Chapter 5

Fats, Oils, and Other Lipids

PowerPoint® Lecture Slide Presentation
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What Are Lipids and Why Do You Need Them?

Lipids: category of compounds containing carbon, hydrogen and oxygen that are hydrophobic (they don’t dissolve in water)

- Perform a variety of functions in foods:
  - Give flaky texture to baked goods
  - Make meats tender
  - Provide flavor and aromas
  - Contribute to satiety

YUMMY
What Are Lipids and Why Do You Need Them?

Perform important functions in the body:

- Energy storage
- Insulation
- Transport of proteins in blood
- Cell membrane structure

Three types of lipids:

- Triglycerides, phospholipids and sterols
Usefulness of Fats in the Body

- When we say “fat,” we generally mean triglycerides.
- The general term for dietary fats and oils is triglyceride.
Usefulness of Fats in Food

Carbohydrate-rich lunch
1 low-fat muffin
1 banana
2 oz carrot sticks
8 oz fruit yogurt

calories = 550
weight (g) = 500

Fat-rich lunch
6 butter-style crackers
1 1/2 oz American cheese
2 oz trail mix with candy

calories = 550
weight (g) = 115
# Usefulness of Fats in the Body and in Food

## Table 5-1 The Usefulness of Fats

<table>
<thead>
<tr>
<th><strong>Fats in the Body</strong></th>
<th><strong>Fats in Food</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy stores</strong></td>
<td><em>Nutrient</em> Fats provide essential fatty acids.</td>
</tr>
<tr>
<td>Fats are the body's chief form of stored energy.</td>
<td><strong>Energy</strong> Fats provide a concentrated energy source in foods.</td>
</tr>
<tr>
<td><strong>Muscle fuel</strong></td>
<td><strong>Transport</strong> Fats carry fat-soluble vitamins A, D, E, and K along with some phytochemicals, and assist in their absorption.</td>
</tr>
<tr>
<td>Fats provide most of the energy to fuel muscular work.</td>
<td><strong>Raw materials</strong> Fats provide raw material for making needed products.</td>
</tr>
<tr>
<td><strong>Emergency reserve</strong></td>
<td><strong>Sensory appeal</strong> Fats contribute to the taste and smell of foods.</td>
</tr>
<tr>
<td>Fats serve as an emergency fuel supply in times of illness and diminished food intake.</td>
<td><strong>Appetite</strong> Fats stimulate the appetite.</td>
</tr>
<tr>
<td><strong>Padding</strong></td>
<td><strong>Satiety</strong> Fats contribute to feelings of fullness.</td>
</tr>
<tr>
<td>Fats protect the internal organs from shock through fat pads inside the body cavity.</td>
<td><strong>Texture</strong> Fats help make foods tender.</td>
</tr>
<tr>
<td><strong>Insulation</strong></td>
<td><strong>Cell membranes</strong> Fats form the major material of cell membranes.</td>
</tr>
<tr>
<td>Fats insulate against temperature extremes through a fat layer under the skin.</td>
<td><strong>Raw materials</strong> Fats are converted to other compounds, such as hormones, bile, and vitamin D, as needed.</td>
</tr>
</tbody>
</table>
Triglycerides: Fatty Acids and Glycerol

- Triglyceride
- Glycerol + 3 fatty acids
Fatty Acids Vary in Length and Structure - TRIGLYCERIDES

**Saturated fatty acids:** all carbons bonded to hydrogen

- Example: *stearic acid*, 18 C, solid at room temperature

**Unsaturated fatty acids:** 1 or more double bond between carbons (less saturated with hydrogen)

- More liquid at room temperature

**Monounsaturated fatty acid:** one double bond

- Example: *Oleic acid*, 18 C (olive oil)

**Polyunsaturated fatty acid:** >1 double bond (not required on food labels)

- Example: *essential fatty acids* linoleic and alpha-linolenic acids (soybean oil)
Saturated versus Unsaturated Fatty Acids

- Saturated fatty acid – filled to capacity with hydrogen atoms
- Unsaturated fatty acid – missing hydrogen
  - Monounsaturated – one point of unsaturation
  - Polyunsaturated – two or more points of unsaturation (PUFA)

Fatty acids may differ from one another in carbon chain length and in degree of saturation.

Fatty acids in foods influence the composition of fats in the body.
Saturated versus Unsaturated Fatty Acids

- Saturated
- Monounsaturated
  - Point of unsaturation
- Polyunsaturated
  - Points of unsaturation
**Saturated versus Unsaturated Fatty Acids**

Fats melt at different temperatures

- **Saturated fats** – solid at room temperature
- **Unsaturated fats** – liquids at room temperature
- The most polyunsaturated margarines are those which list liquid as the first ingredient.
Saturated versus Unsaturated Fatty Acids

### Key:
- Saturated fatty acids
- Polyunsaturated, omega-6 fatty acids
- Monounsaturated fatty acids
- Polyunsaturated, omega-3 fatty acids

Animal fats and the tropical oils of coconut and palm contain mostly saturated fatty acids.

<table>
<thead>
<tr>
<th>Animal Fat</th>
<th>Saturated</th>
<th>Monounsaturated</th>
<th>Polyunsaturated, omega-6</th>
<th>Polyunsaturated, omega-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coconut oil</td>
<td>75%</td>
<td>5%</td>
<td>20%</td>
<td>0%</td>
</tr>
<tr>
<td>Butter</td>
<td>98%</td>
<td>1%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Beef tallow (beef fat)</td>
<td>94%</td>
<td>4%</td>
<td>2%</td>
<td>0%</td>
</tr>
<tr>
<td>Palm oil</td>
<td>90%</td>
<td>8%</td>
<td>12%</td>
<td>0%</td>
</tr>
<tr>
<td>Lard (pork fat)</td>
<td>92%</td>
<td>6%</td>
<td>2%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Some vegetable oils, such as olive and canola, are rich in monounsaturated fatty acids.

<table>
<thead>
<tr>
<th>Vegetable Oil</th>
<th>Saturated</th>
<th>Monounsaturated</th>
<th>Polyunsaturated, omega-6</th>
<th>Polyunsaturated, omega-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Olive oil</td>
<td>2%</td>
<td>93%</td>
<td>5%</td>
<td>0%</td>
</tr>
<tr>
<td>Canola oil</td>
<td>1%</td>
<td>99%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Peanut oil</td>
<td>3%</td>
<td>94%</td>
<td>3%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Many vegetable oils are rich in omega-6 polyunsaturated fatty acids.

<table>
<thead>
<tr>
<th>Vegetable Oil</th>
<th>Saturated</th>
<th>Monounsaturated</th>
<th>Polyunsaturated, omega-6</th>
<th>Polyunsaturated, omega-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safflower oil</td>
<td>1%</td>
<td>99%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Sunflower oil</td>
<td>1%</td>
<td>99%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Corn oil</td>
<td>2%</td>
<td>98%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Soybean oil</td>
<td>1%</td>
<td>99%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Walnut oil</td>
<td>1%</td>
<td>99%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Cottonseed oil</td>
<td>1%</td>
<td>99%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Only a few oils provide significant omega-3 polyunsaturated fatty acids.

<table>
<thead>
<tr>
<th>Vegetable Oil</th>
<th>Saturated</th>
<th>Monounsaturated</th>
<th>Polyunsaturated, omega-6</th>
<th>Polyunsaturated, omega-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flaxseed oil</td>
<td>1%</td>
<td>99%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Fish oil</td>
<td>1%</td>
<td>99%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

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*a* These families of polyunsaturated fatty acids are explained in a later section.

*b* Fish oil average values derived from USDA data for salmon, sardine, and herring oils.
Phospholipids and Sterols Are More Complex than Triglycerides

**Phospholipids:** have glycerol backbone, two fatty acids and a phosphorus group

- Phosphorus-containing head is hydrophilic (water loving)
- Fatty-acid tail is hydrophobic
  - Major phospholipid in cell membrane = lecithin
  - Lecithin used as emulsifier in foods such as salad dressings to keep oils and water mixed together. Bile is also an emulsifier
Phospholipids and Sterols Are More Complex than Triglycerides

Sterols are comprised mainly of four connecting rings of carbon and hydrogen.

- Example: **cholesterol**
  - Important role in cell membrane structure
  - Precursor of important compounds in body
  - **Not required in diet** since body makes all cholesterol needed
Digestion and Absorption of Fats

In the stomach, the fat and watery digestive juices tend to separate. Enzymes are in the water and can’t get at the fat.

When fat enters the small intestine, the gallbladder secretes bile. Bile has an affinity for both fat and water, so it can bring the fat into the water.

After emulsification, more fat is exposed to the enzymes, and fat digestion proceeds efficiently.
Transport of Fats

- At the intestinal lining, shorter-chain fatty acids and glycerol are absorbed directly into the bloodstream.
- The cells of the intestinal lining convert large lipid fragments back into triglycerides and combine them with protein forming chylomicrons* that travel in the lymph.

* lipoprotein – how fat is transported in the body; a mixture of fat and protein
Major Lipoproteins: VLDL, LDL, HDL

- In addition to the chylomicron, the body uses three other types of lipoproteins to carry fats:
  - **Very-low-density lipoproteins (VLDL)**, which carry triglycerides and other lipids made in the liver to the body cells for their use.
  - **Low-density lipoproteins (LDL)** transport cholesterol and other lipids to the tissues. LDL are made from VLDL after they have donated many of their triglycerides to body cells. (BAD)
  - **High-density lipoproteins (HDL)**, which are critical in the process of carrying cholesterol away from body cells to the liver for disposal. (GOOD)
HDL and LDL play major roles with regard to heart health and are the focus of most recommendations made for reducing the risk of heart disease.
The Importance of LDL and HDL Cholesterol

The more of these factors present in a person’s life, the more urgent the need for changes in diet and other controllable factors to reduce heart disease risk:

- High blood LDL
- Low blood HDL
- High blood pressure
- Type 2 diabetes
- Obesity
- Physical inactivity
- Cigarette smoking
- Atherogenic diet – diet high in saturated fats

How many factors are in your life?
How Does Your Body Use Fat and Cholesterol?

Fat – heart, liver and resting muscles prefer fat as their fuel source

An energy-dense source of fuel: 9kcal/gram

• Glucagon also stimulates release of fat from fat cells to fuel heart, liver and muscle

• Is needed for absorption of fat-soluble vitamins A, D, E, K and carotenoids (plant pigments that have vit A activity)

• Insulates body to maintain body temperature

• Cushions bones, organs, nerves
How Does Your Body Use Fat and Cholesterol?

• **Cholesterol** has many important roles:
  • Part of cell membranes
  • Precursor for vitamin D, bile acids, sex hormones

**Cholesterol** need not be consumed in diet.
  • Body makes all the cholesterol needed
  • For heart health, should limit dietary cholesterol to less than 200 mg/day on average

**Essential fatty acids** help keep cell membranes healthy.

**Linoleic acid** used to make **arachidonic acid**
  • Deficiency interferes with normal growth and causes skin inflammation.
  • Abundant in vegetable oils (linoleic acid)
How Does Your Body Use Fat and Cholesterol?

• **Alpha-linolenic acid** (an essential fatty acid) (omega-3 fatty acid) needed for healthy cell membranes. Deficiency results in scaly skin.

• Limited amount can be converted into EPA and DHA: heart healthy omega-3 fatty acids found in fatty fish.
Essential Polyunsaturated Fatty Acids

- Linoleic acid and linolenic acid

**Table 5-3 Functions of the Essential Fatty Acids**

These roles for the essential fatty acids are known, but others are under investigation.

- Provide raw material for eicosanoids.
- Serve as structural and functional parts of cell membranes.
- Contribute lipids to the brain and nerves.
- Promote normal growth and vision.
- Assist in gene regulation.
- Maintain outer structures of the skin, thus protecting against water loss.
- Help regulate genetic activities affecting metabolism.
- Support immune cell functions.
How Much (and What Types of) Fat Should You Eat?

You need to consume some fat daily

• **AMDR of DRI:** 20–35% of total daily calories should come from fat.

• For heart health, no more than **10%** of calories should come from **saturated fats and trans fats.**
What Are the Best Food Sources of Fats?

Sources of unsaturated fats:

- Vegetable oils (soybean, corn, and canola)
- Soybeans, walnuts, flaxseeds, wheat germ

Limit sources of saturated fats:

- Animal sources: fatty meats, whole-milk dairy products, skin on poultry
- Plant sources: coconut, palm, palm kernel oils
What Is *Trans* Fat and Where Do You Find It?

- Unsaturated fats are more susceptible to rancidity (decomposition due to oxidation).
- **Hydrogenation:** process of adding hydrogen to unsaturated fatty acid to make it saturated, more solid at room temperature and more resistant to rancidity = *Trans* Fats
  - Should be kept as low as possible in diet because they raise LDL cholesterol levels, lower HDL
  - *Trans* fat must be listed on food labels.
  - *Trans* fats are worse for heart health than saturated fat because they not only raise LDLs but they also lower the HDL levels.
Major Food Sources of *Trans* Fat for American Adults

- Animal products: 21%
- Cakes, cookies, crackers, pies, bread, etc.: 40%
- Margarine: 17%
- Fried potatoes: 8%
- Household shortening: 4%
- Salad dressing: 3%
- Breakfast cereal: 1%
- Candy: 1%
- Potato chips, corn chips, popcorn: 5%
Dietary Fat, Cholesterol, and Health

- A diet too high in saturated or *trans* fats invites heart and artery disease.
- Some studies suggest a high saturated fat diet that is also low in fish oils may increase the risk of certain cancers.
- Obesity is more likely since fat has 9 calories per gram.
What Is Heart Disease and What Increases Your Risk?

Heart disease begins with a buildup in the arteries.

- **Atherosclerosis**: narrowing of arteries due to buildup of plaque (hardened debris of cholesterol-laden foam cells, platelets, calcium, cellular waste products)
  - Thought to begin with injury to lining of arteries, contributed by high blood pressure, high cholesterol levels, and smoking
  - Increases chance of blood clots blocking the vessel, causing heart attack or stroke
Atherosclerosis

Figure 5.19

Normal artery

Normal blood flow

Plaque (accumulation of foam cells, platelets and other substances)

Restricted blood flow
# Risk Factors for Heart Disease

## Table 5.5

<table>
<thead>
<tr>
<th>Factors You Cannot Control</th>
<th>Factors You Can Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Your age and gender</td>
<td>Type 2 diabetes mellitus</td>
</tr>
<tr>
<td>Your family history of heart disease</td>
<td>High blood pressure</td>
</tr>
<tr>
<td>Type 1 diabetes mellitus</td>
<td>Smoking</td>
</tr>
<tr>
<td></td>
<td>Physical inactivity</td>
</tr>
<tr>
<td></td>
<td>Excess weight</td>
</tr>
<tr>
<td></td>
<td>A low HDL “good” cholesterol level</td>
</tr>
<tr>
<td></td>
<td>A high LDL “bad” cholesterol level</td>
</tr>
</tbody>
</table>
## Lowering LDL Cholesterol

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Nutrition Facts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pork chop (5 ounces) with 1/2 inch of fat</td>
<td>Calories: 450, Calories from Fat: 315</td>
</tr>
<tr>
<td></td>
<td>Total Fat: 35g, % Daily Value: 54%</td>
</tr>
<tr>
<td></td>
<td>Saturated Fat: 13g, % Daily Value: 65%</td>
</tr>
<tr>
<td>Potato (5 ounces) with 1 tablespoon butter and 1 tablespoon sour cream</td>
<td>Calories: 400, Calories from Fat: 250</td>
</tr>
<tr>
<td></td>
<td>Total Fat: 28g, % Daily Value: 43%</td>
</tr>
<tr>
<td></td>
<td>Saturated Fat: 18g, % Daily Value: 90%</td>
</tr>
<tr>
<td>Whole milk (1 cup)</td>
<td>Calories: 150, Calories from Fat: 70</td>
</tr>
<tr>
<td></td>
<td>Total Fat: 8g, % Daily Value: 12%</td>
</tr>
<tr>
<td></td>
<td>Saturated Fat: 5g, % Daily Value: 25%</td>
</tr>
<tr>
<td>Pork chop (4 ounces) with fat trimmed off</td>
<td>Calories: 230, Calories from Fat: 100</td>
</tr>
<tr>
<td></td>
<td>Total Fat: 11g, % Daily Value: 17%</td>
</tr>
<tr>
<td></td>
<td>Saturated Fat: 4g, % Daily Value: 20%</td>
</tr>
<tr>
<td>Plain potato (5 ounces)</td>
<td>Calories: 150, Calories from Fat: 0</td>
</tr>
<tr>
<td></td>
<td>Total Fat: 0g, % Daily Value: 0%</td>
</tr>
<tr>
<td></td>
<td>Saturated Fat: 0g, % Daily Value: 0%</td>
</tr>
<tr>
<td>Fat-free milk (1 cup)</td>
<td>Calories: 90, Calories from Fat: 0</td>
</tr>
<tr>
<td></td>
<td>Total Fat: 0g, % Daily Value: 0%</td>
</tr>
<tr>
<td></td>
<td>Saturated Fat: 0g, % Daily Value: 0%</td>
</tr>
</tbody>
</table>
Recommendations Applied

- To lower LDL
  - Reduce saturated fat
  - Reduce \textit{trans} fat
  - Substitute monounsaturated or PUFA
  - Eat cholesterol in moderation
What Is High Blood Cholesterol and What Can You Do to Lower It?

1. Minimize saturated fats, \textit{trans} fats, cholesterol in diet
   • Replace saturated fats with unsaturated

2. Eat more fish, plant foods, including soybean and canola oils, flaxseeds, nuts, oatmeal, legumes, fruits, vegetables, and tea.

3. Get plenty of exercise and manage your weight.

4. Moderate use of alcohol may reduce risk of heart disease but some should avoid alcohol.

5. Stop smoking!
What Is High Blood Cholesterol and What Can You Do to Lower It?

Starting at age 20, blood should be tested for “lipoprotein profile.”

Table 5.6

<table>
<thead>
<tr>
<th>What Your Cholesterol Level* Can Tell You</th>
<th>If Your Total Cholesterol Level Is</th>
<th>That Is Considered</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;200</td>
<td>Fabulous!</td>
</tr>
<tr>
<td></td>
<td>200–239</td>
<td>Keep up the good work!</td>
</tr>
<tr>
<td></td>
<td>≥240</td>
<td>Borderline high</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High</td>
</tr>
</tbody>
</table>

|                                            | If Your LDL Cholesterol Level Is   | That Is Considered                  |
|                                            | <100                              | Fabulous!                           |
|                                            | 100–129                           | Congratulations!                    |
|                                            | 130–159                           | Near or above optimal               |
|                                            | 160–189                           | Borderline high                     |
|                                            | 190                               | High                                |
|                                            |                                    | Much too high!                      |

|                                            | If Your HDL Cholesterol Is         | That Is Considered                  |
|                                            | ≥60                                | Fabulous!                           |
|                                            | 40–60                              | Good                                |
|                                            | <40                                | Too low                             |

*All lipoprotein levels are measured in milligrams of cholesterol per deciliter of blood (mg/dl).

The Traditional Mediterranean Diet

Traditional diet of Mediterranean region associated with lower risk of heart disease and cancer

- Very active lifestyle as well as long, relaxing family meals, afternoon siestas, supportive community
- Plant-based diet of whole grains, fruits, vegetables, legumes and nuts
  - With olive oil, low-fat dairy, water
  - Occasional fish, poultry, eggs, meat, sweets, wine
The Traditional Healthy Mediterranean Diet Pyramid

- Daily physical activity
- Daily: Bread, pasta, rice, couscous, polenta, other whole grains, and potatoes
- Weekly: Fruits, beans, legumes, and nuts, vegetables
- Monthly: Eggs, poultry, fish, sweets, meat, beverages (6 glasses of water)

Wine in moderation