Overview of Nutrients Required by Animals

ANSC 3400

Classes of Nutrients Required
- Water
- Carbohydrates
- Lipids (Fats)
- Protein
- Minerals
- Vitamins

Water
- Cheapest, most abundant, most critical nutrient
- ~70% of wt of newborn; 45-60% at maturity
- Functions
**Water (cont.)**

- Sources for animal
  - Drinking water
  - Water in feed
    - 
  - Metabolic water
    - 

**Water (cont.)**

- Dry matter vs. as-fed
  - Water content varies w/ ruminant & horse feeds
  - 
  - Swine and poultry usually “as-fed”
  - 
  - When using tables, be aware of DM vs. as-fed

- Determination of DM content

**Carbohydrates**

- Account for
  - 
  - 
- Main source of energy for animals
- Primarily starches and cellulose
  - Also
  - Cell walls:
    - 
  - Cell contents:
  - Glucose
**Carbohydrates**
- Sugars/starches readily digested
- Fibrous feeds less well digested
- No requirement for CHO *per se*
  - Energy values expressed by several methods:

**Lipids (Fat)**
- Account for
  - Insoluble in H₂O; soluble in organic solvents
- Because oil is valuable it is extracted from many oil seeds
  - Soybeans
  - Cottonseeds
  - Flax seeds (linseed)
  - Peanuts

**Lipids (Fat) cont.**
- Units of measure:
- 2.25X more energy than CHO or protein
Lipids (Fat) cont.  

Functions
- Linoleic acid (C_{18:2} \omega-6)
- Linolenic (C_{18:3} \omega-3)
- Need only ~ 1 tablespoon of oil per day

Protein

Found in greatest amount of any nutrient, except water, in all living organisms
- Made up of amino acids
- Need a continuous supply in diet
- Most N in feeds is in protein
  - Why "crude" protein?

Protein (cont.)

Protein terminology
- True protein -
- Nonprotein nitrogen (NPN) -
- Made up of AA linked by peptide bonds
Protein (cont.)

- Animals require AA... **not** protein

- **Essential** AA (also called *indispensable* AA)
  - Phenylalanine (PHE)
  - Valine (VAL)
  - Threonine (THR)
  - Tryptophan (TRY)
  - Isoleucine (ILE)
  - Methionine (MET)
  - Histidine (HIS)
  - Arginine (ARG)
  - Leucine (LEU)
  - Lysine (LYS)

Protein (cont.)

- **Nonessential** AA (also called *dispensable* AAs)
  - Alanine (ALA)
  - Aspartic Acid (ASP)
  - Asparagine (ASN)
  - Cysteine (CYS)
  - Cystine (CYS-CYS)
  - Glutamic Acid (GLU)
  - Glutamine (GLN)
  - Glycine (GLY)
  - Proline (PRO)
  - Hydroxyproline (OH-PRO)
  - Serine (SER)
  - Tyrosine (TYR)

Protein (cont.)

- **Requirements**
  - Greater for young, rapid growing (as % of diet)
  - Monogastric animals require AA, not protein
  - Balance ruminant diets for protein
  - Exceptions...
Minerals
Minerals = total mineral content of plant or animal
Minerals ~3-5% of animal body
- Ca = approx. ½ of mineral content
- P = approx. ¼
- All other minerals = approx. ¼

Minerals (cont.)
Classification
- Macrominerals (major)
  - Ca, P, Na, Cl, Mg, K, S
  - Units of measure usually expressed in gm or as a % of diet or feed
- Microminerals (usually called "trace minerals")
  - Co, Cu, F, I, Fe, Mn, Mo, Se, Zn
  - F and Se are toxic in excess amounts
  - Units of measure usually expressed in mg or μg or as a % of diet or feed

Minerals (cont.)
General functions
- Skeletal formation/maintenance
- Protein synthesis
- Oxygen transport
- Fluid balance & acid-base balance
- Cofactors in enzyme systems
Minerals (cont.)

- Some specific functions/Signs of deficiency
  - Ca
    - Bone and teeth formation; muscle contraction; blood clotting
    - Def: Rickets (young), osteoporosis (adults); tetany (intermittent muscle contractions); milk fever in dairy cattle (paturient paresis)
  - P
    - Bone and teeth formation; high-energy phosphate bonds
    - Def: Rickets, chewing on wood or boards (depraved appetite), eating soil (pica)

Minerals (cont.)

- Some specific functions/Signs of deficiency
  - Mg
    - Bone formation; enzyme cofactor for ATP formation and utilization
    - Def: Hyperirritability and convulsions; loss of equilibrium; tetany
  - Fe
    - Cellular respiration (hemoglobin; myoglobin; cytochromes)
    - Def: Anemia

Minerals (cont.)

- Some specific functions/Signs of deficiency
  - Zn
    - Cofactor for enzyme systems
    - Def: Parakeratosis in swine (rough, thickened skin); poor hair development; slipping of wool
  - Co
    - Component of vitamin B12 (also called cobalamin)
    - Def: Macrocytic anemia; Ruminants: severely reduced appetite and growth leading to death
  - I
    - Thyroxine formation (regulation of BMR)
    - Def: Goiter
Iodine
Simple goiter - enlarged thyroid gland due to I deficiency

Minerals (cont.)
Some specific functions/Signs of deficiency
- **Se**
  - Component of glutathione peroxidase which protects against cellular membrane damage; functions with vitamin E
  - Def: easily ruptured blood cells; nutritional muscular dystrophy (white muscle disease)
  - Excess: blind staggers; sloughing of hooves, tails
- **F**
  - Bone formation; traces protects against teeth decay
  - Excess: defects in enamel; bone deformities

Minerals (cont.)
Salt
- Always should be available either free choice or incorporated into diet
  - Ruminants and horses - 0.5 to 1% of diet
  - Pigs and poultry - 0.25 to 0.5% of diet
- Trace mineralized salt often used
  - TMS = 97% NaCl + Co, Cu, Fe, I, Mn, Zn & sometimes other minerals
Minerals (cont.)

- Ca, P, and Vitamin D
  - Try to keep the ratio of Ca to P (Ca:P) in the range of 2:1 to 1:1
  - Vitamin D is necessary for Ca absorption from intestines and bone deposition
  - Vit. D involved in renal reabsorption and bone deposition of P

Minerals (cont.)

- General feeding guidelines (Know!)
  - General rule-of-thumb
    - Grains tend to be low in Ca and adequate in P
    - Forages tend to be low in P and adequate in Ca
  - Phytic acid binds ~half the P in plants, and phytin-P is poorly utilized by nonruminants
    - Not a problem for ruminants because of rumen microorganisms
  - Fe needed for young pigs

Vitamins

- The name comes from “vital amines” which was shortened to “vitamines.”
  - “Vital” for life
  - Contain N
  - Vitamins A & C discovered….contained no N
    - Became “vitamins”
  - Necessary for metabolic activity but do not become part of structural components of body
Vitamins (cont.)

- 4 fat-soluble vitamins
  - A, D, E, K
- 10 water-soluble vitamins
  - Thiamin, riboflavin, pantothenic acid, niacin, pyridoxine, biotin, folic acid, choline, B₁₂
  - Vitamin C
- Monogastrics require a dietary source of all
- Ruminants: microorganisms synthesize Vitamin K, B vitamins & Vitamin C

Vitamins (cont.)

- Fat-soluble vitamins have “provitamins” (precursors)
  - Chemically related substances that the body can convert to the active form of the vitamin
    - Carotene → Vitamin A
    - Cholecalciferol (animal) & ergocalciferol (plants) → Vitamin D
    - α-Tocopherol → Vitamin E
    - Menadione → Vitamin K

Vitamins (cont.)

- No provitamins for the B-vitamins or Vit. C
- Storage
  - 
  - 
- Functions
  - B-vitamins
    - 
  - Fat-soluble vitamins
**Vitamins (cont.)**

- **Primary functions/Signs of deficiency**
  - **Vitamin A**
    - Vision, epithelial tissue maintenance, bone formation
    - Def: Night blindness, xerophthalmia; abnormal bone growth
  - **Vitamin D**
    - Bone formation/maintenance of blood Ca conc\(\text{e}\)
    - Ca absorption, P reabsorption (renal tubules)
    - Def: Rickets (growing youth); osteomalacia (adult rickets – softening of bones)

**Vitamins (cont.)**

- **Primary functions/Signs of deficiency**
  - **Vitamin E**
    - Antioxidant / Maintain membrane integrity
      - Protect Vitamin A, essential fatty acids, etc. from peroxidation
      - Membrane lipid bilayers are high in PUFA which are subject to oxidation. Vitamin E's function in maintaining membrane integrity might attribute to its prevention of the membrane damage
    - Def: nutritional muscular dystrophy

**Vitamins (cont.)**

- **Primary functions/Signs of deficiency**
  - **Vitamin K**
    - Prothrombin formation; blood clotting
    - Def: spontaneous hemorrhages; prolonged clotting time
  - **Antivitamin (antagonists)**
    - Sweetclover disease in cattle
    - Dr. Karl P. Link
    - Dicoumarol; warfarin
Primary functions/Signs of deficiency

Niacin
- Coenzyme for oxidation/reduction reactions (energy metabolism)
  - NAD & NADP
- Def: pellagra (*pelle* for skin; *agra* for sour); 1730
  - Rough skin; dermatitis; “black tongue” in dogs
  - Humans: 3D’s - dermatitis, diarrhea, dementia
  - Spread with the spread of the cultivation of corn
  - Epidemic in southern U.S. after Civil War
    - 1915 - 10,000 deaths

Pellagra

1937 - Discovery: caused by niacin deficiency
- Dr. Conrad Elvehjem

Two problems with corn
- Niacin is bound (Bound form called niacytin)
- Corn is low in tryptophan (precursor for niacin synthesis)

Discovery was confusing
- Caused by spoiled corn? Infectious?
- Low protein diets also resulted in pellagra (no Tryp)
- Milk prevented and cured pellagra (niacin but Tryp)
- Mexicans eat tortillas, but very little pellagra
  - Soak corn in lime water to make tortillas; lime frees niacin!