Chapter 9
Fats, Oils, and Emulsifiers

How Baking Works

Words, Phrases, and Concepts

- Lipids
- Tropical oils
- Emulsifiers
- Triglyceride
- Fatty acid
- Saturated, monounsaturated, and polyunsaturated
- Omega-3 fatty acid
- Trans fatty acid
- Hydrogenation
- Beta prime crystals
- Plastic fat
- Interesterified
- Low-lin oil
- High-oleic oil
- Cultured cream
- Sweet cream
- Leaf lard
- Table, baker’s, roll-in, puff pastry margarines
- AP shortening
- High-ratio shortening
- Mono- and diglycerides
- Vegetable oil

Introduction

- Fats, oils, and emulsifiers
  - Are important moisteners and tenderizers.
  - Have health implications.
- Successful bakers and pastry chefs:
  - Know how to use these ingredients properly.
  - Understand the health needs of their customers.

Definitions

Lipids

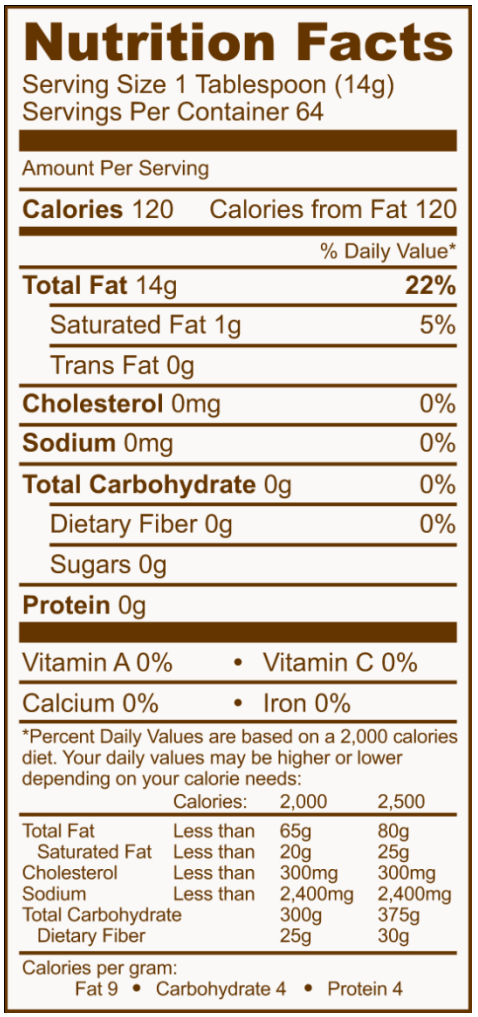
- Do not dissolve in water
- Include:
  - Fats
  - Oils
  - Emulsifiers
  - Flavor oils

    Examples: peppermint oil, lemon oil

Definitions

Fat

- Solid at room temperature
- Sometimes refers to any lipid, solid or liquid



Nutrition Facts

Serving Size 1 Tablespoon (14g)
Servings Per Container 64

Amount Per Serving

Calories 120	Calories from Fat 120
	% Daily Value*
Total Fat 14g	**22%**
Saturated Fat 1g	5%
Trans Fat 0g	
Cholesterol 0mg	0%
Sodium 0mg	0%
Total Carbohydrate 0g	0%
Dietary Fiber 0g	0%
Sugars 0g	
Protein 0g	

Vitamin A 0% • Vitamin C 0%

Calcium 0% • Iron 0%

*Percent Daily Values are based on a 2,000 calories diet. Your daily values may be higher or lower depending on your calorie needs:

	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Saturated Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

Nutrition Facts labels use the term fat to describe the amount of total lipids.

Definitions

Oil

- Liquid at room temperature.
- Typically from vegetable sources.

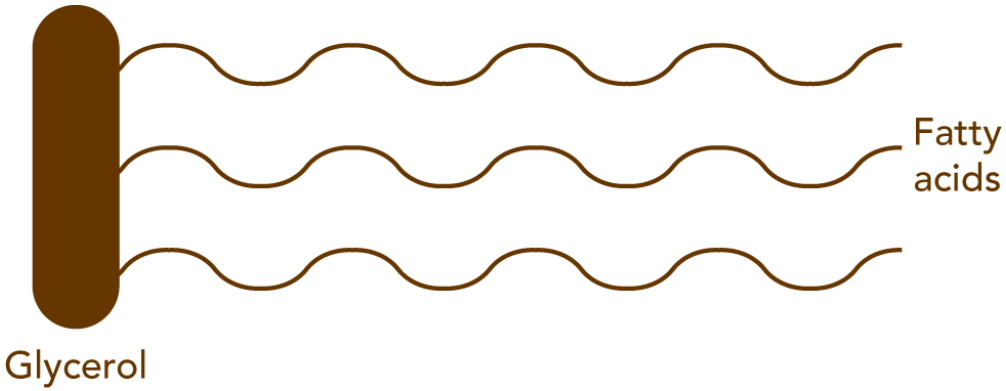
  Examples: soybean, canola, corn.
- Exception: Tropical oils are solid at room temperature (70ºF/ 21ºC).
  - Melt quickly in a warm room (would be liquid in the tropics).

    Examples: coconut oil, palm oil, palm kernel oil.

Chemistry

Triglycerides

- All fats and oils are triglycerides.
- Consists of three (tri) fatty acids attached to a glycerol (glycerine) molecule.



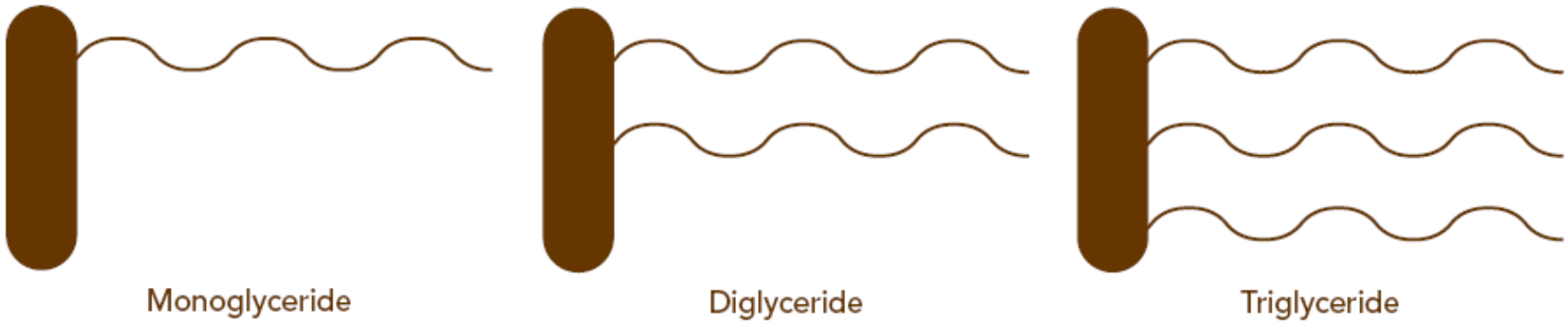
Simplified representation of a triglyceride

Definitions

Emulsifier

- Liquid or solid.
- One important function in baked goods is to keep oil and water together, as an emulsion:
  - Part of molecule is attracted to water: is *hydrophilic*.
    - dissolves in water.
  - Part of molecule is attracted to fats and oils: is *lipophilic*.
    - dissolves in oil.
- *Examples*: lecithin, mono- and diglycerides

Definitions



- Monoglycerides have one (mono) fatty acid attached to glycerol while diglycerides have two.
- The fatty acid part of the molecule is attracted to fats and oils (lipophilic), while the rest of the molecule is attracted to water (hydrophilic).

Chemistry

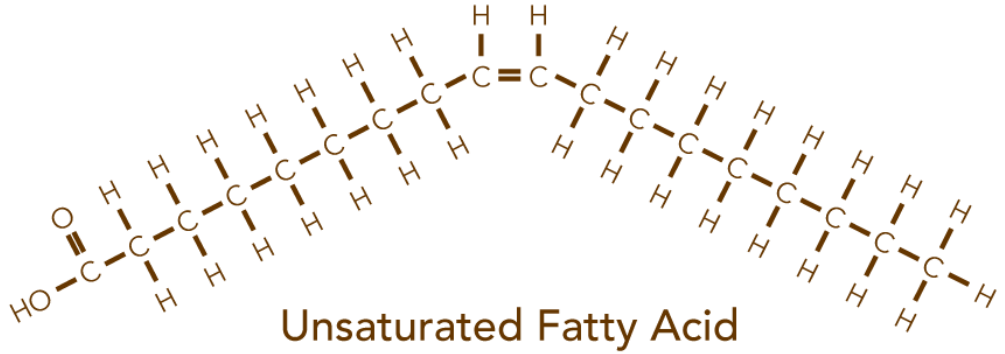
Fatty acid

- Part of the makeup of all fats and oils (triglycerides) and emulsifiers.
- Can be:
  - Short or long.
    - Consists of four to twenty-four carbon atoms.
  - Saturated or unsaturated.
  - Trans (or not).
  - Omega-3 (or omega-6, omega-9, etc.).

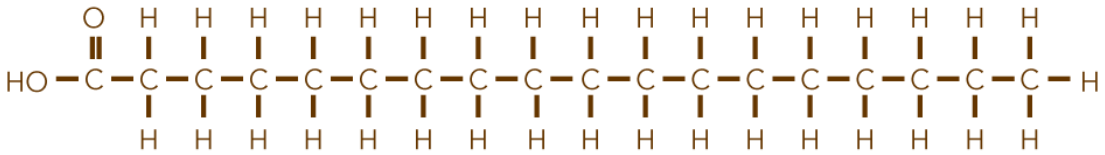
Chemistry

Fatty acid - Saturated

- All carbon atoms are fully saturated with hydrogen.
- No double bonds (C=C) between carbon atoms.
- Molecule is straight.



Unsaturated Fatty Acid

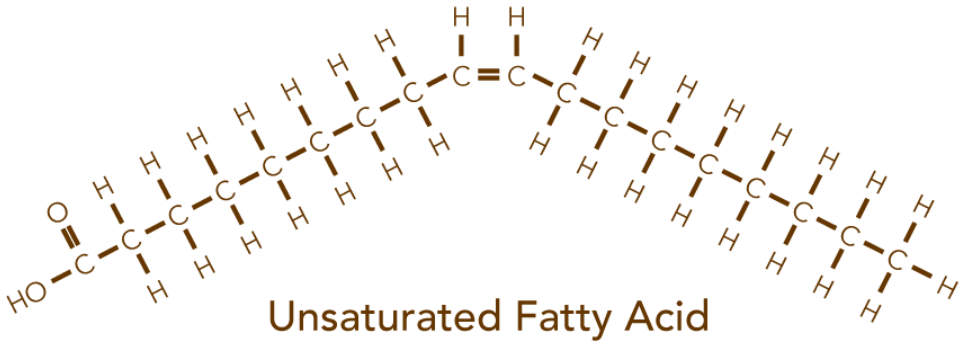


Saturated Fatty Acid

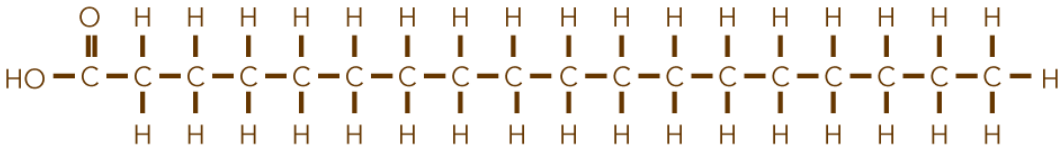
Chemistry

Fatty acid - Monounsaturated

- Two carbon atoms are not saturated with hydrogen.
- One C=C double bond on molecule.
- Molecule is bent at C=C double bond.



Unsaturated Fatty Acid

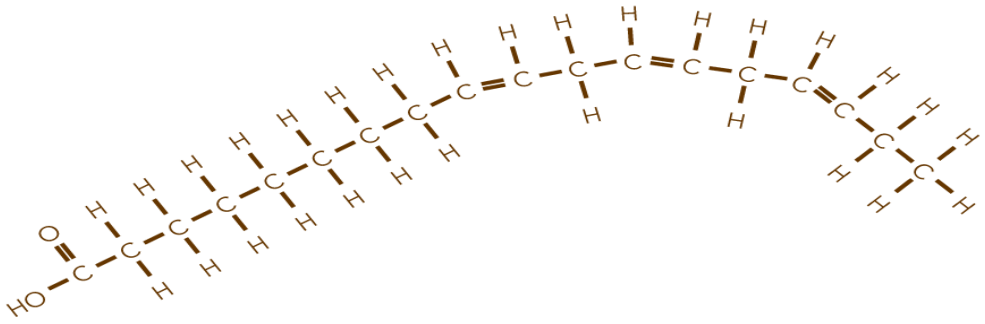


Saturated Fatty Acid

Chemistry

Fatty acid - Polyunsaturated

- Several carbon atoms are not saturated with hydrogen.
- Two or more C=C double bonds on molecule.
- Molecule is bent at each C=C double bond.
- Fatty acid is further described by the location of the last C=C.
  - An omega-3 fatty acid has the last double bond three carbons in from the omega (last) end on the molecule.



An omega-3 polyunsaturated fatty acid

Chemistry

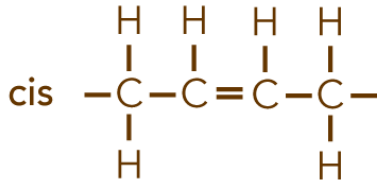
Fatty acid - Trans

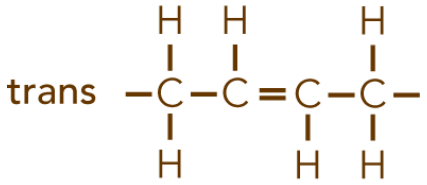
- Called trans fatty acid or trans fat.
- Present in butter and in partially hydrogenated fats.
- Unsaturated fatty acid with hydrogen atoms on opposite sides of the C=C double bond.
  - Unlike naturally occurring (“cis”) unsaturated fatty acids.

Chemistry

Fatty acid – Trans (cont.)

- Molecule is straight.
  - Unlike naturally occurring (“cis”) unsaturated fatty acids.



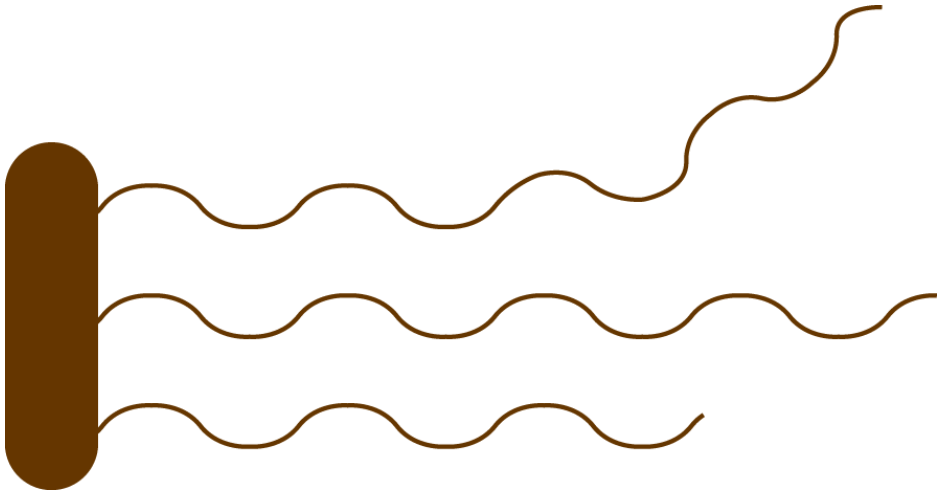


- Dietary guidelines recommend limiting trans fats.
  - They increase bad (LDL) and decrease good (HDL) cholesterol, increasing the risk of coronary heart disease.

Chemistry

Mixed triglyceride

- Contains a mix of fatty acids: short, long, saturated, unsaturated, etc.
- Common type of triglyceride in foods.



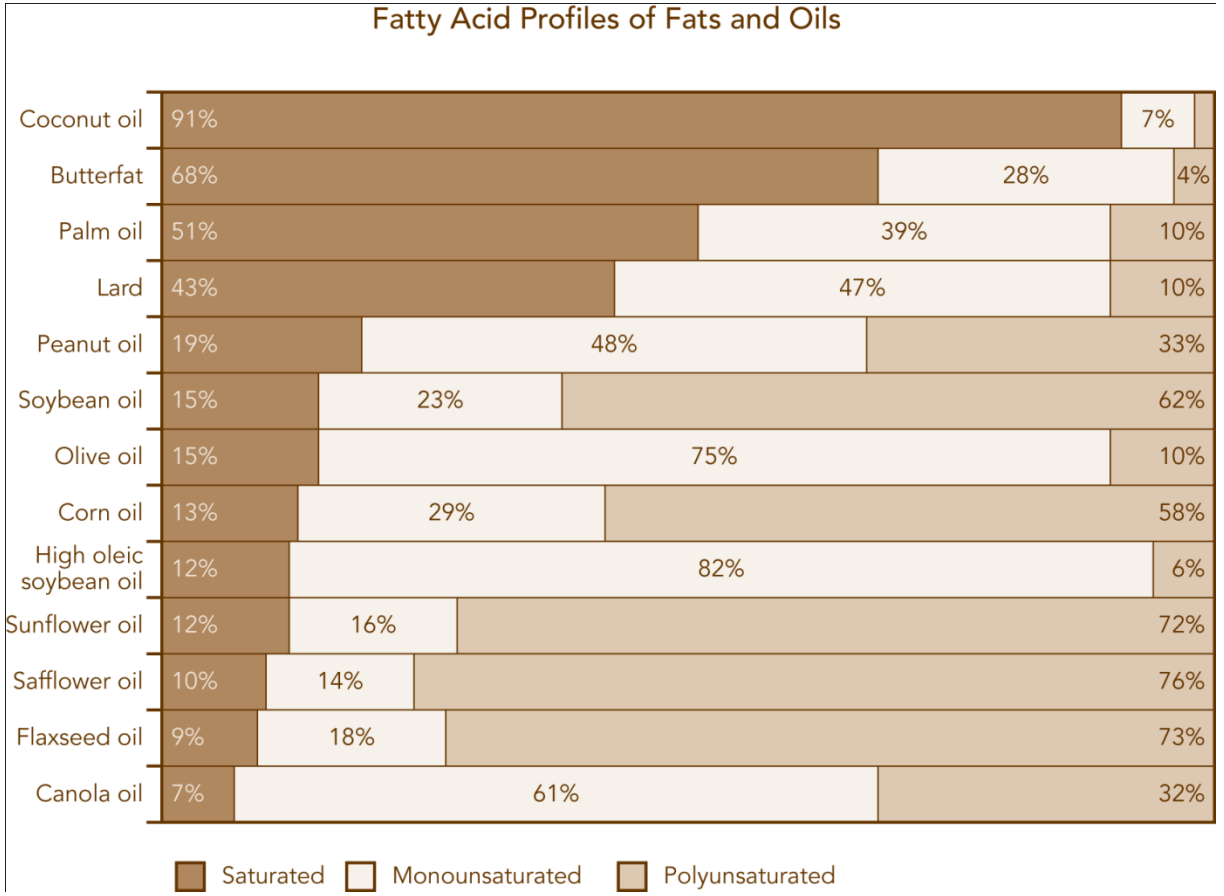
Simplified representation of a mixed triglyceride

Chemistry

Fatty acid profile

- Each fat contains a distinct mix of fatty acids (or fats).
  - The higher it is in saturated fats, the more solid the fat.
    - Also, the higher the fat's melting point.
    - Animal fats, tropical oils, and cocoa butter are high in saturated fatty acids.
    - Dietary guidelines recommend limiting saturated fats in the diet.
  - The higher it is in polyunsaturated fats, the more likely it is a liquid oil at room temperature.
    - Also, the lower the oil's melting point.
    - Monounsaturated fats also lower melting point, but to a lesser degree.
    - Most vegetable oils are high in unsaturated fatty acids.
    - Dietary guidelines recommend increasing unsaturated fats in the diet.

Chemistry



Which is higher in saturated fat: butterfat or lard?

Which is higher in monounsaturated fatty acids: soybean or canola oil?

Which is higher in polyunsaturated fatty acids: peanut or soybean oil?

Chemistry

Solid fats:

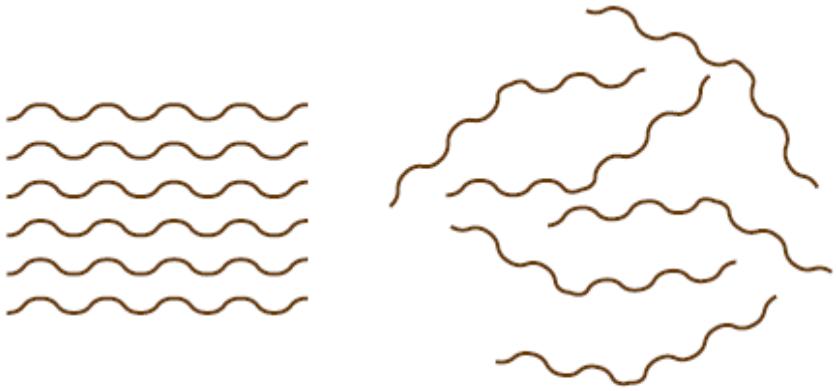
- Contain many tiny solid fat crystals.
  - Highly ordered arrangements of molecules bonded one to the next, all along their lengths.
  - Fat crystals are so tiny that most fats feel creamy smooth.
- Are high in saturated fatty acids, especially long ones.
  - Saturated fatty acids are straight; they line up and bond more easily than bent unsaturated fatty acids.

Chemistry

Solid fats (cont.)

What Makes Saturated Fats Solid?

All solid fats contain a certain amount of solid fat crystals. Like all crystals, fat crystals are highly ordered arrangements of molecules bonded one to the next. Saturated fatty acids are more apt to form solid fat crystals because they are straight molecules (refer back to Figure 9.3). Straight molecules easily line up in an orderly fashion, bonding and packing tightly into crystals. Unsaturated fatty acids are bent, and it is more difficult for bent molecules to line up and bond. Instead, unsaturated fatty acids arrange themselves loosely, and while they might tangle, they do not tightly bond into solid crystals, at least at room temperature. The more unsaturated the fatty acid, the more bent the molecule, and the harder it is for the fatty acid to crystallize into a solid fat.



Left: saturated fatty acids easily line up to form solid crystals; **right:** unsaturated fatty acids do not

Chemistry

Plastic fats:

- Are soft and moldable, that is, they are workable.
- Consist of liquid oil trapped in a network of solid fat crystals.
- Examples (at room temperature): All-purpose shortening, lard, butter.
- Plasticity is temperature dependent.
  - Butter is plastic at room temperature, but it is rock solid in the freezer and completely liquid in a hot bakeshop.
  - All-purpose shortening is plastic across a wider temperature range.
- When a fat is in its plastic range, it is easier to cream, spread, pipe, roll, laminate, etc.
  - That is, a plastic consistency is often desirable in the bakeshop.

Processing of Fats and Oils

Main steps in processing fats and oils:

- Extraction
- Refining
- Optional, for increasing functionality: hydrogenation, aeration, fractionation, interesterification, etc.

Most bakeshop fats and oils are highly refined.

- Composed of almost 100% pure triglycerides, with everything else removed.
- Exceptions: butter, virgin olive oil.

Processing of Fats and Oils

Extraction:

- Oil is removed from
  - Oilseed, such as soybean, sunflower seed, safflower seed.
  - Nut, such as peanut, coconut, palm kernel.
  - Fruit, such as palm fruit, olive.
- Extracted using solvents or by pressing.

Processing of Fats and Oils

Hydrogenation makes a liquid oil solid. The more hydrogenation, the more solid the fat. Also:

- The less likely it will undergo oxidative rancidity
- The higher it is in unhealthful
  - Saturated fats
  - Trans fats

Processing of Fats and Oils

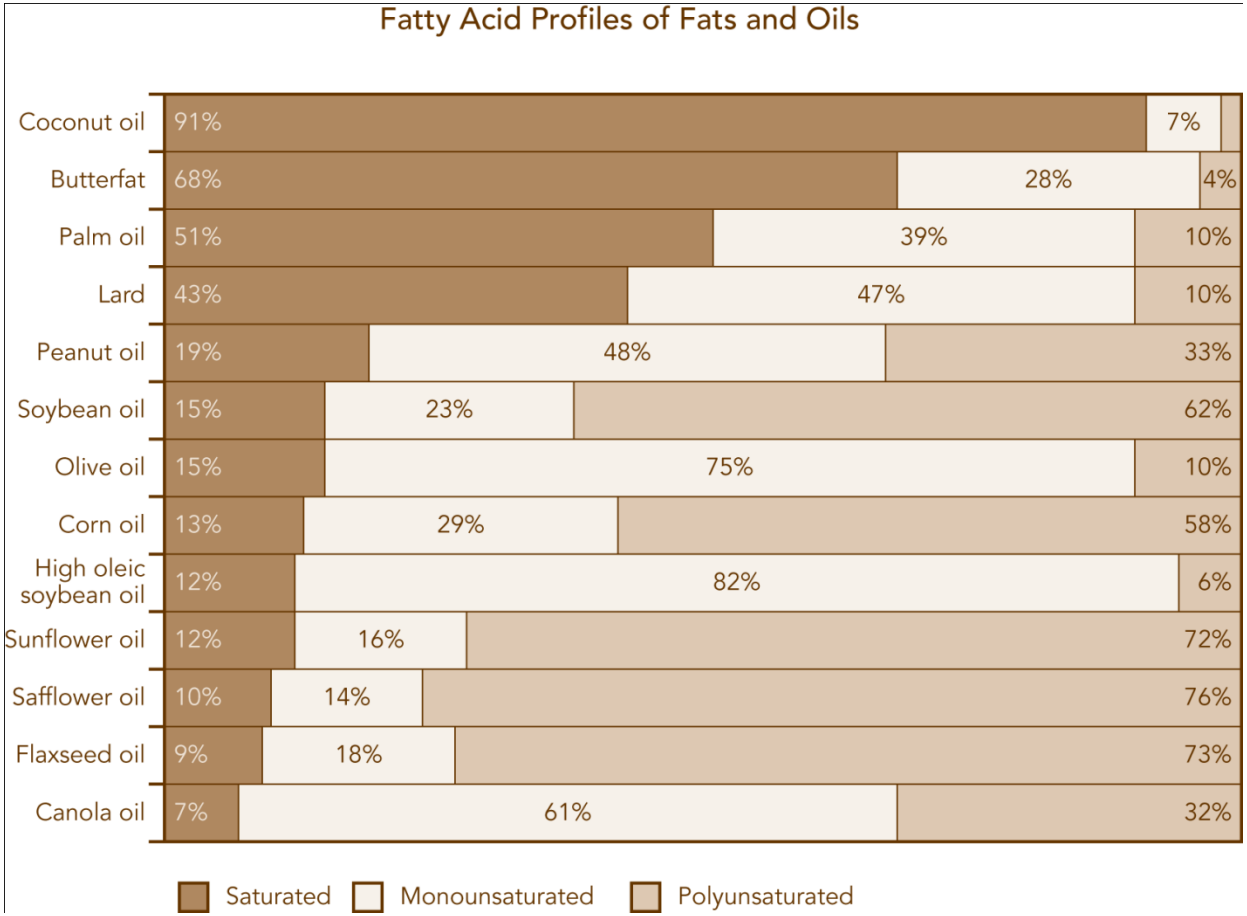
Liquid oils were previously lightly hydrogenated.

- Made them less likely to oxidize and become rancid.
- Especially important for oils used for frying.
  - High heat of the fryer requires the most stable of oils.
- Partial hydrogenation meant that they contained trans fats.

Trans-free, stable oils are now extracted from specially bred oilseeds.

- Soybean, sunflower, safflower seeds, etc. bred through traditional means or through genetic engineering to be:
  - Lower in polyunsaturated fatty acids, which oxidize easily.
  - Higher in monounsaturated fatty acids, which oxidize slowly.
- Stable oils are called low-lin oils, high-oleic oils, or omega-9 oils.

Processing of Fats and Oils

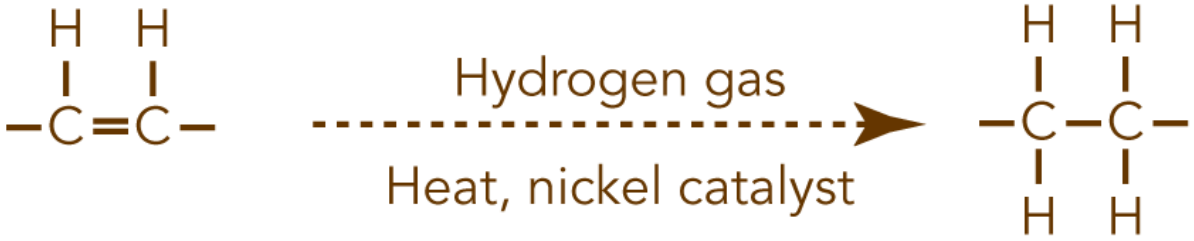


Compare regular soybean oil with high-oleic soybean oil. Which is higher in polyunsaturated fats? Which is higher in monounsaturated fats? Which is more stable, and why?

Processing of Fats and Oils

Plastic shortening or margarine can be made by:

1. Partial hydrogenation of a liquid oil, where some unsaturated fatty acids are converted to saturated ones.



Unsaturated liquid oil *Saturated solid fat*

This is the traditional means of producing shortenings and margarines.

- Being phased out because of unhealthful trans fats.
- Trans fats do contribute positively to the functionality of shortening, making it plastic and workable over a greater range of temperatures.

Processing of Fats and Oils

Plastic shortening or margarine can be made by:

2. Using a naturally saturated fat, like palm oil.
    - Contains no trans fats.
    - More sensitive to changes in temperature.
        - Softens and melts more easily at warm temperatures.
        - Hardens more easily at cold temperatures.
        - More difficult to cream, pipe (in icings), have flaky pie crusts.
    - Can still be up to 50 percent unhealthful saturated fat.
    - To improve plasticity, can be interesterified; that is, fatty acids can be rearranged on the fat molecule.
3. Blending a fully hydrogenated fat with a liquid oil or with a naturally saturated fat.
    - Has some of the same features as palm oil, above; can also be interesterified, so that it is more plastic.

Processing of Fats and Oils

Once it is processed to be soft and plastic, a shortening or margarine is

- Cooled and aerated, under controlled conditions.

  Encourages formation of the proper crystalline structure: tiny beta prime crystals.

  - Provide a smooth, creamy, texture.
  - Best for creaming.

Different Fats and Oils

Butter

- Made from heavy cream.
- Two main types:
  - Sweet cream.
    - Cream is fresh, that is, has not been soured.
  - Cultured cream.
    - Also called ripened cream.
    - Bacterial culture added, to first produce sour cream.
- Quality of butter depends on many factors.
  - Quality of cream (freshness, flavor, etc.).
  - Cow's diet.
  - Pasteurization process.
  - How cream is chilled, churned, and washed.
  - How much air is incorporated.
  - How much fat it contains.

Different Fats and Oils

Advantages of butter

- Great flavor.
- Superior mouthfeel.
  - Melts quickly and cleanly.

Disadvantages of butter

- Expensive.
- High in saturated fat; also contain cholesterol.
- Has a narrow plastic range: too hard when cold, too soft when warm.
- Susceptible to bacterial spoilage; needs refrigeration.

Different Fats and Oils

Makeup of butter

- Butterfat
  - Includes small amounts of natural emulsifiers, including mono- and diglycerides and lecithin.
  - Minimum 80 percent, by law.
    - European and European-style butters: minimum 82 percent.
- Water, 16-18 percent.
- Milk solids: proteins, lactose, minerals.
  - Contribute to Maillard browning.
- Optional ingredients
  - Salt
  - Natural butter flavoring
  - Annatto (natural coloring)
- Air, up to 10 percent, by volume.

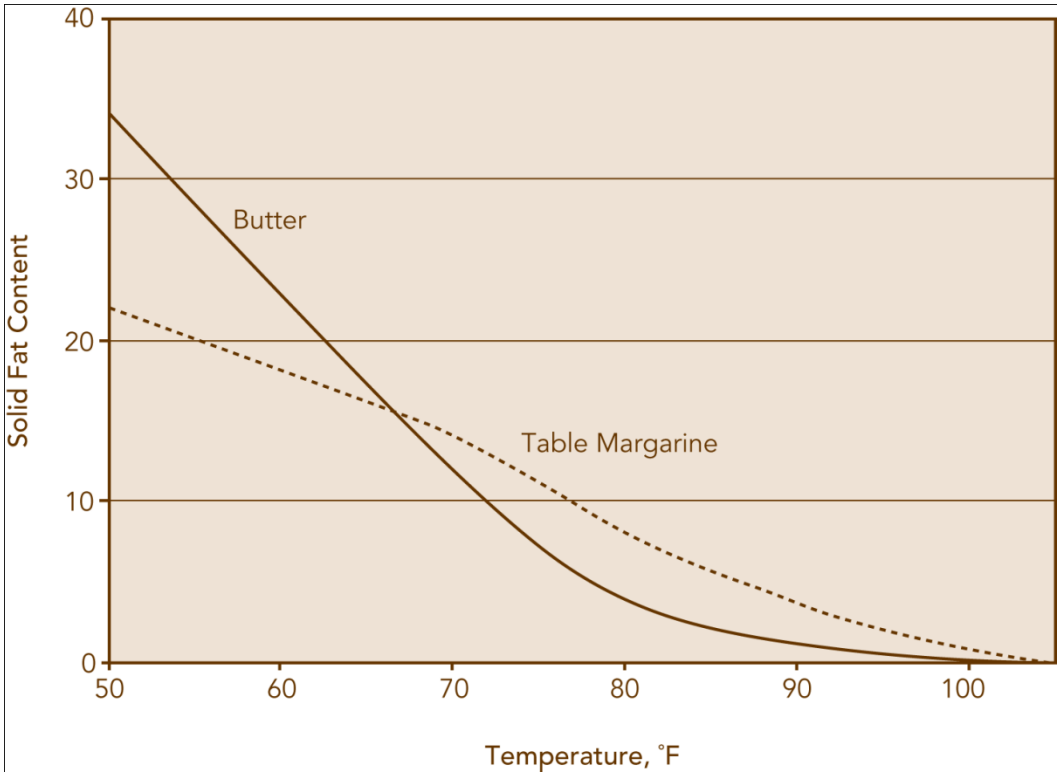
Different Fats and Oils

Lard

- Rendered (extracted) from hog fat.
  - Pork-based; not allowed in strict kosher (Jewish) or halal (Islamic) diets.
- Several grades available.
  - Grade varies depending on source.
    - Highest grade is leaf lard, which surrounds kidneys and abdomen of hog.
- Advantages of traditional lard.
  - Ideal for flaky pastry.
    - Solidifies into large, grainy beta crystals, naturally.
  - Has characteristic mild meaty flavor
- Today, lard is often highly refined, bleached, deodorized, even hydrogenated.
  - More like all-purpose shortening: mild flavor, smooth and white, creams well; not as desirable for flaky pastry.

Different Fats and Oils

Margarine is imitation butter. It will not have same pleasant flavor or mouthfeel as butter.



Butter starts firmer than margarine but melts faster. This provides a more pleasant, meltaway mouthfeel.

Different Fats and Oils

Many types of margarine available.

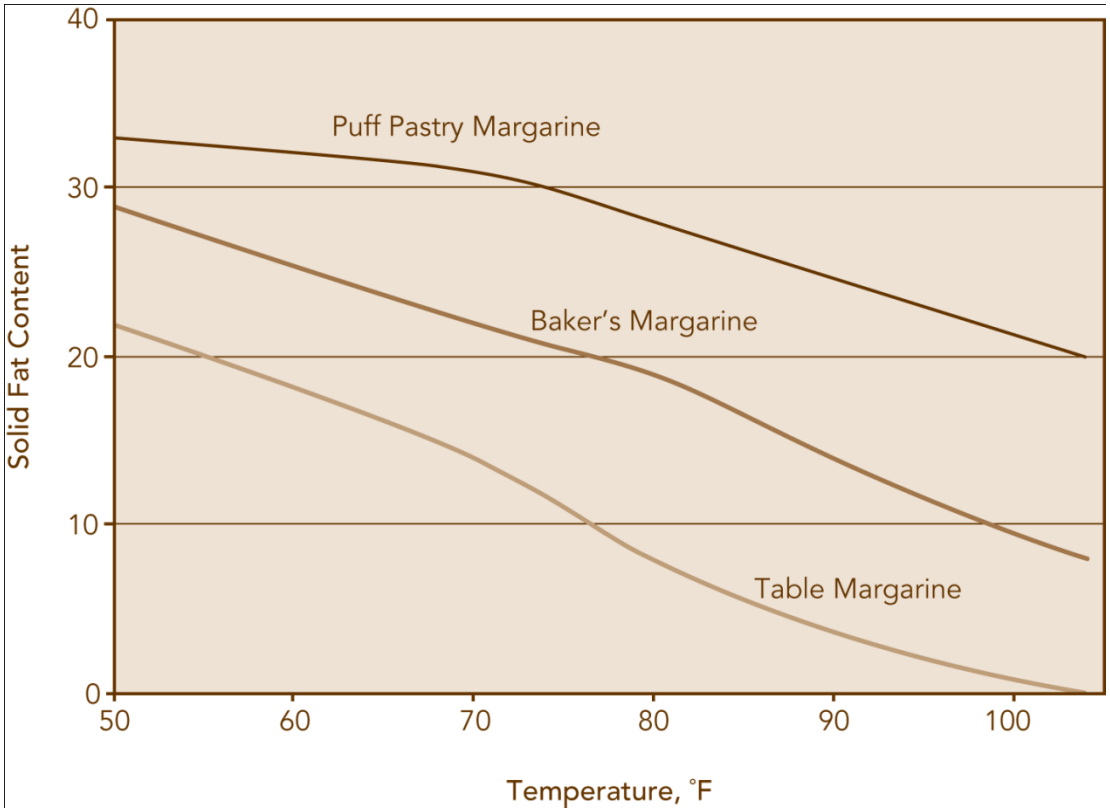
- Most made from vegetable fats, especially soybean and palm oils.
- All have a makeup that is similar to butter.
  - Minimum 80 percent fat (vegetable fat, not butterfat) and 16 percent water.
  - Other common ingredients: butter flavor, beta carotene (for color), anti-microbial agent, milk solids, salt, lecithin.
- All have one or more advantages over butter.
  - Lower in price.
  - Most are lower in saturated fat and contain no cholesterol or trans fats.
  - Many different types available, each suitable for a specific task.

Different Fats and Oils

Margarine Classifications

- Commonly classified by firmness and melting point.
- As melting point increases, mouthfeel becomes firmer and waxier.
- From softest to firmest:
  - Table margarine.
    - Uses: spread on bread, icings with easy-melting mouthfeel.
  - Baker's margarine.
    - Uses: for cakes and cookies that require creaming; for icings resistant to warm temperatures.
  - Roll-in margarine.
    - Uses: Danish pastries, puff pastries, croissants
  - Puff pastry margarine.
    - Uses: Puff pastry.

Different Fats and Oils



The higher the solid fat content of a margarine at body temperature, the waxier it will feel.

Different Fats and Oils

Shortenings.

- Made of 100 percent fat.
  - Main difference between shortening and margarine, which is only 80 percent fat.
- Originally developed as a replacement for lard.
- Most made from vegetable fats, especially soybean and palm oils.
- Many types available, each suitable for a specific task. Some designed specifically for:
  - Frying.
  - Fluffiest icings.
  - Lightest, most tender cakes.
  - Flakiest pastries.
  - Softest breads.

Different Fats and Oils

All-purpose (AP) shortening

- Contains no emulsifiers.
- May contain an antifoaming agent, for use in fryer.
  - Dimethylpolysiloxane is commonly added for this purpose.
- Plastic and workable over a wide temperature range.
  - Shortening that has melted and rehardened will lose its smooth, creamy texture and its ability to cream.
- Uses:
  - Creaming, as for cookies.
  - Flakiness in pie dough and biscuits.
  - Frying.

Different Fats and Oils

High-ratio plastic shortening

- Contains added emulsifiers; otherwise, similar to AP shortening.
  - Most common emulsifier: mono- and diglycerides.
  - Emulsifiers help cream air into shortening and distribute it evenly throughout cake batters.
  - Emulsifiers also help distribute fat and oil evenly throughout.
- Also called:
  - Emulsified shortening, or
  - Cake and icing shortening.
- Uses:
  - High ratio cakes.
  - Light and fluffy icings.
  - Soft breads (delays staling).
- Do not use in frying or for flaky pie dough.

Different Fats and Oils

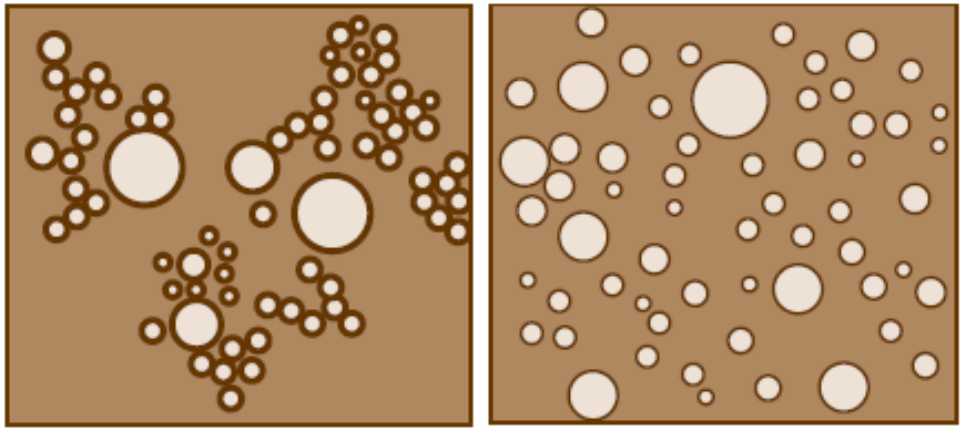
High-ratio liquid shortening

- An opaque, creamy pourable shortening.
- Contains high level of emulsifiers.
  - Emulsifiers are specifically designed to stabilize air bubbles whipped into batter and oil droplets dispersed in it.
    - Air bubbles and oil droplets would normally separate out.
  - Provides lightness, high volume, tenderness, and moistness.
  - Provides higher yield (low density cake), which lowers costs.
  - Simplifies cake-making process.
  - Can often reduce amount of shortening by 20 percent over plastic shortening.
- Use: liquid shortening cake, where air is whipped into batter rather than creamed into fat.

Different Fats and Oils

Emulsifiers provide a range of functions

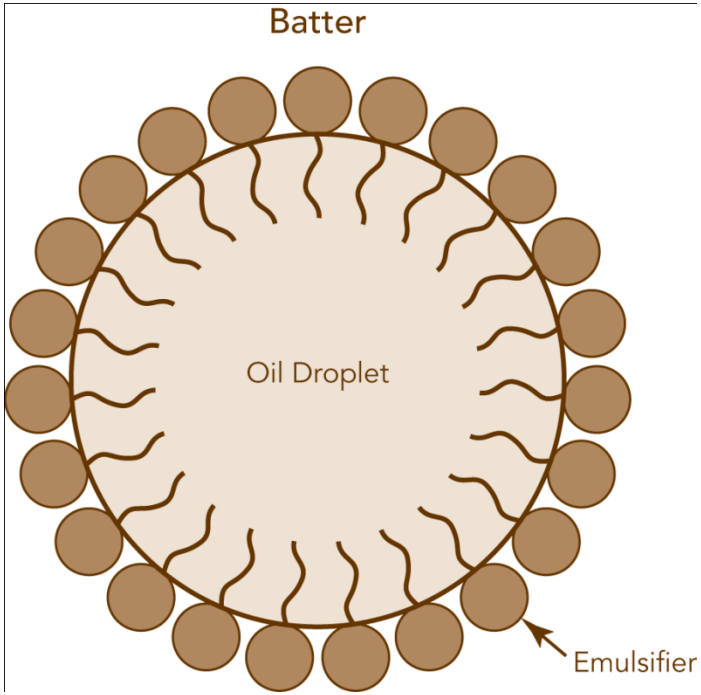
- Because they interact with a range of ingredients.
- Two important functions of emulsifiers in cake-baking:
  - To stabilize fat and oil droplets, and distribute them throughout batter.
  - To stabilize air bubbles creamed into shortening or whipped into liquid batters, and distribute them throughout batter.



(a) Butter without added emulsifier **(b)** Butter with added emulsifier

Different Fats and Oils

Close-up of oil droplet stabilized by emulsifiers.



Emulsifiers orient themselves around oil droplets (and air bubbles), keeping the droplets intact and helping to disperse them throughout batters and doughs.

Different Fats and Oils

Oil

- Contains 100 percent fat; no added water.
- Liquid; high in poly- and monounsaturated fatty acids.
- Many different vegetable oils available, including:
  - Soybean.
  - Corn.
  - Canola.
  - Sunflower.
  - Peanut.
- Most common is soybean oil.
  - “Vegetable oil” typically refers to soybean oil.
- Only common fat that does not contribute to leavening.
- Uses: Quick bread, muffins, chiffon cake, mealy pie crusts.

Different Fats and Oils

Olive oil

- Most expensive of all oils used in bakeshop.
- Comes refined (“light”) or unrefined (virgin; extra virgin).
- Unrefined virgin olive oil is more common.
  - Has distinct olive oil flavor and green or gold color.
  - Graded by the amount of free fatty acids present.
    - Extra virgin: highest quality; lowest level of free fatty acids.
  - Use virgin or refined olive oil where high heat is involved.
    - Extra virgin loses its fine flavor and becomes bitter when exposed to high heat.
- Uses: Savory flatbreads, focaccia, pizza; also, regional Mediterranean specialty desserts.

Functions of Fats, Oils, and Emulsifiers

Providing tenderness.

- By coating structure builders–gluten proteins, egg proteins, and starch granules– and preventing them from hydrating and forming extended structure.
- Also called shortness.
  - Gluten strands, for example, are literally shortened in length.
- Tenderizing abilities of a fat depend on:
  - The amount present; the more fat, the more tenderizing.
  - How soft and fluid it is; the more fluid, the more easily it is distributed, and the more tenderizing.
  - Piece size; the smaller the piece size of the fat and the better it is distributed, the more tenderizing.
  - The presence of emulsifiers, to help distribute fat.
  - The ability of the fat to leaven, which also provides tenderness.

Functions of Fats, Oils, and Emulsifiers

Providing flakiness in pastries.

- Flakiness is the formation of thin, flat, often crisp layers within pastry.
- Requires that flattened chunks of solid fat separate bits of dough.
- The later the fat melts in the oven, the greater the flakiness, and leavening.
- Ability of fat to provide flakiness depends on:
  - How solid it is: in general, the more solid the fat and the higher its melting point, the later it melts and greater the flakiness.
  - Piece size: the larger the pieces of fat, the more flakiness.

Functions of Fats, Oils, and Emulsifiers

Functions of Fats, Oils, and Emulsifiers

Assisting in leavening.

Four main ways that fats assist in leavening and the overall rise of baked goods:

1. By providing gaps and spaces upon melting, for steam and other leavening gases expand into. *Example*: flaky pastries.
2. By the air trapped in plastic fats, which then are incorporated into batters and doughs.
3. Through the incorporation of additional air during creaming.
4. Through the assistance of emulsifiers during creaming or during the mixing of high-ratio shortenings.

Functions of Fats, Oils, and Emulsifiers

Functions of Fats, Oils, and Emulsifiers

Contributing moistness.

- Moistness is the sensation of something being liquid.
- Both moisture (water) and liquid oil provide moistness.
- Moistness and tenderness often go together.
  - Because many fats provide both moistness and tenderness.
- Ability of a fat to provide moistness depends on:
  - How fluid it is; the more fluid the fat at body temperature, the more moistening.
  - The presence of emulsifiers, such as mono- and diglycerides.

Functions of Fats, Oils, and Emulsifiers

Preventing staling.

- Lipids interfere with the retrogradation of starch, which is a major cause of staling.
  - The emulsifier blend of mono- and diglycerides is particularly effective.
    - Mono- and diglycerides are in most high-ratio shortenings.
  - By preventing starch retrogradation, high ratio shortenings prevent the hard, dry crumbly texture and the loss of flavor associated with staling. They keep baked goods softer longer.

Functions of Fats, Oils, and Emulsifiers

Contributing flavor.

- A major reason for using butter is for its flavor.
- Other fats often used for their flavor:
  - Lard
  - Olive oil
  - Margarine
- Flavor of fried foods comes primarily from the breakdown of fats and oils exposed to high heat.
- Neutral fats also contribute flavor because of the richness that they add.

Functions of Fats, Oils, and Emulsifiers

- Additional functions
  - Contributing color.
  - Providing a fine crumb to baked goods.
  - Adding creaminess to sauces, custards, confections, and frozen desserts.
  - Conducting heat.
  - Providing bulk and substance to icings and fillings.
  - Promoting smoothness in confections.
  - Blending flavors and masking off flavors.
  - Acting as a release agent.
  - Increasing softness and extensibility of doughs.
  - Thinning out melted chocolate and couvertures.
  - Increasing spread in cookies.

Storage and Handling

Fats must be protected from flavor and texture changes during storage.

- Off-flavors come from three sources.
  - Oxidative rancidity.
    - Occurs with exposure to light, heat, air, and metal catalysts, including iron and copper.
    - Occurs fastest with fats high in polyunsaturated fatty acids.
  - Bacterial spoilage.
    - Of butter primarily; refrigerate or freeze, to prevent.
  - Absorption of odors from the bakeshop.
    - Keep fats covered and away from strong-smelling ingredients.
- Texture changes occur when plastic fats are allowed to melt. To prevent,
  - Store most fats covered and in a cool, dry place.
  - Refrigerate or freeze butter and low-melting margarines.

Storage and Handling

Substituting butter or margarine for shortening:

- Divide the weight of shortening by 0.80 (the percent fat in butter).

  Example: for 1 pound (16 ounces) of shortening use 16 ÷ 0.8 = 20 ounces butter; reduce liquid in formula by 20 – 16 = 4 ounces.

  Example: for 500 grams of sugar use 500 ÷ 0.8 = 625 grams butter; reduce liquid in formula by 625 – 500 = 125 grams.

Storage and Handling

Substituting shortening for butter or margarine:

- Multiply the weight of butter by 0.80 (the percent fat in butter).

  Example: for 1 pound (16 ounces) of butter use 16 x 0.8 = 12.75 ounces butter; increase liquid in formula by 16 – 12.75 = 3.25 ounces.

  Example: for 500 grams of sugar use 500 x 0.8 = 400 grams butter; increase liquid in formula by 500 – 400 = 100 grams.