

What is Food Chemistry?

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Modified from IFT Experiments Series “Food Chemistry”

What is food chemistry? Food Science deals with the production, processing, distribution, preparation, evaluation, and utilization of food. Food chemists work with plants that have been harvested for food, and animals that have been slaughtered for food. Food chemists are concerned with how these food products are processed, prepared, and distributed. For example, to address consumer demands, some food chemists are involved with finding fat and sugar substitutes that do not alter food taste and texture.

Basic food chemistry deals with the three primary components in food: carbohydrates, lipids and proteins.

Carbohydrates make up a group of chemical compounds found in plant and animal cells. They have an empirical formula $C_nH_{2n}O_n$ or $(CH_2O)_n$. Since this formula is essentially a combination of carbon and water these materials are called “hydrates of carbon or carbohydrates”. Carbohydrates are the primary product of plant *photosynthesis*, and are consumed as fuel by plants and animals. Food carbohydrates include the simple carbohydrates (sugars) and complex carbohydrates (starches and fiber).

Lipids include fats, oils, waxes, and cholesterol. In the body, fat serves as a source of energy, a thermal insulator, and a cushion around organs; and it is an important component of the cell. Since fats have 2.25 times the energy content of carbohydrates and proteins, most people try to limit their intake of dietary fat to avoid becoming overweight. In most instances, *fats* are from animal products – meats, milk products, eggs, and seafood and *oils* are from plants – nuts, olives, and seeds. We use lipids for flavor, to cook foods, and to improve the texture of foods.

Proteins are important components of food. Every cell requires protein for structure and function. Proteins are complex polymers composed of amino acids. There are 20 amino acids found in the body. Eight of these are essential for adults and children, and nine are essential for infants. *Essential* means that we cannot synthesize them in large enough quantities for growth and repair of our bodies, and therefore, they must be included in our diet. Proteins consist of long chains of 100-500 amino acids that form into three-dimensional structures, their native state. When you change the native state of the protein, you change the three-dimensional structure, which is referred to as denaturation. Factors that cause denaturation include heating, acid, beating and freezing.

Vocabulary – Food Chemistry

- **Amino acids** – contain carbon, hydrogen, nitrogen and sometimes sulfur and serve as the monomers to make peptides and proteins. Amino acids have a basic structure that includes an amino group (NH₂) and a carboxyl group (COOH) attached to a carbon atom. There are 20 amino acids found in the body.
- **Amylase** – an enzyme (protein) in saliva that breaks down starch.
- **Antioxidant** – substance that prevents or slows down oxidation; inhibits reactions promoted by oxygen; often used as a preservative.
- **Carbohydrate** – a compound of carbon and water. Carbohydrates are the most abundant of all carbon-containing compounds, composing nearly three-fourths of the dry mass of all plant life on earth. It is the product of photosynthesis. Examples: glucose, sucrose (table sugar), starch, and cellulose.
- **Casein** – a protein from milk.
- **Coagulation** – transformation of a liquid into a soft or solid mass.
- **Denatured** – changed from its natural state. In a denatured protein, its characteristics or properties have been altered in some way, by heat, chemicals, or enzymatic action, resulting in the loss of its biological activity.
- **Digestion** – the chemical breakdown of large food compounds into smaller molecules that can be absorbed by the intestines in humans and animals. The smaller food molecules travel in the blood and are used by cells to make other components or produce energy needed by the body. Digestion begins in the mouth as salivary amylase begins to break down starch into simple sugars. It involves the hydrolysis of proteins to amino acids.
- **Emulsion** – a property where two liquids are evenly spread out in each other, yet not dissolved in each other. Oil and water form the most common emulsions, and milk is an emulsion of butterfat in water. Emulsions are important in the production of foods that contain water and fat, such as mayonnaise or margarine. These products require the addition of an **emulsifier**, to stabilize food emulsions.
- **Enzymatic browning** – a biochemical process in which fruit or vegetable tissues turn brown when exposed to oxygen. This process is catalyzed by polyphenol oxidase.
- **Enzymes** – protein catalysts, which control specific chemical reactions in living systems (plants and animals). Enzymes are active at low concentrations.

- **Ester bonds** – bonds between fatty acids and glycerol molecules.
- **Fatty acid** – building blocks of fats, having hydrogen atoms attached to chains of carbon atoms and a oxygen containing carbonyl group (-C=O). Fatty acids are found in every cell of the human body.
- **Glycerol** – backbone for fatty acid molecules.
- **Glucose** – a simple sugar (C₆H₁₂O₆) and the primary source of energy for all mammals and many plants. It is also known as dextrose, grape sugar, and corn sugar. It is about half as sweet as table sugar.
- **Hormones** – substances that can influence enzyme action, metabolism, and physiology.
- **Insoluble** – not capable of being dissolved. Fats are insoluble in water. On the other hand, sugar is soluble in water unless more is added than what a certain volume of water can dissolve, which means that the solvent has become saturated with sugar.
- **Lecithin** – emulsifier found in eggs and soybean oil.
- **Lipids** – compounds commonly of fatty acids and glycerol. Lipids are the most efficient source of fuel in living things. Food lipids are divided into 1) **fats**, which usually come from animal sources and are solid at room temperature; and 2) **oils**, which usually come from plant sources and are liquid at room temperature. Another type of lipid is cholesterol. Cholesterol is a sterol compound made by animals and is used to make certain steroid hormones in the body. It is not found in plants.
- **Melanin** – any of a group of brown or black pigments occurring in plants and animals.
- **Organic** – related to the branch of chemistry dealing with carbon compounds. Though all living things contain carbon and thus are considered to be organic, other carbon-containing compounds have been produced in the laboratory.
- **Peptide bonds** – covalent bonds between two amino acid molecules.
- **Peptides** – short chains of amino acids.
- **Photosynthesis** – process by which a plant uses water and carbon dioxide to produce a simple sugar (glucose) and oxygen. Plants store excess sugar as starch.
- **Polymers** – contain ten or more monomers. Starch is a polymer of the monomer glucose. A protein is a polymer of amino acids.

- **Polyphenol oxidase** – a copper-containing enzyme, also called phenolase, that catalyzes the oxidation of phenolic compounds contained in plant tissue. Example – it speeds the process of browning of cut apple slices.
- **Polyunsaturated** – fatty acids that have multiple double bonds.
- **Proteins** – complex polymers composed of amino acid monomers. Some examples of protein are muscle, hair, skin, hormones, and enzymes.
- **Rennin** – enzyme used to make cheese.
- **Shortening** – crystalline form of a solid fat.
- **Soluble** – capable of being dissolved. Gases or solids that dissolve are called **solutes**, while the liquid that does the dissolving is called the **solvent**. Like substances are usually soluble in like solvents.
- **Starch** – a polymer of glucose. It is a complex carbohydrate found in green plants and an important source of energy for animals and humans. During the day, green plants store energy by converting glucose to starch. At night, plants convert starch back to glucose for growth.
- **Triacylglycerol** - a lipid compound consisting of three fatty acids linked to one glycerol molecule. This compound is an important source of energy for the human body.
- **Vegetable oils** – come from plants like corn or soybeans and are an important source of polyunsaturated fats.

NAME _____

Freaky Fats: Fill in the blank spaces with the appropriate terms to complete the sentences. Solve hidden message by entering the boxed letters in the spaces at the bottom of the page.

1. _____ _____
are long chains of carbon and hydrogen atoms that combine with glycerol molecules to form a lipid.
2. _____
extracted from olives, canola, and corn are plant lipids and are liquid at room temperature.
3. _____ _____
is a phospholipid emulsifier found in eggs and soybean oil.
4. _____ _____
are found between the fatty acids and the glycerol molecules in triacylglycerols.
5. _____ _____
is a crystalline form of solid fat.
6. _____ _____
are used to prevent the cocoa butter from separating out of chocolate bars.
7. _____ _____
fatty acids have multiple double bonds.
8. _____ _____
molecules form the backbone of attachment for fatty acid molecules.
9. _____ _____
fat is saturated because it contains all single bonds and is solid at room temperature.
10. _____ _____
oils like corn and soybean are important food sources of polyunsaturated fatty acids in our food supply.

HIDDEN MESSAGE:

In the United States, this once popular oil is no longer used by the food industry as an ingredient, because it was reported to increase blood cholesterol level. It was used primarily in cookies, cakes, and snack foods.

NAME _____

Powerful Proteins: Fill in the blank spaces with the appropriate terms to complete the sentences. Solve the hidden message by entering the boxed letters in the spaces at the bottom of the page.

1. _____
are short chains of amino acids.
2. __________
of amino acids make up protein molecules.
3. _____
are the building blocks of proteins.
4. _____ _____
can influence enzyme action, metabolism, and physiology.
5. _____
is a proteolytic enzyme that is used to make cheese.
6. __________
is a milk protein.
7. __________
involves the hydrolysis of proteins to amino acids.
8. __________
is a protein enzyme that breaks down starch in the mouth.
9. _____ _____
is the transformation of a liquid into a soft semi-solid or solid mass.
10. ____
proteins are used for their foaming properties in desserts, cakes, and whipped toppings.

HIDDEN MESSAGE:

Elementary school children frequently use this casein-based adhesive that was introduced by *Borden*® over 50 years ago. Hint: There is a picture of Elsie the cow on the container.

Secret Code for “Food Chemistry”

Name: _____

All these sentences have one word written in a secret code.**Decode these words.**

1. Starch is a _____ of glucose.
ktnuydb
2. Amino acids are bound together by _____ bonds to form proteins.
kdkrjgd
3. A _____ protein has been changed from its natural state by heat, chemicals, or enzymes.
gdihrlbdg
4. The chemical breakdown of the food we eat, or _____, begins in the mouth.
gjadxrjti
5. Amino acids are the basic building blocks of _____.
kbtrdjix
6. The primary source of energy for all mammals is _____, a simple sugar.
anumtxd
7. Food _____ are divided into two groups: fats, which come from animals and oils, which come from plants.
njkjgx
8. Fats are _____ in water, which means they will not dissolve in water.
jixtnlond
9. Starch and sugar are two examples of _____, compounds of carbon and water.
mhbotqugbhrdx
10. The process by which fruits and vegetables turn brown is called _____ browning.
dipuyhrjm