Muscle Composition

ANSC 4400

Composition of Muscle

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>WATER</td>
<td>75%</td>
</tr>
<tr>
<td>PROTEIN</td>
<td>18.5%</td>
</tr>
<tr>
<td>LIPIDS</td>
<td>3%</td>
</tr>
<tr>
<td>NPN</td>
<td>1.5%</td>
</tr>
<tr>
<td>CHO</td>
<td>0.8%</td>
</tr>
<tr>
<td>INORG.</td>
<td>1%</td>
</tr>
</tbody>
</table>
Water

- Varies inversely with fat content
  - Muscles with more fat contain less water
  - Typical range = 65 to 80 percent

- Carrier of intra- and inter-cellular constituents

Protein

- Averages 18.5% in muscle
- Is least variable component
- Is the most important component
- Is the food component in shortest supply in food supply (world)
Protein

- Composed of amino acids with following basic structure:

```
  COOH
   /   \
H2N-C-H
    |    \
   R
```

Amino Acids

<table>
<thead>
<tr>
<th>Essential</th>
<th>Nonessential</th>
<th>Less Common, Nonessential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Histidine (His)</td>
<td>Alanine ( Ala)</td>
<td>Cystine (Cys)₂</td>
</tr>
<tr>
<td>Isoleucine (Ile)</td>
<td>Arginine (Arg)</td>
<td>Hydroxyproline (Hyp)</td>
</tr>
<tr>
<td>Leucine (Leu)</td>
<td>Asparagine (Asn)</td>
<td>Hydroxylysine (Hyl)</td>
</tr>
<tr>
<td>Lysine (Lys)</td>
<td>Aspartic acid (Asp)</td>
<td>Citrulline</td>
</tr>
<tr>
<td>Methionine (Met)</td>
<td>Cysteine (Cys)</td>
<td>R-alanine</td>
</tr>
<tr>
<td>Phenylalanine (Phe)</td>
<td>Glutamine (Gln)</td>
<td>Aminobutyric acid</td>
</tr>
<tr>
<td>Threonine (Thr)</td>
<td>Glutamic acid (Glu)</td>
<td>Diaminopimelic acid</td>
</tr>
<tr>
<td>Tryptophan (Trp)</td>
<td>Glycine (Gly)</td>
<td>Dihydroxyphenylalanine</td>
</tr>
<tr>
<td>Valine (Val)</td>
<td>Proline (Pro)</td>
<td>Ornithine</td>
</tr>
<tr>
<td></td>
<td>Serine (Ser)</td>
<td>Taurine</td>
</tr>
<tr>
<td></td>
<td>Tyrosine (Tyr)</td>
<td></td>
</tr>
</tbody>
</table>
Types of Protein

- Myofibrillar – 9.5%
  - Myosin and actin
- Sarcoplasmic – 6%
  - Enzymes and pigments
  - Mb and Hb
  - Functional roles
  - Globular

Myoglobin
Types of Proteins

- Stromal – 3%
  - Connective tissues
  - Collagen, elastin, reticulin

- Collagen
  - Most abundant protein in body
  - Increase age, what happens?
  - Degrades to gelatin at 65 degrees C

Types of Proteins

- Elastin
  - Does not degrade to gelatin
  - Example is *ligamentum nuchae*
  - Imparts elasticity in arterial walls
## Lipids - Fats and Oils

- Influence flavor, juiciness, and calorie content
- Averages 3% in muscle
- Cattle with higher marbling scores = higher or lower fat content?

## Kinds of Lipids

- **NEUTRAL LIPIDS** - 1%
- **PHOSPHOLIPIDS** - 1%
- **CHOLESTEROL** - 0.5%
**NEUTRAL LIPIDS**

Tryglycerides = 3 mole of fatty acid attached to a glycerol

$$\begin{align*}
\text{CH}_2\text{OH} & \quad \text{H}_2\text{C-O-} \\
\text{C(\text{CH}_2)_{16}\text{CH}_3} & \quad \text{H}_2\text{C-O-C-R} \\
1 & \quad 3 \\
\text{CHOH} + 3 \text{HOOC(\text{CH}_2)_{16}\text{CH}_3} & \quad \text{H}_2\text{O} \\
1 & \quad 3 \\
\text{CH}_2\text{OH} & \quad \text{H}_2\text{C-O-C-R} \\
\text{GLYCEROL + STEARIC ACID} & \quad \text{TRISTEARIN}
\end{align*}$$

**KINDS OF TRIGLYCERIDES**

- If the same kind of fatty acid occupies all three positions on the glycerol molecule, the result is a simple triglyceride.

- If more than one kind of fatty acid is attached to glycerol, the result is a mixed triglyceride.

- What determines what kinds of tri-glycerides an animal manufactures?
SATURATED FATTY ACIDS
Stearic Acid – Saturated Fatty Acid

No double bonds between carbon atoms
Third most predominant FA in meat animals

UNSATURATED FATTY ACIDS
OLEIC ACID:
The most prevalent fatty acid in animal fats
Mono-saturate fatty acid (contains one double bond)
Polyunsaturated Fatty Acids

- Linoleic Acid
  - Polyunsaturate fatty acid
  - Has two (or more) double bonds

Unsaturated fatty acids are more reactive

O₂ attaches at double bonds
  - Results in rancidity and oxidation
Melting Points of Some Fats

<table>
<thead>
<tr>
<th></th>
<th>Pork</th>
<th>Beef</th>
<th>Lamb</th>
<th>Poultry</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Backfat</td>
<td>External fat</td>
<td>External fat</td>
<td>Abdominal fat</td>
</tr>
<tr>
<td></td>
<td>86°–104 °F</td>
<td>89°–110 °F</td>
<td>90°–115 °F</td>
<td>80°–110 °F</td>
</tr>
<tr>
<td></td>
<td>Leaf fat</td>
<td>Kidney fat</td>
<td>Kidney fat</td>
<td></td>
</tr>
<tr>
<td></td>
<td>110°–118 °F</td>
<td>104°–122 °F</td>
<td>110°–124 °F</td>
<td></td>
</tr>
</tbody>
</table>

WHY THE RANGES AND SPECIES DIFFERENCES?

**In General:**

- Fats with longer carbon chains and more saturation have higher melting points.
- Internal fats are more saturated and have higher melting points than external fats.
- Why?

What practical difference does melting point of fats *per se* make in animal bodies and in industry?
The Third Kind of Lipids

- Phospholipids - compounds containing phosphorus and lipids

  An example is ethanolamine

Function in rancidity development in fats.

The Fourth Kind of Lipids

- Cholesterol - that much maligned, essential dietary component.

- Required for hormone function and cell wall integrity.

- About 20% of body needs is consumed whereas, 80% is manufactured.

- If we don’t eat enough, our bodies manufacture more.

- Contrary to popular belief, cooked meats of different species vary little in cholesterol content.
NPN – Non-Protein Nitrogen

- About 1.5% in muscle
- Molecules contain nitrogen but are not proteins
- Some NPN compounds contribute to meat flavor
- NPN example
  - ATP (Adenosine triphosphate)

CHO - Carbohydrates

- About 1% (0.8%) found in muscle
  - ranges from 0.5 - 1.5% in muscle.
- Although low in amount, CHO’s play large roles in meat properties and appearance.
- Best example is Glycogen
  - storage form composed of glucose units
Inorganic Compounds - Minerals

- About 1% in muscle
- Measured as ash after burning samples in a muffle furnace
- Meat (particularly beef) is a good source of some minerals, particularly Fe and Zn.
- Fe in meat is in a heme form that is more readily available than Fe from plants.
- Zn is in many enzymes and hormones, including sex hormones.

Individual Compositional Components

- Carcass
- Muscle
- Fat
- Bone
Fat Partitioning

1. Mesenteric
2. KPH
3. Intermuscular
4. Subcutaneous
5. Intramuscular

Measuring Carcass Composition

- Direct Method
  - Ideal reference endpoint - where there are no limitations on cost, time, labor
    - Chemical analyses of carcass tissues
  - Predictors - depend on objectives and resources
    - Biological - whole body chemical comp
    - Economical
      - Edible product, saleable product, etc
Measuring Carcass Composition

- Indirect Method
  - Linear measurements
  - Specific gravity
  - Ultrasound
  - Probes
    - Thermistor – temp
    - Ulster – color
    - Danish meat-fat automatic probe – electrical
    - Hennessy Probe – fat depth

Muscle Fiber Types

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Type 1</th>
<th>Type 2A</th>
<th>Type 2X(D)</th>
<th>Type 2B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Redness</td>
<td>++++</td>
<td>+++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Myoglobin content</td>
<td>++++</td>
<td>+++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Fiber diameter</td>
<td>+</td>
<td>+</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>Contraction speed</td>
<td>+</td>
<td>+++</td>
<td>+</td>
<td>+++</td>
</tr>
<tr>
<td>Fatigue resistance</td>
<td>++++</td>
<td>+++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Contractile action</td>
<td>tonic</td>
<td>tonic</td>
<td>phasic</td>
<td>phasic</td>
</tr>
<tr>
<td>Number of mitochondria</td>
<td>++++</td>
<td>+++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Mitochondria size</td>
<td>++++</td>
<td>+++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Capillary density</td>
<td>++++</td>
<td>+++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Oxidative metabolism</td>
<td>++++</td>
<td>++++</td>
<td>+</td>
<td>++++</td>
</tr>
<tr>
<td>Glycolytic metabolism</td>
<td>+</td>
<td>+</td>
<td>+++</td>
<td>+</td>
</tr>
<tr>
<td>Lipid content</td>
<td>++++</td>
<td>+++</td>
<td>+</td>
<td>++++</td>
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<tr>
<td>Glycogen content</td>
<td>+</td>
<td>+</td>
<td>++++</td>
<td>++++</td>
</tr>
<tr>
<td>Z disk width</td>
<td>++++</td>
<td>+++</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

* The characteristics are relative to the other fiber types.
Book Reading

- Pages 36 – 43
- Table 2.2
- Table 2.3