Carbohydrates & Dietary Fats

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Carbohydrates and Dietary Fat

September 11, 2020
Jamie I. Baum, PhD
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Objectives

• Identify the different types of carbohydrates and fats

• Define the dietary recommendations for carbohydrate and fat intake

• Understand the role of carbohydrates and fat in the body

• Understand the link between dietary fat and risk of cardiovascular disease

• Understand the health benefits of carbohydrates and fat

What are carbohydrates?

**Composition**
- Carbon, hydrogen, and oxygen \( \text{CHO} \)
- Composed of one or more sugar (saccharide) units
- Contains 4 kcal per gram

**Functions in Food**
- Source of fiber
- Adds sweetness and flavor

**Functions in the Body**
- Source of energy for all cells in the body
- Indispensable source of energy for the brain, red blood cells, and muscles during intense exercise
- Important for intestinal health
- Reduces the use of protein for energy

Fruits, vegetables, grains, and milk and milk products are sources of carbohydrates.

Ivonne Wierink/Shutterstock
Carbohydrates have vital functions in nutrition and health

- Source of energy for all cells of the body
  - Provide 4 calories per gram
  - Recommendation: Consume 45% to 65% of total calories from carbohydrate

- Indispensable source of energy for the brain, red blood cells, and exercising muscles

- Reduces the use of protein for energy

- Source of fiber (intestinal health)

- Adds sweetness and flavor to foods
Carbohydrates are classified as simple or complex

- **Simple carbohydrates**
  - Sugars and syrups
  - Fruits
  - Many vegetables
  - Milk

- **Complex carbohydrates**
  - Grains
  - Beans and legumes
  - Some vegetables
Simple carbohydrates are made from one or two sugars

<table>
<thead>
<tr>
<th>Simple Carbohydrates</th>
<th>Monosaccharides: made up of one sugar unit</th>
<th>Disaccharides: made up of two sugar units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose</td>
<td>Circulates in the bloodstream. It is found in fruits, vegetables, and honey.</td>
<td>Maltose is formed in large amounts as a product of starch digestion; however, very little is found in the foods we eat.</td>
</tr>
<tr>
<td>Fructose</td>
<td>Is found in fruits, vegetables, and honey.</td>
<td>Sucrose is otherwise known as “table sugar.” It is found in fruits and vegetables.</td>
</tr>
<tr>
<td>Galactose</td>
<td>One of the monosaccharides that make up milk sugar.</td>
<td>Lactose is often called “milk sugar,” as it is found only in milk, yogurt, and other dairy products.</td>
</tr>
</tbody>
</table>

Added sugars comprise approximately 13% of the daily calories in the United States.
Sugar alternatives and non-nutritive sweeteners

<table>
<thead>
<tr>
<th>Sweetener</th>
<th>Trade Name</th>
<th>Kcal/g</th>
<th>Sweetness Relative to Sucrose</th>
<th>Uses &amp; Highlights</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acesulfame K</td>
<td>Sunett, Sweet One</td>
<td>0</td>
<td>200X</td>
<td>Long-lasting and heat stable. It is used in a wide variety of products, particularly in sugar-free beverages and desserts.</td>
</tr>
<tr>
<td>Aspartame</td>
<td>Equal, NutraSweet</td>
<td>0</td>
<td>160–220X</td>
<td>Widely used in sugar-free soft drinks. Composed of two amino acids (aspartate, phenylalanine). Can withstand elevated temperatures for only a brief period but is destroyed at baking temperatures. When in solution it is not as stable as other sweeteners.</td>
</tr>
<tr>
<td>Neotame</td>
<td>Used infrequently</td>
<td>0</td>
<td>7,000–13,000X</td>
<td>Very similar in structure to aspartame. Much greater stability in solution and can withstand high temperatures encountered during baking.</td>
</tr>
<tr>
<td>Saccharin</td>
<td>Sweet’N Low</td>
<td>0</td>
<td>300X</td>
<td>Discovered in 1878. Widely used in sugar-free soft drinks and as a tabletop sweetener. Can be used in baking without losing its sweetness. Once listed as a possible carcinogen, it has since been shown to not cause cancer in humans.</td>
</tr>
<tr>
<td></td>
<td>Sugar Twin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stevia</td>
<td>Pure Via</td>
<td>0</td>
<td>250X</td>
<td>Rebaudioside A (rebiana) is the active compound that is isolated from the leaves of the South American plant stevia. Approved for use in the United States in 2008. Used primarily in beverages, as a tabletop sweetener, and in yogurt. It is heat stable.</td>
</tr>
<tr>
<td></td>
<td>Truvia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sucralose</td>
<td>Splenda</td>
<td>0</td>
<td>600X</td>
<td>It is made from sucrose by replacing 3’-OH groups with chlorine. It is used as a tabletop sweetener, and it is widely used in beverages where it is remarkably stable over long periods. It is also used as a tabletop sweetener.</td>
</tr>
</tbody>
</table>


Infographic 4.8 part 2
Scientific American: Nutrition for a Changing World
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Sugar alternatives and non-nutritive sweeteners

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</thead>
<tbody>
<tr>
<td>Tagatose</td>
<td>Naturlose</td>
<td>1.5</td>
<td>0.75-0.92</td>
<td>A monosaccharide almost identical to fructose. Provides fewer calories because it is poorly absorbed. It also occurs naturally in foods (dairy) in small amounts. Is used much like sucrose to provide both bulk and sweetness in foods such as ice cream, cakes, and candies.</td>
</tr>
<tr>
<td>Sugar Alcohol Sweeteners (Polyols) Provide reduced calories because they are poorly absorbed. Also occur naturally in foods.</td>
<td>Sorbitol</td>
<td>2.6</td>
<td>0.5-0.7</td>
<td>Used in sugarless gums, chocolate candies, and ice cream. It is not metabolized by bacteria in the mouth and therefore does not promote tooth decay. Prunes naturally contain high amounts. Likely to cause a laxative effect when consumed at ≥ 50 g/day.</td>
</tr>
<tr>
<td>Mannitol</td>
<td>Mannitol</td>
<td>1.6</td>
<td>0.5-0.7</td>
<td>Used primarily in making chewable tablets. Likely to cause a laxative effect when consumed at ≥ 20 g/day.</td>
</tr>
<tr>
<td>Xylitol</td>
<td>Xylitol</td>
<td>2.4</td>
<td>1</td>
<td>Used in mouthwash, sugarless gums, and candies. Like sorbitol, it does not promote tooth decay. Causes a cooling sensation in the mouth when used in chewing gums and hard candies (as do sorbitol and mannitol). The laxative effect appears to be slightly less than that of sorbitol.</td>
</tr>
</tbody>
</table>
### COMPLEX CARBOHYDRATES (POLYSACCHARIDES)

<table>
<thead>
<tr>
<th>Starch</th>
<th>Fiber</th>
<th>Glycogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amylose</td>
<td>Cellulose</td>
<td></td>
</tr>
<tr>
<td>Amylopectin</td>
<td>Hemicellulose</td>
<td>Glycogen is the storage form of glucose in animals and is found primarily in skeletal muscle and the liver. It is the most highly branched of all polysaccharides.</td>
</tr>
</tbody>
</table>

**Starches** are abundant in grains, legumes, and starchy vegetables and are long chains of glucose—either branched or unbranched. Amylopectin may contain as many as 100,000 glucose units.

**Dietary fibers** are a diverse group of polysaccharides found in plants (within the cell wall). They may be straight chains of glucose (such as cellulose), or they may be branched chains composed of a variety of sugars (such as hemicelluloses and some pectins). They are abundant in legumes, nuts, whole grains, vegetables, and some berries.

Humans lack the digestive enzymes that can break the bonds in fiber, whereas starch can be fully broken down into glucose molecules.

**Fiber bonds** are indigestible by humans.

Recommended Fiber Intake

- Males ages 19–50: 38 grams/day
- Females ages 19–50: 25 grams/day
- Average U.S. intake: 17 grams/day
Fiber has multiple health benefits

• Soluble fiber may reduce the risk of cardiovascular disease.

• High-fiber foods promote satiety and may reduce the risk of obesity.

• High intakes of insoluble cereal fiber may reduce the risk of type 2 diabetes.

• Soluble fiber slows the increase in blood glucose following carbohydrate ingestion.

• High insoluble fiber intake softens stools and reduces the occurrence of constipation.
Anatomy of a Whole Grain

**Endosperm** contains the highest amount of starch and protein and is all that remains when a grain is refined.

**Bran** contains the majority of dietary fiber and a significant amount of B vitamins and minerals.

**Germ**, the embryo of the seed that germinates and grows and contains essential fatty acids and a number of B vitamins and minerals.

The vast majority of vitamins, minerals, and phytochemicals are found in the germ and bran of whole grains.

Whole grains contain the endosperm, germ, and bran in original proportions

- Refined grains (white grain)
  - Stripped of the germ and bran, leaving only the endosperm
- Enriched grains
  - Some nutrients lost in processing are added back

![Whole grains image](fcafotodigital/Getty Images)
The Whole Grains Stamp used in 36 countries tells consumers that a product contains at least 8 grams of whole grains per serving.

- Dietary Guidelines for Americans
  - Consume at least half of grains as whole grain
- USDA MyPlate
  - Look for whole grains as the first ingredient in food products
- American Heart Association
  - Look for products with a total carbohydrate-to-fiber ratio that is less than 10:1
## Recommendations for Carbohydrate Intake

<table>
<thead>
<tr>
<th>Source</th>
<th>Total Carbohydrates</th>
<th>Fiber</th>
<th>Added Sugars</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015 Dietary Guidelines for Americans</td>
<td>Consume at least half of all grains as whole grains. Increase whole grain intake by replacing refined grains with whole grains.</td>
<td></td>
<td>Consume less than 10% of total calories from added sugars.</td>
</tr>
<tr>
<td>Health and Medicine Division Recommendations (DRIs)</td>
<td>RDA: 130 g/day&lt;br&gt;AMDR: 45–65% of total calories&lt;br&gt;• 2,000 kcal/day diet: 225–325 g/day&lt;br&gt;• 2,500 kcal/day diet: 281–406 g/day</td>
<td>AI: 14 g per 1,000 kcal/day</td>
<td>≤ 25% of total calories consumed</td>
</tr>
<tr>
<td>American Heart Association (2009)</td>
<td>Women Age 19–50: 25 g/day&lt;br&gt;Age ≤51: 21 g/day&lt;br&gt;Men 38 g/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>World Health Organization (2003)</td>
<td>Women ≤ 100 kcal/day (25 g)&lt;br&gt;Men ≤ 150 kcal/day (38 g)</td>
<td></td>
<td>≤ 10% of energy intake</td>
</tr>
</tbody>
</table>

You can help meet dietary recommendations for carbohydrates by limiting added sugars such as sweets and soda, eating more fruits and vegetables, and checking the ingredient list on foods for the words whole or whole grain.

Dietary Fats (Lipids)
Types of fats/lipids

- Lipids include fatty acids, triglycerides, sterols, and phospholipids
- Diverse in structure and function
- Contain carbon, hydrogen, and oxygen
- Generally insoluble in water

Functions of fats in the body

- Component of cell membranes
  - Give cell membranes flexibility and integrity

- Various lipids required for synthesis of hormones
- Fats supply a concentrated source of energy and fat-soluble nutrients
  - 9 calories per gram
  - Essential fatty acids (linoleic acid and alpha-linolenic acid)
  - Fat-soluble vitamins A, D, E, and K

- Facilitate the transport of nutrients
- Enhance the absorption of fat-soluble vitamins
- Lipids are the primary source of the body’s energy reserves (stored in adipose tissue)
- Adipose tissue cushions, protects, and insulates the body’s organs
Functions of fats in food

• Fats contribute to the sensation of feeling full
  • Fats stay in the stomach longer
  • Fats are absorbed over a longer period of time

• Fats increase the palatability (flavor and taste) of foods

• Fats contribute to the texture and aroma of foods
Fats in food are a mixture of different fatty acids.

**TRIGLYCERIDES**: Compounds made up of a glycerol molecule and three fatty acids.

**FATTY ACIDS**: Vary in degree of saturation and chain length.

<table>
<thead>
<tr>
<th>Fatty Acid Type</th>
<th>Solid or Liquid at Room Temperature?</th>
<th>Food Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saturated Fatty Acid</td>
<td>Solid</td>
<td></td>
</tr>
<tr>
<td>Each carbon has 4 bonds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carboxylic acid end</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shorthand notation for fatty acid: (every bond represents a carbon and 2 hydrogen atoms)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Monounsaturated Fatty Acid  | Liquid                              |              |
| A carbon-carbon double bond replaces the missing C=C bonds and each carbon still has 4 bonds. | | |
| Hydrogen atoms “missing”   |                                      |              |

| Polyunsaturated Fatty Acid | Liquid                              |              |
| Polyunsaturated fatty acids contain more than one carbon-carbon double bond. | | |

| Cis and Trans Fatty Acids   |                                 |              |
| In a “cis” arrangement, hydrogen atoms are on the same side of the double bond. | | |
| In a “trans” arrangement, hydrogen atoms are on opposite sides of the double bond. | | |

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Photo credits: Eli Ennor (top 3 photos), Africa Studio/Shutterstock (bottom photo—main), orinocoArt/Shutterstock (bottom photo—butter)
All dietary fats contain saturated, monounsaturated, and polyunsaturated fatty acids in varying proportions.

![Percent Fatty Acid Composition Chart]

The composition of fats in our diet affects our health. Choose cooking oils and foods that are low in saturated fat and provide a mixture of the remaining types of fatty acids.
Cholesterol

• Cholesterol is found only in animal foods

• It is not an essential nutrient, as the liver produces sufficient amounts to meet the body’s needs

• Required for synthesis of bile acids, vitamin D, and steroid hormones

• Does not provide energy
Essential fatty acids must be supplied through the diet

- Body cannot synthesize these fatty acids
- Linoleic acid
  - Omega-6 fatty acid
- Linolenic acid
  - Omega-3 fatty acid
- Both long-chain polyunsaturated fatty acids
  - 18 carbon molecules
The AMDR for total fat is 20–35% of total calories, and most should come from unsaturated fats.

- Eat as little saturated fat (<10%), trans fat, and cholesterol as possible.
- Use caution when substituting fat with simple or refined carbohydrates.
Reduce intake of foods and added fats high in saturated in favor of unsaturated fats.
How do we determine the amounts and types of fats in the foods we eat? Read food labels.
Is fish really brain food?

Dietary lipids may play a role in decreasing humans’ risk of developing dementia
The Bogalusa Heart Study was the first study to demonstrate that heart disease begins in childhood

- Gerald Berenson, M.D., conducted the study from 1972 to 1998 in a rural southern town
  - Followed 16,000 individuals from childhood
  - 40% living below poverty

- Physical and lifestyle attributes contribute to developing heart disease
Cardiovascular disease is the leading cause of death in the United States
Certain risk factors increase the likelihood of developing CVD

Some risk factors cannot be modified
• Family history of heart disease at an early age
• Race
  • African Americans at higher risk
• Age
  • Risk increases with age for both men and women
Appropriate diet and lifestyle choices may reduce our risk for CVD by about 80%.

**Poor Diets:** Diets high in trans fats, saturated fats, and cholesterol and low in polyunsaturated fats, vegetables, fruits, and whole grains increase the risk of CVD. Excess intake of sodium can lead to hypertension, which increases the risk of CVD.

**Physical Inactivity:** It is estimated that individuals who engage in 150 minutes of moderate- to vigorous-intensity exercise per week will reduce the risk of CVD mortality by 30-35% compared with those who are physically inactive.

**Obesity:** Particularly central or abdominal obesity is a major independent risk factor for CVD. It also increases the occurrence of other CVD risk factors (hypertension, diabetes, high blood cholesterol, and high triglycerides).

**Smoking:** Smokers are two to four times more likely to develop heart disease or experience a stroke than are nonsmokers. Exposure to secondhand smoke at home or work increases the risk of heart disease.

**Excessive Alcohol Consumption:** Excessive alcohol consumption causes hypertension that dramatically increases the risk of stroke. Drinking large amounts can also cause the heart to enlarge and heart muscles to thin and weaken. Heavy or at-risk alcohol use is defined as more than 3 drinks a day or 7 per week for women, and 4 drinks a day or 14 per week for men.

**Heart-Related Conditions:** The risk of CVD is increased by high blood pressure, blood glucose, LDL cholesterol, and triglycerides and by low HDL cholesterol. Improving one’s diet and exercising regularly will help manage these conditions.

Unmodifiable risk factors for CVD are age, race, and family history of CVD (genetics).
The concentrations of total cholesterol, HDL cholesterol, LDL cholesterol, and triglycerides in the blood affect the risk of cardiovascular disease.
A complex relationship exists between dietary fats and heart disease

• Saturated fats and trans fats
  • Raise total cholesterol and LDL cholesterol
• Polyunsaturated fats
  • Lower risk of heart disease
  • Lower cholesterol without lowering HDL cholesterol
• Monounsaturated fats
  • May raise HDL, and lower cholesterol and overall triglyceride levels
• Omega-6 fatty acids
• Omega-3 fatty acids
  • Ratio of omega-6 and omega-3 fatty acids
Percent contribution of specific foods to saturated fat intake for Americans age 2 and older

Summary

• Identify the different types of carbohydrates and fats

• Define the dietary recommendations for carbohydrate and fat intake

• Understand the role of carbohydrates and fat in the body

• Understand the link between dietary fat and risk of cardiovascular disease

• Understand the health benefits of carbohydrates and fat