Nutrients and Nutrient Requirements

Reminders....
- Lab this week and next week: AGAD21
- Bring a calculator and your NRC tables to labs

Nutrients...
- Definition
- Chemical Facts and Features
- Requirements

Nutrients...
- What is the definition of a nutrient?
  - Chemical component of a feed ingredient that is required for normal body function.

Nutrients...
- Definitions and Characteristics
  - Chemical molecules or elements used for:
    - Maintenance
    - Growth
    - Production
    - Reproduction

Nutrients...
- Chemical classifications:
Nutrients...

- Chemical classifications:
  - Carbohydrates
  - Lipids
  - Proteins (amino acids)
  - Vitamins
  - Minerals
  - Water

Carbohydrates- \((\text{CH}_2\text{O})_n\)

- Glucose

Monosaccharides
  - Glucose, Fructose, Galactose

Disaccharides
  - Maltose, Sucrose, Lactose

Polysaccharides
  - Starch, Cellulose

Carbohydrates...

- soluble in nonpolar organic solvents (as chloroform and ether)
- Contain C, H, and O (C,H > O)

Lipids...

18:1ω or 18:2

\[
\text{CH}_3(\text{CH}_2)_7\text{CH} = \text{CH}(\text{CH}_2)_2\text{COOH}
\]

- Triacylglycerol ester

Lipids...

Table 1. Common fatty acids

<table>
<thead>
<tr>
<th>Fatty Acid</th>
<th>Chain Length</th>
<th>Saturated or Unsaturated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palmitic acid (16:0)</td>
<td>16 carbon atoms</td>
<td>Saturated</td>
</tr>
<tr>
<td>Oleic acid (18:1)</td>
<td>18 carbon atoms</td>
<td>Unsaturated</td>
</tr>
<tr>
<td>Linoleic acid (18:2)</td>
<td>18 carbon atoms</td>
<td>Unsaturated</td>
</tr>
<tr>
<td>Linolenic acid (18:3)</td>
<td>18 carbon atoms</td>
<td>Unsaturated</td>
</tr>
<tr>
<td>Arachidonic acid (20:4)</td>
<td>20 carbon atoms</td>
<td>Unsaturated</td>
</tr>
<tr>
<td>Docosahexaenoic acid (22:6)</td>
<td>22 carbon atoms</td>
<td>Unsaturated</td>
</tr>
</tbody>
</table>

The first number indicates the number of carbon atoms along the carbon chain; the second number denotes the number of double bonds per molecule.
Proteins...

- Amino acids
  - Amino (NH$_2$) group and carboxyl (COOH) group, with asymmetric carbon (except glycine)

Amino Acids...

- Gray - carbon
- White - hydrogen
- Blue – nitrogen
- Red - oxygen

Nonpolar, aliphatic R groups

<table>
<thead>
<tr>
<th>Polar, uncharged R groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>H, CH$_3$, COOH</td>
</tr>
<tr>
<td>CH$_2$OH</td>
</tr>
<tr>
<td>Serine</td>
</tr>
</tbody>
</table>

Aromatic R groups

<table>
<thead>
<tr>
<th>Positively charged R groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>H, CH$_3$, COOH</td>
</tr>
<tr>
<td>H$_2$, OH</td>
</tr>
<tr>
<td>Lysine</td>
</tr>
</tbody>
</table>

Negatively charged R groups

<table>
<thead>
<tr>
<th>Negatively charged R groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>H, CH$_3$, COO$^-$</td>
</tr>
<tr>
<td>Aspartate</td>
</tr>
</tbody>
</table>

Nutrients...

- Chemical classifications:
  - Carbohydrates
  - Lipids
  - Proteins (amino acids)
  - Vitamins
  - Minerals
  - Water
Nutrients... 

- Dietary Classifications:
  - Nonessential - raw materials consumes, animal synthesizes
  - Essential - consumes and used directly

Typically used to refer to amino acids and fatty acids

Nutrients Requirements... 

- What is the definition of a nutrient?
  - Chemical component of a feed ingredient that is required for normal body function.

Dietary content  Physiologic Need

Nutrient Requirements...

- It is the physiologic need that we are concerned about meeting
- The diet content is the means by which we ensure the physiologic need is met
- If the need is not met, a nutrient deficiency will develop

Nutrient Requirements...

- There are ~40 nutrients which are nutritionally important. However, only a few are considered in diet formulation. Others are handled by premixes or practical ingredients.

Nutrient Requirements...

1. The dietary requirement is determined based on physiologic need.
2. The contribution of each ingredient toward the total dietary content of a given nutrient is counted in diet formulation.

Nutrient Requirements...

A. Classifications common to animal industries:
   1. Maintenance: maintain body function without gain or loss of body weight.
   2. Production: level of nutrient intake necessary to support processes beyond maintenance.
      a. growth
      b. production of eggs, hair or wool
      c. lactation
      d. work
      e. reproduction
Nutrient Requirements...

a. Genetics
b. Injury
c. Disease
d. Activity
e. Environment
f. Feed quality
B. Expressing nutrient requirements for diet formulation.

1. g per day or (total intake per quantity of another nutrient)
2. percentage of diet
3. units

C. Practical considerations

1. Meat animals are typically fed in groups. Therefore, it is impossible to feed each animal to its specific requirement.

Within Group and Group-to-Group

- $\pm 1 \text{SD} = 67\%$
- $\pm 2 \text{SD} = 97.5\%$
The objective for food animals is to feed nutrients at concentrations that provide optimal performance and cost per unit of gain/production for the majority of the population.

Recreation or companion animals - health and performance are key drivers, and feed intake can easily be adjusted on an individual basis.

Stages of growth have very different nutrient requirements.

D. Interrelationships and “sparing”

1. Glycine, Serine (avian species)

<table>
<thead>
<tr>
<th></th>
<th>0-3</th>
<th>3-6</th>
<th>6-8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glycine + Serine</td>
<td>1.25</td>
<td>1.14</td>
<td>0.97</td>
</tr>
</tbody>
</table>

The requirement for either amino acid can be met by the other; glycine is synthesized but the rate is insufficient.

2. Methionine, Cystine

<table>
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<th>3-6</th>
<th>6-8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methionine</td>
<td>0.50</td>
<td>0.38</td>
<td>0.32</td>
</tr>
<tr>
<td>Methionine+cystine</td>
<td>0.90</td>
<td>0.72</td>
<td>0.60</td>
</tr>
</tbody>
</table>

The requirement for cystine can be met by methionine, or a combination of methionine and cystine; the methionine requirement must be met by methionine.

3. Phenylalanine, Tyrosine: as with methionine and cystine.

4. Tryptophan, Niacin

Tryptophan can be converted to niacin, and will alleviate symptoms of a niacin deficiency.

5. Methionine, Choline: labile methyl group of methionine spares choline (methionine is NOT converted to choline).
## Nutrient Requirements...

- Bioavailability...

## Bioavailability...

<table>
<thead>
<tr>
<th>Body Weight (kg)</th>
<th>3–5</th>
<th>5–19</th>
<th>20–50</th>
<th>50–80</th>
<th>80–120</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphorus, total (%)</td>
<td>0.70</td>
<td>0.65</td>
<td>0.60</td>
<td>0.50</td>
<td>0.45</td>
</tr>
<tr>
<td>Phosphorus, available (%)</td>
<td>0.55</td>
<td>0.40</td>
<td>0.32</td>
<td>0.23</td>
<td>0.19</td>
</tr>
</tbody>
</table>

- Corn
  - Phosphorus, total (%) = 0.28
  - Bioavailability of Phosphorus (%) = 14

- Available P =
  - $0.14 \times 0.28 = 0.039\% \text{ aP}$

## Bioavailability...

- Ca^{2+}

- Zn^{2+}