Paper No.: 13

Paper Title: FOOD ADDITIVES

Module – 11: Emulsifiers for the food industry

11.1 Introduction

Emulsifiers are additives that allow normally immiscible liquids, such as oil and water, to form a stable mixture.

An emulsion is a blend of two immiscible liquids, with droplets of one phase (dispersed phase) distributed in the other phase (continuous phase). In general these are unstable systems in which the dispersed phase droplets tend to agglomerate or coalescence and separate out. The boundary between the two phases is called the interface.

Emulsifiers contain both hydrophilic and lipophilic parts. The hydrophilic head is easy to hydrate (water soluble) and the lipophilic tail is impossible or very difficult to hydrate (oil soluble). Emulsifiers concentrate at the interface between oil and water and reduce the surface or interfacial tension, thereby making the emulsion more stable (Figure: 11.1). In many industries emulsifiers are referred to as "surfactants", which is an abbreviation of surface active agents.

[Refer: Story Board]

Figure: 11.1 Working of Emulsifier

In commercial food emulsifiers the hydrophilic part can consist of glycerol, sorbitol, sucrose, propylene glycol or polyglycerol. The lipophilic part is formed by fatty acids derived from fats and oils such as soybean oil, rapeseed oil, coconut oil and palm kernel oils.

The stability of an emulsion depends on:

- Droplet size: a smaller droplet size facilitates emulsion stability. The droplet size can be influenced by homogenization.
- Viscosity of continuous phase: a higher viscosity facilitates emulsion stability. The viscosity of the water phase can be influenced by the addition of hydrocolloids or thickening agents.
- Specific density of the two phases: if the difference in density between the two phases is small, the emulsion will be more stable. For essential oils in beverages weighting agents can be used to increase the density of the essential oil.
- Quality of the interfacial film: the film can consist of emulsifiers and / or proteins.

11.2 HLB: Hydrophilic Lipophilic Balance Concept

Emulsifiers can be characterized by the Hydrophilic Lipophilic Balance. The balance is measured on molecular weight and is an indication of the solubility of the emulsifier. The HLB scale varies between 0 and 20.

An emulsifier with a low HLB value is more soluble in oil and promotes water-in-oil emulsions. An emulsifier with a high HLB value is more soluble in water and promotes oil-in-water emulsions.

The HLB value is a somewhat theoretical value, it only considers water and oil, and food systems are more complicated. But the HLB value of an emulsifier can be used as an indication about its possible use.

11.3 Emulsifiers used in the food processing industry

Following emulsifiers are generally used in the food processing industry

E number	Short name	Long name
E 322	Lecithins	Lecithins
E 432 – 436	Polysorbates	Polyoxyethylene sorbitan esters
E 471	MDG / Monoglycerides	Mono- and diglycerides of fatty acids
E 472 a	ACETEM	Acetic acid esters of MDG
E 472 b	LACTEM	Lactic acid esters of MDG
E 472 c	CITREM	Citric acid esters of MDG

E 472 e	DATEM	Diacetyl tartaric acid esters of MDG
E 473	Sucrose esters	Sucrose esters of fatty acids
E 475	Polyglycerol esters	Polyglycerol esters of fatty acids
E 476	PGPR	Polyglycerol polyricinoleate
E 477	Propylene glycol esters	Propane-1,2-diol esters of fatty acids
E 481	SSL	Sodium stearoyl-2-lactylate
E 482	CSL	Calcium stearoyl-2-lactylate
E 491 – 495		Sorbitan fatty acid esters

11.4 Functions of emulsifiers:

- Formation of emulsion: Reduction of surface as interfacial tension at the surface or interface, which promotes mixing of two immiscible liquids. (Emulsification)
- Stabilization of emulsion: Formation of phase equilibrium between water-emulsifier-oil at the interface which stabilizes the emulsion.
- Modification of textural and rheological properties of foods: By interaction with starch and protein components in foods.
- Modification of the crystallization of fats and oils.
- Other: aeration, agglomeration, antisplattering, coating, creaming, crumb softening, dough strengthening, extrusion aid, fat distribution , fat sparing, foam stabilizing, foam stiffing, increase hat stability, moisture retention, plasticity, decrease stickiness, release, viscosity increase or decrease.

In addition to their major function of producing and stabilizing emulsions, food emulsifiers (or surfactants) contribute to numerous other functional roles. Table 11.1 is a list of functional properties of food emulsifiers compiled from a variety of sources.

Table 11.1 Functional Properties of Food Emulsifiers

Functions	Product examples
Emulsification, water-in-oil emulsions	Margarine
Emulsification, oil-in-water emulsions	Mayonaise
Aeration	Whipped toppings
Whippability	Whipped toppings
Inhibition of fat crystallization	Candy
Softening	Candy
Antistaling	Bread
Dough conditioner	Bread dough
Improve loaf volume	Bread
Reduce shortening requirements	Bread
Pan-release agent	Yeast-leavened and other dough and batter products
Fat stabilizer	Food oils
Antispattering agent	Margarine and frying oils
Antisticking agent	Caramel candy
Protective coating	Fresh fruits and vegetables
Surfactant	Molasses
Control viscosity	Molten chocolate
Improved solubility	Instant drinks
Starch complexation	Instant potatoes
Humectant	Cake icings
Plasticizer	Cake icings
Defoaming agent	Sugar production
Stabilization of flavor oils	Flavour emulsions
Promotion of ‘‘dryness’’	Ice cream
Freeze–thaw stability	Whipped toppings
Improve wetting ability	Instant soups
Inhibition of sugar crystallization	Panned coatings

11.5 Emulsifier Selection Criteria

Several parameters should be considered during emulsifier selection. These parameters include

- Approval of the emulsifier by the appropriate government agency
- Desired functional properties
- End product application
- Processing parameters
- Synergistic effect of other ingredients
- Cost

11.6 Desirable Characteristics of Food Emulsifiers

- Ability to reduce surface or interfacial tension.
- Ability to be readily absorbed at the interface.
- Possessing the proper balance at hydrophilic and lipophilic parts (groups), so that desirable type of emulsion (O/W or W/O) can be stabilized.
- Ability to impact a large electro kinetic potential to dispersed phase (droplets)
- Ability to function effectively at low concentration.
- Resistance to chemical changes.
- Lack of odour, colour, etc.
- Safe non toxic.

11.7 Application of Emulsifier

It should be noted that in many food applications combination of emulsifiers are used to achieve the optimal performance.

11.6.1 Bakery

Application	Emulsifier	Benefits
Cake, Bread	MDG	Reacts with starch to delay retrogradation resulting in an improved softness of the crumb and extended shelf life.
Bread	DATEM Lecithin	Strengthens the gluten, resulting in improved dough stability and improved gas retention. The final product shows a higher volume and a good crumb structure.
Cake, Bread	CSL SSL	Provide starch as well as gluten interaction.
Cake	LACTEM ACETEM Polyglycerol esters Polypropylene glycol esters Sucrose esters	Facilitate whipping of the batter and enhance volume as well as texture. The final choice of (combination of) emulsifier depends on the type of cake and the preparation method.
Fillings	LACTEM ACETEM Polyglycerol esters Polypropylene glycol esters Sucrose esters	No fat, low fat and fat fillings, aerated or not aerated fillings use emulsifiers to achieve the right texture and stability. Depending on the type of filling and the required functionality, the optimal (combination of) emulsifier needs to be selected.
Icings, fondants, fillings	Sucrose esters	Controlled sugar crystallisation resulting in small sugar crystals with a long shelf life and a whiter appearance.

11.7.2 Confectionary

Application	Emulsifier	Benefits
Soft candy Chewy candy	Sucrose esters	Controlled sugar crystallisation resulting in small sugar crystals with a long shelf life and an improved texture.

Chocolate	Lecithins PGPR	Viscosity reduction and control in chocolate and reduction of fat bloom. The combination of PGPR and lecithin makes cocoa butter reduction possible while maintaining optimal viscosity and fluidity.
Chewing gum	Lecithins ACETEM	Softening of the gum base, improved chew-ability and anti-sticking.

11.7.3 Convenience food

Application	**Emulsifier**	**Benefits**
Emulsified cooking sauces	Several	Stabilise the O/W emulsion
Salad dressings Mayonaise	Several	Stabilise the O/W emulsion

11.7.4 Dairy Products

Application	**Emulsifier**	**Benefits**
Icecream	MDG	Icecream is a multiphase system. MDG acts on each interface providing stabilisation, improved extrusion, improved heat shock and controlled overrun. MDG is the main used emulsifier in icecream, the MDG is often combined with other emulsifiers as used in the other whipped products.
(Whipped) toppings and cream	LACTEM ACETEM Polyglycerol esters Polypropylene glycol esters Sucrose esters	Emulsion stabilisation, controlled overrun and volume, influence texture.

Whipped dairy desserts	LACTEM ACETEM Polyglycerol esters Polypropylene glycol esters Sucrose esters	Emulsion stabilisation, controlled overrun and volume, improved texture and mouthfeel. LACTEM is preferred in RTE dessert, ACETEM is preferred in instant products.
Aereated products	Several	Powders consisting of emulsifier combinations, vegetable oils and proteins on carbohydrate carrier. The emulsifiers within the concentrates are in the functional state so will be fully effective in any preparation method.
Coffee whiteners	MDG Sorbitanesters Polysorbates Sucrose esters	Different emulsifiers are used to stabilise the emulsion and prevent oil out. Sucrose esters protect proteins in acid products such as coffee, thus prevent feathering of coffee whiteners and creamers.
UHT products	Sucrose esters	Sucrose esters interact with dairy proteins resulting in less sensitivity for heat and prevention of fouling of UHT equipment.

11.7.5 Fats & Oils

Application	**Emulsifier**	**Benefits**
Margarine and spreads	MDG	Emulsification and crystal modification in all types of margarines and spreads. In general MDG is the main emulsifier used and will be combined with other emulsifiers for additional functionalities.
Cooking margarine	CITREM Lecithin	Anti-spatttering in cooking margarines.
Reduced fat	PGPR	Supports emulsification especially in low fat

margarine and spreads		(40%) and very low fat (<30%) spreads.
Industrial margarine	Polyglycerol esters	Improve plasticity in industrial margarine. Helps to create a dry surface in puff pastry margarine.
Industrial margarine	Polyglycerol esters PGPR	Providing aeration by control of crystallisation in industrial margarines for cake preparation.

11.7.6 Meat processing

Application	**Emulsifier**	**Benefits**
Emulsified meat products	CITREM	Emulsification in emulsified sausages and pates, resulting in a better fat distribution and reduced fat separation.
Meat Casing	ACETEM	Film forming properties which can be applied in meat casings.

11.7.7 Other Applications

Application	**Emulsifier**	**Benefits**
Release or demolding agents	ACETEM Lecithin PGPR	Release agent in demolding agents and lubricant for food processing equipment
Dry powders	Lecithin	Excellent wetting agent to improve dispersability of powders
Beverage base	Polysorbates	Stabilisation of flavour emulsions
Extruded products	several	Lubrication in extruded starch based products such as pasta and noodles
Canned coffee	Sucrose esters	Anti microbial properties, preventing spores development in canned coffee drinks.

11.8 Conclusion

Food emulsifiers have versatile application in food industry. Food emulsifiers exert several technical effects and can be useful tools to address new product trends. Some trends that may impact on demands for new and modified emulsifier compositions and applications.