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Food Emulsifiers—Science and Art

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ABSTRACT

General classifications of food emulsifiers are presented, and their functions are discussed. Examples of many food products are given, and recommended emulsifier usage levels are presented. Some of the food applications cited include: cakes, icings, toppings, bread, sweet goods, frozen desserts, coffee whiteners, peanut butter, margarine and confectionery coatings.

The marketing trend of food products has changed substantially over the last several years. Food companies are catering to the accepted principle of “less work for mother.” This has led to the growth of “convenience” and “instant” foods, resulting in a greater selection and variety for the consumer. Because many of these products are being processed in plants many hundreds of miles from final consumption, the requirements for processing, distribution and storage have resulted in the need for increased stability and longer shelf life. This has led to the use of specialized food ingredients and additives including emulsifiers.

The term emulsifier is often used interchangeably with surface active agent or surfactant. It is not necessary to discuss at length the theory of surfactant or emulsifier chemistry. Most emulsifiers are esters or modified esters formed by the combination of polyalcohols with edible fatty acids or fats. The old thinking is that the food emulsifier functions by affecting solubility and miscibility behavior at the surface between two immiscible fluids. Later in this paper it will be pointed out that these concepts have become more sophisticated and that the food emulsifier serves many additional functions.

Emulsifiers are usually made by either alcoholysis or direct esterification. In direct esterification, fatty acids and polyalcohols are reacted together under controlled conditions to form esters. In alcoholysis, fats are reacted with polyalcohols to make analogous products. For example, the process is called glycerolysis when a shortening is reacted with glycerine to form mono- and diglycerides.

There are a limited number of natural emulsifiers which are used in foods. Lecithin is a good example. Often the natural emulsifier may be modified, e.g., hydroxylated lecithin, to change its properties. This paper will be devoted mostly to applications of synthetic emulsifiers. Listed below are the emulsifiers most often used in foods.

Types of Food Emulsifiers
1) Mono- and diglycerides
   a) Glycerol esters
   b) Distilled glycerol esters
2) Propylene glycol esters
3) Sorbitan esters
4) Polyoxyethylene sorbitan esters
Mono- and diglycerides are the most commonly used of the food emulsifiers. These consist of glycerol esters of various edible fatty acids and fat blends. Three types are usually manufactured: 40-45% alpha mono content, 50-56% alpha mono content and the distilled monoglycerides with 90% alpha mono content. Mono- and diglycerides are used in a great number of food products with strong emphasis in bakery products such as bread, cake, cake mixes and also frozen desserts. There are three physical forms of the mono- and diglycerides: “hard, soft and liquid.”

Distilled monoglycerides are usually blended with mono- and diglycerides or fats in order to improve their dispersing properties. The mono- and diglycerides are on the GRAS list. The levels of use are limited to application requirements and to Standards of Identity where they apply.

The propylene glycol esters are usually offered as propylene glycol monostearate (PGMS) and propylene glycol monopalmitate (PGMP). They are most often used in cakes, cake mixes, whipped toppings and bread. The mixed propylene glycol esters are made by alcoholysis. Selected fats are reacted with propylene glycol; these are mostly used in cakes. The propylene glycol esters are approved for use in foods by the Food Additive Regulations at “levels required to produce their intended effect.”

Sorbitan esters are made by reacting sorbitol with fatty acids. At present, sorbitan monostearate is the only one of this group that has been approved for food use at limited levels. It is most often used in combination with the polysorbates in cakes, cake mixes, whipped toppings, cake icings, fillings, confectionery coatings and coffee whiteners. The polyoxyethylene sorbitan esters are reaction products of 20 moles of ethylene oxide with mono- and diglycerides. Whereas sorbitan monostearate is the only sorbitan ester approved for food use, the polyoxyethylene derivatives of sorbitan monostearate (Polysorbate 60), sorbitan tristearate (Polysorbate 80) are approved for food use at limited levels. Polysorbate 60 is most often used in cakes, prepared dry mixes, whipped toppings, icings, bread and yeast-raised products and coffee whiteners. Polysorbate 65 is used in frozen desserts, whipped toppings, coffee whiteners, cakes and cake mixes. Polysorbate 80 is most often used in frozen desserts, nonstandardized baked goods, prepared mixes, icings, fillings, toppings and very often as a solubilizing agent for flavors.

The polyglycerol esters are reaction products of polymerized glycerine and edible fatty acids or fats. Polyglycerol esters of fatty acids, up to and including the decaglycerol esters, may be safely used in foods at levels required to produce the intended effect. These represent a unique and diversified class of food emulsifiers. They are being used in whipped toppings, coffee whiteners, cakes, cake mixes, confectionery coatings and powdered desserts. The ethoxylated esters are a group of emulsifiers, the use of which has grown in the last several years. Ethoxylated mono- and diglycerides are reaction products of 20 moles of ethylene oxide with mono- and diglycerides. They are used as dough conditioners in yeast-raised baked products in an amount not to exceed 0.5% by weight of the flour used. The ethoxylated fatty acids, such as polyoxyethylene (20) monostearate, are very versatile and interesting materials, but unfortunately have not been approved for food use.

There are several forms of lactated esters used in foods. Calcium and sodium stearyl lactate have been approved for use as a dough conditioner in yeast-raised baked products. They are also used in whipped toppings, starch puddings, coffee whiteners and cake icings. Glycerol lacto palmitate (GLP) and glycerol lacto stearate (GLS) are reaction products of glycerine, lactic acid and fatty acids. They are most often used in cakes, cake mixes and whipped toppings.

Lecithin is most often used in chocolate and confectionery coatings, whipped toppings, coffee whiteners and bakery products. Hydroxylated lecithin is often used in cakes, cake mixes, bread and yeast-raised doughs.

There are a number of miscellaneous esters in use, such as: acetylated tarrated monoglycerides, acetylated monoglycerides, succinylated monoglycerides and sodium stearly fumarate.

Emulsifiers perform one or more functions in a specific system. In many cases it is necessary to combine two or more emulsifiers to accomplish the desired effect. Often an emulsifier may perform one function at one level and a completely opposite function at another level. For example, Polysorbate 80 at 0.03-0.1% will act as an aerating agent, but at 0.005% will act as a defoamer. Emulsifiers perform in the manners as outlined in Table I.

In many cases it becomes necessary to combine the functions of two or more emulsifiers in order to obtain the desired effect in the food. As stated before, there is a definite optimum level of use for most emulsifiers. Low levels may not accomplish the functions desired, and high levels may destroy the system completely. This is further complicated by the fact that it becomes necessary to obtain the optimum blends of specific emulsifiers.

Based on these observations it is our feeling that the hydrophylic-lipophilic balance (HLB) system used for the selection of emulsifiers has limited value. This system is useful in the selection of emulsifiers for water-oil emulsions such as margarine or salad dressings, but has limited value in the more sophisticated foods that are currently being developed. For these reasons the selection of an emulsifier becomes an “art.” In other words, the scientific method is applied to previous experience. In new applications it is suggested that analogous or similar food emulsifier systems be used as the starting point. For example, the emulsifier system used in frozen desserts such as ice cream and ice milk has been modified into a suitable system for whipped toppings.

Listed below are some of the influencing factors in the selection of a food emulsifier system.

Influencing Factors in Selection of Food Emulsifier System

1) Functional requirements of food product
2) Method of processing
   a) Homogenizing equipment used, if any
   b) Pasteurizing or sterilizing equipment
   c) Whipping and aeration equipment
3) Finished product form, e.g., liquid, powder, etc.
4) Consumer preparation technique
5) Storage requirements
6) Flavor
7) Formulation—effect of other ingredients
8) Cost
9) Legal aspects

It is important to clearly spell out the properties of the new food product being developed. The processing technique will also govern the final selection. The type of homogenizing and heating equipment available must also be taken into consideration.