Mineral and Vitamin Supplementation of the Cow-calf Herd

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Functions of Minerals & Vitamins

- Bone formation
- Immune function
- Enzyme co-factors
- Nervous system
- Antioxidant
- Hemoglobin
- Cell membranes
- Muscle contraction
- Energy metabolism
- RNA and DNA
- Digestion
- Blood clotting
- Hormone synthesis
- Several other biological processes

Minerals

Ruminant Mineral Deficiencies

- Tropical regions – McDowell 1997
  - Calcium, magnesium, selenium, phosphorus, potassium, sodium, sulfur, cobalt, copper, iodine, iron, manganese, zinc
- United States – similar to those listed above

Deficiency or Imbalance?

- In some instances mineral imbalances result in deficiency
  - Ex. Cation/Anion balance believed to be important for prevention of milk fever in dairy cows
  - Ex. Minerals antagonsitic to one another

Antagonistic Minerals

- Copper deficiencies result of
  - Sulfur & Molybdenum forming thiomolybdates that bind copper (Suttle, 1991)
  - Iron believed to form ferrous sulfide complex that dissociates in the abomasum and binds copper making it unavailable (Suttle et al., 1984)

Soil Mineral Levels

Tropical soils – Miller and Reetz, 1995

- Low in phosphorus & calcium
  - Resulting in low soil pH
- High in aluminum, manganese, & selenium
  - Resulting in formation of insoluble phosphorus complexes with other trace minerals as well

Mineral availability and soil pH

Mineral	4.0	5.0	6.0	7.0	8.0	9.0
Nitrogen	Low	Low				Low
Phosphorus	Low					
Potassium	Low	Low				
Sulfur	Low	Low				
Calcium	Low	Low	Low			
Magnesium	Low	Low	Low			
Iron					Low	Low
Manganese	Low				Low	Low
Boron	Low				Low	Low
Copper & Zinc	Low				Low	Low
Molybdenum	Low	Low	Low			

Adapted from Miller and Reetz, 1995

United States

- Mineral deficiencies vary by region/soil type
- Intensive agricultural production has resulted in soil accumulation of some minerals resulting in water quality issues
  - Regulations regarding production practices
    - Incorporation of manure during application
    - Limitations on application rates

Production Practices

- Injectable mineral solutions
- Mineral supplementation
- Forage fertilization

Se Status by Region in U.S.

	Se Supplemented			Non-Supplemented		
Status	West	Central	Southeast	West	Central	Southeast
Severe	4.4	0.0	16.7	4.9	7.9	29.1
Moderate	8.0	3.6	23.3	4.4	9.2	32.0
Adequate	20.3	30.9	40.9	13.1	36.4	30.8
High	67.3	65.5	19.1	77.6	46.5	8.1

Dargatz and Ross, 1996

Fertilizer Effects on Forage Content

- Selenium fertilizer applied at 10 g/ha compared with 52 ppm salt-mineral suppl.
- Forage Se levels
  - Non-fertilized = 0.033 ppm
  - Se-fertilized = 0.225 ppm
- Blood Se levels
  - Fertilized forage = 0.469 ppm
  - Salt-mineral mix = 0.170 ppm

Hathaway et al., 2001

Phosphorus Fertilization

	Phosphorus Fertilization rate, kg/ha			
	0	2.5	5	15
	P level in Buffel grass (g/kg DM)			
Jan.	1.3	1.9	2.3	2.8
April	1.3	1.7	2.4	2.7
July	0.7	1.2	1.7	2.4
	Growth rate of steers over 15 mo., kg/d			
ADG	0.33	0.40	0.46	0.50

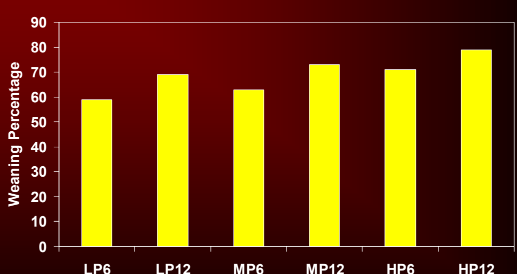
McClean and Ternouth, 1994

Phosphorus and Steer Gain

		Liveweight Gain, kg	
	Forage P, g/kg	Total	ADG
Yaragua grass	1.4	71.3[c]	0.182[c]
Yaragua & Stylo legume	1.6	160.3[b]	0.409[b]
Yaragua, Stylo, & P	1.6	189.5[a]	0.488[a]

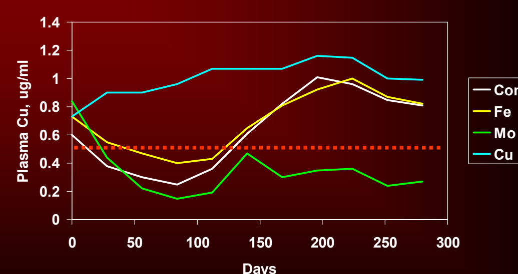
Echevarria et al., 1987

Phosphorus and Reproduction



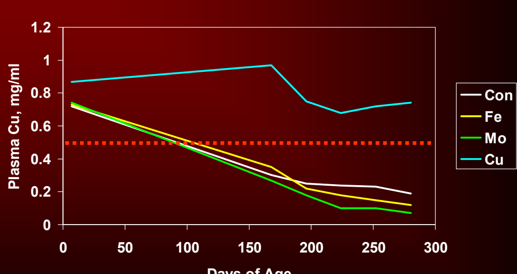
deWaal et al., 1996

Cu Status of 2-year old Heifers Consuming Fe or Mo



Gengelbach, et al., 1994

Cu Status of Calves from 2-year old Heifers Consuming Fe or Mo



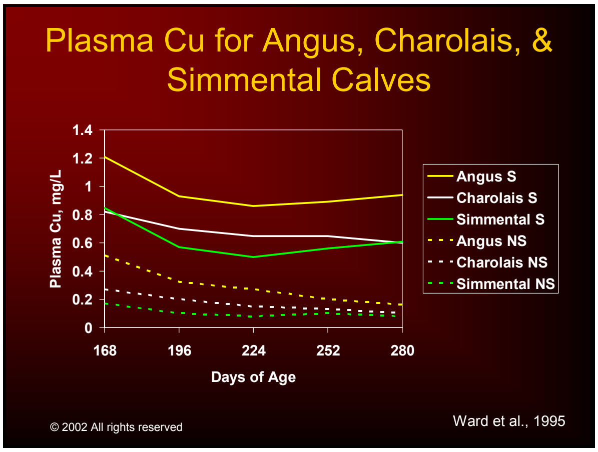
Milk poor Cu source = 1 mg/kg

Gengelbach, et al., 1994

Milk Cu and Zn Levels

	Colostrum, mg/L		Milk, mg/L	
Item	N	Mean	N	Mean
<u>Cu</u>				
Con	15/25	0.30	1/5	0.12
Inorganic	14/25	0.30	1/8	0.01
Organic	14/25	0.22	3/8	0.24
<u>Zn</u>				
Con	25/25	27	5/5	5.5
Inorganic	25/25	30	8/8	4.8
Organic	25/25	32	8/8	4.6

Muehlenbein et al., 2001


Plasma Cu for Angus, Charolais, & Simmental Calves
Plasma Cu, mg/L
1.4
1.2
1
0.8
0.6
0.4
0.2
0
168
196
224
252
280
Days of Age
Angus S
Charolais S
Simmental S
Angus NS
Charolais NS
Simmental NS
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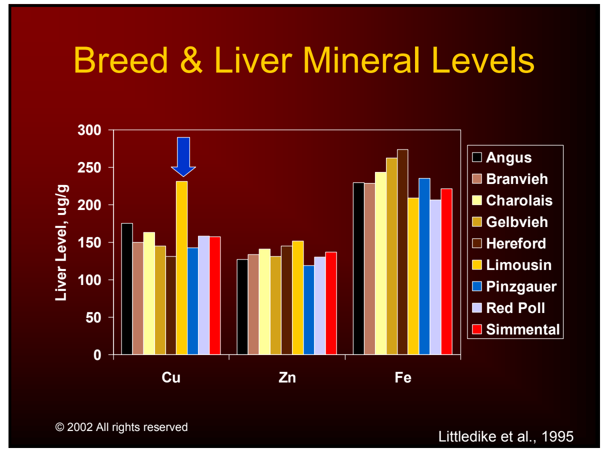
Ward et al., 1995


Breed & Liver Mineral Levels
Liver Level, ug/g
300
250
200
150
100
50
0
Cu
Zn
Fe
Angus
Branvieh
Charolais
Gelbvieh
Hereford
Limousin
Pinzgauer
Red Poll
Simmental
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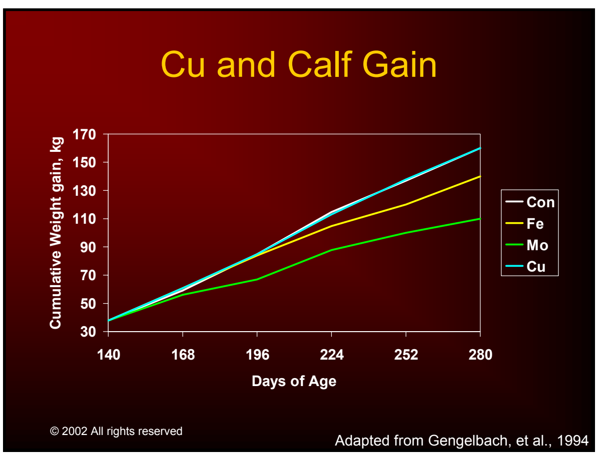
Littledike et al., 1995


Cu and Calf Gain
Cumulative Weight gain, kg
170
150
130
110
90
70
50
30
140
168
196
224
252
280
Days of Age
Con
Fe
Mo
Cu
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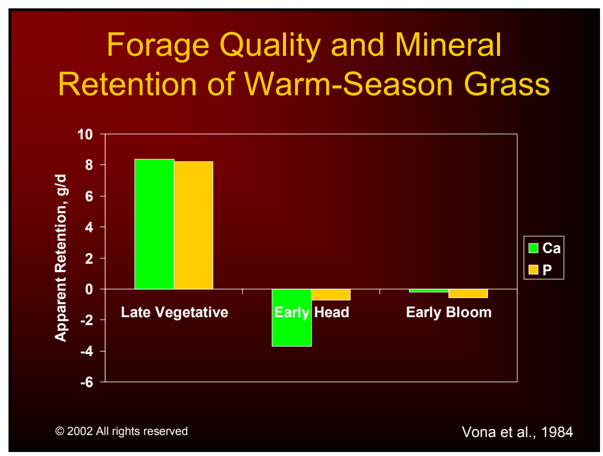
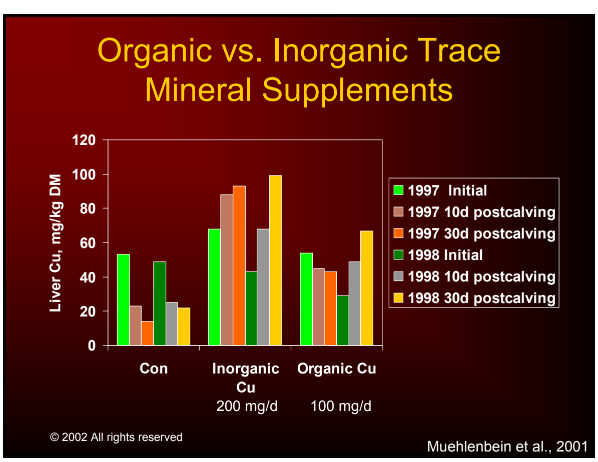
Adapted from Gengelbach, et al., 1994


Forage Quality and Mineral Retention of Warm-Season Grass
Apparent Retention, g/d
10
8
6
4
2
0
-2
-4
-6
Late Vegetative
Early Head
Early Bloom
Ca
P
© 2002 All rights reserved
Vona et al., 1984


Organic vs. Inorganic Trace Mineral Supplements
Liver Cu, mg/kg DM
120
100
80
60
40
20
0
Con
Inorganic Cu
200 mg/d
Organic Cu
100 mg/d
1997 Initial
1997 10d postcalving
1997 30d postcalving
1998 Initial
1998 10d postcalving
1998 30d postcalving
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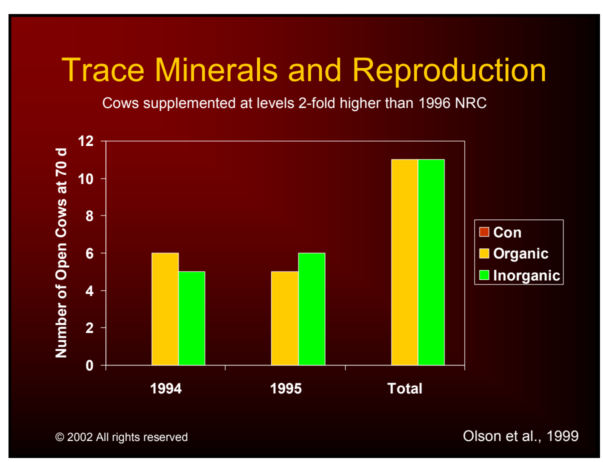
Muehlenbein et al., 2001


Trace Minerals and Reproduction
Cows supplemented at levels 2-fold higher than 1996 NRC
Number of Open Cows at 70 d
12
10
8
6
4
2
0
1994
1995
Total
Con
Organic
Inorganic
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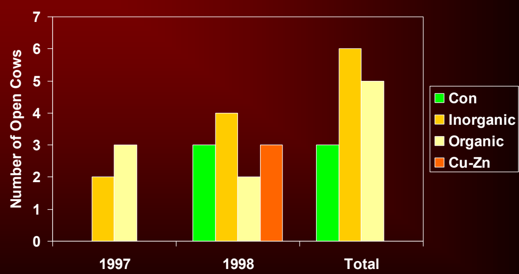
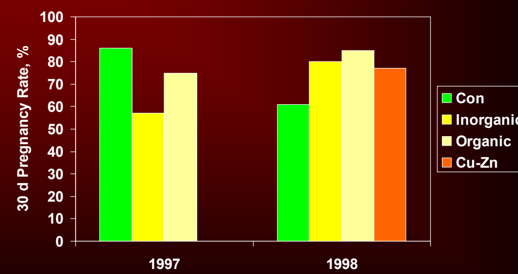
Olson et al., 1999

Open Cows and Trace Minerals



Muehlenbein et al., 2001

Reproduction & Trace Minerals



Muehlenbein et al., 2001

Other Responses

- Zinc – may assist in immune function of newly arrived feedlot cattle
- Copper – may alter fatty acid metabolism resulting in increased polyunsaturated fatty acids, lower backfat cover, and similar intramuscular fat content

Vitamins: Recent Advances

Water Soluble Vitamins

- Deficiencies are not common
- Rumen microflora synthesize most of these vitamins in sufficient quantities
- Stress, low rumen pH, high sulfur, low cobalt, moldy clover – may result in deficiencies

Fat Soluble Vitamins

- Important to remember that vitamins are “delicate compounds”
- UV light may destroy them – stored out of the sun
- Can be oxidized easily – do not store mixed with minerals
- Harvested forages such as silage and hay can have lower levels of the vitamins than expected

Vitamin A

- Beta-carotene from forage
  - Jersey cattle have lower enzyme activity resulting in yellowing of the fat
  - UV light can destroy and should be a concern with harvested forage
  - Common practice to supplement grazing cattle with vitamin A for prevention of pink eye

Vitamin D

- Animal synthesizes with a reaction involving the skin and UV light
- Generally not a concern unless animals are confined and do not have access to the sun
- Important for the absorption of Ca from the gut

Vitamin E

- Found in the chloroplasts of plants
- Generally not a concern for grazing animals
- Important for membrane integrity, immune function, and prevention of white muscle disease in combination with Se

Supranutritional Levels

- Supplementing animals well above the requirement
- Carcass quality / Meat quality
  - Ex. Color stability of meat during display is increased with Vitamin E (Arnold et al., 1992)
  - Ex. Water holding capacity and tenderness increased for longissimus muscle with 6X10^6 IU/d of Vitamin D (Karges et al., 2001)

Vitamin D: Tenderness

Strip Loin Shear Force, kg				
Aging	Control	5X10^6 IU/d	7.5X10^6 IU/d	P
3	3.58	3.11	3.17	0.16
7	3.32	3.20	2.89	0.19
14	3.25[a]	2.80[b]	2.78[b]	0.002
21	3.38	2.90	3.02	0.11

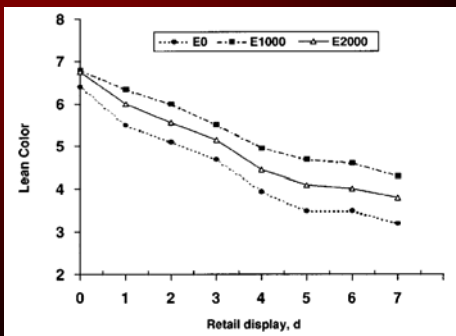
Montgomery et al., 2000

Vitamin D: Tenderness

Item	Control	5X10^6 IU/d	P
Ca, ug/g	13.9	19.9	0.05
7 d shear, kg	4.70	4.12	0.01
14 d shear, kg	4.03	3.87	NS
21 d shear, kg	3.58	3.60	NS

Swanek et al., 1999

Vitamin E: Shelf-Life



Sanders et al., 1997

Other responses

- Vitamin A / Beta carotene and reproduction ??
- Choline – does not appear to improve feedlot cattle performance
- Vitamin E – may improve reproduction and immune function

Conclusion

- Mineral deficiencies many times are a result of low soil fertility
- Mineral imbalances may also result in deficiencies
- Supplementation with organic vs. inorganic may depend on the severity of the deficiency

Conclusion

- Vitamin deficiencies may occur as a result of rumen disorders and mineral deficiencies
- Forage quality and type should be considered with vitamin supplementation

Thank You

Questions??