



Trace mineral supplementation in Beef Cattle

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Overview

- What are trace minerals?
- What do they do?
- Some myths about trace mineral supplementation
- Important minerals
 - Copper / Molybdenum
 - Selenium
 - Zinc
 - Sulfur
- Considerations for supplementation
 - How do I know I need to supplement?
 - How to supplement
 - How to read the labels for mineral supplements
 - Injectables
- Summary

What are trace minerals

• Required in traces:

- mg/kg or µg/ kg dry matter intake

- Cobalt (Co)
- Copper (Cu)
- Iodine (I)
- Iron (Fe)
- Manganese (Mn)
- Molybdenum (Mo)
- Selenium (Se)
- Zinc (Zn)

Macrominerals:

- Salt (NaCl)
- Calcium (Ca)
- Phosphorus (P)
- Magnesium (Mg)
- Sulphur (S)

Required at > 0.1% of the diet
 g/kg dry matter intake
 = 1 g/kg = 1000 mg/kg
 1,000,000 µg/kg

What do they do? – e.g. Copper

Immune system:

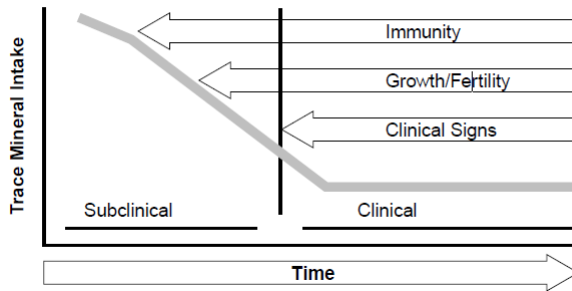
- DNA configuration

➔ Rapid cell expansion

- Antioxidant function
 - Helps fend off toxic substances
- Connective tissue
- Nutrient metabolism
- Reproduction

Trace mineral function

Figure 1. Trace Mineral Functions



Wikse, 1992 Texas A&M Veterinary Beef Cattle Short Course

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Types of deficiency

Primary deficiency

- Not enough intake
- Often requires extended period for development

Secondary deficiency

- Impaired absorption, distribution or retention
- Antagonism (Mo – Cu)

One deficiency often combined with others

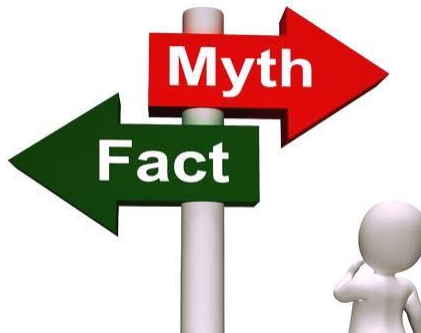
One deficiency impairs organ function => requirements for other nutrients go up

Low copper => diarrhea => malabsorption of other nutrients

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Mineral Myths



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Appetite for minerals

- Not an indication for mineral needs:
 - Overconsumption of free-choice (2-week supply consumed in 1 week)
 - Additional mineral can be withheld for second week
 - Overconsumption may lead to inefficiency and wasted money

- Underconsumption of free choice minerals
- May need to be altered to improve palatability

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Do plants grown in one area contain the same amount of trace minerals?

- Mineral concentrations depends on
 - Plant species - legumes vs grasses
 - Soil characteristics – e. g. pH -> mineral uptake
 - ↑pH ↑ Mo ↓ Co, Zn, Cu
 - Soil fertility
 - Stage of plant maturity – mineral uptake declines as plant matures
 - Climactic conditions

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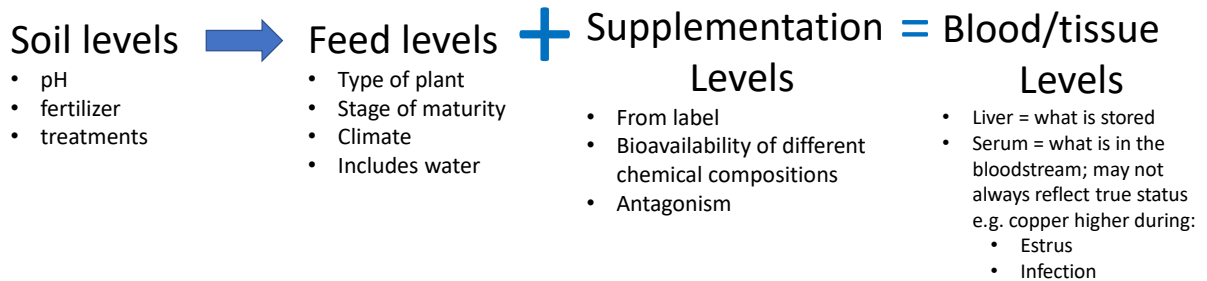
Legumes vs grasses when grown in same soil

- | | |
|---|--|
| <ul style="list-style-type: none"> • Legumes higher in: <ul style="list-style-type: none"> • CA • K • Mg • Cu • Zn • Fe • Co | <ul style="list-style-type: none"> • Grasses higher in: <ul style="list-style-type: none"> • Mn • Mo |
|---|--|

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Contributors to trace mineral status



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Most important trace minerals in beef cattle

Copper

Molybdenum

Selenium

Zinc

Rare deficiencies:

Manganese, iron,
Cobalt, iodine

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Which ones are typically not a problem?

- Fe = Iron
 - Problems from parasite infestation or blood loss
 - Anemia, decreased weight gain
 - Iron oxide (FeO) often added for color.
 - Not readily available as iron source
 - Can exacerbate low Cu
- Mn = Manganese
 - Bone abnormalities in calves, subfertility
- Co = Cobalt; forms Vitamin B12
 - Diarrhea, anemia
- I = Iodine
 - Goiter, stillborn, hairless calves
 - 50 mg / head /day legal max. of ethylenediamine dihydroidide (EDDI)

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Problem minerals - Copper

- Requirement: 10 mg/kg = 10 ppm of diet (depends on Mo, S and Fe in diet)
 - Adequate if < 0.25% Sulfur and < 2 ppm Molybdenum and < 400 ppm Iron (mg/kg DM) in forage.
- Deficiency often due to antagonism:
 - Sulphur, Molybdenum, Iron
 - Breed differences: Simmental and Charolais > Angus (20 – 50% higher requirements)

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Signs of deficiency

- Copper
 - Affects all stages of growth and production
 - Connective tissue problems: bones, blood vessels => growth failure
 - Depigmented hair => first sign – reddish Angus, yellow Hereford
 - Anemia
 - Infertility
 - Diarrhea
 - Often won't see anything but calves getting sick after weaning and shipping

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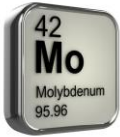
Supplementation

- In mineral mix:
 - Inorganic as sulfate, carbonate or oxide form
 - Availability: sulfate > carbonate >> oxide
 - Organic forms (proteinate)
- Bolus:
 - Copper oxide needles
 - Up to 12 months
- Injectable:
 - Copper glycinate
 - Prescription only, caustic, lumps
 - 4 – 6 months

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Problem mineral - Molybdenum



- Importance is due to antagonism of copper
- Minimum requirements unknown
- Want >4.5:1 Cu : Mo ratio (e.g. >9 ppm copper: 2 ppm molybdenum)
- Increased Cu requirements if Mo is > 2 ppm and S > 0.25%

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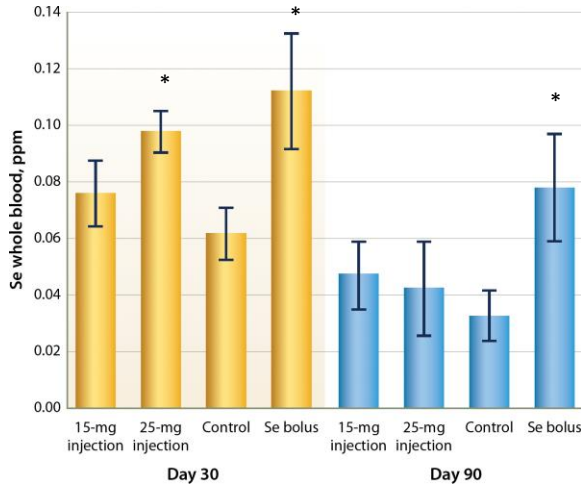
Problem minerals – Selenium

- Interrelated with Vitamin E
(if Vit. E low => need more Se)
- Small window of safety
- Se is regulated to be ≤ 0.3 ppm of the diet
 - Due to fear of carcinogenicity and toxicity, FDA regulated
 - **Do not exceed 3 mg per head/day**
 - Bolus provides 3 mg or less – available from CCA
- Supplement with care
 - Toxic levels (lameness, deformed hoofs, loss of tail hair)
- Deficiency: early embryonic death, retained placenta, weak calves
- If severe deficiency: white muscle disease

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Comparing forms of Se supplementation



Davy et al. 2016 Efficacy of selenium supplementation methods in California yearling beef cattle and resulting effect on weight gain, California Agriculture 70(4): 187-193

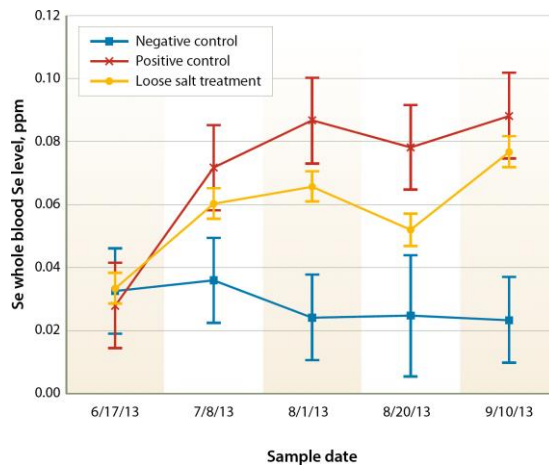
15 mg injection = Mu-Se
25 mg injection = Multimix

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Comparing forms of Se supplementation

Positive control = Se bolus



Davy et al. 2016 Efficacy of selenium supplementation methods in California yearling beef cattle and resulting effect on weight gain, California Agriculture 70(4): 187-193

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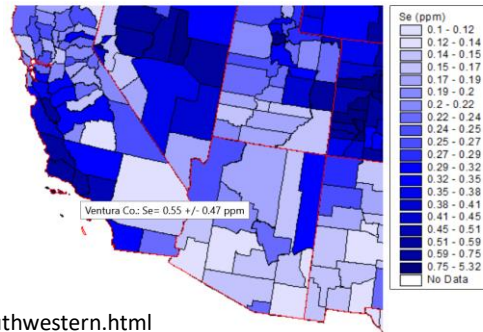
Average concentrations of elements in Ventura County, California

[Counties page](#) > [Se in Conterminous US](#) > [Se in southwestern US](#) > Averages in Ventura County (Calculated from cells in the geochemical grid plotting in this area.)

Element	Symbol	Mean	Std. dev.	Minimum	Maximum
Aluminum	Al (wt%)	6.998	0.538	4.101	8.416
Arsenic	As (ppm)	6.175	2.614	1.259	30.241
Calcium	Ca (wt%)	3.285	1.709	0.682	12.820
Copper	Cu (ppm)	25.085	8.764	4.889	58.066
Iron	Fe (wt%)	3.286	1.290	0.715	9.034
Mercury	Hg (ppm)	0.064	0.034	0.022	0.232
Magnesium	Mg (wt%)	1.123	0.604	0.238	3.649
Manganese	Mn (ppm)	562.276	229.450	163.548	1487.760
Sodium	Na (wt%)	1.969	0.274	1.188	2.565
Phosphorus	P (wt%)	0.091	0.036	0.041	0.348
Lead	Pb (ppm)	18.162	12.134	5.457	109.380
Selenium	Se (ppm)	0.552	0.467	0.100	2.659
Titanium	Ti (wt%)	0.430	0.148	0.180	1.146
Zinc	Zn (ppm)	67.327	22.295	16.600	150.947

[Click here to download point data](#)

Selenium in Counties of the Southwestern US



Selenium in the Counties of the Conterminous States

USGS webpage

<https://mrddata.usgs.gov/geochem/doc/averages/se/southwestern.html>

(Hold the mouse over a county to view the concentration of the element; click on a county to retrieve all geochemical data within the county.)

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Problem mineral - Zinc

- Requirement; 30 mg/kg DM
- Deficiency: reproductive problems, especially males, hoof integrity compromised, delayed wound healing, hair loss
- Do not exceed total dietary requirement
- Oversupply of zinc can interfere with copper storage (keep ratio Zn:Cu at 3:1)

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Problem minerals – Sulfur toxicity

- Polioencephalomalacia – neurological signs
 - Want dietary sulfur max
 - < 0.15% ideal
 - Want Water sulfate levels max
 - 600 mg/L **sulfate**
- Subclinical toxicity
 - Binds Copper
 - Lowers Selenium digestibility
 - Reduces Manganese and Copper and Zinc retention

Pogge et al., 2014 JAS

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Sources of Sulfur

- Molasses
- Distillers grains and other ethanol production byproducts
- Feathermeal
- Water

- Forage – usually not a source of excess S
 - Ammonium sulfate fertilizers can contribute

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California survey

Mineral	Adequate blood / serum level	% below adequate level				
		Intermountain region	Northern foothills	Central region	Southern region	Statewide
Selenium	0.08 µg/ml	3%	4%	28%	2%	12%
Copper	0.8 µg/ml	1%	13%	31%	55%	28%
Zinc	0.8 µg/ml	47%	35%	23%	40%	36%
Magnesium	18 µg/ml	9%	3%	11%	7%	7%
Manganese	6 ng/ml	96%	90%	92%	97%	92%

Davy et al. 2018: Mineral status of California beef cattle

Intermountain: Siskiyou, Shasta

Northern foothills: Humboldt, Yuba, Tehama, Colusa, Glenn, Shasta

Central: San Joaquin, San Benito, Alameda

Southern: Inyo, Los Angeles, Ventura, Santa Barbara

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How do I know I need to supplement? Check feed and water

- Analysis of water and farm-raised forages, grains and crop residues
 - Collect samples where cattle are observed grazing
 - Cut 1 – 3 inches from ground – avoid soil contamination
 - Collect during morning and evening over several days
 - Store chilled in clean container
 - Several times a year
- Test each purchase of out-sourced forages, grains and by-products
- Use lab certified by National Forage Testing Association:
<http://www.foragetesting.org/>

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Mineral requirements and maximum tolerable limits in feed

Mineral	Unit mg/kg=ppm	Gestating	Early lactations	Maximum tolerable
Cobalt	mg/kg	0.15	0.15	25.00
Copper	mg/kg	10.00	10.00	40.00
Iodine	mg/kg	0.50	0.50	50.00
Iron	mg/kg	50.00	50.00	500.00
Magnesium	%	0.12	0.20	0.40
Manganese	mg/kg	40.00	40.00	1,000.00
Molybdenum	mg/kg	--		5.00
Potassium	%	0.60	0.70	2.00
Selenium	mg/kg	0.10	0.10	5.00
Sodium	%	0.06-0.08	0.10	-
Sulfur	%	0.15	0.15	0.30-0.50
Zinc	mg/kg	30.00	30.00	500.00

NRC, 2016

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How do I know I need to supplement? Check animals

- Liver biopsies:
 - Best representation
- Submission of aborted calves to diagnostic lab
 - Good opportunity to evaluate trace minerals
- Blood levels
 - Changes reflected more slowly in whole blood (red blood cells live about 160 days)
 - Preliminary screening tool
 - May not be able to identify marginally deficient animals

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How to supplement?

- Diverse forage base (legumes and grasses)
- Direct mineral supplementation:
 - In water
 - In feed
 - As drench – rapid pass through
 - Injectable – not long lasting
 - Rumen bolus – typically designed to supply mineral for 12 months
 - Free choice supplements – most practical

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What about injectable forms?

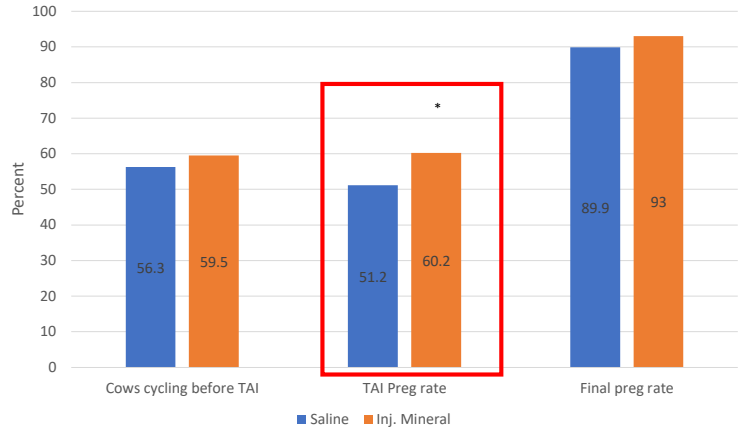
- Mu-Se, Bo-SE:
 - Combination of Selenium/Vitamin E (not a major source of Vitamin E)
 - Prescription only
 - Anaphylaxis
 - Meat withdrawal
- Multimin:
 - Cu, Zn, Se, Mn
 - Fewer injection site reactions
 - Prescription only
 - Do not use together with copper boluses or other selenium containing products

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A study with Multimin

- 460 cows and heifers in Kansas
 - Injectable minerals 105 days before calving and 30 d before TAI
 - Checked serum levels pre-treatment



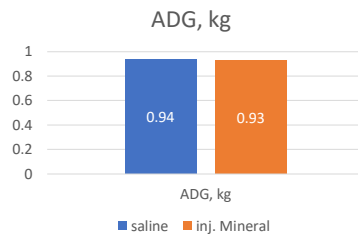
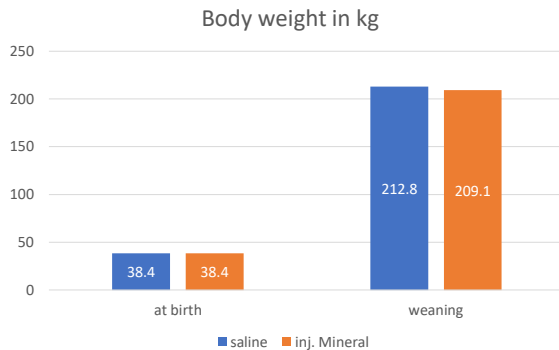
Mundell et al. 2012, The Professional Animal Scientist, 28, 82-88

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Results for calves

- Calves received minerals at birth and 71 d of age
- No difference in body weight at birth or weaning, or ADG



Mundell et al. 2012, The Professional Animal Scientist, 28, 82-88

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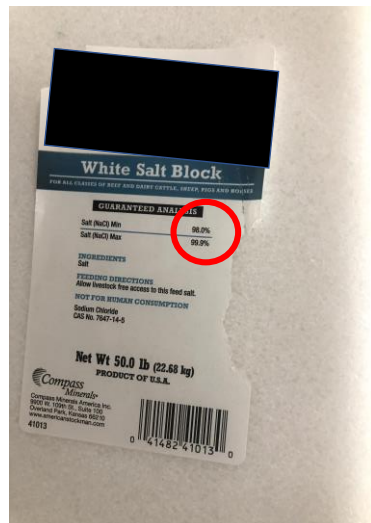
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Free choice minerals

- Position close to normal lanes of travel within pasture
- One mineral feeder / 40 mature animals
- Consider water mineral profile: if high solute content => mineral supplement should not be based on salt for palatability; use molasses or grain based supplement
- Overconsumption: can add salt (sodium chloride) to adjust for intake (e.g. if cattle consume 6 ounces/day instead of 3 ounces/day as required on label, mix 50:50 salt : mineral mix so cattle get the 3 ounces mineral mix/day)
- Loose form versus block
- Not all animals will consume same amount
- As moisture content of forages increases, intake of supplements increases

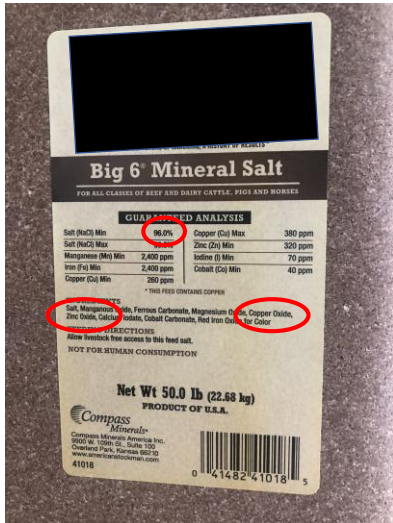
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Trace mineral supplementation

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Mineral	Amount (g) in 3 ounces (85 g)	Amount from diet (Fescue)	Total mineral intake (g)	Requirement Gestating cow (g)	% Requirement
Fe	0.204	0.5665	0.7705	0.55	140
Mn	0.204	0.04158	0.2456	0.44	56
Zn	0.0272	0.099	0.1262	0.33	38
Cu	0.0323	0.0055	0.0378	0.11	34
I	0.00595	0	0.00595	0.0055	108
Co	0.0034	0	0.0034	0.0011	309

96% salt
No Calcium, Phosphorus, Magnesium, Selenium

Probably won't consume 3 ounces per day

ppm on block ≠ ppm in feed
e.g. Cu 380 ppm in block => if 3 ounces/day:
85 g x 380 mg/kg = 0.085 kg x 380 mg/kg = 32.3 mg = 0.0323 g

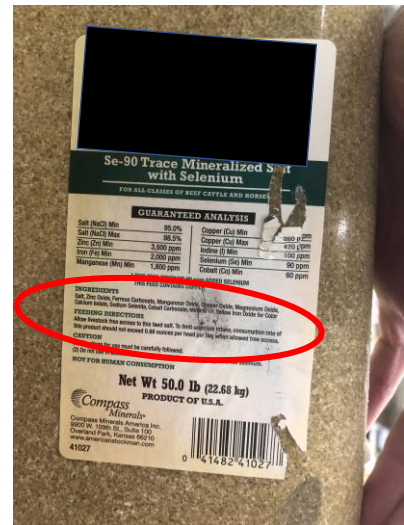
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Mineral	Amount (g) in 0.88 ounces (25 g)	Amount from diet (Fescue)	Total mineral intake (g)	Requirement Gestating cow (g)	% Requirement
Fe	0.0625	0.5665	0.629	0.55	114
Mn	0.045	0.04158	0.087	0.44	20
Zn	0.0875	0.099	0.19	0.33	58
Cu	0.0105	0.0055	0.016	0.11	15
I	0.0025	0	0.0025	0.0055	45
Co	0.0015	0	0.0015	0.0017	88
Se	0.00225	0.000165	0.002415	0.0011	220

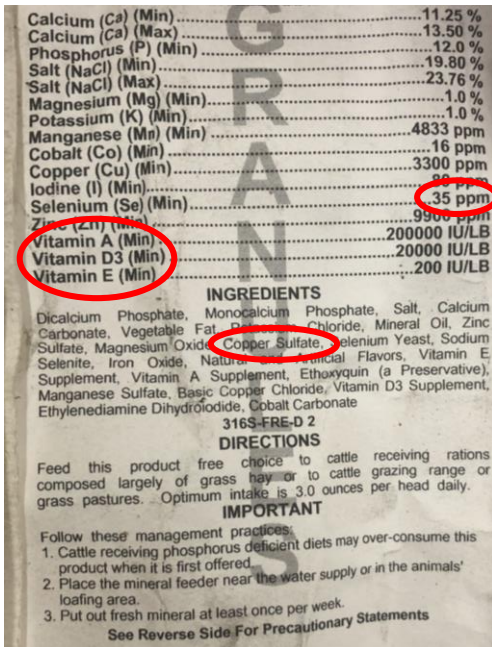
“To limit selenium intake, consumption of this product should not exceed 0.88 ounces per head per day when allowed free access”

Salt blocks not a reliable source of copper, iodine, selenium
Copper oxide: low bioavailability



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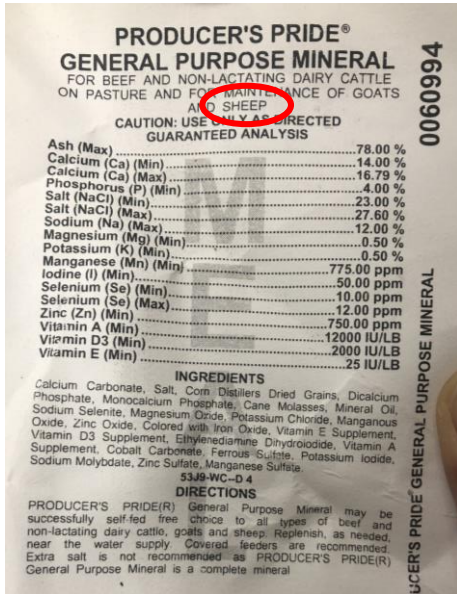
Mineral	Amount (g) in 3 ounces (85 g)	Amount available from diet (Fescue) (g)	Total mineral intake (g)	Requirement Gestating cow (g)	% Requirement
CA	9.6	25.74	35.34	30	118
P	10.2	16.45	26.65	18	148
Mg	0.85	10.89	11.74	12.0	98
K	0.85	107.25	108.1	66	164
S	0	12.1	12.1	16.5	73
Fe	0	0.5665	0.5665	0.55	103
Mn	0.41	0.04	0.45	0.44	102
Zn	0.842	0.099	0.941	0.33	285
Cu	0.28	0.0055	0.2855	0.11	260
I	0.0068	0	0.0068	0.0055	124
Se	0.002975	0.000165	0.00314	0.0011	285
Co	0.00136	0	0.00136	0.0017	80

Trace mineral supplementation

Quick word about vitamins

- Beef cattle only need Vitamins A, D and E as supplements
- Vitamin A: in fresh green growing grass, needed for skin and mucous membranes
- Vitamin D: Ca and P absorption, exposure to sunlight usually provides adequate amounts
- Vitamin E: if Se deficient can be problem, otherwise adequate amounts in feed

Trace mineral supplementation



Mineral	Amount (g) in 3 ounces (85 g)	Amount from diet (Fescue) (g)	Total mineral intake (g)	Requirement Gestating cow (g)	% Requirement
CA	11.9	25.74	37.64	30	125
P	3.4	16.45	19.85	18	110
Mg	0.425	10.89	11.32	12.0	94
K	0.425	107.25	107.675	66	163
S	-	12.1	12.1	16.5	73
Fe	-	0.5665	0.5665	0.55	103
Mn	0.066	0.04158	0.108	0.44	245
Zn	0.064	0.099	0.163	0.33	49
Cu	-	0.0055	0.0055	0.11	0.05
I	0.0043	0	0.0043	0.0055	78
Se	0.001	0.000165	0.001165	0.0011	106
Co	-	0	0	0.0017	0

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Example free-choice mineral mix specifications for lactating cows

Mineral	4 ounce intake per day
Cobalt	0.001% (10 ppm)
Copper	0.12% (1200 ppm)
Iodine	0.008% (80 ppm)
Magnesium	1% 10 - 14% if grass tetany is a concern
Selenium	0.0026% (26 ppm)
Sodium chloride (salt)	15 – 22 %
Zinc	0.3% (3000 ppm)
Calcium : Phosphorus ratio	2:1 to 4:1
Vitamin A	120,000 IU / lb

Unnecessary: B-vitamins (thiamine, riboflavin, folic acid) – produced by rumen bacteria

<http://extension.uga.edu>

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Bioavailability of mineral forms

Element	Source	Bioavailability
Magnesium	Oxide	High
	Sulfate	High
Copper	Oxide	Low
	Carbonate	Intermediate
	Sulfate	High
	Proteinates	High
	Carbonate	High
Iron	Oxide	Unavailable
	Ferrous carbonate	Generally high
	Ferrous sulfate	High
Selenium	Sodium selenite	High
Zinc	Oxide	High
	Sulfate	High

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Supplementation – chelated vs inorganic

- **Chelated:**
 - complexes, proteinates, organic
 - bound to organic molecule – neutral charge
 - more efficiently absorbed and metabolized, higher bioavailability
 - more expensive
 - Recommended during periods of stress (preconditioning, from 2 months before calving through breeding)
- **Inorganic:**
 - bound to inorganic ion, e.g. oxide or sulfate

Trace mineral supplementation

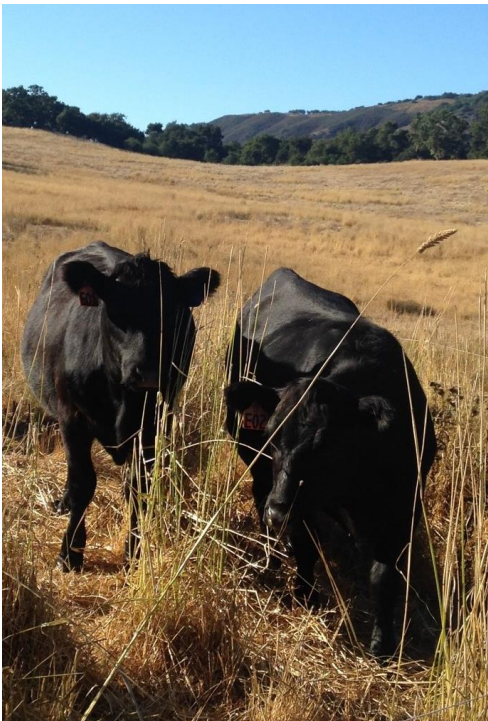
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Summary

- Test forage to assess intake from feed
- Test water for total dissolved solids and sulfates
- Supplement as needed – talk to your vet/nutritionist before making changes
 - Many different options, each with advantages/disadvantages
- Ensure cattle consume what they need if oral supplementation
- Test cattle if concerned with performance

Trace mineral supplementation

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Thank you – questions?

Contact: Gaby Maier
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