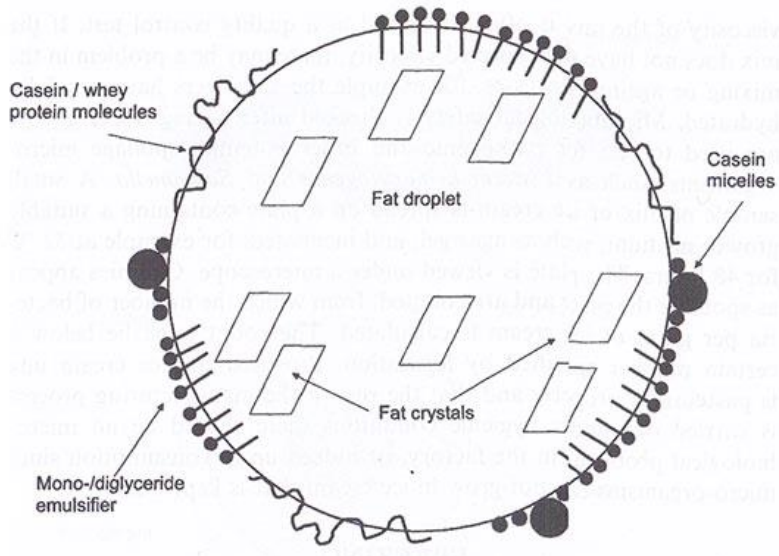


# Roll of Emulsifier in ice cream preparation

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# Emulsifiers

- Emulsifier are surface active agents known to improve the sensory quality of ice cream by aiding the whipping process, improving air cell distribution and enhancing the products heat shock resistance.
- They also impart a dry appearance and stiffness or ‘stand up’ property to the product being extruded from the freezer.
- These effects are brought about by the interfacial properties of emulsifiers. Their ability to reduce surface tension seems to promote development of smaller but numerous air cells.
- The primary effect of emulsifiers in ice cream is related to their ability to de-emulsify the fat globule membrane formed during homogenization.

- This de-emulsification arising from the disruption of the fat globule membranes during freezing, facilitates the agglomeration and coalescence of fat globules, leading to partial churning out of the fat phase.
- The agglomerated fat globules stabilize air cells. Thus, emulsifiers are used to improve the whipping qualities of ice cream by producing smaller ice crystals and smaller air cells, resulting in a smoother ice cream texture and drier, stiffer ice cream.
- Generally, a mixture of high and low hydrophile-lipophile balance (HLB) emulsifiers, such as mono- and diglycerides and polysorbate 80 are used.
- HLB concept was put forth by Griffin in the year 1949. HLB number ranges from 0 to 20. The HLB number is derived by calculating the proportion of the molecular weight of the emulsifier molecule represented by the hydrophilic portion and dividing that value by 5.

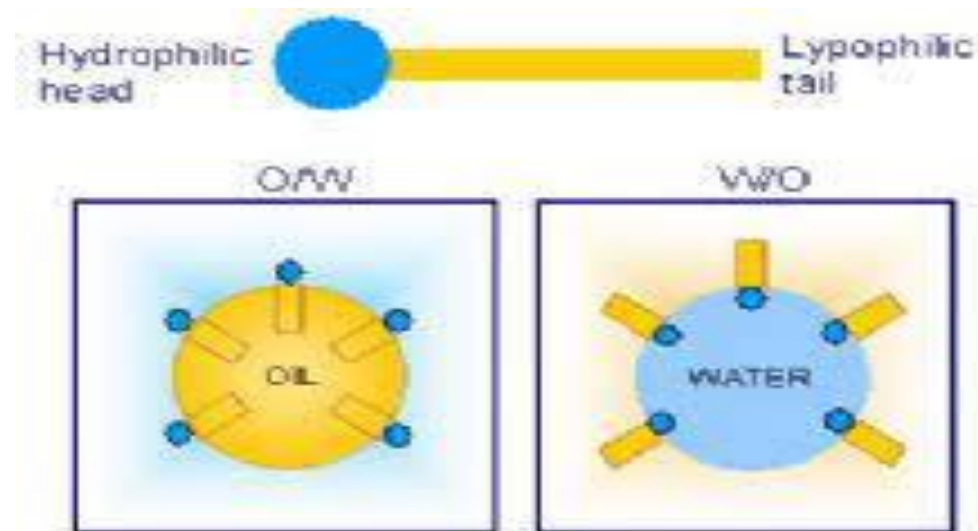
Emulsifiers can be classified as

### 1. Hydrophobic :

Examples- Sorbitan esters, Mono- and di-glycerides of fatty acids, Polyglycerol polyricinoleate, Highly substituted sugars, Poly-glycerol esters, and Propylene glycol esters.

### 2. Hydrophilic:

Examples- Ethoxylated sorbitan esters, Monoglyceride derivatives such as lactates, tartarates, citrates, Low-substituted polyglycerol esters, and Monosubstituted sugar esters



# Role of emulsifiers in ice cream:

Emulsifiers are used to:

- Promote nucleation of fat during aging thus reducing aging time
- Improve the whipping ability of the mix due to their function at the air interface resulting in reduced air cell sizes and homogenous distribution of air in the ice cream.
- Produce a dry and stiff ice cream as they enhance fat destabilization, facilitating molding, fancy extrusion and sandwich manufacture.
- Increase resistance to shrinkage and rapid melt down
- Increase resistance to the development of coarse/icy texture, due to the effect of fat agglomerates, more numerous air bubbles, and thinner lamellae between adjacent air bubbles on the size and growth of ice crystals.
- Provide smooth texture in the finished product, due to fat structuring and interaction of fat agglomerates within the mouth during consumption.

# Properties of individual emulsifiers

## a) Mono-/diglycerides

- The most commonly used emulsifiers in ice cream manufacture are mono-/diglycerides (E471).
- Mono-/diglycerides are mixtures of monoglycerides and diglycerides.
- Mono- and diglycerides are surface active because the glycerol end of the molecule is hydrophilic and the fatty acid end is hydrophobic.
- Mono-/diglycerides are made by partially hydrolysing vegetable fats, such as soybean oil and palm oil.
- They normally contain 40-60% monoglyceride, together with diglyceride, and a small amount of triglyceride.
- Fully saturated mono-/diglycerides that contain predominantly stearic and palmitic acids, such as glycerol monostearate, are often used for ice cream production and typically make up about 0.3% of the ice cream mix.
- Materials with high monoglyceride content ( $> 90\%$ ) are difficult to disperse because they can become extremely viscous and form a gel in aqueous systems.
- However, this may be helpful in the manufacture of very low fat ice cream.



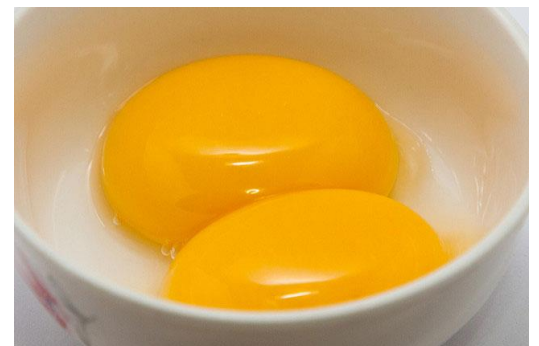
## b) Sorbitan esters

- ❑ The sorbitan esters are similar to monoglycerides in that the sorbitan esters have a fatty acid molecule such as stearate or oleate attached to a sorbitol (glucose alcohol) molecule, whereas the mono glycerides have a fatty acid molecule attached to a glycerol molecule.
- ❑ To make the sorbitan esters water soluble polyoxyethylene groups are attached to the sorbitol molecule.
- ❑ **Polysorbate 80** is a very active drying agent in the ice cream and is used in many commercial stabilizer/emulsifier blends. Although it is normally a component of stabilizer/ emulsifier blend, it can be added in pure form directly to mix flavour tank post homogenization and will become effective at enhancing dryness within a few minutes. Polysorbate 80 can be used as an ice cream emulsifier, typically at concentrations of 0.1-0.2%.



### c) Egg Yolk

- ❑ Egg yolk, which contains several components with emulsifying properties, notably **lecithin**, is often used in ‘all-natural’, premium or homemade ice creams.
- ❑ Egg yolk has the approximate composition (by weight) of 50% water, 16% protein, 9% lecithin, 23% other fat, 0.3% carbohydrate and 1.7% minerals.
- ❑ Lecithin consists of phosphatides and phospholipids. Egg yolk is usually used in ice cream manufacture either as pasteurized fresh egg yolk, frozen sugared pasteurized egg yolk (which has about 10% sucrose added to protect it from damage during freezing) or as dehydrated egg yolk. Egg yolk solids are normally used at about 0.5- 3%. High concentrations are only used for super-premium products, and can give the ice cream an eggy flavour.





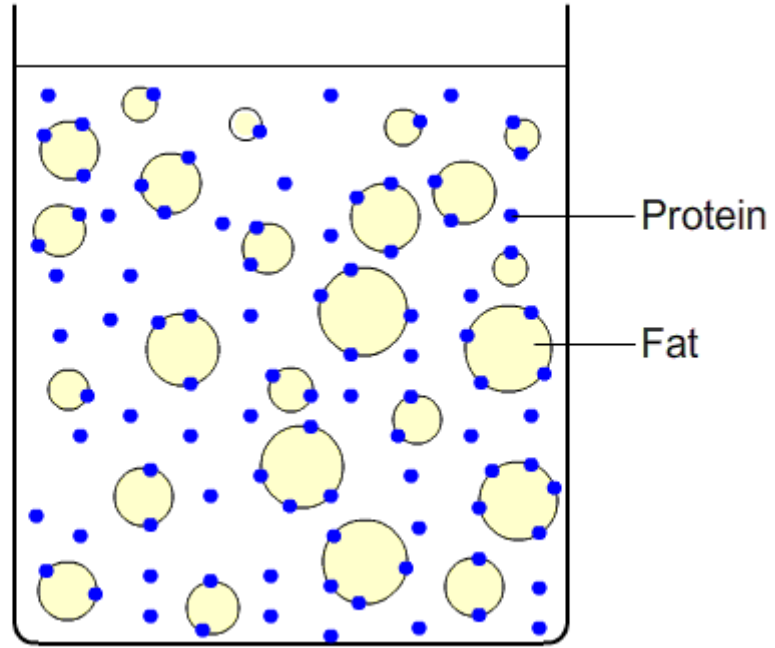
# Selection of emulsifier:

The following criteria are used in choosing an emulsifier

- Fat percentage of mix
- Type of frozen dessert
- Effect on flavour of product
- Cost
- Composition of fat in mix
- Compatibility with stabilizer used
- Type of freezer used
- Method of processing – homogenization
- Formulation – effect of other ingredients
- Legal standards

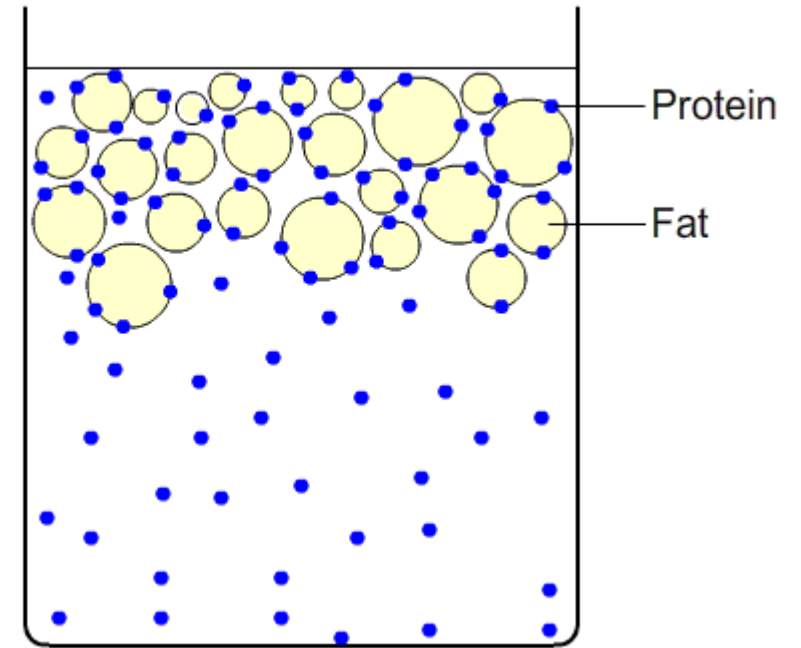
Need of addition of Emulsifier

1



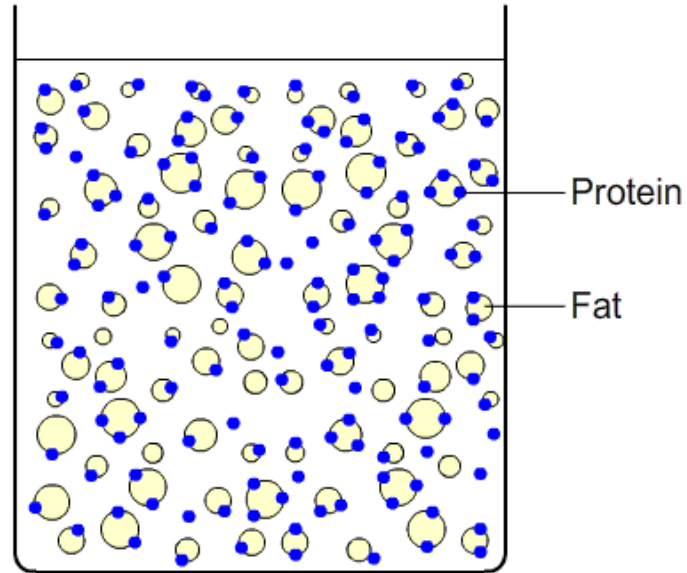
Un-homogenized milk

2



Separated milk

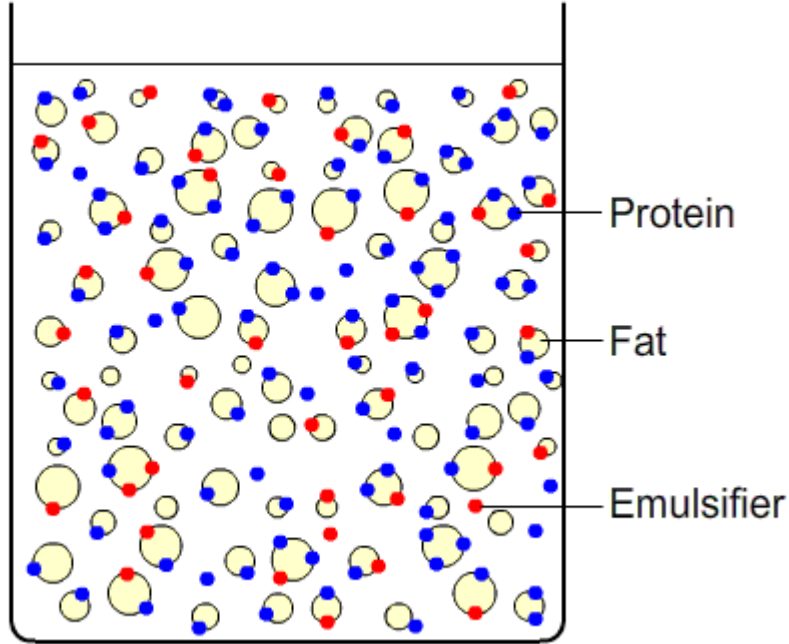
3



Homogenized milk

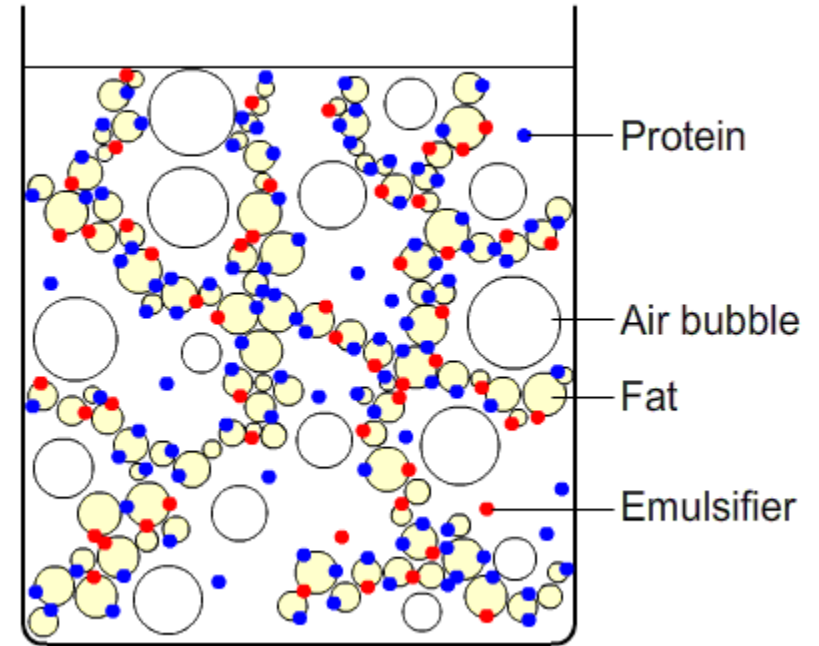
- This homogenized milk is a *stable* emulsion in which the fat globules are very small and prevented from clumping together by the proteins that anchor them in the water.
- But to make ice cream with that milk, we need to *de-stabilize* the emulsion, so that the fat globules *do* clump together to form the scaffolding that supports the air bubbles in the ice cream.
- The motion of the dasher alone is not enough to de-stabilize the emulsion. There's just not enough fat in an average ice cream mixture for it to be de-stabilized by just agitation.
- And this is where the emulsifiers come in. So, we add emulsifiers to the ice cream mixture to de-stabilize (or de-emulsify) the fat emulsion in the milk.
- We already know that in homogenized milk, the emulsion is stabilized by protein molecules that attach themselves to the surface of the fat globules and prevent them from clustering together.
- So to encourage "partial coalescence" in which the fat globules *do* clump together, we need to remove those protein molecules. And this is the job of the emulsifiers.

1



Ice cream mix with emulsifiers

2



Air bubbles trapped in partially coalesced mixture

So in this way, they de-stabilize the emulsion. And later on, when the motion of the dasher starts to cause those fat globules to collide, they're much more likely to separate from the water and start clumping together to support the air bubbles!

# Mechanism of action of emulsifier

- The two phase emulsion is stabilized by casein micelles adsorbed at the fat globule serum interface in the homogenized ice cream mix. But when an emulsifier such as a monoglyceride is used, the fat globules are covered with an emulsifier layer and the milk proteins form an outer layer.
- Monoglycerides effectively compete with protein if they form crystals at the interface. Hence, the outer protein layer tends to be repelled from the fat globules. As a result, the emulsion is prone to destabilization by mechanical action during freezing. This destabilizing effect, in conjunction with other processing factors, is considered to be primarily responsible for development of the desired product structure.
- The dry appearance of ice cream coming out of the freezer is believed to be caused by several phenomena, one of which is an emulsifier induced clustering of fat globules at the liquid air interface. Also, more air cells of smaller size foaming on account of presence of emulsifiers appear to provide more surfaces with the available liquid, which implies that the liquid is spread over a larger area.

- The de-emulsification effect of emulsifiers is related not only to the quantity of emulsifiers used but also to the fat content of the product. With increasing emulsifier concentration, fat de-emulsification is enhanced and beyond a certain limit, greasy texture and short body result due to butter formation in the freezer.
- Higher fat levels magnify this de-emulsification phenomenon. Thus, an emulsifier level just enough to provide the correct amount of ‘partial churning’ is necessary, and less emulsifier is required in a high-fat ice cream than in a low fat one.
- Excessive emulsifier may promote slow melting and curdy meltdown.

# Effect of emulsifier on mix and ice cream

## 1) Effect of type of an emulsifier

- Different emulsifiers differ structurally, and so their action in ice cream differs, too. Therefore, the quantity of emulsifier required varies with the type of emulsifier used.
- Mono- and diglycerides are often used in combination, although the former is more effective. When unsaturated fatty acids such as oleic acid are present in the molecule, these emulsifiers promote better dryness at drawing from the freezer.
- The fat destabilization responsible for stiffness of the frozen mix is in the decreasing order for mono laurate > mono oleate > mono stearate in that sequence used at 0.1-0.2%, mono and diglycerides are less likely to cause churning.
- However, their drying and whipping ability is somewhat limited as compared to polysorbates which are water soluble components of sorbitol.



- Tween 80 or polysorbate 80 (polyoxyethylene sorbitan monooleate) has a high drying power and aids in heat shock resistance, but the unsaturated fatty acid may undergo auto oxidation to develop an off flavour, particularly when a certain level is exceeded.
- Used usually at 0.02 to 0.06%, Tween 80 in excess may cause churning especially in soft serve and high fat ice creams.
- Tween 65 (polyoxyethylene sorbitan tristearate) has a little lower drying power as compared to Tween 80 but has excellent whipping properties. Because of its flavour stability, Tween 65 can be used at higher levels (e.g. 0.1%) without any adverse effect on the products flavour.
- The fat destabilizing ability of different polysorbates is in the order

Tween 80 > Tween 40 (polyoxyethylene sorbitan monopalmitate) > Tween 60 (polyoxyethylene monostearate) > Tween 65.

## **2) Mix processing in relation to emulsifier action**

- It is necessary that for an emulsifier to be effective in ice cream mix, the ice cream mix has to be homogenized.
- While milk protein, casein in particular helps achieve size reduction of fat globules by homogenization, presence of emulsifiers promote greater size uniformity as, for example, mix containing a monoglyceride displays upon homogenization, a very narrow band of size distribution (about 1 $\mu$ ) as compared to mix without monoglyceride (1-5  $\mu$ ).
- The greatly decreased fat globule size coupled with controlled de-emulsification caused by emulsifiers develops the right kind of structure and corresponding texture in ice cream.

- During ageing of ice cream mix, milk fat crystallizes, much of crystallization taking place during the first hour. Presence of emulsifiers leads to more extensive fat crystallization. The emulsifier caused protein desorption from fat globules is time dependent and takes place during ageing.
- Further, the initial desorption from the surface of the fat globules, in the presence of emulsifiers, occurs as the removal of a coherent protein layer rather than individual casein particles. The process of de-emulsification continues into the freezer to yield the desired body and texture.

# Conclusion

- Stabilizers and emulsifiers are important ingredients in ice cream and they contribute to a great extent to the desired body and texture characteristics of ice cream and other frozen desserts.
- Generally a mixture of two or more emulsifiers/stabilizers is preferred to overcome drawbacks of individual compounds.
- Most of the commercial preparations are blends of emulsifiers and stabilizers which not only provide the convenience of use, but also make it possible to integrate stabilizers in a continuous emulsifier phase thereby facilitating dispersion of the stabilizer.
- The ice cream industry in India is growing at a commendable rate so the demand of good quality stabilizers and emulsifiers is bound to go up. Intensive research is required to produce stabilizer emulsifier formulations to suit varying needs of the ice cream manufacturer.