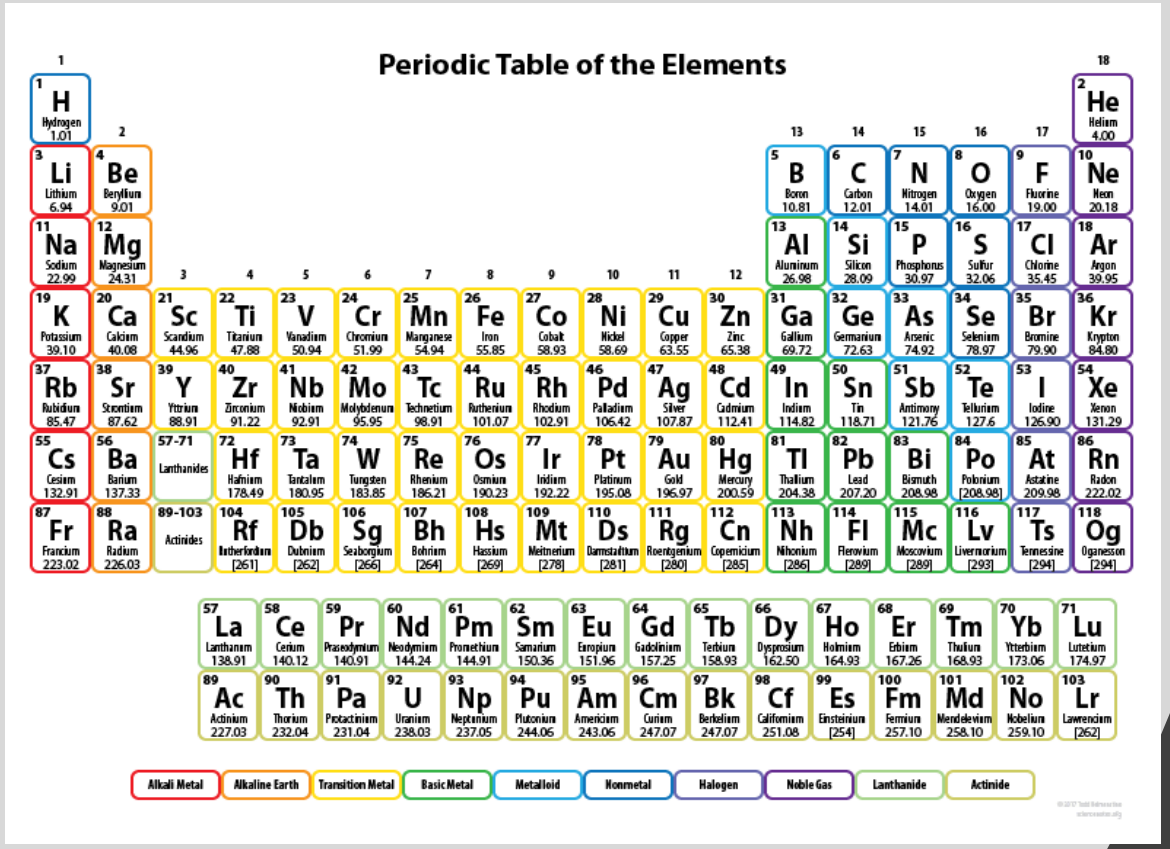

NASEM 2021: *Minerals and vitamins*

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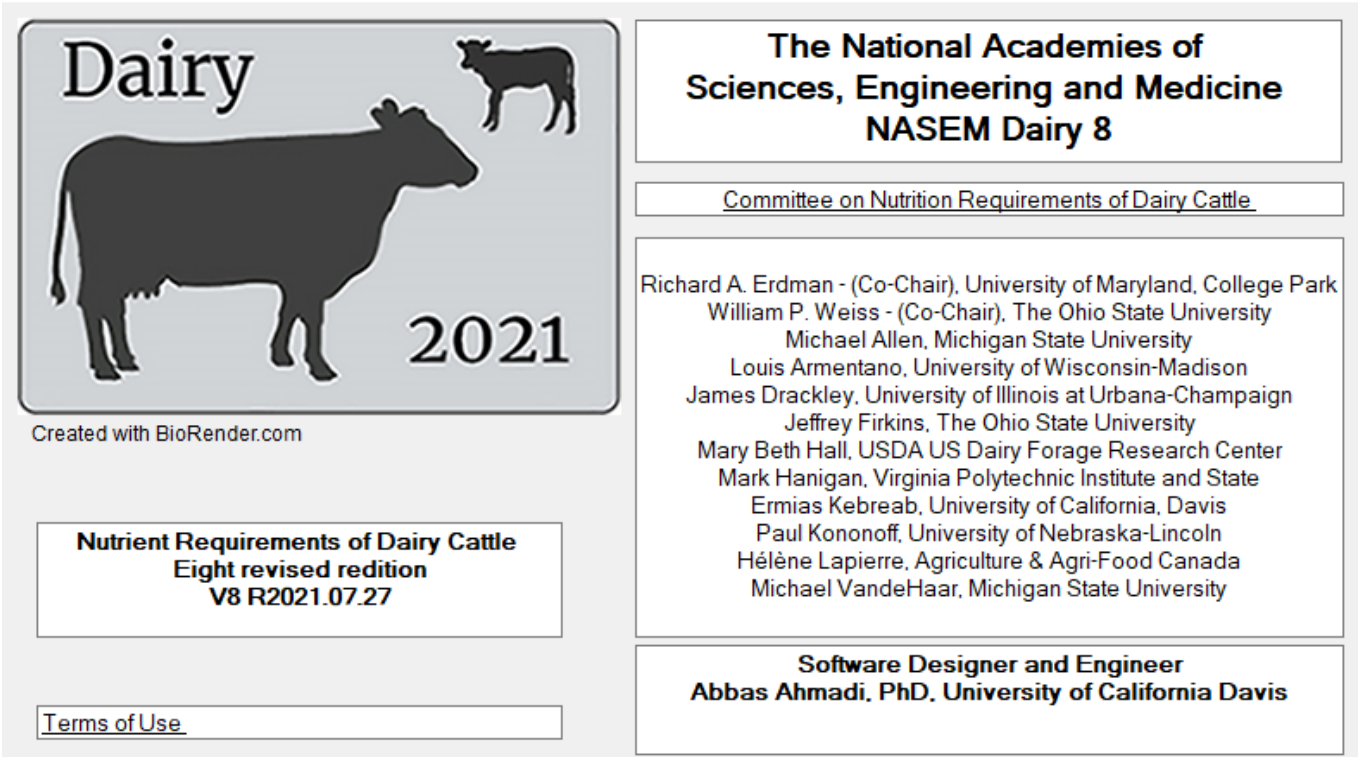
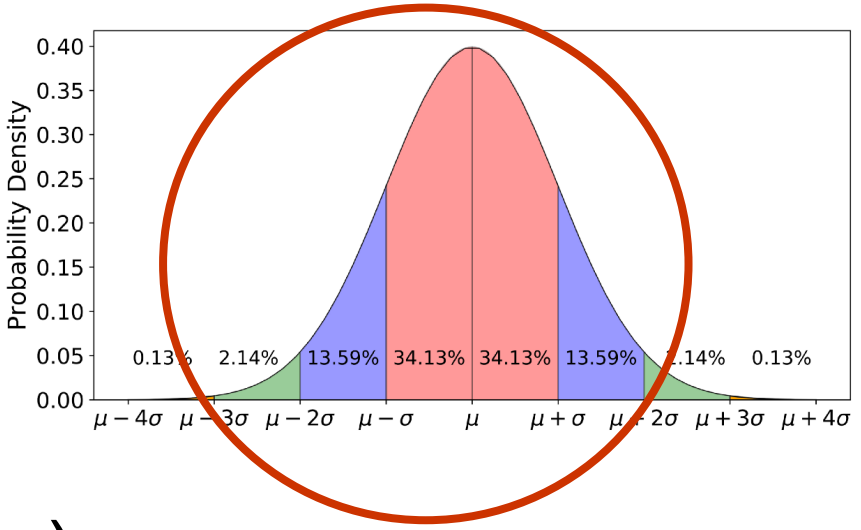


1. Lit search for all essential minerals and vitamins
2. Validity of NRC 2001 requirements was evaluated
3. Equations and absorption changed when appropriate
4. Determined whether ‘Requirement’ or ‘Adequate Intake’

‘Requirements’ vs Adequate intake



Requirement

- ✓ Adequate data to establish average requirement
- ✓ Reqt meets 50% of population
- ✓ Human RDA = Reqt + 2 SD (98% of pop.)
- ✓ SD usually unknown so RDA = Reqt x 1.2

Adequate Intake (AI)

- ✓ Inadequate data to quantify with high confidence
- ✓ Based on expert opinion: *“if most cows eat this much, they will probably be ok”*

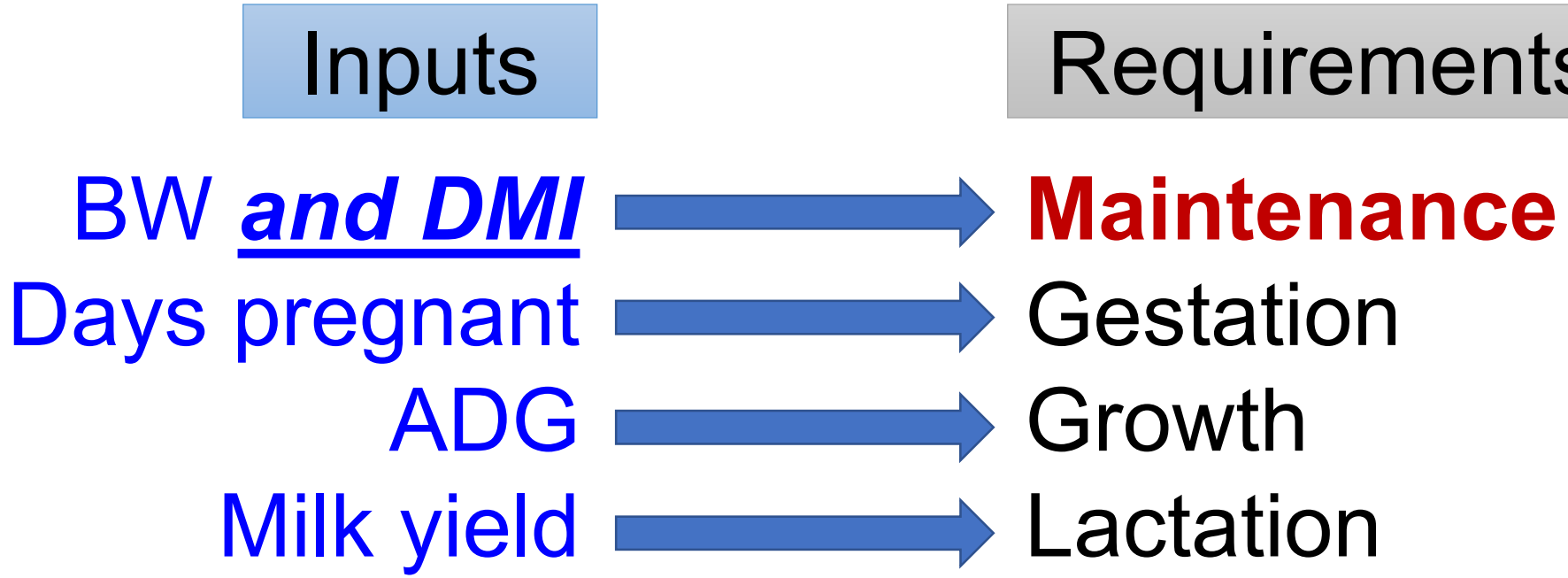
Factorial system for requirements and some AI

$$\text{Reqt} = \frac{\overbrace{(\text{EF} + \text{EU})}^{\text{Maintenance}} + \text{Milk} + \text{Growth} + \text{Fetal}}{\text{Absorption Coefficient}}$$

Key Points

- ✓ Animals assumed to be in good status and healthy
  - Status improvement not included
  - No ‘health requirement’ included
- ✓ Requirement model, not response function

NASEM 2021 Factorial Approach

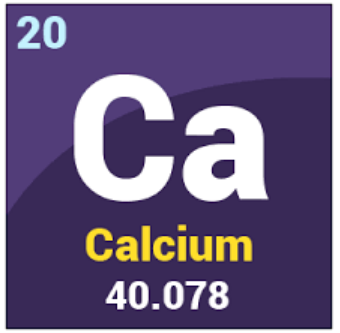


1. Often changed maintenance
2. Minimal/no changes in growth and gestation
3. Improved estimates of TM concentrations in milk

Calcium (Changed maintenance, lactation, and AC)

- **NRC (2001) Absorbed**
  - Maint = 0.0154 (nonlact) or 0.031 (lact) g/kg BW
  - Milk = 1.22 (H) or 1.45 (J) g/kg milk

- **NASEM (2021) Absorbed**
  - Maint = 0.9 x DMI (kg)
  - Milk = 1.03 (H) to 1.13 g/kg milk (function of milk protein)



Absorbed Ca Reqt

	2001	2021	
1600 lb dry cow, 27 lbs DMI			
Maint, g/d	11.2	11.0	
1500 lb cow, 90 lbs milk, 55 lb DMI			
Maint, g/d	21.1	22.5	
Milk, g/d	49.9	42.1	
Total, g/d	71.0	64.6	(-9%)

Dietary Requirements = TAS/AC
NASEM also evaluated AC

NRC Calcium Absorption Coefficients (AC)

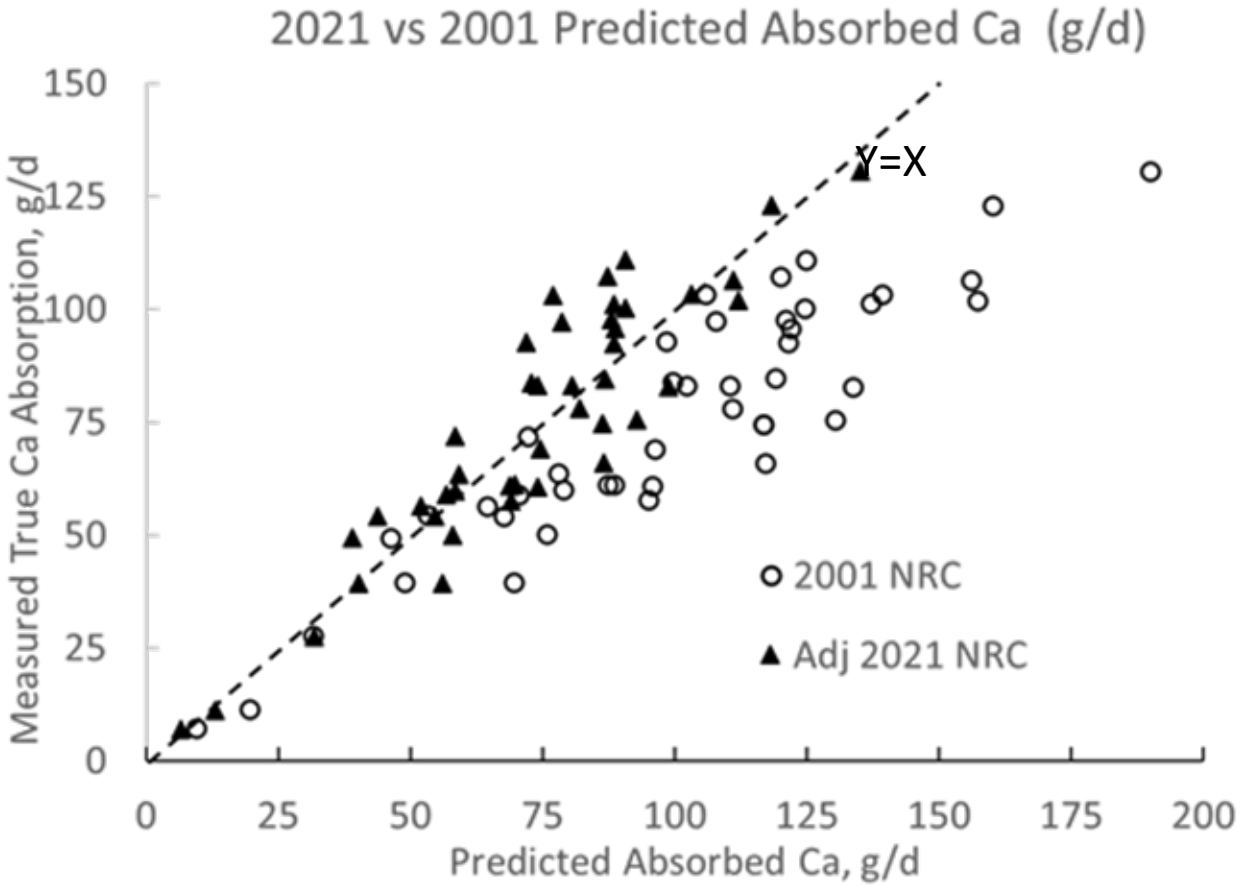
Year	Basis	AC
1989	Diet	0.38
2001	Ingredient	**0.60**
2021	Ingredient	**0.45**

Main problem was with 2001:

- AC for $CaCl_2$ (0.90) was from calves, but in weaned calves, AC was 0.60
- Most supplement AC calculated relative to $CaCl_2$

Ingredient Ca AC (2001 vs 2021)

Ingredient	2001	2021
Ca Carbonate	0.75	0.50
Limestone	0.70	0.45
Dical	.94	0.60
Ca Chloride	0.95	0.60
Alfalfa	0.30	0.40
Corn silage	0.30	0.40
Concentrates	0.60	0.60
Typical diet	**~0.53**	**~0.43**



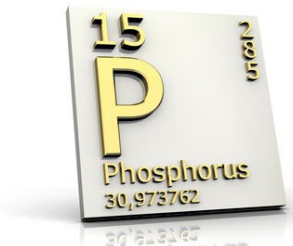
Dietary Ca Reqt

1600 lb dry cow, 27 lbs DMI	**2001**	**2021**
Total, g/d	36	38 (+5%)

1500 lb cow, 90 lbs milk, 55 lb DMI		
Total, g/d	144	150 (+4%)

Dietary Requirements changed very little

Phosphorus



- Absorbed requirements tweaked (very small changes)
- Absorption coefficients of supplements not changed
- AC for feeds based on inorganic/organic fractions
  - Inorganic P AC = 0.84
  - Organic P AC = 0.68
  - No fraction data AC = 0.72
- **Dietary Requirements will change very little**

NASEM (2021) recommends labs offer inorganic P assay to improve accuracy of AC estimates

Magnesium: Absorbed Requirement was Increased

- ✓ **Maintenance**
  - **NRC(2001):** 3 mg/kg BW or **2.0 g** for 1500 lb cow
  - **NASEM:** 0.7 mg/kg BW + 0.3 g/kg DMI
    - 1500 lb dry cow eating 26 lbs = **4.1 g**
    - 1500 lb lactating cow eating 55 lbs = **7.9 g (+5.9 g/d)**
- ✓ **Milk**
  - **NRC (2001):** 0.15 g/kg (highest reported lit value)
  - **NASEM:** 0.11 g/kg (mean of reported values)
  - 100 lbs of milk = **6.8 vs 5.0 g/d (-1.8)**
  - **Total change = +4.1 g/d for high cow**

Magnesium AC

- ✓ **NRC(2001)**
  - Basal: Calculated at 0.3 but set at 0.16 (-1 SD)
  - MgO (assumed high qual): 0.7
  - $MgSO_4$: 0.9
  - Total diet (75% basal, 25% MgO) = 0.295
- ✓ NASEM
  - Basal: 0.31 @1.2% K
  - Adjusted downward based on diet K
  - MgO: 0.23 @1.2%K
  - MgSO4: 0.27 @1.2%K
  - Total diet (75:25) = 0.29

Magnesium: Dietary Requirement

- ✓ **NRC (2001)**
  - Dry cow: **8 g**
  - 100 lb cow: **29 g**

- ✓ **NASEM**
  - Dry cow (1.7% K): **15 g (~2X)**
  - 100 lb cow (1.3% K): **52 g (1.8X)**

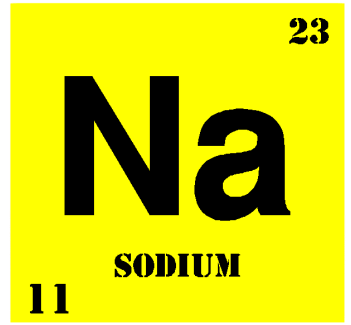
Potential benefits of high Mg on hypocalcemia are not included

The Electrolytes: K, Na, Cl and DCAD

- K, Na, and Cl act as strong ions (fully dissociated)
- Major role in regulating osmotic pressure
  - **Includes rumen, intestinal and fecal water balance**
- **Regulators of rumen and urine pH**
- Homeostatic regulation at kidney, not gut

The factorial system doesn't include the value of altering water flux or rumen pH

Sodium



- 137 Balance Studies

  Absorbed Na, g/kg DM = **-1.45** + **0.98** Diet Na, g/kg DM

- Implied AC = 0.98; Dietary AC set to 1.0 (NRC 2001 = 0.90)

Requirement	2001 NRC	2021 NASEM
Endogenous Urinary, g/kg BW	0.015, 0.038 (heifers, cows)	NA
Metabolic Fecal Na, g/kg DMI	NA	**1.45**

- Na maintenance increased by 10-15 g/d in lactating cows
- Growth and pregnancy: no change

Sodium

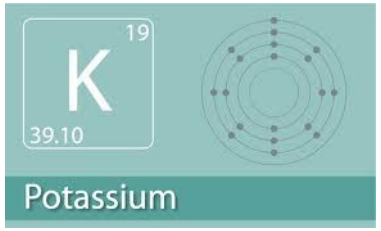
Lactation

- 2001 Milk Na = 0.65 g/kg, based on 1965 ARC estimate
- Literature since 2001 (bulk tank and research pubs) = 0.41 g/kg
- Milk Na correlated with mastitis (a lot less mastitis now)

Milk Na requirement set at 0.40 g/kg
Decreased lactation requirements by 6 to 12 g/d

Equations changed a lot but little overall change in dietary requirements

Potassium



- 149 Balance Studies

  Absorbed K, g/kg DM = -2.48 + **1.02** Diet K, g/kg DM

- Dietary AC set to 1.0 (NRC 2001 = 0.90)

Requirement	2001 NRC	2021 NASEM
Endogenous Urinary, g/kg BW	0.038	0.20[1]
Metabolic Fecal, g/kg DMI	6.10	2.5

[1] Added for lactating cows diet K to at least 1.0 and 0.6% of diet DM, respectively

1500 lb cow eating 55 lbs: Dietary Maint 198 vs 199 g/d (2001 vs 2021)

- Growth- Increased from 1.6 to 2.5g/kg BWG
- Pregnancy and lactation: no change

Chloride

- 144 Balance Studies

  Absorbed Cl, g/kg DM = -1.11 + 0.92 Diet Cl, g/kg DM

- Dietary AC set to 0.92 (NRC 2001 = 0.90)

Requirement	2001 NRC	2021 NASEM
Endogenous Urinary Cl, g/kg BW	0.0225	NA
Metabolic Fecal Cl, g/kg DMI	NA	1.11

Increased Maintenance requirement by 10-15 g/d

- Growth and pregnancy: No change

Chloride

Lactation

- 2001 Milk Cl = 1.15 g/kg, based on 1965 ARC estimate
- Literature since 2001 (bulk tank and research pubs) = 1.0 g/kg
- Milk Cl correlated with mastitis; better udder health justifies lower value
- Milk Cl set at 1.0 g/kg

Cow at 100 lbs/d total Cl requirement is 4-8 g/d greater in NASEM vs NRC 2001

DCAD Requirement [(Na+K) – (Cl+S)]

- Low DCAD (less than 175 mEq/kg DM; Ender (DCAD-S)
  - Metabolic acidosis (low urine pH)
  - Decreased DMI (Hu and Murphy 2004)
  - Decreased rumen pH
  - Reduced milk fat
- Minimum DCAD requirement set at minimum requirements for K, Na, Cl, and S (~175 mEq/kg)
- **Economic** optimal DCAD is considerably higher depending on value of increased milk and milk fat (Iwaniuk and Erdman, 2015)

Heat Stress and Electrolytes

- NRC (2001) increased Na about 35 g/d and K about 3 g/d when temp > 85F

- NASEM has no allowance for heat stress
  - Available data shows sweating causes very low losses
  - Production data not highly supportive
  - Questions about quantifying heat stress and heat abatement practices

Trace minerals

- Factorial approach retained for most TM (is this appropriate?)
- **Requirements** set for:
  - Cu
  - Zn
- **AI** set for:
  - Co
  - Fe
  - Mn
  - Se
- Extensive search for additional AC data

AC changed when new data were found

NRC 2001

Cu: 0 to 0.05

Basal: 0.04

Fe: 0.01 to 0.20

Basal 0.10

Mn: 0 to 0.01

Basal 0.0075

Zn: 0.1 to 0.20

Basal 0.15

NASEM 2021

Cu: 0.001 to 0.05

Basal: 0.05

Fe: 0.01 to 0.20

Basal 0.10

Mn: 0.002 to 0.005

Basal 0.004

Zn: 0.16 to 0.20

Basal 0.20

Notes about AC values

- Extremely difficult to measure
- Endogenous fecal and AC can be correlated (changing one often changes the other)
- AC for individual feeds not needed but more data on AC for mixed diets is needed
- Still very limited incorporation of antagonist relationships (eg, Cu and S; Cu, S and Mo, etc.)

Things that didn't change

- **Iron (AI)**
  - No change
  - Supplementation almost never needed)

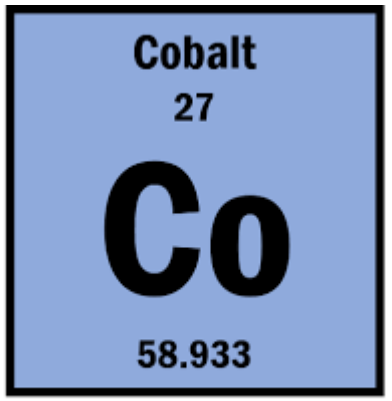
- **Selenium (AI)**
  - AI is set at 0.3 mg supplemental/kg DMI
  - FDA regulation
  - No indication more is needed for lactating cows

Things that didn't change much

- **Chromium**
- No AI or requirement established
  - Limited titration data
  - Limited basal diet data (total intake is usually unknown)
  - *But* production response likely at ~6 mg/d

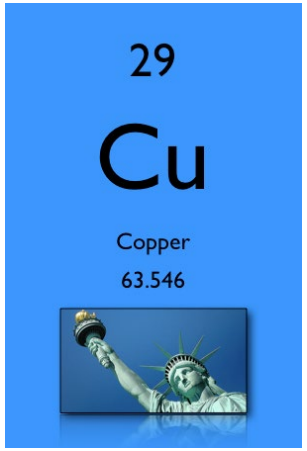
- **Iodine (AI)**
  - AI is about 0.5 mg/kg DMI (~0.4 mg/kg DMI in 2001)
  - Milk I is included in AI

Changes from 2001



- **Cobalt (AI)**
  - AI = 0.2 mg/kg DMI (0.11 in NRC, 2001)
  - Based on newer data
  - Multiple response variables gave variable AI but all at least 0.2 mg/kg
  - Data on basal concentrations extremely limited

Major Changes from 2001



- **Copper**
  - Maintenance increased about 2X (AC also higher)
  - Lactation reduced from 0.15 to 0.04 mg/kg
  - For cow at 35 kg/d milk little change (~11 mg/kg; 240 mg/d)
  - Dry cow ⇧ ~40% (~17 mg/kg; 205 mg/d)
  - High producing cow: ⇩ ~45% (~9 mg/kg; 260 mg/d)

Although excess Cu intake is a concern, it was not caused by NRC 2001 overestimating requirements

Major Changes from 2001

- **Manganese (AI)**
  - Data with pregnant beef heifers suggested NRC 2001 could result in clinical deficiencies in newborn calves
  - Maintenance increased ~30% (very limited new data)
  - AC for feeds reduced from 0.75 to 0.4% (more data)
  - Dry cow: ↑ **~40 mg/kg DMI** vs 19 in 2001
  - Average lactating cow: ↑ **~30 mg/kg DMI** vs 13 in 2001

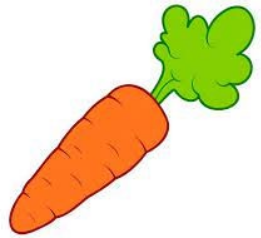
Major Changes from 2001

- **Zinc**
  - Maintenance based on DMI and is greater than 2001
    - Minor affect on dry cows, larger effect on high cows
  - AC for basal feeds increased from 0.15 to 0.20
  - Dry cow: **~28 mg/kg DMI** vs. 25 in 2001 (~⬆10%)
  - High producing cow: **~60 mg/kg DMI** vs. 52 in 2001 (~⬆15%)

Vitamins

- AI not requirements
- AI established for vitamins A,D, and E
- Water soluble vitamins reviewed extensively but no AI established
  - Often data from single commercial product
  - Economic response rather than nutrient requirement
  - Titration data lacking

Vitamin A



- ✓ AI is supplemental. Grazing cattle need less, not quantified
- ✓ AI for dry cows, growing heifers and lactating cows <35 kg/d: **110 IU*BW**
  - No evidence suggesting that NRC 2001 was incorrect
  - Most old data from cows <35 kg/d and cows secrete about 1000 IU/kg milk
- ✓ AI for cows >35 kg milk/d : **110*BW + (1000*(milk-35))**
- ✓ AI for prefresh same as dry cow, no data indicating benefits of feeding more

Vitamin D

- ✓ AI is supplemental. Discussion on value of sun exposure
- ✓ Standard IU conversions used but data strongly suggest D_2 only worth ~50% of D_3
- ✓ In NRC 2001, AI based almost exclusively on Ca metabolism
- ✓ In 2021 data on immunity and general health considered
  - Response variable was blood 25-OH vit D $\geq$ 30 ng/ml
- ✓ AI maintained at **30 IU/kg BW** for heifers and dry cows
- ✓ AI increased to **40 IU/kg BW** for lactating cows (assumed D_3)

Vitamin E

- ✓ AI is supplemental with adjustment for grazing
- ✓ Bioactivity (IU/mg) increased for *RRR* relative to *all-rac*
- ✓ AI for dry cows maintained at **1.6 IU/kg BW** (~1100 IU/d)
- ✓ AI for lactating cows and heifers maintained at **0.8 IU/kg BW**
- ✓ AI for prefresh (2-3 wk pre) set at **3 IU/kg BW** (2100 IU/d)

Summary: TM and Vitamins

	Heifer	Dry cow	Lactating cow
Co	↑	↑	↑
Cu	↔	↑↑	↔ ↓
Fe	↔	↔	↔
Mn	↑↑	↑↑↑	↑↑↑
Se	↔	↔	↔
Zn	↔	↑	↑
Vit A	↔	↔	↔ ↑
Vit D	↔	↔	↑
Vit E	↔	↔ ↑	↔

Needed Research:

- Sensitive and specific response measures needed
- Data on growing heifers almost non-existent
- MTL for vitamins need re-evaluation
  - Human data suggest lower MTL for vit A
  - Limited data suggest lower MTL for vit E
- Should we use response model rather than production model (e.g., DCAD, Cr, biotin, choline …)
- Quantify antagonism/more AC data

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