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Emulsifiers and stabilizers in dairy products: Functions, applications regulatory aspects

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Abstract
The dairy industry continuously strives to improve product quality, stability, texture, sensory attributes, and shelf life while meeting evolving consumer expectations and regulatory requirements. Emulsifiers and stabilizers are among the most important functional additives used in dairy products to achieve these objectives. Emulsifiers are amphiphilic compounds that reduce interfacial tension between immiscible phases, particularly fat and water, thereby facilitating the formation and maintenance of stable emulsions. Stabilizers, primarily hydrocolloids and proteins, enhance viscosity, improve water-holding capacity, control phase separation, and maintain product consistency during processing and storage. Their combined application plays a crucial role in the manufacture of a wide range of dairy products, including milk beverages, flavored milk, yogurt, fermented dairy products, ice cream, frozen desserts, cream, whipped cream, butter, margarine, and processed cheese.
This review provides a comprehensive overview of the principles, mechanisms, classification, and functional properties of emulsifiers and stabilizers used in dairy systems. The article discusses commonly employed emulsifiers such as lecithin, mono- and diglycerides, polysorbates, and milk proteins, as well as stabilizers including carrageenan, pectin, gelatin, guar gum, locust bean gum, xanthan gum, alginates, and modified starches. Product-specific applications, mechanisms of action, synergistic interactions, and effects on texture, stability, mouthfeel, and shelf life are critically examined. Furthermore, the review highlights current regulatory frameworks governing the use of these additives and addresses emerging trends such as clean-label ingredients, natural hydrocolloids, plant-derived emulsifiers, protein-polysaccharide complexes, nano emulsions, and sustainable dairy formulations. Understanding the role and functionality of emulsifiers and stabilizers is essential for the development of innovative, high-quality dairy products that meet consumer demands for safety, functionality, and superior sensory characteristics.

Keywords: Dairy products, emulsifiers, stabilizers, hydrocolloids, ice cream, yogurt, processed cheese, food additives, texture modification, shelf-life enhancement introduction

Introduction
The dairy industry is one of the most dynamic sectors of the global food market, providing a wide variety of products that contribute significantly to human nutrition and health. Milk and dairy products are important sources of high-quality proteins, essential fatty acids, vitamins, minerals, and bioactive compounds. Modern consumers increasingly demand dairy products with superior texture, appearance, convenience, extended shelf life, and enhanced sensory characteristics. To meet these expectations, manufacturers employ various processing technologies and functional ingredients that improve product stability and quality while maintaining safety and nutritional value.
Among these functional ingredients, emulsifiers and stabilizers play a central role in dairy product formulation. Dairy products are complex colloidal systems containing water, fat, proteins, carbohydrates, minerals, and air cells in varying proportions. The inherent incompatibility between fat and water phases, combined with the susceptibility of proteins and other components to physical and chemical changes during processing and storage, creates significant formulation challenges. Common defects such as fat separation, creaming, sedimentation, syneresis, ice crystal growth, shrinkage, graininess, and texture deterioration can negatively affect product quality and consumer acceptance.

Emulsifiers are surface-active compounds characterized by their amphiphilic structure, possessing both hydrophilic and lipophilic regions. This unique molecular arrangement enables them to adsorb at oil-water interfaces, reduce interfacial tension, and stabilize dispersed systems. In dairy applications, emulsifiers contribute to the formation and maintenance of stable emulsions, improve fat dispersion, enhance whipping properties, facilitate air incorporation, and improve texture and mouthfeel. Common emulsifiers used in dairy products include lecithin, mono- and diglycerides, polysorbates, sorbitan esters, and naturally occurring milk proteins such as casein and whey proteins.

Stabilizers, in contrast, primarily function by increasing viscosity, binding water, strengthening structural networks, and controlling the mobility of dispersed phases within dairy systems. Most stabilizers used in dairy products belong to the hydrocolloid family and include substances such as carrageenan, pectin, guar gum, locust bean gum, xanthan gum, alginates, gelatin, and modified starches. These compounds contribute significantly to water retention, prevention of phase separation, improvement of texture, and enhancement of product stability during storage and distribution.

The importance of emulsifiers and stabilizers is particularly evident in products such as ice cream, yogurt, flavored milk, processed cheese, whipped cream, and dairy desserts. In ice cream, emulsifiers promote controlled fat destabilization and improve overrun, while stabilizers regulate ice crystal growth and melting characteristics. In yogurt, stabilizers reduce syneresis and enhance viscosity, whereas in processed cheese, emulsifying salts facilitate uniform fat distribution and improve meltability. Similarly, flavored milk beverages depend on stabilizers to prevent sedimentation and maintain a homogeneous appearance throughout storage.

In recent years, increasing consumer preference for natural, minimally processed, and clean-label foods has driven substantial research into alternative emulsifiers and stabilizers derived from natural sources. Plant proteins, microbial polysaccharides, seed gums, dietary fibers, and protein-polysaccharide complexes are gaining attention as sustainable alternatives to synthetic additives. Furthermore, advances in nanotechnology, encapsulation systems, and ingredient engineering are creating new opportunities for improving functionality while reducing additive usage levels.

Despite their widespread use and technological importance, the selection and application of emulsifiers and stabilizers require careful consideration of regulatory requirements, ingredient interactions, processing conditions, and product-specific characteristics. Regulatory authorities worldwide, including the U.S. Food and Drug Administration (FDA), the European Food Safety Authority (EFSA), the Joint FAO/WHO Expert Committee on Food Additives (JECFA), Codex Alimentarius, and the Food Safety and Standards Authority of India (FSSAI), establish guidelines governing the safety, purity, labeling, and permissible levels of these additives in dairy products.

Therefore, a comprehensive understanding of the mechanisms, functions, applications, and regulatory aspects of emulsifiers and stabilizers is essential for dairy scientists, food technologists, researchers, and industry professionals. This review aims to provide an updated and critical overview of emulsifiers and stabilizers in dairy systems, highlighting their functional roles, applications in various dairy products, safety considerations, and future prospects in the evolving dairy industry.

Food additives used in dairy products

Food additives are substances added to foods to improve safety, quality, texture, appearance, flavor, and shelf life. In dairy products, additives are used carefully because many dairy foods have strict standards of identity and are widely consumed by children and vulnerable populations. Common functional classes of additives include stabilizers, emulsifiers, preservatives, colors, flavors, sweeteners, acidity regulators, and enzymes.

In dairy products, the most commonly used additives are stabilizers and thickeners such as carrageenan, guar gum, locust bean gum, xanthan gum, pectin, and modified starch. These help improve body and mouthfeel, prevent whey separation in yogurt and flavored milk, and improve freeze-thaw stability in ice cream and desserts. Emulsifiers such as mono- and diglycerides, lecithin, and polysorbates are used to keep fat evenly dispersed, improve whipping properties, and enhance melting behaviour in products like ice cream and whipped toppings.

Preservatives such as potassium sorbate, sodium benzoate, and natamycin are used mainly in cheeses, flavored milk beverages, and dairy toppings to inhibit mold and yeast growth and extend shelf life. Colors like annatto and beta-carotene are commonly used in cheese and butter to provide consistent appearance, while natural and artificial flavors are added to yogurts, milk drinks, desserts, and ice creams to enhance taste and aroma. Sweeteners, including sugar, glucose syrup, and low-calorie sweeteners such as stevia or sucralose, are used in flavored and reduced-sugar dairy products.

Acidity regulators such as citric acid, sodium citrate, and phosphates help control pH during processing and fermentation, improving stability and texture. Enzymes such as rennet (chymosin), lactase, and lipase are widely used in cheese making and lactose-free dairy products and are considered processing aids rather than additives in many regions. Overall, food additives in dairy are used at low levels to maintain product quality, safety, consistency, and consumer acceptability while complying with strict regulatory standards.

Challenges in Dairy Products

Fat separation in milk and cream occurs when fat globules rise to the surface and form a cream layer. Emulsifiers help keep the fat evenly dispersed within the water phase, while stabilizers increase the viscosity of the product, reducing the movement of fat globules and preventing creaming. Whey separation in yogurt, also known as syneresis, happens due to a weak protein gel structure or loss of moisture. Stabilizers strengthen the protein network, enhance water-holding capacity, and help maintain a smooth and uniform yogurt texture. In ice cream, large ice crystals may form during freezing and storage, resulting in a coarse or icy texture. Stabilizers bind free water and slow down ice crystal growth, while emulsifiers promote controlled fat destabilization, contributing to a smoother body and creamier texture. Texture inconsistency in processed cheese is mainly caused by poor interaction between fat and proteins. Emulsifying salts help disperse fat evenly and modify milk proteins, producing a smooth, homogeneous, and easily spreadable cheese.

Need for additives: Emulsifiers and stabilizers play an important role in improving the texture, stability, and shelf life of dairy products. They help maintain a uniform structure during processing and storage, reducing defects such as graininess or water release. By preventing phase separation, these additives keep fat, water, and other components evenly distributed, avoiding problems like fat separation in milk and cream, whey separation in yogurt, and oiling-off in cheese. Additionally, emulsifiers and stabilizers enhance sensory qualities by improving creaminess and smoothness, resulting in better mouthfeel and overall consumer acceptance of dairy products.

How emulsifiers work in milk products

Emulsifiers work by enabling the stable mixing of two immiscible phases, most commonly oil and water, which would otherwise separate due to differences in polarity and density. An emulsifier molecule has a unique amphiphilic structure, meaning it contains two distinct parts: a hydrophilic (water-loving) head and a lipophilic or hydrophobic (fat-loving) tail. When an emulsifier is added to an oil-water system, the hydrophobic tail aligns itself with the oil phase while the hydrophilic head interacts with the water phase. This orientation occurs at the oil-water interface, where the emulsifier forms a protective layer around dispersed droplets. By doing so, emulsifiers reduce interfacial tension, making it easier to break large droplets into smaller ones during mixing or homogenization. The coated droplets repel each other through electrostatic or steric forces, preventing them from merging back together (coalescence). As a result, the emulsion remains stable for a longer period. In food systems, this mechanism improves texture, mouthfeel, and appearance, as seen in products like mayonnaise, milk, ice cream, and salad dressings. Additionally, emulsifiers can interact with proteins and starches, further enhancing stability and functional performance in complex food matrices. McClements, D. J. (2015) [12].

How stabilizers work in dairy products

Stabilizers play a crucial role in dairy products by improving texture, consistency, and physical stability throughout processing, storage, and distribution. In dairy systems, stabilizers such as gelatin, carrageenan, pectin, guar gum, locust bean gum, and xanthan gum function mainly by binding water and increasing viscosity. These hydrocolloids form a network within the aqueous phase of dairy products, which helps prevent phase separation such as whey syneresis in yogurt and curd products. In milk-based beverages and flavoured milk, stabilizers keep fat globules and other solids uniformly dispersed, preventing sedimentation and creaming. In ice cream, stabilizers limit the movement of free water, thereby controlling ice crystal growth during freezing and storage, which results in a smoother texture and improved melting resistance. Some stabilizers, such as carrageenan, interact specifically with milk proteins (casein micelles), forming weak gel structures that enhance body and mouthfeel in products like chocolate milk and dairy desserts. Overall, stabilizers help maintain product uniformity, enhance sensory quality, and extend shelf life by protecting dairy products against physical and temperature-induced changes. Tamime, A. Y., & Robinson, R. K. (2007) [21].

Common types of emulsifiers in dairy systems

Emulsifiers are essential in dairy systems to maintain stable dispersions of fat and water, improve texture, and enhance product quality. One of the most common emulsifiers in dairy products is lecithin, a natural phospholipid derived from soy or egg yolk. Lecithin contains both hydrophilic and lipophilic groups, enabling it to effectively stabilize fat globules in milk-based beverages, chocolate milk, and cream, while also improving mouthfeel and preventing fat separation. Another widely used group is mono- and diglycerides, which are partial glycerides of fatty acids. These emulsifiers are particularly effective in ice cream and whipped dairy products, where they help displace proteins from the fat globule surface, promote partial fat coalescence, improve air incorporation, and enhance melting resistance.

Polysorbates: (such as polysorbate 80) are synthetic emulsifiers commonly used in ice cream and flavoured dairy products. They are highly surface-active and help produce finer fat droplet distributions, leading to smoother textures and improved stability. Sorbitan esters are often used in combination with polysorbates to balance hydrophilic-lipophilic properties and stabilize complex dairy emulsions. Additionally, protein-based emulsifiers, such as milk proteins (casein and whey proteins), naturally act as emulsifiers in dairy systems. Casein micelles adsorb at the oil-water interface and provide steric and electrostatic stabilization to fat globules in milk and cream. Together, these emulsifiers help maintain uniformity, improve sensory attributes, and extend the shelf life of dairy products. Goff, H. D., & Hartel, R. W. (2013) [5].

Natural sources of emulsifiers

Natural emulsifiers are substances derived from plant, animal, or microbial sources that help stabilize mixtures of oil and water without the use of synthetic chemicals. One of the most widely used natural emulsifiers is lecithin, which is obtained from egg yolk, soybeans, sunflower seeds, and rapeseed. Lecithin is rich in phospholipids that contain both hydrophilic and lipophilic groups, making it highly effective in stabilizing emulsions in foods such as mayonnaise, chocolate, margarine, bakery products, and dairy beverages. Egg yolk lecithin is especially valued in traditional emulsions due to its strong emulsifying capacity and clean-label appeal. Milk proteins, particularly casein and whey proteins, are also important natural emulsifiers. Casein micelles naturally stabilize fat globules in milk by forming a protective layer around them, while whey proteins, when denatured by heat, can adsorb at oil-water interfaces and improve emulsion stability. These proteins are commonly used in dairy products, infant formula, and
nutritional beverages. Plant-based emulsifiers include gums and polysaccharides such as gum arabic, pectin, and mustard mucilage. Gum arabic, derived from Acacia trees, is widely used in beverage emulsions because of its excellent solubility and emulsifying ability. Saponins, extracted from plants like quillaja bark and yucca, act as natural surfactants and are used in beverages and foaming products. Together, these natural emulsifiers support clean-label formulation, improve texture and stability, and meet consumer demand for minimally processed ingredients. Smith, A.K. (Ed.). (2015) [20].

Why emulsifiers are important in dairy products

Emulsifiers are critically important in dairy products because they help maintain the stable coexistence of fat and water, which are the two major and naturally incompatible components of milk and many dairy formulations. Milk itself is a natural oil-in-water emulsion, where fat globules are dispersed in an aqueous phase. Emulsifiers, both naturally occurring (such as milk proteins) and added ones, stabilize these fat globules by forming a protective layer at the fat-water interface. This prevents fat separation, creaming, and coalescence during processing, storage, and transportation, thereby ensuring product uniformity and visual appeal.

In products such as ice cream, whipped cream, and dairy desserts, emulsifiers play a key role in controlling fat structure and air incorporation. They help partially destabilize fat globules in a controlled manner, which improves whipping properties, enhances body and texture, and increases melting resistance. Without emulsifiers, ice cream would have a coarse texture, poor overrun, and rapid melting. In flavoured milk and cream-based beverages, emulsifiers ensure even distribution of fat and flavour compounds, preventing sedimentation and phase separation.

Emulsifiers also improve the sensory qualities of dairy products by enhancing smoothness, creaminess, and mouthfeel. Additionally, they contribute to processing efficiency by improving heat stability and shelf life. Overall, emulsifiers are essential for achieving consistent quality, desirable texture, extended storage stability, and consumer acceptance in modern dairy products. Smith, A. K. (Ed.). (2015) [20].

Functions of Emulsifiers in Dairy Products

Emulsifiers perform several important functions in dairy products by improving stability, texture, and overall quality. one of their primary functions is to stabilize fat-water emulsions. Dairy products such as milk, cream, flavoured milk, and ice cream contain both fat and water phases, which naturally tend to separate. Emulsifiers help keep fat globules evenly dispersed in the aqueous phase, preventing creaming and fat separation during storage.

Another key function of emulsifiers is texture improvement. In ice cream and frozen desserts, emulsifiers promote controlled fat destabilization and improve air incorporation (overrun), resulting in a smoother, creamier texture and better melting resistance. in whipped cream, they enhance whipping ability and foam stability, allowing the product to hold its structure for longer periods.

Emulsifiers also contribute to uniform distribution of ingredients such as Flavors, colours, and fat-soluble vitamins. This ensures consistent taste and appearance throughout the product. In heat-treated dairy products, emulsifiers can improve heat and processing stability, reducing protein aggregation and phase separation during pasteurization or sterilization. additionally, emulsifiers help extend shelf life by maintaining physical stability over time. they improve mouthfeel, enhance creaminess, and increase consumer acceptability. overall, emulsifiers are essential functional ingredients that support product consistency, processing efficiency, and high-quality sensory characteristics in dairy products. Smith, A. K. (Ed.). (2015) [20].

Milk and Flavoured Milk

Milk is a natural oil-in-water emulsion in which fat globules are dispersed within an aqueous phase containing proteins, lactose, minerals, and vitamins. The stability of milk is mainly maintained by the natural milk fat globule membrane and milk proteins, especially casein. However, in flavoured milk, additional ingredients such as sugar, cocoa, coffee, fruit Flavors, and colorants are added, which can disturb this natural balance and lead to problems like fat separation, sedimentation, or creaming during storage.

To maintain uniformity in flavoured milk, emulsifiers and stabilizers are often used. Emulsifiers help keep milk fat evenly distributed and assist in dispersing fat-soluble flavour compounds, ensuring a consistent taste and appearance. Stabilizers such as carrageenan or guar gum are commonly used to prevent sedimentation of cocoa particles and to reduce whey separation by interacting with milk proteins and increasing viscosity. These additives help maintain smooth texture, improved mouthfeel, and visual appeal throughout the product's shelf life.

In both milk and flavoured milk, proper emulsification and stabilization are essential for heat stability during pasteurization or ultra-high-temperature (UHT) processing. They also improve storage stability and consumer acceptance by preventing phase separation and ensuring a uniform, pleasant drinking experience.

Ice Cream and Frozen Desserts

Ice cream and frozen desserts are complex dairy systems composed of fat, water, air, proteins, sugars, and other solids. Achieving a smooth texture and stable structure in these products requires careful control of emulsification and stabilization. Emulsifiers play a vital role by improving the interaction between fat, water, and air. They help reduce interfacial tension and promote controlled fat destabilization during freezing and whipping. This partial coalescence of fat globules creates a stable fat network that surrounds air bubbles, resulting in improved overrun, creaminess, and melting resistance.

Stabilizers are equally important in ice cream and frozen desserts because they control water mobility. Stabilizers such as guar gum, locust bean gum, carrageenan, and xanthan gum bind free water, increase viscosity, and limit ice crystal growth during freezing and storage. By preventing the formation of large ice crystals, stabilizers ensure a smooth texture and reduce defects such as iciness and shrinkage. They also help maintain product structure during temperature fluctuations.

Together, emulsifiers and stabilizers enhance texture, body, and mouthfeel while improving storage stability and shelf life. Without these ingredients, ice cream and frozen desserts would be coarse, unstable, and prone to rapid melting, making them essential components in high-quality frozen dairy products.

Butter and Margarine

Butter and margarine are fat-rich spreads in which the balance between fat and water is critical for texture, stability, and spread ability. Butter is a water-in-oil emulsion made from milk or cream, where tiny droplets of water are dispersed within a continuous fat phase. Its stability is largely provided by milk fat crystals and residual milk proteins. Proper emulsification during churning ensures uniform distribution of water droplets, which influences butter's firmness, mouthfeel, and resistance to water leakage during storage.

Margarine, on the other hand, is a manufactured water-in-oil emulsion produced from vegetable oils or blends of vegetable

and animal fats. Because margarine does not contain the natural emulsifying components found in milk fat, emulsifiers such as mono- and diglycerides or lecithin are essential. These emulsifiers stabilize the water droplets within the fat phase, prevent phase separation, and improve consistency and spread ability. They also help control crystal formation in the fat phase, giving margarine a smooth texture. In both butter and margarine, emulsification affects shelf life, melting behaviour, and sensory quality. Effective emulsifier use ensures uniform texture, prevents water separation, and provides desirable functional properties for cooking, baking, and spreading applications.

Cheese and Processed Cheese

Cheese and processed cheese differ significantly in structure and formulation, but emulsification plays an important role in both. Natural cheese is formed through the coagulation of milk proteins, mainly casein, which trap fat and water within a protein network. During ripening, changes in protein and fat structure influence texture, flavour, and meltability. Although natural cheese does not rely heavily on added emulsifiers, the balance between fat, moisture, and protein is critical for maintaining body and structural integrity.

Processed cheese, in contrast, depends strongly on emulsifying agents to achieve a uniform and stable product. Emulsifying salts such as sodium citrate, sodium phosphate, and sodium polyphosphate are added during processing. These salts work by modifying the calcium balance in casein, allowing proteins to better bind water and fat. As a result, fat is evenly dispersed within the protein matrix, preventing oil separation when the cheese is heated.

Emulsifiers in processed cheese improve meltability, slice ability, and spread ability while ensuring a smooth, homogeneous texture. They also enhance heat stability and extend shelf life. Without proper emulsification, processed cheese would show defects such as greasing off, grainy texture, and poor melting behaviour, reducing product quality and consumer acceptability.

Cream and Whipped Cream

Cream is a high-fat dairy product in which milk fat globules are dispersed in an aqueous phase, making it an oil-in-water emulsion. The stability of cream depends on the size and distribution of fat globules and the integrity of the milk fat globule membrane. During processing and storage, fat separation or creaming can occur if the emulsion is not stable. Emulsifiers and stabilizers help maintain uniform fat dispersion, improve viscosity, and enhance heat stability, especially in UHT and flavoured creams.

Whipped cream relies heavily on controlled emulsification for its characteristic light and airy structure. During whipping, air is incorporated into the cream, and fat globules partially destabilize and aggregate around air bubbles, forming a stable foam structure. Emulsifiers such as mono- and diglycerides facilitate this process by weakening the fat globule membrane, allowing fat crystals to interact and form a supporting network. Stabilizers may also be added to increase viscosity and improve foam stability, preventing rapid collapse or whey separation.

In both cream and whipped cream, emulsification directly affects texture, whipping ability, overrun, and stability. Proper use of emulsifiers ensures smooth mouthfeel, good volume, prolonged foam stability, and consistent quality, making these ingredients essential for high-performance cream-based dairy products.

Yogurt and Fermented Dairy Products

Yogurt and other fermented dairy products are formed through the fermentation of milk by lactic acid bacteria, which convert lactose into lactic acid. This process lowers the pH and causes milk proteins, mainly casein, to coagulate and form a gel-like structure. The quality of yogurt largely depends on the strength and stability of this protein network, as well as the distribution of water and fat within it.

Stabilizers play an important role in yogurt and fermented dairy products by improving texture, viscosity, and water-holding capacity. Stabilizers such as pectin, gelatin, guar gum, and starch help prevent whey separation (syneresis) by binding free water and reinforcing the protein gel. This results in a smoother, creamier texture and improved mouthfeel. In stirred and drinkable yogurts, stabilizers also help maintain uniform consistency and prevent phase separation during storage.

Although emulsifiers are less commonly added to traditional yogurt, milk proteins naturally act as emulsifiers by stabilizing fat globules within the fermented matrix. In flavoured or low-fat fermented products, emulsifiers and stabilizers together help improve body, flavour distribution, and stability. Overall, these ingredients enhance sensory quality, extend shelf life, and ensure consistent consumer acceptance of yogurt and fermented dairy products.

Table 1: Applications of Emulsifiers in the Dairy Industry:

Dairy Product	Type of Emulsifier Used	Main Function	Effect on Product Quality
Milk & Flavoured Milk	Lecithin, Mono- & Diglycerides	Stabilize fat and flavour compounds	Prevent creaming and sedimentation
Ice Cream & Frozen Desserts	Mono- & Diglycerides, Polysorbates	Control fat destabilization, improve air incorporation	Smooth texture, better overrun, slower melting
Butter & Margarine	Mono- & Diglycerides, Lecithin	Stabilize water-in-oil emulsion	Improved spread ability, reduced water leakage
Processed Cheese	Emulsifying salts (sodium citrate, phosphates)	Disperse fat uniformly in protein matrix	Better melting, smooth texture, no oil separation
Cream & Whipped Cream	Mono- & Diglycerides	Enhance whipping and foam stability	Higher volume, stable foam structure
Yogurt & Dairy Desserts	Milk proteins (natural emulsifiers)	Maintain fat dispersion	Improved mouthfeel and consistency
Infant Formula	Lecithin, Milk proteins	Disperse fat and nutrients evenly	Improved digestibility and stability

What Regulators Care About with Emulsifiers

Regulatory authorities pay close attention to the safety, quality, labelling, and usage levels of emulsifiers in food, including dairy products. Their main concerns include:

1. Safety and Toxicity

Emulsifiers must be proven safe for human consumption. Regulatory bodies like the FDA (USA), EFSA (Europe), and FAO/WHO JECFA assess toxicology data,
acceptable daily intake (ADI), and any potential long-term effects. Only approved emulsifiers within safe dosage limits are allowed.

2. Permitted Types and Purity

Not all emulsifiers are approved for all food categories. Regulators specify which emulsifiers can be used in dairy products (e.g., lecithin, mono- and diglycerides, polysorbates). Purity standards, absence of contaminants, and proper processing methods are also required.

3. Maximum Usage Levels

Authorities set maximum allowable concentrations, often expressed as a percentage of the product or per kg of food. Exceeding these limits can pose health risks or affect product quality.

4. Labelling Requirements

Emulsifiers must be declared on product labels, either by name or INS number (e.g., lecithin E322, mono- & diglycerides E471). Transparency ensures consumer safety and compliance with food laws.

5. Allergen Considerations

Some emulsifiers are derived from potential allergens, like soy or egg lecithin, which must be disclosed to protect sensitive consumers.

6. Interactions with Other Ingredients

Regulators consider whether emulsifiers interact with other additives, vitamins, or nutrients in ways that could reduce safety or nutritional value. European Food Safety Authority (EFSA). Scientific Opinion on Food Additives. 2017.

Major Regulatory Authorities for Emulsifiers in the Food and Dairy Industry

Several national and international agencies regulate the use of emulsifiers and other food additives to ensure safety, quality, and proper labelling.

The use of emulsifiers in the food and dairy industry is strictly regulated by several national and international authorities to ensure safety, quality, and proper labelling. In the United States, the Food and Drug Administration (FDA) evaluates food additives, including emulsifiers, and maintains the Food Additive Status List and GRAS (Generally Recognized as Safe) notifications. In the European Union, the European Food Safety Authority (EFSA) assesses the safety of emulsifiers and enforces regulations such as Regulation (EC) No 1333/2008 on food additives. Globally, the Joint FAO/WHO Expert Committee on Food Additives (JECFA) conducts toxicological evaluations and establishes acceptable daily intake (ADI) values, which serve as references for national authorities. The Codex Alimentarius Commission, also under FAO/WHO, develops international standards and guidelines to harmonize safety and labelling of food additives worldwide. Other national agencies, such as Health Canada, Food Safety and Standards Authority of India (FSSAI), ANVISA in Brazil, and FSANZ in Australia and New Zealand, regulate emulsifier use in dairy products, set maximum permitted levels, and ensure compliance with labelling and purity requirements. Together, these regulatory authorities ensure that emulsifiers used in dairy and other foods are safe, properly declared, and consistent with international standards, protecting consumers while enabling innovation in the food industry.

What is a Stabilizer?

A stabilizer is a substance added to food, particularly dairy products, to maintain physical and chemical stability during processing, storage, and consumption. In dairy systems, stabilizers are usually hydrocolloids such as gums, gelatin, pectin, and starches that interact with water, proteins, and other ingredients to improve viscosity, texture, and water-holding capacity. Unlike emulsifiers, stabilizers do not mix fat and water but help prevent undesirable changes such as whey separation (syneresis), sedimentation, or ice crystal formation in frozen products. For example, in yogurt, stabilizers strengthen the protein gel and reduce whey leakage, while in ice cream, they control ice crystal growth and improve smoothness. Overall, stabilizers enhance the mouthfeel, appearance, consistency, and shelf life of dairy products, ensuring a high-quality product for consumers. McClements, D. J. (2015) [12].

Functions of Stabilizers in Dairy Products

Stabilizers play a vital role in maintaining the quality, texture, and stability of dairy products. Their primary function is to improve water-holding capacity, which prevents whey separation (syneresis) in products like yogurt, fermented milk, and dairy desserts. By increasing viscosity and forming a network within the aqueous phase, stabilizers help maintain a uniform and smooth texture, enhancing mouthfeel and sensory appeal. In frozen dairy products like ice cream, stabilizers control ice crystal formation and water migration, ensuring a creamy, smooth consistency and reducing graininess during storage. They also help suspend solids such as cocoa, fruit particles, or flavourings in flavoured milk and other beverages, preventing sedimentation. Additionally, stabilizers contribute to heat and freeze-thaw stability, allowing dairy products to maintain their structure during pasteurization, UHT processing, or temperature fluctuations. Overall, stabilizers enhance product consistency, shelf life, and consumer acceptability, making them essential in modern dairy formulation. Walstra, P., Wouters, J. T. M., & Geurts, T. J. (2006) [22].

Common Stabilizers Used in Dairy Products

Stabilizers are widely used in dairy products to improve texture, viscosity, water-holding capacity, and overall stability. Gelatin, an animal-derived protein, is commonly used in yogurts, dairy desserts, and ice cream to form gels, enhance body, and prevent whey separation. Pectin, a plant polysaccharide from citrus peel or apples, is added to yogurts and fruit-based dairy products to stabilize acidified systems and reduce syneresis. Carrageenan, extracted from red seaweed, interacts with milk proteins to improve viscosity and prevent separation in chocolate milk, cream, yogurt, and ice cream. Guar gum, from guar seeds, is used in ice cream, yogurt, and flavoured milk to increase viscosity, improve

mouthfeel, and control ice crystal formation. Locust bean gum, derived from carob seeds, works synergistically with carrageenan to strengthen gel structure and enhance freeze-thaw stability, especially in ice cream and yogurt. Xanthan gum, a microbial polysaccharide, stabilizes low-fat ice cream, flavoured milk, and sauces by increasing viscosity and preventing phase separation. Modified or native starches are also used in puddings, yogurt, and dairy desserts to provide thickness and control water migration. Finally, sodium alginate, from brown seaweed, forms gels with calcium ions, stabilizes suspensions, and improves viscosity in ice cream and milk beverages.

Together, these stabilizers ensure that dairy products maintain a smooth texture, uniform appearance, and longer shelf life, while many of them are used in combination to achieve optimal functional and sensory properties. McClements, D. J. (2015) [12].

Why Stabilizers are Important in Dairy Products

Stabilizers are essential in dairy products because they ensure product quality, consistency, and shelf life. Dairy systems often contain water, fat, proteins, and other solids that are prone to separation or structural changes during processing and storage. Stabilizers, usually hydrocolloids like gelatin, pectin, carrageenan, guar gum, and locust bean gum, help bind water, increase viscosity, and strengthen protein networks. This prevents problems such as whey separation (syneresis) in yogurt, sedimentation in flavoured milk, and ice crystal formation in ice cream, maintaining a smooth and uniform texture. In frozen dairy products, stabilizers control water mobility, which improves creaminess, mouthfeel, and melting resistance. They also enhance heat and freeze-thaw stability, ensuring the product maintains its structure under temperature fluctuations. By improving texture, consistency, and stability, stabilizers play a critical role in producing high-quality dairy products that are appealing to consumers and commercially viable. Tamime, A. Y., & Robinson, R. K. (2007) [21].

Functions of Stabilizers in Dairy Products

Stabilizers serve several important functions in dairy products, ensuring consistency, texture, and stability. One of their primary roles is to increase water-holding capacity, which prevents whey separation (syneresis) in yogurt, fermented milk, and dairy desserts. By interacting with proteins and water, stabilizers help maintain a uniform and smooth texture, improving mouthfeel and sensory appeal. In frozen products such as ice cream and frozen desserts, stabilizers control ice crystal growth and water migration, resulting in a creamy, smooth consistency and reduced graininess during storage. Stabilizers also help suspend solids like cocoa particles, fruit pieces, or flavourings in flavoured milk and other beverages, preventing sedimentation. Additionally, they enhance heat and freeze-thaw stability, allowing products to maintain their structure during pasteurization, UHT processing, and temperature fluctuations. Overall, stabilizers are crucial for improving product quality, shelf life, and consumer acceptability in dairy products. Tamime, A. Y., & Robinson, R. K. (2007) [21].

Classification of Stabilizers in Dairy Products: Stabilizers used in dairy products are generally hydrocolloids substances that form gels or increase viscosity in water. They can be classified based on their source, chemical nature, or functional properties as follows:

1. Animal-Derived Stabilizers

- **Gelatin:** Obtained from collagen in animal bones or skin.
- **Function:** Forms gels, improves body, prevents whey separation.
- **Applications:** Yogurt, dairy desserts, ice cream.

2. Plant-Derived Stabilizers

- **Pectin:** Extracted from citrus peels or apples; stabilizes acidified dairy products.
- **Guar Gum:** From guar seeds; increases viscosity and improves mouthfeel.
- **Locust Bean Gum (LBG):** From carob seeds; enhances gel strength, often used with carrageenan.
- **Carrageenan:** Extracted from red seaweed; interacts with milk proteins to prevent separation.
- **Starches:** Corn, potato, or modified starches; provide thickness and control water migration.

3. Microbial-Derived Stabilizers

- Xanthan Gum: Produced by microbial fermentation; increases viscosity and stabilizes suspensions.
- Applications: Low-fat ice cream, flavoured milk, dairy sauces.

4. Algal or Seaweed-Derived Stabilizers

- **Sodium Alginate:** Extracted from brown seaweed; forms gels with calcium ions.
- **Applications:** Ice cream, milk beverages.

These stabilizers are chosen depending on the type of dairy product, desired texture, processing conditions, and shelf-life requirements. McClements, D. J. (2015) [12].

Application of Stabilizers in Specific Dairy Products

Stabilizers are widely used in dairy products to enhance texture, consistency, and stability. In yogurt and fermented milk, stabilizers like gelatin, pectin, and guar gum improve water-holding capacity, strengthen the protein gel, and prevent whey separation (syneresis), giving a smooth, creamy texture. In ice cream and frozen desserts, stabilizers such as carrageenan, locust bean gum, guar gum, and xanthan gum control ice crystal growth, increase viscosity, and improve overrun, resulting in a creamy, smooth product with better melting resistance. Flavoured milk and milk-based beverages often contain stabilizers like carrageenan and xanthan gum to suspend cocoa, fruit, or other solid particles evenly, preventing sedimentation and ensuring a uniform appearance. In cream and whipped cream, stabilizers help maintain foam stability, improve whipping properties, and prevent phase separation. Dairy desserts and puddings use starches, gelatin, or pectin to increase thickness, enhance mouthfeel, and maintain structural integrity during storage. By selecting the appropriate stabilizer for each product, manufacturers can achieve desired texture, stability, and shelf life, ensuring high-quality, consumer-acceptable dairy products.

Table 2: Table showing the application of stabilizers in specific dairy products

Dairy Product	Common Stabilizers Used	Function / Role
Yogurt & Fermented Milk	Gelatin, Pectin, Guar Gum	Improve water-holding capacity, prevent whey separation (syneresis), enhance texture and creaminess
Ice Cream & Frozen Desserts	Carrageenan, Locust Bean Gum, Guar Gum, Xanthan Gum	Control ice crystal growth, increase viscosity, improve overrun, enhance smoothness and melting resistance
Flavoured Milk & Milk Beverages	Carrageenan, Xanthan Gum	Suspend solids (cocoa, fruit), prevent sedimentation, maintain uniform appearance
Cream & Whipped Cream	Gelatin, Carrageenan, Guar Gum	Stabilize foam, improve whipping properties, prevent phase separation

This table provides a clear and concise view of how stabilizers are used depending on the type of dairy product and the functional requirement. McClements, D. J. (2015) [12].
Stabilizer in ice cream: Stabilizers in ice cream are ingredients added in small amounts to improve texture, body, and storage stability. They work by binding free water in the mix, which helps control ice crystal growth during freezing and storage. This prevents the formation of large ice crystals and results in a smoother, creamier texture. Stabilizers also increase the viscosity of the ice cream mix, improve melting resistance, reduce shrinkage, and help maintain uniform air distribution, thereby enhancing the overall quality and shelf life of ice cream. Walstra, P., Wouters, J. T. M., & Geurts, T. J. (2006) [22].
Stabilizers in Yogurt & Fermented Milk: Stabilizers in yogurt and fermented milk are used to improve texture, consistency, and product stability. They help strengthen the protein gel formed during fermentation and increase the water-holding capacity of the product, which reduces whey separation (syneresis). Stabilizers also enhance viscosity and provide a smooth, uniform body, especially in stirred or drinkable yogurts. By maintaining structural integrity during storage and handling, stabilizers improve mouthfeel, appearance, and overall consumer acceptability of yogurt and fermented milk products. Walstra, P., Wouters, J. T. M., & Geurts, T. J. (2006) [22].
Stabilizers in Cream & Whipped Cream: Stabilizers in cream and whipped cream are used to improve consistency, stability, and whipping performance. They help increase viscosity and strengthen the structure of the cream, which reduces fat separation and prevents liquid drainage during storage and after whipping. In whipped cream, stabilizers support air bubble stability, helping the foam maintain its volume and shape for a longer time. They also improve texture, giving whipped cream a smoother, firmer body and better mouthfeel, while extending shelf life and product stability. McClements, D. J. (2015) [12].
Stabilizers in Flavored Milk / Creamed Milk: Stabilizers in flavoured milk and creamed milk are used to maintain uniformity, texture, and product stability. By increasing viscosity and improving water-binding capacity, stabilizers keep solids and fat evenly dispersed throughout the product. This results in a smooth mouthfeel, consistent appearance, and improved shelf life of flavoured and creamed milk beverages. McClements, D. J. (2015) [12].

Combination of Stabilizers: The combination of stabilizers is commonly used in dairy products to achieve better texture, stability, and functionality than a single stabilizer alone. Different stabilizers complement each other by providing synergistic effects, such as improved viscosity, enhanced water-holding capacity, and stronger gel formation. For example, combining gums, starches, or proteins can help control whey separation in yogurt, improve melt resistance and smoothness in ice cream, and enhance foam stability in whipped cream. Using stabilizer blends allows manufacturers to tailor product texture, processing tolerance, and shelf life while using lower overall stabilizer levels and maintaining desirable sensory qualities. Walstra, P., Wouters, J. T. M., & Geurts, T. J. (2006) [22].

Regulations & Safety: Regulations and safety considerations are essential in the use of stabilizers in dairy products. Food stabilizers must be approved by food safety authorities such as FSSAI, FDA, or Codex Alimentarius before use, and they are permitted only within specified limits. These regulations ensure that stabilizers are safe for consumption and do not pose health risks when used correctly. Manufacturers must follow good manufacturing practices (GMP) and clearly declare stabilizers on product labels. Proper regulation and monitoring help ensure consumer safety, maintain product quality, and build trust in dairy products. U.S. Food and Drug Administration (FDA). (2020).

Combined Applications: In ice cream, emulsifiers and stabilizers play a crucial role in achieving desirable quality and texture. Emulsifiers help in the uniform dispersion of fat throughout the ice cream mix and promote controlled fat destabilization during freezing, which contributes to smoothness and creaminess. Stabilizers bind free water in the mix, preventing the formation and growth of large ice crystals during freezing and storage. This improves texture, enhances melting resistance, and maintains the overall stability and mouthfeel of ice cream.

In processed cheese: emulsifiers and stabilizers are essential for achieving a smooth, uniform, and stable product. Emulsifying salts help disperse fat evenly by modifying milk proteins, allowing fat and water to form a stable emulsion. This prevents oil separation and ensures a consistent texture. Stabilizers contribute to improved body and firmness, help retain moisture, and maintain product stability during heating and storage. Together, they provide processed cheese with a homogeneous structure, good melting properties, and extended shelf life.
In yogurt and fermented milk, stabilizers are used to improve texture, consistency, and overall product stability. They strengthen the protein gel formed during fermentation and increase water-holding capacity, which helps prevent whey separation (syneresis). Stabilizers also enhance viscosity and provide a smooth, uniform body, especially in stirred and drinkable products. As a result, yogurt and fermented milk products have better mouthfeel, appearance, and shelf life.

In flavoured milk and creams, stabilizers are used to maintain uniformity and product stability. They help prevent sedimentation of added ingredients such as cocoa, flavouring agents, and sugar, as well as reduce fat separation during storage. By increasing viscosity and improving water-binding capacity, stabilizers ensure even dispersion of solids and fat, resulting in a smooth texture, consistent appearance, and improved shelf life of flavoured milk and cream products.

Conclusion

Emulsifiers and stabilizers are widely used in dairy products to enhance quality and stability. Emulsifiers mainly control fat-water interactions by ensuring uniform fat dispersion and preventing separation, which improves smoothness and consistency. Stabilizers help maintain texture and viscosity by binding water, strengthening structure, and reducing defects such as syneresis or ice crystal growth. When used together, emulsifiers and stabilizers work synergistically to improve product stability, enhance sensory qualities like creaminess and smoothness, and extend the shelf life of dairy products.

Hydrocolloid stabilizers effectively reduce whey separation and enhance yogurt texture without altering flavour. This approach is commonly used in commercial yogurt and fruit yogurt production. (Tamime, A. Y., & Robinson, R. K. (2007). Emulsifiers stabilize the fat phase, prevent coalescence, and improve texture, overrun, and overall sensory quality in ice cream. Mono- and diglycerides, often combined with polysorbates, are widely used in commercial ice cream production to achieve premium texture and storage stability. Goff, H. D., & Hartel, R. W. (2013) [6].

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