Vitamins and Trace Minerals

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Fat Soluble Vitamins

A   D   E    K

Are stored in the body
Can accumulate
Could potentially be toxic
Vitamin D

- Produced by the body when UV rays strike the skin
- Produced in sun-cured forages
- Supplementation rarely needed
- Converted by liver to 25-hydroxyvitamin D (calcidiol)
- Converted by kidney to active 1,25-dihydroxyvitamin D (calcitriol)
- Interacts with parathyroid hormone (PTH)
- Promotes calcium absorption, serum calcium homeostasis, bone remodeling
- Critical for inter- and intracellular communication
- Deficiency: rickets/osteomalacia (brittle bones)
- Toxicity: high blood calcium, loss of appetite, calcification of soft tissues
Vitamin K

• Present in green, leafy plants
• Synthesized by ruminal/intestinal bacteria
• No need to supplement
• Critical for normal blood clotting
• Important to bone, cartilage, smooth muscle
• Deficiency rare
• Toxicity not known
• Testing not performed
Vitamin A

• Precursor β-carotene present in green forages – seasonal
• Grains contain very little, except some in yellow corn
• Degrades rapidly in the rumen when high concentrate present
• Sunlight and oxygen break it down, not much in hay
• Ensiling preserves β-carotene but makes it less bioavailable
• Stored in liver, but not more than 2-4 months’ worth
• Serum levels not affected until liver stores almost gone
• Supplemental: all-trans-retinyl acetate, all-trans-retinyl palmitate
Vitamin A

- Component of visual purple required for dim light/night vision
- Component of visual pigments (rods & cones)
- Critical for maintenance of all epithelial tissues
- Required for bone development
- Protective against infection (particularly mastitis)
- Essential for normal growth and reproduction
- Barely crosses placenta – colostrum critical
Vitamin A

- Deficiency: reduced feed intake, rough hair coat, joint & brisket edema, lacrimation, xerophthalmia, improper bone growth, slow growth, increased incidence of infections, low conception rates, abortion, stillbirths, blind calves, abnormal semen

- Toxicity: rarely a problem in livestock

- Stored in liver, but not more than 2-4 months’ worth
- Serum levels not affected until liver stores almost gone
- Liver biopsy or test livers of animals that die, stillbirths, abortions run weekly at TVMDL-CS
- protect from light and freeze before shipping for best results
Vitamin E

• Occurs naturally in green grass as α-tocopherol
• Degraded in hay
• Degraded by ruminal bacteria
• Destroyed by heat, oxygen, moisture, unsaturated fatty acids, trace minerals and high nitrate concentrations
• Level of supplementation needed varies with bovine diet
  • Difficult to formulate
  • Supplemental form all-\textit{rac}-α-tocopheryl acetate
  • Depends on amounts of antioxidants, sulfur-containing amino acids, and selenium present
• Water-soluble supplements may increase levels rapidly for horses
Vitamin E

• Lipid-soluble cellular antioxidant – membrane maintenance
• Arachidonic acid metabolism (prostaglandins)
• Free radical scavenger in the immune system
• Protects and facilitates uptake & storage of Vitamin A
• Functions closely linked with Selenium
• Maintains structural and functional integrity of
  • skeletal muscle
  • cardiac muscle
  • smooth muscle
  • peripheral vasculature
Vitamin E

- Present in many tissues, but not stored in high concentrations
  - Highest in liver and body fat
  - Barely crosses placenta – colostrum critical
- Deficiency: classically, white muscle disease; general muscular dystrophy, leg weakness, crossover walking, impaired suckling ability, heart failure, paralysis, hepatic necrosis
- Toxicity: Not known to occur, since large stores not maintained
- Serum levels not affected until liver stores almost gone
- Liver biopsy or test livers of animals that die, stillbirths, abortions
  - Run weekly at TVMDL-CS
  - Protect from heat, freeze before shipping if possible
Water Soluble Vitamins

Generated by ruminal microbes
- Biotin
- Folic acid
- Inositol
- Niacin (nicotinamide)
- Pantothenic acid
- Riboflavin (B2)
- Thiamine (B1)
- Cobalamin (B12)
- B vitamins in general

Vitamin C
- Water soluble antioxidant
- Synthesized by ruminants over 3 weeks old

Choline
- Required in g rather than mg amounts
- Required in milk replacers
- Degraded in rumen
- Deficiency: muscular weakness, fatty liver, renal hemorrhage
ICP/MS

Trace minerals
Chromium

- Component of glucose tolerance factor
- Increases immunity and growth rate in cattle
- Trivalent chromium, maximum tolerable level, bovine: 1000 mg/kg diet [hexavalent is the more toxic form]
- Dietary recommendations not yet set
Cobalt

- Vitamin B12 made by ruminal bacteria from dietary cobalt
- High concentrate diets reduce B12 production
- B12, with its attached cobalt, is stored in the liver
- Deficiency: Decreased appetite, failure to grow, weight loss, decreased resistance, fatty liver, anemia
- Toxicity: Unlikely unless mineral mixing error. Test liver cobalt.
- Liver and serum levels not tightly defined

Gathering data to develop better normal ranges in liver and serum
Copper

- From feedstuffs, incorporated into enzymes in tissues
- Bone and connective tissue strength
- Transporting iron for hemoglobin synthesis
- Cellular antioxidation and phagocytic cell function
- Melanin pigment
- Pre-ruminants absorb up to 60% of oral copper
- Adults absorb 1 - 5% (reduced more by dietary S, Mo, Fe)
- Stored in the liver
Copper Deficiency

- Reduced growth
- Black-hair turns reddish
- Decreased reproductive efficiency
  - Delayed or depressed estrus
- Decreased disease resistance
- Cardiac failure
- Brittle bones
Copper Toxicity

- Accumulates in liver when over-supplemented
- Sheep far more susceptible than cattle
- Stress-induced sudden release to circulation
- Intravascular hemolysis
  - Reduced oxygen to tissues
  - Hemoglobinuria
  - Renal dysfunction
- Molybdate compounds antidotal
Iodine

- From feedstuffs
- Critical component of thyroid hormones
  - Regulation of metabolism
  - Calcium homeostasis
- Secreted into milk – reasonable indicator of dietary status
- Deficiency: fetal death with normal cows; goiter in newborn calves
- Toxicity: 5 mg/kg dm too high; decreased milk production, excess nasal and ocular discharge, salivation, coughing
Iron

- From feedstuffs, incorporated into enzymes in tissues
  - Myoglobin and hemoglobin
  - Metabolic enzymes in liver and kidney
  - Required for cellular energy management
- Deficiency: anemia, decrease rate of gain, reduced immune response
- Toxicity: Interference with Cu, Zn; may deposit in tissues; oxidative stress; decreased gain
- Stored in the liver
Manganese

• From feedstuffs, incorporated into enzymes in tissues
• Mucopolysaccharide production
• Critical for bone and cartilage growth/maintenance
• Important to immunity
• Deficiency: decreased growth, skeletal abnormalities, ataxia due to incomplete inner ear development
• Toxicity is unlikely: Feed intake and growth are depressed with diets > 1000 mg/kg
• Stored in the liver

Gathering data to develop better normal ranges in liver and serum
Molybdenum

- From feedstuffs, incorporated into enzymes in tissues
- Important in several basic metabolic pathways
- Deficiency is difficult to reproduce, signs unclear; suggests supplementation is not necessary
- Toxicity: Directly antagonizes Cu absorption, clinical signs are due to Cu deficiency
- Stored in the liver

Gathering data to develop better normal ranges in liver and serum
Selenium

• From feedstuffs, incorporated into enzymes in tissues
  • Cellular antioxidant – part of glutathione peroxidase
    • Particularly in muscle and cartilage
    • Synergistic with Vitamin E
  • Critical to thyroid hormone metabolism
  • Important for prostaglandin metabolism
• Stored in the liver
Selenium

• Deficiency
  • Classically, white muscle disease
  • Leg weakness, stiffness, flexion of hock joints, muscle tremors, heart failure
  • Unthriftiness, diarrhea, fetal membrane retention, cystic ovaries, udder edema
• Toxicity: Sloughing hoofs, lameness, hair loss, emaciation (alkali disease, blind staggers – not)
Zinc

- Cofactor for many enzymes
- Critical for immunity and metabolism
- Needed for thyroid hormone binding
- RNA synthesis & protein production
- Deficiency: decreased rate of gain, decreased testicular growth, hoof/horn weakness, parakeratosis, thymic dystrophy, lymphoid depletion; decreased cell-mediated immunity
- Toxicity: Suppression of copper uptake
Vitamin A, Vitamin E

Serum, off the clot
Liver

For Vitamin A – protect from light
# Mineral Panels at TVMDL

## Trace Minerals
- Cobalt
- Copper
- Iron
- Manganese
- Molybdenum
- Selenium
- Zinc

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Trace Minerals</th>
<th>Heavy Metals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serum only</td>
<td>Serum &amp; EDTA</td>
<td>Arsenic</td>
</tr>
<tr>
<td>Liver</td>
<td></td>
<td>Cadmium</td>
</tr>
<tr>
<td>Feed</td>
<td></td>
<td>Lead</td>
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</tbody>
</table>

## Heavy Metals
- Arsenic
- Cadmium
- Lead
- Thallium
- Zinc

**Comprehensive Metal Panel = Trace Minerals + Heavy Metals**
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