# What Are the Potential Benefits of Automated Feeding Robots?


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# Introduction to Automated Mixing & Feeding Robots

- Automated feeding systems are not new, but feeding robots are!
  - Previous systems were rail-guided or conveyer belt distributors
- Robotic systems are battery-powered self-propelled
- Laser-guided and programmable to feeding fence
- Most feed up to ~ 12 times per day depending upon herd size and pen length

https://www.youtube.com/watch?v=oyiboTI8R6I

Disclaimer: I am independent don't want to endorse any specific company's product

# Existing Automated Feeding Robots on the Market

Lely Vector*


Triolet Triomatic*

Delaval OptiWagon

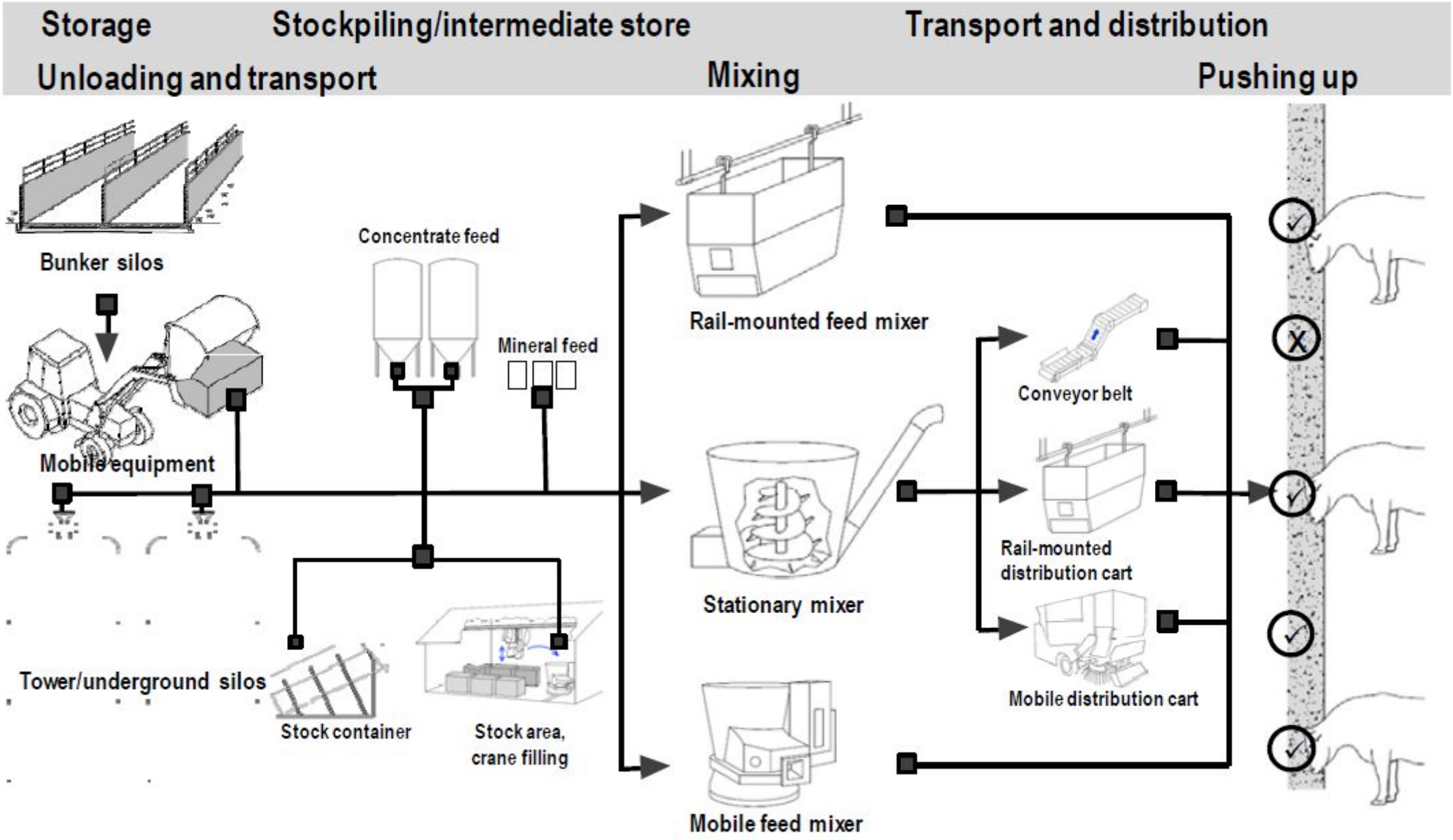
AMS Galaxy Aranom

Wasserbauer Shuttle Eco

*Currently have systems in the U.S.

# Summary of Available Automated Feeding Systems

| Product | Mixing in Robot? | Tub Volume | Load Capacity | Herd Size Served | Speed | Times Fed/D |
|---|---|---|---|---|---|---|
| AMS Galaxy Aranom | Yes | 141 $ft^3$ | 2397 lbs. | 425 cows | 0.62 to 0.93 mph | 6 |
| DeLaval OptiWagon | No- Uses stationary mixer | 88 $ft^3$ | 1760 lbs. | 425 cows | 0.62–1.24 mph | Up to 32 |
| Lely Vector | Yes | 71 $ft^3$ | 1322 lbs. | ≤ 300 cows | 0.37 – 0.75 mph | 8 to 14 |
| Lely Vector MFR Next | Yes | 71 $ft^3$ | 1760 lbs. | 425 cows | 0.75 mph | 8 to 14 |
| Triolet Triomatic MB | Yes | 88 $ft^3$ | 1984 lbs | ≤ 300 cows | 0.31 | 8 to 12 |
| Wasserbauer Shuttle Eco | Yes | 77 $ft^3$ | 1760 lbs. | 250 cows | 0.62–0.93 mph | 10 to 10 |




Oberschätzl et al. (2015). XXXVI CIOSTA CIGR V Conference

# Feed Kitchen Design

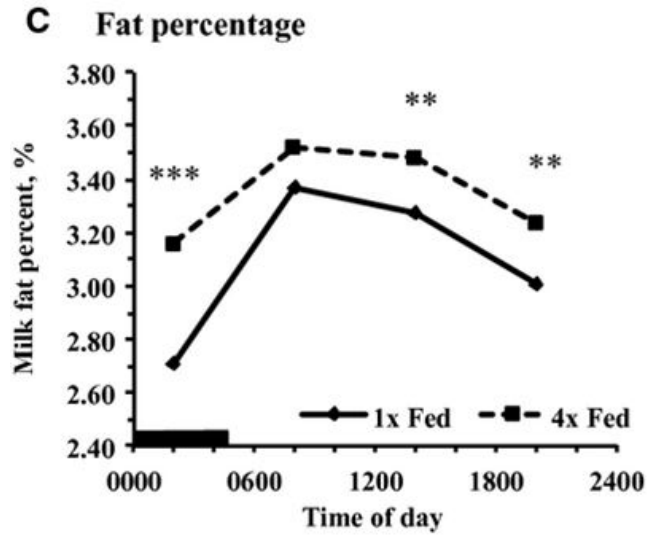


- **Every feed kitchen is different!**
  - **Can be customized to your system**
- **Careful with feed losses & sorting**

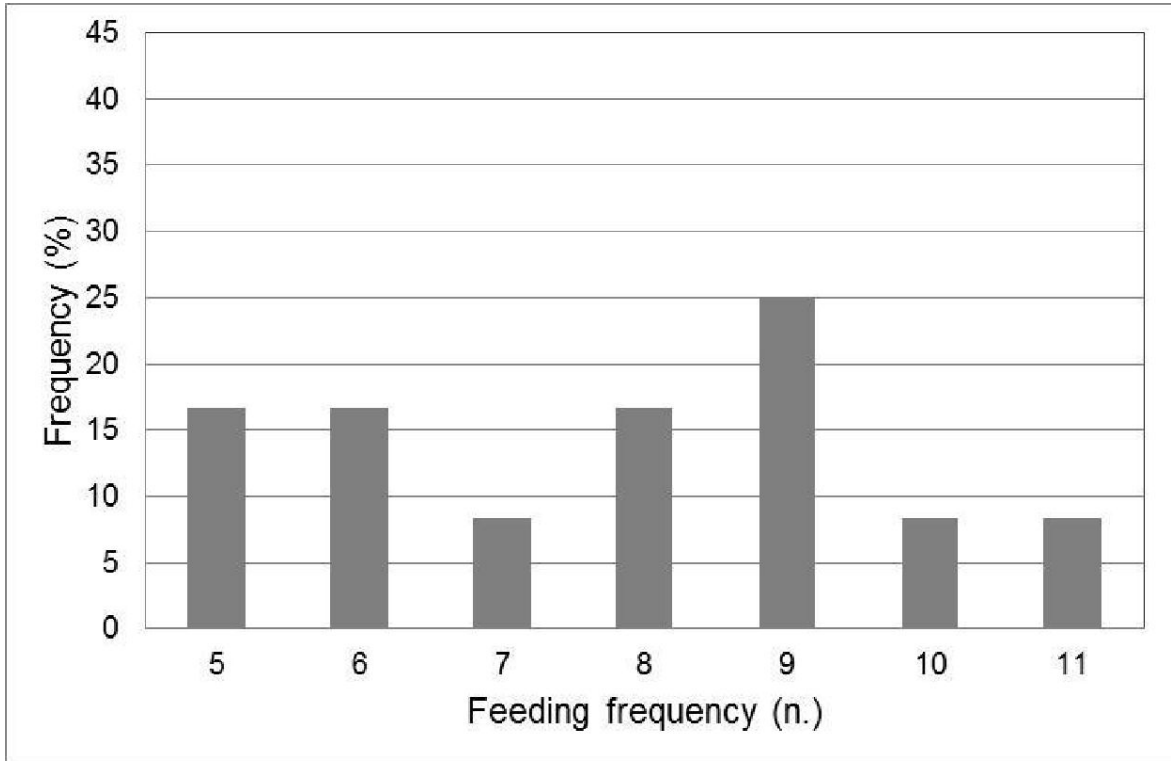
# Increased Frequency of Feeding Delivery can Increase Milk and Especially Milk Fat production

**Table 2.** Daily milk production and feed intakes in cows fed once per day or in four equal meals every 6 h when milked every 6 h.

| | Treatment[1] | | | *P*-values[2] | | |
|---|---|---|---|---|---|---|
| Parameter | 1× Fed | 4× Fed | SEM | Trt | Time | Trt × Time |
| Milk Yield, kg | 47.3 | 47.1 | 1.5 | 0.64 | <0.001 | 0.05 |
| Fat, % | 3.09 | 3.35 | 0.15 | <0.001 | <0.001 | <0.05 |
| Fat Yield, g/day | 1465 | 1592 | 90 | <0.001 | <0.01 | 0.05 |
| Protein, % | 2.96 | 2.90 | 0.03 | <0.001 | <0.001 | <0.001 |
| Protein Yield, g/day | 1389 | 1360 | 45 | 0.06 | <0.01 | <0.05 |
| DMI, kg | 28.2 | 30.4 | 1.0 | <0.01 | - | - |



# Bisaglia et al. (2012) study – feeding frequency in 22 herds with AFR



# We conducted an observational study to compare herds with and without AFR

- Herds located in MN, IA, and WI (8 Conventional, 8 AFR)
- Pair matched based on:
  - Geographic location: within 60 miles
  - Breed
  - Diet ingredient composition
  - *All herds had Lely Automated Milking Systems*
  - AFR had to be on farm for at least 1 year
- TMR was sampled from both herds at 4 times (5 AM, 11 AM, 5 PM, 11 PM) each day for 3 days [within 1 h of each other]
- Bulk tank milk samples were collected for fat, protein and FA analysis
- Visit behavior to AFS was determined

# Demographics of Herds Enrolled in the Experiment

| Block | Dates Visited | Location | # of AMS[1] | | # of Cows in Tank | | Cows/AMS | | Average DIM | | Average Parity | | Bunk Space/Cow | | x Fed/d |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | CFS | AFR | CFS | AFR | CFS | AFR | CFS | AFR | CFS | AFR | CFS | AFR | CFS |
| 1 | 8/9/21- 8/12/21 | NE IA | 2 | 3 | 111 | 188 | 55.5 | 62.7 | 157 | 190 | 2.6 | 2.6 | 16.8 | 14.2 | 2 |
| 2 | 8/28/21- 8/30/21 | Central WI | 4 | 2 | 207 | 116 | 51.8 | 51.8 | 204 | 181 | 1.8 | 2.1 | 27.8 | 23.3 | 2 |
| 3 | 8/28/21- 8/30/21 | Central WI | 2 | 1 | 113 | 65 | 56.5 | 44 | 189 | 131 | 2.2 | 2.5 | 30.1 | 22.3 | 2 |
| 4 | 10/02/21-10/04/21 | Central MN | 2 | 3 | 134 | 181 | 67 | 60.3 | 164 | 193 | 2 | 2.2 | 17.5 | 17.9 | 2 |
| 4 | 10/16/21-10/19/21 | SE MN | 2 | 2 | 125 | 125 | 62.5 | 62.5 | 151 | 194 | 2.1 | 2.2 | 20.8 | 31.9 | 1 |
| 6 | 11/24/21-11/26/21 | NW MN | 3 | 3 | 132 | 177 | 44 | 59 | 240 | 208 | 2.1 | 2.3 | 17.7 | 15.7 | 2 |
| 7 | 11/27/21-11/29/21 | NW MN | 2 | 3 | 154 | 170 | 77 | 56.7 | 196 | 205 | 2.5 | 2.8 | 22.3 | 19 | 2 |
| 8 | 01/31/22 - 2/3/22 | Central MN | 2 | 3 | 200 | 116 | 66.7 | 58 | 188 | 195 | 2.5 | 2.6 | 25.2 | 17.6 | 1 |
| | | | | | | | | | | | | | | | |
| Ave. | | | 2.5 | 2.4 | 147 | 142 | 60.1 | 56.9 | 186 | 187 | 2.2 | 2.4 | 22.3 | 20.2 | 1.75 |

Kamau et al. (2025). *Animals* 15(8). https://doi.org/10.3390/ani15081103

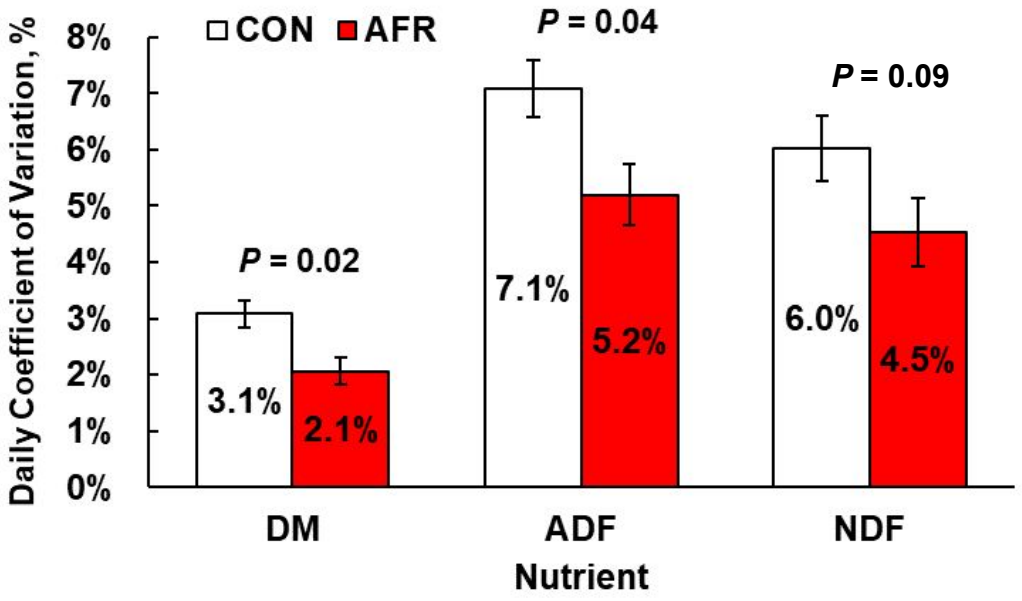
# Nutrient composition at the feed bunk by feeding system and time

| | Feeding System | | | | | | | | SEM | *P*-Value | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CFS | | | | AFR | | | | | | | |
| | 0500 h | 1100 h | 1700 h | 2300 h | 0500 h | 1100 h | 1700 h | 2300 h | | System | Time | S × T[3] |
| **Feed Bunk Nutrient Composition** | | | | | | | | | | | | |
| **DM, %** | 46.9 | 47.6 | 47.8 | 47.6 | 45.8 | 46.1 | 45.9 | 45.7 | 1.44 | **0.44** | **0.33** | **0.57** |
| **CP, % of DM** | 15.7 | 15.9 | 15.8 | 15.7 | 15.7 | 15.7 | 15.5 | 15.5 | 0.34 | **0.68** | **0.51** | **0.64** |
| **SP, % of DM** | 6.38 | 6.36 | 6.57 | 6.51 | 6.27 | 6.18 | 6.15 | 6.21 | 0.37 | **0.64** | **0.54** | **0.12** |
| **Starch, % of DM** | 25.4 | 24.9 | 25.4 | 25.0 | 24.6 | 24.0 | 24.0 | 24.2 | 1.10 | **0.61** | **0.73** | **0.95** |
| **ESC, % of DM** | 4.10[xy] | 4.01[y] | 4.49[x] | 4.18[xy] | 4.92[x] | 4.75[x] | 4.81[x] | 4.55[x] | 0.38 | **0.30** | **0.05** | **0.08** |
| **Total FA, % of DM** | 2.90 | 2.87 | 2.90 | 2.87 | 2.78 | 2.76 | 2.77 | 2.76 | 0.10 | **0.41** | **0.95** | **0.99** |
| **Ash, % of DM** | 8.35 | 8.33 | 8.39 | 8.30 | 7.79 | 7.73 | 7.72 | 7.72 | 0.24 | **0.12** | **0.78** | **0.80** |
| **Feed Bunk Particle Size Distribution** | | | | | | | | | | | | |
| **Upper Sieve (> 19 mm), %** | 21.4 | 21.8 | 20.4 | 21.5 | 23.1 | 22.4 | 22.4 | 24.5 | 4.25 | **0.76** | **0.58** | **0.77** |
| **Middle Sieve (19 to 8 mm), %** | 36.5 | 36.6 | 37.1 | 37.4 | 35.3 | 36.0 | 35.5 | 35.0 | 3.50 | **0.78** | **0.96** | **0.75** |
| **Lower Sieve (8 to 4 mm), %** | 13.5[y] | 13.6[y] | 13.5[y] | 12.8[y] | 16.2[x] | 16.4[x] | 18.2[x] | 15.9[x] | 1.27 | **0.06** | **0.31** | **0.59** |
| **Bottom Pan (< 4 mm), %** | 28.6 | 28.0 | 28.9 | 28.3 | 25.3 | 25.2 | 23.9 | 24.6 | 1.94 | **0.19** | **0.91** | **0.52** |

**No Difference Was Observed for system, time or the interaction of system and time**

Kamau et al. (2025). *Animals* 15(8). https://doi.org/10.3390/ani15081103

# Feed bunk dry matter and fiber concentration were less variable across the day in herds with AFR




| Item | Feeding System CFS | Feeding System AFR | SEM | *P*-Value |
|---|---|---|---|---|
| **Daily Variation in PMR Nutrient Composition[3]** | | | | |
| **CV of CP, %** | 2.50 | 3.23 | 0.32 | 0.15 |
| **CV of SP, %** | 5.27 | 3.40 | 0.94 | 0.22 |
| **CV of ADIN, %** | 4.53 | 3.08 | 0.72 | 0.20 |
| **CV of NDIN, %** | 7.33 | 6.03 | 0.86 | 0.26 |
| **CV of Lignin, %** | 7.40 | 6.26 | 5.19 | 0.40 |
| **CV of Ethanol-Soluble Carb., %** | 13.0 | 8.42 | 3.08 | 0.32 |
| **CV of Starch, %** | 6.44 | 5.38 | 0.65 | 0.32 |
| **CV of Total Fatty Acids, %** | 7.34 | 8.75 | 0.74 | 0.21 |
| **CV of Ash, %** | 2.92 | 3.30 | 0.50 | 0.61 |

CON: Conventional TMR mixer fed 1x to 2x/d (n=8)
**AFR:** Automated feeding robot, (Lely Vector; n=8)

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# No difference in variation of particle size distribution was observed

| Item | Feeding System | | SEM | *P*-Value |
|---|---|---|---|---|
| | CFS | AFR | | |
| **Daily Variation in PMR Particle Size Distribution[4]** | | | | |
| **CV of Upper Sieve (> 19.0mm), %** | 23.3 | 26.7 | 3.02 | 0.41 |
| **CV of Middle Sieve (19.0 to 8.0 mm), %** | 8.84 | 10.3 | 1.78 | 0.57 |
| **CV of Lower Sieve (8.0 to 4.0 mm), %** | 6.80 | 12.1 | 2.74 | 0.20 |
| **CV of Bottom Pan (< 4.0mm), %** | 10.7 | 13.4 | 2.15 | 0.33 |

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# Milk Yield and Components did not differ between feeding systems

| Item | Feeding System | | SEM | P-Value |
|---|---|---|---|---|
| | CFS | AFR | | |
| Milk yield, kg/d | 37.5 | 37.3 | 0.25 | 0.68 |
| Milk fat indication[2], % | 4.01 | 4.03 | 0.010 | 0.18 |
| Milk protein indication, % | 3.12 | 3.14 | 0.020 | 0.51 |
| Fat yield[3], g/d | 1503 | 1499 | 9.76 | 0.84 |
| Protein yield[4], g/d | 1170 | 1172 | 7.23 | 0.90 |
| Fat + protein, g/d | 2676 | 2670 | 16.72 | 0.87 |

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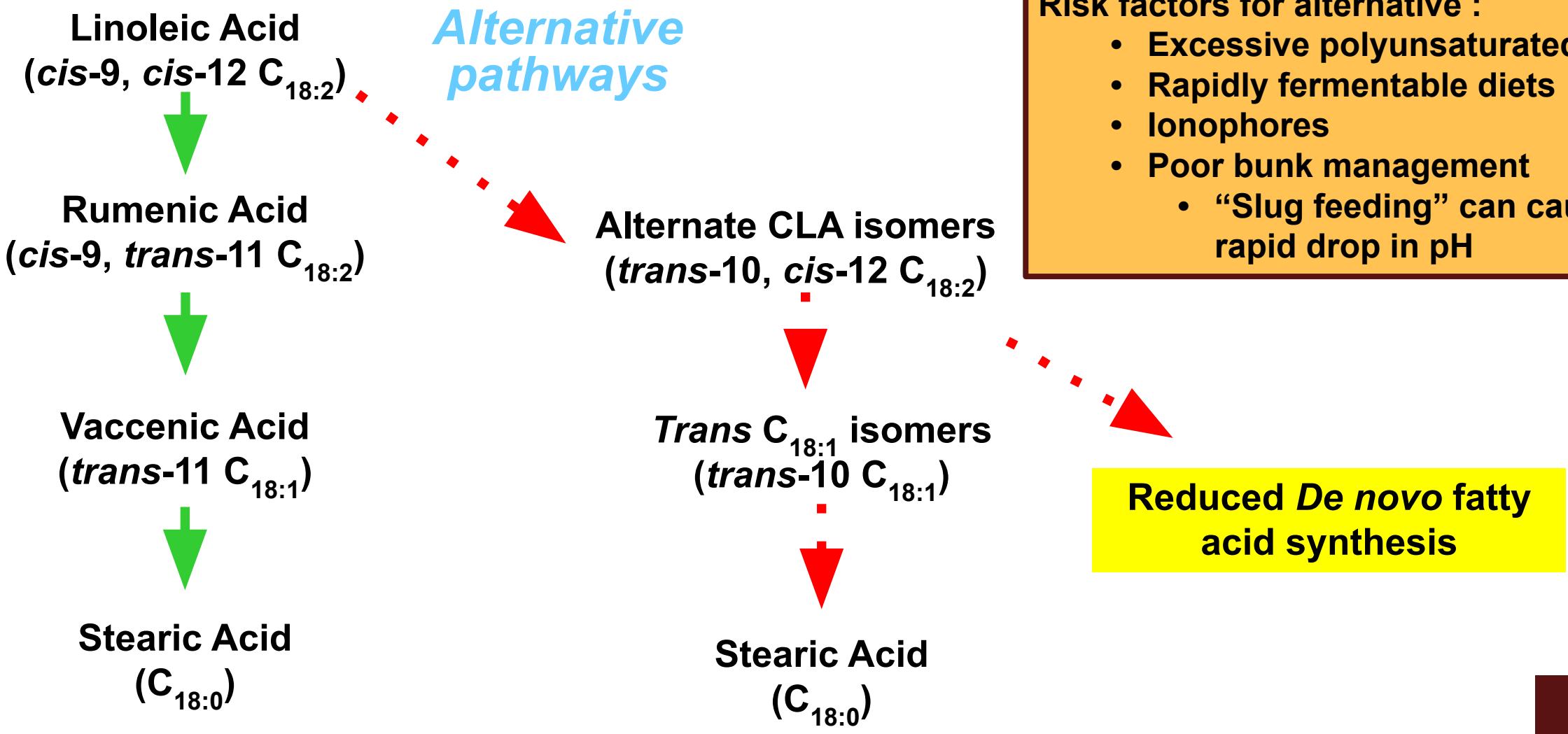
# De novo fatty acids are indicative of rumen fermentation




Courtesy of Kevin Harvatine. Adapted from Griinari and Bauman, 1999

# Milk fatty acid profile can tell us about rumen function

**We can tell properties about fatty acids based on their carbon chain length**

| Chain Length | Source |
|---|---|
| < 16 carbons | De novo synthesis |
| 16 carbons | Both De novo & preformed |
| > 16 carbons | Preformed |

**How do we know this?**

- Plant fats are all over 16 C or greater
- The mammary gland cannot synthesize fats >16C

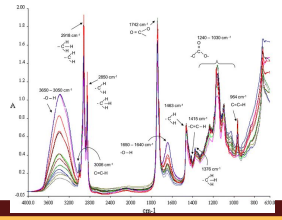
**De novo synthesized fatty acids are more highly correlated with total milk fat**

**A reduction in de novo FA is indicative of milk fat depression**

**A reduction in preformed FA can indicate decreased lipid mobilization or opportunity for fat feeding**

| Source | % of total FA |
|---|---|
| De novo | 20-30% |
| Mixed | ~35% |
| Preformed | 35-40% |

**Currently, many milk testing labs can analyze for de novo, mixed and preformed FA**

# Herds with AFR had increased de novo synthesized fatty acids

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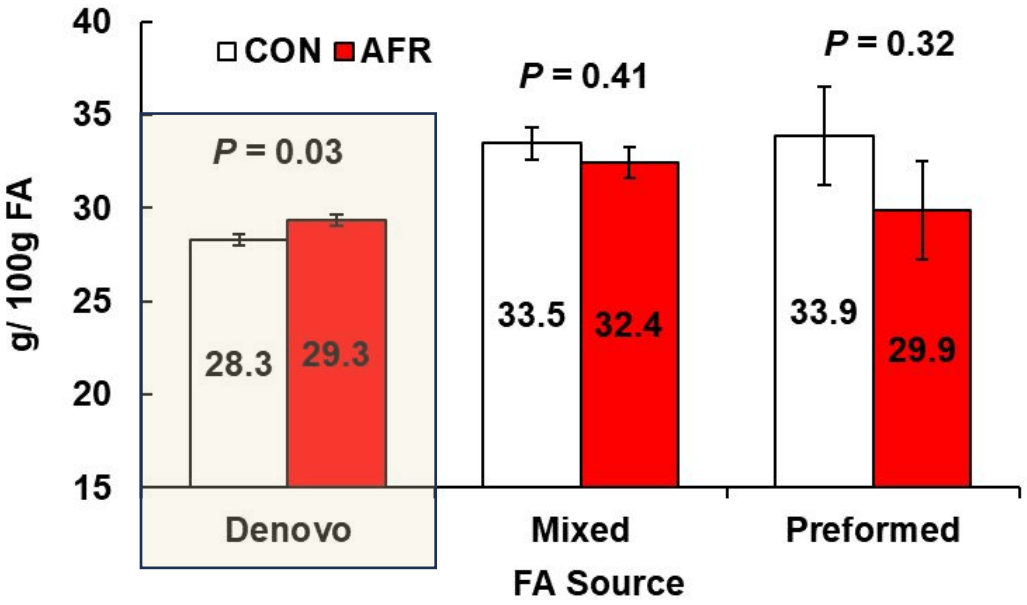
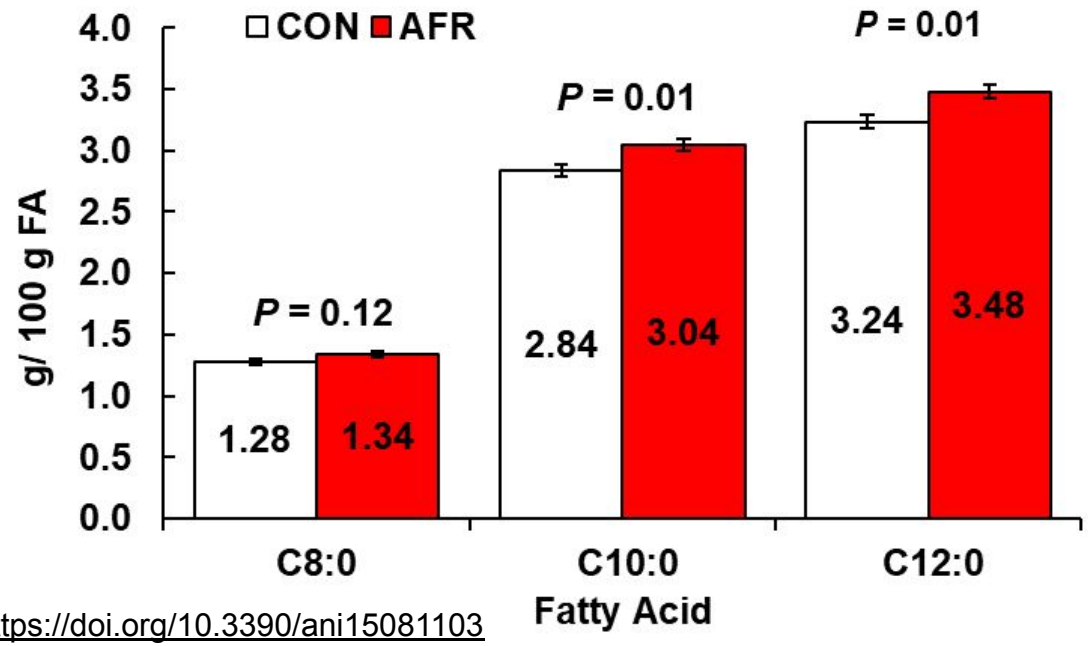
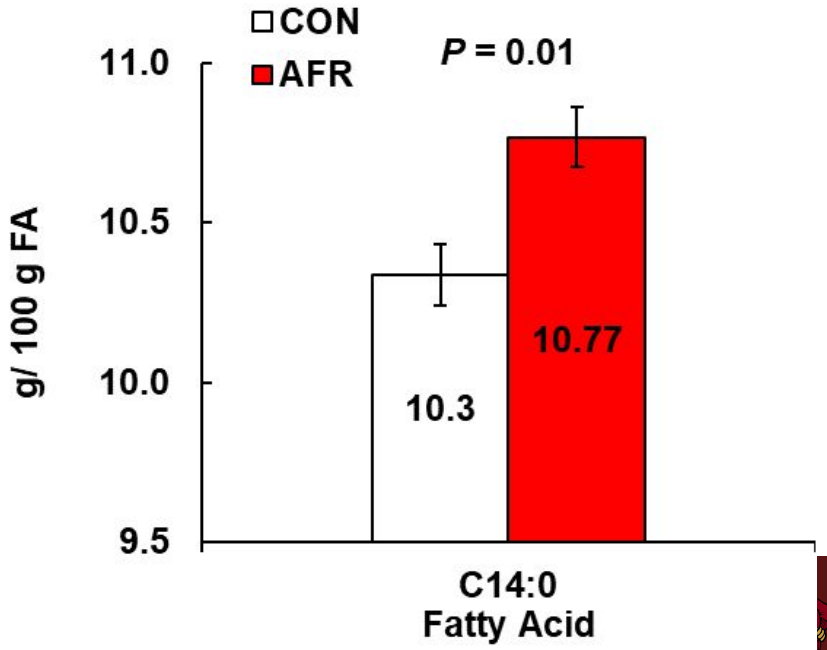
**AFR:** Automated feeding robot, (Lely Vector; n=8)

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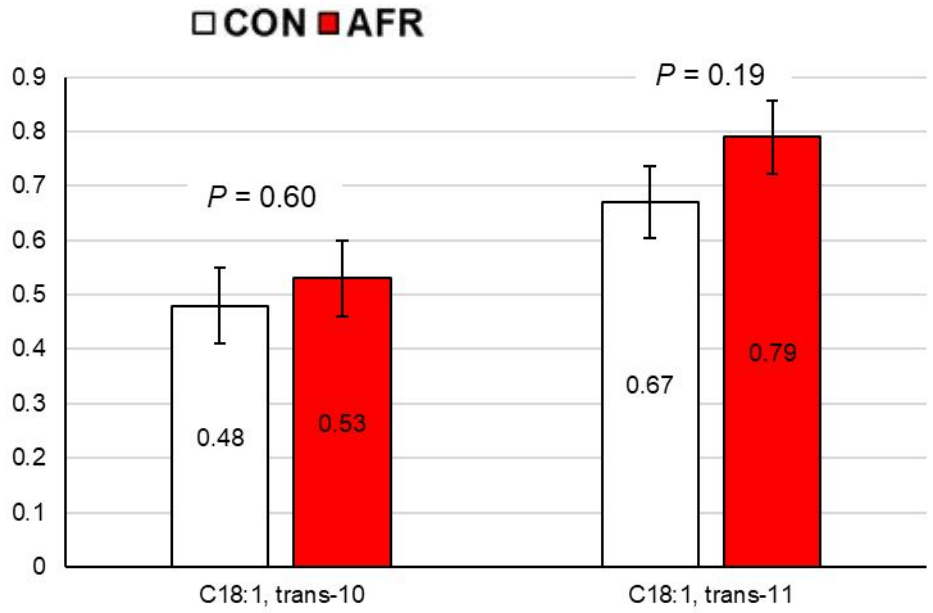
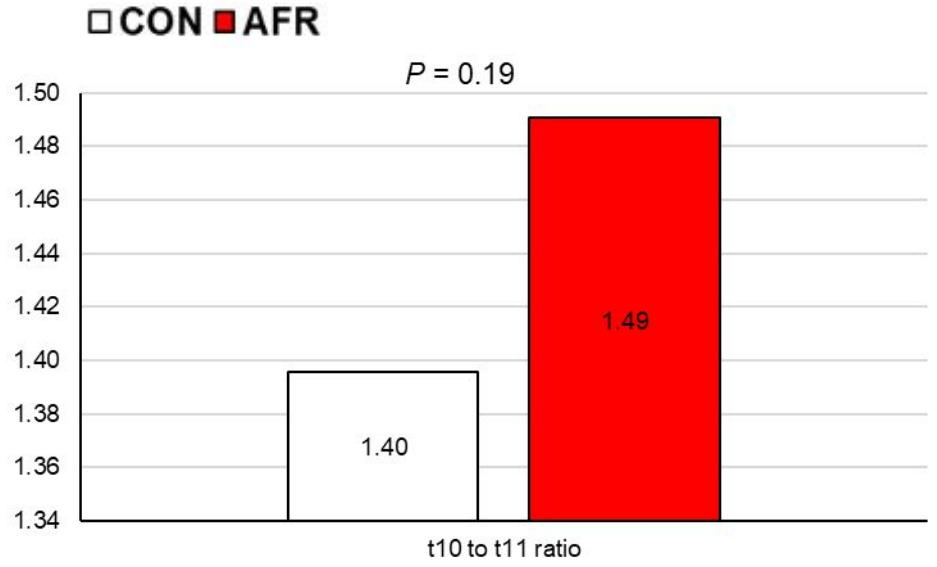
# No difference in trans-10 or trans-11 C18:1 were observed

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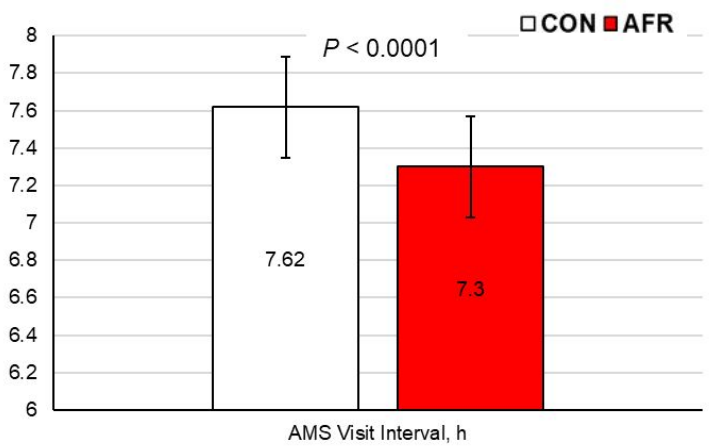
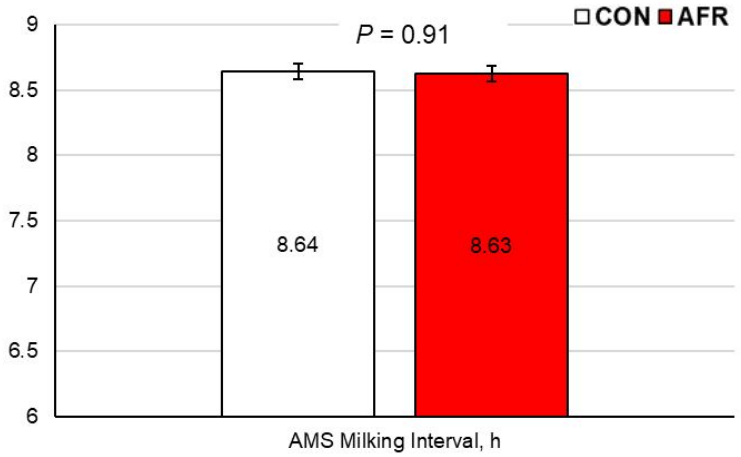
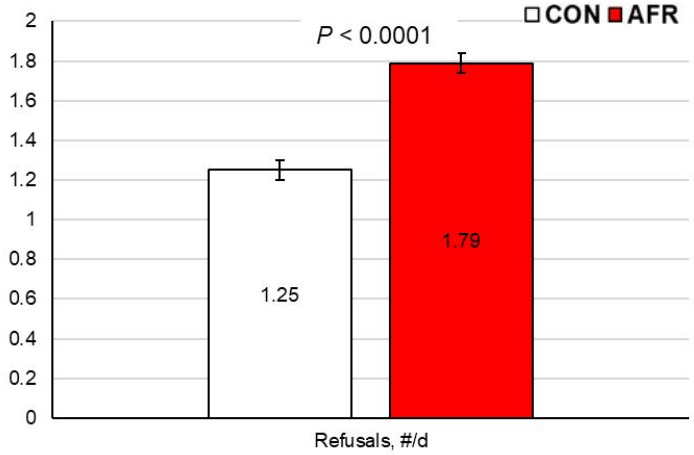
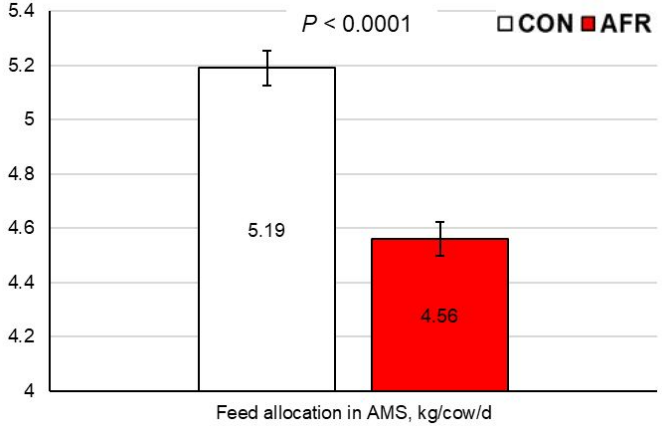
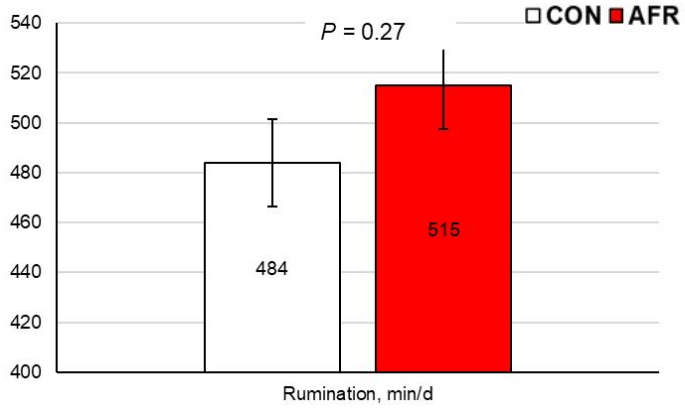
# Herds with AFR had a shorter visit interval greater refusals, and lower feed allocation in the robot

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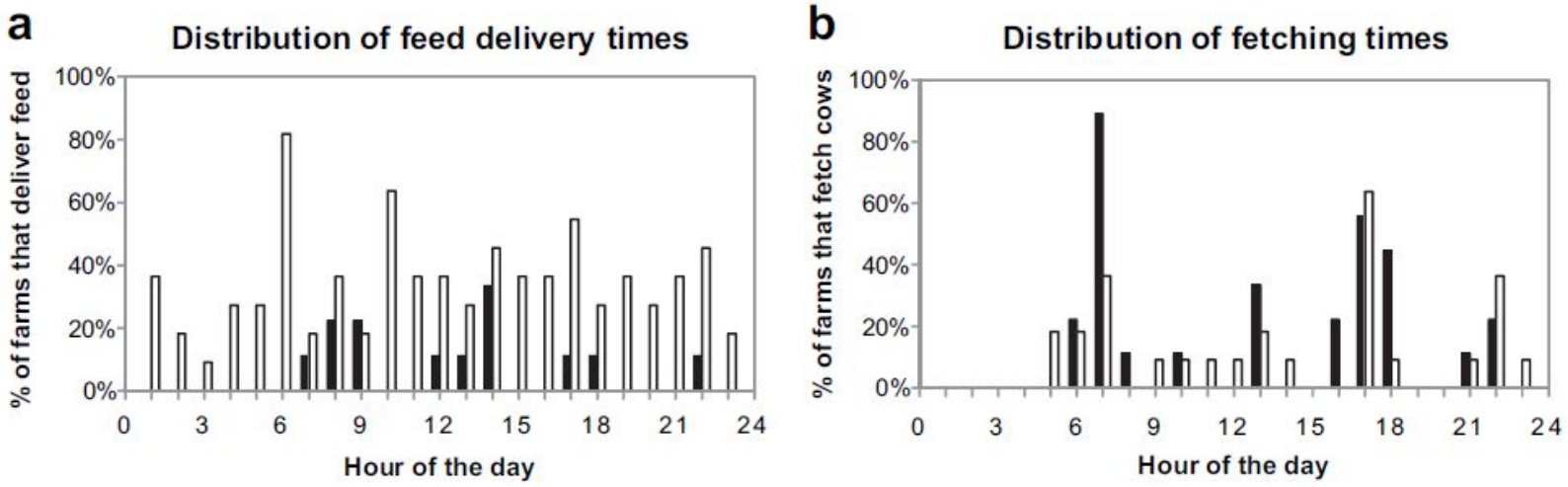
# Study Limitations

- Limited # of farms
  - Used all but 1 vector herds in the Upper Midwest at the time
- Uncontrolled variation
  - No direct comparison of automated vs. conventional feeding on the same operation
- Did not study similar metrics with other brands of feeding systems
- No daily feed intake or feeding behavior recorded
- Unable to collect feeding frequency of AFR herds
- Did not measure *true* sorting because PMR sampling was collected based on time of day not time relative to feeding

# Belle et al (2012) study in the Netherlands

**Table 1 – Main characteristics of the farms with conventional feeding systems (CFS) and of the farms with automatic feeding systems (AFS).**

| Feeding system | CFS | | AFS | |
|---|---|---|---|---|
| Number of farms | 9 | | 11 | |
| General characteristics | Mean | s.d. | Mean | s.d. |
| No. of cows farm$^{-1}$ | 88.2 | 52.7 | 80.7 | 23.7 |
| Milk production, kg cow$^{-1}$ year$^{-1}$ | 8705 | 845 | 8900 | 697 |
| No. of AMS farm$^{-1}$ | 2.0 | 1.1 | 2.2 | 0.8 |
| No. of cows AMS$^{-1}$ | 42.4 | 11.3 | 40.6 | 7.7 |
| Milking and feeding related actions | | | | |
| No. of feed deliveries day$^{-1}$ | 1.4 | 1.0 | 7.4 | 1.7 |
| No. of feed push-ups day$^{-1}$ | 2.3 | 1.3 | 0 | 0 |
| No. of AMS cleanings day$^{-1}$ | 2.60 | 0.52 | 2.75 | 0.45 |
| No. of fetchings day$^{-1}$ | 2.0 | 0 | 2.1 | 0.51 |



# Belle et al (2012)

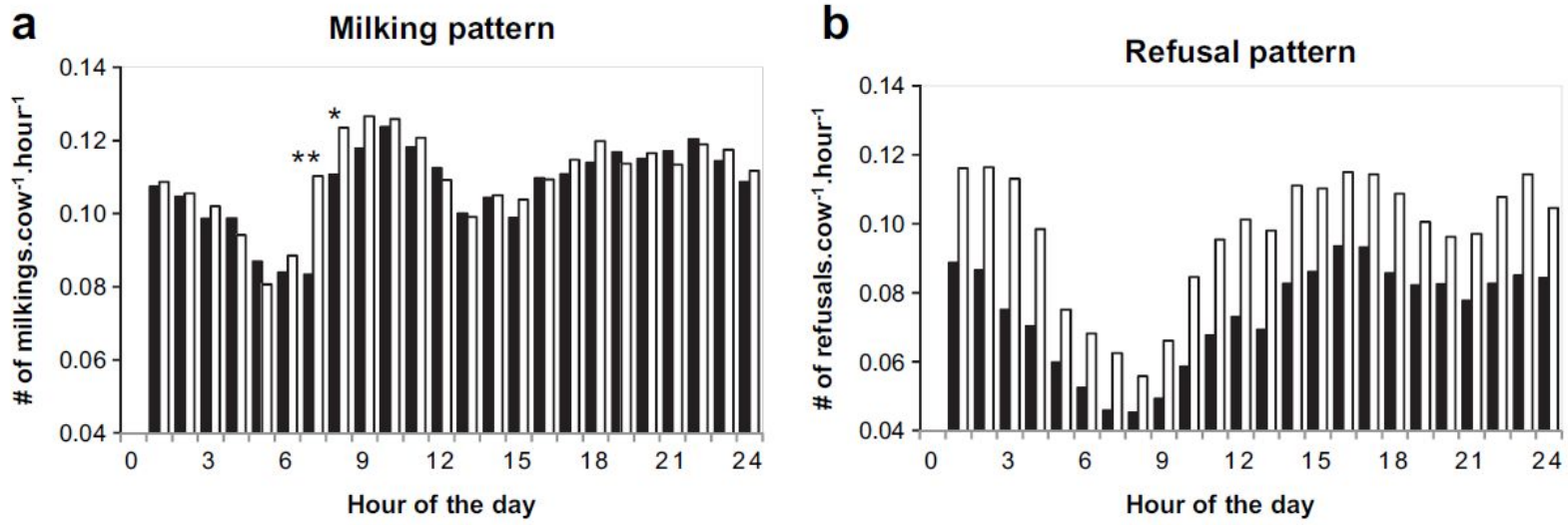



**Table 2 – Summary of the daily number of visits to the AMS and the AMS occupation rate for CFS and AFS farms.**

| Feeding system | Daily number of milkings | Daily number of refusals | Daily number of failures | Daily occupation of the AMS |
|---|---|---|---|---|
| | No. cow$^{-1}$ day$^{-1}$ | | | % day$^{-1}$ |
| CFS | 2.567 | 2.056 | 0.105 | 59.71 |
| AFS | 2.614 | 2.483 | 0.118 | 56.83 |
| s.e.d. | 0.123 | 0.515 | 0.027 | 4.131 |
| P value | 0.71 | 0.42 | 0.64 | 0.49 |

CFS = Conventional Feeding System; AFS = Automatic Feeding System.

# Observations/Comments from the Field

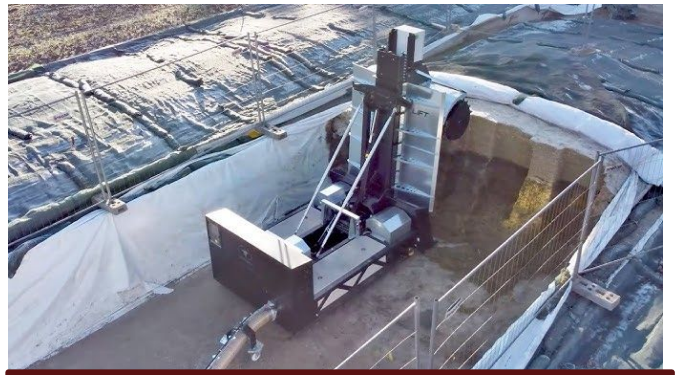
- Reduced energy costs by switching from gas-powered TMR mixer to electric AFR
- Increased cow activity in the barn & fewer fetches after implementing AFR
- Less frequent feed cleanup
  - Herds typically removed feed from the bunk about every week
- Like all technology, there is an adjustment period after adoption
- Variable reports about feed mixing consistency
- Limited herd size – current systems are designed for herds <300 cows

Picture courtesy of Jake Pisig, JTP Farms

# Summary

- Major advantage is labor savings and flexibility
- Opportunity to reduce feed shrink through more precise feeding
  - Can feed to essentially <1% refusals pretty easily
- Currently difficult to implement on larger farms due to small capacity mixer & needing to run multiple systems
- Definitely seems to stimulate cow activity and improve cow flow due to more frequent feeding
- Does not appear to be major impacts on production of cows
- Could allow more flexibility # of rations fed
  - Both for different groups or even within a day
- **I do believe that automated feeding has future of feeding cows, but new options with ability to feed more cows/unit are required before I see large scale adoption in the U.S.**


Self-Driving Feed Delivery Truck



Automated silage extractor

# Questions?

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