HIGH SCHOOL EDITION
Journal of Student Research
Volume 13 Issue 4 (2024)

Artificial Food Additives and Their Impacts on Carcinogenicity

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ABSTRACT

In the modern era, food processing and preservation have become indispensable practices to meet the demands of an ever-growing global population. Additives and preservatives are pivotal in extending the shelf life of foods and drinks and maintaining their palatable value. However, as the prevalence of food additives and preservatives rises, concerns regarding their potential health implications have increased as well. The primary concern and focus of this research paper is associated with food additives and preservatives and their effects on the formation, accumulation, and abundance of carcinogens in food products. Carcinogens are substances capable of inducing mutations and other cancerous changes within cells, posing a prevalent threat to human health when consumed over extended periods.

Introduction

The link between food components and cancer incidence is well-documented, but various specific components are yet to be identified and the underlying mechanisms are still unclear. Foods and drinks contain complex mixtures of chemicals, and the interactions between different present in these products for potential carcinogenic effects are not fully understood. Studying these interactions could provide insights into potential synergistic or antagonistic effects on carcinogenicity. Food additives, preservatives, pesticides, and environmental contaminants can potentially contribute to the amount of carcinogens in foods and drinks. With the growing interest and attraction to processed foods and drinks, the global population is vulnerable to its effects. Although the interaction between additives and carcinogens remains a complex and multifaceted issue, it is crucial to understand it for the safeguarding of public health.

Methodology

This research paper provides a comprehensive analysis of the effects of artificial additives and preservatives on the abundance and potency of carcinogens in common processed foods and beverages. By synthesizing existing literature, examining experimental findings, and evaluating regulatory frameworks to form a secondary literature review, this study seeks to elucidate the mechanism underlying carcinogen formation and its existence in the presence of additives and preservatives. This paper will explore the potential health implications of prolonged exposure to carcinogens in food, addressing concerns related to cancer risk and other adverse health outcomes. Through a critical examination of relevant studies and scientific evidence, this research paper aims to identify gaps in current knowledge and propose avenues for future research to mitigate the risks associated with food additives and preservatives. Ultimately, by shedding light on the intricate interplay between additives/preservatives and carcinogens, this research endeavor strives to facilitate informed decision-making among consumers, policymakers, and food industry stakeholders. By fostering a deeper understanding of the potential risks and benefits associated with food preservation techniques, we can work to ensure the safety and integrity of the global food supply while prioritizing public health and well-being.

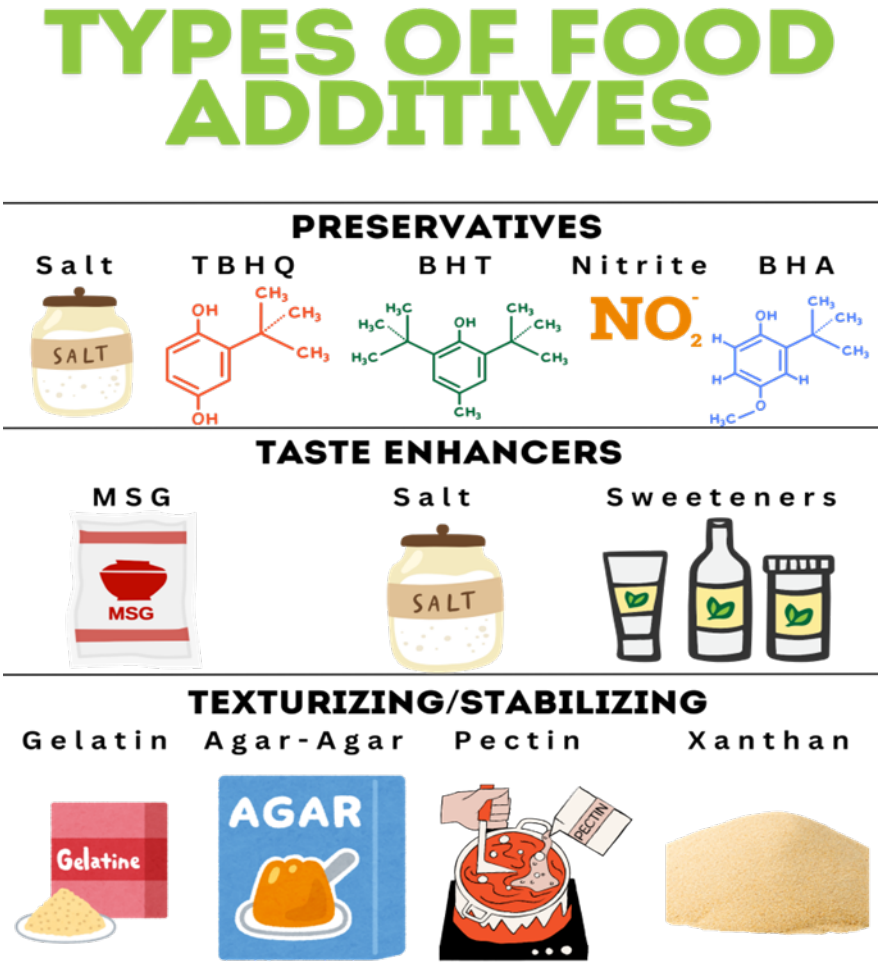
Introduction To Artificial Food Additives

Artificial additives are substances added to food products to enhance flavor, texture, appearance, and shelf life, which undergo rigorous evaluation and regulation to ensure they are safe for consumption or storage to achieve specific purposes like improving taste, texture, color, freshness, shelf life, and nutritional value ("Food Additives."). They are typically not consumed as food themselves but serve particular functions in food products and are classified based on their function regarding food processing. Preservatives, on the other hand, specialize in inhibiting microbial growth and preventing spoilage in food products, therefore extending their shelf life ("What Are Preservatives and What Are Common Examples Used in Food?"). They also protect against bacteria, molds, yeast, and other microorganisms that can cause decay as well as food-borne illnesses ("What Are Preservatives and What Are Common Examples Used in Food?"). In addition, along with the estimated amount of over 2,500 chemical substances added to processed food products, about 1,200 chemicals could enter the food supply without intention ("Food Additives, Contaminants, Carcinogens, and Mutagens"). This could happen with processes of packaging materials, residual pesticides, or animal hormones contributing to the addition of chemicals in the food product. ("Food Additives, Contaminants, Carcinogens, and Mutagens"). Types of food additives are listed in the adjacent original infographic, depicting the main categories of these food additives: preservatives, taste enhancers, and texturizing and stabilizing additives (Prasanna 2024).

Carcinogenicity Of Artificial Food Additives

Although the FDA is in charge of regulating the safety of a variety of food products and production processes, it is apparent that many carcinogens go unregulated through the many loopholes of the limitations on food safety. For example, in a study published in 2006, a group of rats accustomed to a standard diet were split into two groups; one being fed drinking water, and the other being fed Coca-Cola. The second group experienced significantly increased incidents of malignant mammary tumors in females and exocrine adenomas of the pancreas in both genders, implying that many ingredients in Coca-Cola are carcinogenic (Belpoggi). Evidently, due to a lack of understanding of the mechanisms of carcinogenesis regarding regularly used chemicals in manufacturing common foods and drinks, many carcinogens and harmful chemicals are unregulated. Most additives confirmed to be carcinogenic are tested on animals to confirm their state and then prohibited, but some are permitted for use by Congress. Some examples of exceptions are saccharin, a sweetening agent, and vinyl chloride and acrylonitrile, both of which are chemicals residing in the packaging material of multiple processed foods. Both vinyl chloride and acrylonitrile are not classified as additives and thus are exempt by the FDA law which limits food additives only ("Food Additives, Contaminants, Carcinogens, and Mutagens"). Because of the loopholes in the FDA laws regarding the safety of food additives to human health, companies are able to get away with using potential and confirmed carcinogenic additives in processed and packaged foods. In addition, it was found in long-term studies that aflatoxin B1 and polychlorinated biphenyls, unavoidable chemical additives in food, are carcinogenic, but are maintained at the lowest levels possible by the FDA ("Food Additives, Contaminants, Carcinogens, and Mutagens"). Though the FDA limits the levels of many unavoidable carcinogens in foods, it is imperative to understand that no amount of exposure to carcinogens is beneficial. There is a guarantee that the risk of obtaining cancer will be lower, but this will not guarantee being cancer-free. A crucial factor that plays into analyzing risk factors of cancer is understanding the multifactorial nature of the disease, meaning that cancer is caused by multiple different accumulated factors. This is important to know because even small amounts of exposure to carcinogens could contribute to the accumulation of different factors adding to the increasing risk of cancer. A common process is testing for salmonella, which usually provides a clear view of whether a food and its components are safe for consumption but this test could miss out on identifying many mutagens, which can cause heritable alterations in the genetic material of cells or carcinogens in food. ("Food Additives, Contaminants, Carcinogens, and Mutagens"). Additives like nitrites, nitrates, and heavy metals are some common substances tied to the possibility of being potentially carcinogenic in humans. Nitrates and nitrites, found in cured meats and sometimes tap

water, can form nitrosimines, otherwise known as cancer-causing compounds, which are linked to many cancers such as ones of the stomach, esophagus, brain, and thyroid (Khakham). Along with nitrates and nitrites, heavy metals such as arsenic and cadmium are tied to numerous complications like DNA damage, cell death, and an increase in the risk of acquiring cancer (Khakham).



Introduction to Carcinogens

Carcinogens are any agents that have the capability of causing cancer, and can naturally occur in the environment as UV rays and viruses, but can also occur from the actions of mankind, like smoke from cigarettes and exhaust fumes. Carcinogens produce mutations by interfering with a cell's DNA to ultimately result in cancer ("Carcinogen"). 3 classes of carcinogens are distinguished by Weisberger to be ultimate carcinogens, pro-carcinogens, and co-carcinogens. Ultimate carcinogens, or direct action carcinogens, have the ability to create cancer without having a metabolic activation in an organism (Baba). Examples of ultimate carcinogens are epoxides, ethylenimines, β-propiolactone, and nitrosamines. As discussed before, nitrosamines can create cancer without having a metabolic activation in an organism, which leads to the creation of many cancers listed previously. Next, procarcinogens are chemical carcinogens that rely on a previous metabolic activation to create cancer, and some common examples include various colorants and aflatoxins, which were previously described to be essential in preparing processed food for the market, making it impossible to avoid them and be guaranteed safety (Baba). Lastly, co-carcinogens are chemical substances that can

intensify their effect on the carcinogenicity of other substances, but they themselves have no effect on the development of cancer alone (Baba). The direct link between cocarcinogens and food additives is still unclear, but it can be inferred that many carcinogenic food additives contribute to the development of cancer by intensifying their effect on the carcinogenicity of many other substances, further implying the multifaceted nature of cancer is important to be taken into consideration. Carcinogens target the hepatic microsomal system, residing in the endoplasmic reticulum of hepatocytes, and then bind to DNA, RNA, and proteins with a covalent bond in the organs that are targeted (Surat). In the process of binding, the carcinogens damage the DNA directly to create abnormalities, which then leads to the development of cancer (Fayed and Scott). Carcinogens can also have more indirect effects regarding the creation of cancer. Once a cell's DNA is damaged, the body's regulatory processes will not work correctly to repair the damaged DNA because the carcinogens indirectly impact the process, which results in mutations and cancer (Fayed and Scott).

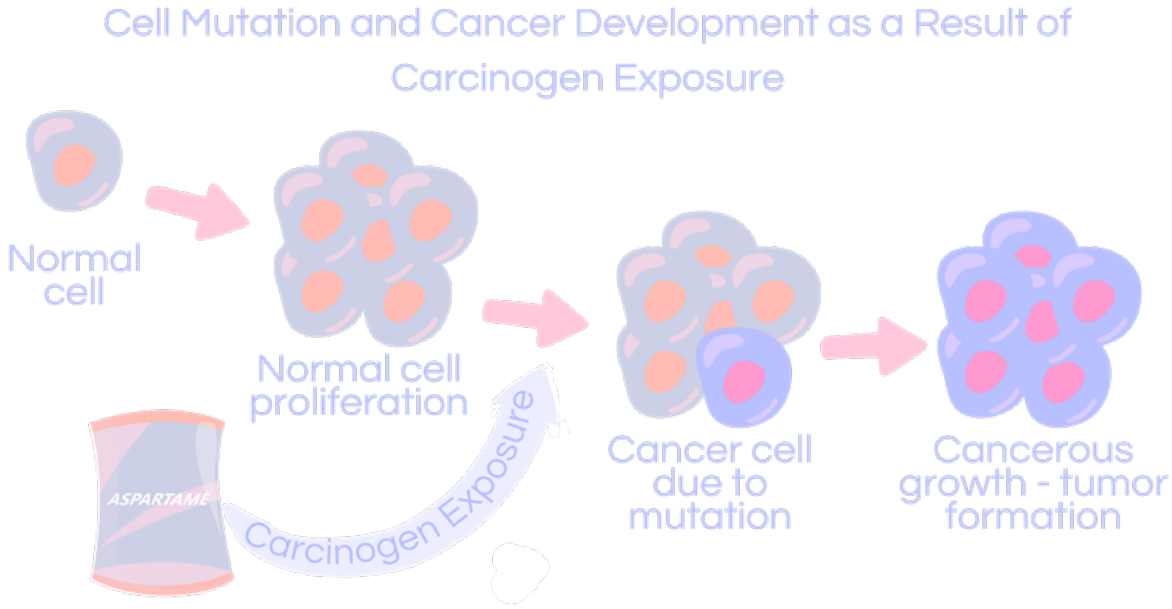
Mechanisms of Carcinogenesis

As technology advances and new methods of molecular analysis cancer biology research have grown more popular, it is shown that carcinogenesis is a multifaceted issue and is more complex than previously perceived (Maronpot). To go deeper into the explanations of the mechanisms of carcinogenesis, it is vital to understand their hallmarks of them and results in genetic alterations in sustaining proliferative signaling, evading growth suppressors, resisting cell death, enabling replicative immortality, inducing angiogenesis, activating invasion and metastasis, reprogramming energy metabolism, and evading immune destruction (Hanahan and Weinberg). There were two predominant theories revolving around carcinogens: humoralist and cellular, meaning that cancer originates from hereditary traits that make a person susceptible to cancer, or that many chemicals can transform cells to create mutations respectively (Maronpot). Cellular theory for carcinogenesis remains the most dominant theory as of now, correlating with recent research and studies conducted that truly explore the mechanisms of how exactly carcinogenesis occurs. Two phases of carcinogenesis are present; initiation and promotion. In the initiation phase, the normal cell has to be activated by physical or chemical carcinogens or viruses for it to then have reversible damage done to itself and in the promotion phase, the cell mutates uncontrollably to a point where it is unrecognizable as a result of the carcinogens (Scott and Wille). Even though there is increasing insight into the initiation and promotion stages of carcinogenesis through recent research, the topic and its biochemical basis are yet to be fully established. Carcinogens, especially common ones found in food additives, have a very limited understanding behind them regarding their mechanisms of action, so there is no specific organization of different groupings of carcinogens other than their effectiveness in their ability to cause tumors and mutative growth (Stewart).

Health Implications

Although it has been mentioned several times that chemicals in certain food additives have to potential to cause cancer, it is important to truly understand all of the other health implications that could be caused as well. For starters, emulsifiers are used to stabilize a food or drink, but an experiment published on Feb 13, 2024 suggests that emulsifiers could increase susceptibility to carcinogenesis, negatively affect the intestinal microbiota, and metabolome, and cause host inflammation (Sellam). The higher intakes of mono and diglycerides of fatty acids and all carrageenans associated with the emulsifier were tied to increased chances of acquiring breast cancer, prostate cancer, or both (Sellam). Emulsifiers are widely used among many processed foods, especially in packaged juices or sodas, and are usually a necessary additive in order to make sure that the goods are ready for the market. This study shows that there is a potential link between emulsifiers and cancer risk but further research and studies are needed to truly solidify these results. Many chemicals that have ties to being carcinogenic, are still found in multiple processed foods in the United States. For starters, a chemical that is found in all supermarkets in many foods is red 40, a red food dye, which contains benzene, a confirmed carcinogenic substance ("Is Red Dye 40 Safe?"). Too much ingestion of red 40 through

artificially dyed foods and drinks such as a seemingly delicious sugar cookie or a refreshing fruit punch drink could result in potential health complications in the future. Furthermore, research conducted with animals shows that the animals who consumed higher amounts of food dyes had tumor growth compared to the group with no amounts of food dyes ingested ("Is Red Dye 40 Safe?"). Similarly, synthetic artificial food colors (AFCs), which include red 40, are used for coloring food in bright, appetizing colors, but they may potentially affect a child's behavior and attention, making them more hyperactive and distracted ("Food Additives: What Parents Should Know"). Another example is titanium dioxide, a chemical still allowed to be used in many processed food products in the U.S. This chemical has the potential to accumulate in the body and cause potential chromosomal damage, which could create gene deregulation or the formation of a hybrid gene, which leads to cancerous growth (Khakham). Next, potassium bromate, found in over 130 packaged food products in the U.S. and a commonly used chemical in flour used in baked goods, is a potential carcinogen to humans, confirmed carcinogen to animals, and hasn't been reviewed by the FDA since 1973 (Khakham). Brominated vegetable oil (BVO) is added to certain soft drinks as a stabilizing agent to ensure it doesn't separate and is tied to increasing risk of cancer, nervous system issues, hyperactivity, and many more behavioral problems when ingested frequently over a long period of time. Recently, in July of 2024, the FDA banned BVO; this law went into effect on August 2, 2024 (Medintz and Krajeski). Also, commonly found in packaged pastries and in about 49 common packaged goods, propyl parabens have links with being a potential endocrine-disrupting agent but are yet to be restricted in the United States (Khakham). When the endocrine system gets damaged or disrupted by a chemical, both benign and malignant tumors can form uncontrollably and have adverse effects on the human body, like extreme genital or hormonal issues ("Endocrine and Thyroid Cancer Types, Stages, and Risk Factors"). To add on, many cancers such as breast, prostate, uterine, ovarian, testicular, and thyroid are impacted by the effects of hormones in the body, and if these are somehow damaged or disrupted by dangerous chemicals or carcinogens in the endocrine system, then the possibility of getting any of these cancers increases drastically (Eldridge). Finally, the chemical aspartame, found in many commonly accessible soft drinks, acts as an artificial sweetener and is ruled as possibly carcinogenic by the International Agency for Research on Cancer, or the IARC, because of limited evidence on the intricacies of its mechanisms in the process of it creating cancerous cells ("Aspartame and Cancer Risk"). This chemical is said to possibly be able to cause liver cancer and blood-related cancers like leukemia and lymphoma. Also, the chemical perchlorate, often found in drinking water and dry food packaging, can disrupt early brain development and function and thyroid function, which can seriously compromise human health (McCarthy). Often the additives meant to make the processed foods more appetizing and appealing to their audience will result in allergic reactions such as diarrhea, colicky pains, hyperactivity, insomnia, irritability, asthma, rhinitis, sinusitis, hives, itching, rashes, swelling ("Food Additives"). The examples listed above are just a handful of suspected and confirmed carcinogens; many more harmful chemicals are still in the market which could possibly have the potential to be carcinogenic or harmful to the human body. Although the effects of food additives on carcinogenicity is the main focus, it is indispensable to acknowledge the other various health effects of food additives on humans.



Taking Action

The regulatory system of the FDA contains many issues within its framework that need reformation in order to further safeguard consumers from the many dangers of food additives. The title “generally recognized as safe” or GRAS is used to group about one thousand commonly used chemicals by manufacturers, who use this title to avoid complications in the process of getting their product out in the market (“Fixing the Oversight of Chemicals Added to Our Food”). According to the FDA regulations, manufacturers require no obligations to tell the FDA about which chemicals they have titled to be GRAS. To continue, it is indispensable for the FDA to be able to come into possession of necessary information in order to draw a parallel concerning chemicals that have already been approved and are currently on the market, but the FDA does not have the authority to do so by the law (“Fixing the Oversight of Chemicals Added to Our Food”). Because of this, the FDA only reassesses chemicals when brought up by a company or when there has been a serious incident and a supposed link to a certain chemical has been made and has not reassessed many chemicals that have been previously approved that are available for purchase currently (“Fixing the Oversight of Chemicals Added to Our Food”). It is recommended by the Pew Charitable Trusts that the FDA should be able to approve the initial use of all new chemicals added to food, review new applications or changes to the uses of previously approved additives, streamline the decision-making process to ensure it is timely and efficient, enhance scientific methods to assess safety, and utilize advanced scientific tools and data to prioritize the reassessment of the safety of existing chemicals in food and takes necessary actions. In addition, the FDA should try and limit the overuse of the GRAS exemption to the best of their abilities, review their outdated information about older chemicals, and use more contemporary scientific processes to ensure the utmost protection of the food supply from dangerous chemicals (“Fixing the Oversight of Chemicals Added to Our Food”). Until these changes are made, it is vital for the general public to be careful of what they are consuming and knowledgeable about the dangers of certain additives. Chemicals such as humectants, anti-caking agents, emulsifiers, stabilizers, thickening agents, gelling agents, and color additives are just some of the dangerous additives in the food supply (“5 Ways to Reduce Intake of Food Additives”). It is important to be able to know to compare ingredients with other food products, find hidden food additives, and know their dangers, but eating locally, cooking homemade meals with basic ingredients, and swapping out unhealthy foods with healthier alternatives are some infallible ways to reduce intake of artificial food additives.

Conclusion

The interactions of food additives and their potential carcinogenic impacts reveal a complex and multifaceted issue that needs further investigation and invested time. The research highlights the significant role that food additives play in extending the shelf life and improving the taste and marketability of processed foods and beverages. However, the potential health risks associated with over-exposure over a long period of time to certain additives, particularly their carcinogenic potential, cannot be ignored. The findings highlight the importance of rigorous regulation and monitoring of food additives to ensure the general public is safeguarded. While some carcinogenic substances are regulated and limited in their usage, loopholes, and gaps in current regulatory frameworks allow certain harmful chemicals to continue to be used in the packaged food supply. The active existence of known carcinogens like nitrites, nitrates, and traces of heavy metals in food packaging, along with additives like emulsifiers, artificial colors, and sweeteners, raises immense concerns about their long-term health implications. Moreover, the mechanisms of carcinogenesis, including the initiation and promotion phases, and the role of various unidentified carcinogens, highlight the intricate nature of cancer development, which is still broadly unclear. Understanding these mechanisms is crucial and necessary for developing effective strategies to mitigate the risks associated with certain food additives and their chemicals. This research emphasizes the need for a proactive, motivated approach to food safety rules and regulations, highlighting the necessity of advocating for stricter regulations on the limits of many food additives, better testing methods, and increased truthfulness in the use of food additives. Additionally, it calls for more complex and detailed studies to fill the gaps in current knowledge of carcinogenesis as a result of certain food additives and to explore the mutually stimulating and negative effects of multiple additives in packaged food products. Ultimately, prioritizing public health safety stands in need of a collaborative effort among the general public buyers, policymakers, and the food industry themselves. By encouraging food literacy, and other forms of informed decision-making and prioritizing the safety and transparency of the food supply of the United States, we can work towards reducing the potential carcinogenic risks associated with food additives and preservatives, therefore enhancing overall well-being and preventing adverse health implications for Americans.

Acknowledgments

I would like to thank my advisor for the valuable insight provided to me on this topic.

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