Interaction of Nutrition and Health in Cows

Dr. Matt Hersom
Extension Beef Cattle Specialist
Dept. of Animal Sciences
Overview

- Why is nutrition important for immunity
- What nutrients are utilized for immunity
- Where do nutrients integrate into immunity
- What happens with micronutrients are supplemented
- Practical considerations
Immune system

Acquired

- T-cell immunity (cell-mediated immunity)
  - Whole T-cells released into:
    - Suppressor T-cells
    - Helper T-cells
    - Cytotoxic T-cells
    - Death of the body's cells that are infected with a virus or otherwise damaged

- B-cell immunity (humoral immunity)
  - Antigen exposure
    - Lymphoblasts
      - Plasma cells
        - Antibodies
          - Complement cascade
            - Classical pathway
      - Clonal B-cells
        - Memory B-cells
          - Complement cascade
            - Alternative pathway

Innate

- Bloodbourne
  - Complement cascade
    - Alternative pathway
      - Neutrophils
      - Macrophages
      - Basophils
      - Eosinophils
      - Natural killer cells
      - Death of dangerous organisms
      - Direct killing of bacteria

- Physical barriers
  - Skin
  - Mucous membranes
  - Saliva
  - 1. Neutrophils
  - 2. Macrophages
  - 3. Basophils
  - 4. Eosinophils
  - 5. Natural killer cells
  - Stops infection before it enters the body
Importance of Nutrition
## Nutritional Profile

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>units</th>
<th>Bahiagrass</th>
<th>NRC Req.</th>
<th>Deficiency</th>
<th>Supplement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chromium</td>
<td>ppm</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Cobalt</td>
<td>ppm</td>
<td>0.4 – 0.6</td>
<td>0.10</td>
<td>0.06 – 0.04</td>
<td>5 – 300</td>
</tr>
<tr>
<td>Copper</td>
<td>ppm</td>
<td>4 – 8</td>
<td>10.0</td>
<td>2 – 6</td>
<td>1200 – 1500</td>
</tr>
<tr>
<td>Iodine</td>
<td>ppm</td>
<td>0.15</td>
<td>0.50</td>
<td>0.35</td>
<td>80 – 200</td>
</tr>
<tr>
<td>Iron</td>
<td>ppm</td>
<td>47 – 102</td>
<td>50.0</td>
<td>-3 – +52</td>
<td>4 – 9000</td>
</tr>
<tr>
<td>Magnesium</td>
<td>%</td>
<td>0.18 – 0.30</td>
<td>0.20</td>
<td>-0.12 – +0.10</td>
<td>1.0</td>
</tr>
<tr>
<td>Manganese</td>
<td>ppm</td>
<td>55 – 139</td>
<td>40.0</td>
<td>+15 – +99</td>
<td>500</td>
</tr>
<tr>
<td>Selenium</td>
<td>ppm</td>
<td>0.017</td>
<td>0.10</td>
<td>-0.08</td>
<td>26 – 40</td>
</tr>
<tr>
<td>Zinc</td>
<td>ppm</td>
<td>22 – 51</td>
<td>30.0</td>
<td>-8 – +21</td>
<td>3000</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>IU/lb</td>
<td>670,000</td>
<td>8600</td>
<td>-8 – +21</td>
<td>70 – 200,000</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>IU/lb</td>
<td>--</td>
<td>600</td>
<td></td>
<td>20 – 30,000</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>IU/lb</td>
<td>50,000</td>
<td>110 – 220</td>
<td></td>
<td>20 - 200</td>
</tr>
</tbody>
</table>
NRC Requirement for Nutrients

Dietary concentration

Equal

Less

Greater

optimal immun.

optimal immun.

optimal immun.

NRC Req.
Effect of Nutrient Deficiencies

Nutrient Status
- Normal
- Marginal
- Deficient

Time
- Immunity
- Fertility
- Growth
- Clinical Signs
Nutritional Concerns

• Undernourished cattle have poorer responses to vaccinations and are more susceptible to disease

• Problem-low feed intake is common during stress/disease
  – decreased rumen function
  – metabolic changes associated with stress
  – shrink---50% of shrink is loss of gut contents
Impaired
GIT Function

Concurrent
Infections

Impaired
Nutrition

Infectious
Agents

Impaired Immunity

Poor Performance of:
Vaccines, Growth, Reproduction, Lactation

Genetic Factors

Other Environmental Factors
Nutrients for Immunity
## Nutritional Modulators of Immunity Mechanisms

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td>All nutrients</td>
<td>Supply substrates for immune system function</td>
</tr>
<tr>
<td>Energy, protein, feeding</td>
<td>Regulate immunity through altering balance of hormones</td>
</tr>
<tr>
<td>Fatty acids, vitamins A, D, E</td>
<td>Direct regulatory on cells of immune system</td>
</tr>
<tr>
<td>Trace minerals</td>
<td>Important components of enzymatic reactions</td>
</tr>
<tr>
<td>Iron, biotin, manganese</td>
<td>Deprave pathogens of nutrients</td>
</tr>
<tr>
<td>Antioxidants</td>
<td>Reduce damage caused by immune response</td>
</tr>
<tr>
<td>Non-starch polysaccharides, lectin, sugars</td>
<td>Physical and chemical actions of feeds in the intestine</td>
</tr>
</tbody>
</table>

Adapted from Klasing, (2002)
What nutrients should we concern ourselves with?

• Energy
• Protein / Amino acids
• Essential Fatty Acids
• Micominerals
  – Chromium, Cobalt, Copper, Selenium, Zinc
• Vitamins
  – A, B, D, E
• What to ignore?
  – Vitamin B (likely), vitamin C (yes)
Integration of Micronutrients into Immunity
**Vit. A, E**

**Acquired**

**T-cell immunity** (cell-mediated immunity)
- Whole T-cells released into:
  - Suppressor T-cells
  - Helper T-cells
  - Cytotoxic T-cells

**Death of the body's cells that are infected with a virus or otherwise damaged**

**Vit. A, B, D, E**

**B-cell immunity** (humoral immunity)
- Antigen exposure
- Lymphoblasts

**Clonal B-cells**
- Antibodies
- Complement cascade

**Classical pathway**

**Vit. A, B, E**

**Complement cascade**

**Vit. A, E**

**Memory B-cells**


**Vit. A**

**Innate**

**Bloodbourne**
- Complement cascade
- Phagocytes
- Alternating pathway

**Vit. B, C, E**

1. Neutrophils
2. Macrophages
3. Basophils
4. Eosinophils
5. Natural killer cells

**Vit. A, B, C**

**Death of dangerous organisms**

**Vit. C, D**

**Direct killing of bacteria**

**Physical barriers**
- Skin
- Mucous membranes
- Saliva
- Fluxing action of urine and tears
- Stomach acid

**Vit. A**

**Stops infection before it enters the body**

$\text{UF University of Florida}$

$\text{IFAS Extension}$
Outcomes of Micronutrient Supplementation
Energy and Protein

Stress/disease
- 10 to 13% increase in metabolism with increase body temp.
- Increase in immune cell synthesis
- Increase in total Energy/Protein needs
- Pot. decrease in membrane integrity
- Mobilization of fat/muscle
- Body Condition Score

Decreased Appetite
- Decreased Intake
- Decreased E/P Supply
- Decreased Immune Response
Zinc

- 300 different enzymes
- Innate and acquired systems
- Tissue integrity
- Protein synthesis
- Inflammation
- T-cells, B-cells-antibodies, Neutrophils, Macrophages, Cytokine cascade, Skin
Copper

- Essential physiology and metabolism
- Enzyme: Superoxide Dismutase
- B-cell humoral response
- Inflammation
- B-cells antibodies, General phagocytes production, Neutrophils, Cytokine cascade
Selenium

- Definitive deficiency in FL soil
- Antioxidant system
- Enzyme: Glutathione peroxidase
- Mucous membranes
- Facilitates immune transfer from dam to calf
- B-cells antibodies, General phagocytes production, Neutrophils, Macrophages
Chromium

- Carbohydrate metabolism = energy supply
- T-cell cell mediated and B cell humoral response systems
- Lympoblasts, B-cells antibodies
- Alleviate suppression from stress
Micromineral supplementation summary

• Impacts may be dictated by
  – the specific immune stimulus
  – animal’s mineral status
  – concentration and bioavailability of the supplemental
  – mineral/vitamin complement/interaction
  – the animal itself

• The beneficial effect in times of stress, but limited to no affect in non-stress situations
Vitamin A

- Occurs only in plant material
- Cattle not efficient converters
- Intake is key
- Fat soluble-liver storage
- Skin, mucous membranes, killer cells, and lymphocytes
Vitamin E

- Tocopherol
- Fat soluble-liver storage
- Antioxidant system
  - Fxn with selenium
- Free radical formation, DNA repair, cell membranes
- Increase inflammatory process, antibody conc., decrease severity of stress response
Vitamin B Complex

- Water soluble
- Synthesized in rumen
- Multiple immune system functions
- B12 and Cobalt relationship
- Generally no direct need for B-vitamin supplementation
Vitamin C and D

• **Vitamin C** – antioxidant
  – Free radical control
  – Works with Vitamin E
  – Rely on tissue formation rather than intake

• **Vitamin D**
  – Bone formation
  – Ca/P regulation
  – Sunlight and forage
Vitamin supplementation summary

• Several work to effectively mitigate oxidative stress
• Consumption of fresh forage-plant based feeds supply adequate levels
Cow’s Perspective

• What insults and stresses occur with each production step?

• What is the immune aspect affected?

• What is the nutritional limitation?
Practical Considerations

• Energy and Protein
  – Supply issue primarily
  – Feed intake
  – Body Condition Score

• Microminerals
  – Inorganic vs Organic
  – Concentration
  – Conditions

• Vitamins
  – Specificity
  – Conditions

• Trace mineral status of animal before challenge
• What is the immune stimulus
• What is the physiological condition of the animal
Health and Immunity are more than vaccines and shots, more than feeds and good intentions. Health and Immunity in the cow herd is the combination of attention to detail, planning, and purposeful decision making.