



# Health Risks of Food Additives in Modern Diets and Implications for Food Safety

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## Abstract

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Food additives are widely used in modern food systems to enhance quality, stability, and sensory characteristics, but their increasing presence in processed foods raises concerns regarding potential health risks. This study evaluates the health implications of food additives by synthesizing recent evidence on additive types, dietary exposure patterns, toxicological mechanisms, and regulatory frameworks. A qualitative Systematic Literature Review (SLR) approach was applied to analyze peer-reviewed studies published between 2017 and 2025. The findings indicate that additives are commonly consumed in combination through processed foods, leading to cumulative exposure. Toxicological effects are associated with mechanisms such as oxidative stress, inflammation, and metabolic disruption, which may contribute to long-term health outcomes. The study also highlights limitations in current risk assessment approaches, particularly in addressing combined and long-term exposure. These findings emphasize the need for more integrative frameworks to improve food safety evaluation and regulatory strategies.

## **1. Introduction**

Food additives play a crucial role in modern food systems by enhancing shelf life, improving sensory qualities, and maintaining product stability. These substances, which include preservatives, colorants, emulsifiers, and sweeteners, are intentionally added during food processing to achieve specific functional purposes (Pressman et al., 2017; Kumar et al., 2019). As the demand for processed and convenience foods continues to increase, the use of food additives has become more widespread across global food supply chains. While many additives are considered safe within regulated limits, concerns have emerged regarding their potential long-term health effects. These concerns are particularly relevant given the increasing frequency and quantity of additive consumption in modern diets. Consequently, understanding the implications of additive exposure has become an important focus in food safety research.

The health impact of food additives is influenced by both their chemical properties and patterns of dietary exposure. Certain additives have been associated with adverse health outcomes, including metabolic disorders, gastrointestinal disturbances, and potential carcinogenic effects (Trasande et al., 2018). In addition, growing evidence suggests that high consumption of ultra-processed foods, which often contain multiple additives, may be linked to increased health risks (Pagliai et al., 2021; Fiolet et al., 2018). These findings highlight that exposure is not limited to individual additives but often involves combinations that may produce cumulative or interactive effects. Furthermore, the variability in individual consumption patterns

and susceptibility adds complexity to assessing health risks. This indicates that traditional safety evaluations may not fully capture real-world exposure conditions.

Regulatory frameworks have been developed to ensure the safe use of food additives, typically based on toxicological data and acceptable daily intake (ADI) thresholds. These frameworks provide important guidance for controlling exposure and maintaining food safety standards. However, recent research has questioned whether current regulatory approaches adequately address emerging challenges, such as long-term exposure, combined effects, and new forms of additives such as nanoparticles (Wu et al., 2022). The increasing diversity of additives and their applications in food production further complicates risk assessment and monitoring efforts. As food systems continue to evolve, ensuring the effectiveness of regulatory measures becomes increasingly important. This calls for continuous evaluation and adaptation of existing safety frameworks.

Despite extensive research, several gaps remain in understanding the health risks associated with food additives in modern diets. Many studies focus on individual additives under controlled conditions, which may not reflect the complexity of real-world consumption patterns. In addition, there is limited integration between toxicological findings and dietary exposure data, which is necessary for comprehensive risk assessment. The rapid expansion of processed food consumption further amplifies these challenges, as it increases the likelihood of cumulative exposure. These limitations suggest that current approaches may underestimate the true impact of additives on human health. Addressing these gaps

requires a more integrative perspective that considers both exposure and biological mechanisms.

This study aims to evaluate the health risks of food additives in modern diets and their implications for food safety by synthesizing recent evidence on additive types, exposure patterns, toxicological mechanisms, and regulatory considerations. Using a qualitative Systematic Literature Review (SLR) approach, this study seeks to provide a comprehensive understanding of how food additives influence human health in contemporary food systems. The analysis emphasizes the importance of considering cumulative exposure, evolving consumption patterns, and emerging scientific evidence. By integrating these aspects, the study contributes to improving risk assessment and supporting more effective food safety strategies.

## **2. Literature Review**

### **2.1. Types and Functional Roles of Food Additives**

Food additives encompass a wide range of substances that are intentionally incorporated into food products to achieve specific technological and sensory functions. These include preservatives, colorants, emulsifiers, flavor enhancers, and sweeteners, each serving distinct roles in maintaining food quality and stability (Sharma et al., 2018). Colorants are used to improve visual appeal, while preservatives inhibit microbial growth and extend shelf life. Emulsifiers contribute to texture and consistency by stabilizing mixtures of immiscible components, and sweeteners provide taste enhancement with reduced caloric content. Maronpot et al. (2020) highlight that both natural and synthetic additives are widely used, often with

varying toxicological profiles. In addition, classification systems for additives are essential for regulatory purposes and safety evaluation (Sezgin et al., 2017). These functional roles demonstrate that additives are integral to modern food production but also introduce complexity in assessing their safety.

## **2.2. Dietary Exposure and Consumption Patterns**

Dietary exposure to food additives is largely influenced by consumption patterns, particularly the increasing intake of processed and ultra-processed foods. Studies have shown that individuals with higher consumption of such foods are more likely to experience elevated exposure to multiple additives simultaneously (Pagliai et al., 2021). This is significant because additives are rarely consumed in isolation, and their combined presence in food products may contribute to cumulative exposure. Fiolet et al. (2018) report associations between ultra-processed food consumption and increased health risks, suggesting that additive exposure may play a contributing role. Emulsifiers, for example, are widely present in processed foods and have been linked to changes in gut microbiota and metabolic effects (Cox et al., 2021). The frequency and quantity of additive intake therefore depend not only on food composition but also on dietary habits. These patterns highlight the importance of considering real-world consumption in evaluating exposure risks.

## **2.3. Toxicological Mechanisms of Food Additives**

The potential health effects of food additives are closely related to their interactions with biological systems at the cellular and molecular levels. Certain additives have been shown to induce cytotoxicity, oxidative stress, and inflammatory responses, depending on their chemical composition and concentration. Youn and

Choi (2022) demonstrate that some nanoparticle-based additives, such as zinc oxide, can exhibit unique toxicological behaviors due to their size and reactivity. Artificial sweeteners have also been studied for their potential metabolic and physiological effects, including alterations in glucose metabolism and gut microbiota (Ali et al., 2021). In addition, experimental studies have identified varying levels of toxicity among different additives, indicating that effects are not uniform across categories (Samoilov et al., 2019). These findings suggest that understanding mechanisms of action is essential for assessing potential health risks. The diversity of additives further complicates the evaluation of their biological effects.

#### **2.4. Risk Assessment and Regulatory Frameworks**

Risk assessment for food additives is primarily based on toxicological testing and the establishment of acceptable daily intake (ADI) levels. These frameworks aim to ensure that additives are safe for consumption within defined limits. Fitch et al. (2021) explain that ADI values are used as health-based benchmarks to guide regulatory decisions and exposure assessments. Regulatory agencies also evaluate additives based on factors such as chemical properties, exposure levels, and intended use in food products. However, emerging evidence suggests that traditional approaches may not fully capture the complexity of long-term and combined exposures (Gürtler, 2021). EFSA (2021) highlights the need to consider new forms of additives, including nanomaterials, which may require updated assessment methods. Stanković and Zrnić-Ćirić (2021) further emphasize that regulatory frameworks must adapt to evolving scientific knowledge and food production

practices. These developments indicate that risk assessment is an evolving process that requires continuous refinement.

### **2.5. Limitations and Research Gaps**

Despite extensive regulatory oversight and scientific research, several limitations remain in understanding the health risks associated with food additives. Many studies focus on individual substances under controlled experimental conditions, which may not reflect real-world consumption scenarios involving multiple additives. Ukwo et al. (2022) note that safety concerns persist due to uncertainties regarding long-term exposure and combined effects. In addition, there is limited integration between toxicological data and dietary exposure patterns, which is necessary for comprehensive risk evaluation. Wu et al. (2022) highlight the importance of improving analytical methods to better detect and quantify additives in complex food systems. The growing diversity of additives and their applications further complicates assessment and monitoring efforts. These gaps suggest the need for more integrative and interdisciplinary approaches in future research.

## **3. Methods**

This study employs a qualitative Systematic Literature Review (SLR) approach to examine the health risks of food additives in modern diets and their implications for food safety. The SLR method enables a structured and comprehensive synthesis of existing scientific literature across disciplines such as food science, toxicology, and public health, without generating new experimental data. Relevant studies were identified through academic databases including Google Scholar, Scopus-indexed

journals, and publisher platforms such as Elsevier, Springer, and MDPI to ensure broad and reliable coverage. The search strategy utilized combinations of keywords including “food additives,” “dietary exposure,” “toxicology,” “risk assessment,” and “food safety” to capture studies addressing additive types, exposure patterns, biological effects, and regulatory considerations. The inclusion criteria were limited to peer-reviewed articles published between 2017 and 2025, ensuring both foundational and recent developments were considered. Selected studies were evaluated based on their relevance to human health implications and were analyzed using thematic synthesis to identify key patterns, relationships, and research gaps.

#### **4. Results**

This section presents the synthesized findings on food additive exposure, focusing on functional roles, dietary intake patterns, toxicological mechanisms, and risk assessment considerations. The results indicate that food additives are widely distributed across modern food systems and are consumed regularly through processed and ultra-processed foods. Their presence is closely linked to technological functions in food production, which influence both product quality and shelf life. However, the widespread use of additives also increases the likelihood of repeated and cumulative exposure among consumers.

The analysis further shows that exposure patterns vary depending on dietary habits, food preferences, and consumption frequency. These variations highlight the importance of considering real-world consumption scenarios in evaluating health

risks. Overall, the findings emphasize that food additive exposure is a routine and multifactorial aspect of modern diets.

#### 4.1. Sources and Distribution of Heavy Metals in Food Systems

The findings show that food additives serve multiple functional roles in food systems, including preservation, coloration, emulsification, and flavor enhancement. These functions are essential for maintaining product stability, improving sensory qualities, and extending shelf life. Sharma et al. (2018) note that additives are widely used across various food categories, reflecting their importance in industrial food production. Colorants and preservatives are among the most commonly used additives, while emulsifiers and sweeteners are prevalent in processed foods (Maronpot et al., 2020). Classification systems help organize additives based on their functions and chemical properties, supporting regulatory evaluation (Sezgin et al., 2017). The distribution of additives across food products indicates that consumers are exposed to multiple additive types simultaneously. This widespread use highlights the need to understand both their benefits and potential risks.

**Table 1.** Functional Categories and Roles of Food Additives

<b>Additive Type</b>	<b>Function</b>	<b>Common Use in Food</b>	<b>Example Effect</b>
Preservatives	Inhibit microbial growth	Packaged foods	Extended shelf life
Colorants	Enhance visual appearance	Beverages, snacks	Improved product appeal
Emulsifiers	Stabilize mixtures	Processed foods	Improved texture
Sweeteners	Provide sweetness	Low-calorie products	Reduced sugar content

## **4.2. Dietary Exposure and Consumption Patterns**

The results indicate that dietary exposure to food additives is primarily driven by consumption of processed and ultra-processed foods. Individuals with higher intake of such foods tend to experience greater exposure to multiple additives simultaneously (Pagliai et al., 2021). Fiolet et al. (2018) report that increased consumption of ultra-processed foods is associated with higher health risks, suggesting a link between additive exposure and adverse outcomes. Emulsifiers, for instance, are commonly found in a wide range of processed products and contribute significantly to overall intake (Cox et al., 2021). Exposure levels are influenced by factors such as dietary habits, socioeconomic conditions, and food availability. These variations make it difficult to generalize exposure across populations. The findings highlight the importance of considering cumulative exposure rather than isolated intake.

## **4.3. Toxicological Mechanisms and Biological Effects**

The findings show that food additives can influence biological systems through various toxicological mechanisms, depending on their chemical composition and level of exposure. Certain additives have been associated with oxidative stress, inflammation, and cellular damage, which may contribute to long-term health effects. Youn and Choi (2022) demonstrate that nanoparticle-based additives can exhibit unique interactions within biological systems due to their size and reactivity. Artificial sweeteners have also been linked to metabolic changes and potential alterations in gut microbiota (Ali et al., 2021). Experimental studies indicate that toxicity levels vary among additives, highlighting differences in their biological

impact (Samoilov et al., 2019). These findings suggest that evaluating additive safety requires understanding both their chemical properties and biological interactions. The diversity of additives further complicates the assessment of their effects.

**Table 2.** Mechanisms and Health Effects of Food Additives

<b>Mechanism</b>	<b>Description</b>	<b>Biological Impact</b>	<b>Potential Health Outcome</b>
Oxidative stress	Imbalance of ROS and antioxidants	Cellular damage	Chronic disease
Inflammation	Activation of immune response	Tissue damage	Metabolic disorders
Metabolic disruption	Interference with metabolic pathways	Altered physiology	Obesity, diabetes
Cellular toxicity	Direct damage to cells	Functional impairment	Organ-related diseases

#### **4.4. Risk Assessment and Regulatory Considerations**

The results indicate that risk assessment for food additives is based on toxicological evaluation and regulatory frameworks designed to ensure safe consumption levels. Acceptable daily intake (ADI) values are commonly used as benchmarks for evaluating safety (Fitch et al., 2021). Regulatory agencies assess additives based on their chemical properties, intended use, and exposure levels. However, emerging evidence suggests that traditional approaches may not fully capture the complexity of long-term and combined exposure scenarios (Gürtler, 2021). EFSA (2021) highlights the need to consider new forms of additives, such as nanomaterials, which may require updated assessment methods. Stanković and Zrnić-Ćirić (2021) emphasize that regulatory frameworks must adapt to evolving

scientific knowledge and consumption patterns. These findings suggest that current risk assessment approaches require continuous refinement.

#### **4.5. Interpretation of Key Findings**

The synthesis indicates that food additive exposure is a routine component of modern diets, shaped by industrial food production and consumption patterns. The interaction between additive functions, dietary habits, and biological mechanisms creates complex exposure scenarios that vary across populations. A key insight is that additives are rarely consumed individually, and their combined presence may influence overall health outcomes. The findings also highlight that biological effects are influenced by both chemical properties and exposure conditions. In addition, regulatory frameworks play a critical role in managing risk but must evolve to address emerging challenges. These insights suggest that a more integrative approach is needed to evaluate additive safety. This interpretation reinforces the importance of aligning scientific evidence with real-world consumption patterns.

### **5. Discussion**

The findings indicate that food additives are deeply embedded in modern food systems and play a significant role in shaping dietary exposure patterns. Their widespread use in processed and ultra-processed foods means that consumers are routinely exposed to multiple additives rather than isolated substances. This highlights the importance of considering cumulative exposure when evaluating potential health risks. In addition, the functional necessity of additives in food

production creates a balance between technological benefits and potential health concerns. The variability in consumption patterns across populations further complicates the assessment of exposure and risk. These factors suggest that food additive safety cannot be fully understood without considering real-world dietary behaviors. A broader perspective is therefore needed to evaluate both the benefits and risks of additive use.

Another important implication is that current risk assessment approaches may not fully capture the complexity of additive exposure in modern diets. Traditional models often rely on individual substance evaluation and fixed safety thresholds, which may not reflect combined or long-term exposure scenarios. The presence of shared biological mechanisms, such as oxidative stress and metabolic disruption, suggests that different additives may contribute to similar health outcomes. In addition, emerging forms of additives, including nanomaterials, introduce new uncertainties in safety evaluation. These challenges highlight the need for more integrative frameworks that consider interactions between additives and variability in exposure. Improving regulatory strategies will require continuous adaptation to evolving scientific evidence and consumption trends. Such developments are essential for maintaining effective food safety systems.

## **6. Conclusion**

This study highlights that food additives are an integral component of modern food systems, contributing to product stability, safety, and consumer appeal. However, their widespread use also results in continuous dietary exposure,

particularly through processed and ultra-processed foods. The findings demonstrate that additives are consumed in combination rather than individually, which increases the complexity of assessing their overall impact on human health. In addition, variability in dietary habits and consumption patterns influences exposure levels across populations. These factors indicate that food additive safety must be evaluated within the broader context of modern dietary behavior. A system-level perspective is therefore essential for understanding the implications of additive use in food systems.

From a toxicological standpoint, the study emphasizes that food additives can affect biological systems through mechanisms such as oxidative stress, inflammation, and metabolic disruption. These mechanisms are associated with a range of potential health outcomes, depending on exposure level and duration. The diversity of additives and their varying chemical properties further complicate the evaluation of their effects. Importantly, the findings suggest that even low-level exposure may have cumulative impacts when it occurs over extended periods. This reinforces the need to consider long-term exposure and biological interactions in risk assessment. Understanding these mechanisms provides a more comprehensive basis for evaluating additive safety.

In terms of practical implications, the study underscores the need to enhance current risk assessment and regulatory frameworks for food additives. Traditional approaches based on individual substances and fixed thresholds may not adequately reflect real-world exposure conditions. Future research should focus on developing more integrative assessment models that account for cumulative exposure and

variability in dietary patterns. Strengthening monitoring systems and improving analytical methods are also important for accurately detecting additives in complex food products. In addition, promoting transparency in food labeling can help consumers make informed choices. These efforts require collaboration across scientific, regulatory, and industrial sectors. By addressing these challenges, it is possible to improve food safety and better protect public health.

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