# 11.Week:EMULSIFIERS

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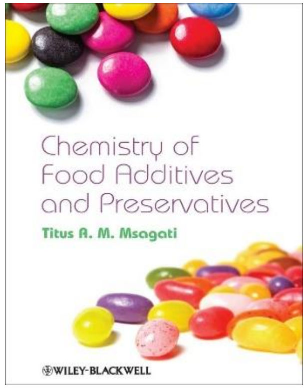

Chemistry of Food Additives and Preservatives
Titus A. M. Msagati
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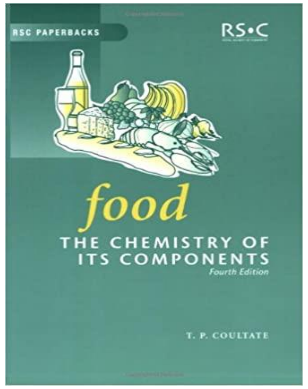

RSC PAPERBACKS
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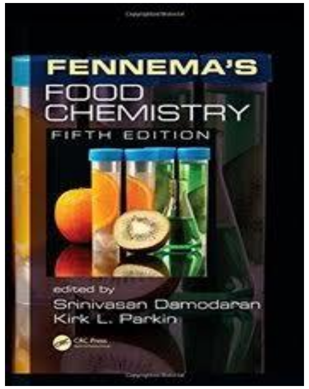

FENNEMA'S
FOOD CHEMISTRY
FIFTH EDITION
edited by
Srinivasan Damodaran
Kirk L. Parkin
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**2.** Coultate T. P. 2002. *FOOD: The Chemistry of Its Components*, RSC Paperbacks, Royal Society of Chemistry, Cambridge, UK.

**3.** Ekşi A., Tayfur M., Ercan A., Bağcı Bosi A. T., Kıvanç P., Soylu P., Berat Özdemir M. ve Şişik N. 2014. *A'dan Z'ye Gıda Katkı Maddeleri*, Detay Yayıncılık, Ankara.

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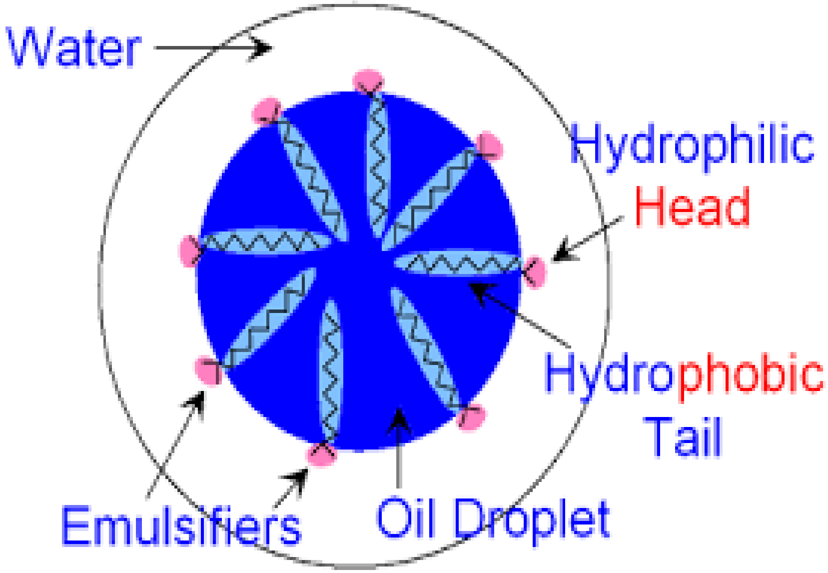
# EMULSIFIERS

In food industries, forming a homogeneous mixture of food components which are totally immiscible (such as oil and water) is a challenge. Food emulsifiers are chemical molecules characterised by the presence of a hydrophilic and a hydrophobic part. The hydrophobic component is made up of fatty acid, while the hydrophilic portion consists of either glycerol or one of its ester derivatives generated from the reaction with organic acids such as lactic, citric, acetic or tartaric acid. Examples of emulsion food products include mayonnaise, ice-cream and homogenised milk, which are composed of hydrophilic and hydrophobic substances.

**Emulsifier**, an amphiphilic substance, has usually a hydrophilic head and a hydrophobic tail. When emulsifier molecules are adsorbed to the interface, the head and the tail will point into the water and oil respectively, which will decrease the surface tension and increase stability of the disperse system.



**Source:** https://www.gcsescience.com/o77.htm

# MECHANISMS OF FOOD EMULSIFIERS

By definition, emulsions are heterogeneous colloid mixtures of small molecule droplets of one component suspended in another component immiscible to it.

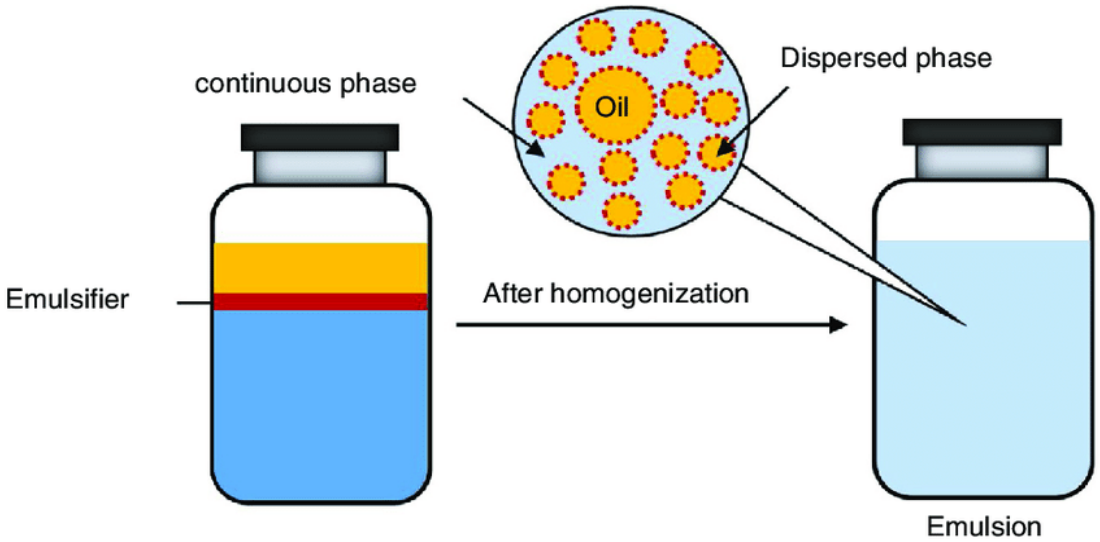
This is possible because the surface tension that exists between the immiscible components is reduced by the action of emulsifiers which enable the immiscible phases to form one stable homogeneous phase known as an emulsion. In the case of liquids, the term emulsion refers to the dispersion of two liquids that, under normal circumstances, are not miscible (e.g. oil and water). When mixed, an emulsion will form as tiny droplets of one phase dispersed into a continuous phase of another.

Among those emulsifiers used by the food industry are the monoglycerides, which are prepared using fats and oils as raw materials. Fats are made up of a hydrophilic backbone of triglyceride with three fatty acid molecules attached to it, making the whole molecule lipophilic in nature. When the triglyceride molecule is cleaved, the lipophilic nature of the tail of the fatty acids balances the hydrophilic properties of the glyceride head to stabilise the emulsion.

# THE ROLE OF EMULSIFIERS IN FOODS

The primary role of emulsifiers as food additives is to improve food palatability, maximise the volume and aeration of food items, reduce the stickiness, enhance food flavour, improve the textural properties of foods and impart foam stability. Apart from the role of assisting oil and water to remain in stable emulsions, a property useful in the preparation of many food products such as salad dressings, emulsifiers have many other roles that they play in the food industry. Their unique molecular structures enable them to perform a variety of other roles in the improvement of the quality of a wide variety of food products.

**1. Emulsification:** Emulsification (the process of maintaining the emulsions) is one of the primary roles of emulsifiers in foods. The choice of the emulsifier is largely dependent upon the type of food material which forms the dispersed phase and the continuous phase. For example, if oil is the continuous phase, the emulsifier must be more lipophilic; if it is an aqueous system such as water then a hydrophilic emulsifier will be the best choice for use.



*Source:* Biosurfactants—a new frontier for social and environmental safety: a mini review *Biotechnology Research and Innovation* (2018), https://doi.org/10.1016/j.biori.2018.09.001

**2. Starch complexing:** Another role of emulsifiers in food is that of starch complexing, which has a wide range of applications. Starch granules comprise a linear polymer polysaccharide of water-insoluble D-glucose sugar units known as amylose and another highly branched watersoluble glucose polymer molecule known as amylopectin. When starch is dispersed in water and heated the granules tend to absorb water and swell. They become gelatinised in the sense that the starch molecules attain a viscous state, forming a gel structure. When the product is cooled the starch molecules will tend to be closer to one another, squeezing the absorbed water out. This causes the starch to recrystallise in a process known as retrogradation. In products where retrogradation takes place (e.g. bread), emulsifiers are incorporated to retard this process and maintain the softness of the product.

**3. Foam stabilisation and aeration:** Food emulsifiers also play the important role of foam stabilisation and provide aeration in baked and dairy products by improving the mechanism by which air is incorporated and retained. Air is important in the process of baking to give the required texture; air sacks in the baking batter expand due to the carbon dioxide generated from the leavening of the baked products, resulting in the form and texture of baked products. Without this process, the products tend to harden.

In other products such as ice-cream, emulsifiers stabilise the foam by destabilising the emulsion of the product as well as the indigenous proteins present in ice-creams; the emulsion is then stabilised by employing hydrophobic binding interactions to the triglycerides on the surface of fat molecules. This mechanism prevents fat agglomeration and forms clusters which are important for creating foam; these clusters have the ability to coat the surface of air sacks, thereby stabilising them.

Another role of emulsifiers in food is that of interactions with gluten proteins in baked products. This interaction results in the formation of an elastic network which actually shapes the dough into a desired structure and prevents the possible loss of leavening gases, thus maintaining the volume of the final product.

# CLASSIFICATION OF EMULSIFIERS

Due to a diverse range of chemistries that exist within so many different types of food emulsifiers, it follows that the choice of appropriate emulsifier for a particular food product can be difficult. Emulsifiers can however be classified in many different ways to provide an indicator of performance. These classifications are based on the hydrophilic-lipophilic balance (HLB), the ionic charge and the crystal stability.

## 1. Hydrophilic-lipophilic balance

The hydrophilic-lipophilic balance (HLB) measurement is important in determining how effective an emulsifier will be in a particular medium, especially for simple foods. The HLB has values ranging from 0 to 20, indicative of the emulsifier’s oil or water affinity property. If an emulsifier exhibits a low HLB value, this indicates that it is strongly lipophilic; high HLB implies is it hydrophilic. In other words, if the continuous phase is formed of a high proportion of oil, the best emulsifier is one with lower value of HLB number. The converse is true in cases where water forms the continuous phase.

## 2. Ionic charge

Another criterion for the choice of an emulsifier for a particular food product is ionic charge. There are certain types of emulsifiers which can form anions when in aqueous media (e.g. stearoyl lactylates) as well as those which possess carboxylic acid functionality (e.g. diacetyl tartaric acid esters of monoglycerides).

## 3. Crystal stability

A number of emulsifiers also possess polymorphic properties which give them flexibility in that they can exist in different crystal forms such as alpha, beta, etc. Emulsifiers may crystallise in one form initially and then transform to another. Examples of emulsifiers with this type of transformation tendency include acetic and lactic acid esters, polyglycerol esters, propylene glycol esters and sorbitan esters.

# TYPES OF FOOD EMULSIFIERS

Food emulsifiers may be classified as one of two main groups: synthetic and naturally occurring.

## Synthetic

They are partial esters of either fatty acids or polyols and watersoluble organic acids, and therefore contain both hydrophilic and hydrophobic functionalities within the same molecule. ***The synthetic types of emulsifiers*** used in the food industry include

**low-molecular weight**

(glycerides: mono- and di-glycerides)

**high-molecular weight**

(polymeric: polysorbates, alginates, carrageenans, gums and gelatins)

## Naturally occurring

They have a hydrophilic polar head as well as a lipophilic portion of the molecule, and two fatty acid tails. The examples of these emulsifiers are

**lecithin, casein, mustard and cayenne pepper**

* lecithin can be modified to many other chemical patterns to perform different functions

# QUALITY AND ANALYSIS OF FOOD EMULSIFIERS

Emulsifiers have a vast number of applications in the food industry and are therefore subject to certain procedural performance checks. These restrictions mean that food products containing emulsifiers are monitored to ensure regulations are adhered to. For this reason, a number of analytical methods have been been developed and reported for the determination of emulsifying molecules such as mono-, di- and tri-glycerides.

*** Iodimetric titration** *** Peroxide value** *** Saponification value**

*** Hydroxyl value** *** Acid number** *** Iodine value** *** Chromatography**

# FOODS CONTAINING EMULSIFIERS

The food types in which emulsifiers are used include milk, cream, salad cream, mayonnaise, salad dressings, soups, sauces, butter, margarine, low-fat spreads, beverages, ice-cream and coffee whitener.

The aqueous phase of many of these foods contains biopolymers that either enhance viscosity or cause gelation. The appearance and rheological properties of an aqueous phase are determined by the nature of the interactions between the biopolymer molecules (hydrogen bonding, hydrophobic interactions, van der Waals forces, electrostatic interactions and disulphide bond formation), as well as the kinetics of the aggregation process.