Current concepts in transition cow feeding and the NASEM requirements

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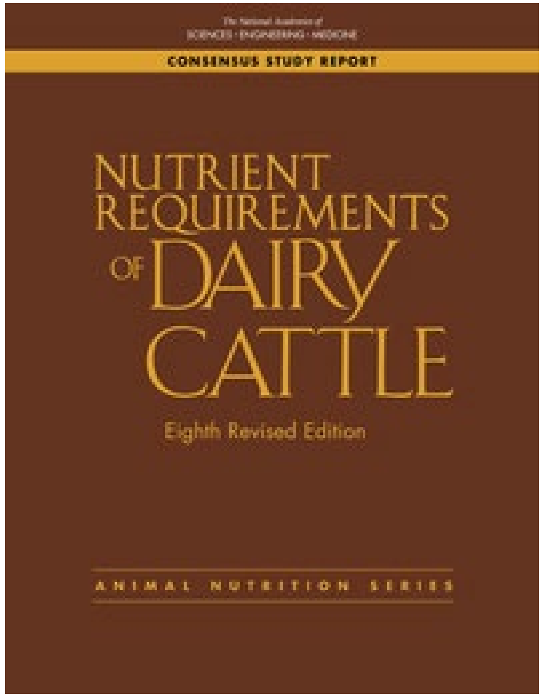
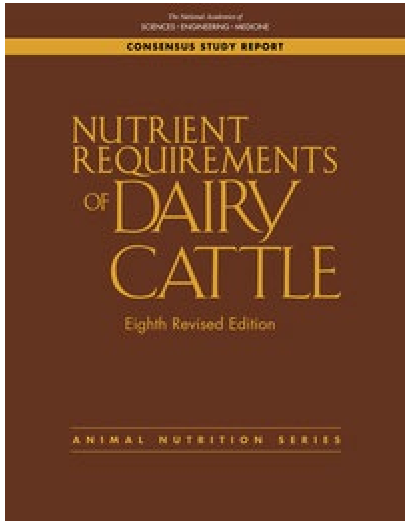
Nutrient Requirements of Dairy Cattle (8^{th} rev. ed.) National Academies of Sciences, Engineering and Medicine (NASEM), 2021

- Replaces “NRC”, 2001
- 21 chapters, over 500 pages
- $149.95 (nap.edu)
- New computer model (similar interface), expanded outputs (free download)
- New material as well as extensively revised material from NRC 2001



Chapter 12
Dry and Transition Cows



Changes from NRC 2001

- Updated literature review
- New DMI equations
- Gestation requirement model structure
- Energy requirements and dietary energy concentrations
- Mineral requirements
- Vitamin E requirements

Estimated DMI by NASEM 2021

- Equations include parity, diet NDF, and week prepartum
  - Week used because of uncertainty of calving date
- Insufficient data for true meta-analysis
- Insufficient data to evaluate interactions among parity, diet, and time prepartum
- Data from 2001 and all newer data available were used
- Almost all experiments used high forage diets; diets with byproduct NDF sources not represented

Estimating DMI using NASEM 2021

- **Cows (% of BW):**

  $= 1.47 - [(0.365 - 0.0028 \times NDF)\ week] - 0.035 \times week^2$

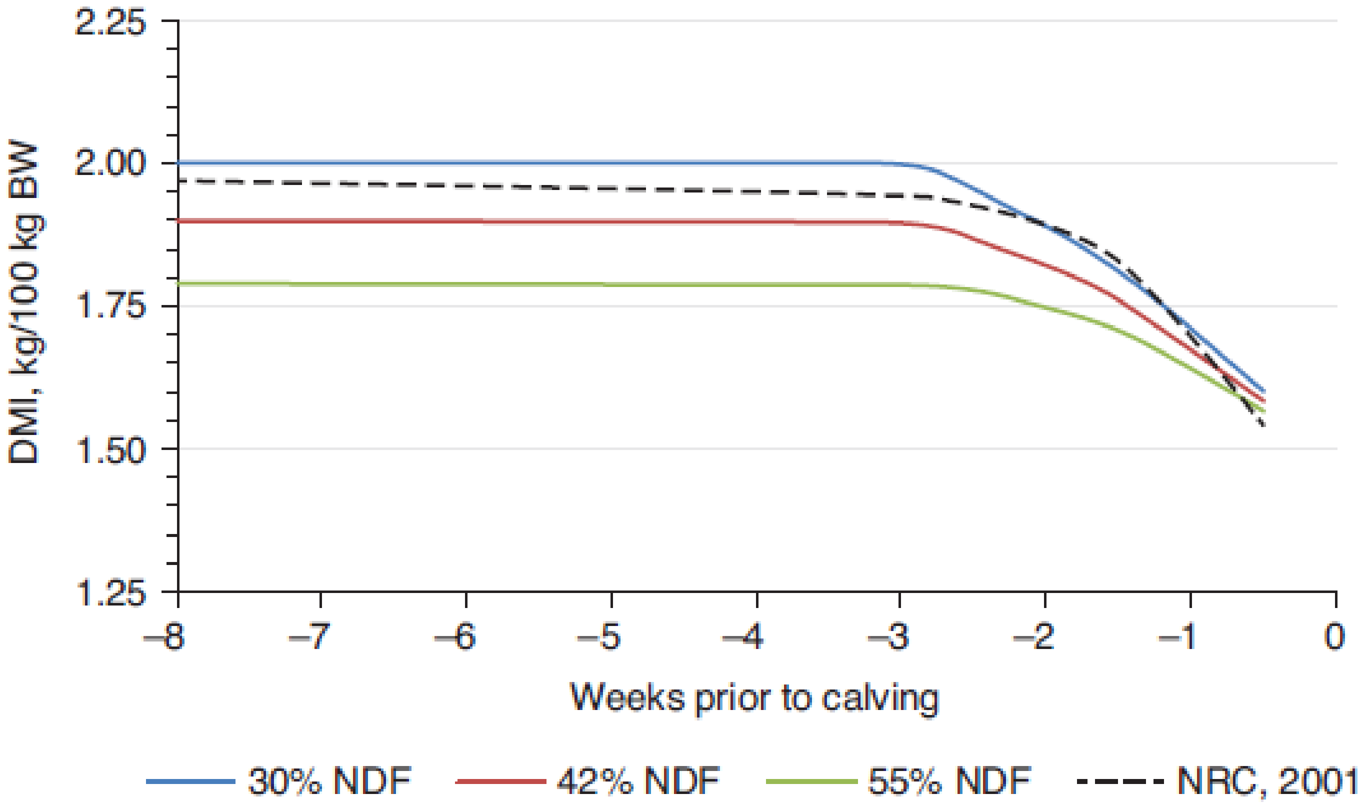
  where week = week from calving (i.e., it is negative)

  If cow > 3 wk from parturition, week = -3

- **Heifers:** Cow equation × 0.88

  Insufficient new data, therefore average parity effect from 2001 was retained

Estimated DMI by cows using NASEM 2021



New DMI equations

For far-off dry cows (>3 wk prepartum)

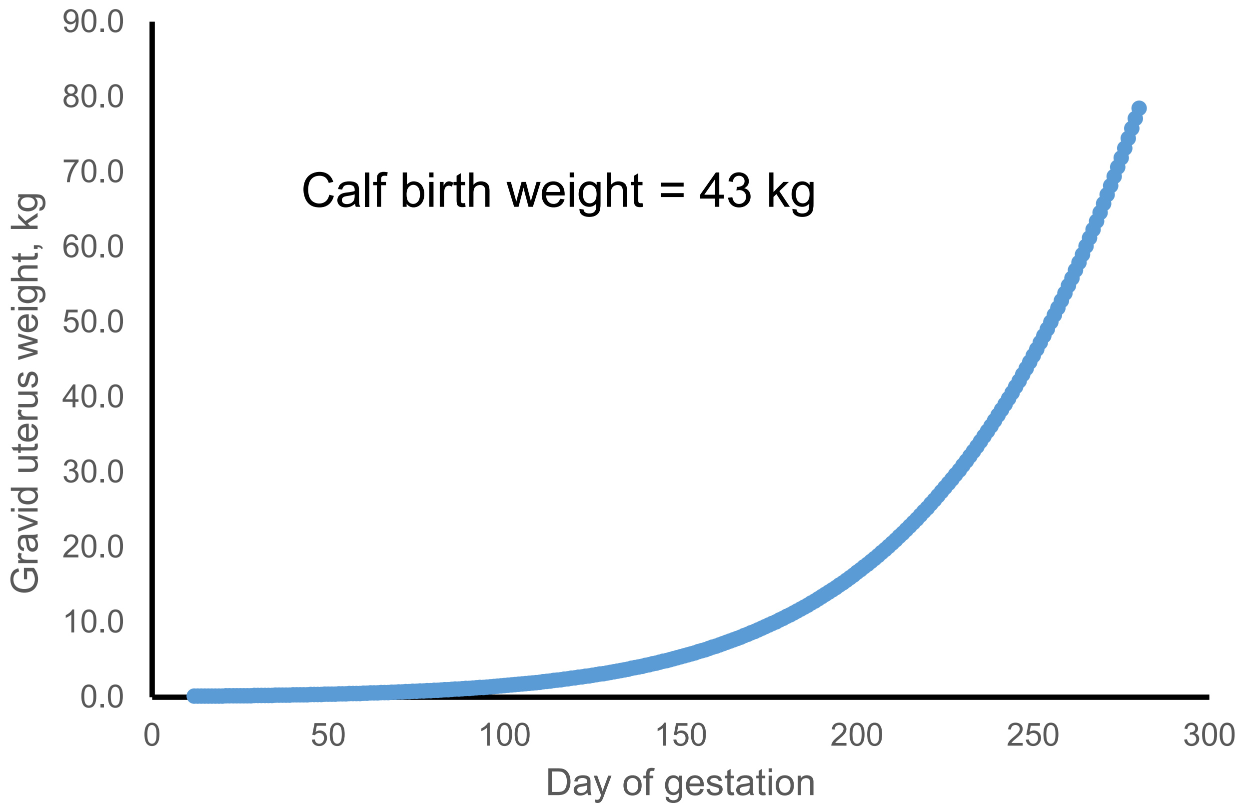
- DMI will be between 1.8 and 2% of BW
- Negatively correlated with dietary NDF

For close-up dry cows (<3 wk prepartum)

- DMI starts decreasing ~2.5 wk prepartum
- Rate of decline negatively correlated with dietary NDF
- At about wk 1 prepartum DMI about the same for all NDF (1.65% of BW)

Calculation of gestation requirements

- Mass model for conceptus starts at d 12 of gestation (compared with d 190 in NRC 2001)
- Function of maternal BW (heifer has smaller calf)
- Energy = 0.88 Mcal/kg
- CP = 125 g/kg



Gestation energy and protein requirements

	Gestation NEL, Mcal/d		Gestation MP, g/d	
Day of gestation	NRC 2001	NASEM 2021	NRC 2001	NASEM 2021
50	0	0.04	0	3
100	0	0.1	0	13
150	0	0.5	0	43
200	2.7	1.4	199	125
220	3.0	2.0	245	185
250	3.4	3.5	306	320
275	3.8	5.4	357	489

Close-up starch, fiber, and energy

- Almost impossible to separate these effects (e.g., as NDF goes up starch and NEL usually go down)
- Increasing prefresh energy (more starch, less NDF):
  - Increases prepartum DMI
  - Generally little effect on postpartum DMI
  - Most studies show no effect on milk yield

Use of pre-fresh diet to adapt rumen

- To “help rumen deal with higher starch postpartum diet”

  “Based on available data, benefits of feeding a diet of moderate starch and fiber to transition ruminal cells and rumen tissue morphology from a high-forage diet to a higher-starch lactation diet are not evident.”

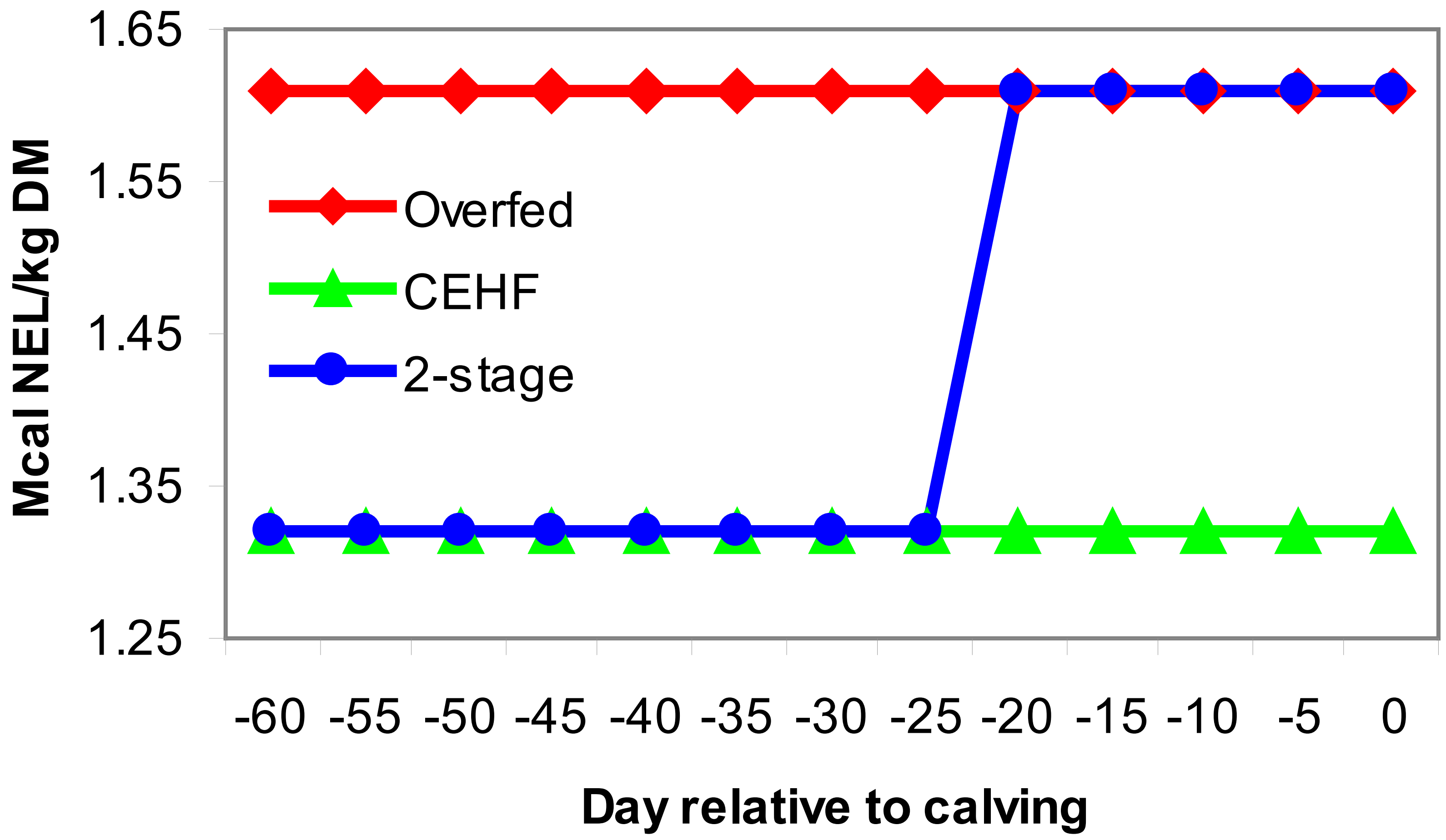
One-diet dry cow management: use of controlled energy diets

Diet composition (% of DM) – dry period

Ingredient	HE	LE
Wheat straw	0.0	40.5
Alfalfa hay, mid-maturity	6.0	3.2
Alfalfa silage, mid-maturity	17.9	9.7
Corn silage	49.9	28.3
Concentrate	26.2	18.3

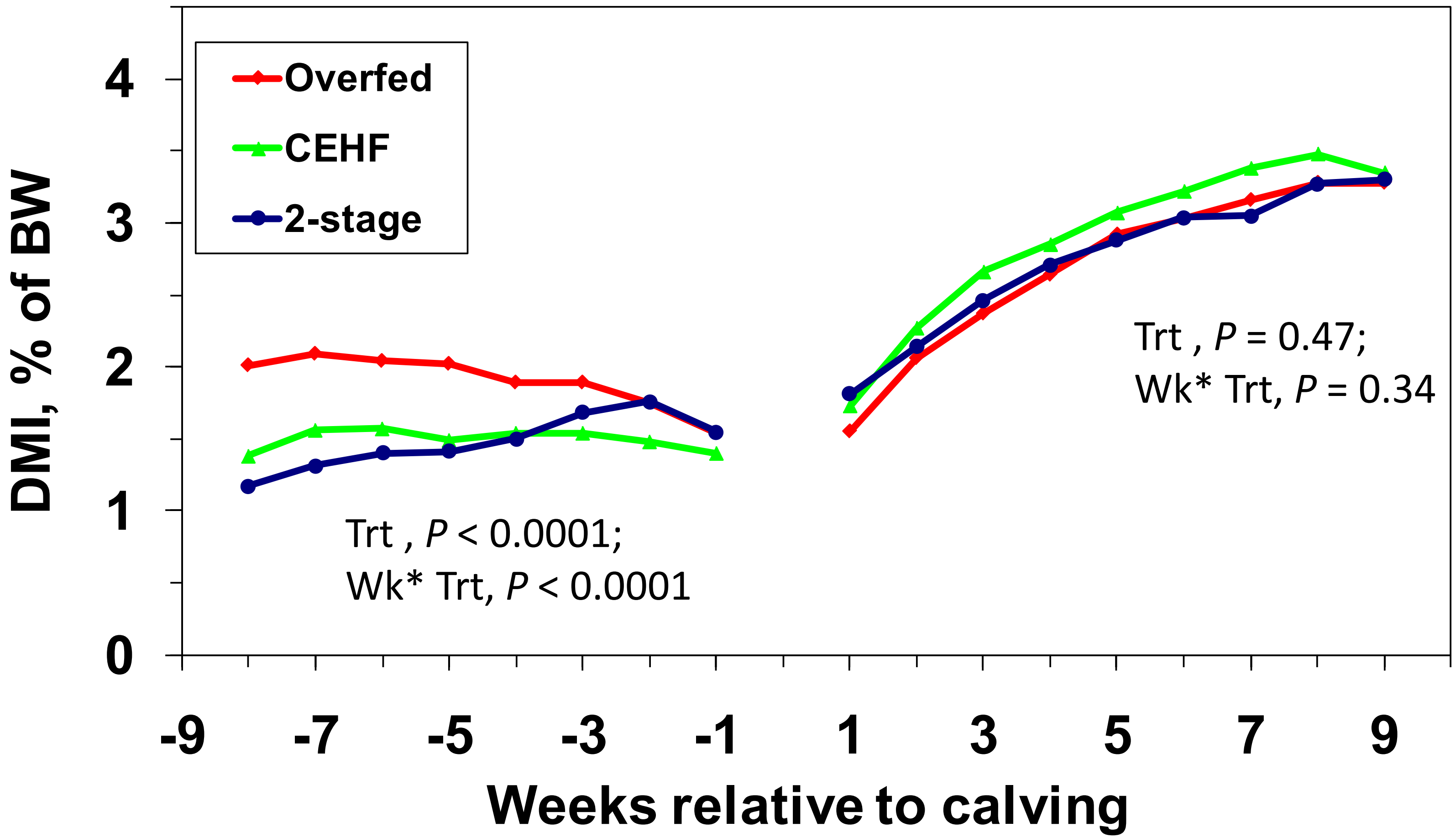
Richards et al., 2020

Dietary treatments



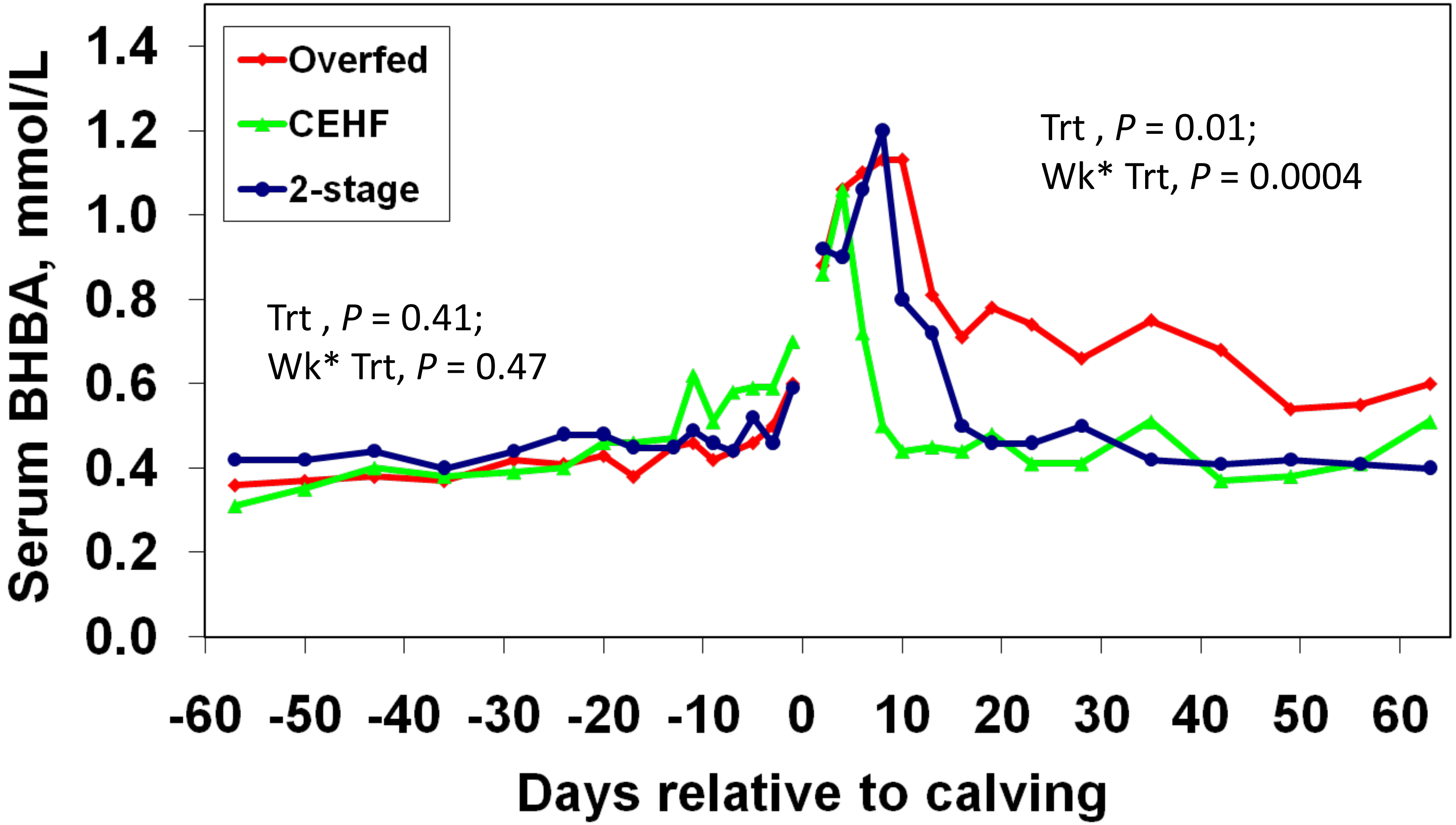
Richards et al., 2020

Dry matter intake for dry cows fed single-group or two-group diets



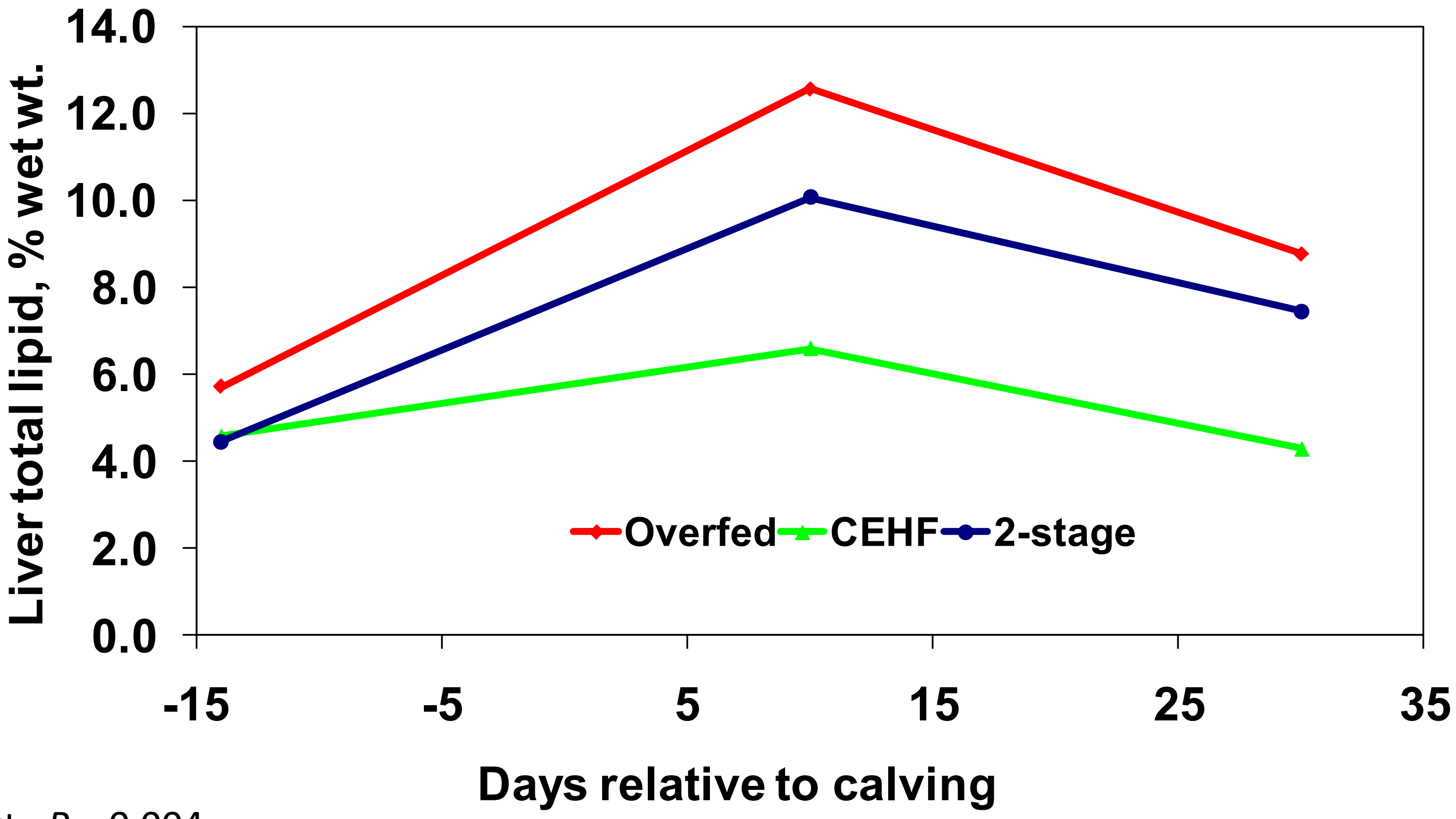
Richards et al., 2020

Controlled energy dry cow diets decreased serum BHBA



Richards et al., 2020

Controlled energy dry cow diets decreased liver total lipid



Trt , *P* = 0.004;
Wk* Trt, *P* = 0.02

Richards et al., 2020

Dry period treatment did not affect milk yield but decreased milk fat percentage and yield

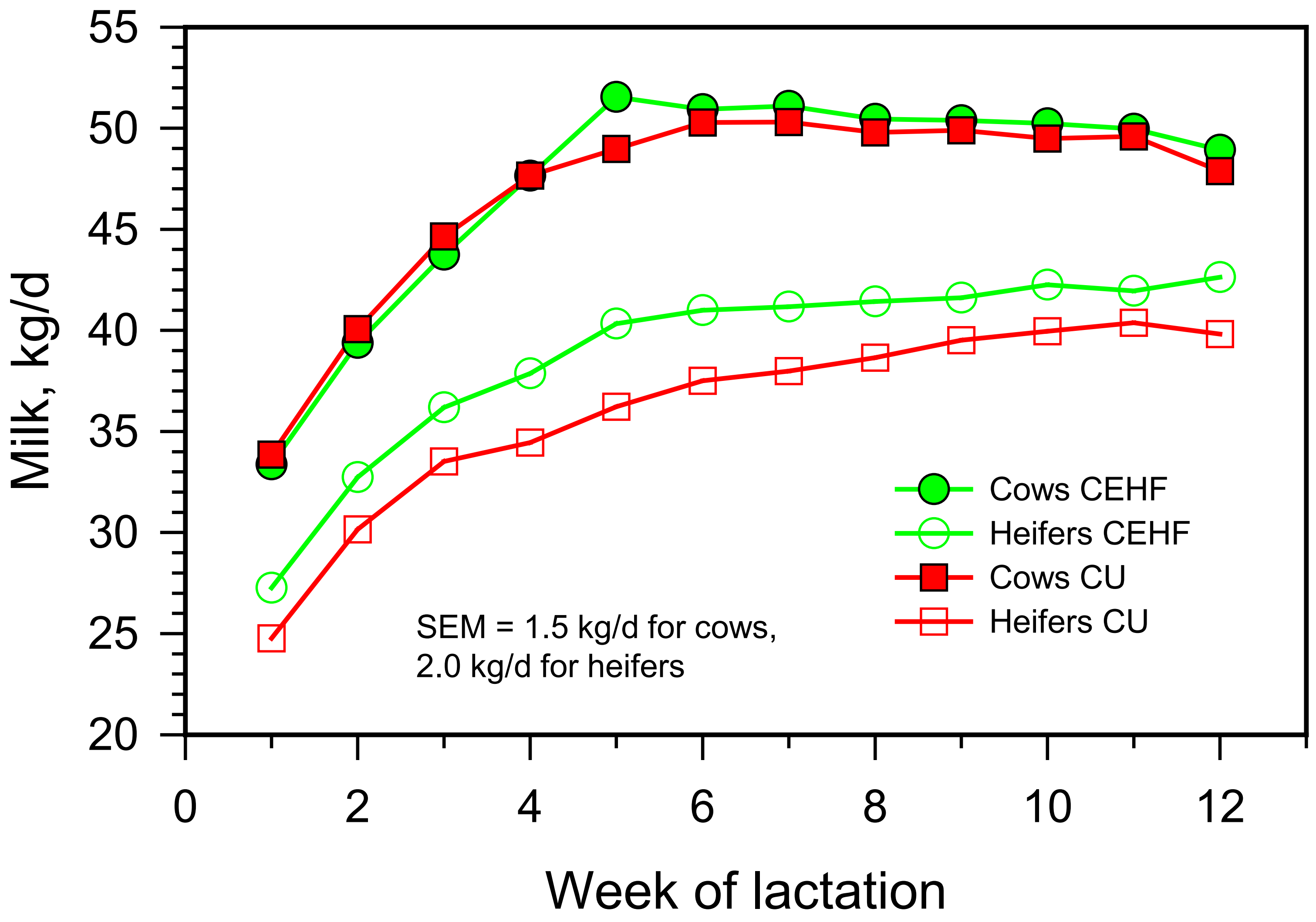
	Dry period treatment			
Variable	LE	HE	LE+HE	SE
Milk, kg/d	32.2	33.6	33.1	1.4
Milk fat, %	3.20[c]	3.87[a]	3.43[b]	0.11
Milk fat, kg/d	1.12[c]	1.41[a]	1.21[b]	0.06

Weeks 1 – 9 of lactation, first lactation cows included

[a,b,c] $P < 0.05$

Richards et al., 2020

Milk yield was not different between strategies



Vasquez et al., 2021

Dry period treatment did not affect milk yield but decreased milk fat percentage

	Dry period treatment		
Variable	CEHF	CU	SE
Milk, kg/d	43.1	41.5	1.0
Milk fat, %	3.54^{b}	3.76^{a}	0.07
Milk fat, kg/d	1.48	1.52	0.03
C18:1 *trans*-10, %	1.14^{a}	0.66^{b}	0.16

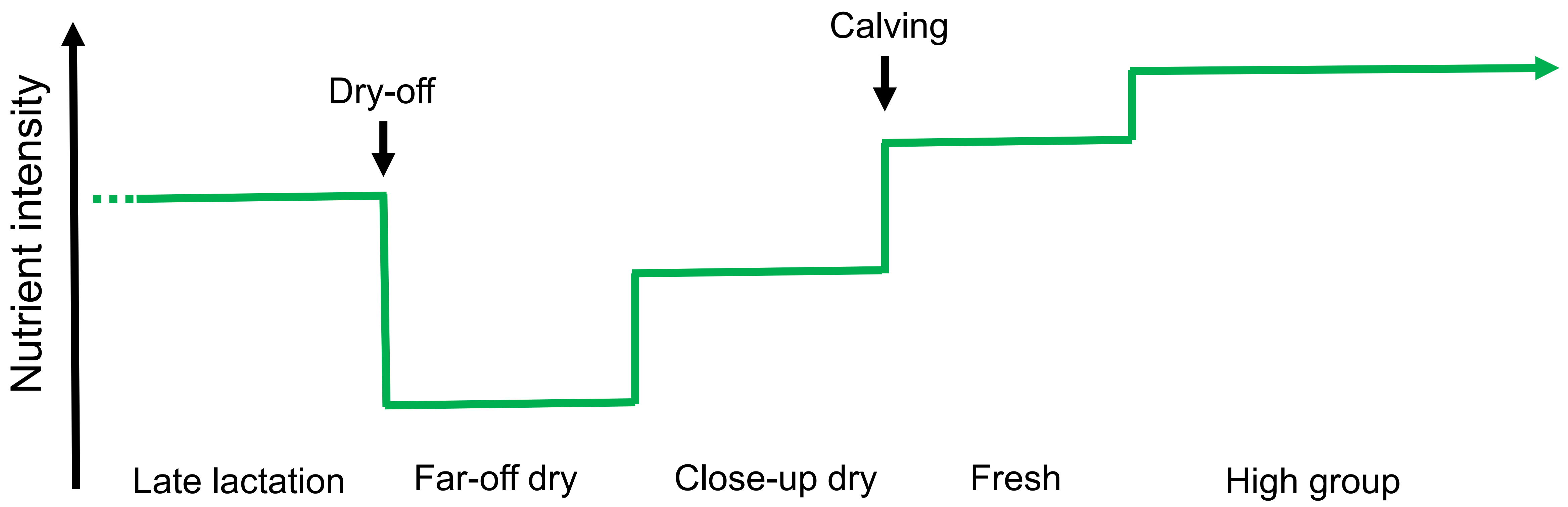
Weeks 1-12 of lactation, first lactation cows included

^{a,b} $P < 0.05$

May indicate lack of rumen adaptation at calving for one-diet strategy

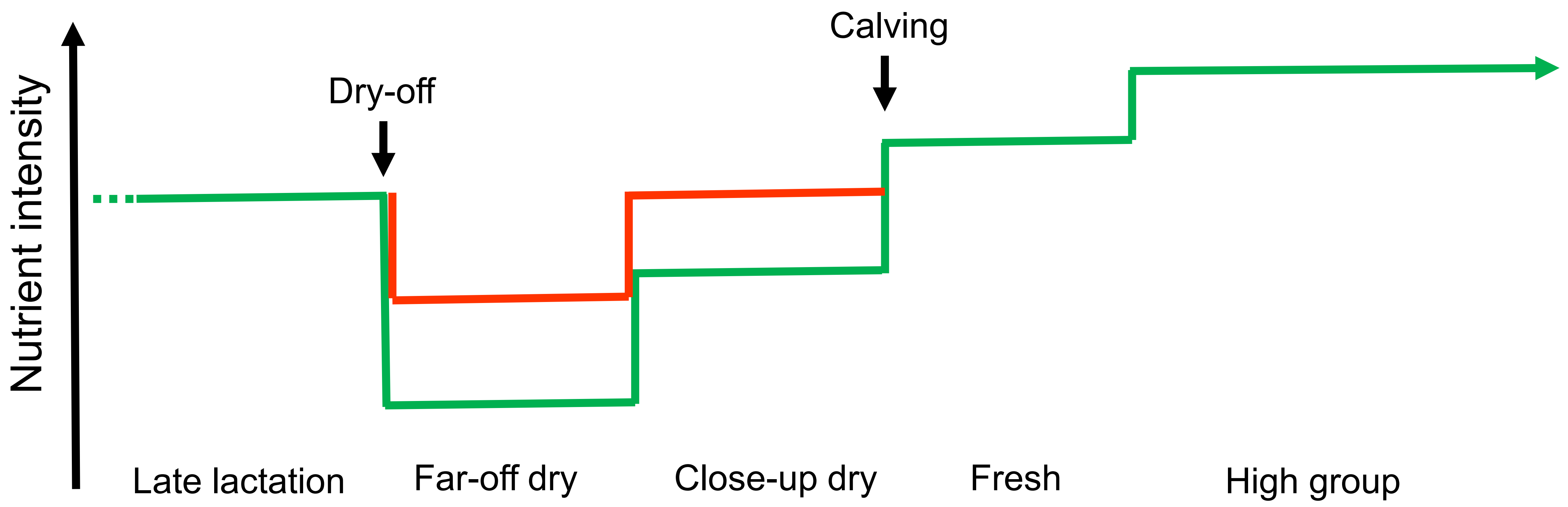
Vasquez et al., 2021

“Nutrient intensity” changes during the transition



"Nutrient intensity" changes during the transition

But don't want this…steps too small and far-off not low enough



NEL concentration of diets: dry cows

Ingredient	% of DM
Corn silage	40.0
Wheat straw	40.8
Corn gluten feed	8.05
Soybean meal	5.9
Canola meal	3.0
Urea	0.30
Minerals and vitamins	1.95

1790 lb, 240 DCC, 30.8 lb/d DMI

- NEL NRC 2001:
  0.63 Mcal/lb
  (19.5 Mcal/d)
- NEL NASEM 2021:
  0.71 Mcal/lb
  (21.8 Mcal/d)

Requirements also increase!

Comparison of energy requirements – dry cows

Ingredient	NRC, 2001	NASEM, 2021
NEL maintenance, Mcal/d	11.4	15.2
NEL pregnancy, Mcal/d	3.6	3.1
Total NEL required, Mcal/d	15.0	18.3

1790 lb, 240 DCC, 30.8 lb/d DMI

Comparison of nutrient balances – dry cows

Ingredient	NRC, 2001	NASEM, 2021
ME balance, Mcal/d	6.3	5.4
NEL balance, Mcal/d	4.5	3.6
MP balance, g/d	219	373

1790 lb, 240 DCC, 30.8 lb/d DMI

Both dietary energy prediction and energy requirements are higher with NASEM 2021.

Must use dietary NEL calculated by NASEM to be accurate!

NEL concentration of diets: close-up cows

Ingredient	% of DM
Corn silage	32.1
Wheat straw	36.3
Corn gluten feed	8.2
Soy hulls	6.6
Wheat midds	6.2
Soybean meal	5.8
Canola meal	2.6
Urea	0.25
Minerals and vitamins	1.95

1790 lb, 270 DCC, 28.6 lb/d DMI

- NEL NRC 2001:
  0.65 Mcal/lb
  (18.6 Mcal/d)
- NEL NASEM 2021:
  0.73 Mcal/lb
  (20.9 Mcal/d)

Requirements also increase!

Comparison of energy requirements – close-up cows

Ingredient	NRC, 2001	NASEM, 2021
NEL maintenance, Mcal/d	11.4	15.2
NEL pregnancy, Mcal/d	3.6	5.2
Total NEL required, Mcal/d	15.0	20.4

1790 lb, 270 DCC, 28.6 lb/d DMI

Comparison of nutrient balances – close-up cows

Ingredient	NRC, 2001	NASEM, 2021
ME balance, Mcal/d	5.0	0.5
NEL balance, Mcal/d	3.6	0.3
MP balance, g/d	240	-113

1790 lb, 270 DCC, 28.6 lb/d DMI

Both dietary energy prediction and energy requirements are higher with NASEM 2021.

Must use dietary NEL calculated by NASEM to be accurate!

NEL concentration of diets: fresh cows

Ingredient	% of DM
Corn silage	30.0
Wheat straw	1.0
Alfalfa silage	15.0
Corn gluten feed	17.0
Corn grain	25.05
Soybean meal	3.0
Soybean meal, expellers	2.0
Blood meal	2.5
Tallow	2.0
Rumen protected Lys Met	0.2
Minerals and vitamins	2.25

1375 lb, 15 DIM, 46.2 lb/d DMI, 88 lb/d milk

- NEL NRC 2001:
  0.76 Mcal/lb
  (35.1 Mcal/d)
- NEL NASEM 2021:
  0.84 Mcal/lb
  (38.8 Mcal/d)

Requirements also increase!

Comparison of energy requirements – fresh cows

Ingredient	NRC, 2001	NASEM, 2021
NEL maintenance, Mcal/d	10.0	12.5
NEL milk, Mcal/d	29.0	29.0
Total NEL required, Mcal/d	39.0	41.5
NEL balance, Mcal/d	-3.9	-3.4

1375 lb, 15 DIM, 46.2 lb/d DMI, 88 lb/d milk

Both dietary energy prediction and energy requirements are higher with NASEM 2021.

Must use dietary NEL calculated by NASEM to be accurate!

Summary – diet energy concentrations (Mcal/lb DM)

Cow class	NRC, 2001	NASEM, 2021
Far-off dry cows	0.63	0.71
Close-up dry cows	0.65	0.73
Fresh cows	0.76	0.84

Don’t mix systems!

Overall changes in energy balance are small.

Cows can consume enough energy to meet requirements during transition period from a variety of diets

Dietary NE_L (Mcal/lb)	DMI (lb) for 19 Mcal
0.70 (high straw)	27.1
0.75	25.3
0.80	23.8
0.85 (high energy)	22.3

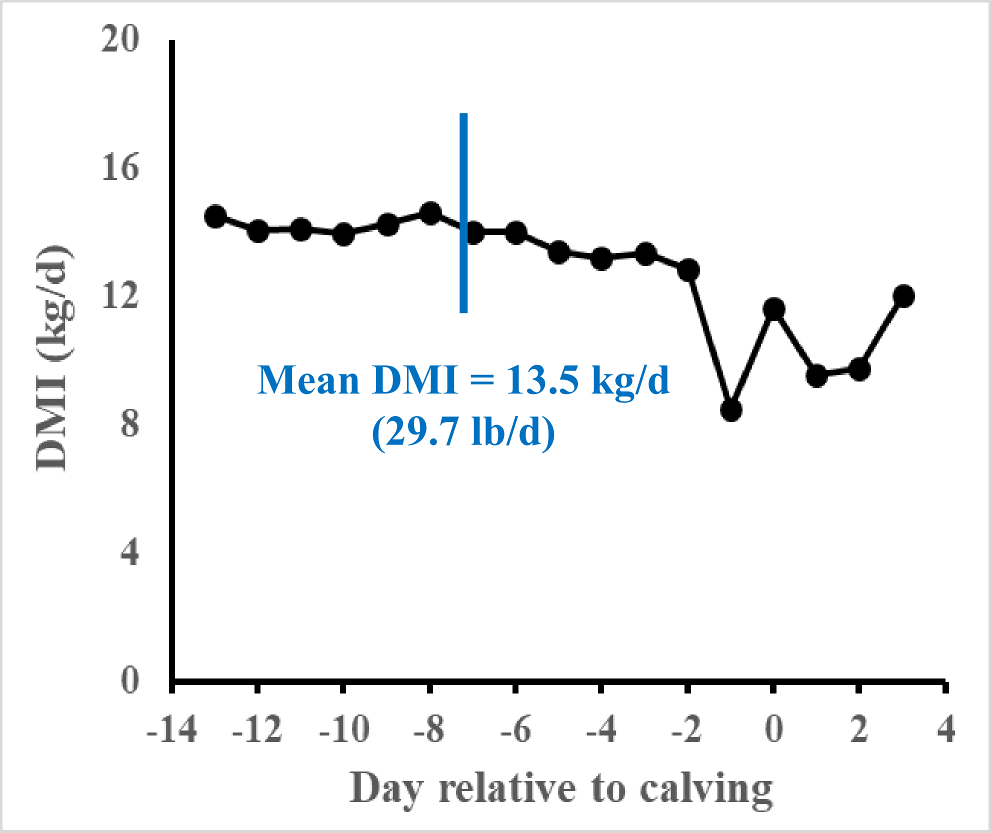
Dry cows will not stop eating once they have eaten enough energy – depends on rumen NDF fill!

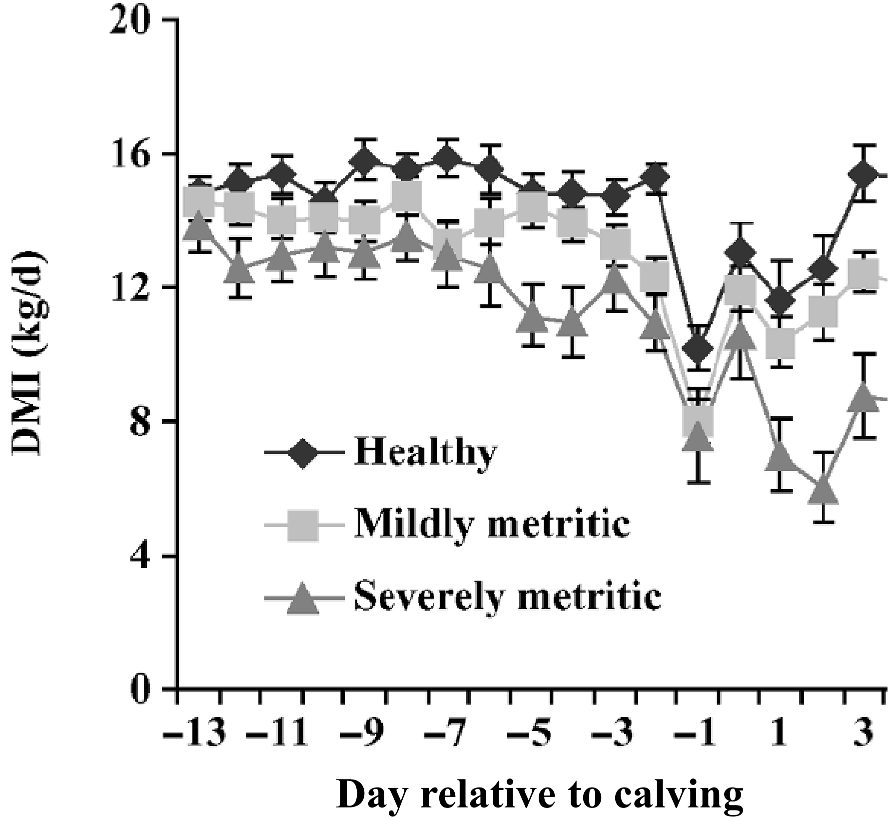
Close-up cows will easily consume more energy than they require

NE_L, Mcal/ lb DM	Forage NDF, % of DM	Predicted DMI, lb/d	NE_L intake, Mcal/d
0.70	55	25.5	18.5
0.75	50	26.4	19.8
0.80	45	27.3	21.8
0.85	40	28.2	24.0

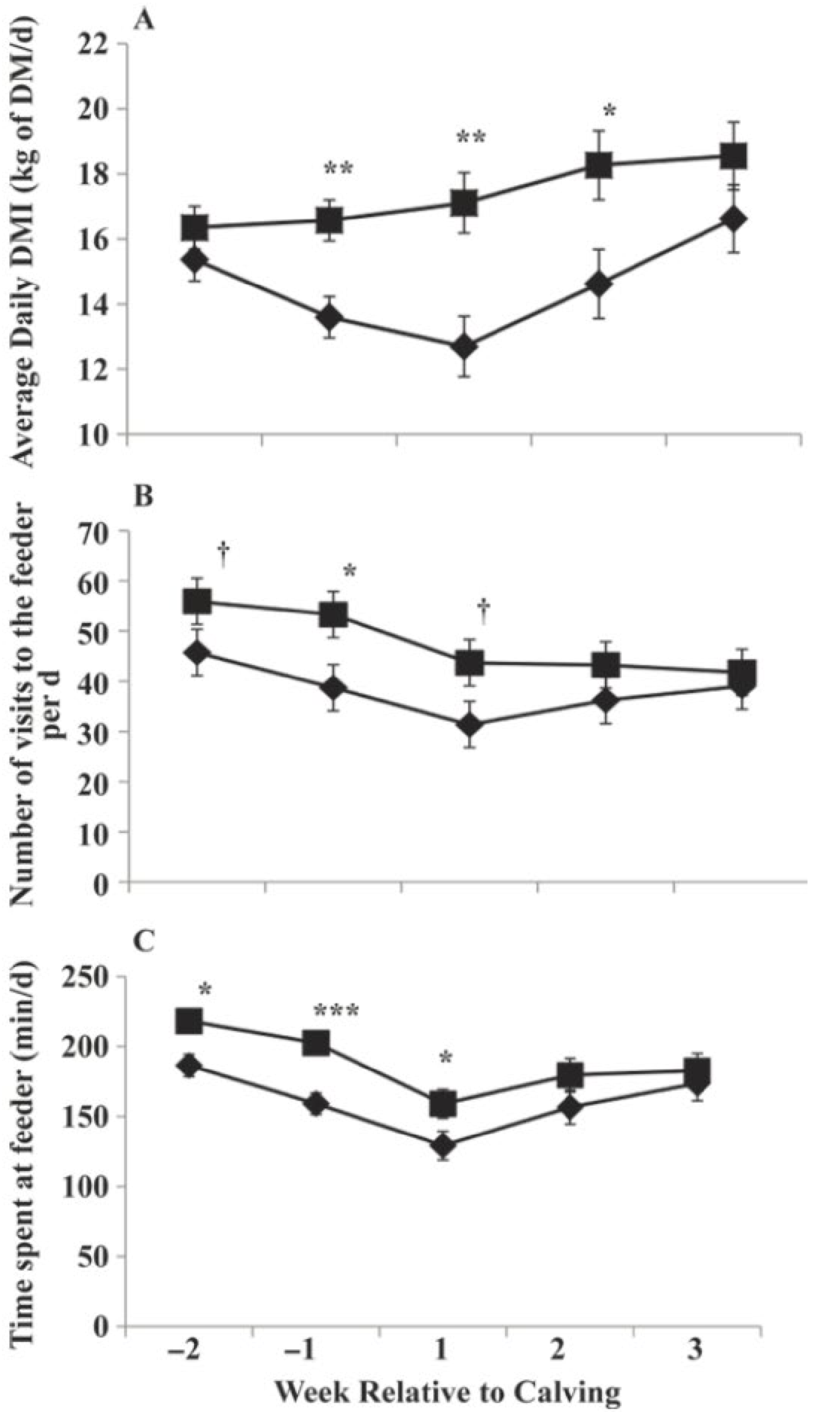
Estimated for 1540 lb Holstein cow at 265 days carried calf using NASEM (2021)

Mean DMI vs sub-groups





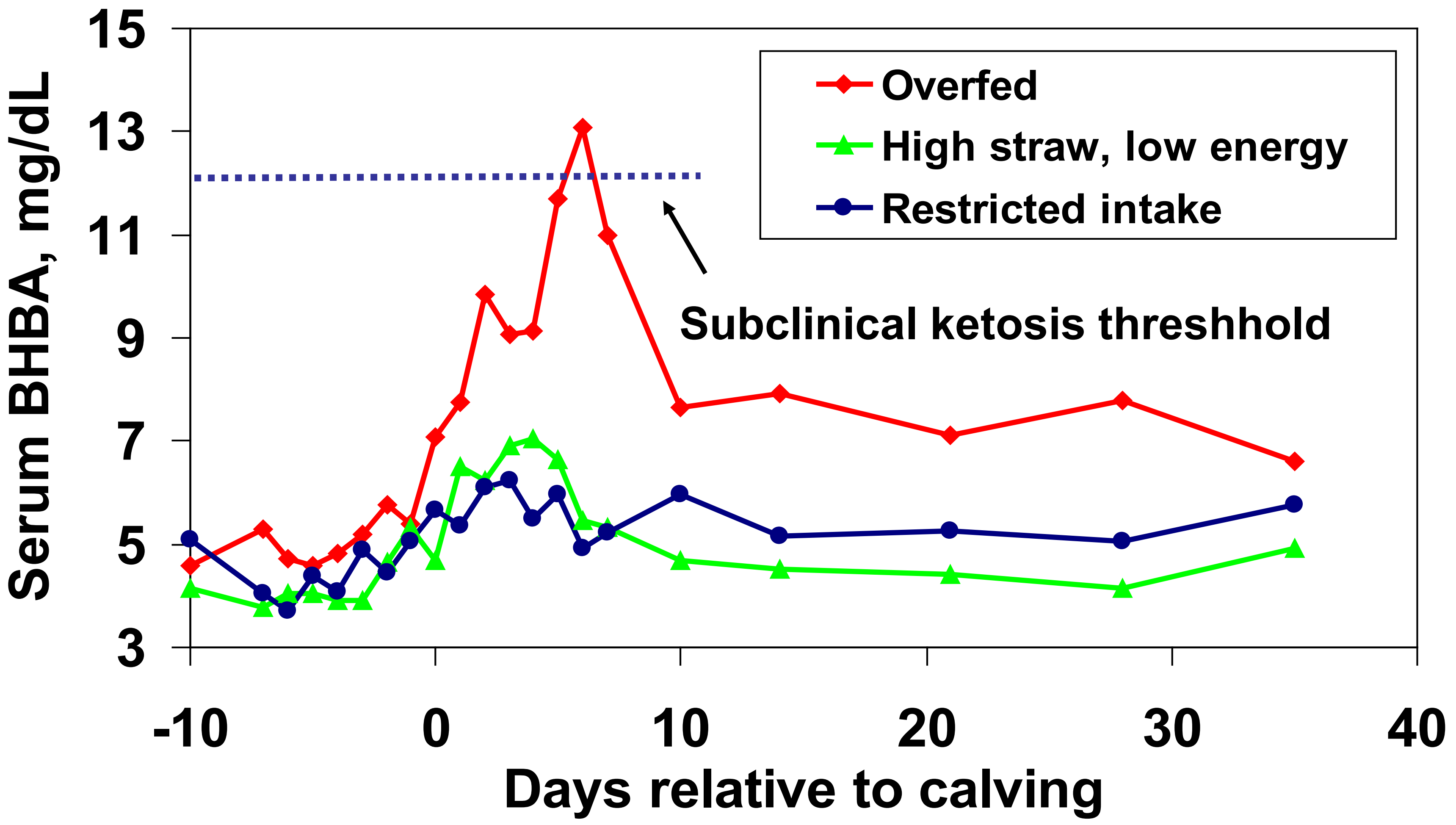
Adapted from Huzzey et al., 2007



Pre-calving DMI, visits to feed bunk, and time spent at feed bunk were lower for cows that developed subclinical ketosis postpartum

Goldhawk et al., 2009

Restricting feed intake precalving in otherwise-healthy cows does *not* cause ketosis or metritis



Janovick et al., 2011

Does high DMI in pre-fresh cows prevent health problems?

- No.
- Indicates there are fewer cows destined for problems as a result of management barriers for cows to adapt to lactation.
- *High DMI is an* ***indicator*** *of a successful program, it is not the reason for it.*

Summary - Energy

- Energy requirements for NASEM 2021 are about 17-18 Mcal/d NEL for dry cows and about 19-20 Mcal/d NEL for transition cows (mature Holstein).
- Diets will be higher in calculated energy with NASEM 2021 than with NRC 2001.
- Balances will be lower with NASEM 2021 than with NRC 2001 – closer to what is observed in field.

Dry cow dietary protein and milk production

- For NRC (2001) most studies fed treatments during entire dry period, not just pre-fresh
- Milk and milk composition during first 3 wk to 17 wk were the primary outcome variables
- In a few studies, diets were as low as 10% CP without effect on milk production (cows)
  - Diet with 10% CP prepartum remained in protein balance at d -10 (Putnam and Varga, 1998)

Dry cow dietary CP and milk production

Meta-analysis (Lean et al., 2013)

12 studies, 26 treatment comparisons

Control diets: 9.7 to 14.1% CP (avg. = 12.3)

Treatment diets: 11.7 to 23.4% CP (avg. = 15.9%)

Milk yield first 28 d to 120 d (avg = 65 DIM)

Average increase in milk for increased CP

= 0.1 kg/d (-0.6 to +1.2 kg/d)

Dry cow dietary MP and milk production

Meta-analysis (Husnain and Santos, 2019)

- 27 comparisons for heifers
- 97 comparisons for cows
- Mostly prefresh treatment comparisons

Diets: 9 to 21% CP (avg. = 14.0%)

6 to 10% MP (avg. 9.3% for cows; 6 to 13%)

MP calculated according to NRC 2001

Dry cow dietary CP and milk production

- No difference in milk yield for cows
  - ➢Milk protein increased 60 g/1000 g MP intake in cows producing >36 kg/d milk
- Increased milk and milk protein in first lactation cows

(Husnain and Santos, 2019)

Protein - NASEM 2001 model

Far-off dry cow and heifer

- ~11% CP (6.5% MP) will ~meet requirement
- 12% CP (7.2% MP) recommended because of limited data and potentially inadequate RDP
- Translates to 864 g/d (DMI 12 kg/d) to 1008 g/d (DMI 14 kg/d)

Protein - NASEM 2001 model

Close-up cow and heifer

- ~13% CP (7.8% MP) will meet requirement
- Translates to 936 g/d (DMI 12 kg/d) to 1014 g/d (DMI 13 kg/d)
- Might not be optimum for heifers
- Model ignores MP for colostrum, mammary development, and immune function (no data to model)

Higher quality MP may improve health outcomes?

	Prepartum diet		
Disorder	Low CP	High CP - SBM	Hi CP - Prolak
Retained placenta	4	6	1
n = 20			

Underwood et al., 2022

Amino acid supply – close-up cows

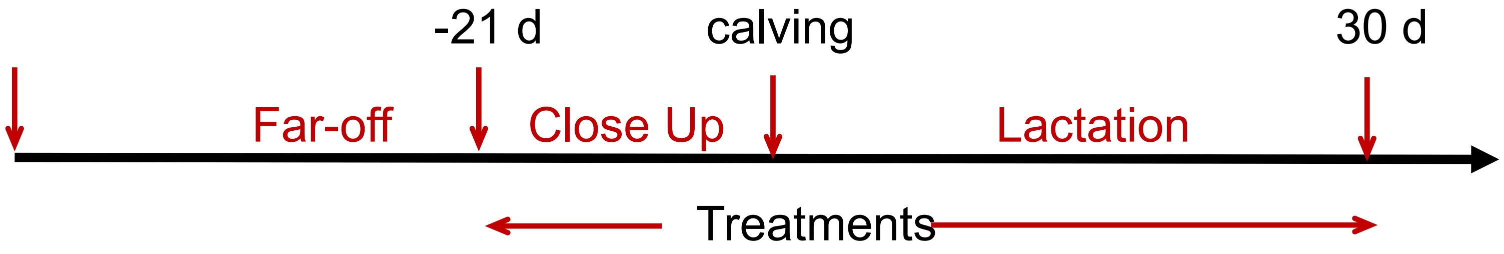
Item	Predicted Supply Mcal or g/d
DE Non-Protein	28
Arg	57
His	27
Ile	66
Leu	96
Lys	86
Met	25
Phe	62
Thr	60
Trp	14
Val	70

Lys:Met = 3.44

Targets (P. French):
Lys = 90 g/d
Met = 31 g/d
Lys:Met = 2.9:1

Would likely benefit from rumen-protected Met supplementation

Experimental design comparing the efficacy of rumen-protected methyl donors



CON: Control

MET: Smartamine (Met; 0.08% of DM)

CHO: ReaShure (Choline; 60 g/cow/d)

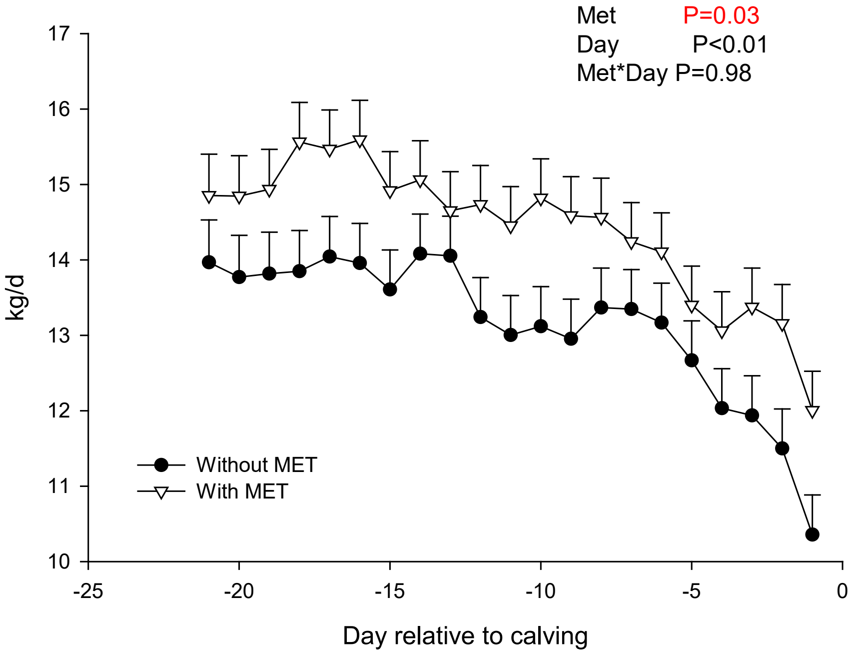
MIX: Smartamine + ReaShure

2×2 Factorial arrangement		Methionine	
		no	yes
Choline	no	CON	MET
	yes	CHO	MIX

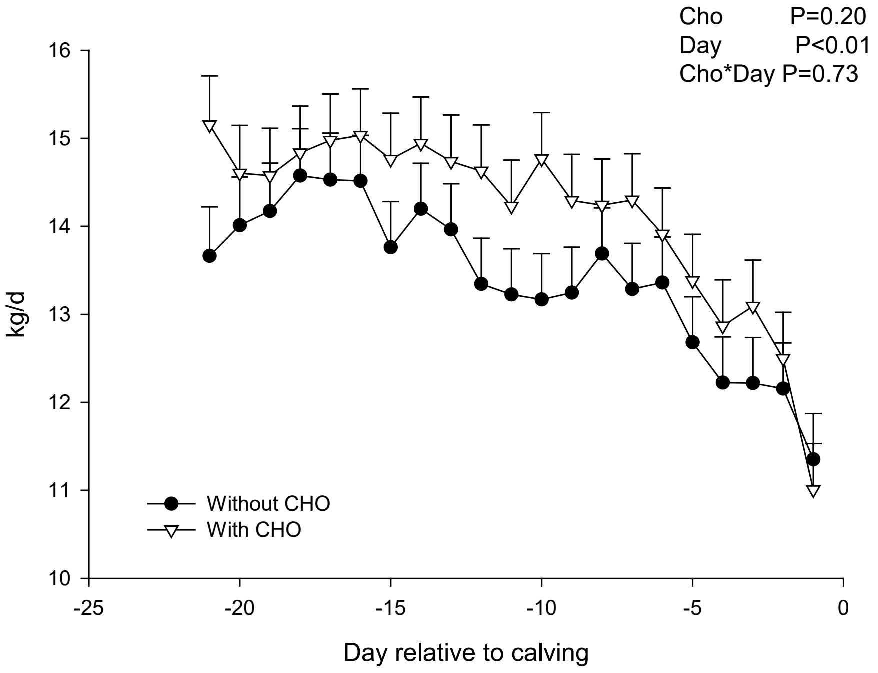
(Zhou et al., 2015 JAM Orlando, FL, USA)

Main effects on DMI prepartum

DMI CU

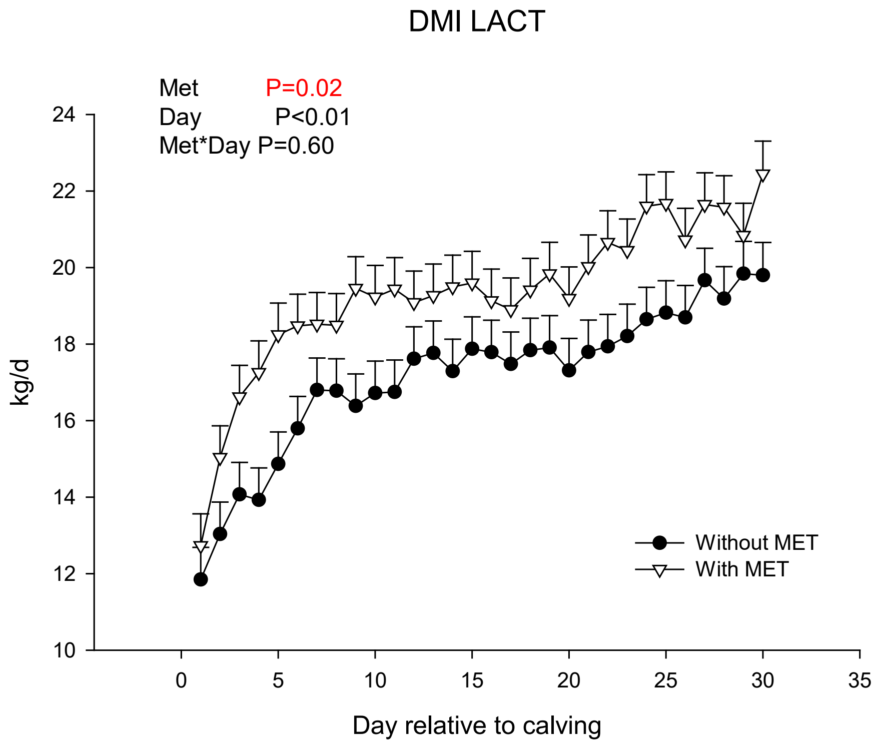


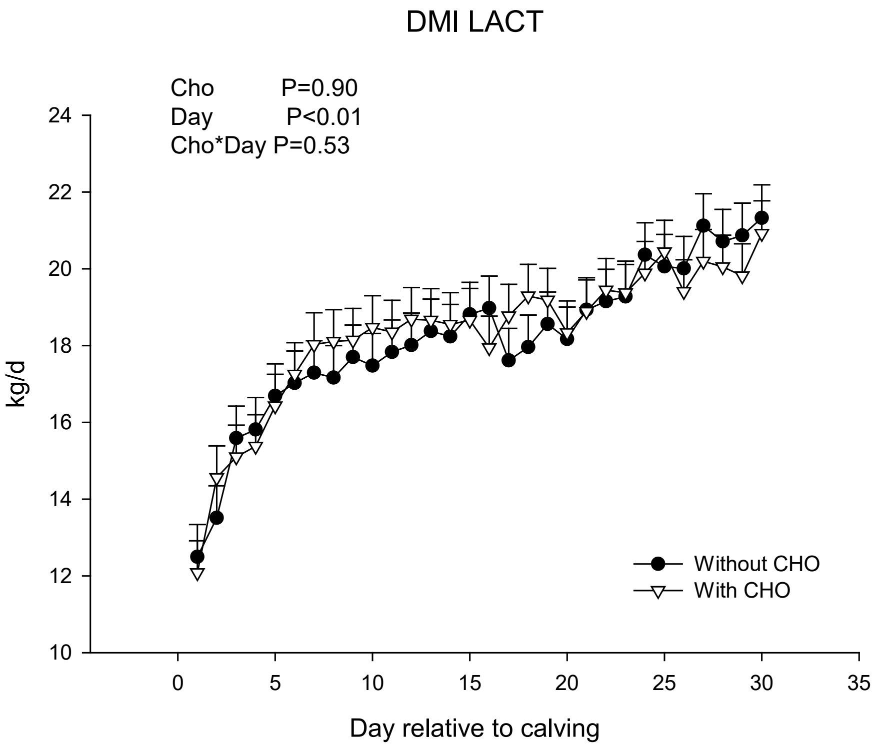
DMI CU



Zhou et al., 2015

Main effects on DMI postpartum





Zhou et al., 2015

Met but not choline increased milk yield and components

Variable	Met		Choline		*P* Met	*P* Cho
	+	−	+	−		
Milk, kg	44.3	40.3	41.6	43.1	**0.03**	0.41
Fat, %	3.72	3.74	3.78	3.68	0.92	0.46
Protein, %	3.32	3.14	3.27	3.19	**0.001**	0.23
Fat, kg	1.67	1.53	1.59	1.61	**0.04**	0.79
Protein, kg	1.51	1.33	1.41	1.42	**0.001**	0.67
FCM, kg	44.8	40.7	42.3	43.2	**0.001**	0.54

Main effects shown; interactions of Met and Cho were not significant.

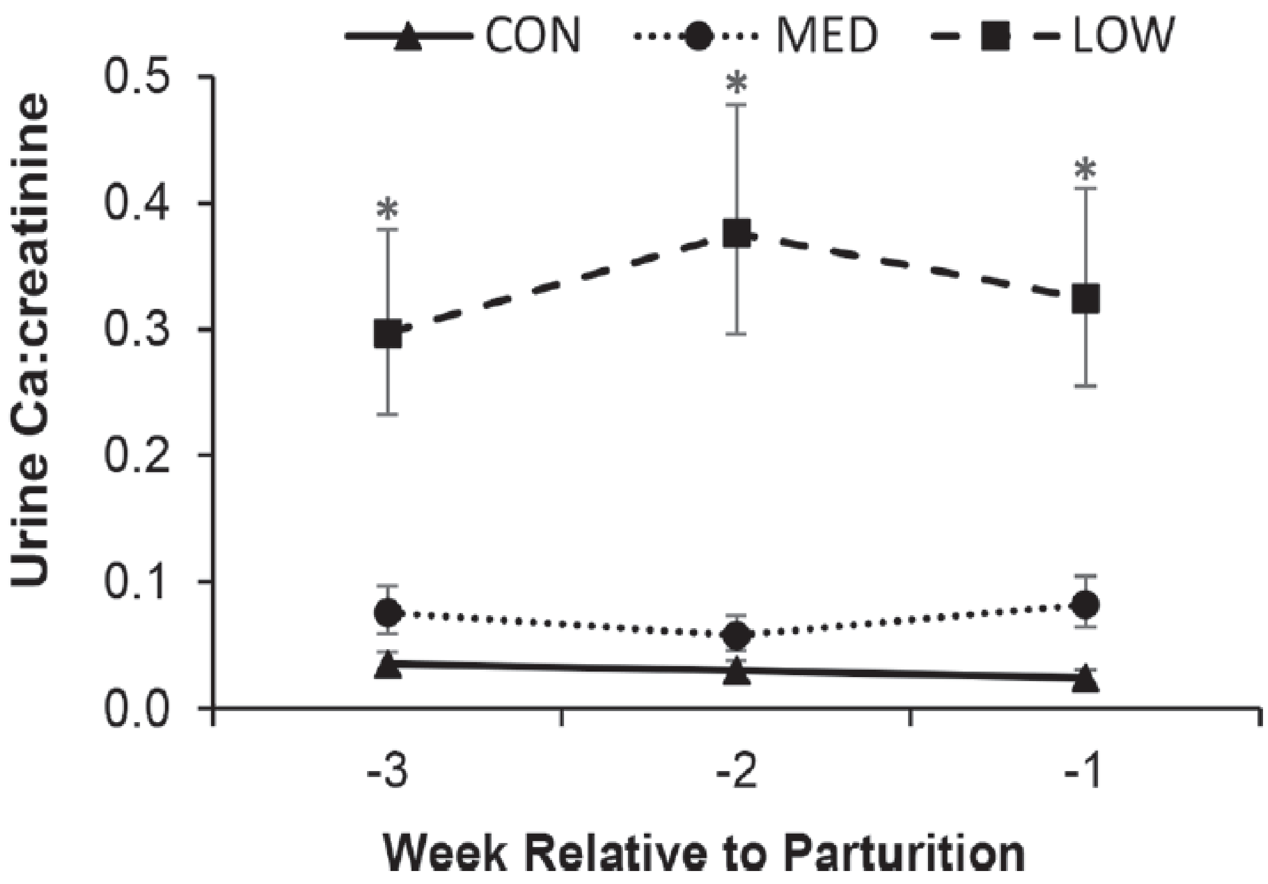
Zhou et al., 2016

Specific minerals/vitamins for transition cows

- Negative DCAD, Ca, P, Mg for hypocalcemia
- Higher vitamin E based on preventing mastitis, RP, and metritis
  - 1000 IU/d for dry cows and 2000 IU/d for prefresh cows (Holsteins)
- No other specific requirements

Metabolic acidosis caused by negative DCAD increases Ca excretion in urine

Dietary DCAD = 18.3 5.9 -7.4



Leno et al., 2017

Effects of partial or full DCAD

Variable	Diet (DCAD) CON	MED	LOW	SEM	*P*
DCAD, mEq/100 g DM	18.3	5.9	-7.4		
DMI, kg/d					
wk -3 to -1	13.6	14.0	13.2	0.2	Q, 0.01
wk 1 to 3	20.2	20.9	21.3	0.5	L, 0.09
% of BW	2.88	2.98	3.07	0.06	L, 0.04
Milk, kg/d	40.8	42.4	43.9	1.0	L, 0.03

Q = quadratic effect, L = linear effect

Leno et al., 2017

Dietary concentrations (% of DM) required to meet the known requirements for macrominerals

Mineral	NRC, 2001	NASEM, 2021	Recommended[1]
Ca	0.45	0.37	1.5 – 2.0
P	0.23	0.21	0.25
Mg	0.12	0.13	0.40
K	0.52	0.65	low as possible
Na	0.10	0.16	0.16
Cl	0.15	0.13	0.7 – 0.9
S	0.20	0.20	0.20 – 0.35

[1] J. K. Drackley recommendation for full anionic program

Dietary concentrations (mg/kg of DM) required to meet the known requirements for trace minerals

Mineral	NRC, 2001	NASEM, 2021	Recommended[1]
Co	0.11	0.20	0.24
Cu	13	19	22
I	0.4	0.54	0.65
Fe	13	14	17
Mn	18	41	50
Se	0.3	0.3	0.3
Zn	22	30	36

[1] J. K. Drackley recommendation, includes 1.2X safety factor

Dietary supply (IU/d) required to meet the known requirements for vitamins

Vitamin	NRC, 2001	NASEM, 2021	Recommended[1]
A	82,610	81,500	100,000
D	22,530	22,000	26,000
E	1202	2000	2000

[1] J. K. Drackley recommendation

No requirement established

- Cr
  - Essentiality recognized but insufficient data to establish an adequate intake
  - Analytical challenges
- Choline
  - Committee acknowledges response to supplementation during transition but declined to establish a requirement
    - Endogenous synthesis
    - Variable results during lactation

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