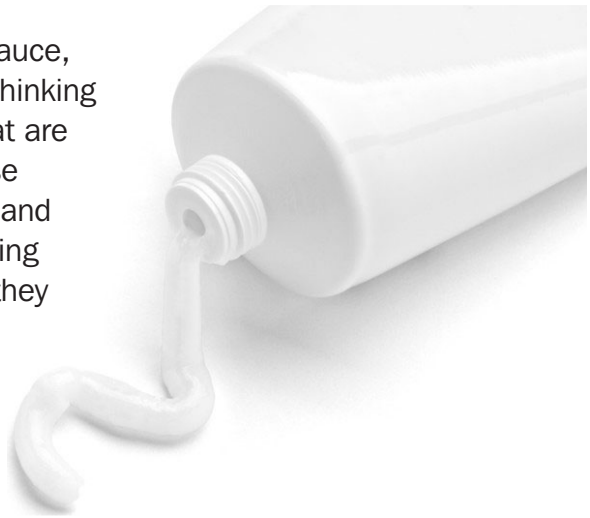
Emulsions

MOST OF US enjoy salad dressing, custard, sauce, jelly, and sandwich spreads without ever thinking that they include combinations of ingredients that are not easily mixed together. If you have eaten these products, brushed your teeth, washed your hair, and applied a skin cream, you have spent the day using emulsions! Let's look at what they are and how they are made.



Objectives:

1. Define and explain the emulsion process.
2. Describe common emulsifiers and emulsions.

Key Terms:

break
density
diglycerides
emulsification
emulsifiers
emulsion
energy
gums
hollandaise sauce
homogenous
immiscible
lecithin
mayonnaise
monoglycerides
sodium stearoyl lactylate (SSL)
stabilizers
surfactants
temporary emulsion

Emulsions and Emulsification

An **emulsion** is a semi-liquid and stable mixture in which one liquid is suspended in another. Emulsions are uniform (**homogenous**) mixtures; they consist of two or more unmixable (**immiscible**) ingredients. One ingredient suspends the other in tiny globules throughout the mixture—as if in limbo. Typically, an emulsion involves a fat or oil and another liquid (e.g., stock or wine). Due to the difference in **density** (compactness or crowding together of the molecules within a product; thickness) between fats and other liquids, the tighter the molecules are packed together, the denser (thicker) the product. Liquids of different density levels effectively repel each other, preventing an even suspension of the two liquids.

Emulsification is the process through which two or more unmixable ingredients become an emulsion. Emulsification brings the ingredients together into a stable mixture in which the "droplets" of liquids are uniformly combined and remain combined. Without emulsification, the mixture separates just as water and oil do when shaken and allowed to sit. Typically, emulsified mixtures are thicker than any of the ingredients were alone. Making an emulsion requires several elements.

FIGURE 1. Notice how the droplets of vinegar stay separate from the oil in this raspberry vinaigrette salad dressing.

ENERGY

Energy is the physical mixing, beating, or whipping of the ingredients, which is one way to bring the ingredients together. A **temporary emulsion** is a mixture that stays together only while the mixing is taking place. When the mixing stops, the temporary emulsion begins to separate. When a mixture remains in a homogenous state, it is emulsified. Energy may be transmitted to the ingredients by hand—with a whisk—or by use of a blender or food processor. Mechanical tools are faster and produce a more stable emulsion due to the higher input of energy.

EMULSIFIERS

Emulsifiers are food additives that allow normally immiscible liquids—such as oil and water—to form a stable mixture. Vigorously beating egg yolks with a fat (e.g., oil or butter) or stock causes the liquid to become evenly suspended in the egg, and the elements are bound together. According to the Food Additives World website, emulsifiers have an "oil-friendly molecule on one end and a water-friendly molecule on the other." The additive may be natural (e.g., eggs, egg yolks, honey, and mustard) or chemical (e.g., monoglyceride and sorbitan ester). One or more may be used in any mixture. Regardless of the type of emulsifier used, most require the addition of energy to bring the ingredients together.

SURFACTANTS

Surfactants are additives that reduce the surface tension between ingredients of different density, allowing a more efficient emulsification to occur. Some emulsifiers are natural surfactants (e.g., lecithin in egg yolks), and others are chemical surfactants with specific purposes.

STABILIZERS

Stabilizers are additives (binders) used in small amounts to ensure an emulsification "holds" and retains body. Stabilizers improve a product's texture, palatability, and shelf life. Sorbitan monostearate is an example of a stabilizer that is also an emulsifier.

Common Emulsifiers and Emulsifications

On a daily basis, you likely come in contact with many common emulsifiers and emulsifications without even knowing it.

LECITHIN

Lecithin is the most common, most easily used, and only organic emulsifier; it is a naturally occurring compound (hygroscopic phospholipid) in egg yolks. The major importance of eggs in sauce making is their ability to form emulsions with different liquids. Yolks are used extensively in baking, dressings, ice creams, and sauces to enrich (due to the fat content of yolks) and emulsify the product. Lecithin is available as an additive for products in which egg yolks are not desired or feasible for use. The use of energy, by beating or whipping, is essential for full incorporation of the ingredients and to allow the surfactant nature of lecithin to work in the product.

Eggs and egg yolks are commonly used as emulsifiers in salad dressings and items such as custards, cakes, and high-fat icing. **Mayonnaise** (a cold sauce made primarily from egg yolks, oil, and seasonings blended or beaten into a thick emulsion) is an example. One egg yolk will typically absorb one cup of oil. Eggs are also used as a binding emulsifier in several classic sauces. An example is **hollandaise sauce**, which is a rich, hot, and creamy sauce usually prepared by beating cold butter cubes into warmed egg yolks and adding lemon juice. Eggs are the only emulsifier that adds flavor to an emulsion.

FIGURE 2. Energy applied to an emulsion through this immersion mixer improves the stability and thickness of the mayonnaise. Do you think this is near the beginning or near the end of the mixing process?

Possible Problems

Emulsions made with eggs are delicate. Adding oil too fast to mayonnaise, or adding too high heat to hollandaise sauce, can **break** (liq-

uefy) or ruin the product. Successful egg-based emulsions require careful control of time, temperature, and the application of heat. All ingredients should be at room temperature because chilled ingredients are too stiff to blend well in a sauce. In addition, oil must be added to eggs and/or egg yolks very slowly. While beating the egg yolks vigorously, oil is added a drop at a time at first. As the mixture thickens, oil is added in a controlled trickle. Gently cooking warm sauces heats the eggs only enough to make the sauce thicker and to add body. When too high heat is applied, the mixture curdles (eggs or yolks separate from the liquid) or "break." Using a water bath—double boiler—to heat the mixture slowly and away from direct heat is one solution to the curdling and breaking of a warm sauce.

The visual effect of a "break" is a mixture that at once looks curdled, oily, and runny. You can "fix" a broken sauce in one of two ways. For cold sauces, beat one fresh, room-temperature egg yolk in a clean dry bowl. Then very slowly whisk in the broken mayonnaise or other sauce. For hot sauces, cool the mixture and then add extra yolks. Sometimes broken mixtures cannot be salvaged, especially when excessive heat has caused the yolks to cook and coagulate (harden) in the mixture.

FIGURE 3. Emulsions made by adding fat to whipping eggs are particularly delicious, but they risk breaking if not prepared properly.

Tricks

Mayonnaise emulsions prepared in a blender or food processor are nearly foolproof. However, you must use whole eggs (rather than egg yolks) to make sure that the mixture is thin enough. If you use egg yolks only in a blender recipe, the mayonnaise will get too thick. Blender-type emulsions are not as rich as the yolk-based, hand-whisked varieties.

CHEMICAL EMULSIFIERS

Chemical emulsifiers are extremely common in food products and in non-consumable items. Products that contain yolks/lecithin may also contain chemical emulsifying additives. Chemical emulsifiers add stability to products.

Monoglycerides and Diglycerides

Monoglycerides and **diglycerides** are tiny fat molecules from soybean, sunflower, palm, and other oils that act as an emulsifier for other fats and ingredients. These fat molecules are artificially manipulated by heating glycerin and oil to create a special type of fat. This spe-

cial fat is a very good emulsifier and stabilizer and is particularly good at attracting and holding moisture. An emulsifier is commonly added to chewing gum, toothpaste, some salad dressings, margarine, ice cream, pudding, some instant potatoes, and breads to improve the texture, palatability, and shelf life of products.

Glycerin's special ability to attract and hold moisture makes it an essential element in soaps. Glycerin's "gentle nature" and skin moisturizing properties also make it a popular addition to body lotions and shampoo. Pure glycerin soap in bar shape is transparent.

Sodium Stearoyl Lactylate

Sodium stearoyl lactylate (SSL) is a chemically made chain of salt and acids that have uncommon properties that emulsify food and non-consumable products. SSL is particularly useful in commercial bread making, particularly the mass-produced loaves that are super soft in texture. SSL helps bread stay "fresh" for a long time (shelf life) and improves the texture.

SSL improves the texture and shelf life of pudding, icing, spreads, chips, cheese products, artificial coffee creamers, dessert toppings, and cake mix. It is also useful as an emulsifier in soap, shampoo, toothpaste, skin cream, hair conditioner, furniture polish, and shaving cream. Picture the creamy nature of these products, and then compare them with the creamy nature of mayonnaise. Are the textures similar?

FIGURE 4. Bread, dips, cheese, and even shampoo are emulsified with sodium stearoyl lactylate.

Gums

Gums are processed natural plant products (fiber) used as emulsifiers. Gum emulsifiers produce a homogenous, thickened, and unified product. Gums swell easily and absorb moisture to create an emulsified, thickened product. Gums cling to fat molecules, so little energy is needed for energy for an emulsion to occur. Xanthan gum, guar gum, and acacia gum are typical examples of gum-type emulsifiers used as thickening agents. These emulsifiers are common in commercially prepared salad dressings, ice cream, jelly and jams, candy, toppings, and glazes. Read a few food labels to find which ones contain gums.

Summary:

Emulsions are homogenous mixtures of two or more liquids that do not combine, usually due to different densities. Mixing or shaking ingredients together makes a temporary emulsion, such as a vinaigrette salad dressing. However, temporary emulsions quickly begin to separate. Long-lasting emulsions require the addition of agents such as eggs, egg yolks, gums, or chemical agents, usually with the inclusion

of energy (mixing, beating, whipping, or heating) to bring the elements together. Emulsions are common in food products and non-consumable products.

Checking Your Knowledge:

1. What compound makes egg yolks a good emulsifier?
2. What is the source of gum emulsifiers?
3. How does heat affect egg-based emulsifications?
4. What is a simple name for monoglycerides and diglycerides?
5. Explain how density affects emulsions.

Expanding Your Knowledge:

Emulsification is used in products throughout our world: paints, medications, cosmetics, fabrics and fabric colorings, solvents and cleaners, paraffin, shoe polish, cookware, and much more. Bringing molecules together that don't readily mix creates new compounds and materials that have revolutionized consumer goods as well as human history. Travel (including space), medicine, military applications, building materials, and entertainment hardware and software have been affected by our ability to form emulsions and manipulate molecules. Do some research to learn more about the uses of emulsions. Find modern food production uses and commerce applications. How many emulsifying agents are available?

Web Links:

What Are Emulsifiers? (podcast)
http://www.basf.com/group/corporate/en/content/news-and-media-relations/podcasts/chemical-reporter/emulsifiers

Emulsifers
http://www.foodadditivesworld.com/emulsifiers.html

Emulsifiers and Stabilizers
http://www.foodsciencecentral.com/fsc/ixid12464

Emulsifiers Reach Beyond the Interface
http://www.preparedfoods.com/articles/emulsifiers-reach-beyond-the-interface