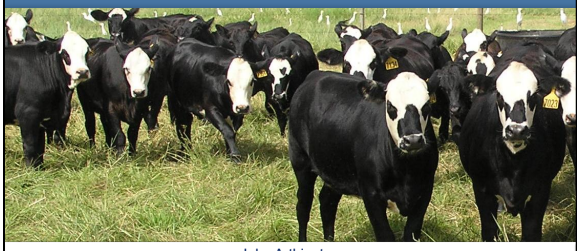
Mineral Programs

Mystery and Magic



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Range Cattle Research and Education Center, Ona

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Overview

- Macro- and micro-minerals – general overview
- Zinc
- Copper and Selenium
- Antagonists
- Mineral Source; Organic Cu, Zn, and Mn
- Summary

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Minerals and Reproduction

- In almost every situation, effects of mineral nutrition on reproduction are secondary to impacts on other physiological functions;
  - –Antioxidant capacity
    - Uterine involution = prolonged post-partum anestrus
  - –Direct impact of antagonists
    - Mo impacts reproduction independent of Cu
  - –Reduced growth and vigor
    - Delayed puberty

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Macrominerals

- Deficiency in macrominerals typically present themselves as;
  - – Depressed growth (Ca:P)
  - – nerve function (tetany)
  - – acid/base balance (DCAD)

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Salt (NaCl)

- Salt (or Na) is the only mineral that cattle have the nutritional wisdom to consume at levels which meet or exceed their requirement.
- Generally, salt intake increases when forages have high moisture. Silage-fed cattle typically consume more salt than dry hay-fed cattle.
- Salt intake often decreases when energy/protein supplements are offered and is limited by the Na content of water. Salt is used to both encourage and limit supplement intake.

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Calcium (Ca)

- The most abundant mineral in the body. Virtually all of the body's Ca is stored in bones.
- Symptoms of Ca deficiency include problems with bone structure and bone growth.
- Low Ca, or rather, a Ca and P imbalance can also result in urinary calculi.
- Rarely, low Ca can cause grass tetany (Ca tetany), which can occur independent of Mg.

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Calcium (Ca)

- Maintenance of Ca homeostasis is critical to ensure normal nerve and muscle function. Thus, mobilization of Ca from bone stores is critical.
- Management systems have been implemented for years to ensure adequate Ca mobilization.
- When Ca loss exceeds the body's ability to replenish = hypocalcemia or "milk fever".

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Phosphorus (P)

- Of the macrominerals, phosphorus has received the most attention when considering reproductive responses of grazing beef cattle;
  - Studies are generally older and do not take into account the phosphorus content of today's supplements.
  - Phosphorus requirements increase during lactation, typically when energy/protein supplements are offered.
  - Much more common to find phosphorus over- vs. under-supplemented.

Supplement Ingredient	Phosphorus, % DM
Corn	0.30
Corn Gluten Feed	1.00
Distillers Grains	0.83
Brewer's Grains	0.70
Whole Cottonseed	0.60

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Phosphorus (P)

- Phosphorus has more biological functions than any other mineral and is often the largest contributor to the overall cost of a free-choice beef mineral.
- Rumen microflora require P for digestion of cellulose and "available" P is often provided through saliva P recycling.
- Prolonged dietary P deficiency has been associated with "pica", which is a behavioral response of livestock seeking and chewing wood, rocks, and bones (S. African studies from early 1900s).

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Calcium (Ca) & Phosphorus (P) Ratio

- Evaluation of Ca and P status is difficult due to their primary storage area being bone.
- Utilization of Ca and P is impacted by both their dietary concentration and the ratio presented.
- The ideal Ca:P ratio is 2:1, but in forage-based diets a 1:1 ratio is not a concern.
- In diets utilizing high-P byproducts, such as DDG, attention to the Ca:P ratio is essential. Often a source of Ca must be included.
- Some cereal grains are very high in Ca, but low in P, thus supplemental P is needed to correct the ratio.

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Magnesium (Mg)

- Magnesium is essential for proper nerve function and is 2nd to potassium as the most abundant cation in the body
- Deficiency is uncommon except when grazing pastures that have experienced rapid regrowth, such as "lush" spring pasture.
- Hypomagnesemic tetany is the most common clinical condition associated with low dietary Mg.
- Typically, for grazing cattle, forage levels > 0.20 % are safe to protect against tetany.

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Potassium (K)

- Like Na and Mg, K participates in osmotic balance and nerve function and is an important cation in acid/base physiology (DCAD).
- Potassium concentrations of grazed forages are seldom lacking to meet requirements of beef cattle. Increased milk production and heat stress increases K requirement.
- Potassium may be inadequate in stockpiled or harvested forage and consideration to the K content of supplemental feeds should be considered.

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Sulfur (S)

- Sulfur is an essential element for formation of the essential amino acids methionine and cysteine.
- Sulfur is also a component of the vitamins thiamin and biotin and "chondroitin" a key component of cartilage, bone, and tendon.
- Under most all conditions a deficiency of S is unlikely to occur in grazing beef cattle.
- General Guideline: Forage-fed cattle consuming over 0.30% total dietary sulfur (approx. 30 to 35 g/d for adult cows) will not accumulate tissue Cu or Se.

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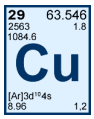
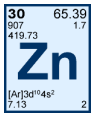
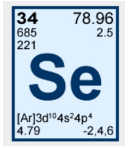
Microminerals

- Three micro-minerals are commonly associated with reproductive function in cattle:
  - –Zinc
  - –Selenium
  - –Copper







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Zinc

- Co-factor for multiple enzymes. Required for all DNA and RNA syntheses and is required at every step of the cell cycle.
- Zinc is essential for proper testicular development and spermatogenesis
- Zinc is the second most abundant trace metal found in eukaryotic organisms, second only to iron. Subtracting the iron found in hemoglobin, zinc becomes the most abundant trace metal found in the human body.

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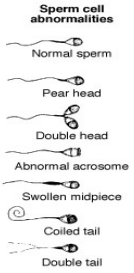
Zinc; Essential for normal spermatogenesis



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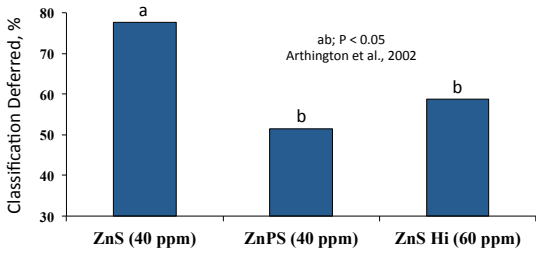
Effect of zinc level and source on yearling Angus bulls "classification deferred"



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Effect of zinc source on bull sperm quality

Item [1]	Inorganic	Organic [2]	P-value
Motile, %	56.1 ± 2.8	65.5 ± 2.6	0.02
Progressive, %	38.4 ± 2.2	47.0 ± 2.0	0.01
Rapid, %	52.8 ± 2.9	62.3 ± 2.6	0.03

[1] Motile = path velocity ≥ 30 µm/s and progressive velocity ≥ 15 µm/s; Progressive = path velocity ≥ 50 µm/s and straightness ≥ 70%; Rapid = progressive percentage with path velocity ≥ 50 µm/s.

[2] Supplemental Zn, Cu, and Mn offered at 450, 150, and 300 mg/d with 80, 83, 66% provided as amino acid complex (Availa 4; Zinpro Corp.).

Rowe et al., 2014

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Selenium and Copper
most limiting trace elements for forage-fed cattle

- Of the trace elements, copper and selenium are typically the most limiting in diets of forage-fed cattle in the southeast.
- Essential for multiple enzymes linked to maintenance of reproduction, immunity, and growth
- Selenium is the only essential trace element that is sometimes toxic. Also, be cautious of **zinc**. Copper should be included at a 1:3 ratio with zinc.
- Liver tissue samples are reliable indicators of status and can be used as sentinels for overall trace mineral nutrition.

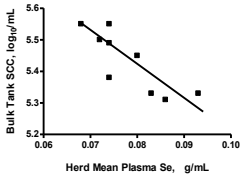

Figure 1. Relationship between herd Se status and milk SCC (adapted from Weiss et al. (1990).

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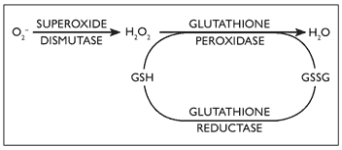
Cooperative Antioxidant Functions
Copper and Selenium



Why are they important;

1. The two most limiting trace mineral in most forages and feedstuffs.
2. Both are strongly antagonized by sulfur.

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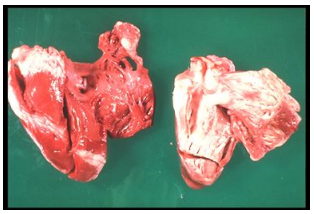
Selenium Deficiency

White Muscle Disease
or Weak Calf Syndrome



Antioxidant capacity

Uterine involution = prolonged post-partum anestrus

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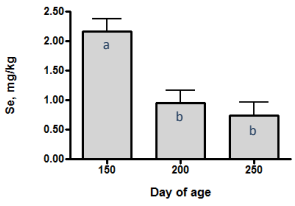
Decline in pre-weaned calf selenium status



Arthington and Havenga, 2014

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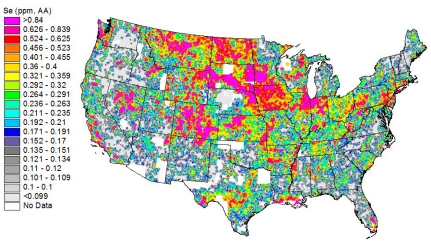
United States Soil Selenium Concentrations



Check the soil selenium content of you county at:
http://mrdata.usgs.gov/geochem/doc/averages/se/usa.html

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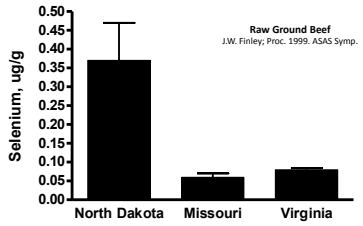
Effect of soil selenium distribution on selenium content of harvested beef



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Mineral Deficiencies: Primary vs Secondary

- Primary Deficiency
  - Deficient mineral intake
  - Rare in improved agricultural practices
- Secondary Deficiency
  - Adequate mineral intake, but deficient status due to the antagonistic influence of another compound
  - Most common type of mineral deficiency

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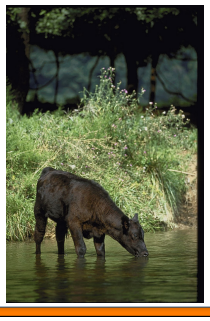
Trace Mineral Antagonists

- Sulfur
- Molybdenum
- Iron
- Aluminum



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Sulfur Antagonism

- High dietary sulfur antagonizes the body's ability to absorb and store Cu and Se.
- Sources include;
  - Forage – due to atmospheric contributions (rainfall) impacted by high-S coal burning
  - Forage – due to S-containing fertilizers
  - High-S supplements
  - High-S water

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Sulfur Content of Feed Supplements

- Some feed supplements are high in sulfur
  - Molasses
  - Corn gluten feed
  - Distillers grains
  - Corn steep liquors
  - Feather meal

Photo; www.noble.org

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Pasture Fertilization

Effect on Cow Mineral Status

Sulfur concentration of bahiagrass	
Ammon. Sulfate	0.50 %
Ammon. Nitrate	0.20 %
No Fertilizer	0.22 %

Arthington et al., 2002

Effect of supplement source on liver Se accumulation and BW gain in growing steers

Item	Corn-based	Molasses-based	SEM	P =
Liver Se Δ, ppm	1.47	0.50	0.18	0.003
ADG, lb/d	0.53	0.23	0.11	0.07

Arthington. JAS. 2009

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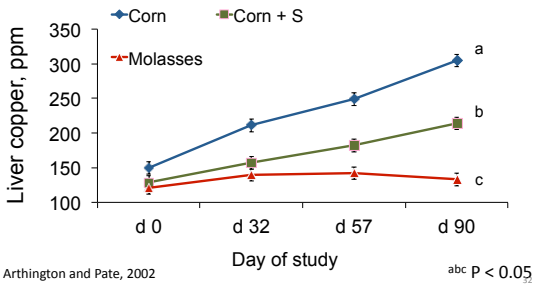
Effect of supplement type

Corn vs. Molasses – inclusion of Sulfur



Arthington and Pate, 2002

abc P < 0.05

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Copper

- Studies have shown that copper deficiency is linked to reduced fertility among beef cows. However, results have been highly variable.
- Copper deficiency, resulting from the consumption of forages lacking Cu, does not seem to impact fertility in cattle (Phillippo et al., 1982).
- Phillippo et al. (1987) suggested that this response may be directly due to S and Mo.
- Studies by Kendall et al (2003 and 2006) have provided further insight into this topic.

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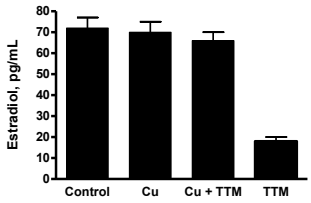
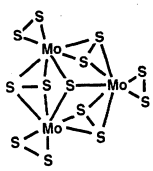
Copper x Thiomolybdate Interaction



Estradiol production from bovine granulosa cells cultured (144 h) with Cu, or tetrathiomolybdate (TTM), or both.



Thiomolybdates
S x Mo x Cu

Kendall et al., 2003

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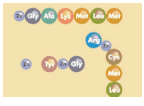
Mineral Source



Organic

IntelliBond
Better trace minerals, better value

Hydroxyl

SEL-PLEX

Yeast

Inorganic

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Inorganic trace minerals

- Inorganic
  - –Sulfate/Oxide
    - Most common ingredient form
    - Solubility and metal content highly variable
  - –Hydroxychloride
    - crystalline inorganic minerals formed by covalent bonds.
    - Metal covalently bound to –OH group
    - Concentrated and low solubility, except at low pH

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Organic trace minerals

- Organic
  - Metal is covalently bound to carbon-containing ligand.
  - Categories (AAFCO, 1998)
    - Metal amino acid complex
    - Metal amino acid chelates
    - Metal proteinates
    - Metal polysaccharides
    - Metal propionates
    - Yeast derived complexes

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Organic trace minerals

- Research has not necessarily supported improved reproductive performance among healthy mature cows.
- A meta-analysis involving 20 dairy cow studies revealed a fewer days open and services per conception (Rabiee at al., 2010)
- Antagonists, age, and level of stress may be contributing factors.

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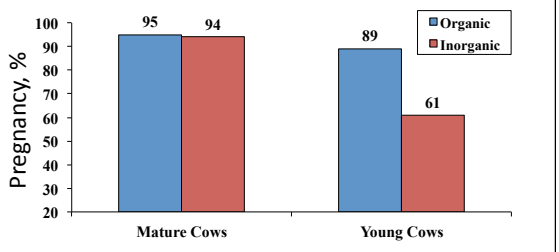
Organic trace minerals

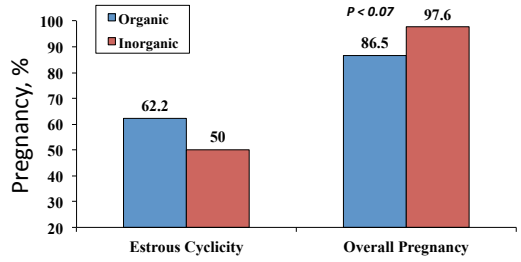
Effect of Trace Mineral Source on Conception Rate of Lactating Cows (3 year study)



Young cows = 1st and 2nd calf

Arthington and Swenson, 2004

Organic trace minerals



Two-year study involving same heifers in their first and second breeding season.

Ahola et al., 2005

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Summary

- Macrominerals
  - Generally associated with growth, osmotic balance, and acid/base physiology. Impacts on reproduction are typically secondary to these functions.
- Microminerals
  - Three essential trace minerals are the most important for reproduction;
    - Zinc
    - Copper
    - Selenium

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Summary

- Antagonists, such as Mo and S, are important contributors to Cu and Se nutrition in cattle.
  - Mo x S (thiomolybdates) impact reproductive function in cattle independent of low Cu.
  - Cattle consuming high-S supplement have reduced accumulation of tissue Se and Cu.
  - Organic sources of Se (and Cu) do not appear to overcome the antagonism.
  - Organic sources of Cu, Zn, and Mn have variable results on cowherd reproductive performance.

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Thank you for your attention

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75TH anniversary 1941-2016 UF/IFAS RANGE CATTLE RESEARCH & EDUCATION CENTER