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USE OF STABILIZERS IN FOOD INDUSTRY AND THEIR BIOSYNTHESIS PATHWAYS WITH HEALTH IMPACT

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Abstract:

The use of stabilizers in the food industry has revolutionized food production by enhancing the texture, consistency, and shelf life of food products. The increasing demand for high-quality, convenient food products has led to an upsurge in the use of stabilizers. Stabilizers are used in a variety of food products, including ice cream, sauces, beverages, and dressings, to improve their sensory attributes and to prevent separation. Hydrocolloids, proteins, emulsifiers, and antioxidants are the four main types of stabilizers used in the food industry. Recent research has focused on developing new and improved stabilizers that are safe and effective for use in food products. However, safety and regulatory concerns must also be taken into account for health impacts. This review article provides a comprehensive overview of the use of stabilizers in the food industry, including their functional properties, applications in various food products, regulatory aspects, safety concerns, and recent research. It offers valuable insights into the impact of stabilizers on the quality and safety of food products.

Keywords: Stabilizers, Food Additives, Thickening agent, Hydrocolloids, Emulsifiers

Introduction:

The food industry has been revolutionized by the use of stabilizers, which are essential additives used to enhance the texture, consistency, and shelf life of food products. The increasing demand for convenient, high-quality food products has led to an upsurge in the use of stabilizers. Stabilizers are added to a variety of food products, including ice cream, sauces, beverages, and dressings, to improve their sensory attributes, such as mouthfeel and viscosity, and to prevent separation.

Additionally, stabilizers help to ensure that food products maintain their quality during transportation and storage.

Recent research has focused on developing new and improved stabilizers that are safe and effective for use in food products. For example, a study by Saleh et al. investigated the use of modified starches as stabilizers in dairy products and found that they improved the texture, consistency, and sensory properties of the products (Saleh et al., 2020). Another study explored the use of carrageenan as a stabilizer in plant-based meat alternatives and found that it improved the texture and mouthfeel of the products (Mirzaei et al., 2023 & Palanisamy eta al., 2018).

While the use of stabilizers has many benefits for the food industry, it is also important to consider the safety and regulatory aspects of their use. Recent studies have highlighted concerns about the potential health risks associated with some stabilizers, such as carrageenan (Mirzaei et al., 2023). Thus, there is a need for ongoing research to ensure that stabilizers used in the food industry are safe and effective.

This review article aims to provide a comprehensive overview of the use of stabilizers in the food industry, including the different types of stabilizers, their functional properties, and their applications in various food products. It will also discuss the regulatory aspects of stabilizer use and the safety concerns associated with their use. Furthermore, this review will examine recent research on the development of new and improved stabilizers. Overall, this review article will provide valuable insights into the use of stabilizers in the food industry and its impact on the quality and safety of food products.

Different Types of Stabilizers Use in Food Industry:

1. Hydrocolloids:

Hydrocolloids are polysaccharides that can form a gel-like structure when they are hydrated. Hydrocolloids can be derived from various sources, such as plant exudates, microbial sources, and seaweeds. Examples of hydrocolloids include agar, carrageenan, guar gum, xanthan gum, and pectin. These hydrocolloids are used to improve the texture and stability of various food products, such as ice cream, salad dressings, and sauces.

Studies have shown that hydrocolloids can significantly enhance the textural and rheological properties of food products. For instance, carrageenan has been found to improve the viscosity and stability of chocolate milk. Guar gum has been reported to enhance the gel-forming properties of yogurt and improve the viscosity and texture of beverages (Gong et al., 2012). Xanthan gum has been shown to increase the stability of salad dressings and sauces.

Ingredient	Source	Purpose	Applications
Agar-agar	Algae	Stabilizing, thickening and gelling	Confectionery, bakery products, dairy products, soups and sauces
Algiantes	Seaweed	Stabilizing and thickening	Reformed foods such as onion rings and fillings, bakery creams and fruit fillings

Carrageenan	Seaweed	Stabilizing	Dairy and meat products
Cellulose Derivatives	Plants	Stabilizing and thickening	Dairy and bakery products, beverages, syrups, sauces and soups
Gelatin	Animal collagen	Stabilizing and gelling	Confectionary, dairy products and desserts and low-fat spreads
Gum Arabic	Tree exudates	Stabilizing and thickening	Alcoholic beverages, frozen desserts, food dressings and flavorings
Gum karaya	Tree exudates	Stabilizing	Icings, confectionary, dressings and sauces, ice creams and baked goods
Pectin	Fruit	Stabilizer, thickening and gelling	Fruit-based products, dairy products, confectionery, bakery products and spreads
Tragacanth gum	Tree exudates	Stabilizing and thickening	Icings, confectionary, dressings and sauces, ice creams and baked goods
Xanthan	Fermented sugar	Stabilizing	Sauces and dressings, baked goods, beverages, desserts and ice creams

Table 1: Source, characteristics and applications of commonly used food hydrocolloids.

2. Proteins:

Proteins are another type of stabilizer used in the food industry. Proteins can be derived from plant or animal sources and are used to improve the texture and stability of food products. Examples of protein stabilizers include gelatin, casein, whey protein, and soy protein. Proteins can act as emulsifiers, foam stabilizers, and gelling agents.

Research has shown that proteins are highly effective stabilizers that can improve the quality and stability of food products. For instance, soy protein has been found to improve the stability and texture of mayonnaise (Mihalca et al., 2021). Whey protein has been reported to enhance the stability of oil-in-water emulsions and improve the texture of cheese (Akhtar et al., 2023). Casein has been shown to improve the stability and texture of ice cream (Shukri et al., 2014)

3. Emulsifiers:

Emulsifiers are molecules that stabilize oil-in-water emulsions and water-in-oil emulsions. Emulsifiers have both hydrophilic and hydrophobic properties, which allow them to stabilize the interface between oil and water. Examples of emulsifiers include lecithin, mono- and diglycerides, and polysorbate 80. Emulsifiers are commonly used in salad dressings, mayonnaise, and margarine.

Studies have demonstrated the effectiveness of emulsifiers in stabilizing food products. For example, lecithin has been found to improve the stability of chocolate products (Zou et al., 2020). Polysorbate 80 has been shown to enhance the stability of oil-in-water emulsions and improve the texture of ice cream (Muse and Hartel 2004). Mono- and diglycerides have been reported to improve the texture and stability of bakery products (Yesil and Levent 2022).

4. Antioxidants:

Antioxidants are used to prevent oxidation and rancidity in food products. These stabilizers can be either synthetic or natural and are commonly used in food products that contain oils and fats. Examples of antioxidants include butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), and tocopherols.

Studies have shown that antioxidants can effectively prevent oxidation and maintain the quality of food products. For example, BHA and BHT have been found to be highly effective in preventing the oxidation of fats and oils in various food products(Olajide et al., 2022). Tocopherols have been shown to prevent the oxidation of oils and fats in meat products, thereby increasing their shelf life (Nacak et al.,2023).

Some Biosynthesis Pathways of Hydrocolloids:

1. Biosynthesis pathway of Xanthan Gum

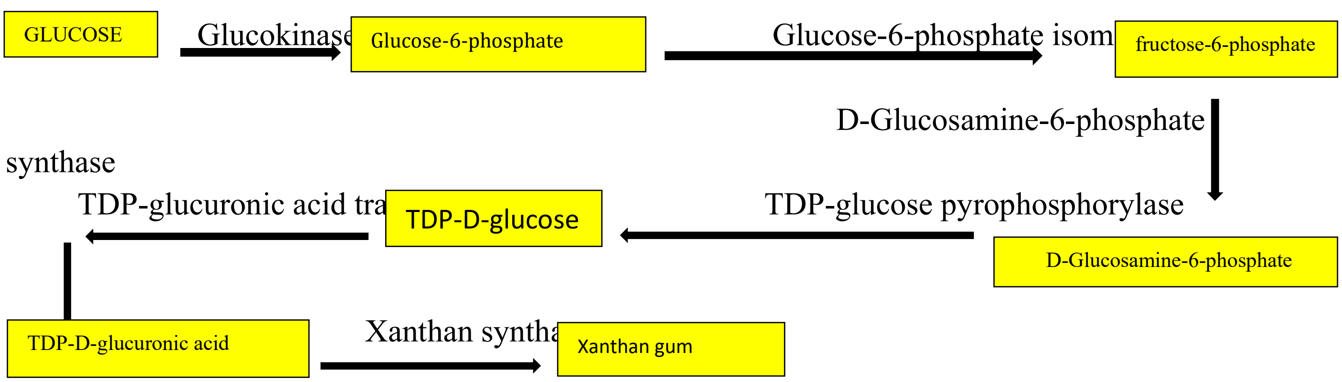

Chart-1 Biosynthesis pathways of Xanthan Gum in *Xanthomonas campestris*.

Glucokinase phosphorylates glucose to form glucose-6-phosphate, which is then isomerized to fructose-6-phosphate by glucose-6-phosphate isomerase. D-Glucosamine-6-phosphate synthase converts fructose-6-phosphate to D-glucosamine-6-phosphate, which is then transformed into TDP-D-glucose by TDP-glucose pyrophosphorylase. TDP-D-glucose is further converted to TDP-D-glucuronic acid by TDP-glucuronic acid transferase. Finally, xanthan synthase polymerizes TDP-D-glucuronic acid and TDP-D-glucose to form the xanthan gum polysaccharide (Bhat et al., 2022 & Hajikhani et al., 2019).

2. Biosynthesis pathway of Guar Gum

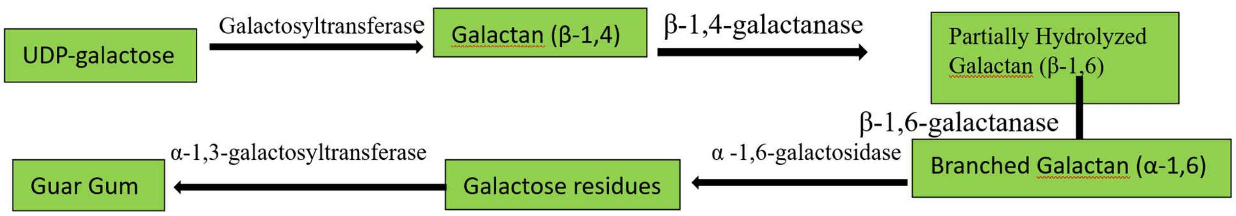

Chart 2: biosynthesis pathway of Guar gum in the plant *Cyamopsis tetragonoloba.*

Galactosyltransferase transfers a galactose residue from UDP-galactose to the growing galactan chain, forming a β-1,4-galactan. β-1,4-galactanase cleaves the β-1,4-galactan into partially hydrolyzed galactan chains with β-1,6 linkages. β-1,6-galactanase cleaves the β-1,6 linkages, leading to the formation of branched galactan chains with α-1,6 linkages. α-1,6-galactosidase cleaves the α-1,6 linkages to release galactose residues, while α-1,3-galactosyltransferase adds galactose residues to form the branched regions of the guar gum polysaccharide (Qi et al., 2020).

3. Biosynthesis pathway of carrageenan

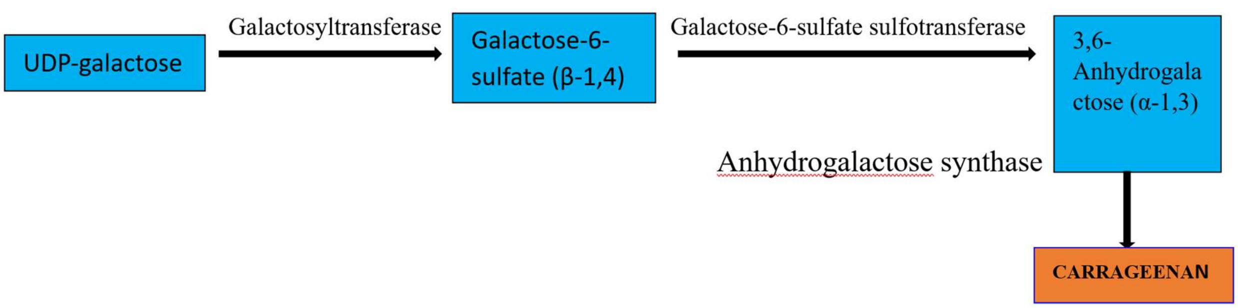

Chart 3: The biosynthesis pathway of carrageenan in red algae

Galactosyltransferase transfers a galactose residue from UDP-galactose to a growing galactan chain, forming a β-1,4-galactan. Galactose-6-sulfate sulfotransferase adds a sulfate group to the C-6 position of some of the galactose residues, forming galactose-6-sulfate residues. Anhydrogalactose synthase then catalyzes the conversion of some of the galactose-6-sulfate residues into 3,6-anhydrogalactose residues by eliminating the C-2 and C-3 hydroxyl groups, resulting in the formation of the carrageenan polysaccharide (Cumashi eta al., 2007 & Chauhan and Saxena, 2016).

4. Biosynthesis Pathway of Pectin

Pectin synthase transfers UDP-activated galacturonic acid from UDP-glucose to a growing homogalacturonan chain, forming α-1,4-galacturonan. Pectin methylesterase removes the methyl ester groups from some of the galacturonic acid residues in the homogalacturonan, creating free carboxyl groups. Rhamnosyltransferase adds rhamnose residues to the carboxyl groups, forming rhamnogalacturonan I. Galactosyltransferase adds galactose residues to the rhamnogalacturonan I backbone, forming rhamnogalacturonan II. Finally, arabinosyltransferase adds arabinose residues to the rhamnogalacturonan II backbone, forming the final structure of pectin (Atmadjo et al., 2013 & Harholt et al., 2012)

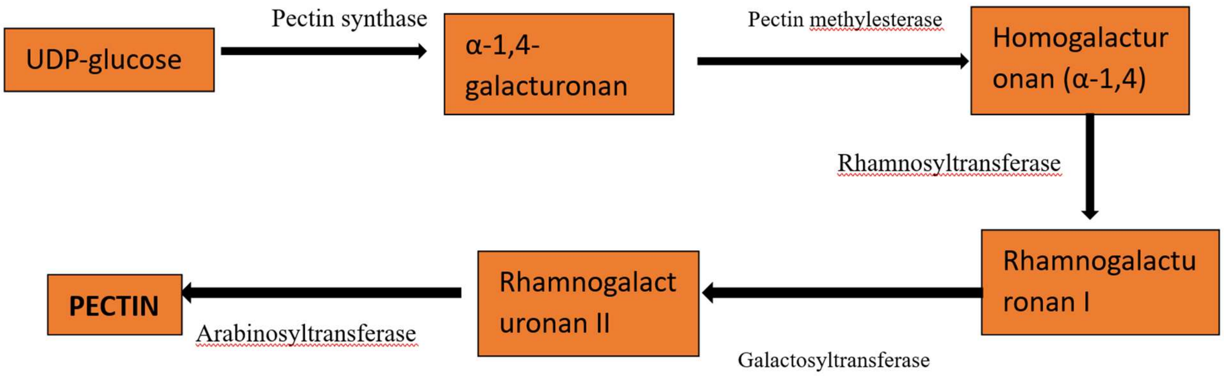

Chart 4: The biosynthesis pathway of pectin in plants

Health Impacts:

Positive health impacts of stabilizers:

Stabilizers are used in a wide range of food products, including dairy products, confectionery, baked goods, beverages, and processed meats. They can provide numerous health benefits when consumed in moderation. For example:

A) Improved digestive health: Some stabilizers, such as inulin, fructooligosaccharides, and resistant starches, act as prebiotics and stimulate the growth of beneficial bacteria in the gut. This can improve digestion, reduce constipation, and enhance overall gut health. A randomized, double-blind, placebo-controlled trial in 120 healthy subjects found that consumption of fructooligosaccharides improved bowel movements and stool consistency, as well as increased the amount of bifidobacteria in the gut (Bouhnik et al., 2004).

B) Lowered cholesterol levels: Carrageenan, a type of seaweed extract commonly used as a stabilizer, has been shown to lower cholesterol levels in animal studies. It works by binding to bile acids in the intestines, preventing their reabsorption, and reducing the amount of cholesterol that the liver needs to produce. A systematic review and meta-analysis of 15 randomized controlled trials found that carrageenan supplementation significantly reduced total cholesterol levels (Pradhan and Ki, 2023)

C) Reduced risk of obesity: Stabilizers can help reduce the caloric content of food products by replacing some of the fat and sugar. This can help reduce the risk of obesity and related diseases, such as type 2 diabetes. A randomized, double-blind, controlled trial in 46 overweight or obese individuals found that consumption of a low-calorie yogurt containing inulin resulted in greater weight loss and reduced waist circumference compared to a regular yogurt (Parnell and Reimer, 2009).

D) Increased satiety: Some stabilizers, such as pectin and guar gum, can increase the feeling of fullness and reduce hunger. This can help with weight management and reduce overeating. A randomized, double-blind, placebo-controlled trial in 24 healthy subjects found that consumption of pectin increased feelings of fullness and reduced food intake (Wu et al., 2009).

E) Enhanced calcium absorption: Some stabilizers, such as xanthan gum, can enhance the absorption of calcium in the gut, which can help maintain healthy bones and prevent osteoporosis. A randomized, double-blind, controlled trial in 44 postmenopausal women found that consumption of xanthan gum significantly increased calcium absorption compared to a placebo (Heaney et al., 2001).

Negative Health Impact of Stabilizers:

A) Digestive Issues: Stabilizers such as carrageenan and xanthan gum have been shown to cause digestive issues, including bloating, gas, and diarrhea. A study found that carrageenan exposure in mice resulted in glucose intolerance, insulin resistance, and inhibition of insulin signaling in HepG2 cells (Bhattacharyya et al., 2012).

B) Allergic Reactions: Carrageenan has been linked to allergic reactions, including hives and skin rashes. According to a review by Tobacman, carrageenan has been shown to induce inflammation in animals, which could contribute to allergic reactions (Tobacman, 2001).

C) Hormonal Disruption: Xanthan gum has been found to cause hormonal disruption in animals. Xanthan gum promoted colonic inflammation and tumor growth in mice through modulation of gut microbiota (Schnizlein et al., 2019). In another study, rats exposed to xanthan gum experienced decreased testosterone levels, increased estrogen levels, and reduced sperm count (Cani et al., 2009).

D) Increased Risk of Cancer: Carrageenan has been associated with an increased risk of colon cancer. Carrageenan exposure caused inflammation and damage to the intestinal lining, increasing the risk of colon cancer (Tobacman, 2001). The combination of carrageenan and xanthan gum had a synergistic effect on the development of colon cancer in mice (Zhang et al., 2023).

Toxic Effect:

One commonly used stabilizer is carrageenan, a seaweed-derived compound used in a wide variety of processed foods, including dairy products, meat products, and infant formula. Studies have shown that exposure to carrageenan can lead to glucose intolerance, insulin resistance, and inhibition of insulin signaling in HepG2 cells and C57BL/6J mice (Bhattacharyya et al., 2012). In addition, carrageenan has been found to disrupt gut permeability and alter gut microbiota, leading to inflammation and exacerbation of colitis in mice (Zhang et al., 2023). These findings suggest that carrageenan may have toxic effects on metabolic health and gut function.

Another commonly used stabilizer is xanthan gum, a microbial-derived compound used in a variety of food products, including sauces, dressings, and baked goods. Recent studies have shown that xanthan gum can promote colonic inflammation and tumor growth in mice by modulating gut microbiota (Schnizlein et al., 2019). In addition, xanthan gum has been found to exacerbate colitis in mice by promoting bacterial growth and altering gut microbiota (Zhang et al., 2023). These findings suggest that xanthan gum may have toxic effects on gut health and contribute to the development of inflammatory bowel disease.

Other stabilizers commonly used in the food industry include guar gum, locust bean gum, and cellulose gum. While these compounds are generally considered safe, there is limited research on their potential toxic effects on human health. Studies have suggested that guar gum may have a laxative effect and cause gastrointestinal symptoms in some individuals (Li et al., 2020). Locust bean gum has been found to cause allergic reactions in some individuals (Mortensen et al., 2017). Cellulose gum has been shown to have a laxative effect in some individuals (Muller-Lissner et al., 2005). While these effects are generally considered mild and transient, further research is needed to fully understand the toxic effects of these stabilizers on human health.

Current Market Scenario:

The use of stabilizers in the food industry has become increasingly important due to the growing demand for convenience foods and longer shelf life. Stabilizers are used to maintain the texture, appearance, and flavor of food products by preventing separation, settling, and other undesirable changes.

One of the most commonly used stabilizers in the food industry is carrageenan, a natural polysaccharide extracted from red seaweed. Carrageenan is widely used in dairy products, such as ice cream and yogurt, as well as in meat products, sauces, and baked goods. Other commonly used stabilizers include xanthan gum, guar gum, and agar.

According to a market research report by Grand View Research, Inc., the global market for food stabilizers was valued at USD 7.5 billion in 2020 and is expected to reach USD 10.2 billion by 2027, growing at a CAGR of 4.3% from 2021 to 2027 (FDA 2021). The report cites the growing demand for processed and convenience foods, as well as the increasing use of stabilizers in the pharmaceutical industry, as key drivers of this growth.

However, the use of stabilizers has also been the subject of controversy due to concerns about their safety and potential health effects. For example, there have been debates about the safety of carrageenan, with some studies suggesting that it may cause inflammation and digestive problems (Tobacman, 2001). Similarly, the safety of some synthetic stabilizers, such as titanium dioxide and butylated hydroxyanisole (BHA), has been questioned due to their potential carcinogenic effects (NIH 2021).

The market for food stabilizers is expected to continue to grow due to the increasing demand for processed and convenience foods. However, the industry will need to address concerns about the safety and potential health effects of these additives to ensure consumer confidence and long-term growth.

Regulations on use of stabilizers by different countries:

Some studies have suggested that certain stabilizers, such as carrageenan and xanthan gum, may have negative health effects, including inflammation and digestive issues (Tobacman, 2001 & Riaz et al., 2021). However, other studies have found no significant health risks associated with these additives, and regulatory agencies have generally deemed them safe for consumption within specified usage levels (FAO/WHO 2018 & FDA 2021).

This ongoing research and debate underscores the importance of robust regulation and monitoring of food additives, as well as the need for transparency and clear communication about the risks and benefits of these additives for consumers.

In addition to scientific research, consumer awareness and advocacy also play a role in shaping regulations for food additives, including stabilizers. For example, in response to concerns about the safety of certain stabilizers, some consumer groups have called for tighter regulation or even outright bans on these additives (CSPI 2021).

The use of stabilizers in the food industry is regulated by different countries to ensure the safety and quality of food products. These regulations typically specify the types and amounts of stabilizers that can be used in food products, as well as the labeling requirements for these additives.

In the United States, the use of food stabilizers is regulated by the Food and Drug Administration (FDA). The FDA maintains a list of approved food additives, including stabilizers, that have been deemed safe for consumption. Stabilizers must be used in accordance with FDA regulations, including maximum usage levels, and must be listed on food labels if present in the product above a certain threshold (FDA 2021).

Similarly, the European Union (EU) regulates the use of stabilizers through the European Food Safety Authority (EFSA). The EFSA evaluates food additives, including stabilizers, for safety before they are approved for use in the EU. Stabilizers must also be labeled on food products in the EU, and manufacturers must adhere to maximum usage levels set by the EFSA (EFSA 2021).

In Japan, the Ministry of Health, Labour and Welfare (MHLW) regulates the use of food additives, including stabilizers, through the Food Sanitation Act. The MHLW maintains a list of approved food additives, and stabilizers must be used in accordance with the maximum usage levels specified on this list. Food products containing stabilizers must also be labeled with the specific name and function of the stabilizer (MHLW 2021).

In Brazil, the use of sodium alginate as a stabilizer in food products is limited to certain categories of products, such as canned fruits and vegetables, and must be used within the maximum usage levels specified by the National Health Surveillance Agency (ANVISA) (NHSA 2021).

Similarly, in India, the use of some stabilizers, such as sodium carboxymethyl cellulose (CMC), is regulated by the Food Safety and Standards Authority of India (FSSAI). The FSSAI specifies the types and amounts of stabilizers that can be used in food products, and these additives must be listed on food labels if present above a certain threshold (FSSAI 2021).

Conclusion:

In conclusion, stabilizers are essential additives that play a crucial role in the food industry by improving the texture, consistency, and shelf life of food products. Hydrocolloids, proteins, emulsifiers, and antioxidants are the four main types of stabilizers used in the food industry. These stabilizers offer a range of functional properties and are used in various food products, such as ice cream, sauces, beverages, and dressings. While the use of stabilizers has many benefits, there are also concerns regarding their safety and regulatory aspects. Therefore, ongoing research is necessary to ensure the safe and effective use of stabilizers in the food industry. Recent research has focused on developing new and improved stabilizers that are safe and effective for use in food products. This review article has provided valuable insights into the use of stabilizers in the food industry, including their functional properties, applications, regulatory aspects, safety concerns, and recent developments. Overall, the use of stabilizers has revolutionized the food industry and is likely to continue to do so in the future, enabling the production of high-quality, convenient, and safe food products.

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