

Essential Minerals and Vitamins for Small Ruminants

Small Ruminant Short Course

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I know there is something lacking in the diet. I confirmed last year that my does are very low in their blood Vitamin D2. I have one goat that gets clinical hypocalcemia at kidding each year, and several others that get a little "off". The worst doe nearly died the first 2 years.

MINERAL AND VITAMIN DEFICIENCY

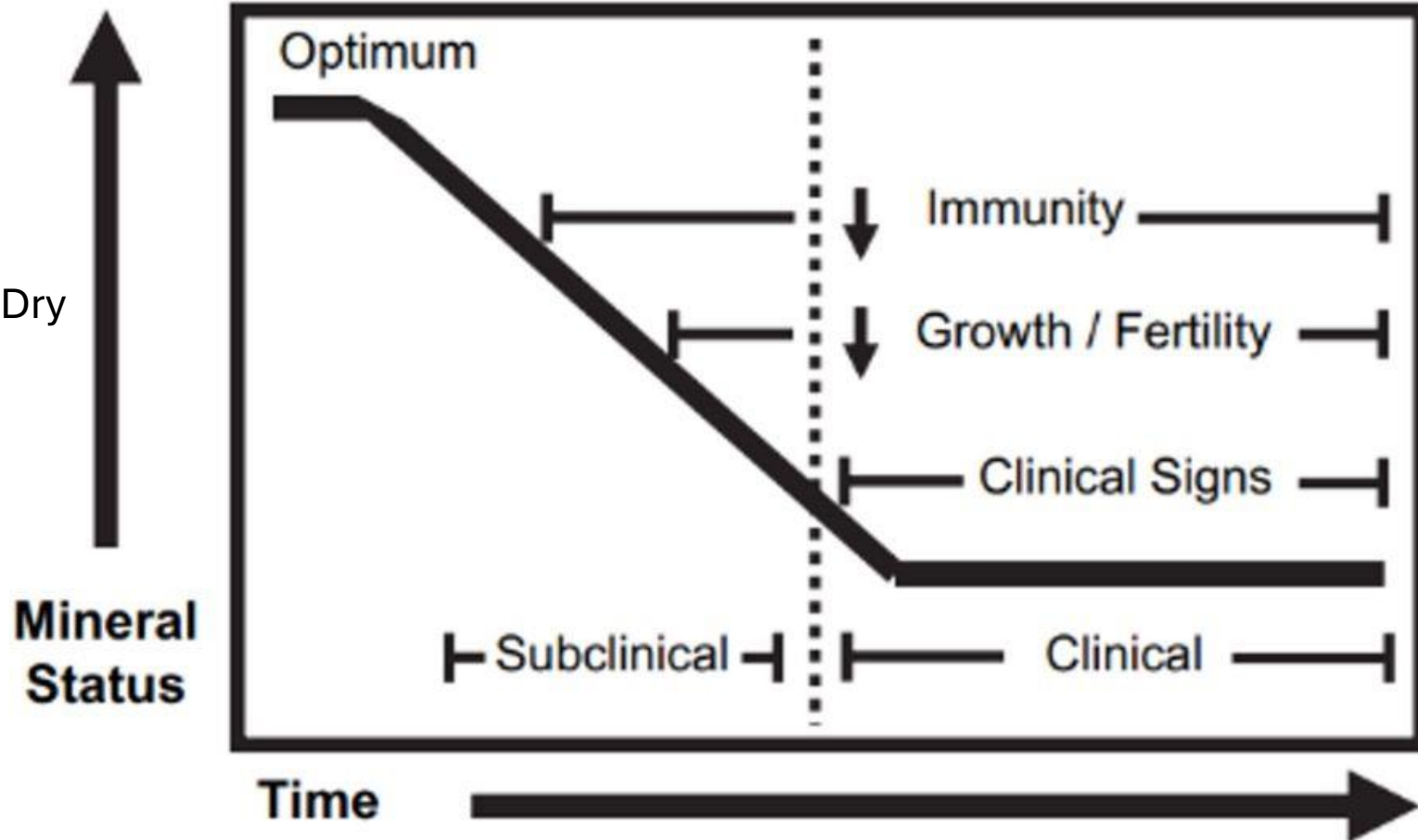
The daily gain on my lambs are
despite well balanced rations

s with still born. I have one ewe
g birth to two twins. The last 5
ad the following in common: low
cium levels. The other minerals all

I am feeding alfalfa hay stored for more than one year. The nutritive values are great but still performance is down.

Mineral status (Clinical vs Subclinical deficiency)

- Decreased weaning weight
- Greater percent ewes open/Dry
- Delayed conception
- Decreased lamb vigor
- Vaccination response
- Colostrum quality



Minerals

Macro Minerals

- Ca
- P
- Mg
- S
- Na
- Cl

0.1-0.7%

Micro Minerals

- Co
- Fe
- Mn
- Se
- Zn
- Mo
- Cu

0.3 to 50
ppm

ppm (mg/kg)
mg/d

%
grams/d

Vitamins

Fat soluble

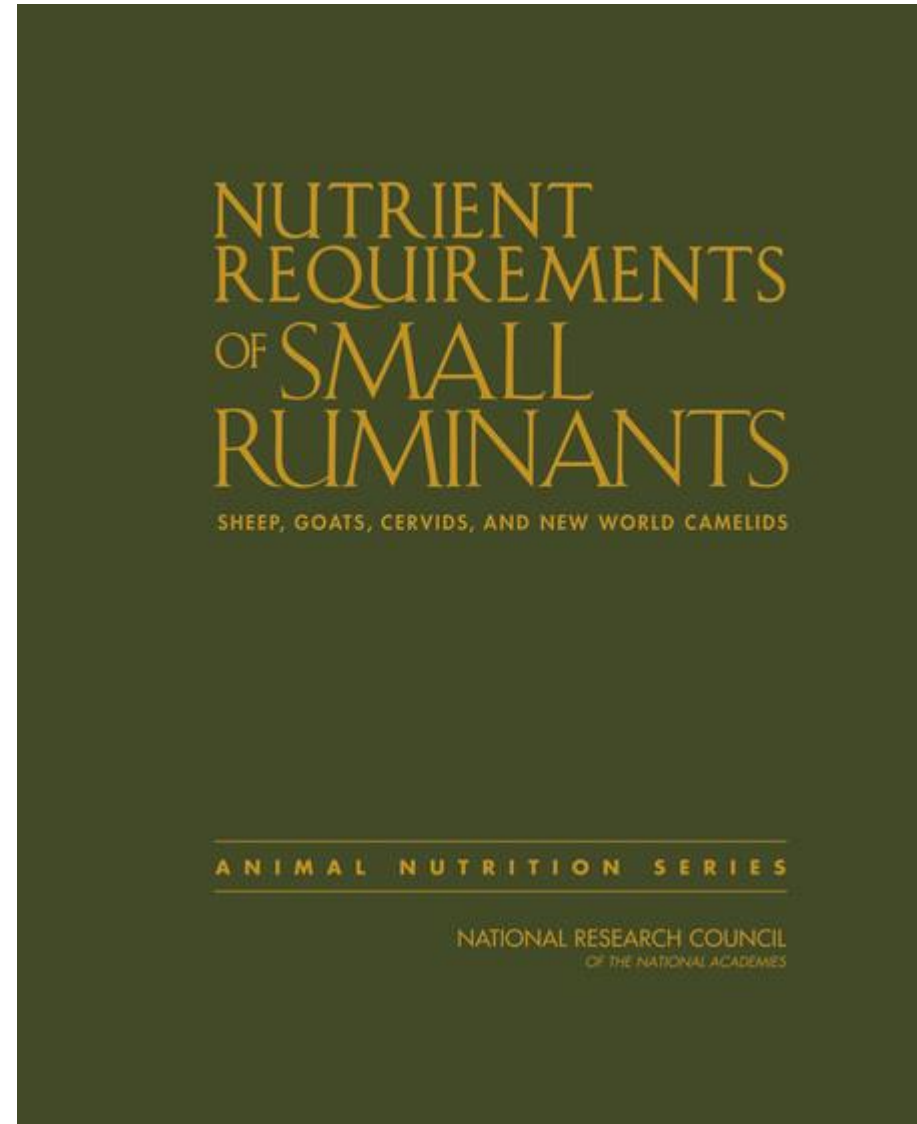
- A
- D
- E
- K

Water soluble

- C
- B complex

IU/kg
IU/lb
IU/day

Nutrient requirements - 2007



Why amounts matter

- **Sheep and goats require specific amounts of minerals**, not just percentages in feed.
- Percentages alone can be misleading – a high percentage in low-feed intake might still provide insufficient minerals.
 - 1% of a mineral in a 1 kg ration = 10g of that mineral
 - But if the sheep only eats 500g of feed, it's getting only 5g – potentially below its requirement.
- Monitor mineral intake

Calcium requirements for mature 130 lb doe

Physiologic state	Calcium, grams (%)
Maintenance	3.0 (0.30)
Late Gestation	6.0 (0.32)
Lactation	
5 lbs /d; 5 % fat	10.8 (0.48)
10 lbs /d; 3.5 % fat	13.1 (0.41)

13.1 grams

Ensuring Adequate Mineral Intake

- To ensure sheep meet their mineral requirements, multiply the feed intake by the percentage of the mineral.
- **Example:** Doe is consuming 1 kg of bermudagrass hay, 0.5 kg grain mix, and 0.5 ounces of mineral mix.

Feed	Daily Feed Intake	% Calcium in Feed	Total Calcium Consumed (g/day)
Bermudagrass hay	1 kg	0.40	4 grams
Grain mix	0.5 kg	1	5 grams

9 grams



2:1 GOAT MINERAL

PRODUCT CODE: 6320

FORM: Meal

APPLICATION:

Formulated to be fed free choice to meat and dairy goats on pasture.

FEATURES and BENEFITS:

- Formulated with chelated trace minerals to maximize absorption and utilization for optimal growth, health and reproduction.
- Maintain healthy hooves to stave off foot rot.
- **OPTIFERM** to promote better rumen function and fiber utilization.
- Added selenium yeast to promote overall health.
- Added flavors to ensure proper consumption of the mineral.

FEEDING DIRECTIONS:

Feed free choice from sheltered feeders or mix into finished rations for goats to provide 1/2 to 1 1/2 ounces per head per day. Always provide a clean, fresh source of water. Consult your Kalmbach representative concerning any questions with the use of this product.

WARNING: Contains added copper. Do not feed to sheep.

GUARANTEED ANALYSIS:

Calcium (Ca) (Min.)	15.50%
Calcium (Ca) (Max.)	18.50%
Phosphorus (P) (Min.)	8.00%
Salt (NaCl) (Min.)	18.50%
Salt (NaCl) (Max.)	22.00%
Magnesium (Mg) (Min.)	1.50%
Potassium (K) (Min.)	1.00%
Selenium (Se) (Min.)	26 ppm
Copper (Cu) (Min.)	1450 ppm
Copper (Cu) (Max.)	1850 ppm
Zinc (Zn) (Min.)	7500 ppm
Vitamin A (Min.)	300,000 USP/lb.
Vitamin D (Min.)	45,000 IU/Lb.
Vitamin E (Min.)	400 IU/lb.

INGREDIENTS:

Monocalcium Phosphate, Dicalcium Phosphate, Calcium Carbonate, Salt, Molasses, Processed Grain By-Products, Magnesium Oxide, Potassium Chloride, Potassium Sulfate, Active Dry Yeast, Yeast Extract, Magnesium Sulfate, Vegetable Oil, Vitamin A Supplement, Vitamin D Supplement, Vitamin E Supplement, Thiamine Mononitrate, Zinc Sulfate, Iron Oxide, Manganese Sulfate, Copper Sulfate, Ethylenediamine Dihydriodide, Cobalt Sulfate, Zinc Amino Acid Complex, Copper Amino Acid Complex, Manganese Amino Acid Complex, Cobalt Glucoheptonate, Zinc Chloride, Manganese Chloride, Copper Chloride, Selenium Yeast, Sodium Selenite, and Natural and Artificial Flavors.

- **0.5-1.5 ounces per day**

Calcium calculation

- **15.5 % (minimum)**
- **100 grams will provide 15.5 grams**
- **0.5 ounce (14 grams) will provide Ca = 2.17 grams**

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Bermudagrass hay	1 kg	0.40	4 grams
Grain mix	0.5 kg	1	5 grams
Mineral mix	0.5 oz	15.5	2.17 grams

13.1 grams

11.17 grams

Ensuring Adequate Mineral Intake

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- **Example:** Doe is consuming 1 kg of bermudagrass hay, 0.5 kg grain mix, and 1 ounces of mineral mix.

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Bermudagrass hay	1 kg	0.40	4 grams
Grain mix	0.5 kg	1	5 grams
Mineral mix	1 oz	15.5	4.34 grams

13.1 grams

13.34 grams

Over-consumption

- Target intake = **1.5 oz/ewe/day**

Example

- 40 ewes
 - 1 bag of mineral (50 lbs each = 800 oz each)
 - $800 \text{ oz} / (7 \text{ days} \times 40 \text{ ewes}) = \mathbf{2.9 \text{ oz/ewe/day}}$
- **Flavoring agents** stimulate intake and often overconsumption
- If ewes eat 10 days worth of mineral in 2 days, don't put out more
- Most minerals stored in liver and very little benefit to consuming more beyond requirement

Test forages



**Macrominerals and
Microminerals**



**Forage Evaluation
Support Laboratory**

<https://agronomy.ifas.ufl.edu/department-labs/forage-evaluation-support-laboratory/>



CUMBERLAND VALLEY ANALYTICAL SERVICES

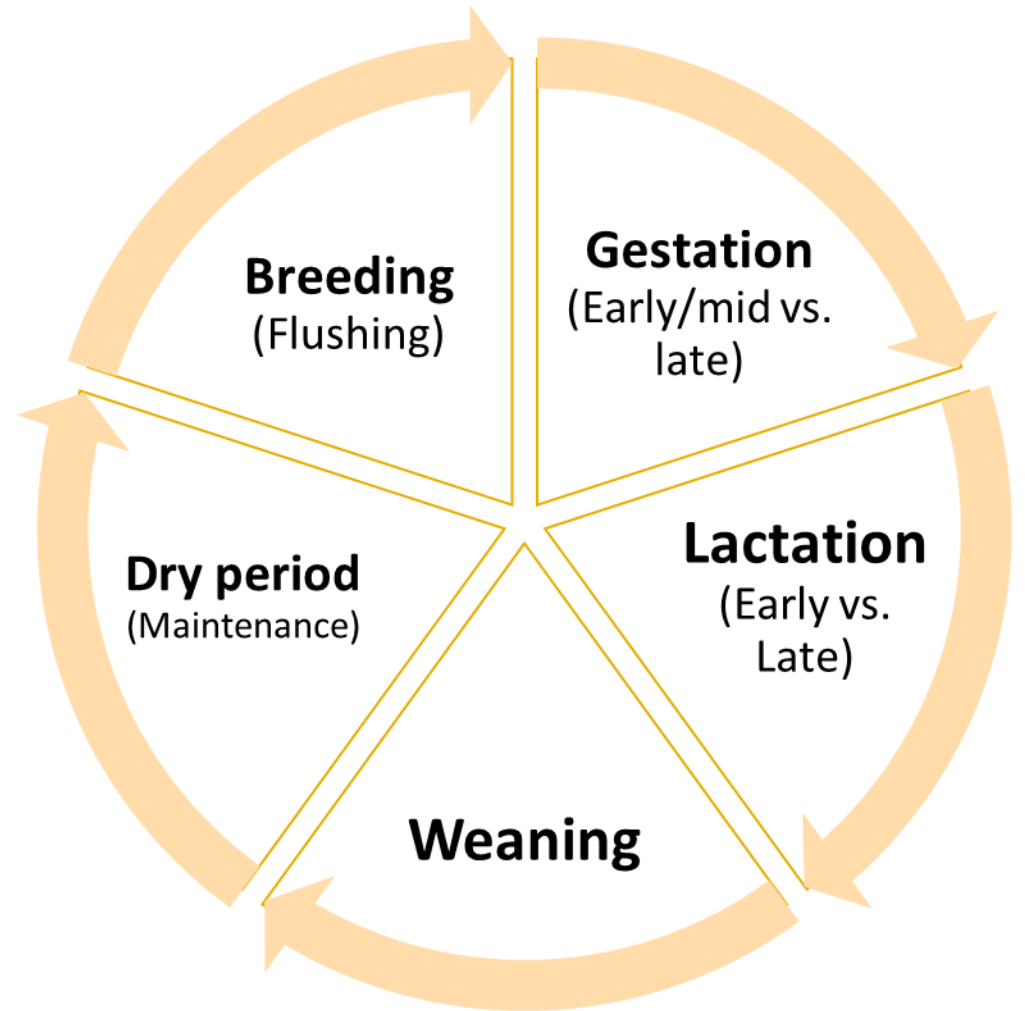
"Laboratory services for agriculture ... from the field to the feed bunk"

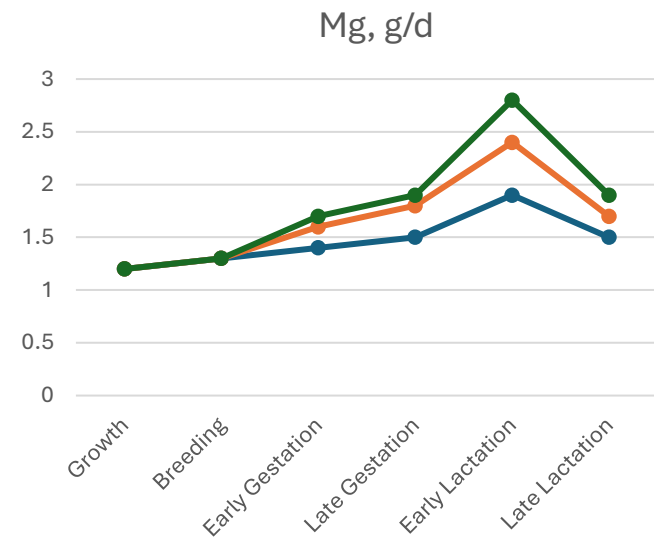
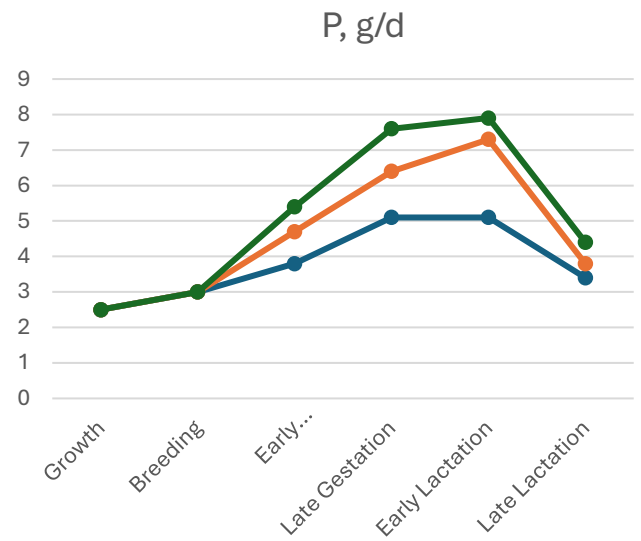
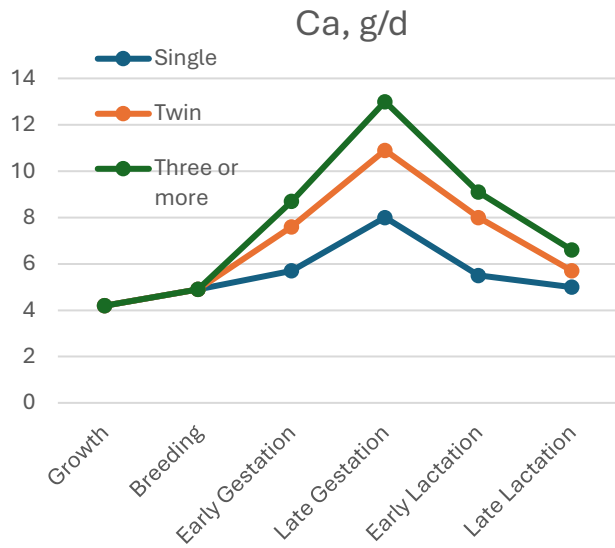


**AGRONOMY
DEPARTMENT**

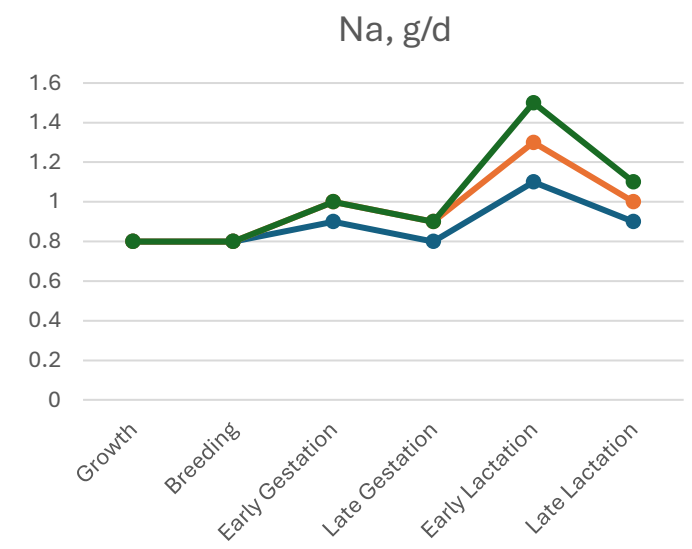
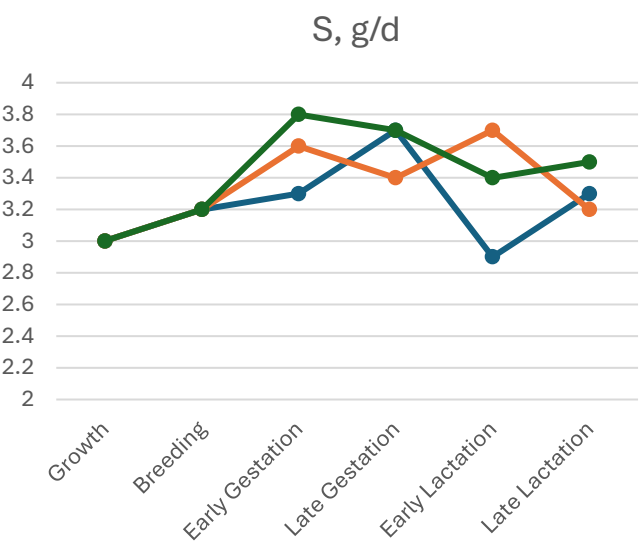
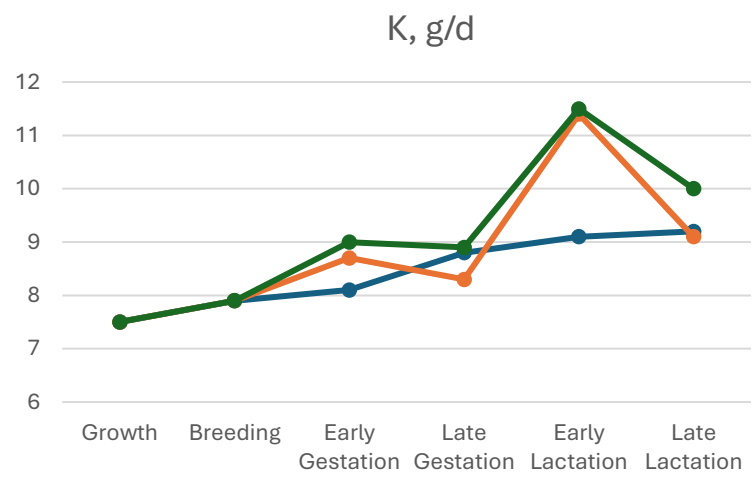
Factors influencing nutrient requirements

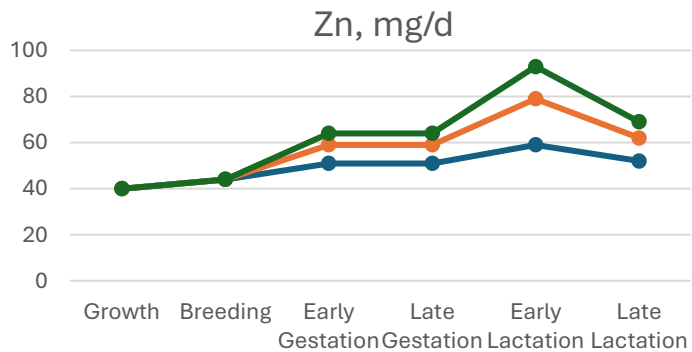
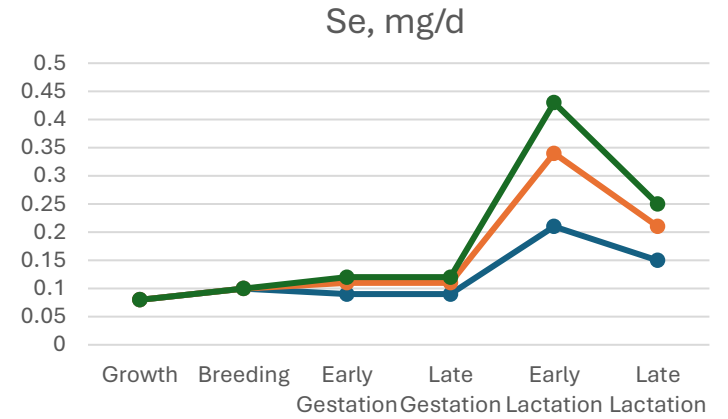
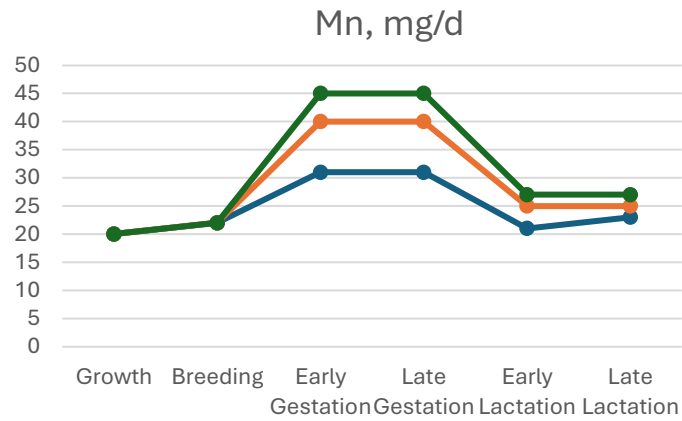
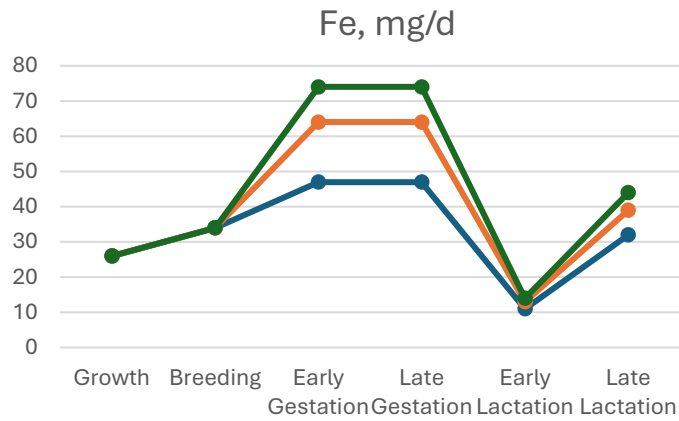
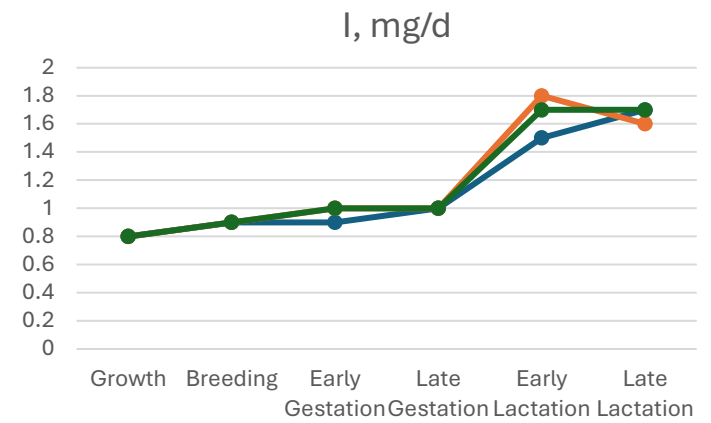
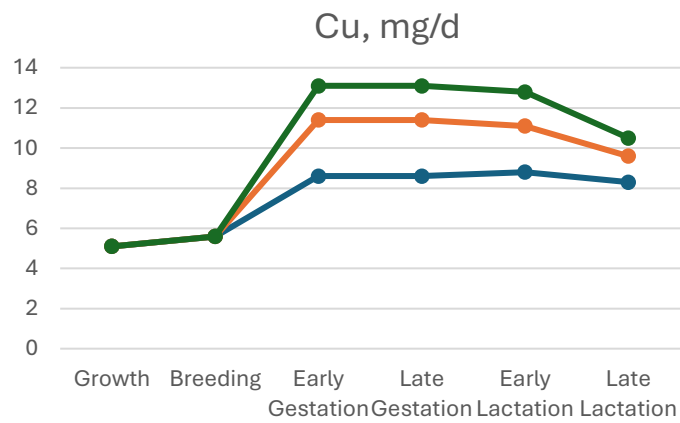
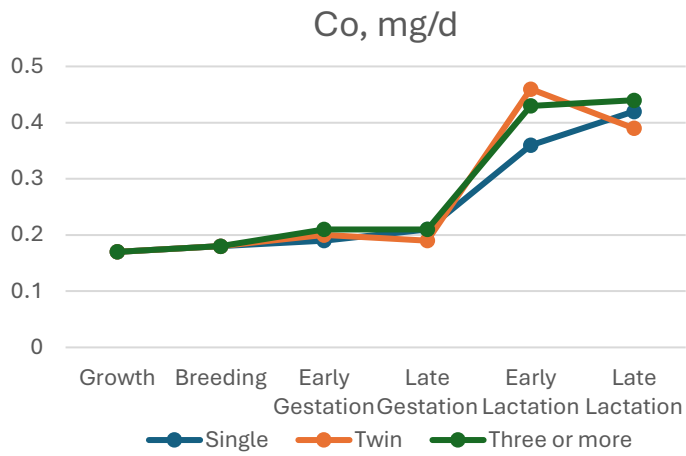
- Stage of production
 - Requirements highest during breeding, gestation, and lactation
- Other mineral levels (Mo, Cu, S, Fe)
- Age, and Level of production
 - Requirements increase with age and level of productivity





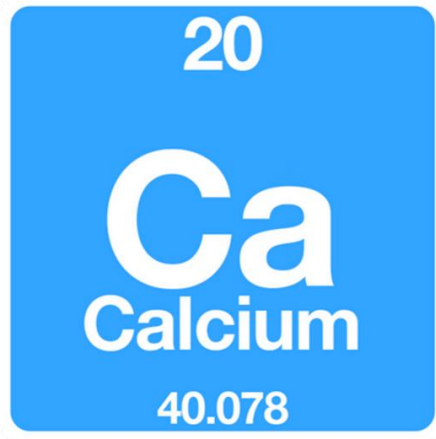
Macromineral requirement, g/d



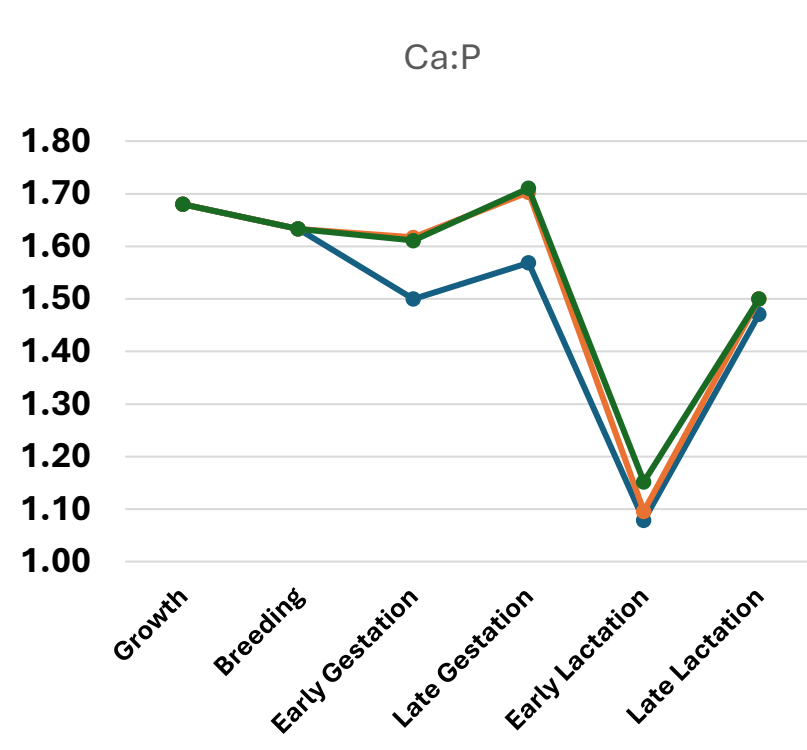
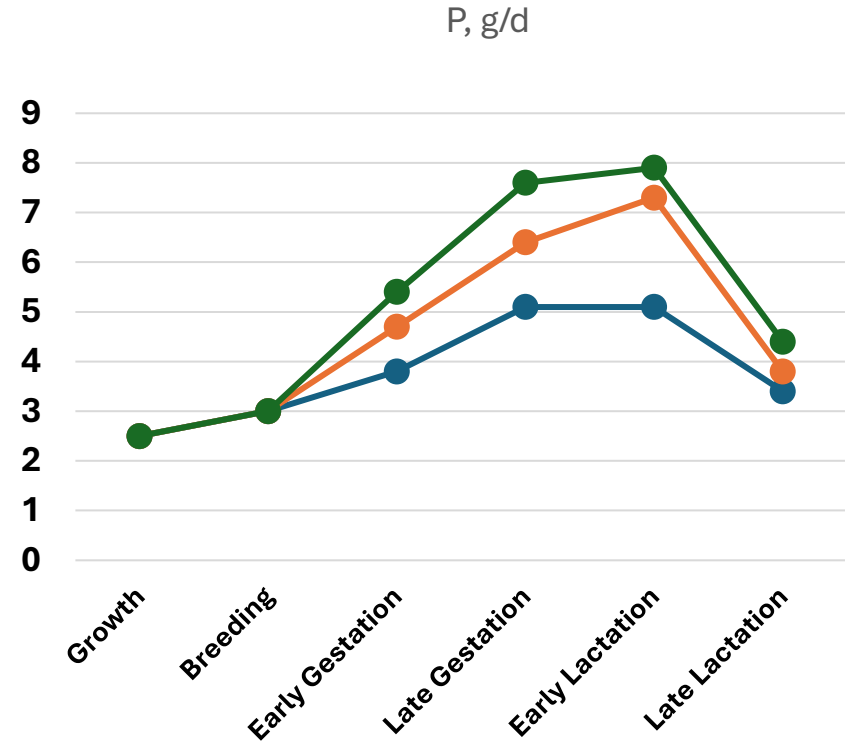
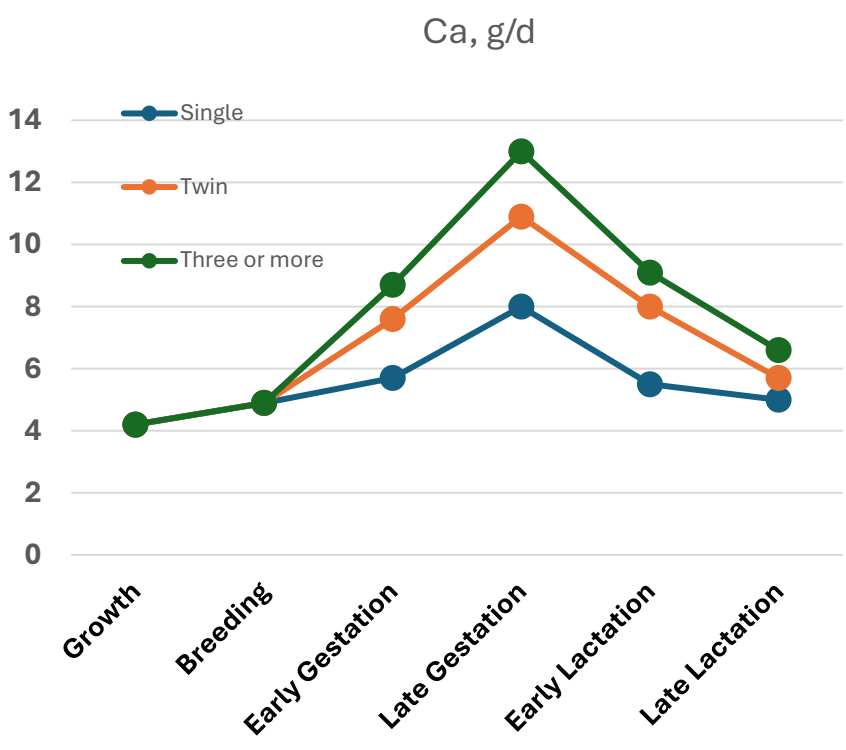
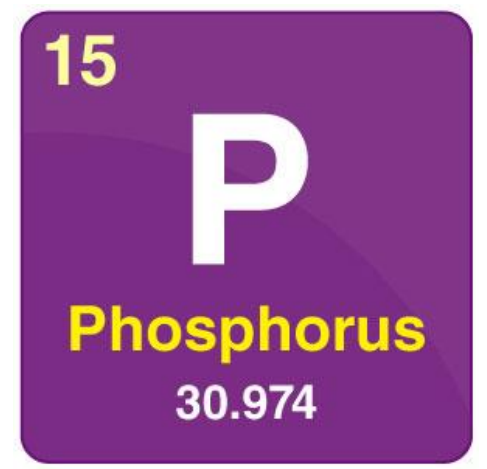


Micromineral requirement, mg/d

Prioritize supplementation when needs are the highest



- If fed alfalfa, Calcium not needed.
- Phosphorus not needed with corn.



20

Ca
Calcium

40.078

Mineral levels in forages

15

P

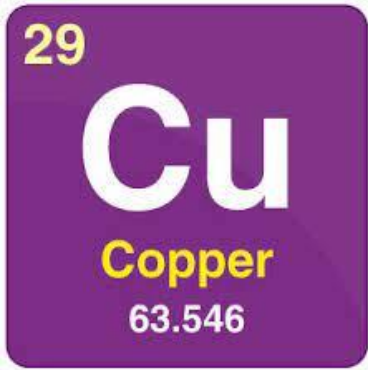
Phosphorus

30.974

Feed Type	P	K	Ca	Mg	S
Pasture					
Grass	0.38 ± .08	3.38 ± .71	0.43 ± .22	0.22 ± .05	0.32 ± .07
Mixed mostly grass	0.38 ± .08	2.76 ± .71	0.75 ± .22	0.26 ± .05	0.33 ± .07
Mixed mostly legume	0.35 ± .08	2.65 ± .71	1.99 ± .22	0.29 ± 0.05	0.30 ± .07
Legume	0.33 ± .08	3.07 ± .71	1.21 ± .22	0.30 ± .05	0.26 ± .07
Hay					
Grass	0.22 ± .06	1.84 ± .57	0.55 ± .21	0.21 ± .06	0.19 ± .09
Mixed mostly grass	0.23 ± .06	1.93 ± .53	0.75 ± .29	0.23 ± .05	0.15 ± .06
Mixed mostly legume	0.25 ± .05	2.26 ± .47	1.14 ± .29	0.26 ± .05	0.18 ± .06
Legume	0.25 ± .05	2.58 ± .51	1.46 ± .29	0.29 ± .06	0.26 ± .07
Silage					
Grass	0.23 ± .08	2.35 ± .86	0.67 ± .26	0.22 ± 0.06	0.22 ± .08
Mixed mostly grass	0.28 ± .06	2.29 ± .67	0.87 ± .27	0.23 ± .05	0.20 ± .06
Mixed mostly legume	0.29 ± .05	2.54 ± .59	1.14 ± .25	0.25 ± .05	0.22 ± .06
Legume	0.30 ± .06	2.64 ± .55	1.26 ± .23	0.25 ± .05	0.23 ± .06

Note: Sodium: <0.05 in all forages, Chloride (Legume/Grass forages): 0.5 to 1.0%.

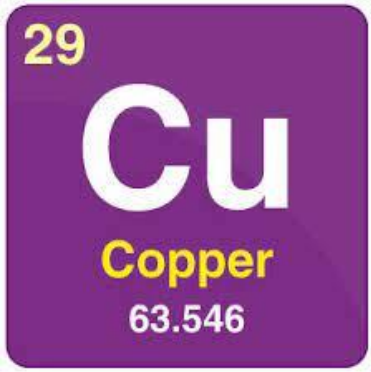
Adapted from Rayburn, 1995.



Copper and Molybdenum

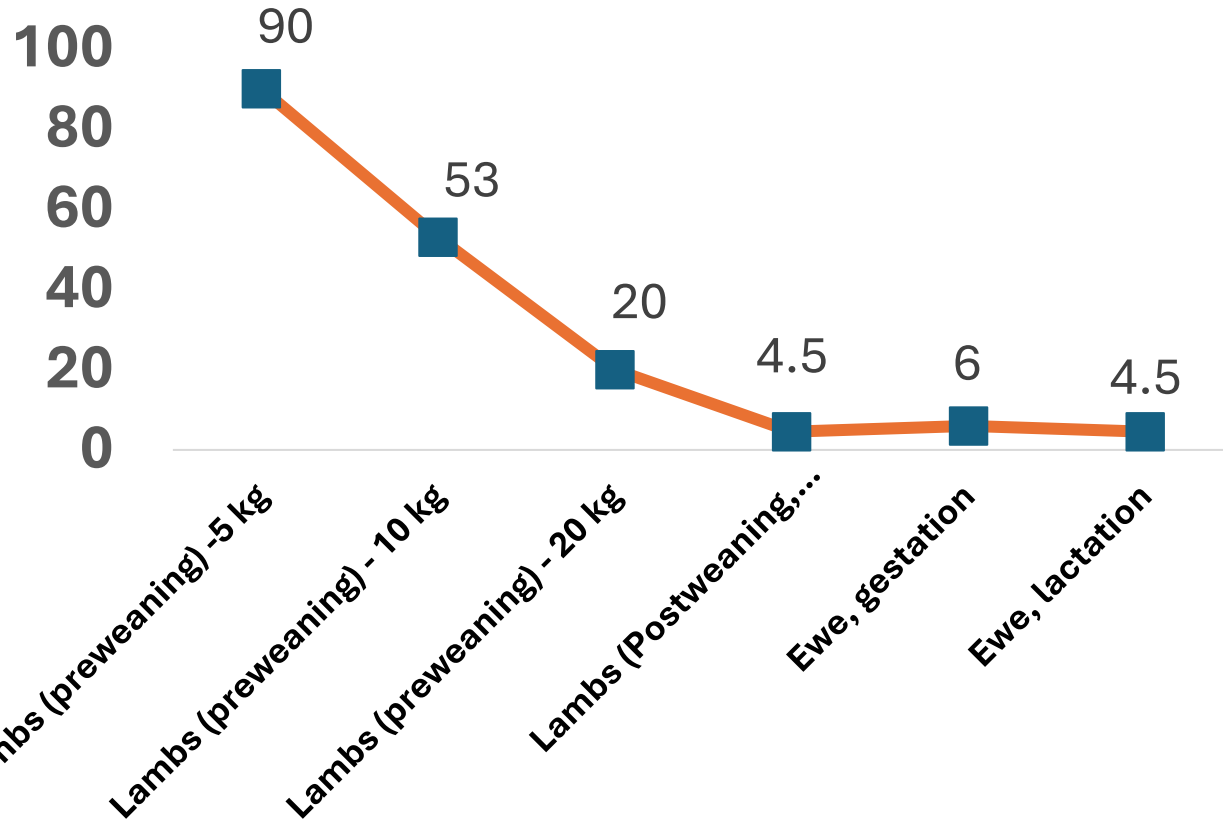


Mineral	Physiological function	Deficiency	Toxicity
Copper and Molybdenum	Enzyme component and catalyst involved in steroidogenesis and prostaglandin synthesis	Delayed and depressed estrus, abortion, death fetuses, infertility, congenital ataxia	Haemolytic crises, haemoglobinuria, haemoglobinaemia, and jaundice; Severe diarrhea, weight loss, anorexia, and reproductive failure

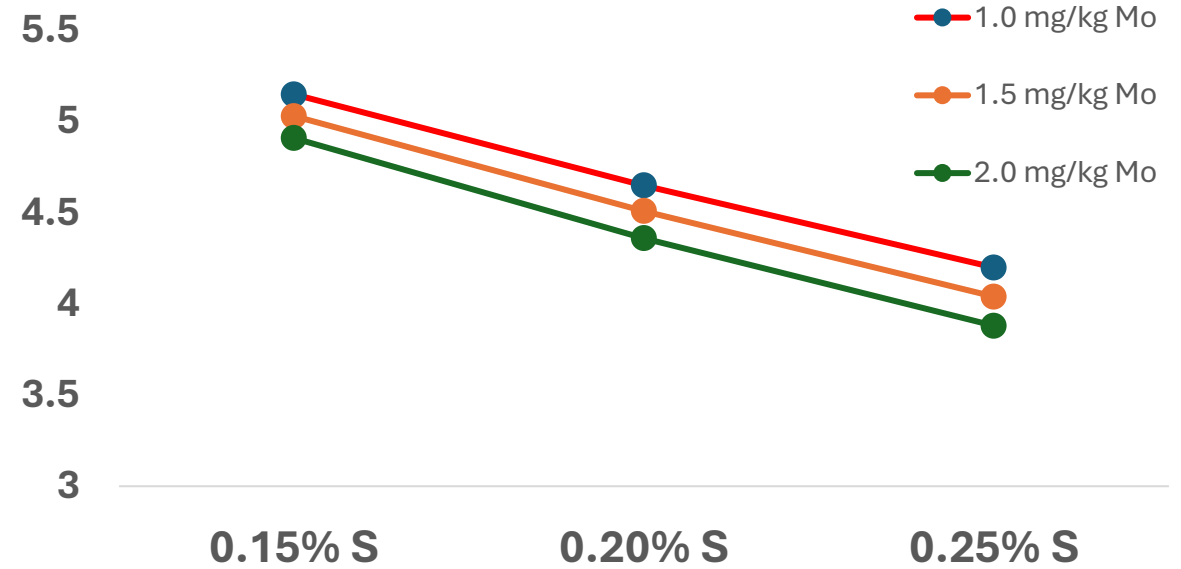


Copper absorption coefficients

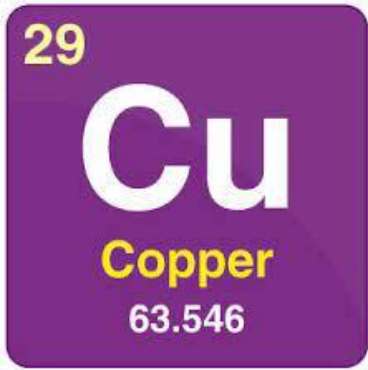
Absorption Coefficient, %



Absorption coefficient, %



Suttle and McLaughlin, 1976

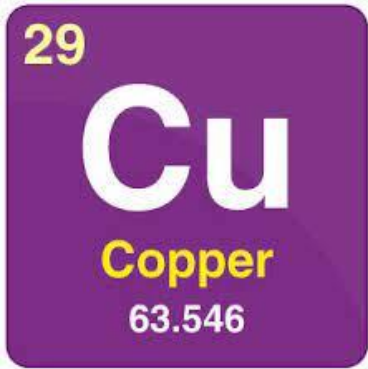


Sheep



- **Copper requirements (Sheep):** 7-11 mg/kg DM
 - Ratio between Cu and Mo should be around 4:1
- **Maximum tolerable levels (Sheep):** 15 mg/kg DM
 - Mo concentration: 1-2 mg/kg
 - S concentration: 0.15-0.25%
- **Molybdenum requirements (Sheep):** 0.5 mg/kg DM





Copper toxicity



FEED

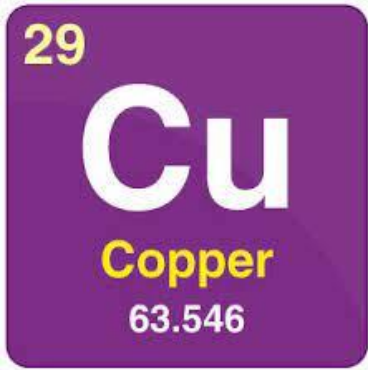
- Do not give sheep feed that is specially formulated for cattle, swine, or poultry
- Have feed tested for copper and other minerals
- Cu:Mo ratio between 4-1 up to 10-1

FORAGE

- Forage test for molybdenum, sulfur, and iron levels
- No grazing on pastures containing swine/poultry waste
- No algae/snail/pest control products with copper

EQUIPMENT

- Clean feed and water equipment thoroughly before use, especially if equipment has previously been used to feed other species with higher copper tolerances



Goats



Copper requirements (Goats):

- **Lactating:** 15 mg/kg DM
- **Bucks:** 20 mg/kg DM
- **Growing:** 25 mg/kg DM

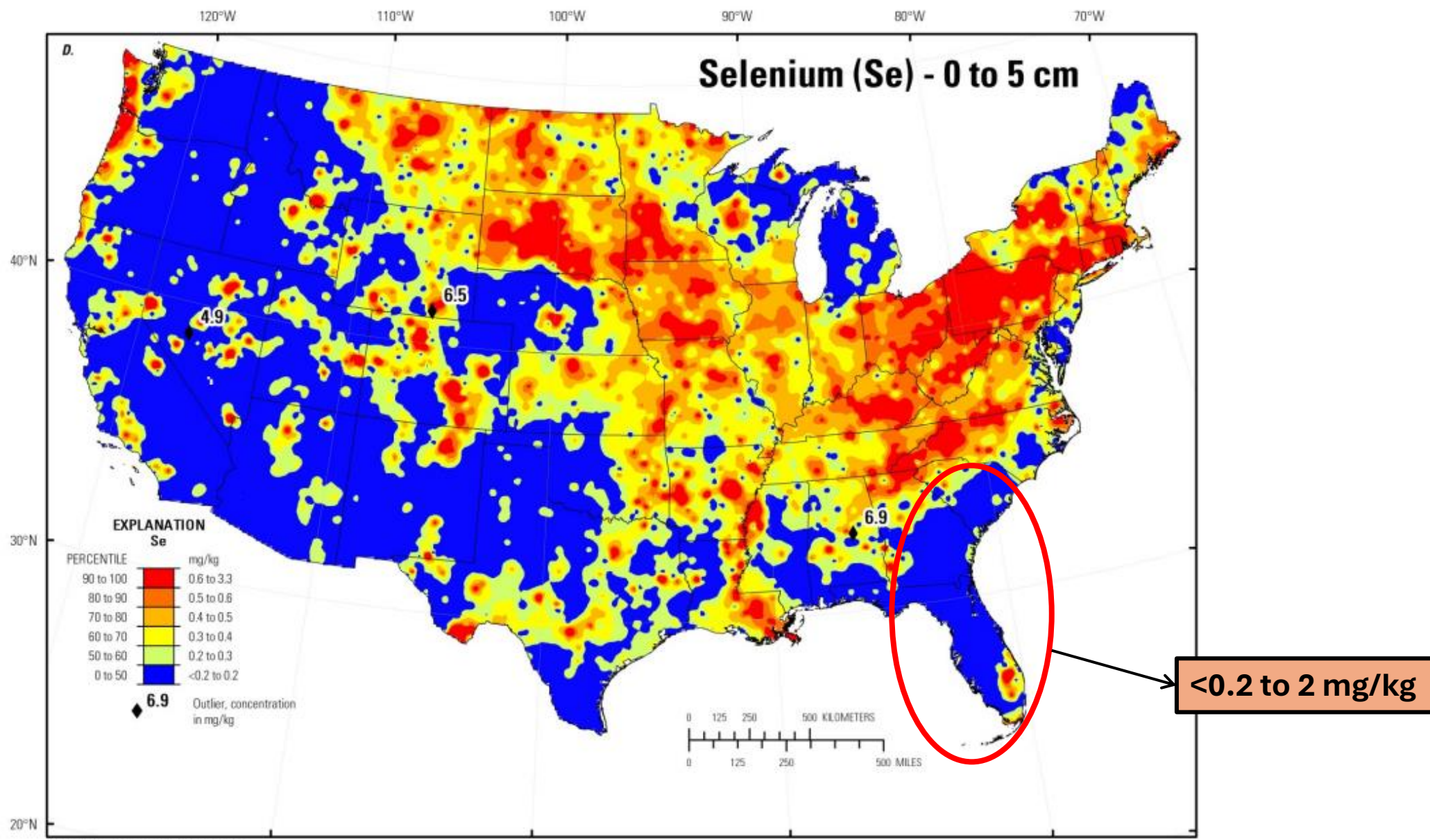
Maximum tolerable levels (Goats):

- Not established
- Cautious approach (40 mg/kg)

- **Molybdenum requirements (Goats):** 0.1 to 1 mg/kg DM

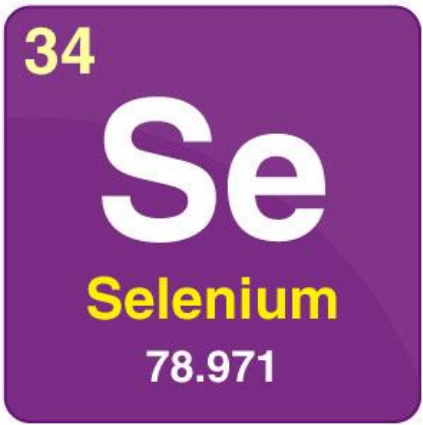


34
Se
Selenium
 78.971



Base map from U.S. Geological Survey digital data
 Lambert Conformal Conic projection
 Standard parallels 33°N and 45°N
 Central Meridian 96°W
 Datum NAD 1983

- [USGS Scientific Investigations Report 2017-5118: Geochemical and Mineralogical Maps, with Interpretation, for Soils of the Conterminous United States](#)



Selenium deficiency

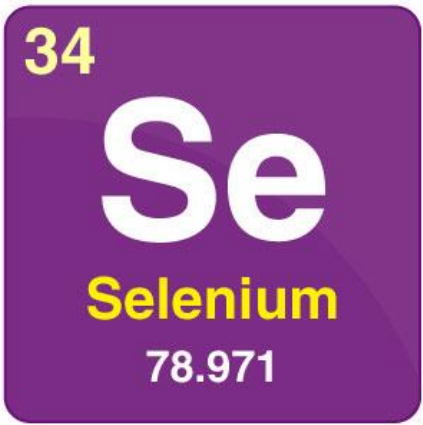
- Pastures grown on selenium-deficient soils (such as acid soils receiving more than 410 mm annual rainfall)
- Lush, rapidly growing pasture
- Legume-dominant pasture
- Paddocks that have received heavy or long-term sulphur-containing or superphosphate fertilizer applications.



Kappel et al., 1985

Forages	Number of samples	Selenium (mg/kg)
Corn silage	19	0.05
Sorghum silage	21	0.06
Bermudagrass	27	0.16
Bahiagrass	41	0.09
Oats and Ryegrass	31	0.08

- Because of toxicity concerns, Se intake is controlled at **0.69 mg intake per day** or **0.30 mg/kg DM**.
- Overdose of Selenium (**5-15 mg**) can be lethal to lambs
- Mineral mixes cannot have more than **90 ppm (mg/kg) Se** and commercial products ranges from **10-90 ppm**



Selenium

Se (Premix, mg/kg)	Intake (grams) of premix to meet requirements (0.69 mg/day)	Intake (oz.) of premix to meet requirements (0.69 mg/day)
10	69	2.4
50	14	0.50
90	8	0.27

A premix with Se concentration of 10 ppm would need sheep to consume 2.4 ounces (69 grams) daily to meet requirement which is difficult to consume. A higher Se concentration premix, such as 50 or 90 ppm, would be more appropriate for adequate intake.

Trace mineral salt (reading labels)

Guaranteed Analysis

		%		PPM	
salt	min	94.0		940,000	
salt	max	99.0		990,000	
sodium	min	37.00		370,000	
sodium	max	39.98		399,800	
selenium	min	0.007		70	
selenium	max	0.009		90	

		%		PPM	
zinc	min	0.350		3,500	
iron	min	0.200		2,000	
manganese	min	0.200		2,000	
cobalt	min	0.005		50	
iodine	min	0.007		70	

Ingredients

Salt, Zinc Oxide, Iron Carbonate, Calcium Carbonate, Manganous Oxide, Red Iron Oxide, Mineral Oil, Sodium Selenite, Calcium Iodate, Cobalt Carbonate, and Anise Flavor.

Guaranteed Analysis

Calcium (Ca), minimum	3.5%	Iodine (I), minimum	6,000 ppm
Calcium (Ca), maximum	5.5%	Manganese (Mn), minimum	16,000 ppm
Sulfur (S), minimum	11.00%	Copper (Cu), minimum.....	50,000 ppm
Cobalt (Co), minimum	600 ppm	Copper (Cu), maximum.....	55,000 ppm
Selenium (Se), minimum.....	990 ppm	Zinc (Zn), minimum.....	245,000 ppm
Iron (Fe), minimum	1,000 ppm		

Ingredients

Zinc Sulfate, Copper Sulfate, Zinc Oxide, Manganese Sulfate, Mineral Oil, Calcium Carbonate, Manganous Oxide, Ethylenediamine Dihydrochloride, Sodium Selenite, Ferrous Sulfate, Cobalt Carbonate.

GUARANTEED ANALYSIS

CHEMICAL ANALYSIS	AVERAGE	MAX	MIN
Sodium Chloride	90% - 95%	96%	91%
Calcium	0.35% - 0.55%	0.85%	0.35%
Copper			3 ppm
Iodine	12 ppm		10 ppm
Iron	500 ppm		300 ppm
Magnesium	0.09%		0.06%
Manganese			5 ppm
Phosphorus			0.02%
Potassium			0.03%
Sulfur	0.2%		0.07%
Zinc			1 ppm

TYPICAL - NOT GUARANTEED

MINERAL	PPM	MINERAL	PPM	MINERAL	PPM
Aluminum	215	Gadolinium	.61	Selenium	0.23
Antimony	1.08	Gallium	2.36	Silicon	3000
Arsenic	<0.02	Germanium	.27	Silver	.29
Barium	9.95	Indium	.37	Strontium	11.9
Bismuth	0.38	Lanthanum	0.08	Tantalum	.97
Boron	1.07	Lead	0.06	Tellurium	0.17
Bromine	10.51	Lithium	0.74	Thallium	.09
Cadmium	<0.05	Lutetium	.07	Thorium	0.19
Carbon	204	Molybdenum	0.08	Thulium	.07
Cerium	.76	Nickel	.07	Tin	.12
Cesium	.33	Niobium	0.11	Titanium	0.93
Chromium	0.16	Praseodymium	.11	Tungsten	.11
Cobalt	0.08	Rubidium	3.77	Vanadium	.18
Dysprosium	.21	Ruthenium	.07	Ytterbium	.07
Erbium	1.34	Samarium	1.44	Yttrium	0.04
Fluoride	10.6	Scandium	.18	Zirconium	2.95

Mineral sources

- Mineral availability - how easily the body can absorb and use minerals from the mineral sources

Form	Absorption
Oxides	Low (20-40%)
Sulfates	Medium (40-60%)
Chelates	High (50-70%)

Vitamins

Fat soluble

- **A**
 - **D**
 - **E**
 - **K**
- Usually adequate in diets containing high quality forages. Sometimes, supplementation is required
- Synthesized in rumen

Water soluble

- **C** Synthesized in tissues
 - **B complex**
 - **Thiamine (B1)**
 - **B12**
 - **Others**
- Synthesized in rumen
No dietary requirement

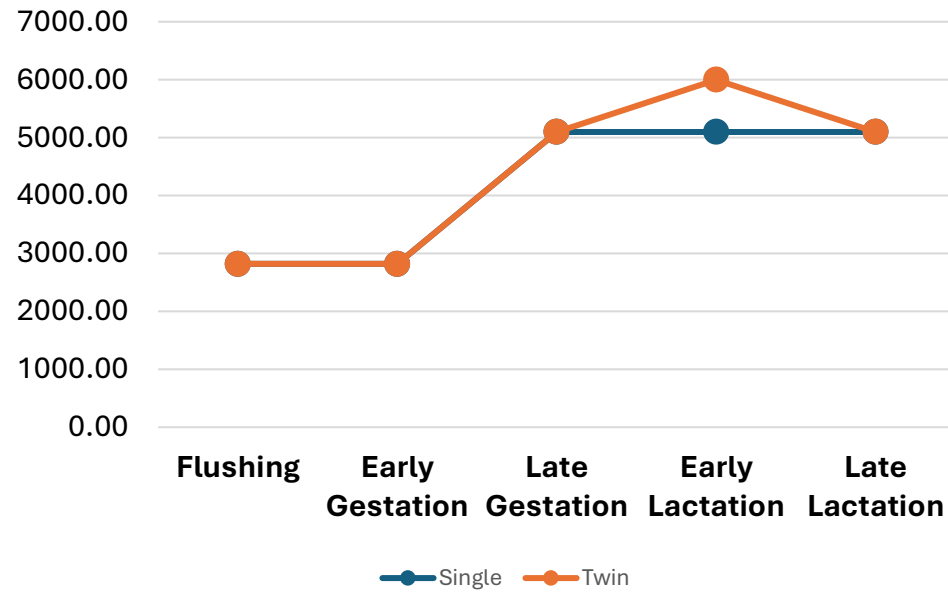
Vitamins

Table 1. Minerals and Vitamins in Forage and Required by Sheep

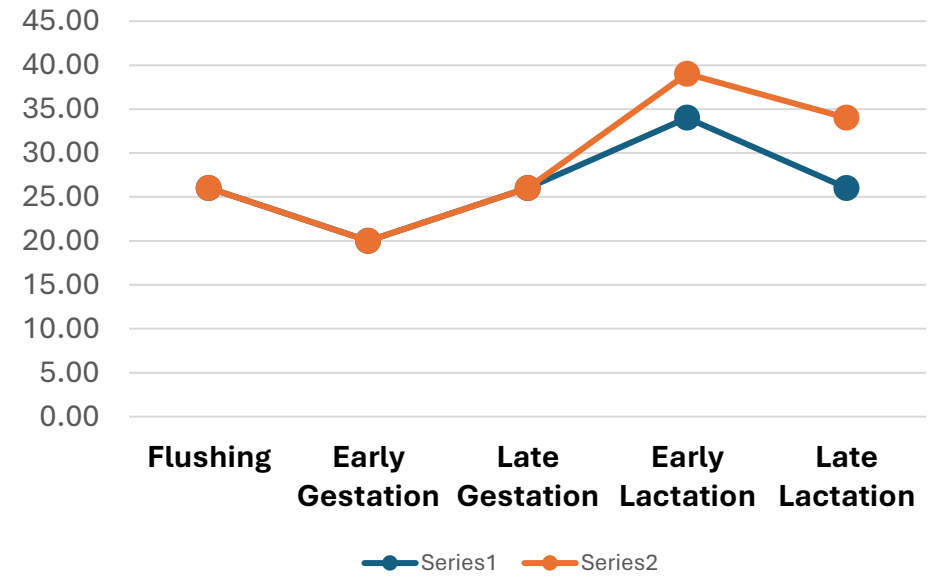
Table 1. Minerals and Vitamins in Forage and Required by Sheep				
		Class of Sheep and Their Requirements (in diet Dry Matter)		
		Mature Ewe		Young Lamb
Nutrient	Good Forage	Early Pregnancy	Nursing Twins	Fast Gain
Vit A, IU/lb DM	50,000	1000	1200	500
Vit D, IU/lb DM	500	100	100	100
Vit E, IU/lb DM	10	7	7	7

Vitamin requirements

Vitamin A, IU/d



Vitamin E, IU/d



Vitamins

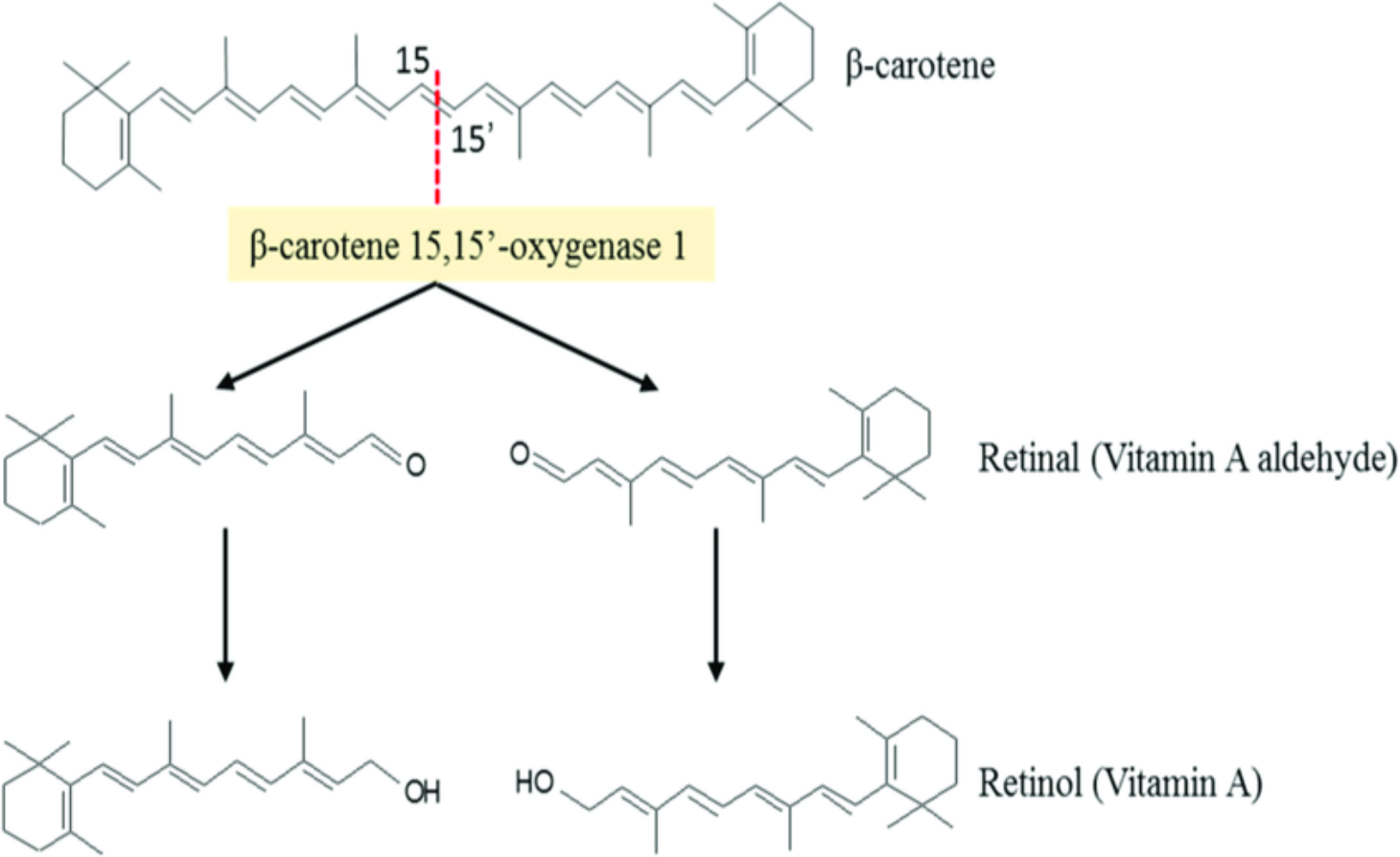
- Vitamins are inactivated during storage
- Half life is 30 days
- On farm Vitamin fortification
 - 50 ewes free choice mineral with ½ ounce intake
 - If needed, supplement ADE premix
 - Ewes need 3500 IU of Vitamin A and 150-300 IU Vitamin E daily

Example

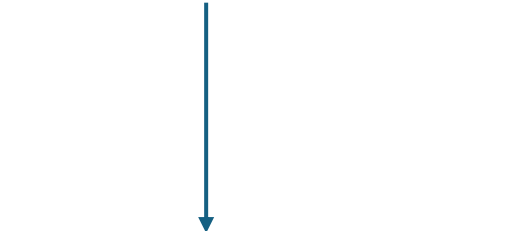
Feeding directions: 1 ounce per day (28 grams or 0.0625 lbs daily)

Nutrient Name	Min Max Indicator	Nutrient Amount
Ash	Max	90%
Calcium	Min	15.75%
Calcium	Max	18.90%
Phosphorus	Min	8%
Salt	Min	16.20%
Salt	Max	19.44%
Sodium	Max	7.80%
Magnesium	Min	0.75%
Potassium	Min	0.10%
Manganese	Min	2500 PPM
Cobalt	Min	10 PPM
Iodine	Min	90 PPM
Selenium	Min	24.5 PPM
Selenium	Max	29.4 PPM
Zinc	Min	4000 PPM
Vitamin A	Min	300000 IU/LB 18,750 IU
Vitamin D3	Min	30000 IU/LB 1,875 IU
Vitamin E	Min	2000 IU/LB 125 IU

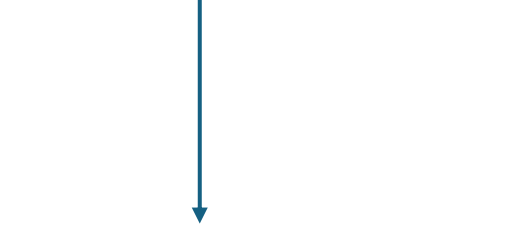
Vitamin A



**Grazing pastures
(Bahagrass, Bermudagrass)**



β -Carotene ~40 ug/g DM



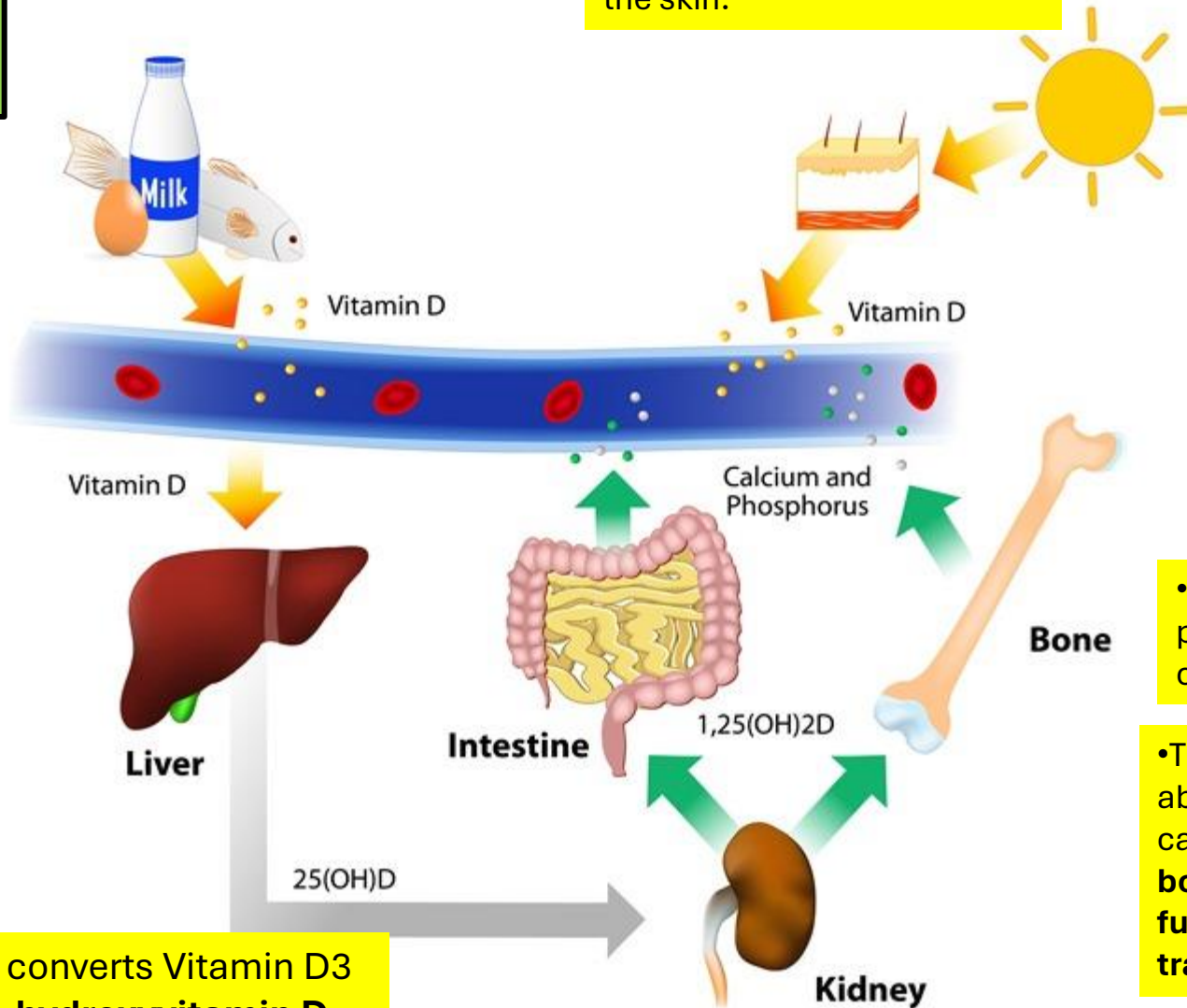
670 IU Vitamin A
synthesized per mg β -
Carotene

Vitamin E

- Feed ewes or nannies > 100 IU/head/days
 - Late gestation and lactation
- Creep feed minimum 60,000 IU/ton
 - Up to 100,000 IU/ton
- Do not count on Vitamin E in mineral
 - Concentration is very low
- Grazing on green grass – no problem because of high levels

Vitamin D and Calcium absorption

Sunlight triggers the production of **Vitamin D3** in the skin.



Liver converts Vitamin D3 to **25-hydroxyvitamin D**.

•**Vitamin D** also interacts with the parathyroid hormone to pull calcium from bones if necessary.

•This boosts calcium absorption, making dietary calcium more available for **bone health, muscle function, and nerve transmission**.

•The kidneys further convert it to the active form, **1,25-dihydroxyvitamin D (calcitriol)**.

Vitamin D levels

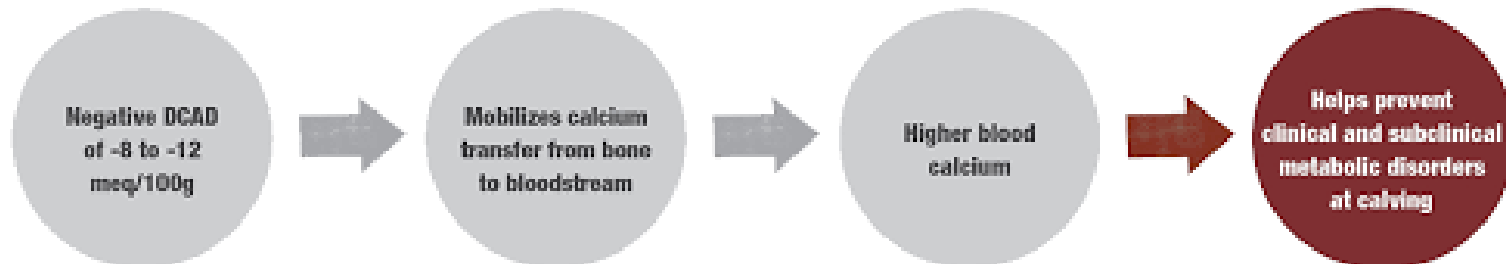
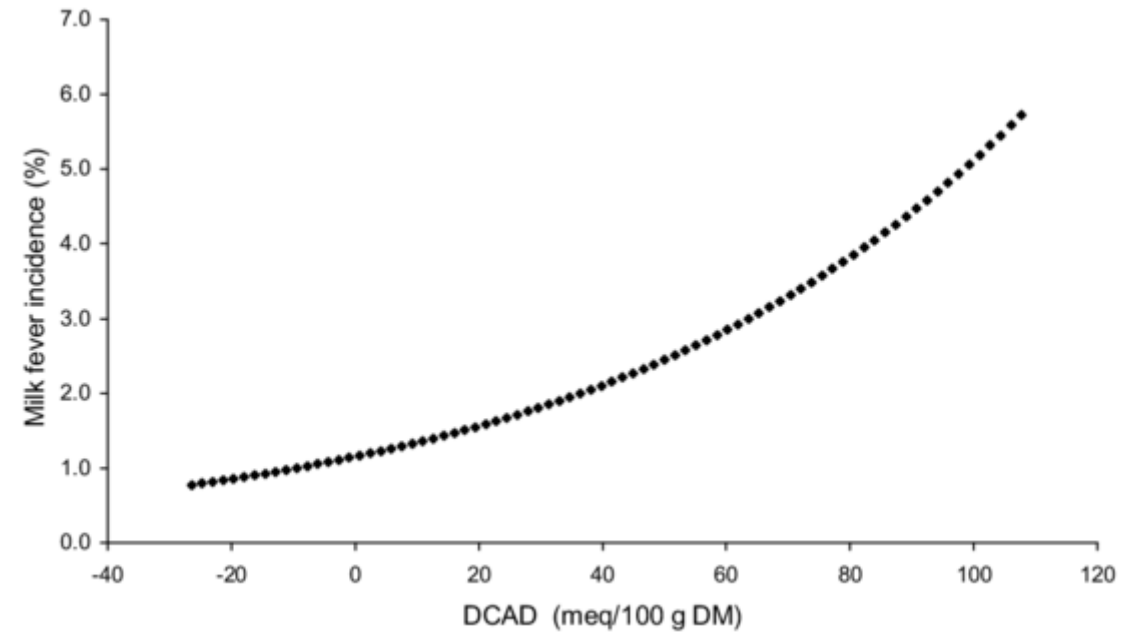
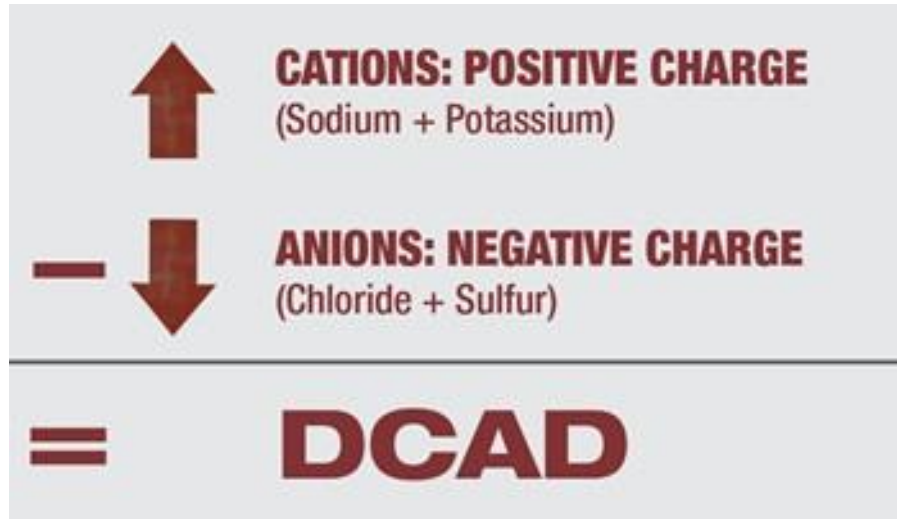
- 25-hydroxyvitamin D2: **2.8 ng/ml**
- 25-hydroxyvitamin D3: **14.5 ng/ml (75 ng/ml)**

Suffers from lactational clinical hypocalcemia

The low Vitamin D2 reflects the quality of the forage perhaps this is aged forage that has been stored for a while and not well sun-cured.

- 25-hydroxyvitamin D2: **4.6 ng/ml**
- 25-hydroxyvitamin D3: **39.0 ng/ml**

Dietary Cation-Anion difference



Take-home

- Sample forages and feeds
 - Trace mineral analysis are around \$40 per sample
 - If feed ingredients are purchased, even more important to test
 - Pasture mineral composition will change withing season and from year to year
- Monitor mineral intake
 - Add to grain mix
 - Read mineral tag and avoid over-consumption
 - Needed year round
- Prioritize mineral and vitamin program during breeding, gestation, lactation and pre-weaning



Thanks

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