.4	86.7	1.41	1.81	1.88

Class III	$ 16.34
Fat $/lb	$ 2.85
Protein $/lb	$ 1.70
other Solids	$ 0.22
Basis - all other	$ 1.50
Cost per lb DM	$ 0.105

Calculations of Financial Performance

Milk, lbs	Fat %	Protein %	DMI	Feed $	$/hd/day	IOFC	ECM	MCM	Milk/DMI	ECM/DMI	MCM/DMI
95.0	3.68	3.10	60.0	$ 6.30	$ 17.60	$ 11.30	98.1	98.6	1.58	1.63	1.64
92.0	3.90	3.10	60.0	$ 6.30	$ 17.62	$ 11.32	97.7	98.8	1.53	1.63	1.65
95.0	3.90	3.10	63.0	$ 6.62	$ 18.19	$ 11.58	100.9	102.0	1.51	1.60	1.62

Class III	$ 16.34
Fat $/lb	$ 2.85
Protein $/lb	$ 1.70
other Solids	$ 0.22
Basis - all other	$ 1.50
Cost per lb DM	$ 0.105

Calculations of Financial Performance

Date	Milk Sold	Cows in Tank	Hosp	% Hosp	% mast	Meter Milk	Tank Milk	Fat	Prot	DMI	SCC	Meter MCM	IOFC
1	491,360	5,235	105	2.0	1.2	78.3	93.9	4.34	3.49	54.6	185	93.5	$12.85
2	382,200	5,251	106	2.0	1.2	79.4	72.8	4.22	3.45	53.9	172	93.2	$12.86
3	437,670	5,147	106	2.1	1.2	83.1	85.0	4.09	3.33	54.4	184	94.1	$12.99
4	445,595	5,160	98	1.9	1.0	84.1	86.4	4.03	3.31	53.9	175	94.2	$13.08
5	437,315	5,171	89	1.7	1.2	84.6	84.6	4.15	3.40	54.9	180	97.6	$13.66
6	382,600	5,191	95	1.8	1.0	80.4	73.7	4.15	3.46	54.4	162	93.9	$12.96
27	441,890	5,116	102	2.0	1.4	82.9	86.4	4.04	3.32	53.5	171	93.1	$12.90
28	381,760	5,114	106	2.1	1.4	84.8	74.6	4.21	3.35	53.2	168	97.5	$13.84
29	435,780	5,143	92	1.8	1.3	85.8	84.7	4.18	3.36	53.6	187	98.5	$14.01
30	489,040	5,154	83	1.6	1.1	86.4	94.9	4.16	3.35	53.8	185	98.8	$14.05
31	443,780	5,080	93	1.8	1.2	83.2	87.4	4.06	3.32	54.3	184	93.7	$12.92
Total	13,200,790	5140	107	2.1	1.4	82.7	82.8	4.18	3.38	54.3	186	95.2	$13.24
											TANK--->	95.4	$13.27

Calculations of Financial Performance

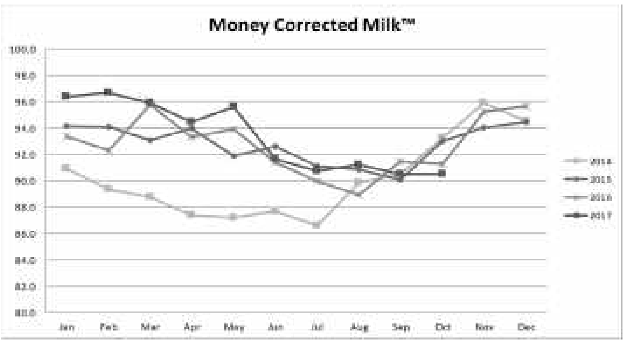
NOTES	
4-Oct	Started feeding Bunker 7 corn silage in heifer, Dry cow and Low cows.
5-Oct	Started feeding Bunker 7 to High and Milk Heifer
10-Oct	Increased corn .4-.7 lbs across milk cows
14-Oct	started blending Bunker 3 haylage into high, low and Milk Heifer
13-Oct	Started blending Bunker 3 into heifer and dry cow loads
13-Oct	Added straw to fresh premix instead of stand alone ingredient
15-Oct	Started blending Bunker 3 into Fresh cows
24-Oct	Started Blending into Bunker 5 2017 Corn Silage in High, Low and Milk Heifer
19-Oct	On all Bunker 3 Haylage
11-Oct	On all Bunker 7 Corn Silage
29-Oct	Changed gearbox on 2906 mixer
30-Oct	Increased corn .5 in High and Milk Heifer

Calculations of Financial Performance

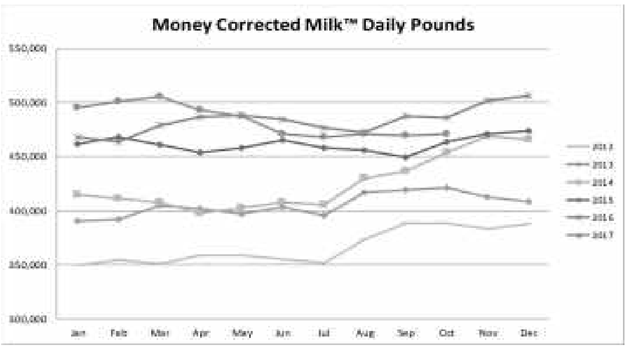
Milk, lbs	Fat %	Protein %	DMI	Feed $	$/hd/day	IOFC	ECM	MCM	ECM/DMI	MCM/DMI
88.8	3.62	3.09	58.2	$ 6.11	$ 16.28	$ 10.17	90.9	91.3	1.56	1.57
87.0	3.82	3.12	58.2	$ 6.11	$ 16.49	$ 10.38	91.6	92.4	1.57	1.59
89.4	3.84	3.15	61.3	$ 6.44	$ 17.04	$ 10.61	94.6	95.5	1.54	1.56

Class III	$ 16.34
Fat $/lb	$ 2.85
Protein $/lb	$ 1.70
other Solids	$ 0.22
Basis - all other	$ 1.50
Cost per lb DM	$ 0.105

Calculations of Financial Performance



Calculations of Financial Performance



Evaluating Feeding Financials

- Develop a better understanding of what influences your financial bottom line. Feed costs should be at the top of your understanding.
- If you do not track and monitor performance and cost, you will make wrong decisions.
- Monitor and track information such as milk, components, DMI, cows milked, cows in tank, ……
- Use metrics like ECM, MCM, and static IOFC to make feeding ecomomic decisons.
- Know your costs per lb DM and how those costs were derived.
- Know the value of your components.

Evaluating Feeding Financials

- Don’t let shrink eat your profits.
- If you do not have feeding software now is the time to invest.
- Don’t underestimate what a farm scale can do for you.
- Invest in a time/person to keep information up to date.