PROCEEDINGS OF

HIGH PLAINS DAIRY CONFERENCE

March 1 – 2, 2022

Edited by: Jennifer A. Spencer, PhD
Texas A&M AgriLife Extension Service
The Texas A&M University System

G. Robert Hagevoort, PhD
NMSU Dairy Extension Program
New Mexico State University

Managing Entity: U.S. Dairy Education & Training Consortium

U.S. Dairy Education & Training Consortium
2471 TAMU
College Station, TX 77843-2471

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2022 High Plains Dairy Conference

March 1 & 2, 2022

Tuesday, March 1

6:30 AM	Registration & Breakfast
8:00 AM	**Welcome,** Robert Hagevoort, PhD; Planning Committee Co-Chair
8:10 AM	**World Dairy Outlook, Markets & Trade** Ben Laine, MS; Dairy Analyst, RaboResearch, Rabobank
9:00 AM	**Panel: Beyond robots - effects on cows, people, and performance** Moderator: Barbara Wadsworth-Jones PhD; Director SW Regional Dairy Center, TSU
	o **Results from robotic survey for large dairy producers** Camila Lage PhD; Dairy Management Specialist, Cornell Cooperative Extension o **Producer Perspective** Adam Wolf, Legendairy, Windhorst, TX Justin Schaffer, Elmegca Farm, Miesville, MN
10:00 AM	Break
10:30 AM	**Panel: Impact of federal farm policies on western dairies** Moderator: Ryan Miltner JD; Partner Miltner Reed LLC
	o **Lessons learned from government intervention during the Pandemic** Geoff Vanden Heuvel; Director of Regulatory and Economic Affairs at Milk Producers Council o **Impacts of USDA pandemic assistance programs on Western Dairies** Scott Brown PhD; Director CAFNR, University of Missouri o **As the industry continues to consolidate, thoughts on the new Farm Bill** Jeremy Witte; Professional Staff, Senate Ag Committee o **Panel Discussion**
12:00 PM	Lunch
1:00 PM	**Corn Silage: Seed to Feed - Top 10 Take Home Messages** Bill Mahanna, PhD; Global Nutritional Sciences Manager, Pioneer
1:40 PM	**Uncovering Hidden or Under Recognized Feed Cost & Margin Opportunities on Your Dairy Farm** John Goeser, PhD; Director Rock River Laboratory, Adjunct Assistant Professor University of Wisconsin Madison, Cows Agree Consulting
2:20 PM	**Nutrigenomics – Impacts on Immunity, Health & Well Being** Mario Vailati Riboni, PhD; Technical Service Specialist, Diamond V
3:00 PM	Break
3:30 PM	**Improving Efficiency through Monitoring Technology and Data Insights** Luis Mendonça, DVM; Ruminant Technical Services, Merck
4:10 PM	**Panel: Beef on Dairy: "Uteri for Rent" - Semen or ET in hot climates?** Moderator: Paul Fricke, PhD; Professor and Extension Specialist, University of Wisconsin Madison
	o **Opportunities and Challenges with ET and IVF vs AI** Jeremy Howard, Sr. Sales Manager, J.R. Simplot Company o **Producer Perspective** Leo Ruijne, Owner, United Ag, LLC, Plainview, TX Luis Davalos, General Manager, Corrales Dairy, Roswell, NM
5:15-6:45PM	Reception

Wednesday, March 2	
6:30 AM	Registration & Breakfast
8:00 AM	**In a tier pricing system: Feeding & Managing for Milk Components** Kevin Harvatine, PhD; Professor of Nutritional Physiology, Penn State University
8:40 AM	**Panel: Determining Tools & Metrics towards Carbon Neutrality for Western Dairies** Moderator: Rick Naerebout, CEO Idaho Dairymen's Association
9:00 AM	o **Monetizing manure projects: where to begin?** Mark Stoermann, CEO Newtrient
10:00 AM	Break
10:30 AM	o **Panel continued: Digester Due Diligence for Dairy Producers** David Claiborne; Attorney and Partner at Sawtooth Law, Boise ID o **Q & A with Panel Members**
12:00 PM	Lunch
1:00 PM	**Carbon Credits in Ag: can carbon be an actual source of income in Ag?** Joe Outlaw, PhD; Regents Fellow, Professor and Extension Economist, Texas A&M University
1:40 PM	**Parlor Throughput with milk quality in mind** Juan Rodrigo Pedraza, DVM; Managing Veterinarian, Zoetis
2:20 PM	Break
2:30 PM	**Impact of positive reinforcement practices on calves and heifers on future behavior.** Joao Costa, PhD; Assistant Professor, University of Kentucky
3:10 PM	**Fit to Transport? A new decision-making tool for producers and employees** Michelle Calvo-Lorenzo, PhD; Chief Animal welfare Officer, Elanco
4:00 PM	Adjourn

High Plains

Dairy Conference

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High Plains Dairy Conference

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World Dairy Outlook, Markets & Trade

Ben Laine, M.S.
Dairy Analyst
RaboResearch, Rabobank

NOTES:

World Dairy Outlook, Markets & Trade

High Plains Dairy Conference 2022

Ben Laine
Vice President, RaboResearch – Dairy
Ben.Laine@RaboAg.com

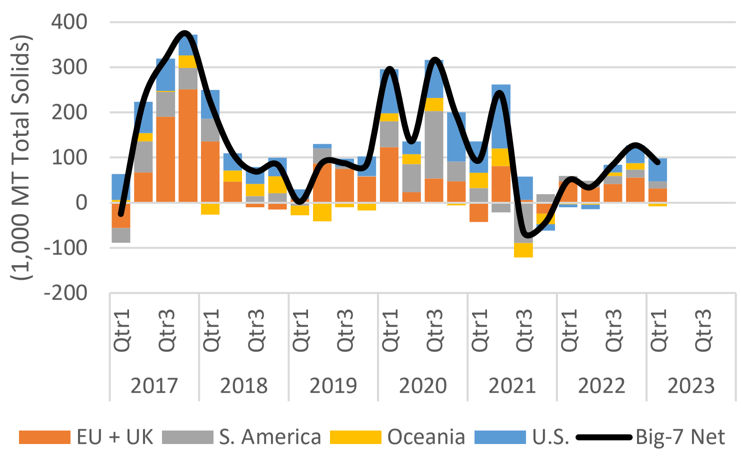
Rabobank

Global Overview

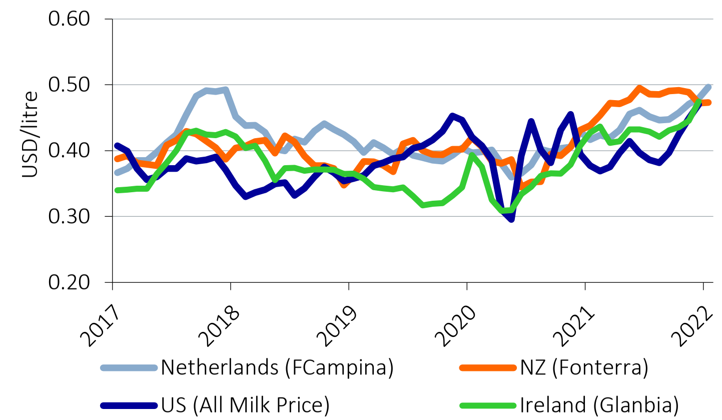
Milk production growth in the "Big 7" turned negative in Q3 2021 and below trend gains are expected through 2022, setting the stage for record-high farmgate milk prices.

Following a strong 1H 2021, global trade converged back near year-ago levels in 2H. Most of this convergence can be attributed to a slowdown in demand from China. A well stocked market and high global prices could lead to reduced imports in 2022.

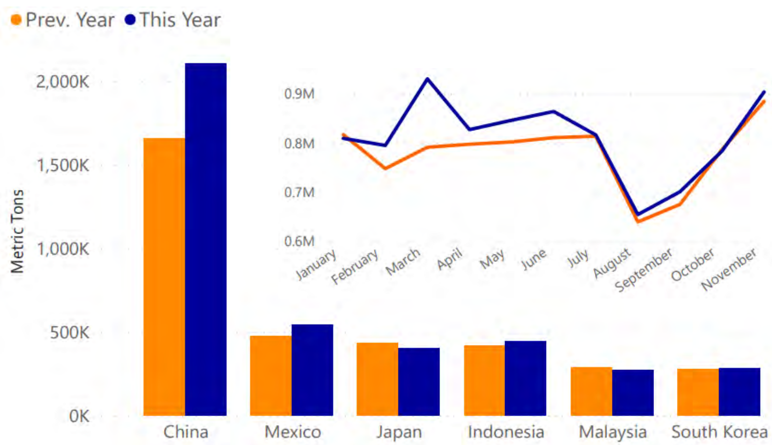
Milk production growth of the "Big 7"



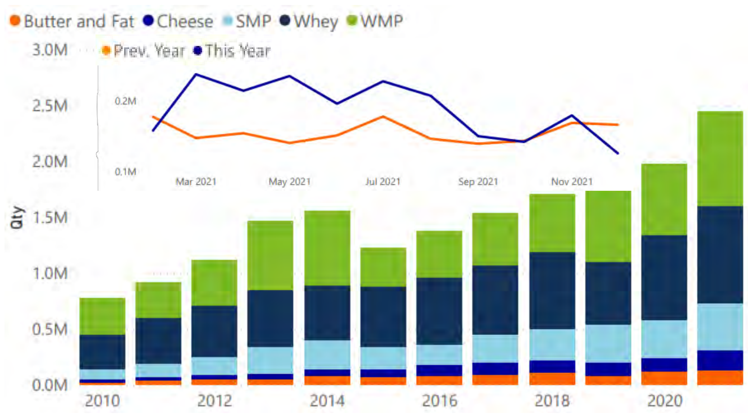
Farmgate milk prices



Global dairy exports



China's imports



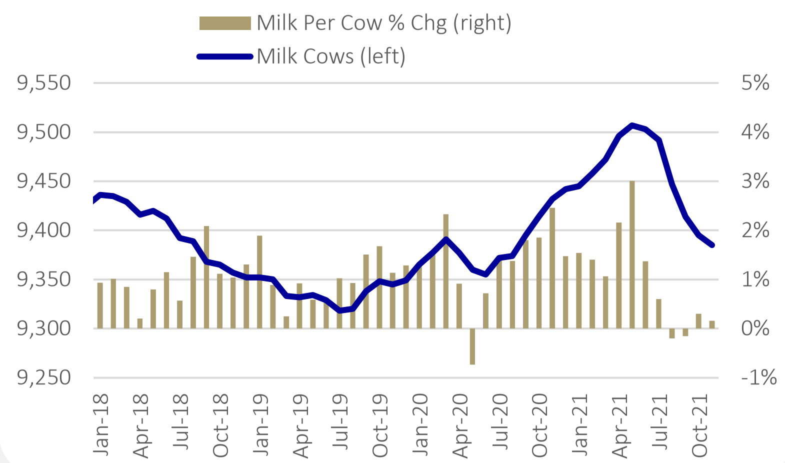
US Overview

US milk production growth turned negative in November. Declining cow numbers and muted growth in yield will maintain this negative YOY growth into the first half of 2022.

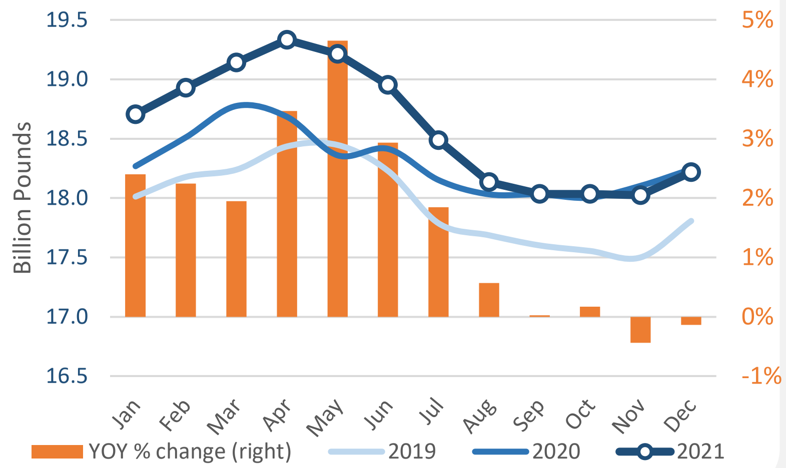
US exports in 2021 were driven in large part by strong demand from China which began to slow in the second half of the year. Whether China returns to the market in 2022 is uncertain.

Tightening milk supplies and strong global demand are lifting milk prices. Class IV is projected to maintain a premium to class III in 2022.

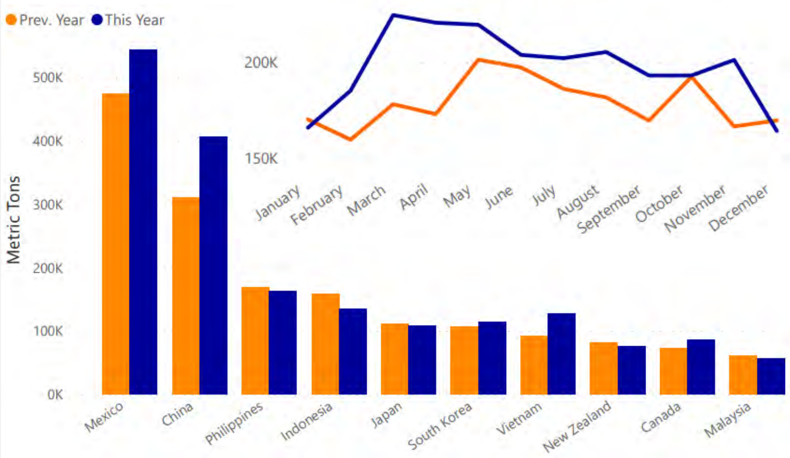
US milk production growth: Herd and Yield



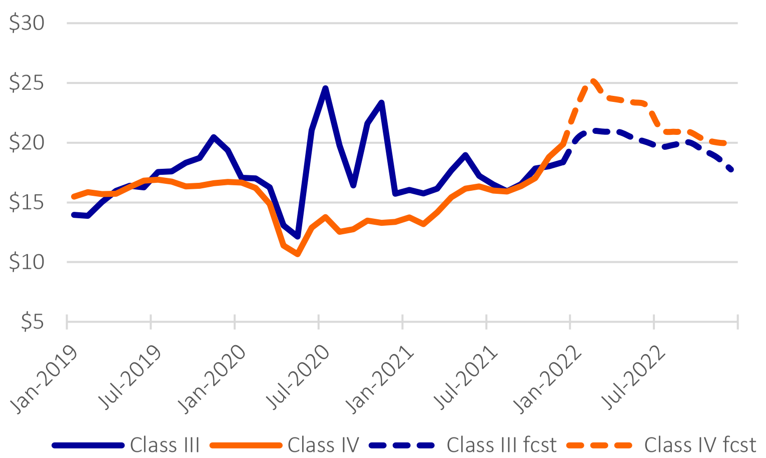
US milk production



US dairy exports

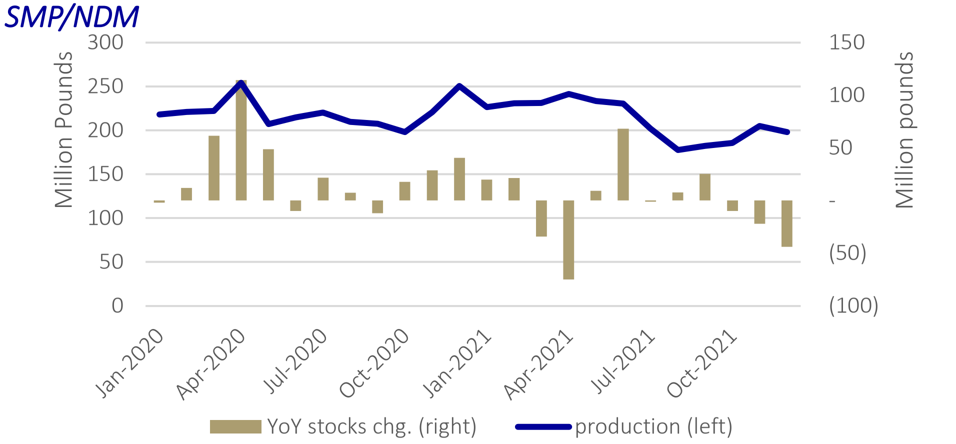


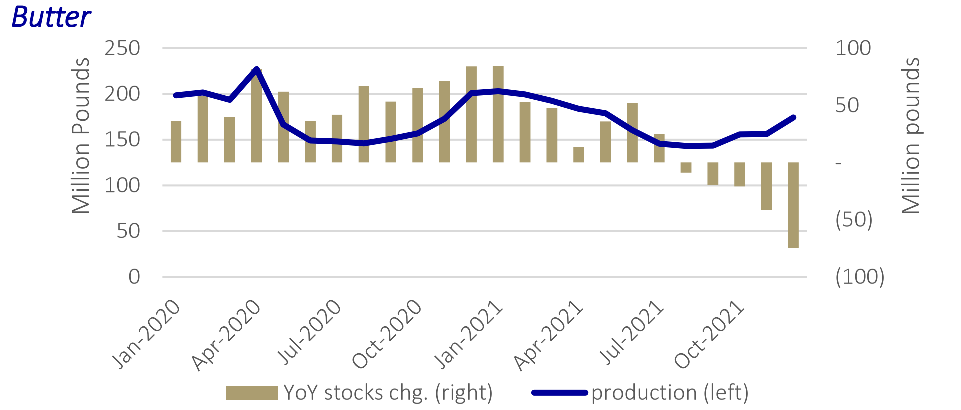
US milk price forecast

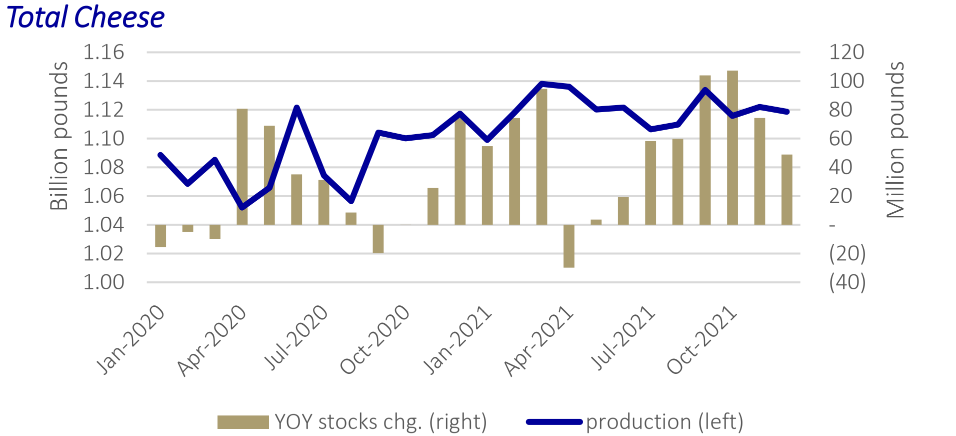


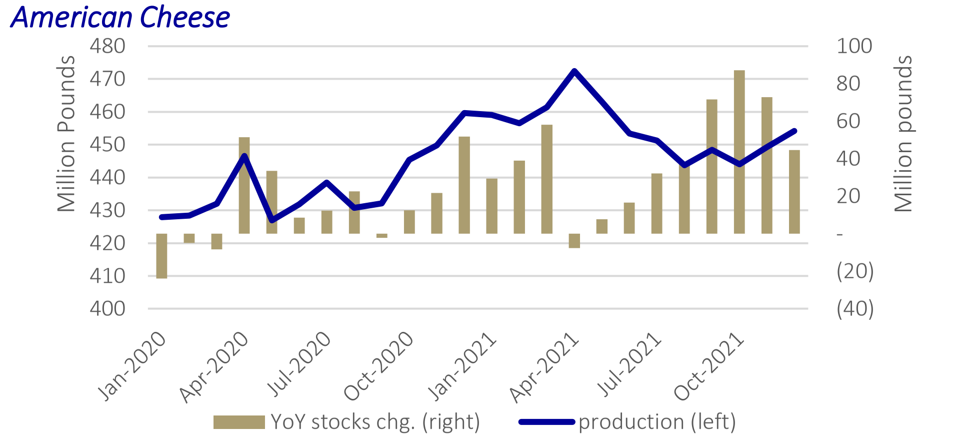
US dairy product production and stocks

Reduced production, stocks with increased exports resulting in near-record price levels for NDM and Butter.



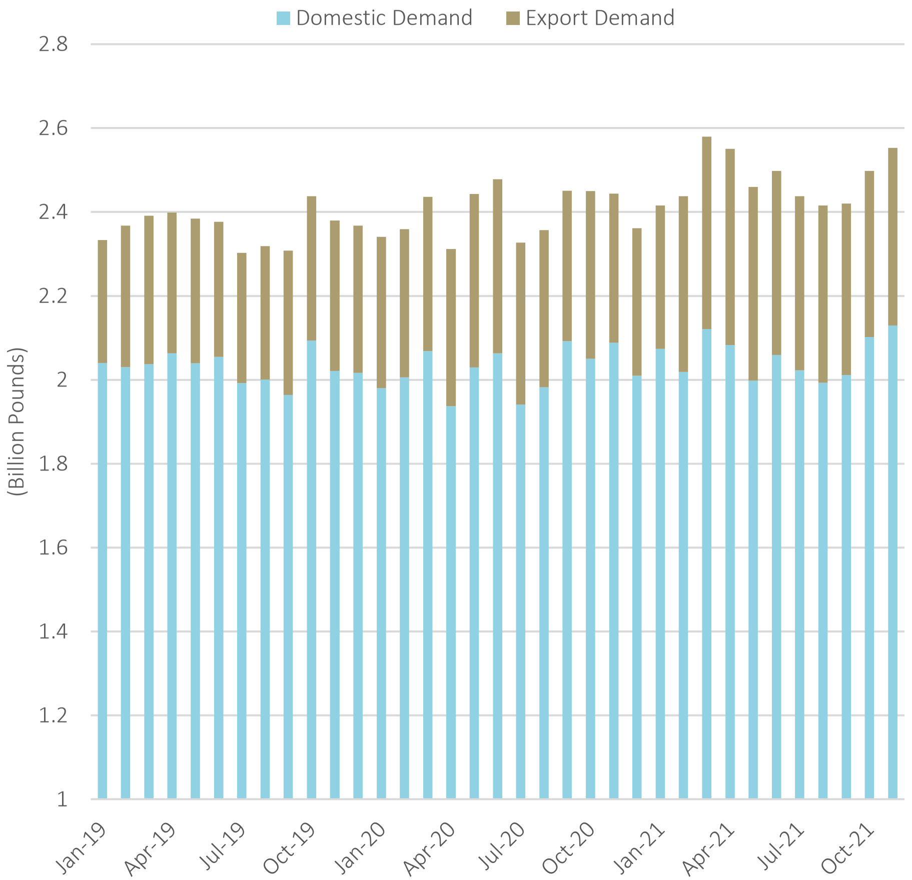




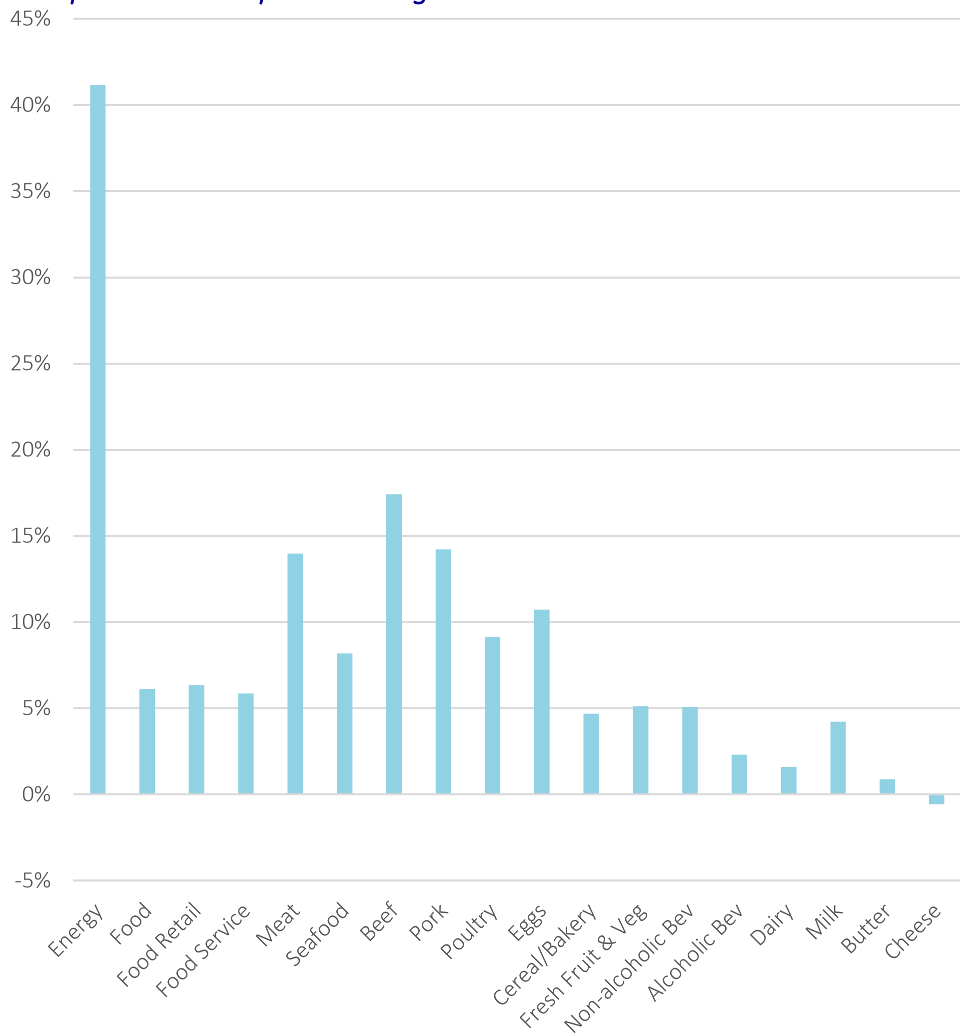


2021 US dairy disappearance supported by domestic and export sales. Higher prices likely to curb demand growth in 2022.

Total solids demand up 3% YTD November due to gains of 12% and 1.4%, respectively in export and domestic demand.

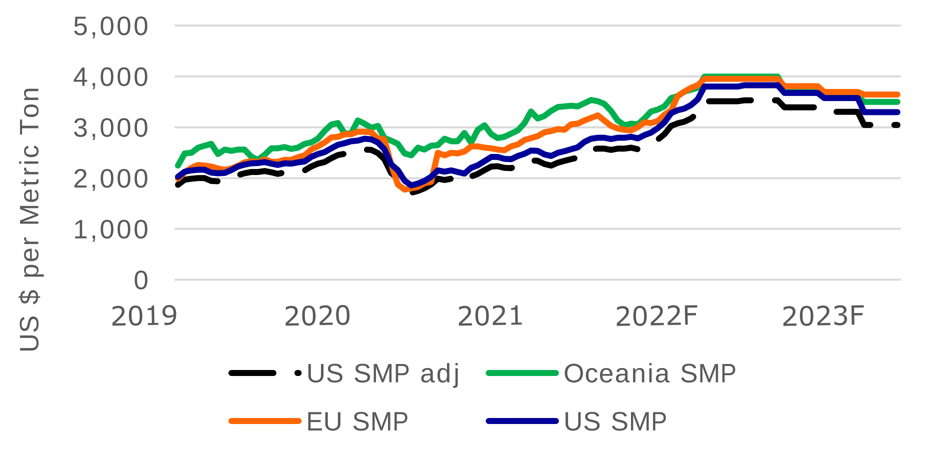


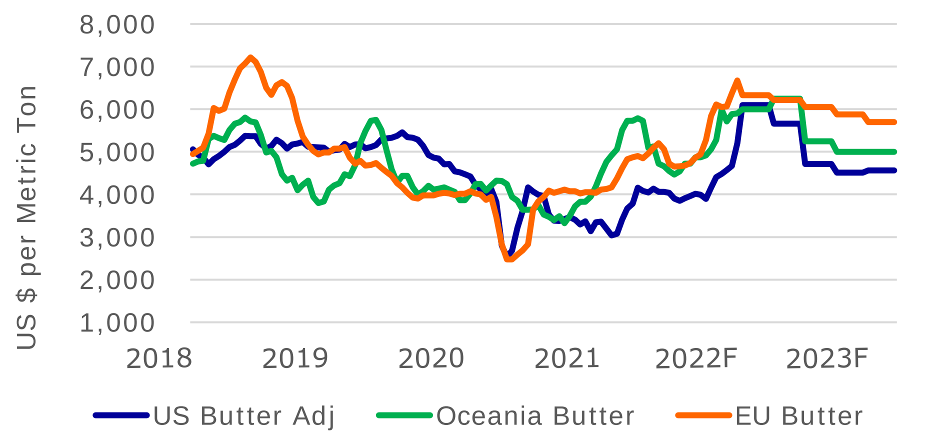
Cumulative monthly change in CPI: Jan-Dec 2021. Dairy remains a bargain compared to other protein categories.

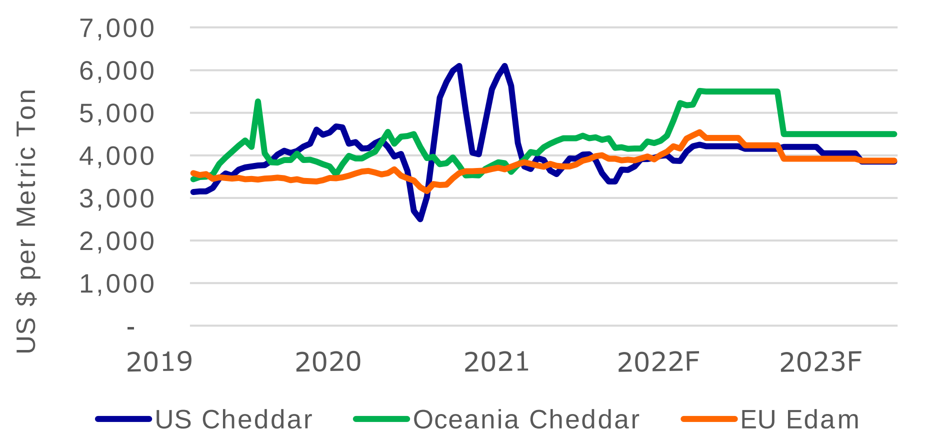


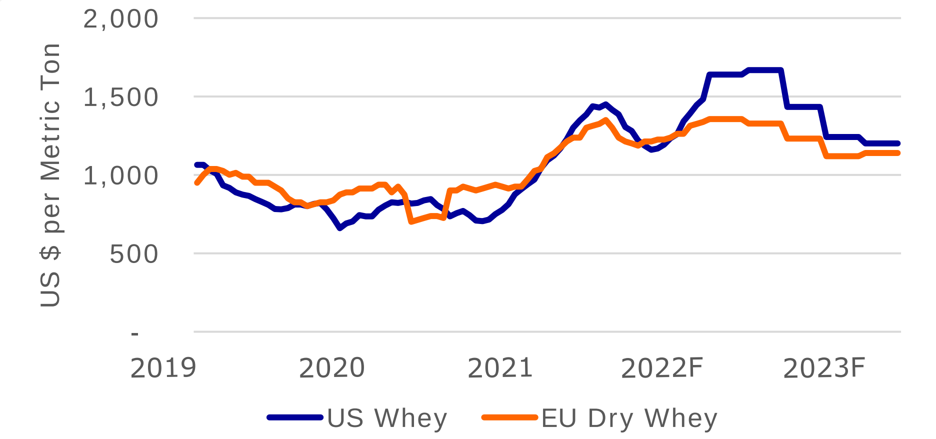
Global dairy product price outlook

Price escalation anticipated until the Northern Hemisphere flush and/or signs of demand erosion due to price.









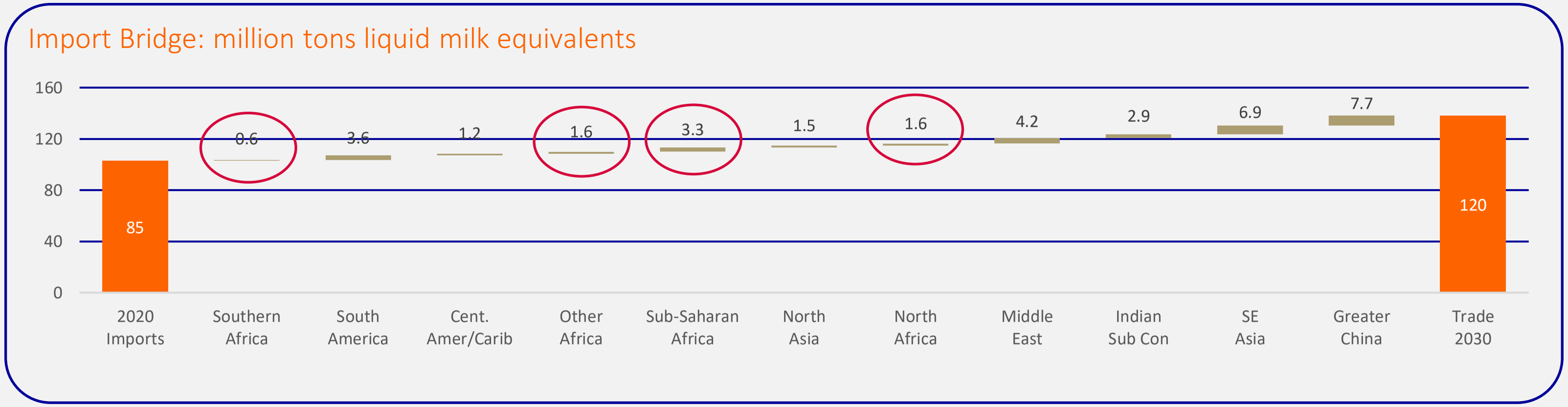
Summary

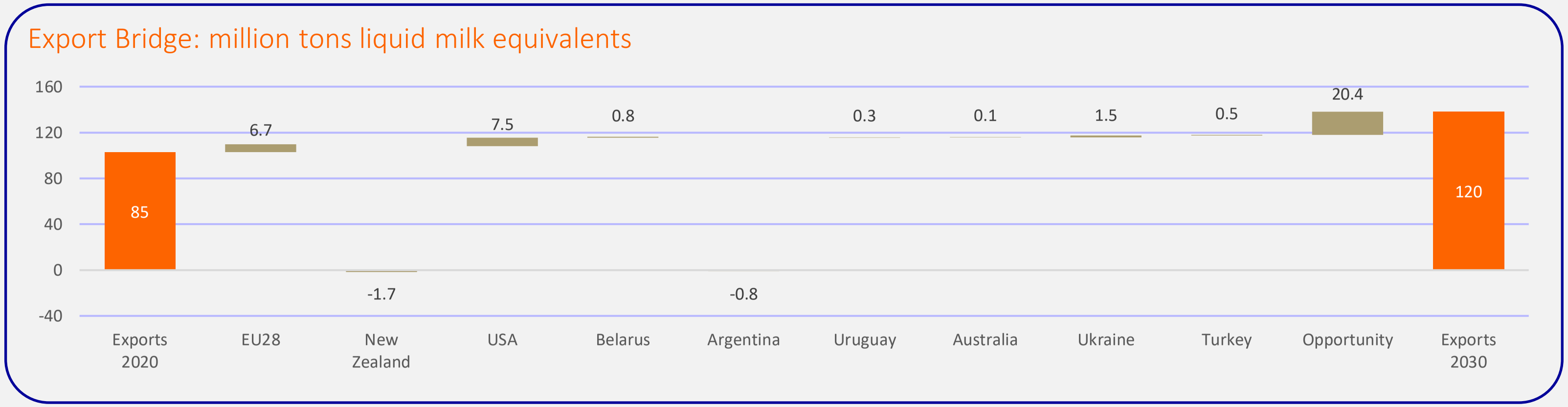
Rabobank

Global Dairy Markets	*Lower year-over-year production during 2H 2021 in world's three largest export regions, Oceania, the EU and the US, has propelled prices 30% over January 2021.*
Global Dairy Markets	*Higher year-on-year production gains are not expected until mid-2022, and rising feed costs will temper the level of supply growth, despite favorable farmgate milk prices.*
Global Dairy Markets	*Despite supply chain disruptions, global dairy trade grew in 2021 driven by record Chinese buying. Looking forward, rising oil prices will increase in the purchasing power of key dairy importers including Mexico, SE Asia, and MENA.*
US Dairy Markets	*Milk supply has tightened, and growth will be limited through 1H 2022 due to reduced cow numbers and flat-to-modest yield gains. Cost pressures will limit the appetite for expansion despite improving milk prices.*
US Dairy Markets	*Strong nonfat dry milk and butter markets will lift class IV milk prices to a premium over class III in 2022. Tighter milk markets, reduced stocks, and lingering staffing challenges at plants could support a higher price level for longer than in the past.*
US Dairy Markets	*Exports have been, and will remain, a critical driver of the strength in US prices. Rising US prices have been enabled by higher global commodity prices, but the northern hemisphere flush and the uncertain demand from China will be factors to watch.*

2030 Global Dairy Supply and Demand Outlook

Global dairy supply and demand outlook





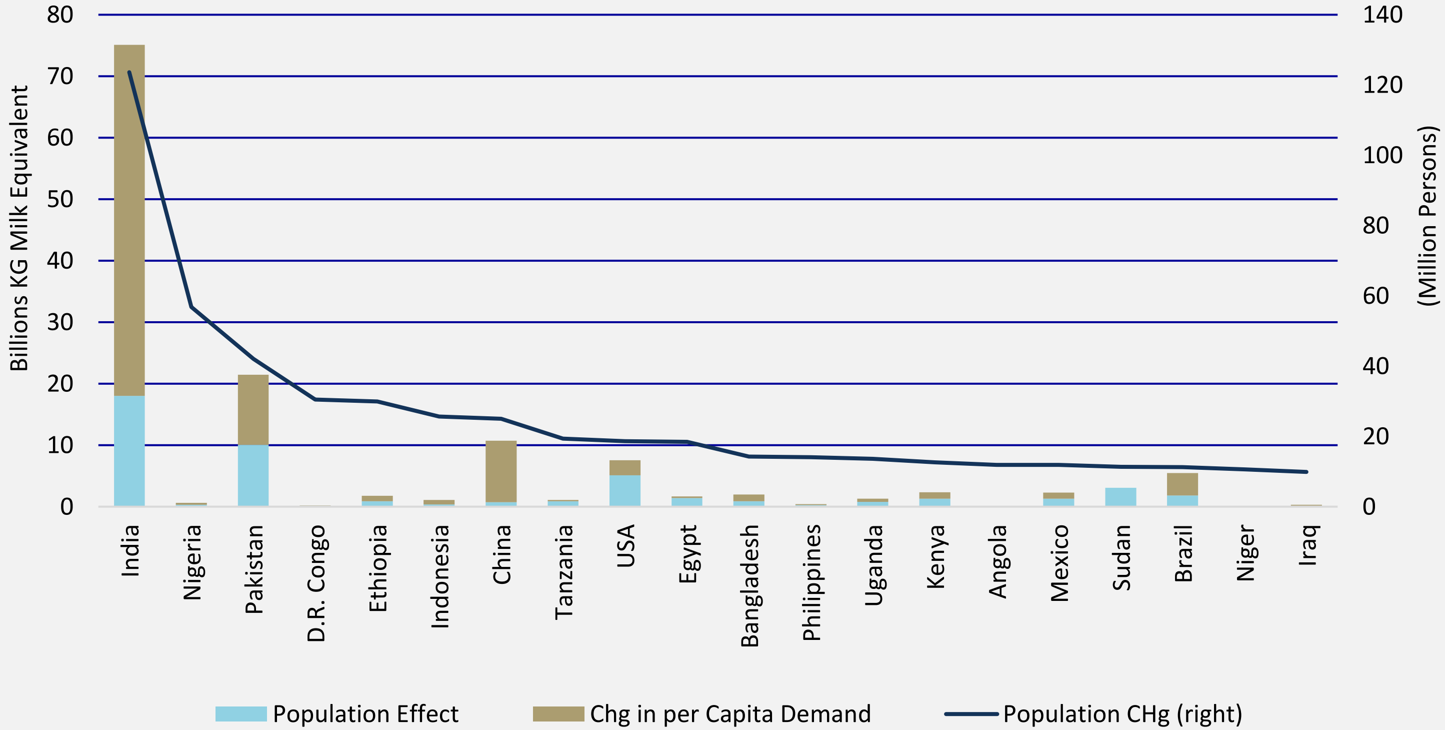
Source: Rabobank, 2021

Key points

- Global dairy trade forecast to increase at 3% CAGR.
- Import demand driven by Greater China, SE Asia and Africa.
- The US grows its export presence.
- New Zealand is expected to have less exportable surplus in 2030 than in 2020 – but remains a key dairy exporting country.
- The 20 million-ton-gap represents a potential market opportunity for the dairy sector, as well as, for alternative dairy products.

How does an additional 750 million people impact the sector?

Growth in dairy consumption from 2020 to 2030 due to population and change in per capita dairy demand



Source: UN Population Estimates, OECD, IFCN, RaboResearch, 2021.

2020 to 2030

Over 35% of the population growth will occur in Africa, followed by India +16%, Pakistan +5.6%, Indonesia +3.4%, China +3.3%, and the US +2.5%. The top 20 countries in population increases account for almost 70% of world growth and drive a 2.5% CAGR in dairy demand.

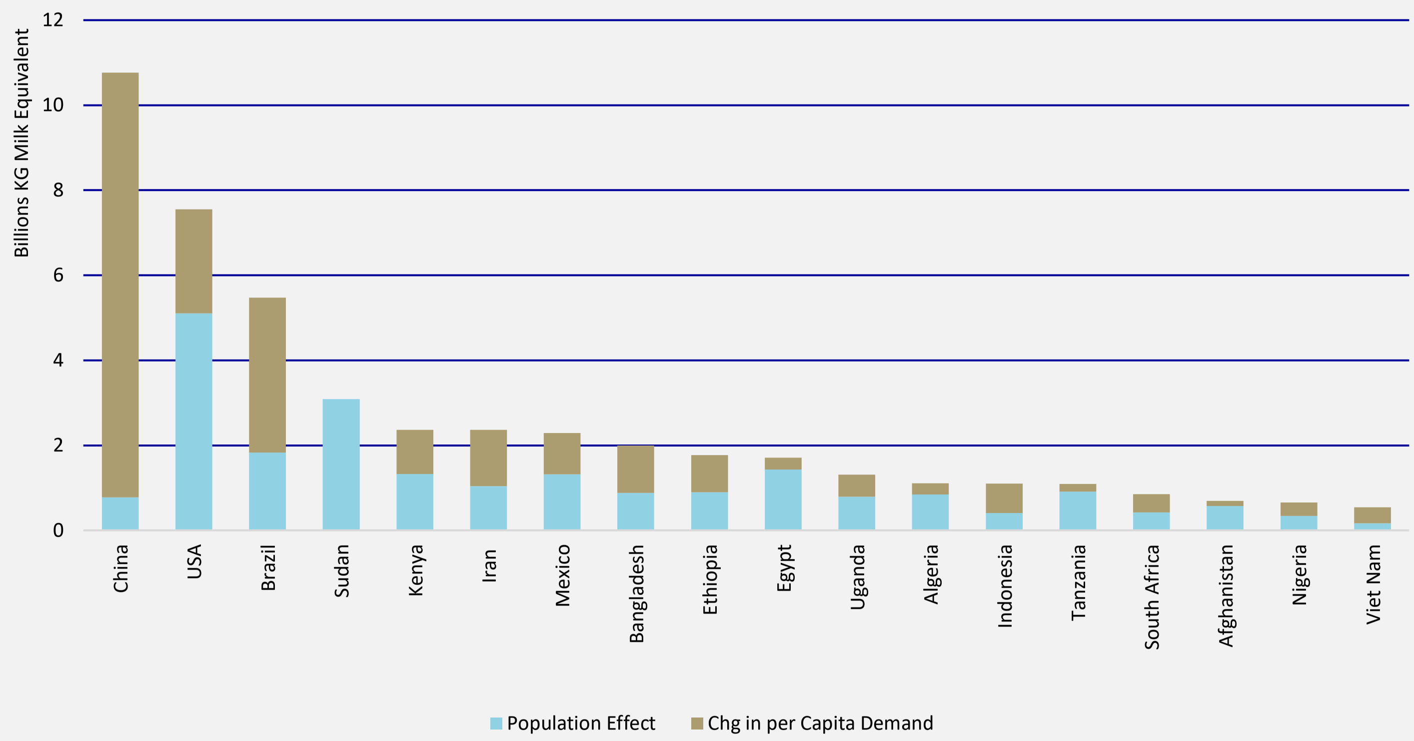
India and Pakistan are home to culturally-dairy-consumers. The countries strive to be self-sufficient, and there are large informal markets, which are evolving.

Many African countries are not traditional dairy consumers but rising incomes and the proliferation of the Western diet will drive dairy demand.

Population and consumption growth will drive impactful demand growth in China, the US, Brazil, and Mexico.

Excluding India and Pakistan, these are the top growing dairy markets

Forecast growth in dairy demand, 2020 to 2030



Source: UN Population Estimates, OECD, IFCN, RaboResearch, 2021.

- **Population growth**

Current forecast indicate on a population growth of 750 million people from 2020 to 2030.

Over 35% of the population growth will occur in Africa, followed by India +16%, Pakistan +5.6%, Indonesia +3.4%, China +3.3%, and the US +2.5%.

- **Market Opportunities**

These markets represent the largest volume growth in dairy demand based on population and per capita consumption (PCC) growth.

China's demand growth is forecast at 2.2%, 0.2% from population and 2% from increase PCC.

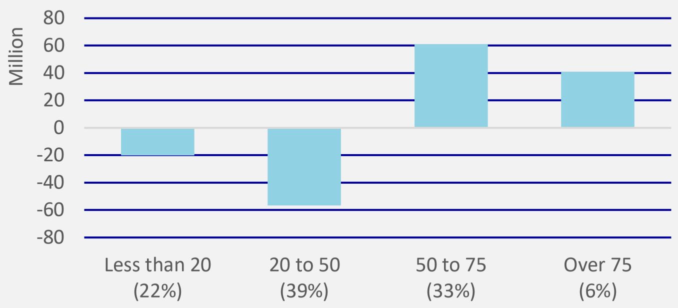
In contrast, the US demand growth is driven by 0.5% increase in population and 0.25% gain in PCC – due to existing high PCC.

Several other countries present interesting market opportunities.

Note: Sudan is primarily an informal market.

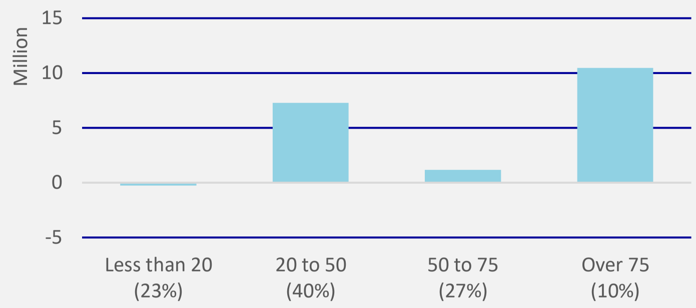
Changing demographics from 2020 to 2030 in key markets will drive dairy demand and product mix

China: Last decade of growth +25m to 1.46b



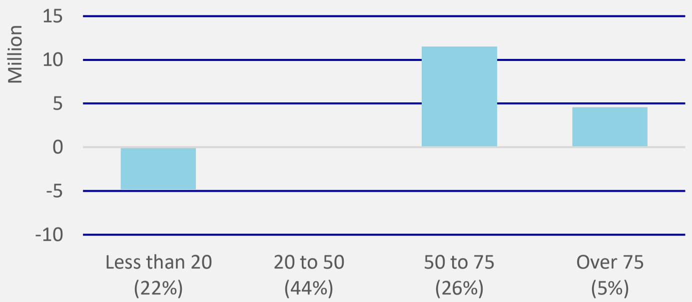
The number of China's active silvers, those over 50, increases by 100m by 2030, spurring demand for functional nutrition, which offsets the declining early life nutrition segment.

US: Population growth of +18.6m to 350m



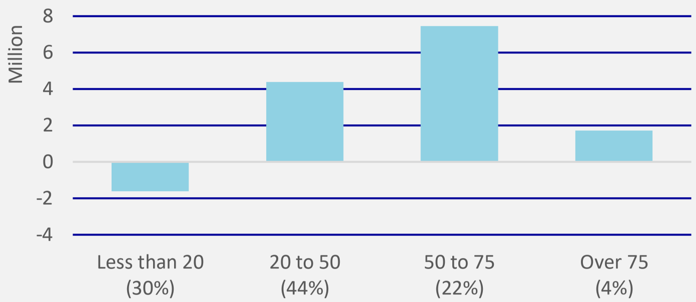
Immigration accounts for 8m of the US gain in population during this period. Fluid milk category stabilizes. Functional nutrition category grows.

Brazil: Population growth of 11.3m to 224m



Brazil's less than 20-year-old bracket declines by about 5m, each decade 2000 to 2050. The aging population requires a new market focus.

Mexico: Population growth of 11.9m to 141m

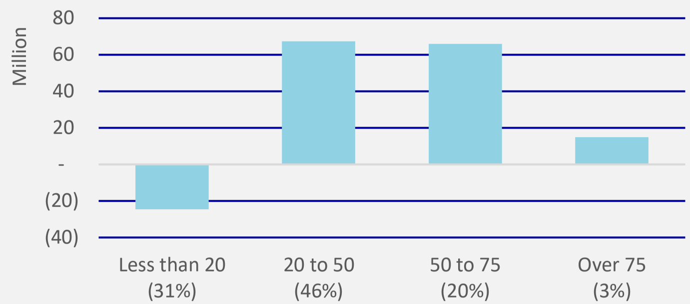


Mexico, the second largest global dairy importer, also shows decline in under 20 bracket. Growth in key working age bracket supports rising consumption.

Percentages listed under the age brackets represent: Percent of population in 2030 in those age brackets.
Source: UN Population Estimates, OECD, IFCN, RaboResearch, 2021. Percentages under the age brackets represent the percent of population in 2030 in the age bracket

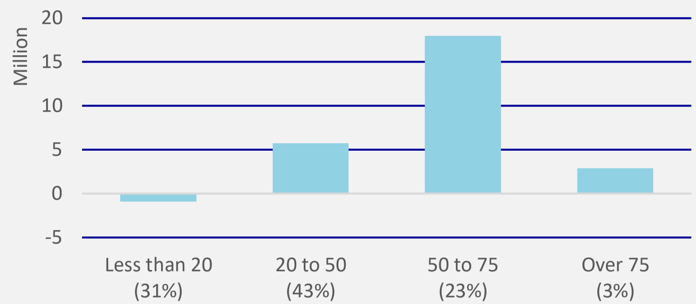
Changing demographics from 2020 to 2030 in key markets will drive dairy demand and product mix

India: The new leader population growth +123.6m to 1.5b



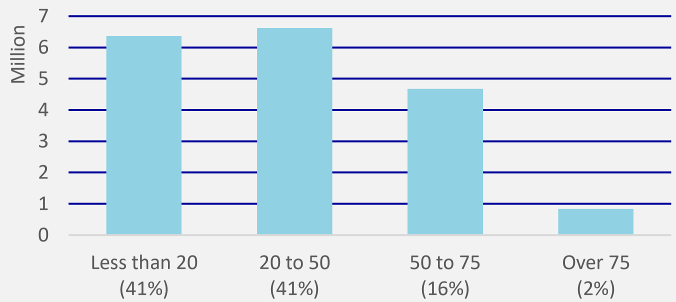
Despite a decline in less than 20 bracket, in 2030 India has over 1b people under 50, driving per capita consumption.

Indonesia: Population growth of +25.7m to 299m



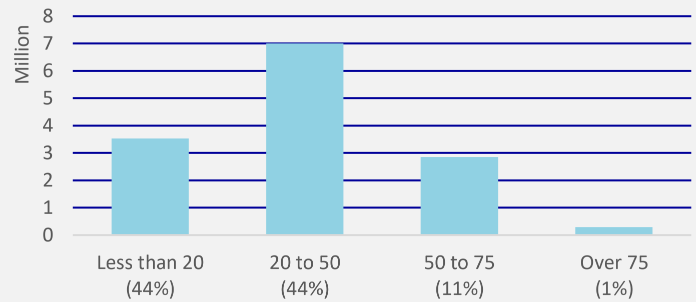
Nearly 75% of Indonesia's population is under 50 in 2030. Per Capita Real GDP, forecast to increase by 4.2% CAGR, supporting demand growth.

Egypt: Population growth of 18.5m to 120.8m



Growing young population, challenged by affordability. PCC declined from 82kg to 60kg from 2010 to 2020, estimated PCC at 62kg in 2030.

Kenya: Population growth of 12.7m to 66m



Growing young population, challenged by affordability. PCC declined from 123kg to 105kg from 2010 to 2020, estimated PCC at 120kg in 2030, driven by domestic production growth.

Percentages listed under the age brackets represent: Percent of population in 2030 in those age brackets.

Source: UN Population Estimates, OECD, IFCN, RaboResearch, 2021. Percentages under the age brackets represent the percent of population in 2030 in the age bracket

Panel Discussion

Beyond Robots – Effects on cows, people, and performance

Moderator – Barbara Wadsworth-Jones, Ph.D., Director of Southwest Regional Dairy Center, Tarleton State University

Results from robotic survey for large dairy producers

Panelist – Camila Lage, Ph.D., Dairy Management Specialist, Cornell Cooperative Extension

Producer Perspective

Panelist – Adam Wolf, Wolf's Legendairy, Scotland, TX

Panelist – Justin Schaffer, Elmegca Farms, Miesville, MN

NOTES:

1

The first robot was installed in 1992 (Jacobs and Siegford, 2012)

In 2017, there was an estimated number of 35,000 units installed around the world (Salfer et al., 2017);

The global milking robots marked size stood at USD 1.25 billion in 2019 and is projected to reach USD 2.94 billion by 2027 (Fortune business insights, 2021).

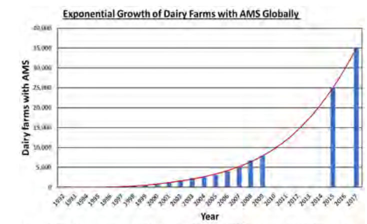


Figure 1. Global exponential growth in the adoption of Automated Milking Systems (AMS). Since the first commercial system was released in 1992, the adoption of robotic milking systems has been growing exponentially worldwide. Sources: Koning, 2010; Siewert et al., 2018; Salfer et al., 2019.

Figure credit: Juan M. Piñeiro, Assistant Professor and Dairy Extension Specialist, Texas A&M AgriLife Research and Extension Center

2

Only about 1% of all AMS located in the United States (de Koning, 2010)

Slower adoption in the US may be related to uncertainty about adopting the new technology (Jacobs and Siegford, 2012)

Higher proportion of large dairies (California)
Cost and return of the investment
Changes in management for large dairies

Reasons driving the increase in interest in AMS adoption in the US

Ag labor shortage, increase in labor costs
Familiar succession.
Increase interest in animal welfare

How does large dairies that transitioned to AMS perceive the benefits?

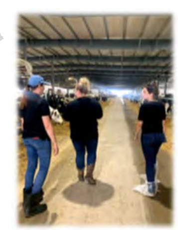
3

Survey to describe the perceptions of US producers on the implementation of AMS in dairies with ≥ 7 AMS units installed

We **estimate that there are approximately 100 farms** with 7 or more AMS boxes across the US (DeLaval and Lely, personal communication).

55 farms directly contacted.
29 responded **(53%)**
11 states across the US

Follow-up visits with some farms to better explore the answers



4

Characteristics of the respondents

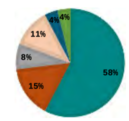
Time since AMS installation
Min: 9 months
Median: 47 months
Max: 187 months

< 5 years

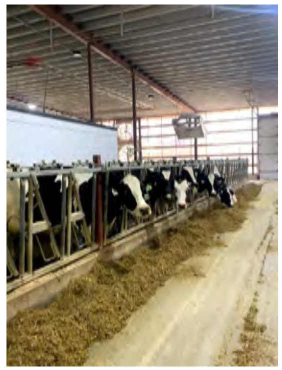
AMS units
Min: 7
Median: 12
Max: 36

Cows under AMS
Min: 400
Median: 663
Max: 2,200

BREED COMPOSITION OF THE HERDS



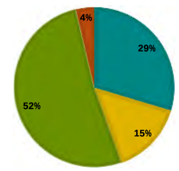
> 50% has 100% Holstein herd



5

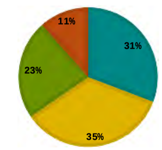
Characteristics of the respondents

RESPONDENTS WERE



> 50% of respondents were herd managers

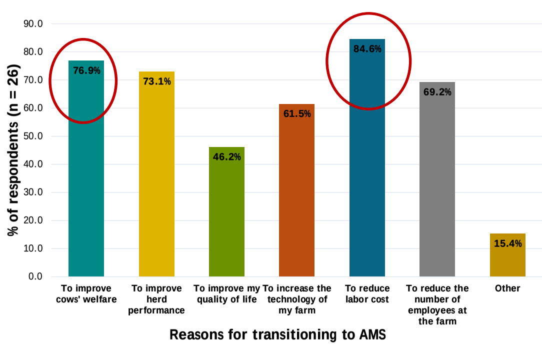
AVERAGE AGE OF RESPONDENTS



66% of respondents were younger than 45 years old

6

Why AMS?



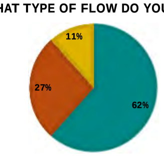
Concerns with labor availability and costs (Martins et al., 2019)

Consumer's perception of dairy cattle welfare (Beaver et al., 2020)

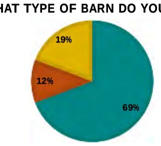
7

Type of flow

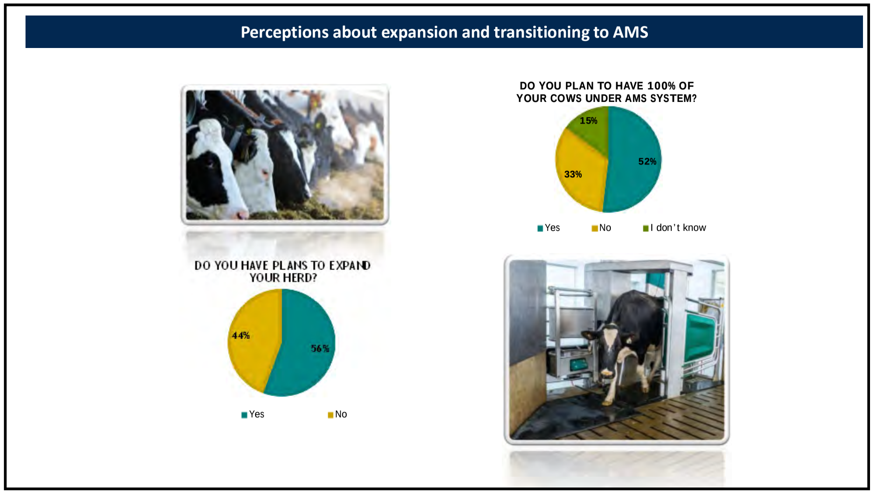
WHAT TYPE OF FLOW DO YOU HAVE?



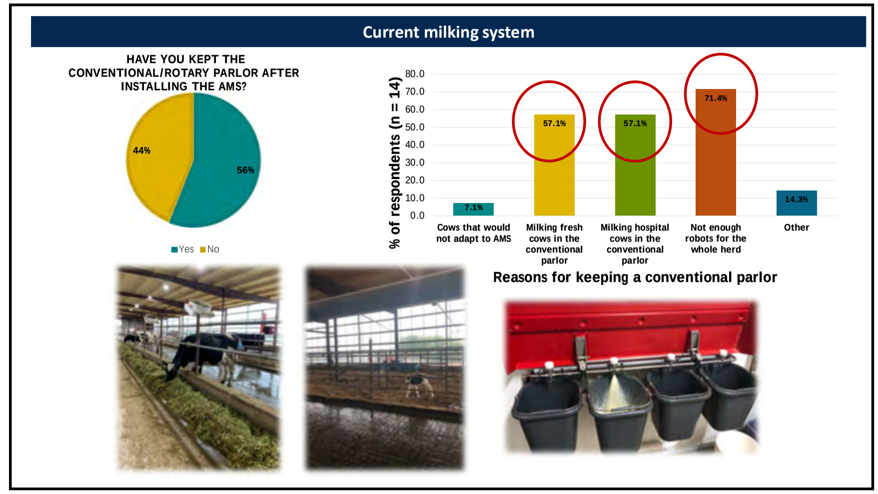
WHAT TYPE OF BARN DO YOU HAVE?



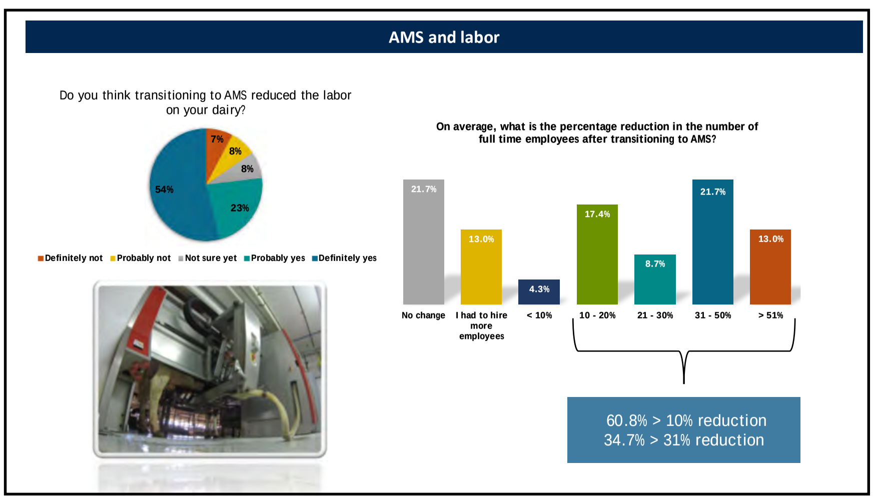
8


Perceptions about expansion and transitioning to AMS
DO YOU PLAN TO HAVE 100% OF YOUR COWS UNDER AMS SYSTEM?
15%
52%
33%
Yes
No
I don't know
DO YOU HAVE PLANS TO EXPAND YOUR HERD?
44%
56%
Yes
No

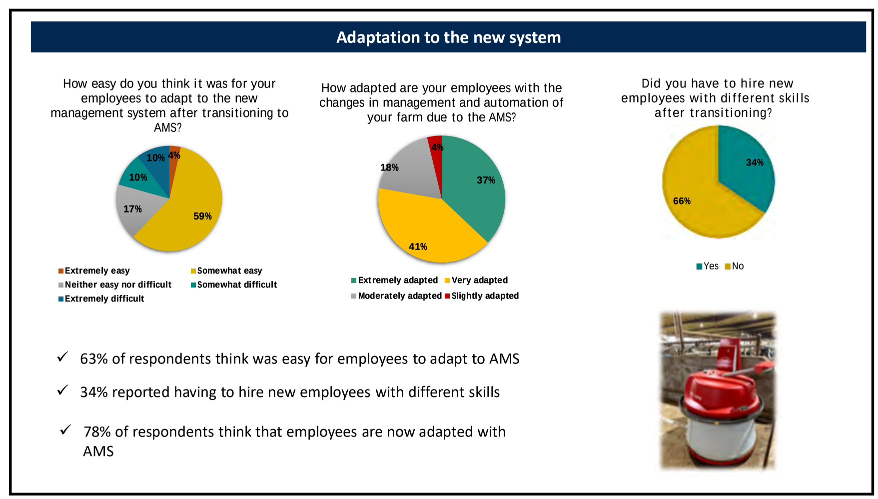
9


Current milking system
HAVE YOU KEPT THE CONVENTIONAL/ROTARY PARLOR AFTER INSTALLING THE AMS?
44%
56%
Yes
No
% of respondents (n = 14)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
7.1%
57.1%
57.1%
71.4%
14.3%
Cows that would not adapt to AMS
Milking fresh cows in the conventional parlor
Milking hospital cows in the conventional parlor
Not enough robots for the whole herd
Other
Reasons for keeping a conventional parlor

10

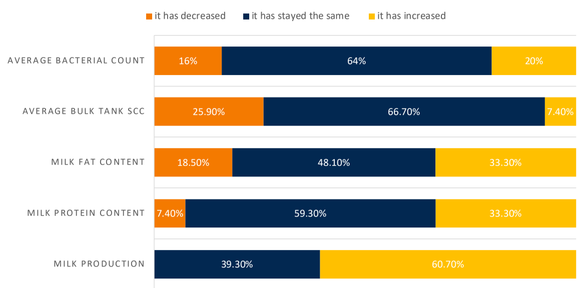

AMS and labor
Do you think transitioning to AMS reduced the labor on your dairy?
7%
8%
8%
54%
23%
Definitely not
Probably not
Not sure yet
Probably yes
Definitely yes
On average, what is the percentage reduction in the number of full time employees after transitioning to AMS?
21.7%
13.0%
4.3%
17.4%
8.7%
21.7%
13.0%
No change
I had to hire more employees
< 10%
10 - 20%
21 - 30%
31 - 50%
> 51%
60.8% > 10% reduction
34.7% > 31% reduction

11


Adaptation to the new system
How easy do you think it was for your employees to adapt to the new management system after transitioning to AMS?
10%
4%
10%
17%
59%
Extremely easy
Somewhat easy
Neither easy nor difficult
Somewhat difficult
Extremely difficult
How adapted are your employees with the changes in management and automation of your farm due to the AMS?
4%
18%
37%
41%
Extremely adapted
Very adapted
Moderately adapted
Slightly adapted
Did you have to hire new employees with different skills after transitioning?
34%
66%
Yes
No
✓ 63% of respondents think was easy for employees to adapt to AMS
✓ 34% reported having to hire new employees with different skills
✓ 78% of respondents think that employees are now adapted with AMS

12

How does your milk quality changed after transitioning to AMS?



Over 60% of respondents didn't report changes
25.9% - decrease in SCC

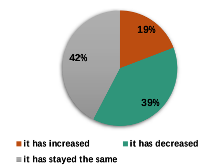
1/3 of respondents reported increase in milk fat and protein content

60.7% of respondents observed increase in milk production

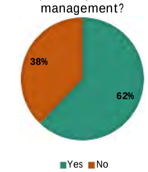
13

Health management after transitioning to AMS

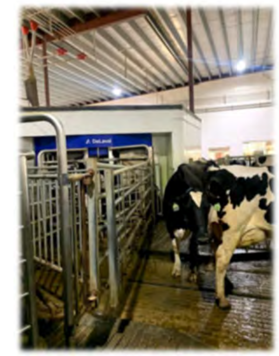
How has your rate of clinical mastitis changed since transitioning to AMS?



Do you think that working with AMS has improved your mastitis management?



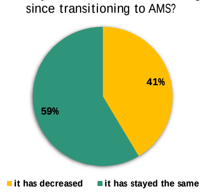
62% of respondents believe working with AMS improved their mastitis management



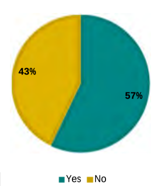
14

Health management after transitioning to AMS

How has your rate of lameness changed since transitioning to AMS?



Do you think working with AMS has improved your lameness detection?

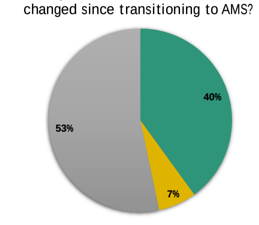


- 41% - AMS decreased lameness rates
- 57% believe that transitioning to AMS improved lameness detection

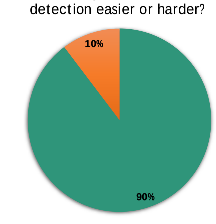
15

Health management after transitioning to AMS

Has your overall transition health changed since transitioning to AMS?



Has transitioning to AMS made sick cows detection easier or harder?

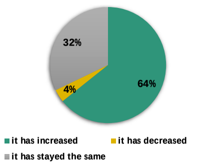


Majority of respondents think that health during transition period stayed the same or improved after installing AMS and 90% think it is easier to detect disease on the AMS

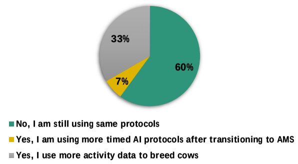
16

Reproductive management after transitioning to AMS

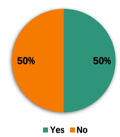
Has your pregnancy rate changed since transitioning to AMS?



Has your reproductive management changed since transitioning to AMS?



Has the use of hormones for reproduction reduced after transitioning to AMS?



Increase in pregnancy rate

33% rely more in activity to breed cows

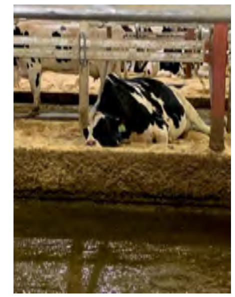
Half of respondents believe they reduced the use of reproduction hormones after transitioning to AMS

17

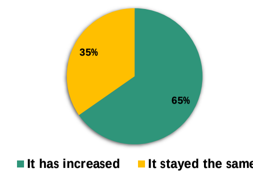
Cow comfort after transitioning to AMS

Did you notice any change in animal behavior after transitioning to AMS?

90.7%	Yes, my cows are calmer
56.7%	Yes, my cows spend more time lying down
6.7%	No



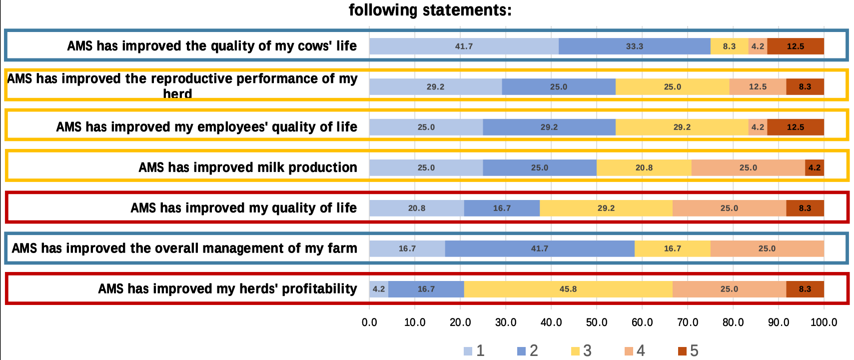
How has the cow comfort changed after transitioning to AMS?



18

Farmer's perceptions of AMS and major changes in their systems

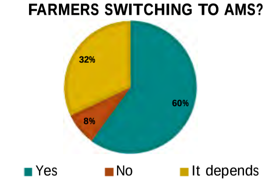
On a scale of 1-5 (1- strongly agree, to 5 - strongly disagree), how would you rate the following statements:

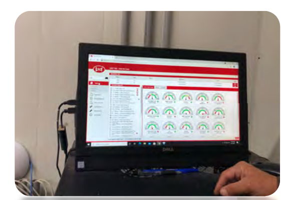


19

Should other farmers switch to AMS?

WOULD YOU RECOMMEND OTHER FARMERS SWITCHING TO AMS?





It depends:
Expectations, short- and long-term goals
Relationship and proximity with dealer
Mindset (change of the type of work vs. improvements in owners' quality of life)
Cow should be the focus – *"I could tell in advance the farmers that would not adapt to AMS"*

20

Take home messages (so far)

- **AMS have met producers' expectations**
  - improving cow production and welfare
  - reducing labor
- The **economic aspect** of the investment is **not clear**
  - relatively recent transition
  - would benefit from further investigation.

Farmers

21

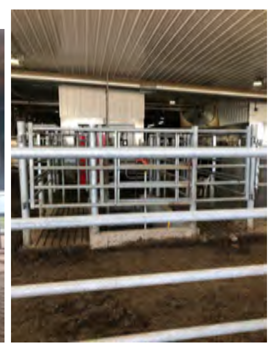
Take home messages (so far)

- **No farm is the same and will need different structures and resources to succeed**
- Aligned objectives among farmer, dealer and other stakeholders (Veterinarian, Nutritionist) appears to be an important component of the success of the transition

Farmers

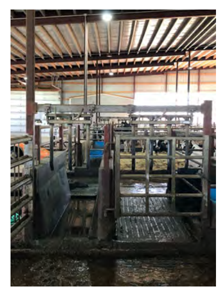
22

Lely Cosmix to help train heifers – help select the ones that will adapt better to AMS vs. the ones that goes to the conventional system



2 examples of management centers used to dry cows in farms that have 100% of cows under AMS (hoof trimming chute and structure with ditch

23

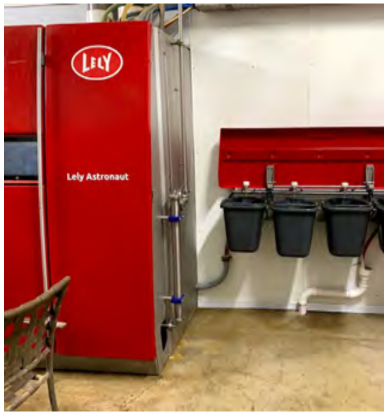


Foot bath structure

Milk-first guided flow

Booth-shaped design and guided flow to improve visits

24



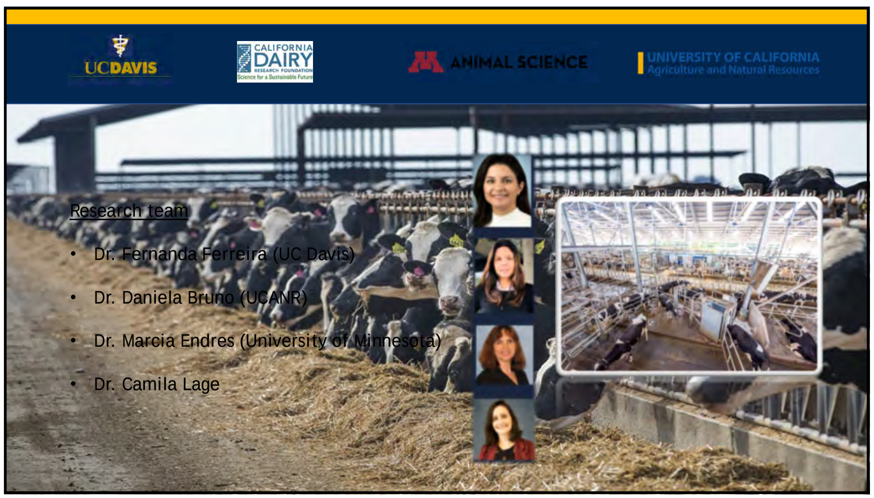
Structure to collect colostrum from fresh cows

Different feed pushers

25

Different manure management systems in different operations

26



27

Panel Discussion

Impact of Federal Farm Policies on Western Dairies

Moderator – Ryan Miltner JD, Partner Miltner Reed LLC

Lessons Learned from Government Intervention During the Pandemic

Panelist – Geoff Vanden Heuvel, Director of Regulator and Economic Affairs at Milk Producers Council

Impacts of USDA Pandemic Assistance Programs on Western Dairies

Panelist – Scott Brown, Ph.D., Director CAFNR, University of Missouri

As the industry continues to consolidate, thoughts on the new Farm Bill

Panelist – Jeremy Witte, Professional Staff, Senate Ag. Committee

NOTES:

Impact of Federal Farm Policies on Western Dairies: A Panel Discussion

Panelists

- **Geoff Vanden Heuvel, Director of Economic and Regulatory Affairs, Milk Producers Council (CA)**
- **Dr. Scott Brown, Associate Extension Professor, College of Agriculture, Food, and Natural Resources, The University of Missouri**
- **Jeremy Witte, Professional Staff, United States Senate Committee on Agriculture, Nutrition, and Forestry**
- **Moderator: Ryan Miltner, Federal Regulatory Counsel, Dairy Producers of New Mexico**

Attendees of this conference certainly do not need an explanation of how dairies in the Southwest differ from dairies in other regions of the country. Unfortunately, there has historically been little acknowledgment of regional differences in federal dairy support programs. Current dairy safety net programs and those of the recent past have, at least facially, operated the same for farms in the Midwest or New England as for those in the Southwest or the West Coast. But beneath these uniformly applicable regulations are real-world geographic disparities.

Using New Mexico as a prime example of these disparities, we can estimate the short-term and long-term implications of limiting the amount of milk covered by these programs in the aggregate and for an average dairy. Digging deeper into the current Dairy Margin Coverage Program, more disparities are unveiled—also the result of applying a single support formula nationwide. The end result is programs that come with a substantial cost and provide little benefit to those farms producing a majority of the milk in the United States.

Similarly, ad hoc dairy support programs fare little better in providing meaningful relief during times of crisis—at least for all producers. Congress and USDA authorized the Farmers to Families Food Box Program to help agricultural producers and the public in the earliest days of the COVID-19 pandemic. Despite good intentions, the structure and execution of the food box program resulted in clear winners and losers. A look at the development of the program suggests that these unintended consequences were not exactly unforeseeable. Adding insult to injury, later pandemic assistance programs have largely failed to compensate Western dairy farmers.

In light of the shortcomings of both standing dairy support programs and ad hoc supplemental support, it is probably worth asking some questions? What exactly do these programs provide to dairy producers in the Southwest? Do the programs even provide meaningful assistance to any class of dairy producer, or are they well-intentioned but ultimately ineffectual? What can we learn from existing data, and what additional data do policymakers need to plan for the future?

With the Farm Bill slated for reauthorization in 2023, legislators are faced with a familiar situation—limited funds and competing interests. But in addition, Congress will need to contend with the continuing pandemic, an inflationary economy, a stressed supply chain, a contentious political climate, and environmental considerations. Oh—there is an election before the Farm Bill expires, too. With all these non-dairy-specific issues, we cannot lose sight of calls for revisiting the Class I mover, making allowances, and other issues.

Corn Silage: Seed to Feed – Top 10 Take Home Messages

Bill Mahanna, Ph.D.
Global Nutritional Science Manager, Pioneer

NOTES:

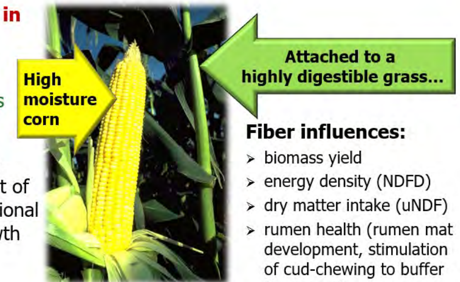
1

Introduction

Corn silage is unique crop (feed) due to the important interplay between growing environment, crop management/fertility, yield, harvest timing, fermentation/feed-out management and the nutritional value of starch versus fiber (biomass).

Source of energy in corn silage:
- 65% grain
- 10% cell contents
- 25% NDF (fiber)

Starch deposition is responsible for most of the increased nutritional value over the growth of the corn plant



Fiber influences:
- biomass yield
- energy density (NDFD)
- dry matter intake (uNDF)
- rumen health (rumen mat development, stimulation of cud-chewing to buffer the rumen)

2

USA Forage Production Trends

Alfalfa Declining,
(transgenic, low-lignin HarvXtra may slow this decline)

- Other sources of protein available
- Varying fiber digestibility
- Requires multiple harvests
- Does not utilize manure

Corn Silage Production Increasing
(but with fewer cows, this means higher dietary inclusion rates)

- Stable, high yields
- High energy (starch)
- High fiber digestibility
- Only 1 harvest/year
- Utilizes manure

3

Take Home Message Number 1

When selecting silage genetics, talk to your agronomist/seed salesman first and your nutritionist second.

4

What Makes Good Silage Genetics

- To be a good silage hybrid, it must **start out as an agronomically-stable hybrid with good grain yield** because you can <u>not</u> overcome lack of starch (>90% digestible) with small increases in fiber digestibility (60-70% digestible)
- **BUT…not every grain hybrid makes a good silage hybrid because they may be too short** and not deliver the desired stover (biomass) yields

5

Traits <u>To</u> Focus on When Selecting Silage Genetics

1. Basic Agronomic Traits (Yield Stability)

Heat units to silk and maturity, technology traits, stress emergence, drought tolerance, disease resistance (NLB, Tar Spot, ear molds)

2. Dry Matter Yield

Influenced by plant height at the ear (biomass yield) and starch (grain) content

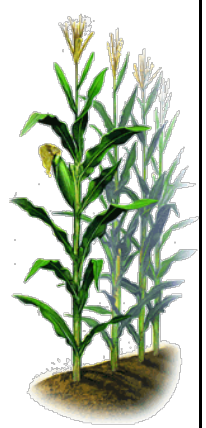
3. Starch Content

- Most energy dense component of the plant
- Influenced heavily by harvest maturity of the kernel
- Shorter statured plants can be high in starch but may lack overall biomass (tonnage).

6

Take Home Message Number 2

Don't get <u>too</u> hung up on silage hybrid nutritional traits other than starch <u>content.</u>



7

Traits <u>Not</u> To Focus on When Selecting Silage Genetics

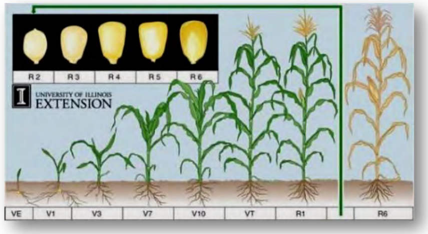
(but important when <u>feeding</u> the silage)

Fiber Digestibility

- <u>Not</u> a selection trait - little genetic variation between <u>non</u>-BMR's (standard hybrids)
  - Look at University silage plots and it is rare for a hybrid to be statistically higher in NDFD than the plot average unless it is a BMR hybrid
  - Why BMR hybrids have been commercialized

8

- The growing environment **during the vegetative stage** affects corn plant height (and biomass yield) and NDFD
  - Dry conditions => shorter plant, higher NDFD
  - Wet conditions => taller plant, lower NDFD



- **After silking** growing environment primarily affects grain yield and thus the starch content and energy density of the resulting corn silage

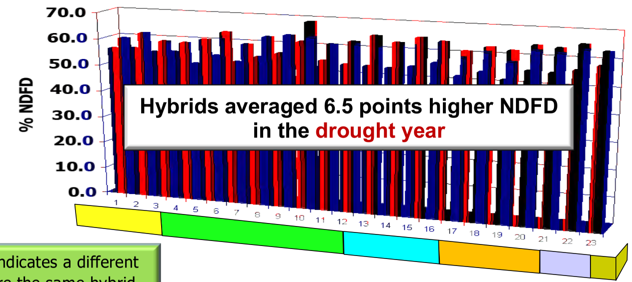
- **The ideal growing environment for corn silage is slightly dry during the vegetative stage (but not so dry as to significantly shorten plant and reduce biomass yield) , then plenty of moisture during grain fill.**

- **Fiber digestibility DOES NOT change due to the ensiling process**
- **Starch digestibility DOES change over time in fermented storage**

9

Growing Environment NOT Genetics Is the Main Influencer of Fiber Digestibility

Growing Environment Effect on the Same Hybrids Grown in MSU silage plots in 2006 (wet year) vs. 2007 (drought year)



Each block color indicates a different plot location where the same hybrid was grown in both years

Source: Dann Bolinger, Pioneer Dairy Specialist - Michigan

10

Table 2. Corn silage NDFD (%) response to growing degree unit and precipitation accumulation during various development stages. Data are derived from the UW Corn Evaluation Program (1995-2020).

	Growing degree units				Precipitation			
	Cool	Average	Warm	LSD(0.10)	Dry	Average	Wet	LSD(0.10)
Season April 1 to September 15	58	59	58	NS	58	60	55	2
Vegetative stages April 1 to July 14	58	59	60	2	60	59	57	NS
Reproductive stages July 15 to September 15	59	59	60	NS	60	60	56	1
Planting April 1 to May 31	57	60	58	1	55	59	60	1
Leaf development June 1 to July 14	60	59	60	NS	60	59	59	NS
Pollination July 15 to August 4	60	59	59	NS	58	59	58	NS
Grain Filling August 5 to September 15	58	59	61	2	58	60	56	2

Arlington S E&L 1995-2020, N= 5495

Source: Dr. Joe Lauer, UW Corn Extension Specialist, December, 2020
http://corn.agronomy.wisc.edu/Extension/AU21/A136-2020%20%20Effect%20of%20Environment%20on%20Corn%20Silage%20Yield%20and%20Quality.pdf

11

NDFD or uNDF240 are not important hybrid selection criteria because growing environment is much more important than genetics in determining NDFD (except BMR), but they are very important to nutritionists in diet formulation.

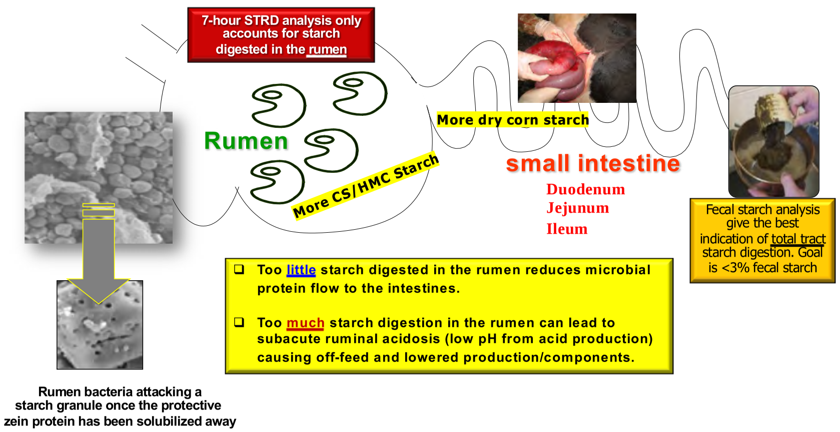
- **Growing environment is 3X more influential on NDFD than genetics.**
  (Dr. Fred Owens, Retired Pioneer Research Scientis

- **Moisture the plant receives is 7-times more influential on fiber digestibility than heat units.**
  (Dr. Mike VanAmburgh, Cornell University

12

Moving to Ruminant Starch Digestion

Rumen vs. Total Tract

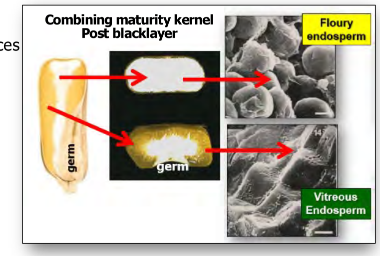


- Too little starch digested in the rumen reduces microbial protein flow to the intestines.
- Too much starch digestion in the rumen can lead to subacute ruminal acidosis (low pH from acid production) causing off-feed and lowered production/components.

13

What About Starch Digestibility?

– **No significant differences among hybrids at silage maturity**
  - Yes, at combining maturity because hybrids have different test weights
    – higher test weight meaning kernels contain more hard, vitreous starch
  - Very little hard, vitreous starch laid down in the kernel at silage harvest maturities (1/2-3/4 milkline)
    – Which is why University silage hybrid trials do **NOT** analyze hybrid entries for starch digestibility
  - Dent hybrids do have higher **ruminal** starch digestion than flints (but we don't have flint hybrids in the USA)
  - Remember that 7-hour starch digestibility data promoting soft-textured, floury corn only references ruminal digestion, not total tract.
    – fecal starch analysis will indicate total tract starch digestibility
  - **Influenced most by growing environment, kernel maturity, degree of processing and time in fermented storage**



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Starch Digestibility of Corn – Silage and Grain

Jeffrey L. Firkins
Department of Animal Science
The Ohio State University

Need to consider if referencing:

- **Silage kernels (pre-blacklayer)**
  or
- **Combined kernels (post-blacklayer)**

Conclusions

Taken together with other studies described, I conclude that there should be an optimum NSC availability in the rumen that is consistent with efficient rumen microbial metabolism. Clearly, the amount of RDS depends on the maturity, DM percentage, and processing of corn silage. Some silages might be lower in RDS than others, so we still need to develop or improve methodology to predict starch availability in silages in a systematic laboratory analysis that will help nutrition advisors to better account for varying RDS. Until more work is done, the Wisconsin index (Ferreira and Mertens, 2005) for particle size should be considered to predict total tract starch digestibility. Vitreousness of corn grain in silage seems to be of relatively little value. In contrast, vitreousness or perhaps gelatinization of dry corn grain should be considered, particularly to help users know when to grind corn more finely. Using these considerations for coarse adjustment of rations, the amount of RDS can be fine-tuned with more slowly available byproducts or increased moderately with small amounts of sugars according to individual herd or group needs. As ration balancing and feeding systems continue to improve in reliability and repeatability, nutrition advisors will still have to use their knowledge of nutrition to continue to keep pace with other feeding management practices.

Presented at the Tri-State Nutrition Conference April 25, 2006

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Do we really want higher ruminal starch digestion?

- SARA (rumen upsets due to low pH) is a major challenge in herd pushing for high production
- We will continue w/ high corn-based diets
- Fecal starch levels on most well-managed herds are already below 3% so improvement in total tract starch digestibility, especially if accompanied by any reduction in yield, seems of little value.
- Nutritionists appear more concerned with reducing, rather than increasing, ruminal starch digestibility in high corn grain/silage based diets exemplified by the move away from high-moisture corn to dry corn in many dairy diets.

The William H. Miner Agricultural Research Institute · January 2015

FARM REPORT

Subacute ruminal acidosis (SARA) is a major challenge in dairy nutrition strategies aimed at fulfilling the energy needs of a high-producing cow. SARA is a prevalent and widespread metabolic disorder in intensive ruminant agriculture systems, including the dairy industry. It's initiated when the equilibrium of the rumen pH goes below 5.6 for more than 3 hours over the course of a day, causing the rumen to be more acidic. But what causes this to happen? How do you identify it? What are the negative effects this disorder has on the animals?

SARA is more likely when the ration contains an imbalance of starch and fiber. Increased amounts of metabolic energy are commonly provided in the cow's diet by adding rapidly fermentable carbohydrates, usually in the form of starch, to meet her high nutritional demands during lactation. This lends itself to increase the risk of SARA, by the rapid fermentation of the carbohydrates which stimulates microbial growth. With increased

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As we move to feeding higher digestible forages (both BMR and HarvXtra alfalfa) DM intakes go up and excessive ruminal starch digestion is even more of a concern…..

Feeding both BMR corn silage and reduced-lignin alfalfa in a TMR*

Type of reduced-lignin alfalfa	Cutting schedule	Lignin drop	NDFD gain	Forage harvest and dietary considerations
Normal selection reduced-lignin alfalfa	Normal	-	+	Minimal with sound harvest and TMR management
Transgenic reduced-lignin alfalfa (HarvXtra®)	Normal	–	++	Check and adjust chop length, diet peNDF, diet forage NDF%, and diet starch %
	Delayed	0	0	None

*Nutrient composition and digestibility values vary – routine and accurate forage analysis with ration formulation as necessary is crucial for success.

Changes that may be required:

- ❑ boosting peNDF via greater dietary forage and forage NDF content
- ❑ reducing dietary starch
- ❑lengthening silage chop settings

Source: Randy Shaver. Doubling down on reduced lignin. HFG March 2018

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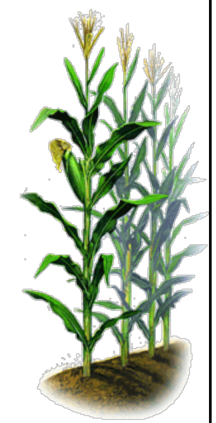
Take Home Message Number 3

Pay close attention to the "farming" side of corn silage production.

Tillage practices and planting accuracy is just as important for silage as for grain production.



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Proper Tillage

Some of the varied root development due to:

- ❑ **compaction layers**
- ❑ **planter** performance (seed to soil contact)
- ❑ **planting too shallow** resulting in nodal roots not developing properly

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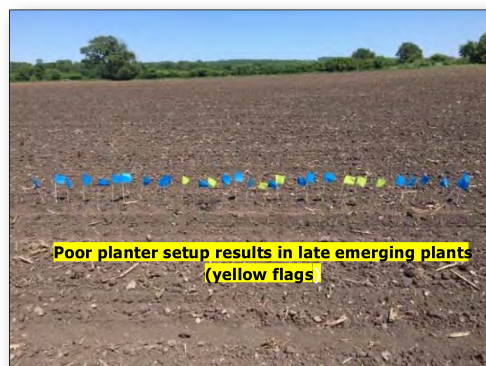
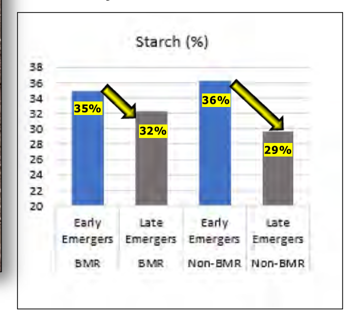
Proper Planter Setup



❑ A 2016 Wisconsin field study on late emerging plants showed that 19% of plants were 12-72 hours late emerging resulting in 7% lower starch content in a standard hybrid and 3 points lower in a BMR hybrid.



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Late-Season Plant Health Can Also Influence NDFD

Plants that develop late-season plant diseases drop significantly in fiber digestibility.

- **Novel approach to positioning fungicides on corn silage based on cost/cow/day, which is how dairymen think about input costs:**
  - **3 cents/cow/day for fungicides based on $25/acre to treat/apply, 25-ton (fresh) silage yields and 60 lbs. (as fed) corn silage intake/cow/day.**

Hybrid	Detail	Date Sampled	NDFD30
X	healthy stalks – field A	9/19/2017	61.7
X	healthy stalks – field A	9/27/2017	60.9
Y	diseased stalks – field B	9/19/2017	59.3
Y	diseased stalks – field B	9/28/2017	46.4

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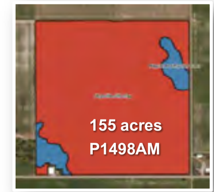
Within Field

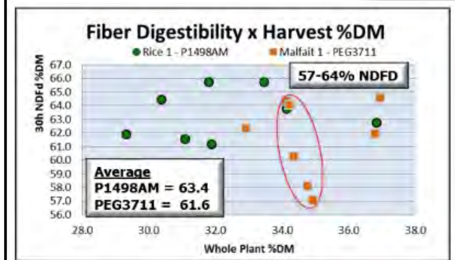
Variation in Soil Types

(Water Holding Capacity, N-profile)

Also Influences NDFD



- Fields were extremely uniform, both internally and by comparison.
- 8 samples representing 8 random loads from a single field for each hybrid.



Within Field Variation Much Greater than Genetic Differences

Source: Dann Bolinger 2016. Pioneer Michigan/Ohio Dairy Specialist

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Take Home Message Number 4

Plant at proper populations to optimize both starch and biomass yield.

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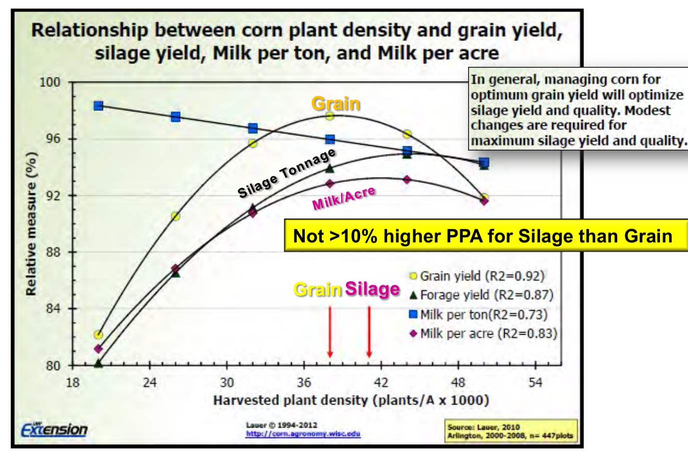

Source: Dr. Joe Lauer, UW State Corn Extension Specialist, Pioneer Corn Silage presentation January 31, 2012, Johnston, IA

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Lower Plant Populations Do NOT Increase NDFD

Figure 6. Planting rate effects on silage NDF, 30-hour NDFD, crude protein and starch of various corn hybrids averaged across the 2008 and 2009 in Aurora, NY (Cox et al., 2009).

	HYBRIDS							
	Pioneer	DeKalb	Leafy	BMR	Pioneer	DeKalb	Leafy	BMR
PLANTING RATE	NDF				NDFD (30 hr)			
Kernels/acre	%				%			
25,000	39.8	39.5	40.1	41.3	58.7	58.3	58.7	71.2
30,000	40.8	39.9	41.4	41.1	59.3	57.7	59.1	72.3
35,000	40.9	39.9	40.4	41.1	57.9	57.2	59.6	72.2
40,000	**41.4**	**40.6**	**42.0**	**42.5**	59.3	57.4	59.5	73.0
Avg.	40.7	39.9	40.9	41.5	58.8	57.6	59.2	72.2
	CP				STARCH			
25,000	**8.9**	**8.6**	**8.8**	**8.8**	33.3	34.6	34.6	33.3
30,000	8.5	8.3	8.6	8.6	34.2	34.6	34.5	32.1
35,000	8.3	8.3	8.4	8.5	33.9	34.9	34.8	32.6
40,000	8.2	8.1	8.2	8.4	33.8	34.7	34.0	31.5
Avg.	8.5	8.3	8.5	8.6	33.8	34.7	34.5	

- A 2-year study at the Cornell University (Aurora) Research Farm in 2008 and 2009 evaluated two Pioneer (34T55 and 34A89), two DeKalb (DKC61-69 and DKC63-42), two leafy (TMF2Q716 and 2W587, Mycogen), and two brown midrib (F2F566 and F2F610, Mycogen) hybrids at planting rates of 25,000, 30,000, 35,000, and 40,000 kernels/acre (Figure 6).
- The researchers concluded that the DeKalb, leafy, and brown midrib hybrids had their highest yield at 35,000 kernels/acre with <u>no real detrimental effect on NDFD and starch concentrations</u>, whereas the Pioneer hybrids yielded best at 40,000 kernels/acre without negatively impacting NDFD (Cox et al., 2009).

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Lower Plant Populations Do NOT Increase NDFD

Figure 4. Effect of planting density on DM yield and plant structure (Ferreira and Teets, 2017).

	Planting density[1]					$P <$[2]		
Item	55K	70K	85K	100K	SEM	Trt	L	Q
DM, %	32.1	31.7	31.5	31.4	0.28	0.29	0.07	0.59
Plant dry weight, g/plant	376	334	284	253	7.4	0.01	0.01	0.46
DM yield, Mg/ha	19.8	21.5	23.4	26.0	0.5	0.01	0.01	0.41
Kernel lines per ear, count	17.1	16.5	16.0	16.3	0.26	0.03	0.02	0.09
Kernels per line, count	42.2	38.9	35.6	33.9	0.69	0.01	0.01	0.25
Kernels per ear, count	720	641	570	553	13	0.01	0.01	0.03
Stem width, mm	19.7	18.9	17.4	17.0	0.32	0.01	0.01	0.64

[1]55K = 55,000 plants/ha; 70K = 70,000 plants/ha; 85K = 85,000 plants/ha; 100K = 100,000 plants/ha.
[2]Trt = treatment; L = linear response; Q = quadratic response

Figure 5. Effect of planting density on nutritional composition (DM basis) of fresh corn (Ferreira and Teets, 2017).

	Planting density[1]					$P <$[2]		
Item	55K	70K	85K	100K	SEM	Trt	L	Q
Ash, %	3.5	3.7	3.7	3.7	0.07	0.17	0.11	0.14
CP, %	10.2	10.2	10.3	10.3	0.12	0.90	0.61	0.85
NDF, %	36.5	38.0	38.2	38.2	0.54	0.09	0.04	0.17
ADF, %	21.6	22.3	23.0	22.7	0.39	0.11	0.04	0.24
ADL, %	2.4	2.5	2.4	2.2	0.13	0.35	0.16	0.27
Starch, %	33.4	34.4	33.5	33.5	0.48	0.46	0.72	0.27
Sugars, %	12.3	12.4	12.7	11.5	0.34	0.15	0.15	0.07
30-h IVNDFD,[3] % of NDF	45.9	43.9	42.4	43.8	1.08	0.12	0.12	0.14

[1]55K = 55,000 plants/ha; 70K = 70,000 plants/ha; 85K = 85,000 plants/ha; 100K = 100,000 plants/ha.
[2]Trt = treatment; L = linear response; Q = quadratic response.
[3]IVNDFD = ruminal in vitro NDF digestibility

- A more recent 2017 study by Ferreira and Teets (2017) examined two different standard hybrids planted in seven different fields at **23,000, 29,000, 35,400, 41,600 ppa.** (55,000, 70,000, 85,000 and 100,000 plants per hectare).
- This study demonstrated that planting density increased yield and <u>while reducing stalk diameter</u> (Figure 4), did <u>not</u> significantly (P>0.12) reduce 30-hour ruminal in vitro NDFD of the resulting silage (Figure 5).

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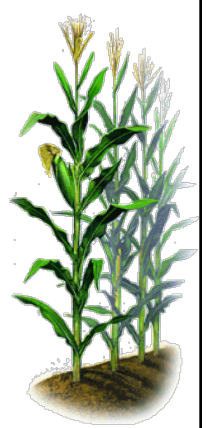
Take Home Message Number 5

Don't harvest <u>healthy</u> plants too early.

Look at <u>both</u> kernel maturity and whole plant moisture as harvest triggers.



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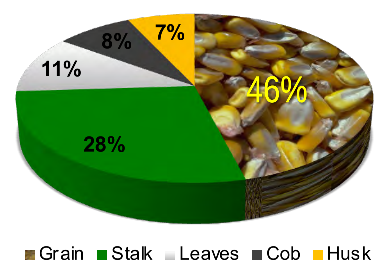
Grain typically makes 45-50% of silage yield

(at ~70% starch =35% starch)



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Factors Affecting Corn Silage Yield

- ❑ The drivers of Corn Silage Yield are:
  - #1 harvest timing
  - #2 hybrid genetics
  - #3 planting date
- ❑ Harvest timing is #1 because grain typically makes 50% of the yield (and 65% of the energy)

Range and Relative Impact (%) of Management Decisions on Silage Yield and Quality

Extension — Lauer © 1994-2012 http://corn.agronomy.wisc.edu — Lauer, 1995-2007 (unpublished)

Factor	N Trials	Yield T/A
Hybrid Top v. Bottom Entry	204	3.1 (39%)
Plant density 22K v. 40K	31	1.2 (14%)
Planting date April 24 v. June 16	28	2.2 (27%)
Row Spacing 30" v. 15"	13	0 (0%)
Rotation CC v. CS v. CSW	--	?
Soil Fertility 160 v. 0 lb N/A	--	
Pest Control Poor v. Good	--	"Do for si Economic
Harvest timing Wet (R3) v. Dry (R5.5)	5	4.4 (40%)

R3 = milk
R5.5 = ½ milkline

Source: Dr. Joe Lauer, UW State Corn Extension Specialist, Pioneer Corn Silage presentation January 31, 2012, Johnston, Iowa

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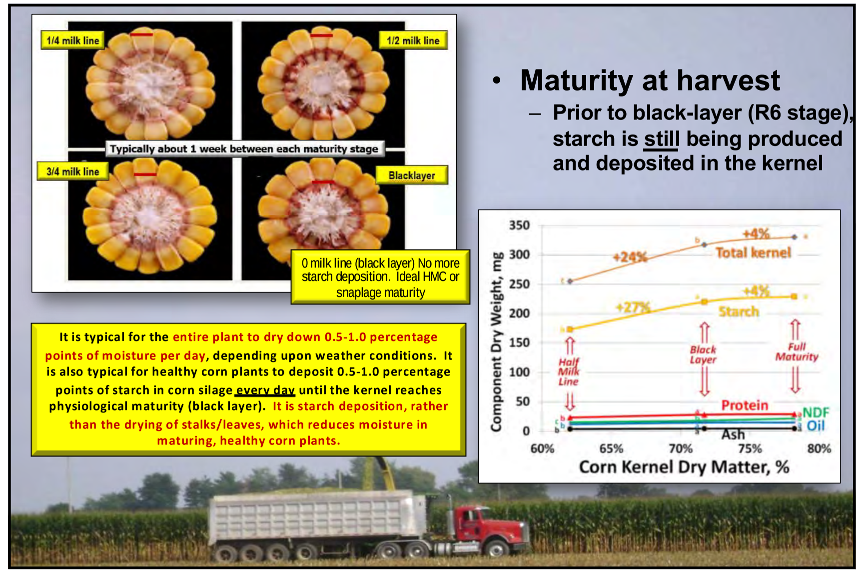

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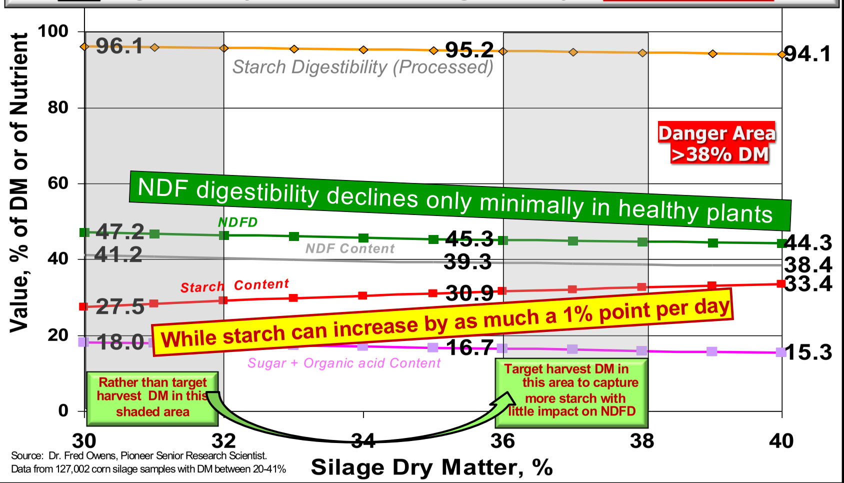
Harvesting at Closer to ¾ Milk Line to Capture More Starch Does Not Significantly Reduce Fiber Digestibility in Healthy Plants



Source: Dr. Fred Owens, Pioneer Senior Research Scientist.
Data from 127,002 corn silage samples with DM between 20-41%

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In the Past, Perhaps Too Much Emphasis on Whole-Plant Moistures to Trigger Silage Harvest

Silage "burn-down" days

Whole-plant moistures then determined with a Koster Moister Tester or Microwave

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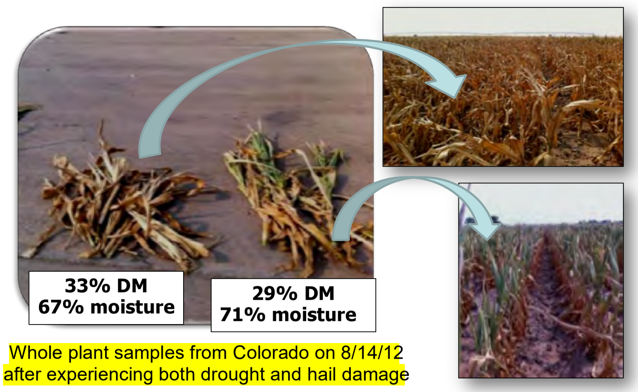
Example of Low DM Content Due to Lack of Ear/kernel Development (starch deposition)



Whole plant samples from Colorado on 8/14/12 after experiencing both drought and hail damage

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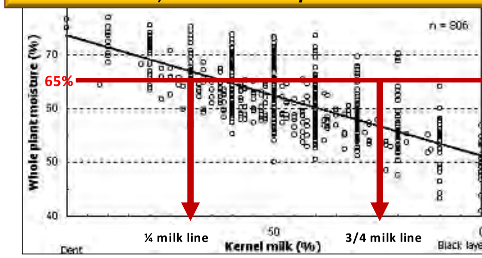
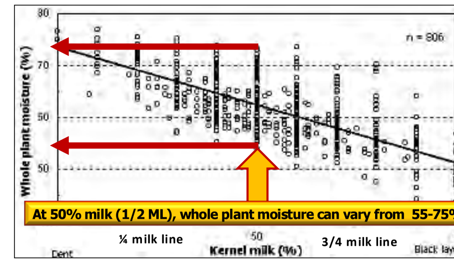


Monitor both kernel milkline and whole plant moisture… but on healthy plants, focus more on kernel milkline.



Source: Joe Lauer. April 1999. Kernel Milkline: How Should We Use It For Harvesting Silage? Field Crops 28.4723. http://corn.agronomy.wisc.edu/AA/A023.aspx

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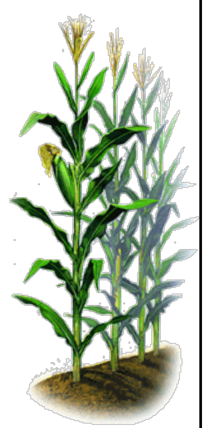
Take Home Message Number 6

Consider management options to improve fiber digestibility.

Target the highest NDFD corn silage to transition and high-string cows.



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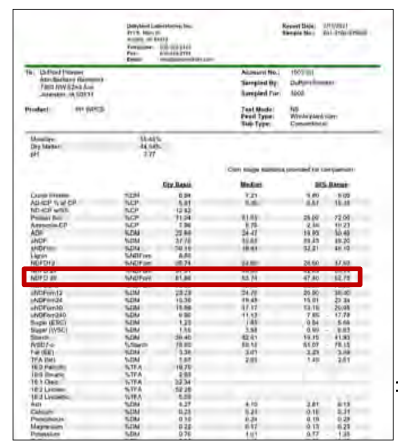
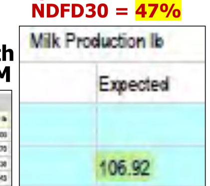
Monetizing Modest NDFD Changes in a Dairy Diet

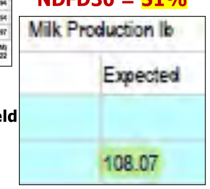


Typical dairy diet with 20 lbs corn silage DM

Expected milk with NDFD30 = 47%



Expected milk with NDFD30 = 51%



1 more lb marginal milk yield = 12-18 cent/cow/day

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High-Chopping Review of 11 Studies

Increasing chop height from 7” to 20”

Table 1. Average nutrient content and production of corn silage harvested at low or high levels of height (summarized from 11 studies)[1].

Item	Low height (6.8 ± 2.5”)	High height (19.3 ± 2.8”)	Change (%)
DM, %	38.1	40.3	6.0
CP, %	7.0	7.1	2.0
ADF, %	24.2	21.8	-10.2
NDF, %	41.6	38.6	-7.4
Starch, %	30.6	32.4	5.9
NEL, Mcal/lb	0.71	0.74	4.2
NDF digestibility, %[2]	50.6	54.0	6.7
DM digestibility, %[2]	78.6	80.6	2.5
Yield, ton/ac, DM	8.1	7.5	-7.4

- In this 11-trial summary whole plant yield decreased about ½ ton (30% DM) silage for every 4” increase in chop height.
- Keep in mind that the yield loss is relatively undigestible fiber from lower internodes, not leaves, ear or more digestible upper stalk internodes.

Source: http://www.das.psu.edu/user/publications/pdf/das03-72.pdf

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You Do Give Up Some Yield When High-Chopping

- The 11 trial summary showed that whole plant yield decreased about ½ ton (30% DM) silage for every 4” increase in chop height
- Keep in mind that the yield loss is relatively undigestible fiber from lower internodes, not leaves, ear or more digestible upper stalk internodes

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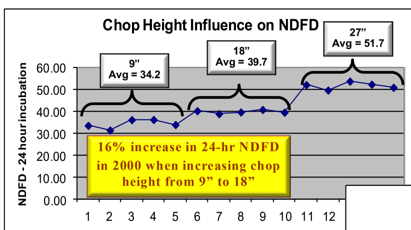
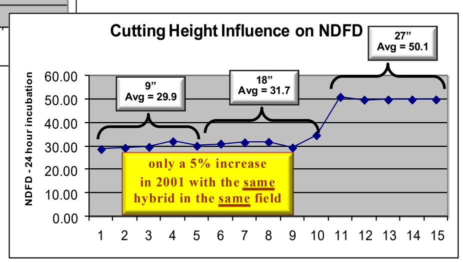
Example of How NDFD Responds Differently to High-Chopping Depending upon the Growing Season



Trial Background: Fiber digestibility data from 5 plants harvested at 3 different chop heights from the same hybrid (34B23) sampled from same section of same field in 2000 and again in 2001



The only way to know if high-chopping will significantly increase fiber digestibility is to sample whole plants just prior (~2 weeks) to harvest and rapidly analyze with a NIR for fiber digestibility (NDFD)

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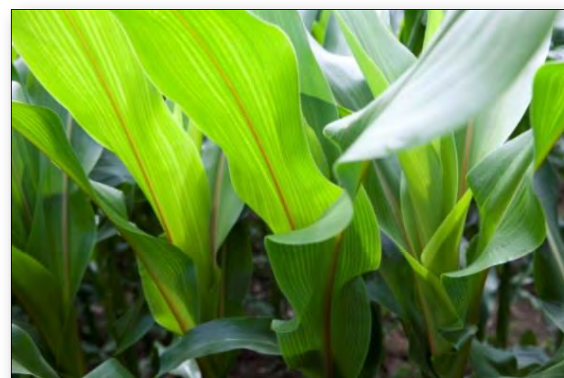
Brown Mid Rib Corn Hybrids



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Higher NDFD with BMR Hybrids

Higher NDFD impacts:

- **The amount of forage in the diet (typically more forage = a cheaper ration)**
- **The energy obtained from the silage**
- **The amount of forage cows can eat per day because BMR fiber is more fragile and exits the rumen faster than fiber from non-BMR hybrids**

The main nutritional advantage of BMR silage is higher intakes from higher fiber digestibility and higher cell wall fragility due to less lignin

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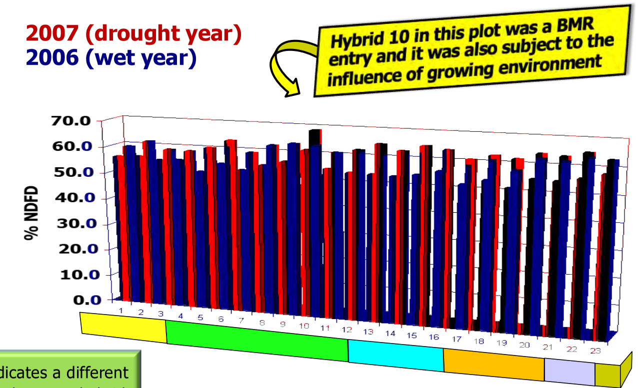
Growing Environment Impacts the Fiber Digestibility of BMR in a Similar Manner To Non-BMR Hybrids



Each block color indicates a different plot location where the same hybrid was grown in both years

Source: Dann Bolinger, Pioneer Dairy Specialist - Michigan

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Set Realistic BMR Expectations

vs. standard corn silage hybrids

- Potential for more agronomic risk (standability, need for fungicides etc.)
- Slightly reduced yields (10-20% depending upon growing conditions)
- Extra inventory needed due to slightly reduced yields and higher feed intake of BMR silage
- **Show most value in transition and high-string diets.**

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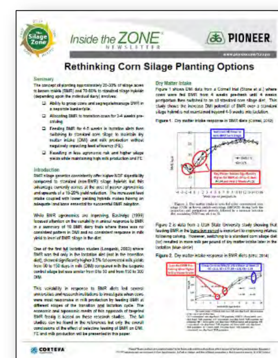
Re-thinking (current) BMR hybrid utilization in terms of milk yield and agronomic risk.

- **The concept of planting approximately 20-30% of silage acres to brown midrib (BMR) and 70-80% to standard silage hybrids (depending upon the individual dairy) involves:**
  - Ability to group cows and segregate/manage BMR in a separate bunker/pile.
  - Allocating BMR to transition cows for 3-4 weeks pre-calving.
  - Feeding BMR for 4-5 weeks in lactation diets then switching to standard corn silage to maintain dry matter intake (DMI) and milk production without negatively impacting feed efficiency (FE).
  - Resulting in less agronomic risk and higher silage yields while maintaining high milk production and FE.



Send Bill Mahanna an email (bill.Mahanna@pioneer.com) and will gladly send you this document highlighting university research studies supporting this concept of BMR feeding.

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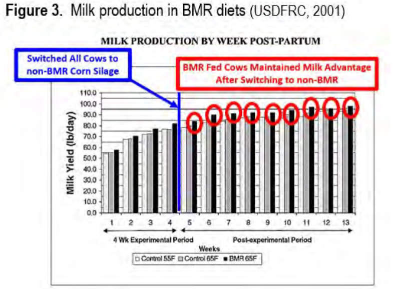
Research justification for feeding “standard” corn silage for “post-peak”, later lactation cows

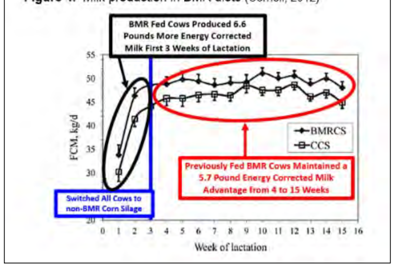
A 2001 trial at the US Dairy Forage Research Center (Figure 3) showed that cows fed BMR 3 weeks pre-fresh and 4 weeks postpartum produced 6.2 pounds more 3.5% fat corrected milk and maintained the milk advantage after switching to a standard corn silage diet (right of the blue line).

Figure 3. Milk production in BMR diets (USDFRC, 2001)



Milk production data from the 2012 Cornell trial is shown in Figure 4. As in other trials, cows fed BMR in the transition group and 3-5 weeks postpartum maintained their energy corrected milk production advantage even when cows were switched to a standard corn silage diet at 4 weeks into their lactation (right of the blue line).

Figure 4. Milk production in BMR diets (Cornell, 2012)



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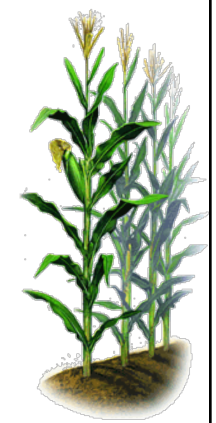
Take Home Message Number 7

Closely monitor chop length and kernel processing at time of harvest.



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Corn Silage Chop Length

- ❑ **There is no “ideal” chop length for corn silage. It depends on the inclusion level of all the other forages in the ration.**
- ❑ **Corn silage is typically chopped at 19mm (3/4”) and haylage about 15-19mm to ensure adequate “effective” fiber levels.**
- ❑ **Research by Miner Institute indicates particle size seems to influence eating time more than rumination time and suggest CS be chopped from 16-22mm and no longer.**
  - ➢ Cows has similar ECM whether the diet was higher in undigested fiber (uNDF240) but chopped fine OR if the diet was lower in uNDF but with coarser particle size (peNDF).
  - ➢ Very long particles in the diet will prolong eating time without providing any greater rumination stimulation because cows tend to chew to a relatively uniform particle size (8mm screen on PSPS) before swallowing.
  - ➢ Cows fed low effective fiber (peNDF) diets that were also low in undigested fiber (uNDF240) ate 5 lb more DM/day and spent 45 minutes less time at the feed bunk (not exceeding 5 hours/day eating to allow for more resting time).

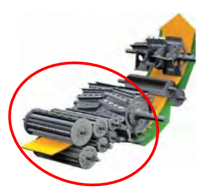

Table 2. Key diagnostics from the cows

Item	Low uNDF240		High uNDF240	
	Low peNDF (1)	High peNDF (2)	Low peNDF (3)	High peNDF (4)
DMI, lbs./day	60.6ᵃ	60.2ᵃ	60.4ᵃ	54.9ᵇ
ECM, lbs./day	103.6ᵃ	100.8ᵃᵇ	102.3ᵃᵇ	98.3ᵇ
Eating time, min./day	255.4ᵃ	262.5ᵇ	279.1ᶜ	300.3ᵈ
Rumination, min./day	523.2	526.5	531.8	544.5

*Means in a row where unlike superscripts differ (P < 0.05).

https://hayandforage.com/article-2769-rethinking-forage-particle-size.html

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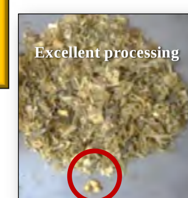
Monitoring Kernel Processing

If chopping longer (19-22mm) and/or harvesting more mature (to capture more starch), it is important to have the kernels adequately processed



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Kernel Processing Scoring

This is the Ro-Tap lab method to quantify kernel damage
Jointly developed by Pioneer, Dave Mertens and Dairyland Labs (Arcadia, WI)

- Quantifies percent of starch in damaged vs. undamaged kernels. Available commercially from Dairyland Labs (Arcadia, WI) and Cumberland Valley Lab (Hagerstown, MD) for ~ $18.00

This is the most important sieve, the 4.75mm screen (0.187 in)

Starch not as available in kernels on or above the 4.75mm screen (traps ¼ kernel pieces and greater)

4.75mm screen

Starch passing this screen is more available and what is reported as "damaged" or "% passing coarse screen" on lab results

Sieve (mm)	Fiber and starch separations
19	coarse
13	coarse
9.5	coarse
6.7	coarse
4.75	coarse / starch sieve
3.35	medium
2.36	medium
1.18	Medium/peNDF sieve
0.6	fine
pan	fine

Can also be used to calculate peNDF using fiber above 1.18mm screen as the pe factor (wet sieving using the Penn State Separator does not give valid peNDF values)

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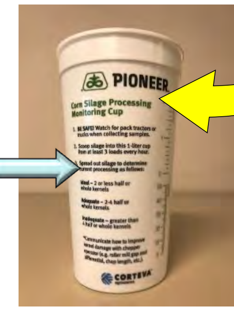
Pioneer Processing Cup to Assess Degree of Kernel Processing During Harvest

Best field test is a 1 liter cup….if you see more than 2-4 half or whole kernels in this volume of silage, then chopper adjustments may be called for:

Ideal = 2 whole kernels or less
Adequate = 2 to 4 kernels
Inadequate = more than 4 kernels



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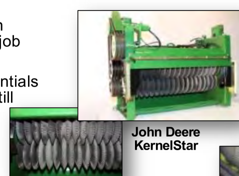
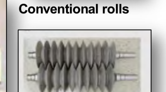
Kernel Processing Guidelines

1. **Check roller mill wear**
   1. Typical life is ~400 hours unless chromed roller mills ~1000 hours
   2. Check aggressiveness of teeth design (# teeth/inch)
2. **Roller mill gap set at 1-3mm for adequate kernel pericarp damage**
3. **Do not set chop length over 19mm (3/4") unless using a processor like Shredlage designed for longer chopping**
   1. set shorter (17mm) if you do not have a great need for peNDF (scratch) coming from the corn silage as because all choppers will do a better job of processing at shorter chop lengths
   2. some processors (Shredlage) with roller differentials over 40-50% can chop as long as 30mm and still achieve excellent kernel damage
   3. any chopper can do a good job if chop length, differential and roller mill setting (and wear) are managed correctly.
4. **Check the roller mill differential**
   1. Historically processors were set at between a 10-20% differential.
   2. The higher the differential (e.g. 40-50%) improves the ability of all processors to adequately damage kernels.
5. **Don't forget to frequently monitor the quality of processing during harvest using the Pioneer Kernel Processing Cup**

Conventional rolls



John Deere KernelStar



Krone Disc Processor

Shredlage rolls (patent purchased by Claas)

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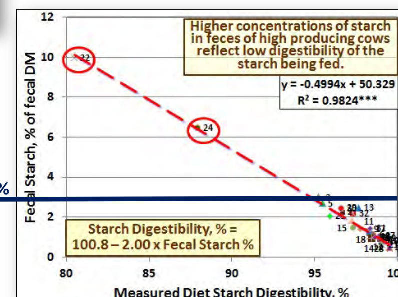
2015 Wisconsin Field Study

Herds: 32 dairies in the Upper Midwest.
Cows: Top strings from each herd (106#)
Diets: Kernel processed corn silage fermented 8 months; corn grain (Dry rolled, HMC, or earlage)
TMRs averaged 26% starch 31% NDF.
Samples: Corn silage, grain, TMR, feces.

Bill Powel-Smith

The two herds with high fecal starch had poor silage kernel processing



Goal is <3% starch in feces. All these high-producing herds met that hurdle except two and they have very poor corn silage kernel processing scores (lots of large kernel pieces). They also obtained high production, but it likely required addition of more expensive starch into the diet.

This data was presented as a research poster (T437) at the Joint Dairy/Animal Science Meeting, Orlando, Florida July 14, 2015

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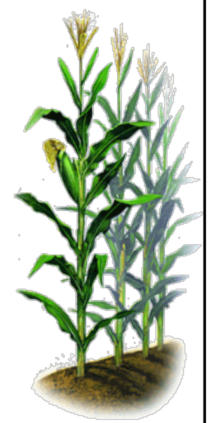
Take Home Message Number 8

Protect your investment with proper ensiling and feed-out management.



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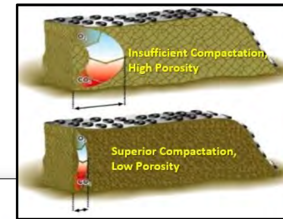
Compaction Density and Moisture (to prevent air porosity)



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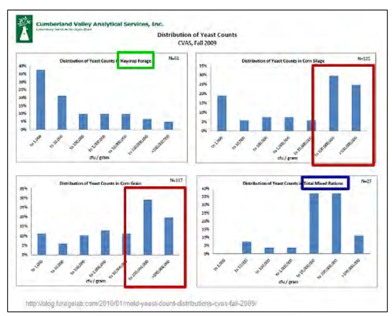
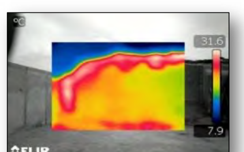
Corn Silage is Loaded with Yeast

Ranking crops in terms of difficulty to ferment (hardest to easiest)

- **HMC** with high yeast loads
- Extremely low moisture
- Extremely low sugar content
  - mostly starch
- **Alfalfa** wilted on the ground
  - ash and clostridial spores
- High buffering capacity
- Relatively low sugar
- **Corn silage** is direct cut
- Low buffering capacity
- High sugar
- Loaded with Yeast





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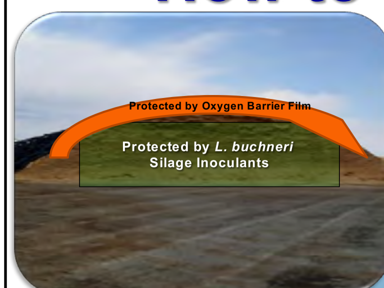
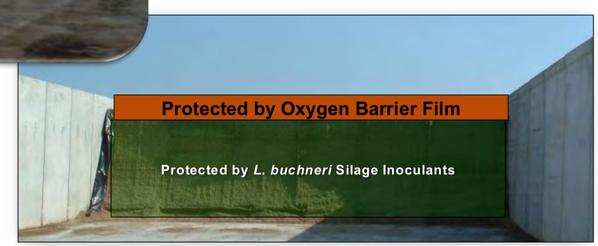
How to Stop Yeast



- ✓ Oxygen Barrier Film
- ✓ Crop specific *L. buchneri* inoculants



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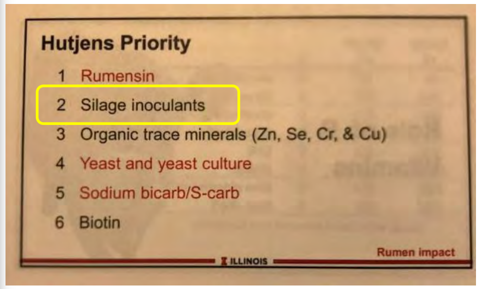
Hutjens Priority
1 Rumensin
2 Silage inoculants
3 Organic trace minerals (Zn, Se, Cr, & Cu)
4 Yeast and yeast culture
5 Sodium bicarb/S-carb
6 Biotin
ILLINOIS
Rumen impact

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Correct Bunker/Pile Face Management

http://easyrakefacer.com/

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Take Home Message Number 9

Talk to your nutritionist about the potential impact of:
- low rumen pH (caused by changes in ruminal starch digestion and
- excessive corn oil (linoleic acid) on butterfat yields.

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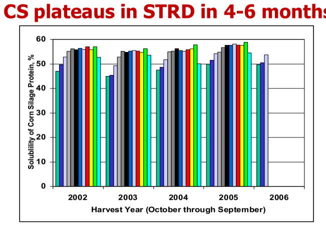
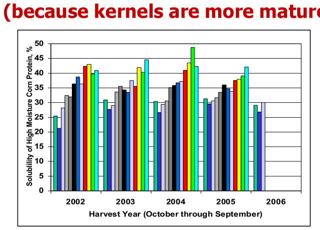
Corn Silage Increases in the amount of starch digested in the rumen over time in fermented storage

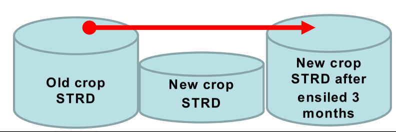
CS plateaus in STRD in 4-6 months



HMC increases for a full 12 months (because kernels are more mature)



- **Many dairies carry 14-16 months of corn silage inventory for:**
  - Hedge against agronomic (yield) risk
  - Ensure consistency in ruminal starch digestibility



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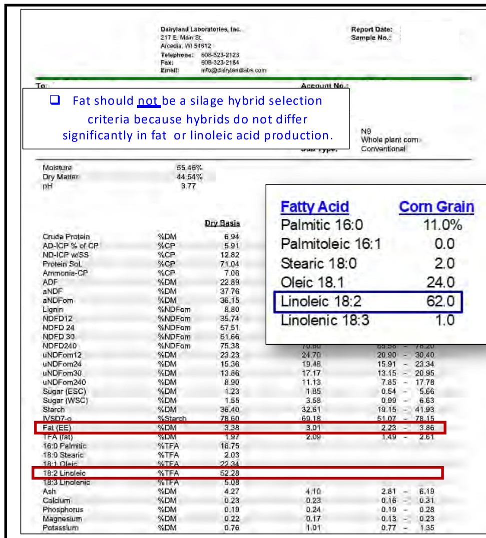
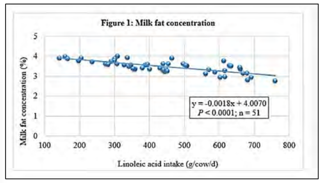
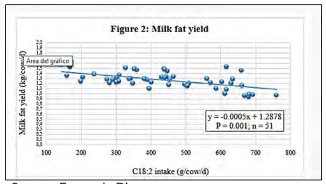


❑ Fat should not be a silage hybrid selection criteria because hybrids do not differ significantly in fat or linoleic acid production.

Fatty Acid	Corn Grain
Palmitic 16:0	11.0%
Palmitoleic 16:1	0.0
Stearic 18:0	2.0
Oleic 18.1	24.0
Linoleic 18:2	62.0
Linolenic 18:3	1.0

	Median	Normal min	Normal max	Count
18:2 Linoleic %TFA	49.21	41.23	55.86	>10,000





Source: Fernando Diaz.
https://dellait.com/research-report-effects-of-linoleic-fatty-acid-intake-on-milk-fat-production-in-lactating-dairy-cows-a-meta-analysis/

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Biohydrogenation pathways of *trans*-fatty acid intermediate production linked to milk fat depression (adapted from Lock, 2009)

Linoleic acid
(*cis*-9,*cis*-12 C18:2)

normal rumen fermentation

altered rumen fermentation (e.g. low rumen pH)

Conjugated linoleic acid (CLA)
(*cis*-9,*trans*-11 C18:2)
(Also known as Rumenic Acid. A desirable CLA accounting for 90% of CLA in milk and linked to anti-carcinogenic activity)

Conjugated linoleic acid (CLA)
(*trans*-10,*cis*-12 C18:2)
(Undesirable CLA linked to milk fat depression)

Only 3-4 grams of trans-10, cis-12 CLA flowing to the intestines can dramatically drop fat test
Source: Overton et al; 2003. Proc 4-States Conf. P 89

Vaccenic acid
(*trans*-11 C18:1)

(*trans*-10 C18:1)

Stearic acid
(C18:0)

Fatty acids should NOT be a hybrid selection criteria
Hybrids differ little in fat or linoleic acid content

Stearic acid
(C18:0)

Source: Mahanna, B. 2009. Milk fat depression involves many factors. Feedstuffs Vol. 81, No 42 October 12, 2009

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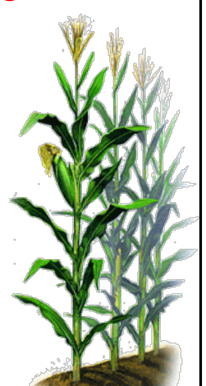
Take Home Message Number 10

Analyze your silage and understand inventory needs.



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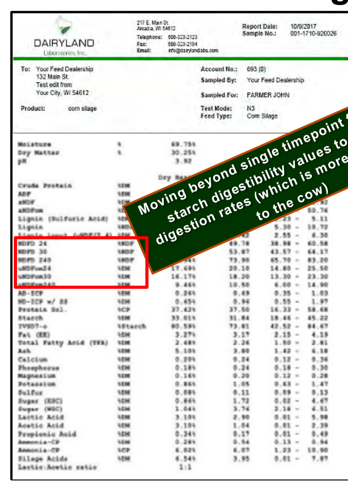
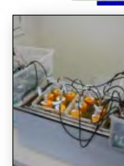
Testing Corn Silage for Digestion Rates, Processing Score and Fecal Starch

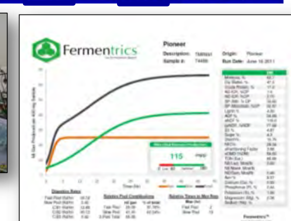


Moving beyond single timepoint fiber and starch digestibility values to actual digestion rates (which is more important to the cow)

Adjusted Crude Protein	%	4.65%
NFC	%	49.67%
NDF kd rate Van Amb	%/hr	3.91%
NDF kd rate MIR_P1	%/hr	5.43%
Starch kd rate MIR_P1T1	%/hr	27.32%

3-YR Means 2010-2012 275 samples	C:B1 Kd %/h	C:B2 Kd %/h	C:B3 Kd %/h	DMD %	Fast pool ml gas	Slow pool ml gas
Ave	19.2	36.1	4.3	53.9	30.1	42.0
Max	54.0	68.7	10.4	82.3	48.0	75.3
Min	8.0	11.4	2.3	36.2	12.5	23.4
SD	6.8	10.3	1.2	7.2	5.9	8.9





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Uncovering Hidden or Under Recognized Feed Cost & Marginal Opportunities on Your Farm

John Goeser, Ph.D.
Director Rock River Laboratory
Adjunct Assistant Professor University of Wisconsin-Madison
Cows Agree Consulting

NOTES:

Uncovering hidden or under recognized feed cost and margin opportunities on your dairy farm*

John Goeser, PhD, PAS, Dipl. ACAN

Over the past 15 years, dairy farms have recognized sizable economic returns and losses. Learning from dairy farm margin summaries and projections reported by Mark Linzmeier, www.marginsmart.com, our industry has recognized dairy margins fluctuating between ($5.00) and $8.00 per hundredweight (cwt). Recently, the estimated net income before tax for an average 1,500 cow dairy in 2018, 2019 and 2020 has been ($1.34), $1.25 and $1.25 per cwt, respectively. In general, dairies in the US are operating on thin margins at best throughout the past half decade. Average is not acceptable, thus we are constantly seeking margin and efficiency opportunities. Forward thinking dairies are tracking feed conversion efficiency and other key performance indicators that are directly related to their balance sheet.

In my experience working with leading dairy consultants, allied industry experts, and business minded dairies, we're recognizing $0.25 or greater margin opportunities per cow per day in some unique spots on the farm. In some cases, $0.05 to $0.10 margin opportunities are captured by recognizing moisture or nutrient content differences relative to that expected. The economic opportunities can be attributed to both forages and commodity feeds. These unrecognized opportunities can appear in two different ways: an abrupt change or a subtle trend over time.

In other experiences, margin opportunities have been uncovered through unlocking more energy in each pound of feed consumed. This has been a focal point with many research efforts, however a simple beginning point is to focus on starch and grain.

The aim with this article will be to review several economic opportunities rooted in unique nutrition trends that may exist for dairy farms across the US.

Corn silage varies more than many recognize

As I've worked with dairies that have dug deeply into their nutrition program to find margin opportunities, the nutrition evaluations have taken numerous forms. It starts with forages. For example, in 2013 one dairy began sampling their forages every 2 weeks to recognize substantial starch content changes within their 13,000+ ton of corn silage piles. I distinctly remember the case, as the nutritionist at the dairy began adjusting the ground corn in the diet to balance against the week to week changes in silage starch content. In this case, corn silage was changing much more than we had previously conceived and I've witnessed this situation play out with other silages and farms.

*This article and proceedings were originally published by the 2021 California Animal Nutrition Conference, and were revised and adapted for this conference.

We tend to think of corn silage as a consistent crop, which is true relative to hay. However, corn silage is a heterogeneous feed consisting of the ear and the stalk. The ear is filled with grain and starch, whereas the stalk and leaves are filled with fiber. Fiber digestibility is extremely important, however fiber is always less digestible than starch and grain. For example, total tract NDF digestibility (TTNDFD, % of aNDF) averages roughly 42% for CA corn silage whereas total tract starch digestibility (TTSD) will average 92 to 95%. While fiber and starch contain a similar caloric value per pound, dairy cattle are only able to unlock roughly half the calories in fiber relative to starch. Hence, the nutrition value with silage begins with the ear to stover ratio. Environmental and agronomic management practices that improve grain yield will ultimately increase forage quality in general assuming harvest maturity and moisture are appropriate.

With the extreme drought experienced in the South and West recently, coupled with variable weather patterns year to year, the grain and starch content in silage may deviate substantially between fields relative to that we'd recognized a decade ago. In the past I've hypothesized that a well made silage pit or pile effectively blends different fields, however experience is now suggesting otherwise.

To visualize an exemplary starch content change with an aggressively sampling dairy, Figure 1 details the 4 sample average with corn silage starch content for a 7,000 ton pit over the duration of feed out. In this case, the dairy sampled the forage several times per week to characterize the nutrition changes. Based upon this experience and others like this, there could be under-recognized corn silage starch content opportunities for many dairies throughout the US. Dairy cows may not

Feed libraries are a rough starting point

With grain prices at near historically high levels, feed costs are increasingly scrutinized. Many dairies and consultants are evaluating alternative protein or energy options. Often, we seek to identify the best cost option(s) and drive down feed costs while maintaining performance. Our comparative efforts with diet software or feed evaluation tools rely upon robust and accurate moisture and nutrient content values. Recent experience is suggesting that feed library values are only a rough starting point for nutrition evaluations.

For example, in Figure 2 the crude protein content (% DM) in canola meal is shown for several hundred samples analyzed by Rock River Laboratory, Inc. over the past two calendar years. Canola meal across the US has been averaging roughly 39 to 40 % of dry matter, and this is well above a feed library value at 38.7% of dry matter. In this instance, canola meal may be a value opportunity for the dairy industry, with one unit of crude protein equating to roughly 18 pounds of crude protein value per ton and an economic value of roughly $8 per ton. This value proposition is not limited to canola meal. In conjunction with forward thinking dairies more frequently testing their feeds, soybean meal and other expensive commodities have been found to substantially

*This article and proceedings were originally published by the 2021 California Animal Nutrition Conference, and were revised and adapted for this conference.

deviate from feed library base values. These differences have often been due to subtle trend changes over time which cows didn't respond to, but the check book may have.

St-Pierre and Weiss (2017) have extensively evaluated dry matter and nutrient variation within and between farms. Their group observed substantial feed variations that should be accounted for over time. The authors recognized that variance can be partitioned between farms and within farms. While the science is sound, measuring and managing these economically impactful variances has proven challenging for dairies and nutritionists. Part of the challenge has been rooted in sampling error and limited replication in sampling. St-Pierre and Weiss (2017) commented that feed library nutrition values may be more realistic than a single sample due to sampling error. This concept is important to grasp. Single samples must be interpreted with caution. There is sampling error associated with any single sample that complicates interpretation. However, as more samples are tested over time and more data available, we can observe statistically meaningful trends and cut through the sampling noise. With larger database insight and through novel intensive feed sampling programs, many have confirmed that feed library values can be improved upon in appropriately depicting the feed's changing moisture content or nutritive value over time.

Differentiate between abrupt and subtle trends over time

Both commercial experience and research studies with dairy cattle have clearly demonstrated cows respond to abrupt changes in moisture or nutrient content. For example, following a rainfall event the moisture content in exposed feeds increases. If left unadjusted, the cows' diet will become unbalanced and can contribute to digestive upset and performance losses. Alternatively, different hay lots are known to affect dairy performance if substantially different in nutritive value and fiber digestibility. In this case, there is meaningful variation tied to the hay lot, which we recognize. In practice, abrupt changes in nutrient supply often elicit a positive or negative response on farm and then samples are taken and adjustments are made. However, dairy herd responses to subtle trends and changes in nutrient or moisture content over time are far less studied and understood.

Meaningful feed trends can be buffered by cows

Two studies have documented that dairy cattle appear capable of buffering changes in protein and moisture changes over a short period of time (St-Pierre and Gerstner, 2005; McBeth et al., 2013). In these studies, substantial dietary changes were made to mimic nutrient or moisture changes. However, dairy cow performance did not change significantly, or as would be predicted by dairy nutrition models. In these studies, the dairy cows apparently exhibited some intrinsic ability to buffer protein or energy changes. More recently over the past two years, numerous commercial dairy experiences have been in line with the research observations described above.

Coming back to Figure 1 detailing corn silage starch content during a 9 month feed out period, the 4 sample moving average clearly detailed that starch content in the silage changed substantially on numerous occasions. During one 6 week period, starch content decreased from 37 to around 32% of dry matter, which represented roughly 1.6 pounds of corn grain equivalents for this diet feeding around 20 pounds silage dry matter per cow. However, this dairy herd did not recognize substantial dairy herd performance swings relative to the measured starch trends. This single observation is intriguing and warrants further evaluation. However, if the dairy herd was able to buffer this change in some capacity then the real world observation would be in agreement with those of the researchers described previously. Beyond dairy performance changes in this case, the change in starch content contributed by the corn silage over time represented roughly $0.20 per cow per day value in corn grain equivalent from mid-May to July. Often we react to changes in performance or components to initiate adjustments. However, based on this field observation and others like this, there are subtle unrecognized feed cost and economic opportunities that dairy cows show us through performance.

Dry matter pounds fed match expectations

In the cases described above, nutrient concentration and supply were affected. One additional, and more simple, set of cases corresponds to moisture changes in expensive feeds. These can also uncover hidden feed cost opportunities. Most dairies recognize the need to monitor moisture content of their wet feeds several times per week. With forage and wet feed moistures changing from week to week. There are near-infrared reflectance spectroscopy (NIR) instruments that are available to improve the farm's ability to measure moisture content and make adjustments in a short period of time. However beyond forages and wet feeds, in my experience very few have considered adjusting moisture content with dry and purchased feeds.

Often, feeders or managers use feed library values within feed management software programs to build dairy recipes. Recent experience has shown there can be substantially less moisture than what tag guarantees list as a limit for feed management software library values indicate. In these cases, less moisture equates to more dry feed per ton than what dairies or nutritionists recognize. Consider the following case study visualized in Figure 3, with two different soybean meal sources.

In this case, two different soybean meal sources guaranteed to be equivalent at roughly 47.5% crude protein (as-is) differed substantially in moisture content. Each of the soybean meals met or exceeded tag guarantee requirements, however one of the soybean meal sources was consistently 1.5 to 2.0 units lesser in moisture content. The ramifications of this difference equate to roughly 40 pounds per ton more dry soybean meal and roughly $8 per ton value at $400 per ton price point. Economic minded dairies can capitalize on cases like this and make adjustments for less moisture content in their purchased feeds.

Ensure purchased grain is being used by cows

Another hidden economic opportunity is nested within undigested corn grain. In the South and West, we tend to feed less corn grain and starch due to more expensive corn grain and alternative feeds or cheaper energy rich byproducts. However, even at 18% dietary starch concentration within a 55 pound dry matter intake, starch and corn grain equivalent in the diet represents roughly $1.65 per cow in feed costs at $6 per bushel corn. Hence, the economic ramifications associated with limited starch digestion can be sizable.

Fecal starch content has been clearly linked to total tract starch digestion (TTSD) in dairy cattle (Fredin et al., 2014). Dr. Jim Ferguson and Dr. Mike Hutjens have taught the industry to begin using this tool over a decade ago (Hutjens, personal communication). More recently, we have analyzed commercial fecal starch data and calculated population statistics to set new goals for today's dairy farms. As of the past 5 years, the 15th percentile for starch content in all dairy manure samples is roughly 0.5% of dry matter. This corresponds to 99% total tract starch digestion and is our new goal. In Figure 4, fecal starch results for 2 years worth of commercial dairy samples from across the United States can be visualized. Recognize that the trendline moves over time, however the average result is nearly always at 2.5% fecal starch or greater. Assuming a 55 pound dry matter intake and 18% dietary starch as described above, 2.5% versus 0.5% fecal starch projects to roughly 0.4 pounds more undigested corn per cow and $15,000 per year economic opportunity for every 1000 cows. Projections such as this with dairy cattle can be determined using an open access web application available from Rock River Laboratory, Inc. The application can be accessed here: https://rockriverlab.shinyapps.io/FecalStarchCalc/

Summary

This article leans heavily upon recent experience and case studies. Admittedly, our industry has much yet to learn and research to continue leading the world in dairy business performance. However, our dairy industry is evolving at a rapid pace due to the demand for continued efficiency and sustainability gains. Whether discussing emissions, environmental stewardship, feed conversion efficiency, income over feed costs, or another efficiency metric, recognize that each of these are highly correlated. Our collaborative goal is to produce more with less, and this will in turn improve the profitability of dairy farms and agribusinesses. Within this article, I've discussed several different areas that may contribute to this collective aim.

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Figure 1: Example corn silage starch content, % DM, for a commercial dairy over a 9 month period.

Figure 2: Canola Meal crude protein content, %DM, by calendar year for commercial feed samples analyzed by Rock River Laboratory, Inc. in 2020 and 2021. The vertical black lines within each distribution plot represent the 15th, 50th and 85th percentiles, respectively.

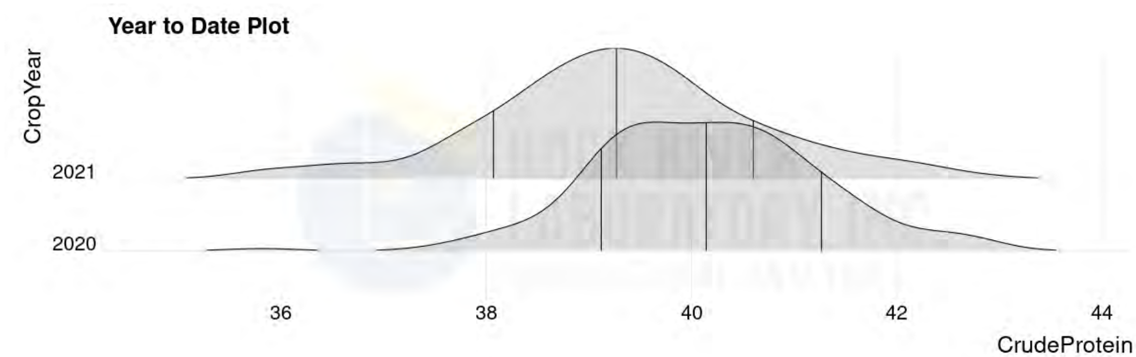


Figure 3: Total moisture content, %, for two different soybean meal sources over a 90 day period.

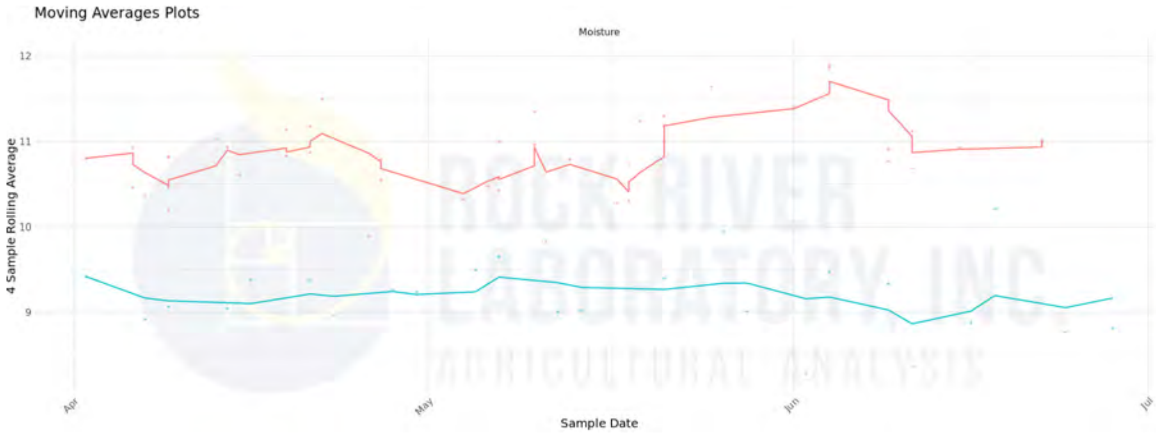
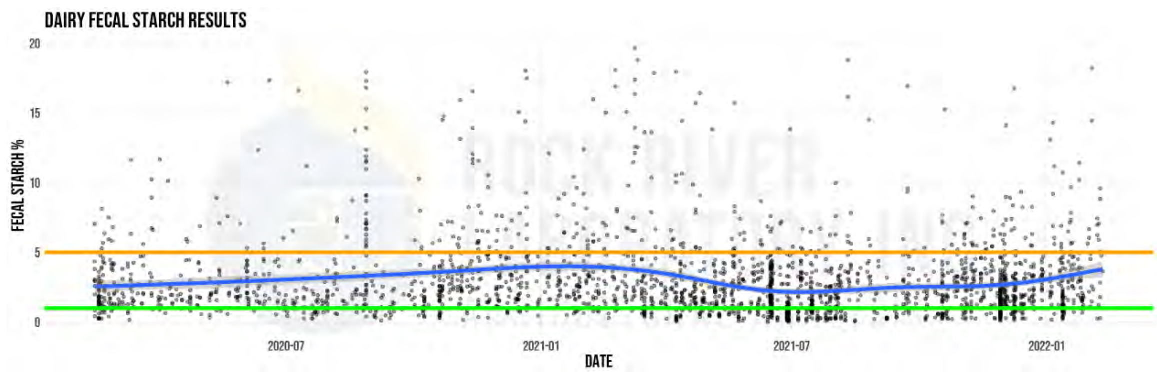


Figure 4: Dairy cattle fecal starch content, %DM, for samples submitted to Rock River Laboratory, Inc. from 2020 through 2022. The flat red line equates to the 15th percentile and goal of 0.5% dry matter fecal starch content. The trendline represents the moving average over a 2 year time period.



Nutrigenomics – Impacts on Immunity, Health & Wellbeing

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NOTES:

Nutrigenomics – Impacts on Immunity, Health and Well Being

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Introduction

Over the last two decades, researchers have increasingly adopted molecular biology techniques and bioinformatics approaches to the study of ruminant nutrition and physiology. This has provided the field with novel and more robust information on how nutrients can affect animals at a cellular level, participating in the regulation of milk synthesis and meat quality and marbling (Osorio and Moisa, 2019). Specifically, dietary nutrients can alter gene expression directly or indirectly, affecting protein expression, metabolic and/or signaling status of cells, and, as a final consequence, can affect tissues, organs, and the entire organism (Bionaz et al., 2015).

The nutrient-genome interaction is at the basis of nutrigenomics as a science, expanding into how this relationship affects the balance between health and disease by altering the expression and/or structure of an animal's genetic makeup (Kaput and Rodriguez, 2004). The concept that food components can directly affect biological functions via genome-wide influences has led to a shift in our understanding of the field of nutrition, where dietary nutrients can no longer be considered just as basic building blocks for cells, tissues, and organs, or energy sources for metabolic processes. All nutrients, from simple fats, amino acids, and carbohydrates, to more complex phytomolecules, gained the status of "bioactives," capable of being detected by cellular sensors leading to a change of the cell biology (Muller and Kersten, 2003).

The Nutrient-Genome interaction

Dietary nutrients and bioactive compounds mainly interact indirectly with the animal's genome, as they don't directly bind with it or change its sequence. Rather, communication is mediated by specialized molecular proteins such as transcription factors for short- to medium-term regulation, and DNA or histone methyltransferases and histone acetyltransferases for medium- to long-term epigenetic effects (Osorio and Moisa, 2019).

Nutrigenomics is a relatively new branch of science in dairy cow research. Building upon data generated in other species, mainly humans and rodents, scientists have identified a short list of transcription factors with nutrigenomic potential in livestock species (Bionaz et al., 2015). This includes, but is not limited to, peroxisome proliferator-activated receptors (PPAR), sterol regulatory element-binding proteins (SREBP) and liver X receptors (LXR), which bind and are activated by fatty acids and metabolites of cholesterol. Similarly, proteins can be sensed by CCAAT/enhancer-binding protein (C/EBPs), and carbohydrates interact with SREBP and carbohydrate responsive element binding protein (ChREBP). Fat-soluble vitamins can also interact with the genome via retinoid X receptors (RXR) and retinoic acid receptors (RAR), vitamin D receptor (VDR), and pregnane X receptor.

The importance of these molecules and mechanisms, and their effect on dairy cow physiology is not always communicated to the dairy farmers, nutritionists, and industry consultants, even though some of the mentioned transcription factors have been linked to the production of milk components, and the well-known milk fat depression, a diet-induced production dysfunction. Most are aware that butterfat can be synthesized by the mammary gland using acetate, one of the three main volatile fatty acids produced by rumen fermentation, and by the uptake of circulating fatty acids which have been mobilized by adipose tissue. However, only few know of the role of PPARγ, LXRα, and SREBP1 in regulating and stimulating fatty acid synthesis in response to specific nutrients (Bauman et al., 2011, Bionaz et al., 2015, Osorio and

Moisa, 2019). Furthermore, most are aware of the process of ruminal biohydrogenation and the effect that specific conjugated linoleic acids (CLA) have on milk fat synthesis. The effect of t10,c12 CLA on depressing milk fat synthesis via inhibition of SREBP1 was among the first and likely, the best-known, examples of nutrigenomics in dairy cows (Bauman et al., 2011).

Several fatty acids, both saturated (SFA) and polyunsaturated (PUFA), can regulate immune-related intracellular pathways and transcription factor activation, regulating inflammation onset, magnitude, and duration. (Sordillo, 2016). One of the central regulators of the inflammatory process is the transcription factor NF-κB which regulates multiple innate and adaptive immune functions. NF-κB induces the expression of various pro-inflammatory genes, including those encoding cytokines and chemokines, and participates in inflammasome regulation (Liu et al., 2017). In non-ruminant models, certain PUFA, such as EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid), were found to have anti-inflammatory functions by inhibiting NF-κB activation induced by gram-negative bacteria (Lee et al., 2010). Moreover, they can also indirectly affect this transcription factor through their interactions with other signaling pathways, including PPARs and SREBPs (Clarke, 2004). In contrast to PUFA, saturated fatty acids, such as lauric, myristic, and palmitic acids, were linked to NF-κB activation, thus leading to a pro-inflammatory response (Erridge and Samani, 2009, Lee et al., 2010).

Liver X receptors, besides regulating fatty acid synthesis (Mu et al., 2021), have also been linked to the mammary gland inflammatory response (Hu et al., 2019). In vitro activators of LXRα inhibited the inflammatory response induced by gram-negative bacteria via inhibition of NF-κB, leading to a lower expression and production of potent pro-inflammatory cytokines, such as TNF-α, IL-1β, and IL-6 (Wang et al., 2018). Similar results were obtained in vivo, where synthetic activation of LXR attenuated mammary inflammation during induced mastitis in mice (Fu et al., 2014). Multiple natural molecules purified from plants or fungi, including phytosterols and terpenes, have been shown to activate LXRs (Komati et al., 2017), making their use a viable option to pursue when researching antibiotic-alternatives to mastitis in dairy cows.

Immunonutrition

Dairy cow rations are primarily formulated to meet production requirements, without truly dissecting what components of maintenance requirement might affect performance. There is substantial evidence indicating that the immune system is intimately involved with other mechanisms that allow cows to adjust quickly to the onset of lactation without suffering chronic disorders. In fact, cows that lag behind the rest of the herd in terms of production outcomes (including fertility) often display a greater inflammatory status and compromised liver function (Bionaz et al., 2007, Bertoni et al., 2008, Trevisi et al., 2012).

Dairy cows experience a period of immunosuppression around parturition, as several studies reported that both the innate and adaptive immune systems of peripartal cows are often compromised. For example, antimicrobial function and antigen response is reduced (Kehrli et al., 1989a, Kehrli et al., 1989b, Dosogne et al., 1999, Batistel et al., 2018), and consequently phagocytic activity by leukocytes is often (Ingvartsen et al., 2003, Batistel et al., 2018), but not always (Sander et al., 2011, Graugnard et al., 2012), reduced. Moreover, parturition influences the expression of multiple leukocyte genes required for normal function of these cells, including those involved in the classic immune response as well as normal cell growth, metabolism, and responsiveness to the blood environment (Burton et al., 2001).

However, this scenario is not so simple. Cows might be immunosuppressed when looking at some immune parameters, yet appear to mount an excessive immune response to pathogens that can cause more damage than benefit (Jahan et al., 2015, Vailati-Riboni et al., 2017c). For this reason, dairy scientists refer to the transition cows as "immunodysfunctional" rather than suppressed. Furthermore, transition cows were shown to display an overt inflammatory response related to pregnancy and lactation (Sordillo et al., 2009), even without signs of microbial infections and/or otherwise determined pathology (Bionaz et al., 2007, Bertoni et al., 2008). The conclusion for dairy producers is that, due to the combined results of immune and metabolic dysfunctions, transition cows may be more susceptible to diseases like mastitis, but also to inflammation-associated tissue damage, than in other lactation periods.

Practical interventions

Since the immune system appears dysfunctional during early lactation, dairy nutrition researchers and the feed additive industry have placed some emphasis on developing dietary strategies and "immunostimulant" supplements to manage or reverse this scenario. In this section we are going to briefly discuss three nutritional strategies that were shown to alter dairy cow gene expression, positively impacting their immunity and health.

1. Energy density of dry cow

Traditional management provides "far-off" dry cows with a high-fiber/low-energy density diet (~1.30 Mcal/kg dry matter), while in the last month of gestation ("close-up" dry period) energy density is increased to approximately 1.60 Mcal/kg dry matter (NRC, 2001). The close-up value has been lowered to 1.50 Mcal/kg dry matter in the recent 2021 revision of dairy cows' requirements (NASEM, 2021). However, studies from different research groups have demonstrated that prepartum overfeeding of energy often results in altered metabolic adaptation (Rukkwamsuk et al., 1999, Holtenius et al., 2003, Janovick et al., 2011, Ji et al., 2012, Ji et al., 2014, Khan et al., 2014), while exerting negative effects on postpartum health indices (Dann et al., 2006, Soliman et al., 2007, Graugnard et al., 2013, Shahzad et al., 2014).

Transcriptome profiling of neutrophils revealed that allowing cows free access to higher-energy diets during late pregnancy resulted in the alteration of pathways associated with the immune response and immune cell survival and proliferation (Moyes et al., 2014, Agrawal et al., 2015, Zhou et al., 2015). Furthermore, phagocytic activity of these cells was impaired, and early prepartal activation of inflammatory genes suggested a chronic state of compromised health (Graugnard et al., 2012, Moyes et al., 2014, Agrawal et al., 2015, Zhou et al., 2015). Transcriptomic studies further highlighted how overfeeding affects the whole system of the cow, as indicated by alterations in endoplasmic reticulum stress in hepatocytes, most likely as a consequence of greater activation of inflammatory pathways (Shahzad et al., 2014). Nutrigenomics mechanisms (i.e.: specific transcription factors) have not yet been clarified, but a recent study was able to provide evidence that a high-concentrate diet induced epigenetic (e.g., methylation) changes that contribute to the expression of immune-related genes in the livers of dairy cows (Chang et al., 2015).

Consensus among these research groups have prompted them to recommend limited use of a higher energy close-up diet, and keeping dry cows on a lower energy "far-off" type diet (around 1.30 Mcal/kg of dry matter) for the whole dry period. Of course, this recommendation has to take the herd body condition score (BCS) into account, as the effect of prepartum plane of nutrition is dependent on the BCS of the cow. Thus, these management tools need to be evaluated together to optimize a cow's biological adaptations during the peripartum period. Omics analysis of the liver transcriptome highlighted how thin animals were more susceptible to prepartal nutritional management. Pathway expression patterns and metabolomics analysis suggested how overfeeding in late pregnancy should be limited to thin cows, while cows with optimal adiposity should be maintained on an energy-restricted diet (Vailati-Riboni et al., 2016a, Vailati-Riboni et al., 2016b, Vailati-Riboni et al., 2017a). The practical focus should be on reaching optimal BCS at the beginning of close-up, and maintaining cows on a slight feed restriction until calving.

2. Inclusion of yeast fermentation products

Fermentation products specifically derived from *accharomyces cerevisiae* (SCFP) have been reported to increase leukocyte function both in vitro and in vivo (Jensen et al., 2008, Magalhaes et al., 2008). Recently, new commercially available SCFPs for dairy cows and calves (NutriTek® and SmartCare®, Diamond V, Cedar Rapids, IA, USA) were the subjects of multiple publications illustrating a wide spectrum of beneficial health and performance effects during immunological challenges, like dietary and respiratory infection, mycotoxins, heat stress, and the transition period (Alugongo et al., 2017, Harris et al., 2017, Knoblock et al., 2019, Olagaray et al., 2019, Velez et al., 2019, Mahmoud et al., 2020, McDonald et al., 2021, Klopp et al., 2022). The SCFP contain multiple vitamins and antioxidants, such as polyphenols, in addition to other bioactive compounds including fermentation end-products, β-glucans, and other components of the yeast cell wall, that have been shown to modulate the immune response in humans and animals by priming the innate and adaptive immune responses through activation of immune cells (Li et al., 2005, Volman et al., 2008).

When NutriTek efficacy against mastitis was tested in 25 large-scale commercial herds throughout the United States, its supplementation reduced incidence of mastitis in 64% of the dairies, with half of these also seeing a reduction in linear scores (Ferguson et al., 2018). To better understand the underlying mechanisms, researchers at the University of Illinois performed gene expression analysis of mammary gland samples collected from control or NutriTek fed dairy cows subjected to a mastitis challenge (Vailati-Riboni et al., 2021). Researchers induced subclinical mastitis by inoculating one quarter of each cow with 1,500 CFU of *treptococcus u eris*, a gram-positive bacteria predominantly responsible for intramammary infection (Keane, 2019). NutriTek supplementation increased gene expression related to (i) a greater antimicrobial capacity of innate immune cells, (ii) the activation of cellular mechanisms to enhance mammary gland protection against side effects of inflammation, and (iii) the maintenance of tissue integrity and health (Vailati-Riboni et al., 2021). These activations resulted in a 4-fold lower somatic cell count (1,076,052 vs 179,415 cells/mL, control vs NutriTek) in the infected quarter of supplemented cows 36 h after infection. These boosted defenses allowed NutriTek fed cows to maintain higher feed intake and milk yield both during the challenge period and in the following month. Similar effects on somatic cell count were observed when NutriTek fed cows were subjected to heat stress. NutriTek fed cows had approximately 50% lower plasma cortisol, a stress-related and immunosuppressant hormone, and higher numbers of immune cells (9 to 26% more) in their blood, compared to the cows in control group. This led to a 36% lower somatic cell count during the intense heat stress challenge (Al-Qaisi et al., 2020).

Anecdotal reports have suggested that SCFP supplementation may also improve the outcome of bovine respiratory disease (BRD) in young calves, in dairy heifers when transitioning to group pens and freestalls, and in feedlot animals. Mahmoud et al. (2020) tested this hypothesis by supplementing neonatal Holstein x Angus calves daily with SmartCare and NutriTek, and challenging them at around 3 wks of life via aerosol inoculation with bovine respiratory syncytial virus (BRSV). Supplemented calves showed reduced clinical disease signs and had lower viral shedding, together with reduced lung pathology, and incidence of secondary bacterial infection. Immune cells gene expression was not investigated, but SmartCare and NutriTek enhanced innate cytokine production of circulating immune cells and had an immunoregulatory effect on innate immune function by cells in the airways. Supplementation also reduced virus-specific IL-17 secretion by cells isolated from the airways, leading to reduced neutrophil recruitment to the lungs. In the context of respiratory disease, limiting inflammation in the lungs is critical for minimizing lung tissue damage and promoting rapid recovery. Similar results were obtained from a follow-up experiment, testing the response to a coinfection of BRSV and *Pasteurella multocida* (McDonald et al., 2021). Again, SmartCare and NutriTek supplemented calves mounted a robust immune response and displayed lower severity of a viral–bacterial respiratory infection. As inflammation is an energy-demanding response, McDonald et al. (2021) also reported no detrimental metabolic consequences in supplemented calves, as these animals showed blood biomarkers changes favoring growth and development.

3. Rumen-protected methionine and choline as an immunostimulant

In addition to being considered one of the two most-limiting amino acids for milk production, methionine (Met), and several of its related metabolites (e.g. choline [Chol] and taurine), display an immunonutritional role, i.e. they help boost certain activities of the immune system in humans (Grimble and Grimble, 1998, Redmond et al., 1998, Grimble, 2006, Li et al., 2007). Since these properties have been tested on immunosuppressed human subjects with positive outcomes (Van Brummelen and du Toit, 2007), dairy scientists hypothesize that enhancing Met supply above what is recommended for optimal lactation performance (Lys:Met < 3:1) would have a positive effect on immune function in the transition period, where cows are in immunocompromised state.

Earlier results indicate the ability of Mepron®, a commercially available rumen-protected form of methionine (Evonik Nutrition & Care GmBH, Hanau-Wolfgang, Germany), to increase T lymphocyte proliferation ex vivo when supplemented at a rate of 30g/d (Soder and Holden, 1999). Since human lymphocytes seem to have an absolute requirement for Met to proliferate (Hall et al., 1986), these results were not unexpected. However, data on immune function were not generated. More than a decade later, researchers from the Univesity of Illinois showed how the use of Smartamine (0.07-0.08% DM, Adisseo Inc., Antony, France), Metasmart (0.19% DM, Adisseo Inc.) or Mepron (0.09-0.10 % DM) during the transition period enhanced immune cell pathogen killing capacity (e.g., phagocytosis, and oxidative burst) (Osorio et al., 2013, Zhou et al., 2016, Batistel et al., 2018). Furthermore, Met supplementation optimized the immune reponse to bacterial components (Vailati-Riboni et al., 2017c) and helped mitigate the detrimental effects of close-up energy overfeeding (Vailati-Riboni et al., 2017b). Feeding rumen-protected Met, thus, helps dairy cows tackle the two aspects of peripartal immune dysfunction, hyporesponse (or suppression), and hyperresponse. Not many data have been generated on the effect of Chol supplementation on direct measures of immune functions, but some beneficial results have been observed (Vailati-Riboni et al., 2017c).

Changes in functionality of immune cells in response to supplementation with Met or Chol are often correlated to changes in their gene expression. Supplementation during the transition period can prime neutrophils, an important innate immune cell type, for mounting a better immune response upon pathogen challenge through fine-tuning of the cell transcriptome. The hyperactivation and response to stimuli observed in peripartal dairy cows (Jahan et al., 2015) has been linked to worsening of the animal oxidative status during this period (Vailati-Riboni et al., 2017b, Vailati-Riboni et al., 2017c). Zhou et al. (2018) observed how neutrophils had lower expression of oxidative stress-related genes in response to Met and Chol supplementation. This then led to a reduction in the expression of pro-inflammatory genes, indicating that a better redox status creates a more balanced immune response. Similar gene expression patterns were observed when supplementing methionine, choline, or taurine in vitro to neutrophils isolated from neonatal (3 wks old) Holstein calves (Abdelmegeid et al., 2017) or mid-lactation adult cows (Lopreiato et al., 2019). Greater methylation of the promoter region of PPARα occurred in the liver of cows supplemented with Met, leading to greater *PPA A* expression and upregulation of some of its downstream genes (Osorio et al., 2016). Activation of hepatic PPARα has been associated with improved lipid metabolism and immune function, both of which were reported in companion publications from this study (Osorio et al., 2013, Osorio et al., 2014).

Through modulation of gene expression and consequent improvement of immune functions, Met and Chol supplementation to levels beyond milk production requirements demonstrate that maintenance and immune system requirements have to be integrated in our modern lactation diets. Supplementation can support practical aspects of herd health, such as reduction in the incidence of mastitis or adverse health events in general (Ardalan et al., 2010, Arshad et al., 2020).

Conclusions

The interface of immunity and nutrition is an emerging field of study. Relatively recently, they were considered separate entities, with the only focus on avoiding deficiencies in key nutrients. Now instead, the fields of nutrigenomics and immunometabolism show that targeted supplementation can boost immune function beyond what is considered normal or average, by modulating expression of cows' genetic potential. These concepts will have to be further applied in dairy science to better define maintenance requirements and develop more complete nutritional management of the dairy cow. As consumer scrutiny of the dairy industry's goods and production strategies increases, nutritional intervention (e.g., macro- and micronutrients, bioactive compounds, pre-, pro-, and postbiotics, phytonutrients) will lend themselves as preventative and prophylactic strategies to ensure food safety and security, while supporting animal productivity, health, and welfare.

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Improving Efficiency through Monitoriing Technology and Data Insights

Luis Mendonça, DVM
Ruminant Technical Services, Merck

NOTES:

MERCK Animal Health

Improving Efficiency Through Monitoring Technology and Data Insights

Luís Mendonça, DVM, MS
Ruminant Technical Services
Merck Animal Health

March 01, 2022

1

J. Dairy Sci. 96:5405–5425
http://dx.doi.org/10.3168/jds.2012-6354
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Invited review: **Sustainability of the US dairy industry**

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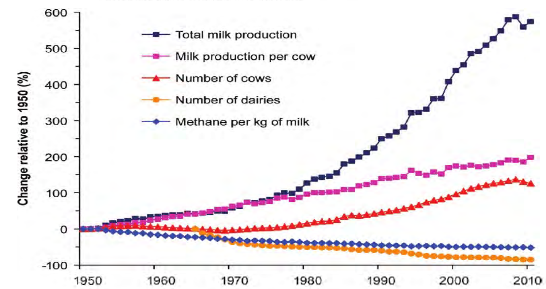

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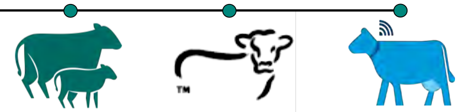
2

Opportunities to improve efficiency by using monitoring technologies:
- Monitor and track animal behavior (wearable technologies)
- Individual-level and herd-level

Heat Stress	Postpartum health	Reproduction
Assessing and monitoring severity of heat stress	The benefit of having access to a health index	Targeted approach to increase reproductive efficiency



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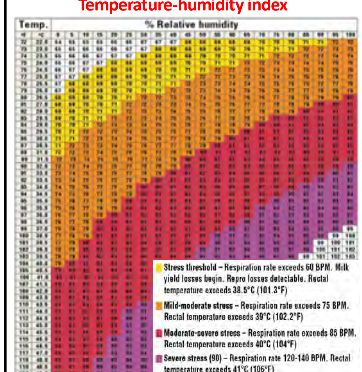
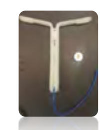
3

How Can We Assess and Monitor Severity of Heat Stress in Dairies?

Temperature-humidity index





Kansas Agricultural Experiment Station Research Reports
Volume 2
Issue 9 *Dairy Research*
Article 2

2016

Evaluation of Weather Information from On-Farm and Meteorological Stations to Assess Heat Stress in Dairy Cows in Southwest Kansas

A. Scanavez
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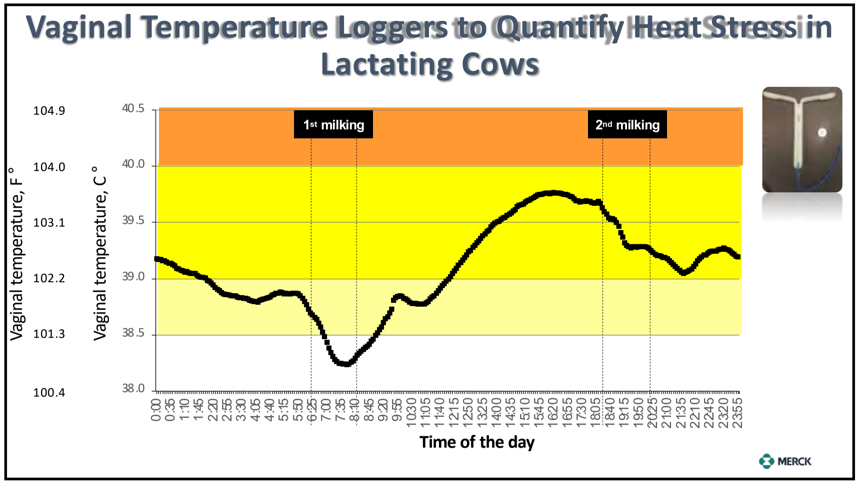
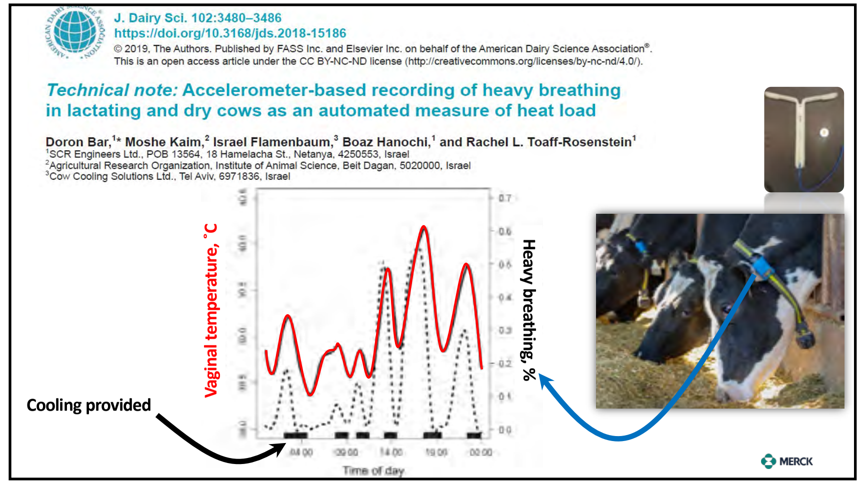
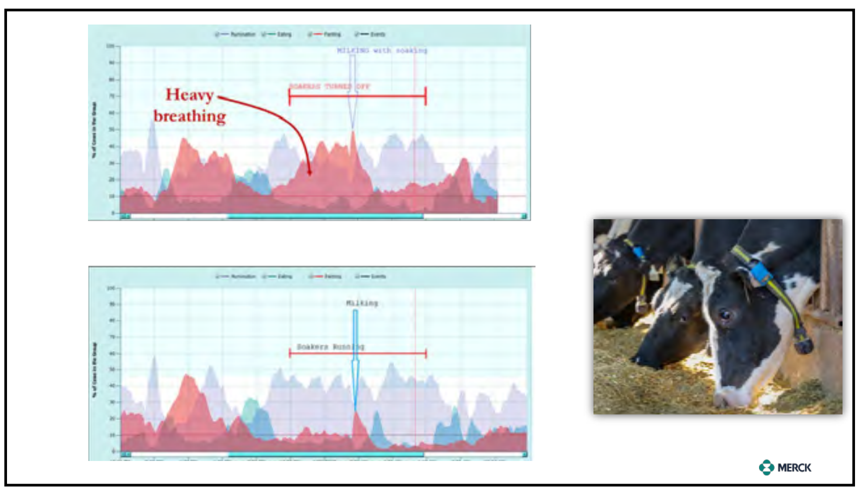
4


Vaginal Temperature Loggers to Quantify Heat Stress in Lactating Cows
1st milking
2nd milking
Vaginal temperature, F°
104.9
104.0
103.1
102.2
101.3
100.4
Vaginal temperature, C°
40.5
40.0
39.5
39.0
38.5
38.0
Time of the day
MERCK

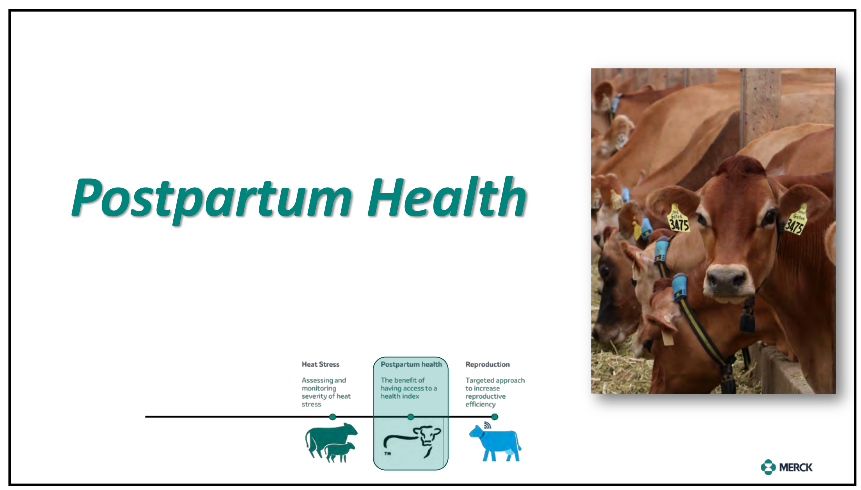
5


J. Dairy Sci. 102:3480–3486
https://doi.org/10.3168/jds.2018-15186
© 2019, The Authors. Published by FASS Inc. and Elsevier Inc. on behalf of the American Dairy Science Association®.
This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
Technical note: Accelerometer-based recording of heavy breathing in lactating and dry cows as an automated measure of heat load
Doron Bar,1* Moshe Kaim,2 Israel Flamenbaum,3 Boaz Hanochi,1 and Rachel L. Toaff-Rosenstein1
1SCR Engineers Ltd., POB 13564, 18 Hamelacha St., Netanya, 4250553, Israel
2Agricultural Research Organization, Institute of Animal Science, Beit Dagan, 5020000, Israel
3Cow Cooling Solutions Ltd., Tel Aviv, 6971836, Israel
Vaginal temperature, °C
Heavy breathing, %
Time of day
Cooling provided
MERCK

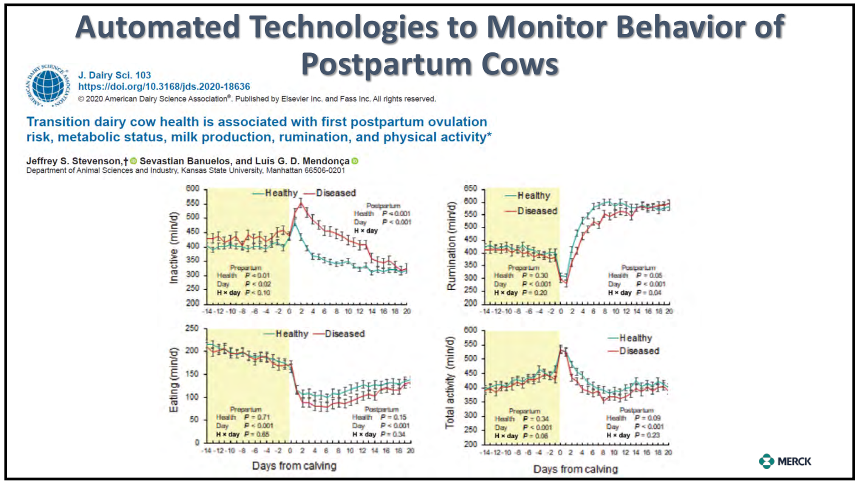
6


Heavy breathing
MERCK

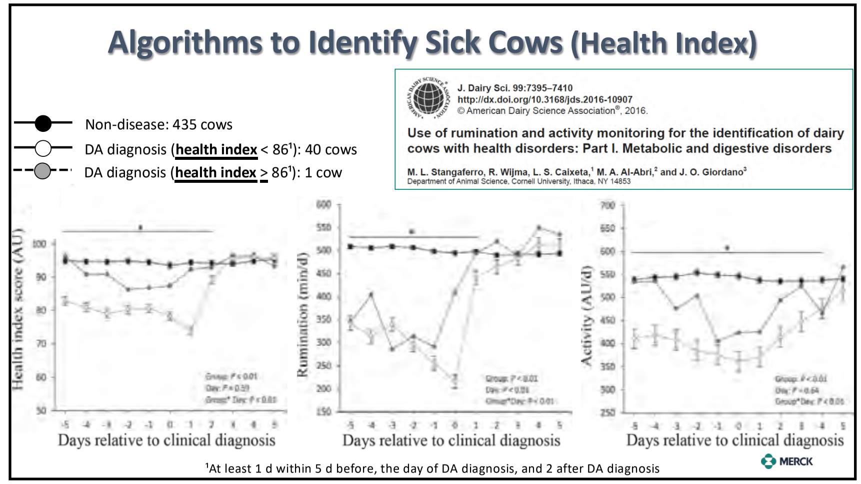
7


Postpartum Health
Heat Stress
Assessing and monitoring severity of heat stress
Postpartum health
The benefit of having access to a health index
Reproduction
Targeted approach to increase reproductive efficiency
MERCK

8


Automated Technologies to Monitor Behavior of Postpartum Cows
J. Dairy Sci. 103
https://doi.org/10.3168/jds.2020-18636
© 2020 American Dairy Science Association®. Published by Elsevier Inc. and Fass Inc. All rights reserved.
Transition dairy cow health is associated with first postpartum ovulation risk, metabolic status, milk production, rumination, and physical activity*
Jeffrey S. Stevenson,† Sevastian Banuelos, and Luis G. D. Mendonça
Department of Animal Sciences and Industry, Kansas State University, Manhattan 66506-0201
Healthy
Diseased
Inactive (min/d)
Rumination (min/d)
Eating (min/d)
Total activity (min/d)
Days from calving
MERCK

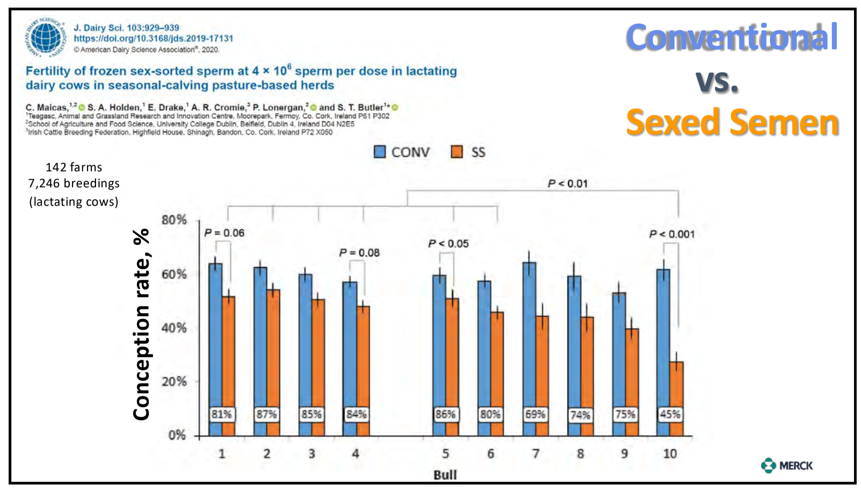
9


Algorithms to Identify Sick Cows (Health Index)
Non-disease: 435 cows
DA diagnosis (health index < 86[1]): 40 cows
DA diagnosis (health index ≥ 86[1]): 1 cow
J. Dairy Sci. 99:7395–7410
http://dx.doi.org/10.3168/jds.2016-10907
© American Dairy Science Association®, 2016.
Use of rumination and activity monitoring for the identification of dairy cows with health disorders: Part I. Metabolic and digestive disorders
M. L. Stangaferro, R. Wijma, L. S. Caixeta, M. A. Al-Abri, and J. O. Giordano
Department of Animal Science, Cornell University, Ithaca, NY 14853
Health index score (AU)
Rumination (min/d)
Activity (AU/d)
Days relative to clinical diagnosis
[1]At least 1 d within 5 d before, the day of DA diagnosis, and 2 after DA diagnosis
MERCK

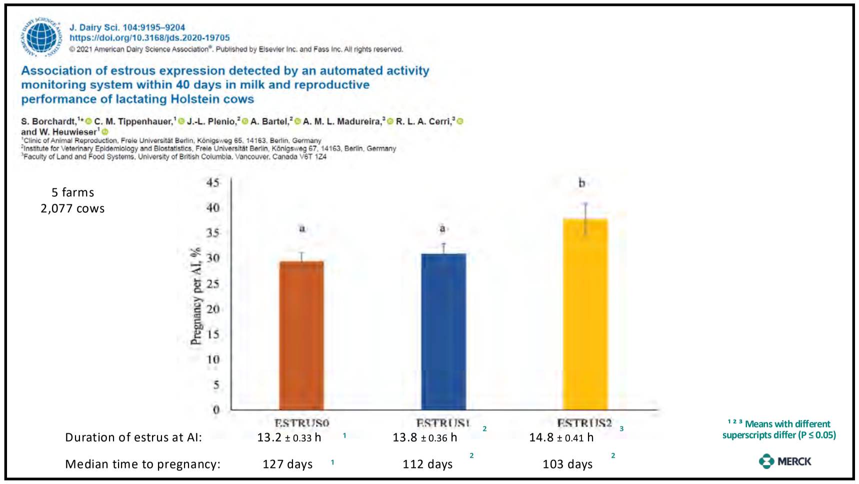
10


Reproduction
Heat Stress
Assessing and monitoring severity of heat stress
Postpartum health
The benefit of having access to a health index
Reproduction
Targeted approach to increase reproductive efficiency
MERCK

11


J. Dairy Sci. 103:929–939
https://doi.org/10.3168/jds.2019-17131
© American Dairy Science Association®, 2020.
Fertility of frozen sex-sorted sperm at 4 × 10^6 sperm per dose in lactating dairy cows in seasonal-calving pasture-based herds
C. Maicas, S. A. Holden, E. Drake, A. R. Cromie, P. Lonergan, and S. T. Butler
Conventional
vs.
Sexed Semen
CONV
SS
142 farms
7,246 breedings
(lactating cows)
Conception rate, %
P = 0.06
P = 0.08
P < 0.05
P < 0.01
P < 0.001
81%
87%
85%
84%
86%
80%
69%
74%
75%
45%
Bull
MERCK

12



J. Dairy Sci. 104:9195–9204
https://doi.org/10.3168/jds.2020-19705
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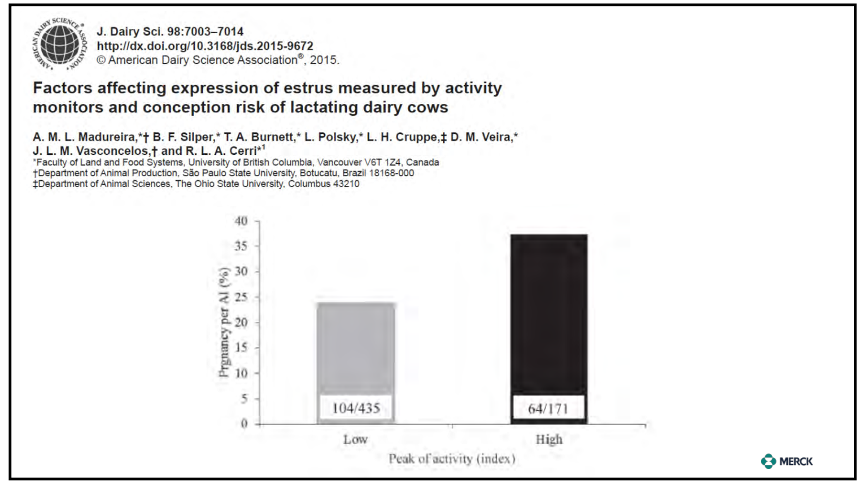
Association of estrous expression detected by an automated activity monitoring system within 40 days in milk and reproductive performance of lactating Holstein cows
S. Borchardt, C. M. Tippenhauer, J.-L. Plenio, A. Bartel, A. M. L. Madureira, R. L. A. Cerri, and W. Heuwieser
5 farms
2,077 cows
Pregnancy per AI, %
ESTRUS0
ESTRUS1
ESTRUS2
Duration of estrus at AI:
13.2 ± 0.33 h
13.8 ± 0.36 h
14.8 ± 0.41 h
Median time to pregnancy:
127 days
112 days
103 days
1 2 3 Means with different superscripts differ (P ≤ 0.05)
MERCK

13



J. Dairy Sci. 98:7003–7014
http://dx.doi.org/10.3168/jds.2015-9672
© American Dairy Science Association®, 2015.
Factors affecting expression of estrus measured by activity monitors and conception risk of lactating dairy cows
A. M. L. Madureira,*† B. F. Silper,* T. A. Burnett,* L. Polsky,* L. H. Cruppe,‡ D. M. Veira,* J. L. M. Vasconcelos,† and R. L. A. Cerri*
*Faculty of Land and Food Systems, University of British Columbia, Vancouver V6T 1Z4, Canada
†Department of Animal Production, São Paulo State University, Botucatu, Brazil 18168-000
‡Department of Animal Sciences, The Ohio State University, Columbus 43210
Pregnancy per AI (%)
104/435
64/171
Low
High
Peak of activity (index)
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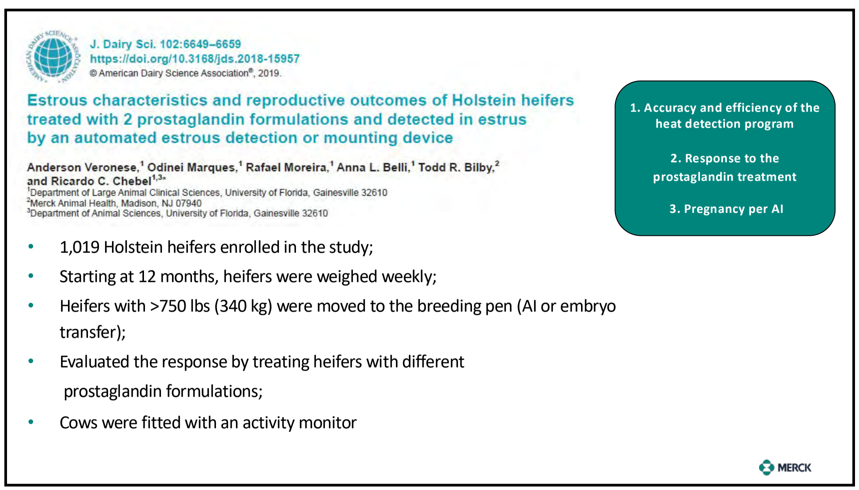
14



J. Dairy Sci. 102:6649–6659
https://doi.org/10.3168/jds.2018-15957
© American Dairy Science Association®, 2019.
Estrous characteristics and reproductive outcomes of Holstein heifers treated with 2 prostaglandin formulations and detected in estrus by an automated estrous detection or mounting device
Anderson Veronese, Odinei Marques, Rafael Moreira, Anna L. Belli, Todd R. Bilby, and Ricardo C. Chebel
1. Accuracy and efficiency of the heat detection program
2. Response to the prostaglandin treatment
3. Pregnancy per AI
1,019 Holstein heifers enrolled in the study;
Starting at 12 months, heifers were weighed weekly;
Heifers with >750 lbs (340 kg) were moved to the breeding pen (AI or embryo transfer);
Evaluated the response by treating heifers with different prostaglandin formulations;
Cows were fitted with an activity monitor
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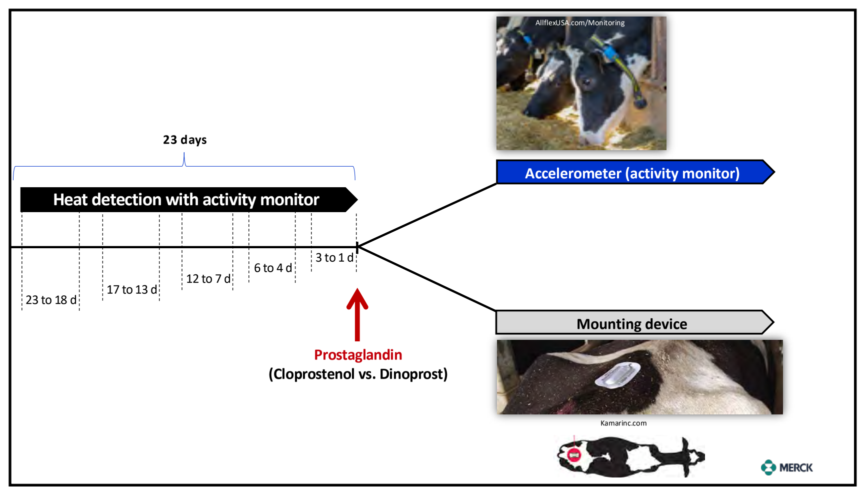
15



23 days
Heat detection with activity monitor
23 to 18 d
17 to 13 d
12 to 7 d
6 to 4 d
3 to 1 d
Prostaglandin
(Cloprostenol vs. Dinoprost)
AllflexUSA.com/Monitoring
Accelerometer (activity monitor)
Mounting device
Kamarinc.com
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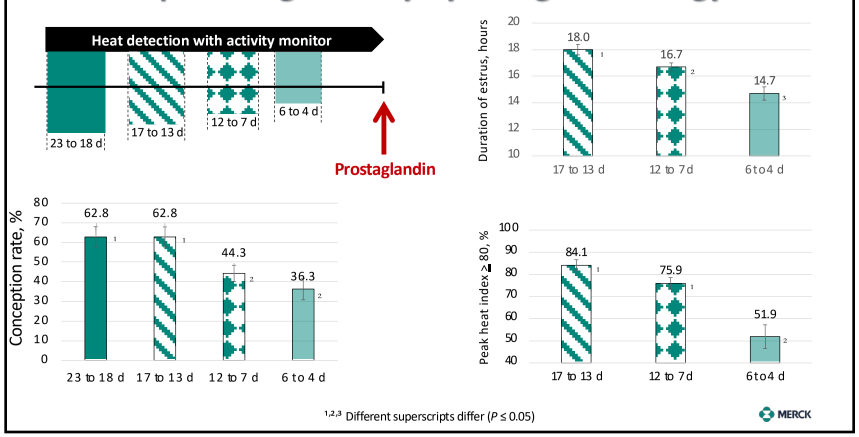
16

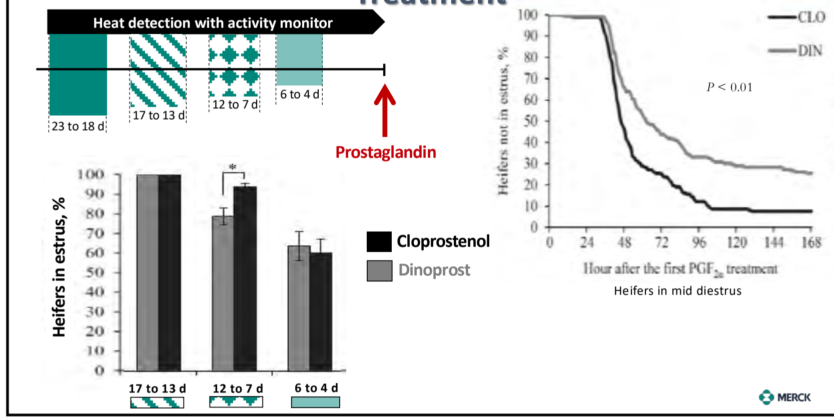
Optimizing Fertility by Using Technology



1,2,3 Different superscripts differ ($P \leq 0.05$)

17

Prostaglandin Formulation Impacts Response to Treatment



18

Take Home Messages

- Data insights from records may uncover areas of opportunities, help monitor changes, and assist in decision making processes in order to optimize efficiency
- Consider a data management strategy to translate investment in technology in meaningful actions to increase efficiency
- Historical information from the herd should be considered when evaluating records to determine major bottlenecks
- Technology provides opportunities to further fine-tune reproductive performance and postpartum cow health. Aspects to consider:
  - Technology must be reliable
  - Proven and validated by researchers
  - Algorithms should assist in determining actionable items
  - Integration with other software systems is extremely important

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19

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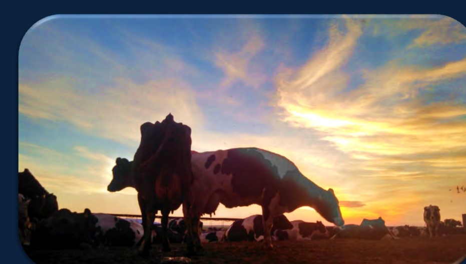
Animal Health

Thank You!



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Panel Discussion
Beef on Dairy: "Uteri for Rent" – Semen or ET in hot climates?

Moderator – Paul Fricke, Ph.D., Professor and Extension Specialist, University of Wisconsin-Madison

Opportunities and Challenges with ET and IVF vs. AI

Panelist – Jeremy Howard, Sr. Sales Manager, J.R. Simplot Company

Producer Perspective

Panelist – Leo Ruijne, Owner, Dairy Fountain, LLC, Plainview, TX

Panelist – Luis Davalos, General Manager, Corrales Dairy, Roswell, NM

NOTES:

Beef on Dairy: "Uteri for Rent" - Semen or ET in hot climates?

2022 High Plains Dairy Conference

Paul M. Fricke, Ph.D.

Professor of Dairy Science

Department of Animal & Dairy Sciences
UNIVERSITY OF WISCONSIN–MADISON

Extension
UNIVERSITY OF WISCONSIN–MADISON

1

"Uteri for Rent"

2022 High Plains Dairy Conference

Ask a question by using slido.com

Enter event code: #22HPDC

Type in your question

Give favorite questions a thumbs up

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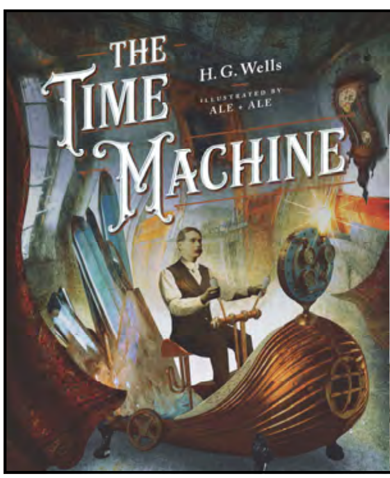

Published in 1895

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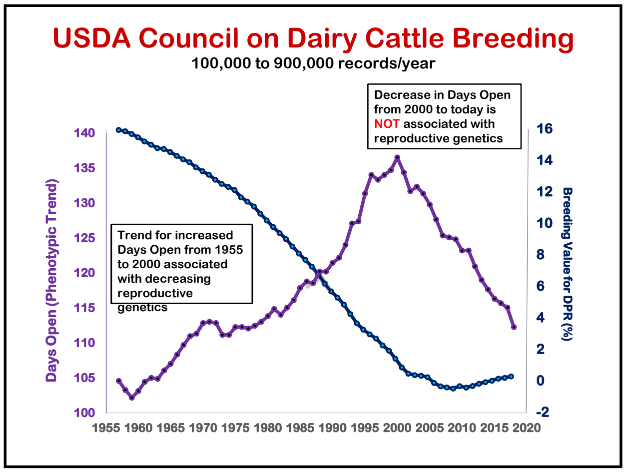
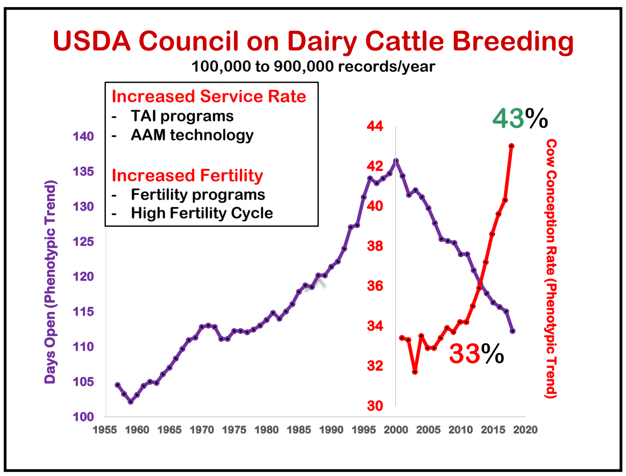
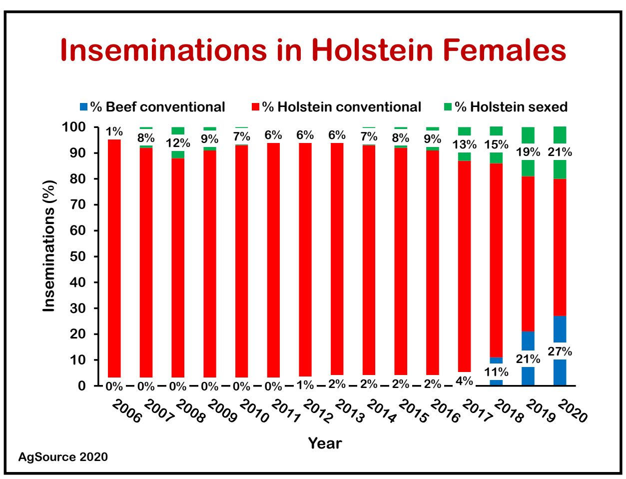

USDA Council on Dairy Cattle Breeding
100,000 to 900,000 records/year
Decrease in Days Open from 2000 to today is NOT associated with reproductive genetics
Trend for increased Days Open from 1955 to 2000 associated with decreasing reproductive genetics
Days Open (Phenotypic Trend)
Breeding Value for DPR (%)
140
135
130
125
120
115
110
105
100
16
14
12
10
8
6
4
2
0
-2
1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020

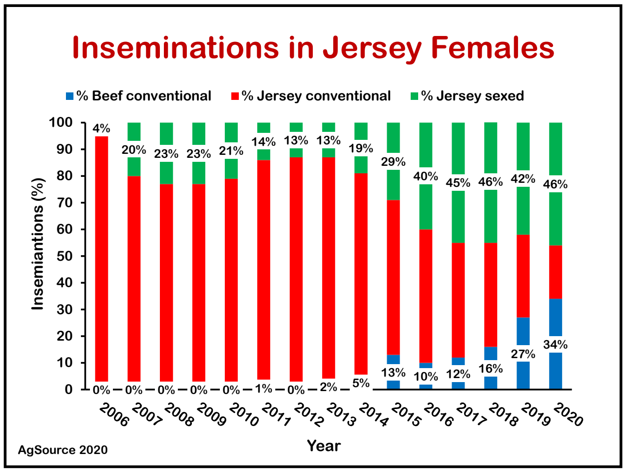
4


USDA Council on Dairy Cattle Breeding
100,000 to 900,000 records/year
Increased Service Rate
- TAI programs
- AAM technology
Increased Fertility
- Fertility programs
- High Fertility Cycle
43%
33%
Days Open (Phenotypic Trend)
Cow Conception Rate (Phenotypic Trend)
140
135
130
125
120
115
110
105
100
44
42
40
38
36
34
32
30
1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020

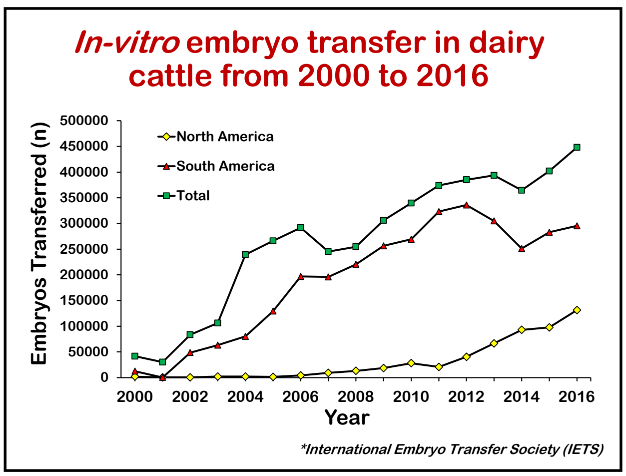
5


Inseminations in Holstein Females
% Beef conventional
% Holstein conventional
% Holstein sexed
Inseminations (%)
100
90
80
70
60
50
40
30
20
10
0
1% 8% 12% 9% 7% 6% 6% 6% 7% 8% 9% 13% 15% 19% 21%
0% 0% 0% 0% 0% 0% 1% 2% 2% 2% 2% 4% 11% 21% 27%
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Year
AgSource 2020

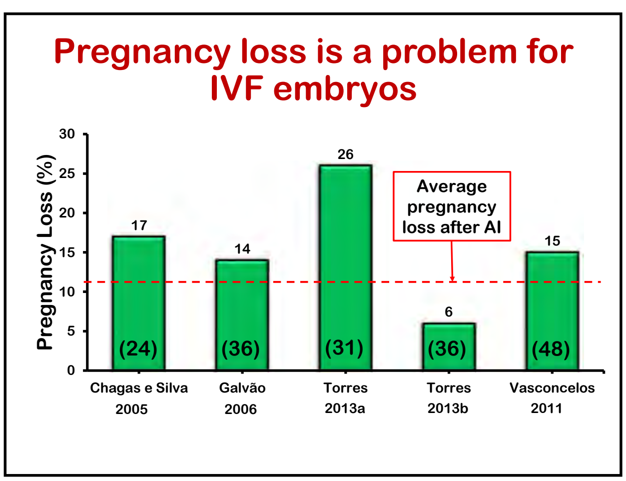
6


Inseminations in Jersey Females
% Beef conventional
% Jersey conventional
% Jersey sexed
Inseminantions (%)
Year
AgSource 2020
4%
20%
23%
23%
21%
14%
13%
13%
19%
29%
40%
45%
46%
42%
46%
0%
0%
0%
0%
0%
1%
0%
2%
5%
13%
10%
12%
16%
27%
34%
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020

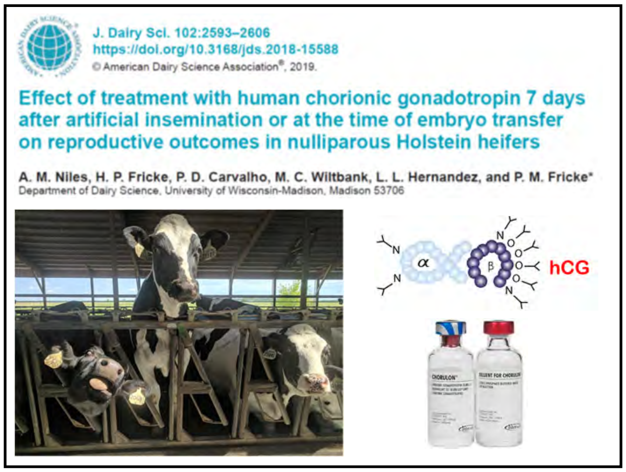
9


In-vitro embryo transfer in dairy cattle from 2000 to 2016
North America
South America
Total
Embryos Transferred (n)
Year
2000 2002 2004 2006 2008 2010 2012 2014 2016
*International Embryo Transfer Society (IETS)

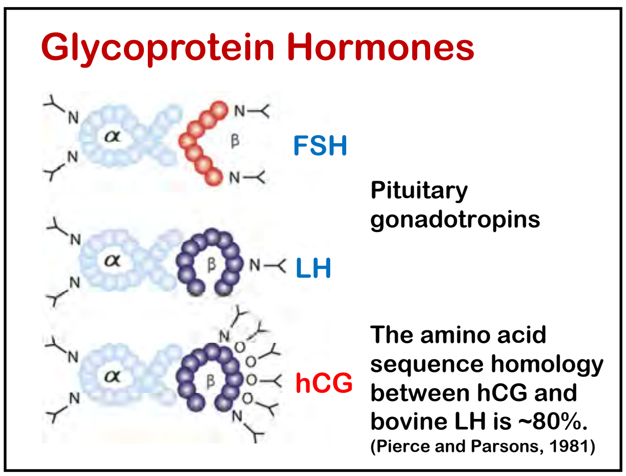
12


Pregnancy loss is a problem for IVF embryos
Pregnancy Loss (%)
Average pregnancy loss after AI
17
14
26
6
15
(24)
(36)
(31)
(36)
(48)
Chagas e Silva 2005
Galvão 2006
Torres 2013a
Torres 2013b
Vasconcelos 2011

13


J. Dairy Sci. 102:2593–2606
https://doi.org/10.3168/jds.2018-15588
© American Dairy Science Association®, 2019.
Effect of treatment with human chorionic gonadotropin 7 days after artificial insemination or at the time of embryo transfer on reproductive outcomes in nulliparous Holstein heifers
A. M. Niles, H. P. Fricke, P. D. Carvalho, M. C. Wiltbank, L. L. Hernandez, and P. M. Fricke*
Department of Dairy Science, University of Wisconsin-Madison, Madison 53706
α
β
hCG

14


Glycoprotein Hormones
FSH
Pituitary gonadotropins
LH
hCG
The amino acid sequence homology between hCG and bovine LH is ~80%.
(Pierce and Parsons, 1981)

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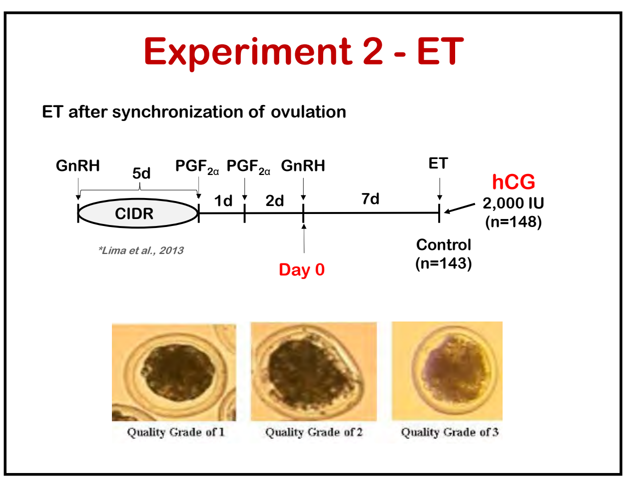
Experiment 2 - ET
ET after synchronization of ovulation
GnRH
5d
$PGF_{2\alpha}$
$PGF_{2\alpha}$
GnRH
ET
CIDR
1d
2d
7d
hCG
2,000 IU
(n=148)
*Lima et al., 2013
Day 0
Control
(n=143)
Quality Grade of 1
Quality Grade of 2
Quality Grade of 3

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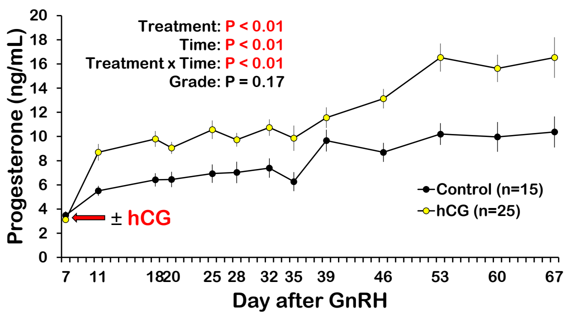
Experiment 2 – ET

Effect of treatment and time on serum progesterone in heifers that maintained pregnancy



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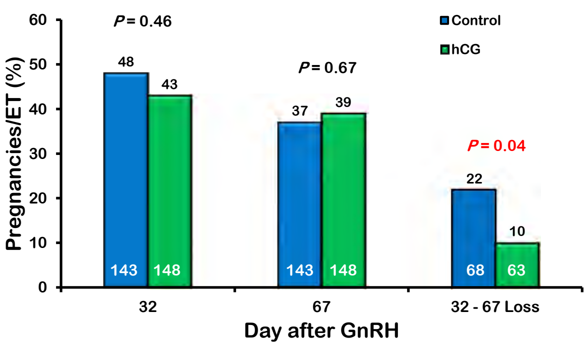
Experiment 2 – ET

Effect of treatment on pregnancy outcomes and pregnancy loss



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Panelists

- **Dr. Jeremy Howard**
  - **Simplot Animal Sciences**
- **Leo Ruijne**
  - **Dairy Fountain**
- **Luis Davalos**
  - **Corrales Dairy**

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YOUR DAIRY ISN'T LIMITED TO MILK

Opportunities and Challenges with ET vs AI

Jeremy Howard
Simplot Animal Sciences

1

Overview

- $ Increase Profitability
- Break into New Markets
- Increase Reproductive Efficiencies

2

2

Increase Profitability

Using Beef Semen and/or Beef Embryos on Low to Average Performing Cows:

Allows you to receive an Extra Premium

Optimize the ROI of Pregnancies not Needed for Replacement

3

Beef Semen

Easy to Implement
- No extra Training
- No new Equipment

Low Cost
- Semen ($0 - $12)

Conception Rates Similar to Dairy Semen

4

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Challenges

Market for B x D Fed Cattle

Some packers hesitant to buy

Early “Emptying of tanks” impacted the value

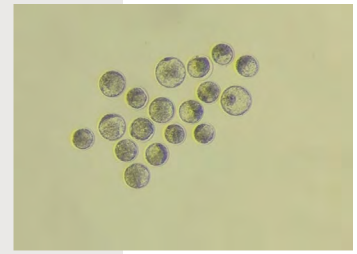
5

Embryo Transfer (Beef in Dairy)

Traditionally assisted reproductive technologies (ART) use has focused on genetically superior animals

- Multiple ovulation embryo transfer (MOET)
- In-vitro fertilization (IVF)

Costs have been too high to implement on a large scale in commercial operations.



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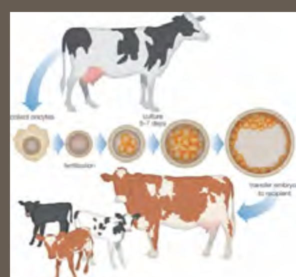
How are Beef Embryos Created?

Commercially Produced High-Quality IVF Embryos

Dams Selected for Specific Characteristics

Dams Mated to High Genetic Value Sires



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Embryos

Supplier Dependent
$35 - $55 per Beef Embryo

Requires
Different Gun

May Require Different Thaw Temp then
AI Special Training for Technicians

Conception Rates should follow AI rates

8

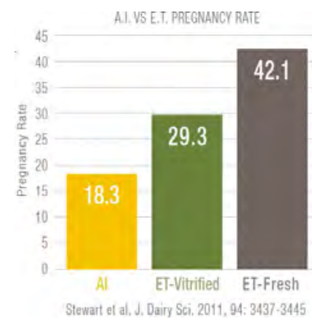
Keys to a Successful Embryo Transfer Program

Estrus Synchrony Between Recipient and Age of Embryo
- 7 Days Post Estrus

Technician
- CL Identification
- Embryo Placement

Recipient Selection
- Heifers> 1st lactation> 2nd Lactation>3rd Lactation
- 1st service > 3rd service

9



Heat Stress

- Frozen Embryos Had Higher Conception Rates then AI

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Increase Reproductive Efficiencies

Beef Embryos	Beef Semen
228 Total embryos transferred	1288 Total Units
91 Pregnancies	438 Pregnancies
39.91% Conception	34.01% Conception

MNSS Heat Stress Data, Unpublished 2019

11

End Result

12

Marketing Options

Scenario 1	Scenario 2	Scenario 2
Sell At a Day Old	Raise to to 400 lbs	Feed Out to Harvest

13

Calf Value (Day Old)

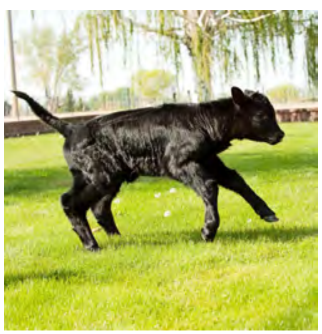
Holstein - $30 - $60
Jersey - ??

Jersey x Angus
$80 - $140

Holstein x Angus
$200 - $280

Beef Embryo
$350-400

14



Which Will Benefit Your Operation?

Depends…

15

Summary

Both Allow for the maximization of ROI on Calves Sold for Beef

Both provide the possibility of diversifying of the operation

Embryos can be Used to Overcome the Effects of Heat Stress

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Summary

Embryos require more management, but have a potential for higher ROI (Especially in Jersey Herds)

Using the strategies together may net the operation the most ROI

17

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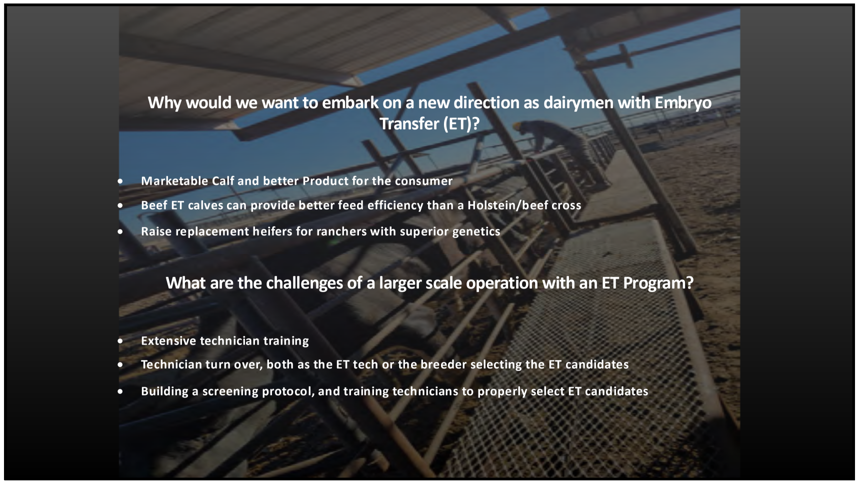
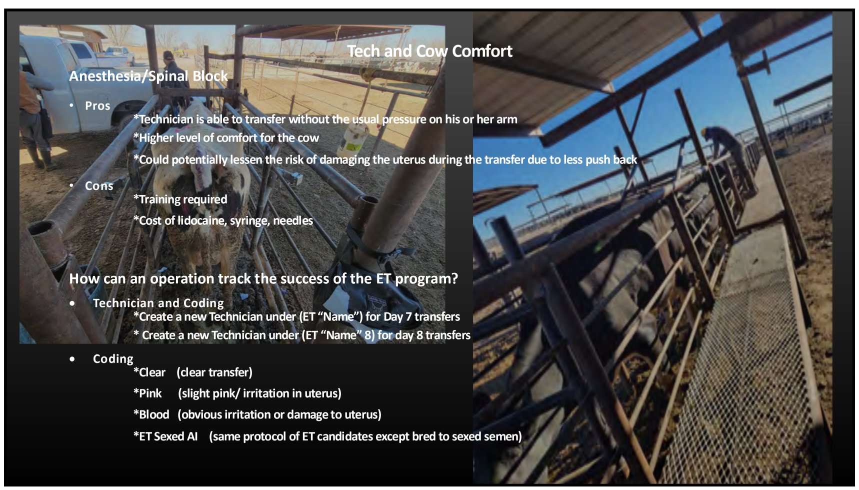

Why would we want to embark on a new direction as dairymen with Embryo Transfer (ET)?
• Marketable Calf and better Product for the consumer
• Beef ET calves can provide better feed efficiency than a Holstein/beef cross
• Raise replacement heifers for ranchers with superior genetics
What are the challenges of a larger scale operation with an ET Program?
• Extensive technician training
• Technician turn over, both as the ET tech or the breeder selecting the ET candidates
• Building a screening protocol, and training technicians to properly select ET candidates

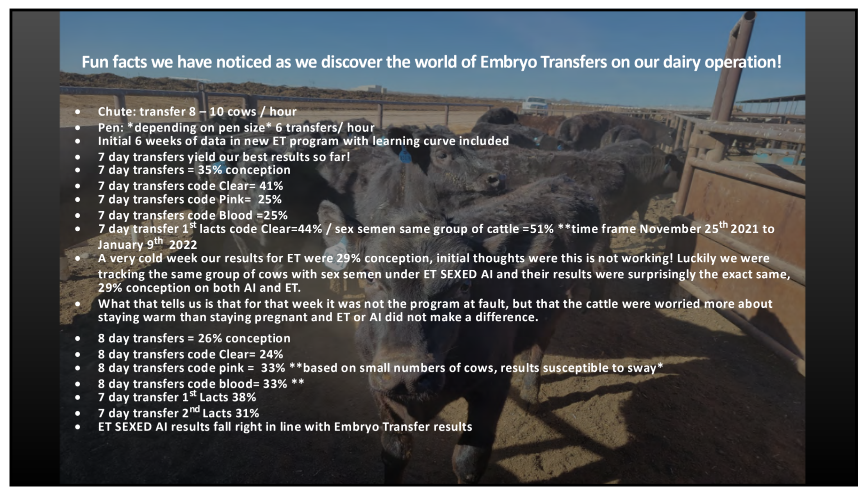
1


Ways to transfer. What works best for your operation?
Out in the pen
• Pros
*Low stress
*Cows may be released without disrupting their day to day routine.
*Can potentially be quicker than moving cows to a chute.
*Less man hours
• Cons
* Cows tend to move more
*Anesthesia/spinal block is more of a challenge
*Higher level of difficulty when transferring higher lactation cows
*Number of clear transfers could potentially be compromised
Controlled environment/chute
• Pros
*Spinal Block
*Squeeze gates
*Step stool
*Ultrasound
• Cons
*Man hours required to pull from pen
*Cows must return to their pen in a timely manner

2


Tech and Cow Comfort
Anesthesia/Spinal Block
• Pros
*Technician is able to transfer without the usual pressure on his or her arm
*Higher level of comfort for the cow
*Could potentially lessen the risk of damaging the uterus during the transfer due to less push back
• Cons
*Training required
*Cost of lidocaine, syringe, needles
How can an operation track the success of the ET program?
• Technician and Coding
*Create a new Technician under (ET "Name") for Day 7 transfers
* Create a new Technician under (ET "Name" 8) for day 8 transfers
• Coding
*Clear (clear transfer)
*Pink (slight pink/ irritation in uterus)
*Blood (obvious irritation or damage to uterus)
*ET Sexed AI (same protocol of ET candidates except bred to sexed semen)

3


Fun facts we have noticed as we discover the world of Embryo Transfers on our dairy operation!
• Chute: transfer 8 – 10 cows / hour
• Pen: *depending on pen size* 6 transfers/ hour
• Initial 6 weeks of data in new ET program with learning curve included
• 7 day transfers yield our best results so far!
• 7 day transfers = 35% conception
• 7 day transfers code Clear= 41%
• 7 day transfers code Pink= 25%
• 7 day transfers code Blood =25%
• 7 day transfer 1st lacts code Clear=44% / sex semen same group of cattle =51% **time frame November 25th 2021 to January 9th 2022
• A very cold week our results for ET were 29% conception, initial thoughts were this is not working! Luckily we were tracking the same group of cows with sex semen under ET SEXED AI and their results were surprisingly the exact same, 29% conception on both AI and ET.
• What that tells us is that for that week it was not the program at fault, but that the cattle were worried more about staying warm than staying pregnant and ET or AI did not make a difference.
• 8 day transfers = 26% conception
• 8 day transfers code Clear= 24%
• 8 day transfers code pink = 33% **based on small numbers of cows, results susceptible to sway*
• 8 day transfers code blood= 33% **
• 7 day transfer 1st Lacts 38%
• 7 day transfer 2nd Lacts 31%
• ET SEXED AI results fall right in line with Embryo Transfer results

4

In a Tier Pricing System: Feeding and Managing for Milk Components

Kevin Harvatine, Ph.D.
Professor of Nutritional Physiology
Penn State University

<u>NOTES:</u>

In a Tier Pricing System: Feeding & Managing for Milk Components

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Department of Animal Science
Penn State University

Introduction

Dairy producers are largely paid for the pounds of milk fat and protein shipped. Milk fat and protein concentration and yield are responsive to multiple dietary, genetic, and environmental factors (Figure 1). Diet-induced milk fat depression explains large decreases in milk fat that occur during disrupted rumen fermentation and was the predominant focus of milk fat research for many decades. A large number of dietary and environmental factors contribute to the risk for diet-induced milk fat depression including large contributions from dietary unsaturated fatty acids and fermentability. More recently, research has focused on other dietary and non-nutritional factors that impact milk fat and protein yield. Importantly, these factors have broad application to allow small, but economically important increases in milk fat yield and profitability. The seasonal variation in milk component concentration and yield has also been characterized and is important for setting goals and expectations. Genetics also affect milk fat and protein, which are highly heritable traits. Large variation exists in genetic potential between cows within a herd, despite there being little variation between herds. Additionally, the average genetic potential has increased in recent years, so goals need to be continually updated. Maximizing milk fat and protein yield requires a holistic approach that spans from nutrition to management and continues to evolve as we gain a better understanding of the impact of each factor.

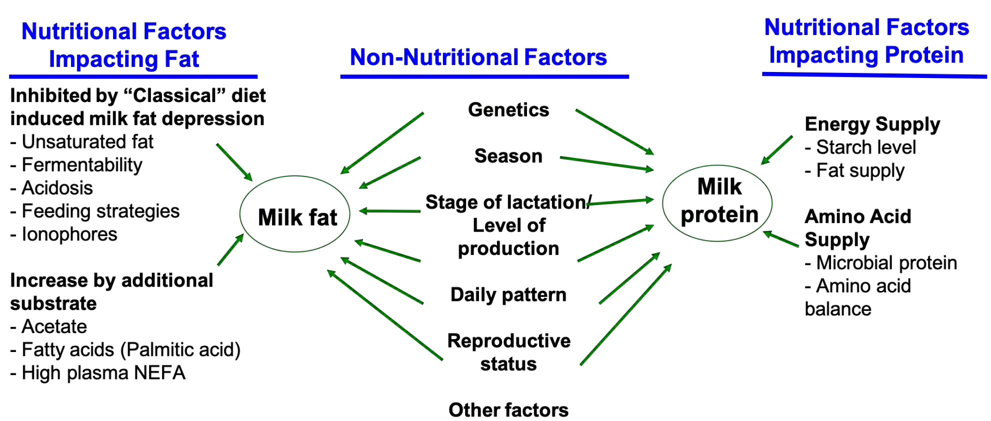

Figure 1. Nutritional and non-nutritional factors influencing milk fat and protein synthesis.

Factors Influencing Milk Fat and Protein Concentration and Yield

Milk fat and protein yield is impacted by many factors that can be broadly categorized as nutritional and non-nutritional factors (Figure 1).

Most of the interest on regulation of milk fat synthesis has focused on diet-induced milk fat depression (MFD), which causes large decreases in milk fat yield. More recently, methods to increase milk fat by providing substrate for milk fat synthesis through fat supplementation and increasing acetate supply have been reported. Fat supplements have recently increased in price and are less available. Remember to consider dietary supply from forages, commodity byproducts, and oilseed along with dry fat supplements. Increasing fiber digestibility will increase acetate supply and may be a good opportunity to increase milk components economically.

Milk protein synthesis can also be modified by nutrition, although responses generally are of a smaller magnitude, in agreement with the less variation observed in milk protein concentration in general. Milk protein is responsive to energy status of the cow through insulin and IGF-I signaling pathways (Mackle et al., 1999) that can be modified by increasing starch and starch fermentability of the diet. It is also responsive to amino acid supply and balance through substrate supply for milk protein synthesis and activation of mTOR signaling pathways (Castro et al., 2016). We generally expect milk protein to increase with increasing metabolizable protein and improving amino acid balances through maximizing microbial protein synthesis, balancing with high quality rumen escape protein, and feeding effective rumen protected amino acid supplements.

Non-nutritional factors are a broad category including seasonal rhythms, stage of lactation, genetics, parity, and other farm and cow factors that have not been well characterized. These factors can impact both milk fat and protein synthesis and are important to consider in analyzing if a herd is meeting its potential and long-term decisions that will maximize components in the future.

What is "Diet-Induced Milk Fat Depression"?

The term "milk fat depression" is a common term used and is defined as a decrease in milk fat associated with disrupted rumen fermentation (Griinari et al., 1998, Bauman and Griinari, 2003). It is important to note that this is a specific condition and not simply any change in milk fat yield. Up to a 50% reduction in milk fat concentration and yield can be observed with no decrease in milk or milk protein yield. Extensive work over the past 20 years has demonstrated that diet-induced MFD is caused by unique bioactive conjugated linoleic acid (CLA) isomers that are made during rumen biohydrogenation of unsaturated FA by an altered rumen microbial community. Investigating this condition has provided insight into the regulation of milk fat synthesis and management strategies to reduce inhibition of milk fat synthesis (Reviewed by Harvatine et al., 2009). Large decreases in milk fat (>15%) is almost undoubtably biohydrogenation-induced MFD, but this mechanism does not explain many other smaller changes in milk fat synthesis. The occurrence of BH-induced MFD is best diagnosed by milk fat concentration of *trans* 10 C18:1, although this requires analysis by gas chromatography.

Variation in Milk Fat and Protein Between and Within Herds

Milk fat and protein concentration and yield are variable between farms because of differences in diet, management practices, and herd genetics among other factors. This variability demonstrates both challenges and opportunities. Milk fat averaged 3.73% [standard deviation (**SD**) = 0.33], but the 10th and 90th percentiles were 3.34 to 4.12% in a database of DHIA test days of Holstein herds in Minnesota, Pennsylvania, Texas and Florida from 2004 to 2016 from the Dairy Records Management Database (http://www.drms.org/; Unpublished).

Milk protein averaged 3.04% (SD = 0.15) and the 10th and 90th percentiles were 2.86 to 3.23%. Average milk fat and protein has been increasing over the last decade based on USDA milk market data and we expect a higher average, but probably similar variation, in current herds. There is also substantial variation in milk fat and protein concentration and yield between cows within a farm. This variation, when consuming the same diet, highlights the influence of non-nutritional factors. A considerable portion of this variability is likely genetics and physiological changes associated with stage of lactation.

The variation between cows and herds highlights the opportunity to increase milk fat. It is important to keep in mind that average milk fat can be increased by two different approaches. You can increase all cows a small amount, but it is probably difficult to increase cows who are already high in the distribution, as they are at their genetic and physiological potential. Alternatively, the cows in the lower part of the distribution are likely below their genetic and physiological potential and interventions may result in substantial increases (25+%). Large increases in these cows can result in an increase in the herd average.

Non-Nutritional Factors Impacting Milk Fat and Protein Yield

enetics of il at Concentration and ield

Milk fat and protein concentration and yield are highly heritable (Welper and Freeman, 1992). We recently characterized the variation in predicted transmitting ability for fat and protein production between nearly 6,000 herds available in the Dairy Records Management System database. Very little variation was observed between herds, although larger variation is observed between cows within a herd. Importantly, average genetic potential has increased considerably over the past decade due to changes in selection indexes and genomic selection, which should be considered when evaluating if a farm is reaching its potential.

Annual hythms in the Dairy Co

Rather than simply *responding* to a change in the environment after it occurs, time keeping mechanisms in the hypothalamus allow the animal to *anticipate* yearly environmental changes before they occur. Yearly patterns of milk production have been recognized for over 40 years (Wood, 1970). When examining average monthly bulk tank records from the United States Federal Milk Marketing Orders, the presence of an annual rhythm is apparent. These yearly patterns fit a robust cosine function, suggesting that they represent a biological rhythm (Salfer et al., 2019). The variation in milk fat concentration due to the annual rhythm is between 0.15 and 0.30 percentage units, depending on the region, with a lower amplitude in southern regions of the United States. The presence of yearly production rhythms was confirmed using ten years of DHIA data from individual herds in Minnesota, Pennsylvania, Texas and Florida (Salfer et al., 2017). Although fat and protein concentration both peak near the first of the year, the annual rhythm of milk yield peaks between late March and early April, right around the vernal equinox (Salfer et al., 2017). Fat and protein yield peak between late February and early March. Contrary to the rhythms of fat and protein concentration, amplitudes of annual milk yield rhythms are greater in the southern U.S. compared to the north. Fat and protein yield also oscillated more in the southern U.S. than the northern U.S. Producers and nutritionists should change their goal for milk fat concentration and yield across the year and future work may provide insight into how to reduce the impact of the cycle on production.

Circadian Patterns of il at and Protein

Circadian rhythms are daily patterns, and the dairy cow has a daily pattern of milk synthesis that impacts milk yield and composition. Generally, milk yield is highest in the morning, but milk fat and protein concentration are higher in the evening (Gilbert et al., 1972, Quist et al., 2008). We have also observed milk yield and milk composition vary across the day while milking every 6 h in multiple experiments. The first consideration is that care needs to be taken in interpreting milk composition of a single milking. We have also observed that daily rhythms are dependent on the timing of feed intake and length of time without feed each day. This demonstrates the importance of feed management, including selecting feeding times and frequency, on milk production

il lo

Milk fat concentration is top of mind for producers and nutritionists, but milk fat and protein yield are what is economically important. Fat yield is influenced both by milk fat concentration and milk yield. First, care needs to be taken to not decrease milk yield when attempting to increase milk fat concentration. This is especially important considering that decreases in milk yield are highly likely to also decrease milk protein yield. Secondly, maximizing milk fat and protein yield requires optimal production. Milk yield is under complex regulation with major influence from endocrine mechanisms and can be limited by nutritional, health, or environmental stressors. With this in mind, all good management practices that increase reproductive efficiency, cow health, cow comfort, etc. and increase level of milk production likely also increase milk fat yield.

Take Home Messages

- There is large variation in milk fat and protein between and within herds, which are impacted by many dietary, genetic, and environmental factors and their interactions make it difficult to manage.
- It is important to consider non-nutritional factors, such as genetic potential, season of the year, and milking sampled, when setting goals and interpreting data.
- Diet-induced milk fat depression explains large decreases in milk fat and is caused by fundamental issues with stable rumen fermentation.
- Increasing dietary fat can increase milk fat, but is most consistent when feeding enriched palmitic acid supplements. Increasing acetate supply by increasing fiber digestibility supports higher milk fat yield.
- Milk protein is impacted both by amino acid supply and energy signals that stimulate protein synthesis. We need to think both about amino acid balancing and optimal energy supply.

References

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Panel Discussion

Determining Tools & Metrics towards Carbon Neutrality for Western Dairies

Moderator – Rick Naerebout, CEO Idaho Dairymen's Association

Monetizing Manure Projects: Where to Begin?

Panelist – Mark Stoemann, CEO Newtrient

Digester Due Diligence for Dairy Producers

Panelist – David Claiborne, Attorney and Partner at Sawtooth Law, Twin Falls, ID

NOTES:

Tools & Metrics for Carbon Neutrality on Western Dairies

IDAHO IDA dairymen's association

Rick Naerebout | CEO

1

US Dairy's 2050
Net Zero Commitments

- Achieve GHG neutrality
- Optimize water use efficiency
- Improve water quality

2

What does this mean
for the industry?

- Pre-Competitive
- Carbon Markets
- Market Driven
- Environmental Research

3

2015 - 2021

Global Warming
Potential Study

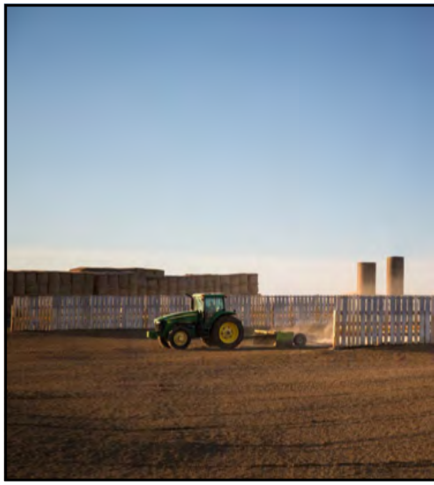
On-farm measurement of greenhouse gas emissions in Idaho & California

Measured & estimated totals of
- CH4
- N2O
- NH3

Evaluated emissions from all areas of the farm

Data used to calibrate national models estimating GHG

4



2021 - 2023

Manure Methane Potential Study

Updating methane estimates & developing strategies for mitigation of manure emissions

Measuring total methane produced in all types of manures

Identifying areas of impact & mitigation practices

Update national emissions models

5

2012 - 2024

Automated GHG Chamber Study

Measuring greenhouse gas emissions from fields with fertilizer & manure applied

Continuous measurements taken each season to generate flux estimates
- Evaluating field management practices' effect on emissions
- Gaging carbon sequestration potential based on emissions

Update national N2O models

6

2021 - 2026

NZI FFAR Grant USDA-ARS Kimberly, ID

Improving on-farm sustainability through soil health & manure management

Measuring soil health & carbon sequestration

5 participating locations across the US
- Large plots
- Strip tillage + cover crops
- Sedron & DAF solids applied to manured and non-manured soils
- 4 years of corn into 1 year alfalfa

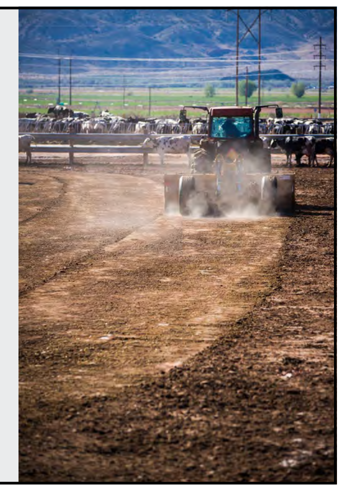
7

Pacific Northwest Partnership

Participants from ID, OR, UT, & WA
- Check-off & policy organizations
- Processor and co-op representation

Share information

Catalyze research that will help the PNW dairy industry lead on sustainability



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March 2, 2022

Monetizing Manure Projects
Where to Begin?

NEWTRIENT
INNOVATIVE SOLUTIONS IN RESOURCE RECOVERY

1

NEWTRIENT

What We'll Cover Today

- What are the potential revenue streams for farms today?
- What future markets should you know about?
- How do you prepare your farm to stay competitive?

Page 2

2

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Representing Dairy Farmers Across the Country

Page 3

3

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Priorities

Page 4

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Dairy Farm Opportunities

Feed production and practice changes:

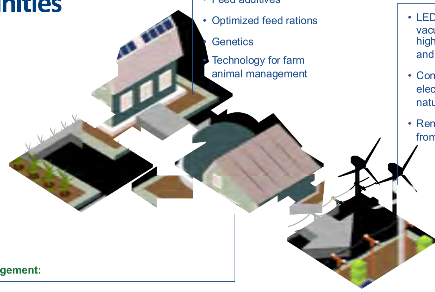
- No/low-till farming and cover crops
- Renewable fertilizers
- Precision agriculture

Cow care & efficiency:

- Feed additives
- Optimized feed rations
- Genetics
- Technology for farm animal management

On-farm energy efficiency and renewable energy usage

- LED lighting, variable speed vacuum pumps, high-efficiency refrigeration, and fans
- Conversion of biogas into electricity and/or renewable natural gas
- Renewable energy sources from wind/solar



Manure handling and nutrient management:

- Reduced liquid manure storage and proper maintenance
- Technologies to capture nutrients and create new manure-based products
- Nutrient Management Planning (NMP)
- Anaerobic digesters turn manure into biogas

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5

Types of Diversified Revenue Streams

Diversified revenue streams are available to farms, including:

- Efficiency & Productivity
- Alternative Energy Sources
- Digestion & Renewable Energy Generation
- Ecosystem Services Markets (ex. carbon and water quality credits)

Note: Avoided costs are the same as a revenue stream, one puts money in your bank account the other keeps it there.

Page 6

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Preparing Your Farm

- **Make Informed Decisions**
- **Set up Your Financials**
- **Analyze Your Costs**
- **Monitor and Check Your Trash**
- **Benchmark**
- **Prioritize & Execute**
- **Planning & Risk Mitigation**

"It's not how much money you **make**, but how much money you **keep**..."

Robert Kiyosaki,
Rich Dad, Poor Dad: What the Rich Teach Their Kids About Money – That the Poor and Middle Class Do Not!

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Cost of On-Farm Manure Management

Annual manure costs for a 3,500-cow dairy farm

Avoided Manure Application Costs 2019 - Scrape to Lagoon

3,500	cows
36	gallons/cow/day
365	days
45,990,000	gallons/year
30,813,300	gallons/year through pivots
$0.01	cost per gallon through pivots
$308,133	cost per year through pivots

15,176,700	gallons/year by
$0.025	cost/gallon custom applicator
$379,418	cost/year custom applicator
$687,551	Total cost per year
3500	Cows
86	lbs per cow
305	day milking per year
91,805,000	lbs per year
918,050	CWT's per year
$0.75	**Cost per CWT**
$196.44	**Cost per Cow**

Costs Include

- Equipment
- Labor
- Utilities
- Consumables
- Services
- Management

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Markets & Outlook: Energy Efficiency

USDA United States Department of Agriculture

NRCS Natural Resources Conservation Service

EQIP

The **Environmental Quality Incentives Program (EQIP)** On-Farm Energy Initiative helps farmers and ranchers make voluntary improvements that can boost energy efficiency on the farm.

Financial assistance is available to inventory and analyze farm systems that use energy and identify opportunities to improve efficiency through the development of an Agricultural Energy Management Plan (AgEMP), also called an energy audit.

Once an AgEMP or other qualifying energy audit has been completed, eligible producers can apply for EQIP assistance for the purchase, installation, or retrofit of certain buildings or equipment to improve energy efficiency.

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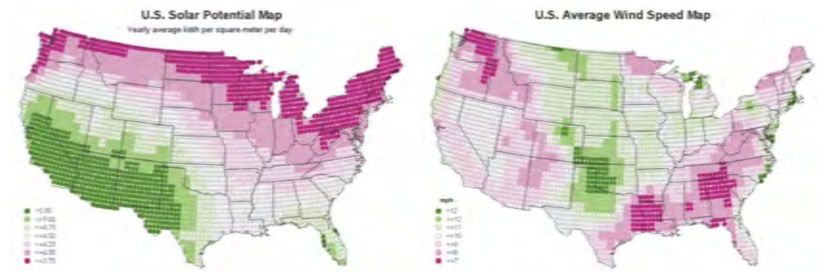
Markets & Outlook: Solar & Wind



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Markets & Outlook: Solar & Wind

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Replacing Fossil Fuel with Biogas

Larson Dairy, Florida October 2021

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Markets & Outlook: Digestion & Renewable Energy

What Drives Renewable Energy Projects?

1. State incentive programs, like the *Low Carbon Fuel Standard (LCFS)* in CA
2. National programs and incentives (RFS)
3. Consumer demand and company/utility sustainability goals
4. Dairy farmers' interest in diversifying farm revenue

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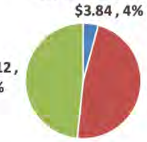
Market Value: Digestion and Renewable Energy

$91.20 RNG VALUE (D3 RIN's and -250 CI)
February 14, 2022



***MMBTU** = unit of sale used for U.S. natural gas

Base Gas = price of a long-term (3 year) contract for fossil natural gas

D3 RIN = federal Renewable Fuel Standard (RFS) Credit for RNG from cellulosic feedstock that is sold into the transportation market

LCFS Credit = California Low Carbon Fuel Standard credit for RNG with a project specific CI score that is sold into the California transportation market

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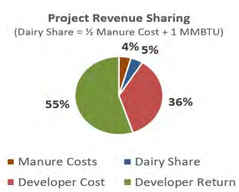
Potential Annual Revenue: Digestion and Renewable Energy

21.1 MMBTU* produced at $91.20 / MMBTU = $1,924 / COW



***MMBTU** = unit of sale used for U.S. natural gas

February 21, 2022

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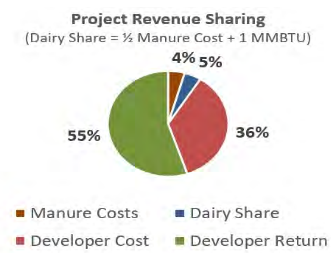
Revenue Sharing: Digestion and Renewable Energy



Revenue Sharing Plan

- Covers developer's costs
- Covers dairy costs
- Provides reasonable return
- Easy to understand
- Easy to calculate
- Fair to all parties
- Adjusts to the changing market
- Subject to review

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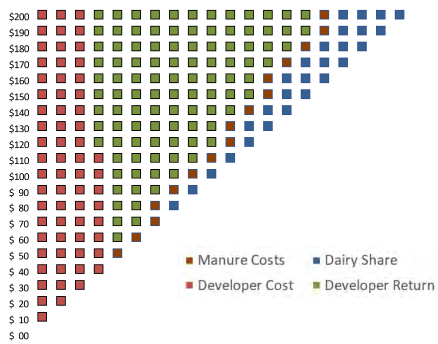
Revenue Sharing Option: Digestion and Renewable Energy

Revenue Sharing Plan

- Covers developer's costs
- Covers dairy's costs
- Provides reasonable return
- Easy to understand
- Easy to calculate
- Fair to all parties
- Adjusts to the market
- Subject to review



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Ecosystem Services Markets - Types of Markets and Buyers

VOLUNTARY (NON-REGULATORY)
:driven by a company's environmental goals

- Non-Governmental Orgs
- Philanthropists
- Food and Beverage Companies
- Companies with CSR Goals
- Investors

COMPLIANCE (REGULATORY)
:driven by regulatory compliance

- Municipalities
- Permit Holders
- States

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Markets & Outlook

Registries/Protocols

VERRA
CLIMATE ACTION RESERVE
Gold Standard
CALIFORNIA AIR RESOURCES BOARD

Trading Platforms/Aggregators

ESMC Ecosystem Services Market Consortium
THE indigo CARBON PROGRAM
BAYER
Soil and Water Outcomes Fund
NORI
Nutrien
TRUCARBON™
FARMERS BUSINESS NETWORK

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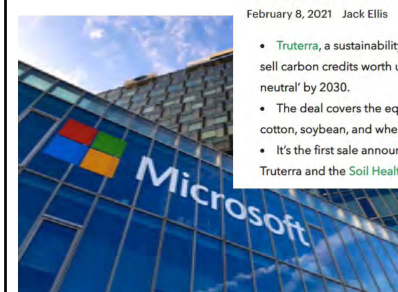
BRIEF: Microsoft to purchase up to $2m in carbon credits from Land O'Lakes

February 8, 2021 Jack Ellis



- Truterra, a sustainability-focused subsidiary of US farmer cooperative Land O'Lakes, has agreed to sell carbon credits worth up to $2 million to tech giant Microsoft, which is aiming to become 'carbon neutral' by 2030.
- The deal covers the equivalent of 100,000 metric tons of carbon sequestered by Land O'Lakes corn, cotton, soybean, and wheat farmers.
- It's the first sale announced under TruCarbon, the new carbon credits trading program launched by Truterra and the Soil Health Institute.

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BIOMASS MAGAZINE

Dominion Energy, Vanguard Renewables partner on dairy RNG

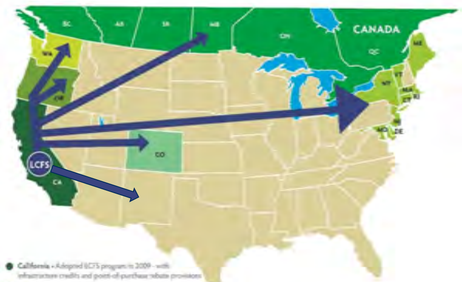
By Dominion Energy | December 11, 2019

Dominion Energy and Vanguard Renewables announced today a more than $200 million, nationwide strategic partnership to convert methane from U.S. dairy farms into clean, renewable natural gas (RNG) that can heat homes, power businesses and fuel vehicles. Multiple projects are under development in Georgia, Nevada, Colorado, New Mexico, and Utah with additional projects planned

The Washington Post

Turning manure into money

Farmers and utilities are burning methane for energy — and curtailing a powerful greenhouse gas in the process



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Airlines must reduce emissions instead of offsetting, say experts

Campaigners warn offset system is flawed and can prod
with no climate benefit

SUSTAINABILITY

Carbon Neutral from March 2020 Onward

Climate Solutions

United Airlines aims to suck carbon dioxide from the friendly skies

The company becomes the first major U.S. carrier to try to remove the greenhouse gases it spews with every flight

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Markets & Outlook: Ecosystem Services Markets

Environmental Assets (Full Farm Approach)

- Eliminate lagoon-related methane emissions
- Cut cows enteric emissions*
- Replace fossil fuel with Biogas
- Replace peat moss with dairy fiber*
- Make cows more efficient*
- Turn phosphorous from cow manure into sustainable fertilizer*
- Practice no-till farming as a means to boost soil health and sequester carbon

**Not currently eligible under any protocol*

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Eligible Services – Eliminating Lagoon-Related Methane Emissions

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Eligible Services – Practice No-till Farming

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Soil Sequestration is the Primary Focus for Most Markets

		ASSET						
		CARBON				WATER		BIO-DIVERSITY
		Removals	Reductions					
Trading Platforms/ Carbon Aggregators	Launch Date	Soil Sequestration	Methane Destruction	NOX Emissions	Enteric Emissions	Quality	Quantity	
Indigo Carbon Program	2019	Yes	No	?	No	No	No	No
NORI	2019	Yes	No	No	No	No	No	No
Soil & Water Outcome Fund	2020	Yes	No	No	No	Yes	No	No
Bayer Carbon Initiative	2020	Yes	No	No	No	No	No	No
Farmer's Business Network	2020	Yes	No	No	No	No	No	No
Nutrient Carbon Program	2021	Yes	No	No	No	No	No	No
TruCarbon	2021	Yes	No	No	No	No	No	No
ESMC	2022	Yes	No	?	?	Yes	Yes	TBD

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Little Consistency in Approach Across Markets

- No universal, precise measure of reductions, captures, etc.
- Contract duration
- Acreage minimum
- Lookback period
- Stacking with government programs (e.g., cost-share)
- Targeted buyers
- Product linkages
- Data control and privacy

United Farmers & Ranchers in Action: Transformative Investment in Climate-Smart Agriculture Unlocking the potential of our soils to help the U.S. achieve a net-zero economy

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Staying Competitive in a Changing Market

- **Tread lightly** when exploring new revenue streams
- **Use caution** when evaluating solutions and the impacts on your farm
- **Keep your options open** knowing that many more opportunities will be coming down the pipeline

- **Use Your Resources**
  - Newtrient Solutions Catalog
  - Trusted Sources and Experts
  - Webinars, Workshops & Roundtables
  - Demonstration Days & Farm Visits

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Questions?
NEWTRIENT

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Contact Information
Mark Stoermann
Chief Operating Officer
mstoerm@newtrient.com
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March 2, 2022

DIGESTER DUE DILIGENCE FOR DAIRYMEN

1

PROCESS

- Opening Phase
  - Approached by digester company
  - Nondisclosure agreement
  - Letter of intent
- Contracting Phase
  - Feedstock supply agreement
  - Leases (and/or options)
  - SNDAs
- Permitting Phase
  - Permitting
  - Site location, design
- Construction Phase
- Operations Phase

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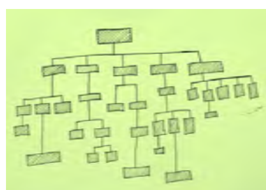
INTERNAL OWNERSHIP



- Important to have the right entities for your contracts
- Know your entities and ownership structure
  - Who owns the land
  - Who owns the cows
  - Who operates the dairy
- An LLC with a manager is generally the preferred entity

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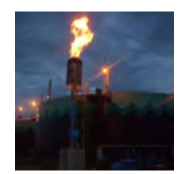
DIGESTER OWNERSHIP & OPERATIONS

- Dairyman due diligence requires investigation of the digester developer
- What projects does the developer already have in operation
- What dairy farms has the digester developer already contracted with
- Can the developer arrange for you to talk independently and privately with other dairymen with developed projects
- Does the digester developer have in place long-term contracts for the sale of energy; with who
- A successful digester developer will be able to answer these questions and will not need to hide behind "confidentiality" – they should have pride in what they have done and be willing to share it



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INTERNAL FINANCING

- Your current and future financing is always critically important
- Is the consent to of your current lender needed to grant a leasehold interest
- Involve your lender early
- What lienholder interests are of concern
  - Land (mortgages, deeds of trust)
  - Cows (UCC liens, security agreements)
  - Manure

DIGESTER FINANCING

- Dairyman due diligence requires investigation of the digester developer
- Does the developer have financing and funding already in place
  - With who, in what amounts, what conditions or contingencies
- Who will be receiving the carbon credits
- Who will be receiving the tax credits
- Negotiate toward obtaining access to developer financials and corporate information to assure financial ability to perform and available capital

COMPENSATION TO THE DAIRYMAN

- Is there a signing payment/bonus
- Are there progress payments, at what stages
- Will there be a lease payment; in what amount
- What will be compensation after commercial operations begin
  - Price by energy unit (mmBTU, mW)
  - Per cow (and then does it vary by cow)
  - Profit share (EBITDA, net income approach)

EFFECT ON DAIRY ANIMAL OPERATIONS

- Digester company focus will be on CI score, TS, VS and other aspects effecting energy production abilities
- Inquire and understand what changes will and will not be needed to your current animal husbandry practices
  - What control will you have over animal rations going forward
  - What control will you have over animal bedding and housing practices going forward
  - What control will you have over herd size going forward
  - What control will you have over water use going forward (e.g., parlor, stalls, foot baths)
  - What control will you have over health management practices going forward

EFFECT ON DAIRY WASTE MANAGEMENT

- Digester company focus will be on CI score, TS, VS and other aspects effecting energy production abilities
- Inquire and understand what changes will and will not be needed to your current waste management systems
  - Flush water
  - Bypasses
  - Use of honey vacs, solid separation, etc.
  - Other pre-digestion handling and treatment
- How long will manure be in digestion
  - What is nutrient value and composition of digestate
  - Post-digestion separation, handling and treatment
  - Temperature control in digestion and outflow
- Who pays for changes and upgrades
  - Responsibility for manure transportation costs
- Effect on frequency of lagoon cleaning
- What changes will be required to NMP, field application, 3rd party export

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PERMITTING CONSIDERATIONS

- Each county will have its own unique considerations re: permitting
  - CUP, CAFO amendment, variance, no process
- Potential trigger for site compliance review of your current CAFO permit
  - Do NOT agree in FSA to number of milking cows that exceeds your permit
- Potential opportunity for CAFO expansion or bring permit in to compliance
- Will variances be needed for building heights, other items
- What neighborhood meetings, county meetings and other public hearings or comment will be required
- Will their be a need for ISDA inspection
  - Avoid disclosure of your NMP documents to any public agency other than ISDA
  - Prefer they simply provide an in compliance letter to local authority
- DEQ and other permitting – digester developer

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OPERATIONAL CONCERNS

- Be involved and ask early re: digester design, location, operation
- Where will interconnection point be to energy transmission system
- Utilities are needed to operate – who supplies, who pays
- What happens if there is a shortfall in manure delivery – penalties
- Who has liability for releases of manure, indemnities
  - Allocation of insurance obligations
- Negotiate the potential force majeure events
  - Severe or unusual weather, freezes, prolonged low temperatures
  - Upset conditions defined by DECA and declared by ISDA
  - Herd infection or disease outbreak
  - Production curtailment orders

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TERM AND TERMINATION

- What is the fixed contract term
- Are there renewal or extension terms; at whose option
- What exit opportunities are available
- What happens to the facilities upon termination
- Assignability of interests – this goes both ways

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TAXES

- Effect on property taxes; who pays incremental increase
- Allocation of available tax credits for siting infrastructure
- Taxes on the production and sale of manure
- Taxes on the production and sale of energy

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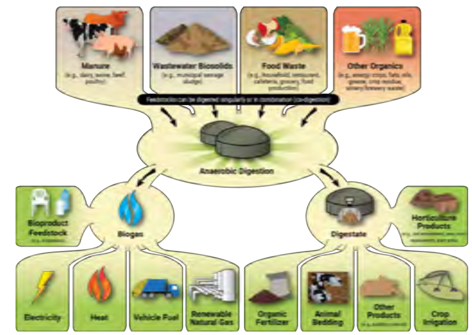
EMERGING ISSUES AND CONCERNS

- Community digesters
- Sales tax

- Solid waste permitting
- Collateral interest in manure



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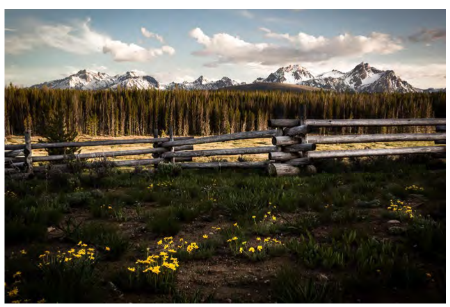
QUESTIONS ?



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Carbon Credits in Ag: Can Carbon be an Actual Source of Income in Ag?

Joe Outlaw, Ph.D.
Regents Fellow, Professor & Extension Economist
Texas A&M University

<u>NOTES:</u>

Parlor Throughput with Milk Quality in Mind

Juan Rodrigo Pedraza, DVM
Managing Veterinarian
Zoeitis

NOTES:

Efficient parlor throughput with milk quality in mind

Juan Rodrigo Pedraza DVM
Zoetis
Willow Park, Texas, USA

Introduction

Parlor throughput has always been a task that all dairymen must consider in order to be efficient and be able to get the maximum number of cows through their facilities without compromising milk quality. There is a very fine line when it comes to make such decision. If milk quality is a top priority, then you will have to slow down the speed but if milking as many cows as possible is the goal then your milk quality will suffer.

Fine tuning your parlor settings, milking procedures and facilities can make a tremendous difference and you would be able to get the best of both worlds.

Some of the most important accelerating factors will be discussed.

Loading speed: How fast you can get your parlor banks loaded is important, but here are several factors that can maximize your cow flow. First one and probably the most important one is cow handling. Your employees need to understand cattle stockmanship, make sure you train your people correctly, so they understand the cow's language and keep cow flow without any interruptions. The second factor will be parlor flooring. Rubber mats will speed up the process, cows like to get on them and they feel safe so therefore move faster. In other hand bad flooring can be either slippery or too rough on their feet, increasing lameness and decreasing loading speeds. On top of this, it makes it difficult to detect clinical mastitis. Good parlor lighting will also help cows and employees to see better, and it will speed up the loading process. Size of parlors obviously affects efficiency but for the most part is something that once the parlor is built there is not that much you could do about it. Once parlors get bigger than double 35, they start losing efficiency because of the walking distances.

Unit on Time: Many parlors' settings affect unit on time.

Pulsation settings: B and D phases are the ones that make the biggest difference. The B Phase is the milking phase and length should be around 500 mS. The D phase is the resting phase, and it should be around 200 mS. These two phases are important when it comes to efficient and safe milking process. If the B phase is not long enough the teat will get congested and therefore it will slow down the milk flow. Phases A and C do not change that much with different pulsation settings these are more dependent on vacuum chamber size and liner material.
Pulsation is there to make sure the cows are milked out as fast as possible without affecting teat end health. The pulsators alternates vacuum with atmospheric pressure this allows the liner to open and close. With each cycle the liner will bend around the teat, applying a mechanical force at the teat end. Liner thickness and tension are some of the factors that can make a liner more or less aggressive on the teat ends.

Vacuum level at the teat end is another factor that will increase or decrease unit on time. The higher the vacuum the higher the milking speed UP to a point. Nothing good happens to a Teat end above 12.5 inHg (42 kPa). This vacuum level should be measured at peak flow by either inserting a needle in the short milk tube getting the needle inside the claw or by using a T-piece at claw outlet. Vacuum fluctuations at the teat end will not cause a direct effect on mastitis incidence but will certainly

increase the risk of liner slips which can be a really important factor in terms of mastitis transmission. The minimum claw vacuum influences milking performance independent of the level of the system vacuum causing low milk flow and long milking times. (Besier, 2016)
Small vacuum fluctuations will help reducing unit on time and will increase milk flow rates.
High vacuum and B phase will increase peak flow but at the same time high vacuum will also increase liner compression. High liner compression will increase hyperkeratosis. (Bade, R.D. 2009)

Liners: There are hundreds of different liners in the market. Find the liners that fit your cows the best. Some are faster than others.
Liner compression, liner tension, liner thickness and Over-pressure are different factors that affect milking performance. The system should be adjusted to the liner, simply follow the manufacturer's recommendations; those will make the liners to perform adequately. Generally speaking, silicone liners because of the material are slower milkers this is usually compensated by setting the system at a higher vacuum and adjusting pulsation settings accordingly. Aggressive liners can cause excessive teat end congestion and therefore hyperkeratosis, this does not mean you cannot use them, is just a matter of making all adjustments in terms of milking procedure and system settings so unit on time can be as short as possible and avoiding overmilking both at the start of the milking process as well as at the end.

Automatic take offs: Probably one of the most important settings that can help on reducing unit on time and therefore reducing excessive exposure to vacuum. Long unit on times are directly related to higher risk of hyperkeratosis. Flow-rate thresholds should be adjusted to be around to 2 lbs/min (900 cc/min). These adjustments need to be done slowly making small changes both on the flow and delay times. Make adjustments weekly and check strip yields. It is Ok to have residual milk volumes up to 400 cc. it has been documented that this volume will not affect SCC nor milk production. (Rasmussen 1993, Stewart 2002, Jago 2010) the main benefits of early unit removal are a reduction of unit on time, teat barrel congestion and hyperkeratosis. (Mein and Reinemann 2014).

At the time of checking strip yields, this assessment should include volume (equally distributed in all four quarters), teat congestion, teat end health, cow behavior like kicking and resistance to the touch.
Mouthpiece vacuum (MPV) increases when milk flow decreases or when liner fit is poor, in both cases barrel congestion will be elevated. At the end of the milking process the milk flow is lower and the teat becomes longer, this affects MPV. In other hand when the teat cistern is empty it follows the pulsation cycles increasing the risk for reverse pressure and increasing the risk of bacteria entering the teat canal.

Milk path: This is another important part of the system. We should apply enough vacuum to the teat in order to extract milk, once this happens this milk should flow to the milk line by gravity and not pulled by vacuum. Make sure there is a downhill path from the udder to the milk line without any type of restrictions. A common one is when the system uses shutoff valves that apply pressure to the hose. These will create memory on the hose and therefore a dramatic restriction on the flow. Long milk hoses will create a loop and then the milk will not flow by gravity to the line but instead vacuum has to pull slugs of milk that will increase teat end vacuum fluctuations. These slugs will act as a piston.

Milking procedure: Timing is the key.

Prep time will influence teat stimulation, it should be 10-20 seconds long with firm movements and pulling 3 to 4 strings of milk per quarter. This part of the process not only helps identifying clinical cases of mastitis which is absolutely critical when it comes to good quality milk and udder health but also will send a strong signal to the hypophysis for oxytocin release which directly affects milk letdown. Not only the prep time is important but the *prep lag time* which starts at the time of physical contact with the teat until unit attachment. This time varies depending on parity, times per day cows are milked

and stimulation time. Many milk quality consultants would recommend a prep lag time of 90 to 140 seconds.
Where I see most of the overmilking is not at the end of the process but at the beginning because of poor stimulation or prep lag times either too short or too long. In my opinion stripping cows is a must.

Milk flows are very important, at least 9 lb/min (4 kg/min) at peak flow and the cow should produce at least 15 lbs in the first 2 minutes. The truth of the matter is that peak flows are not as important as low flows when it comes to unit on time. Avoid overmilking cows at all cost. Do not allow cows to see low flows, here is when automatic take off settings really need to be adjusted.
When prep lag times are too short the cows will show bi-modal let downs this by itself elongates unit on times increasing exposure to vacuum. After hundreds of cows being graphed with an electronic flow meter, I have noticed that poorly stimulated cows will not have a long plateau at peak flow and therefore their unit on times will be longer.

Unit alignment plays a very important role in terms of even and efficient milking. In other hand if alignment is a constant issue in the parlor this will limit milk production, increase the number of liner slips, uneven milking speeds at the quarter level and slowdown cow flow dramatically. Use alignment systems that make the milking process simple. Arms, chains, ropes, silicone blocks can all be useful if they are used correctly. The goal is to use a system that does not need any extra effort to make corrections and that it does not get in the way of the employees, either making a complicated procedure or creating a risk for injuries. Bad unit alignment will truly and consistently affect parlor throughput. Liner slips are detrimental to milk quality because of high-speed air admissions to the claw. Turbulence is created inside of the claw and milk droplets can be propelled to teat ends increasing the risk for intramammary infections. Squawks are always bad, but they are significantly worse at the end of the milking time when milk flow is low and there will not be any flushing effect.

Cow cleanliness is an important factor in terms of mastitis risk, and it also affects milking speed. If cows are coming in with dirty udders it will take more time for the milkers to clean those teats and the odds of attaching units on dirty udders will go up rapidly, causing higher bacteria counts and higher incidence of mastitis.

There is no perfect milking procedure; the key is to make a protocol that benefits both employees and cows. Always take into consideration walking distances for the milkers. When they are doing long shifts this amount of walking will go against the quality of the job. At the same time make sure timing is adequate in terms of contact time for the teat dip, prep time and prep lag time. In my opinion the best milking routine is territorial where each milker has a defined zone where he/she will be responsible for all parts of the process. A full routine (strip, dip, wipe and attach) will be essential for better udder health, milk flows and better milk quality. Some people could argue that cutting corners in the routine could make the parlor faster, the answer is yes but the end result will affect milk quality. Try to find that combination where cows are milked fast, gently and completely without affecting milk production, udder health and milk quality.

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Impact of Positive Reinforcement Practices on Calves and Heifers Future Behavior

Joao Costa, Ph.D.
Assistant Professor
University of Kentucky

<u>NOTES:</u>

Impact of positive handling, environment, and management practices on calf and heifer future behavior and performance as milking cows

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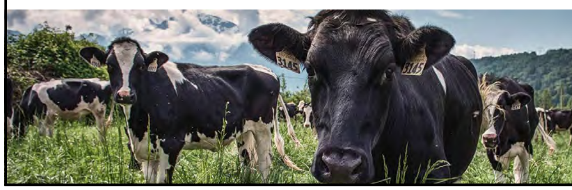
March 2nd, 2022



1

Outline

2

Outline –

- Introduction
  - Calf development and its influence on later performance
- Early socialization
- Human- Animal Interaction
- Myths and solutions

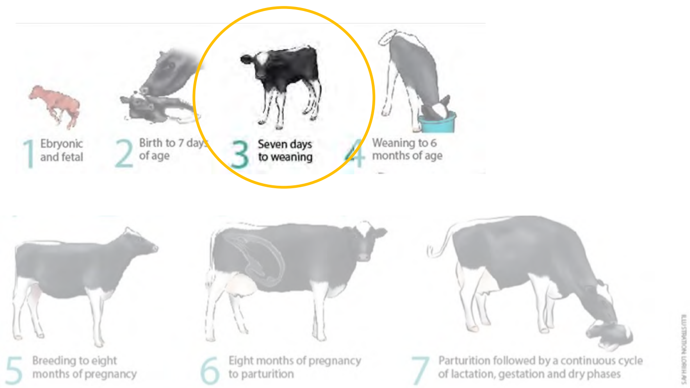
3

Take Home Messages

- Individual housing makes cows behave abnormally. We are just blind to it.
- A more positive management comes in many forms, not just in "fear-free handling".
- A lot of opportunity for all farms, small, median and large. Its time for us to be creative.

4

Introduction



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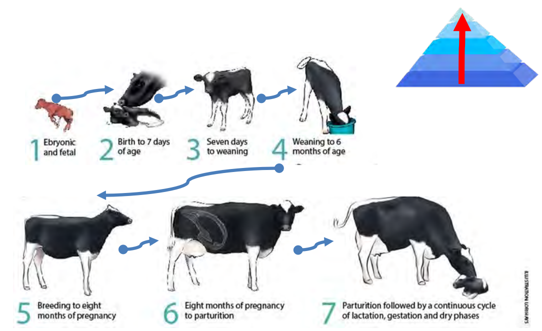
Introduction



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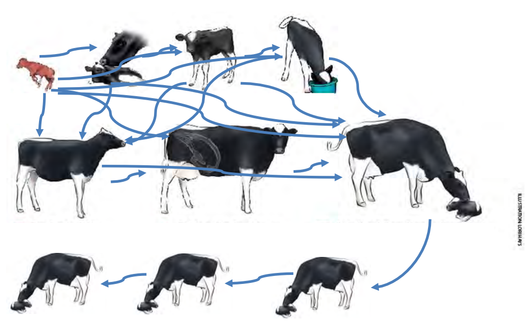
Introduction



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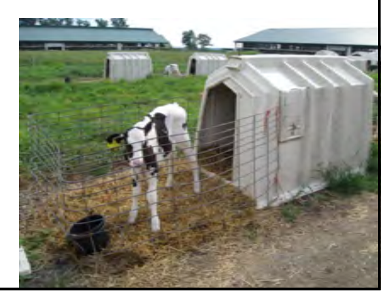
Why are we discussing this: Social Isolation

- An absence or low frequency of peer interaction during an extended period of time *Gottman (1977)*
- More pronounced detrimental effects in early life



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Individual housing is associated with…

- Lower social ranking and competitive success
- Increased aggressiveness
- Increased fear responses

See review by Costa et al., 2016

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Adaptability: Effects of an "enriched" environment….

10

Adaptability and flexibility: Reversal Learning

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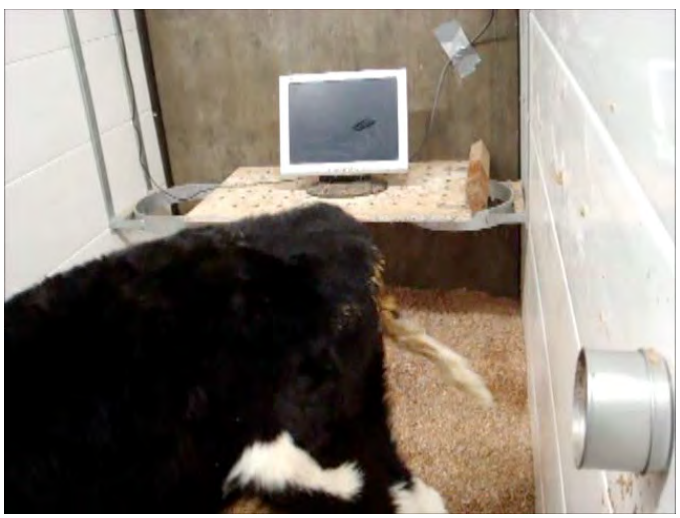
Effects of social rearing on cognition

Initial Discrimination

Positive approach for milk reward	**Negative** do not approach; time-out punishment

14



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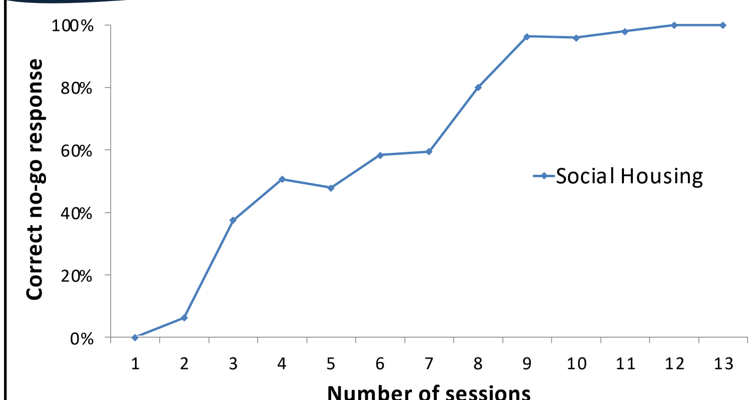
Discrimination learning



Meagher et al., 2015

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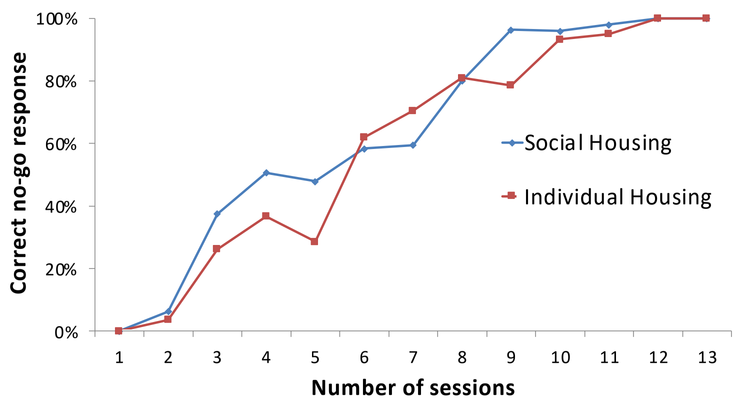
Discrimination learning



Meagher et al., 2015

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Effects of social rearing on cognition

Initial Discrimination

Positive approach for milk reward ⇔ **Negative** do not approach; time-out punishment

Reversal

Positive approach for milk reward ⇔ **Negative** do not approach; time-out punishment

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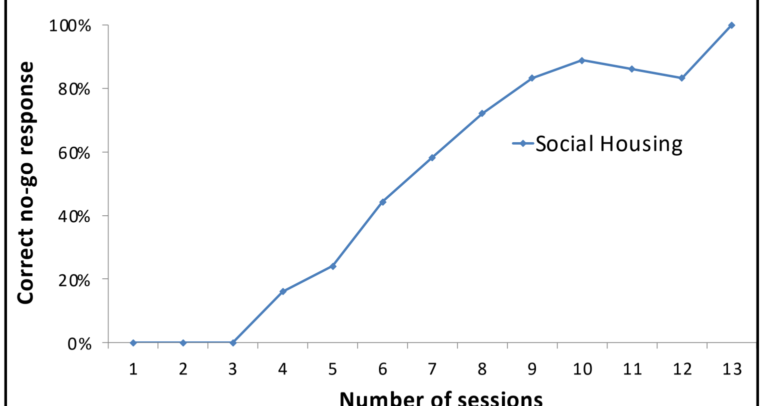
Reversal learning



Meagher et al., 2015

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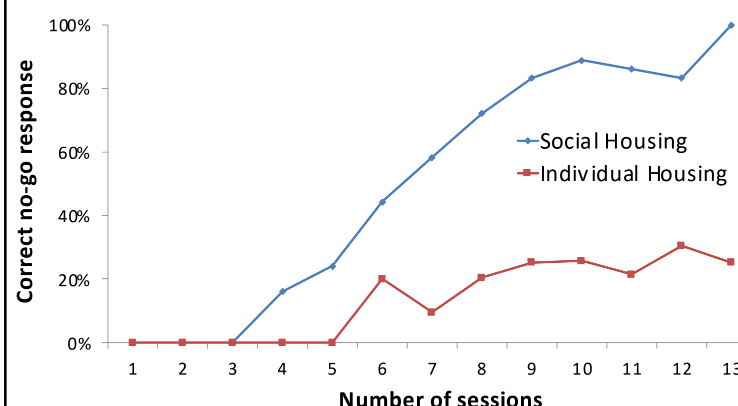
Reversal learning



Meagher et al., 2015

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But my calves do not play with computers….

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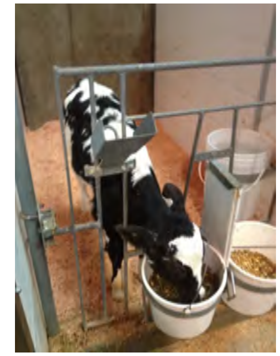
Food neophobia test

- 70 d of age
- Presented 2 kg of:
  chopped carrots (n = 8)

- The test lasted 30 min and was repeated 3 times per calf



Costa et al., (2015) J Dairy Science: 97:7804–7810

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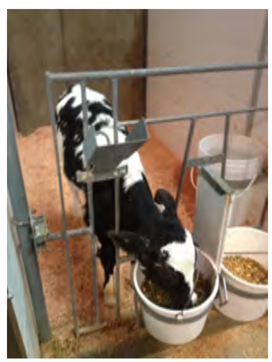
Food neophobia test

- 70 d of age
- Presented 2 kg of:
  chopped hay (n = 8)

- The test lasted 30 min and was repeated 3 times per calf



Costa et al.., (2015) J Dairy Science: 97:7804–7810

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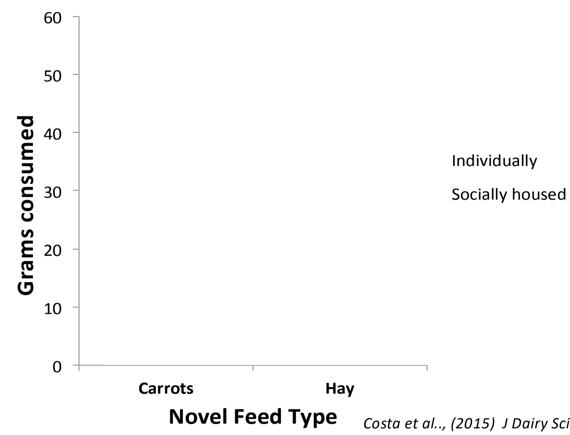
How much novel food did they eat?



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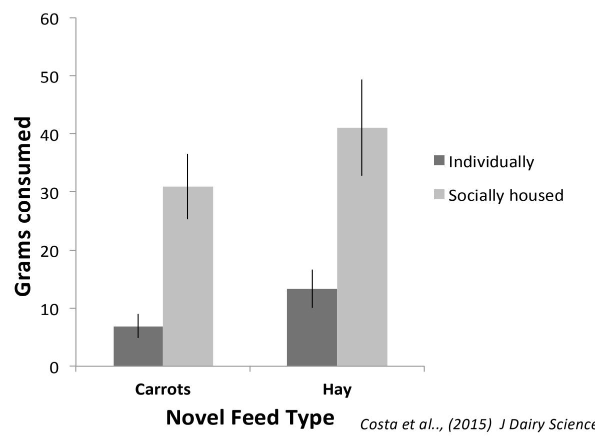
How much novel food did they eat?



Costa et al., (2015) J Dairy Science: 97:7804–7810

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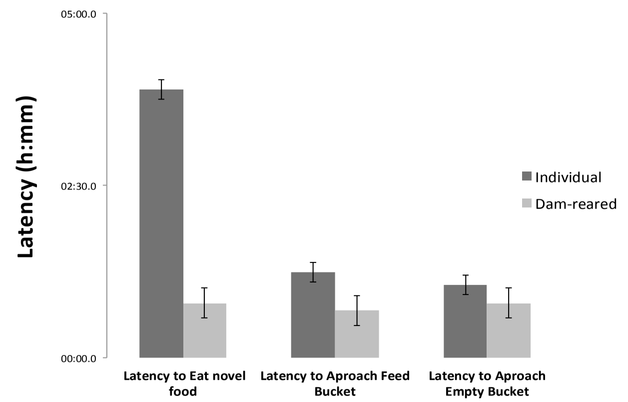
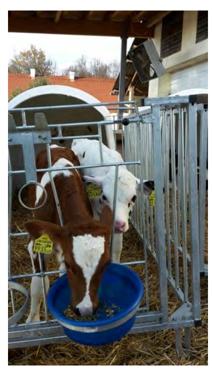
Latency to eat and approach buckets



Costa et al., (2015) J Dairy Science: 97:7804–7810

26

Responses to mixing after weaning? Paired versus individual housing



De Paula Vieira et al. 2010. J. Dairy Sci. 93: 3079-3085

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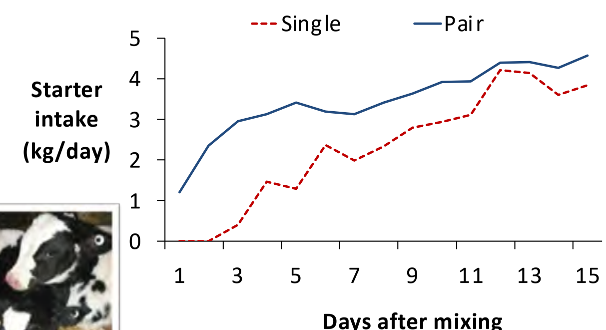
Starter intake was higher after mixing in paired versus individually-housed calves



De Paula Vieira et al. 2010. J. Dairy Sci. 93: 3079-3085

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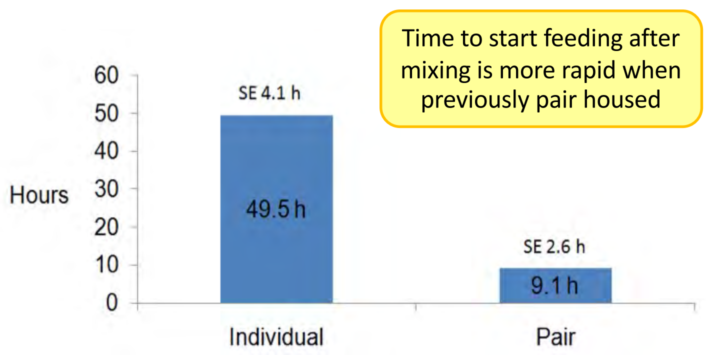
Pair housing improves access to resources at mixing



De Paula Vieira et al. 2010. J. Dairy Sci. 93: 3079-3085

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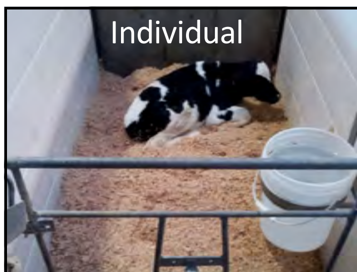
What type of contact is needed?

30



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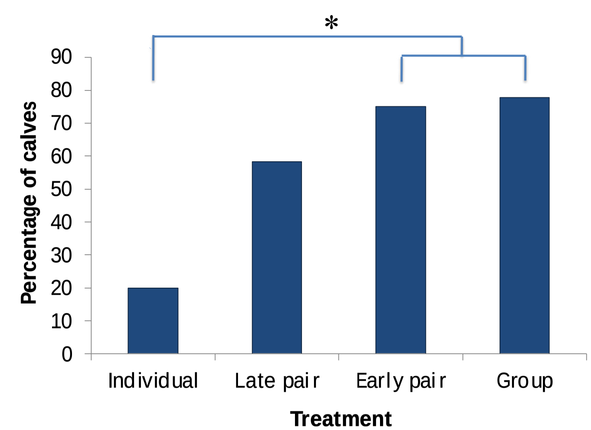
Successful reversal task – Calves that understood the change



Meagher et al., 2015. PLoS One

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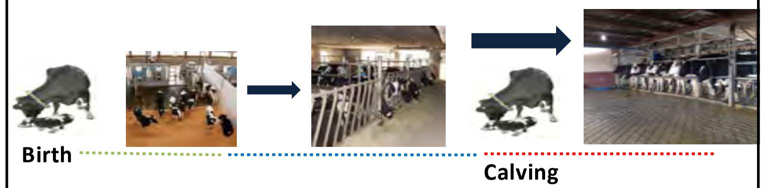
Limitations => Future directions

Are the cows on our farms “normal”?

33

Limitations => Future directions

- Does the early life environment influence how cows cope with stress?



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Take Home Message… Round 1 of 3

- Early life socialization is likely to **promote behavioural flexibility** and **adaptability** to novelty
- The housing system in which young dairy calves are raised **impacts neophobic behaviours** towards new food items.

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Management – Human Animal relationship

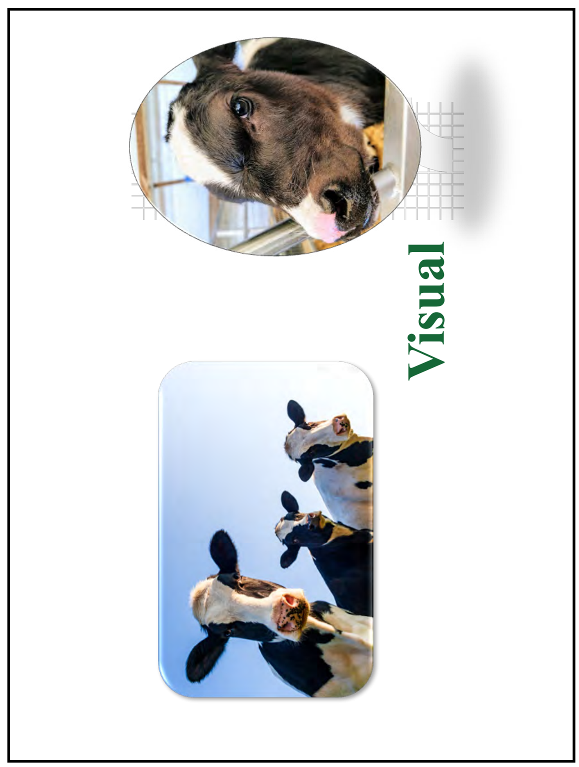
36


Human-animal interactions
in farm animal production

37


Tactile

38


Visual

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Olfactory

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Auditive

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Nature of interaction
Negative

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Nature of interaction
Neutral

43

Nature of interaction
Positive

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Research

Effects of positive reinforcement training for heifers on responses to a subcutaneous injection

J. Lomb, A. Mauger, M.A.G. von Keyserlingk, D.M. Weary

Animal Welfare Program, Faculty of Land and Food Systems, University of British Columbia, 2357 Mall, Vancouver, BC, Canada V6T 1Z4

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Research

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Heifers received a positive reinforcement (i.e., animals received a grain reinforcer for desired behaviors) to enter a headlock,

After habituated some received an injection and were tested against control heifers to latency to come to the headlock.

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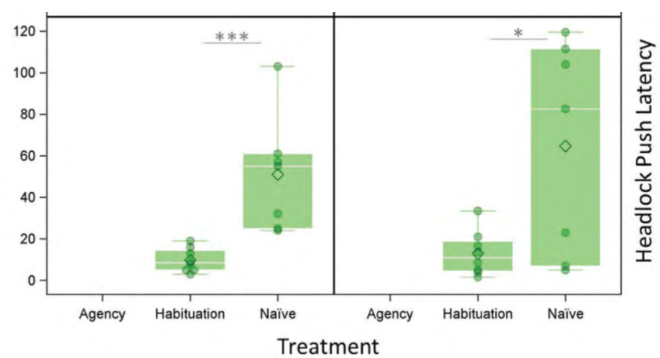
Latency to lock….



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Examples

- Naïve heifers in the milking parlor
- Free-stall teaching
- Robot training

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Tech inclined calves…

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Last point- Cow to cow

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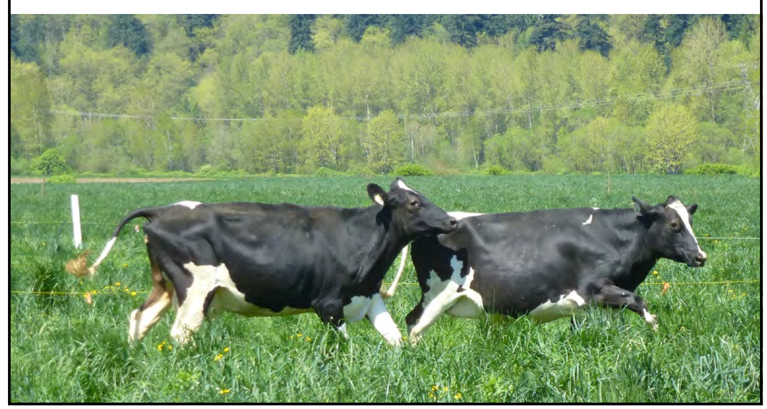
The effect of an **experienced social model** on the responses of heifers to a **novel situation**



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Treatments

– Non-experienced Group: 6 naïve heifers

– **Experienced Group: 3 naïve heifers**

+ 3 experienced dry cows

Costa, et al., 2016b. Confined heifers benefit from having an older experienced cow present when learning how to graze. J. Dairy Sci.

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Groups were introduced to pasture

Costa, et al., 2016b. Confined heifers benefit from having an older experienced cow present when learning how to graze. J. Dairy Sci.

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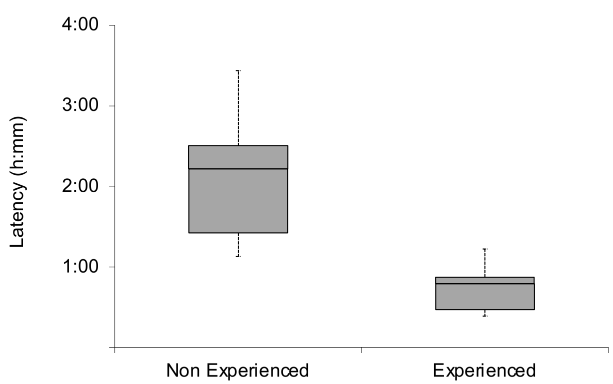
Latency to graze



Costa, et al., 2016b. Confined heifers benefit from having an older experienced cow present when learning how to graze. J. Dairy Sci.

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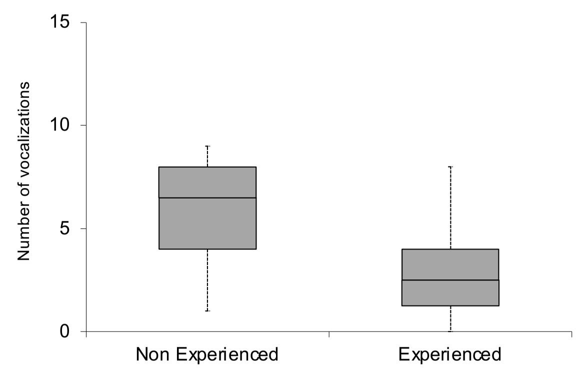
Vocalizations during the 1st hour



Costa, et al., 2016b. Confined heifers benefit from having an older experienced cow present when learning how to graze. J. Dairy Sci.

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Opportunities everywhere….

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Take Home Messages

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- A lot of opportunity for all farms, small, median and large. Its time for us to be creative.

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Questions?

Disclosures

Joao HC Costa, PhD

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Dr. Costa is employed at University of Kentucky

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Colaboradores:
Ceva, Acumen Detection, Future Cow Inc., AAD diagnostics

KENTUCKY

Joao H.C. Costa
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Fit to Transport? A new decision-making tool for producers and employees

Michelle Calvo-Lorenzo, Ph.D.
Chief Animal Welfare Officer
Elanco

NOTES:

Fitness to Transport: New Decision-Making Tool

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[1]Chief Animal Welfare Officer, Elanco Animal Health, Greenfield, IN
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Animal welfare is foundational to the success of a dairy operation. The dairy industry has made tremendous progress in the welfare space, but end-of-life decision-making for cull dairy cattle still remains an area of opportunity (Stojkov et al., 2018; Walker et al., 2020; Cockram et al., 2021). Making end-of-life decisions (e.g. culling, timely euthanasia, fitness to transport, etc.) for dairy cattle is complicated and challenging for a variety of reasons, including but not limited to: lack of protocols, ineffective employee training, the bond between caretakers and their cattle, and economic dis/incentives across the supply chain (Walker et al., 2020). Furthermore, the journey that dairy cattle endure when they leave the dairy is not always known or understood (i.e., how many stops will she make, how long will she be in the trailer, how many days until she is slaughtered). This is why ensuring cull cow welfare during this end-of-life phase is critical, and welfare can be optimized when fitness to transport (FTT) decisions are appropriately made for cows and calves shipped from the dairy. The FTT decision responsibilities are shared by all stakeholders within the dairy cattle supply chain (e.g., dairy employees, sale barn employees, cattle buyers); however, the first decision to ship a culled dairy cow/calf is at the dairy and this emphasizes the impact of these decisions on any animal's journey through the supply chain.

Fitness to transport decisions can also have an impact that extends beyond the animal. For instance, FTT decisions not only affects the quality of life for all animals shipped, but also the culture of the farm, those receiving animals at other points in the supply chain, and the dairy industry's reputation. This is why the FARM Program Manual Version 4.0 (FARM, 2021) includes an entire chapter on FTT, a FTT protocol template, and a poster on the do's and don'ts of transporting dairy animals. Despite the fact that guidelines are provided, culled dairy cattle continue to arrive at terminal markets in unfit and compromised conditions (Harris et al., 2017; Vogel et al., 2018; Stojkov et al., 2020 a, b). It is important for the dairy industry to come together to determine how better decisions about FTT can be made.

Moving forward, what can the dairy industry do to make progress and improve FTT decisions throughout the supply chain? As an industry, there needs to be:

- Continued development and support for industry-wide resources that are practical and relevant
- Improved implementation of FTT principles, which should include on-going efforts beyond trainings and audits alone
- Employees making FTT decisions must be empowered and supported
- FTT decisions must be considered as a shared responsibility across the dairy supply chain

In an effort to support stakeholders when faced with these difficult decisions, key members of the dairy industry (e.g., dairies, sale barn representatives, processor representatives, allied industry, and academia) came together to create a training tool (e.g. video) focused on FTT decision-making. The goals of the video are to inform and empower animal caretakers to be proactive and confident in their FTT decisions and to make the FTT evaluation process more straightforward and easy to execute. All information provided in the video aligns with guidance provided in the FARM Program Manual (FARM, 2021).

The video is nearing completion and will soon be available for on-farm use. The vision for this industry resource is for all stakeholders to integrate this video into their training program and infuse the video's principles into the on-farm culture through on-going conversations, employee feedback, educational opportunities, and reward/incentive programs. Although a training video alone will not solve this industry challenge, the creators feel that bringing the supply chain together to make this video with a shared vision for improvement is a key step towards progress.

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